Report 96-202

Whale Watch Passenger Craft *Uruao*

off Kaikoura

2 March 1996

Abstract

On Saturday, 2 March 1996, at approximately 1230 hours, the rigid inflatable passenger craft *Uruao*, while engaged on a whale-watching trip off Kaikoura Peninsula, suffered a catastrophic failure of the bags that secured her buoyancy pontoons in place and capsized approximately three minutes later. One passenger was trapped under the capsized craft and drowned. The causal factor was the loss of stability experienced when all four buoyancy pontoons were lost. Safety issues identified included maintenance procedures and stability requirements for rigid inflated craft.

Transport Accident Investigation Commission

Marine Accident Report 96-202

Particulars:

Name:	*Uruao*
MSA number:	101969
Type:	NAIAD 12.6 rigid inflatable passenger craft
Class:	New Zealand passenger craft, class IV and V (Kaikoura River Limits and Extended River Limits)
Construction:	Aluminium rigid hull with rubber pontoons secured by PVC bags
Built:	Picton, 1992
Builder:	NAIAD Inflatables (NZ) Ltd
Owner/Operator:	Whale Watch Kaikoura Ltd
Power plant:	Three 250 HP Yamaha two-stroke outboard motors
Top speed:	Loaded - 34 knots Half load - 38 knots
Length over-all:	12.80 m
Breadth:	3.6 m (inflated), 2.4 m (rigid hull)
Gross tonnage:	14 t
Location:	Three nautical miles south-south-east of Atia Point, Kaikoura Peninsula
Date and time:	2 March 1996 at 1230 hours[1]
Persons on board:	Crew: 3 Passengers: 26
Injuries:	Passenger: 1 (fatal)
Nature of damage:	Substantial to inflated buoyancy arrangement, minor to hull and fittings
Inspector in charge:	T M Burfoot

[1] All times in NZDT (UTC + 13 hours)

1. Factual Information

1.1 History of the voyage

1.1.1 At 1130 hours on Saturday, 2 March 1996, a total of 26 tourists had gathered at the Whale Watch booking office in Kaikoura to embark on a whale-watching trip off the Kaikoura Peninsula. The craft on which the group was booked was the *Uruao*, a purpose-built, outboard driven rigid inflatable constructed mainly from aluminium. It was the *Uruao*'s third trip for the day. (See Figure 1.)

1.1.2 Each passenger was issued with a ticket and an information sheet. On the front of the ticket was the highlighted text "Terms and conditions of travel are printed on the reverse". The text on the reverse side of the ticket, written in English, included:

> The passenger acknowledges the following:
>
> (a) That all sea travel undertaken with the Company is carried out with a certain element of risk having regard to the sea and weather conditions. In particular there is a risk of exposure to weather conditions and sea spray which may adversely affect person and property. These risks may vary depending on the type of boat being travelled on. Passengers must ensure that all personal belongings are well secured and protected and it is necessary that passengers inform Company staff in advance of any medical conditions that may be affected by sea and weather conditions.

1.1.3 The information sheet contained information, in English, about the boats and crew members and included the following relevant information:

> **PLEASE READ THE FOLLOWING INFORMATION PRIOR TO BOARDING YOUR VESSEL.**
>
> **BOATS AND EQUIPMENT** - We operate three different types of craft, each of which hold a current certificate of survey and carry a full range of safety equipment. Our boats are crewed by an experienced team, familiar with local sea conditions. All crew hold current First Aid Certificates and are fully conversant in all aspects of safety. As there is a variance in the type of ride associated with each craft, we have outlined information relevant to each.
>
> ***URUAO*** - A 12.6 metre rigid hull NAIAD inflatable, powered by three 250 HP outboard motors. It has a cruising speed of 25 knots, is partially enclosed and has a viewing deck. A maximum of 32 passengers may be carried. This boat is reasonably smooth sailing, however in very rough sea conditions we advise passengers with **BACK** or **HEART** problems or **PREGNANT** ladies to check with the office staff prior to sailing. Passengers will be issued with lifejackets before boarding the boat and we recommend warm clothing (hats and gloves in the winter months). Children must be 5* years of age to travel on this craft.
>
> * Because of the nature of sea conditions along our coastline the captain may increase the age limit on a particular tour.

1.1.4 At 1145 hours the passengers were transported by bus to the South Bay launching ramp from where the *Uruao* would depart. On disembarking from the bus the passengers donned their lifejackets while Whale Watch staff asked them if anybody in the group had back or heart problems or if any were pregnant. None of the passengers indicated that they were affected by any of these conditions.

Figure 1
***Uruao*, in displacement mode**

1.1.5 South Bay had no wharf facilities so passengers embarked on the *Uruao* while she was still on her trailer. As there were no small children or members with medical conditions, the passengers were free to board the craft and sit where they liked on the lower level. For safety reasons the upper viewing deck, where the Master's driving position was located, was only used by passengers when the craft was stationary beside a whale.

1.1.6 When the passengers were on board they were given a safety briefing by one of the two guides. The briefing covered the following points:

- Passengers were to remain seated while the boat was moving.
- Passengers were not to hang over or lean on the side rails and ropes.
- Smoking on board was not permitted.
- Only 10 passengers were allowed on the top deck at one time, and only when the boat was stationary. Everyone would have a chance to go up to this deck but this would be co-ordinated by the crew.
- When a whale was sighted on one side of the boat, passengers on that side should remain seated to allow passengers on the other side to observe. This was to avoid passengers rushing to one side of the boat and causing it to list.

1.1.7 At 1210 hours the *Uruao* was launched and proceeded out of South Bay. On board were the 26 passengers, the Master and two guides. When *Uruao* had cleared the channel slow-speed zone the Master turned her on to a heading of 160°T and increased speed to approximately 20 knots. As the Master applied power, torque from the three right-hand-turning outboard driven propellers heeled the craft to port. As *Uruao* reached planing speed (approximately 10 to 15 knots depending on loading) the Master trimmed the starboard motor up to counter the torque from the propellers and brought the *Uruao* upright on the plane[2].

1.1.8 The sea was calm in the lee of Kaikoura Peninsula, but as *Uruao* headed out past Atia Point the craft began to pitch moderately as she encountered one to two metre confused swells, predominantly from the north-east. The Master was heading the craft for a point three nautical miles south-south-east of Atia Point where whales had been sighted on the previous trips that morning. (See Figure 2.)

1.1.9 One of the guides was on the top deck assisting the Master to spot whales, while the second guide used a public address system to give the passengers a running commentary on proceedings.

1.1.10 As *Uruao* neared its destination the Master sighted a whale but it sounded (dived) before they could reach it. The Master reduced *Uruao*'s speed to idle and waited for another whale to surface. Almost immediately he noticed whale-spotting aircraft circling above a whale approximately 800 m south of their position. The Master turned *Uruao* in that direction and gradually applied power to bring *Uruao* up onto the plane.

[2] When the craft is supported on the water surface in non-displacement mode by hydrodynamic forces generated on the hull by speed.

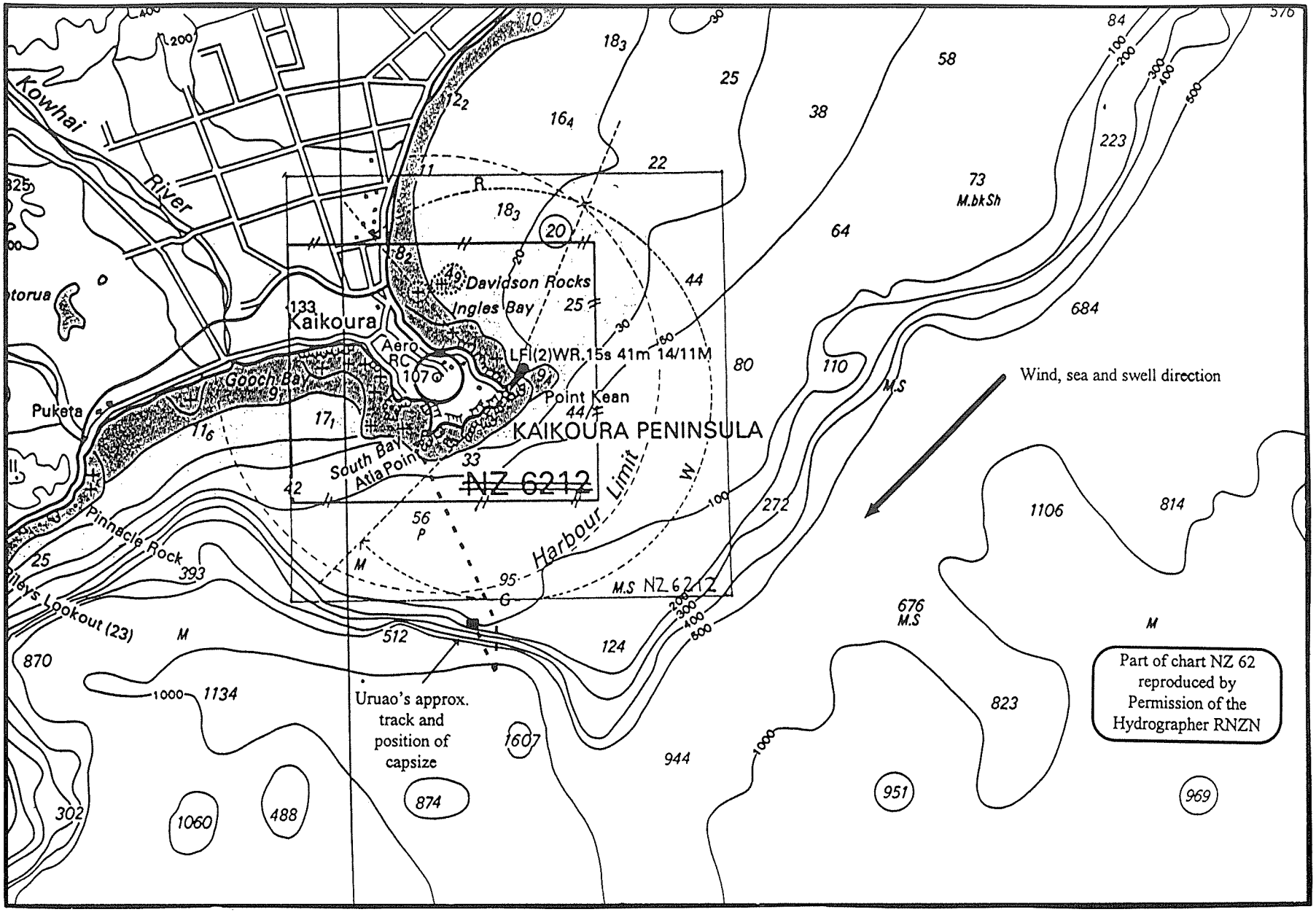

Figure 2
Marine chart showing *Uruao's* track and approximate position of capsize - - - - - - ■

1.1.11 The *Uruao* picked up speed and was planing at 15 to 20 knots running with the sea and predominant swell. The craft overtook a larger wave and was surfing into its trough when the bow fell on to the crest of a secondary wave that had formed in the trough between the two larger waves. The resultant "slamming" sent a shower of spray over the forward part of the craft and the bags that secured the flotation pontoons to the hull failed at the bow. As the craft continued the pontoons progressively separated from the craft.

1.1.12 The guide giving the commentary from the maindeck saw the starboard pontoons separate and banged her fist on the deck-head under the Master's conning position to attract his attention and shouted into the public address for him to "stop". The Master, who could not see the pontoons from his position, noticed the port pontoon "flash" past in his peripheral vision. He disengaged the three engines immediately. The impact with the wave, although louder than expected in the conditions, was not of sufficient force to alarm the Master. It was his glimpse of the port pontoons and the urgent message from below that prompted him to stop the craft.

1.1.13 The Master noticed one of the pontoons partially deflated in the water approximately 50 m astern. He looked over each side and noticed two other pontoons were missing, and the fourth was trailing behind from the port quarter, its end entangled in the outer securing bags which had remained attached by their upper boltrope, the bottom one having torn down the entire length of the craft's sides.

1.1.14 The Master sent the guide down to see if any water had entered the boat and to check if the passengers were all right. The guide returned and informed him that they had lost all buoyancy pontoons but the passengers were "OK" and no water had entered the craft.

1.1.15 At the time of the incident another Whale Watch craft, the *Whahia*, was approximately 400 m from the *Uruao*. The Master of *Whahia* saw the starboard forward pontoon separate from the *Uruao* and shortly after saw another pontoon appear from her port side.

1.1.16 The two Masters communicated by VHF radio and agreed that *Uruao* would proceed back to South Bay with the *Whahia* in attendance. *Uruao*'s Master sent the crew member back down to the main deck to inform the passengers of his intention and to watch for signs of water entering the craft.

1.1.17 The Master turned the *Uruao* around and started back in the general direction of South Bay. Cavitation[3] from the propellers prevented him from applying more than minimal power to all three engines so he continued in at approximately five knots.

1.1.18 *Uruao*'s track back toward South Bay exposed her starboard quarter to the wind, sea and predominant swell. With the loss of the aft pontoons the sea conditions caused her to wallow and over the subsequent two minutes water began to collect on the aft port side of the main deck. At approximately 1225 hours, as one of the guides was on her way up to inform the Master of this, the craft teetered momentarily on the face of a wave, rolled on to her port beam and then slowly capsized.

1.1.19 As the craft teetered, the second guide, sensing that the craft might capsize, shouted at the passengers to move to the starboard side of the craft. A few passengers responded but most stayed "frozen" in their seats.

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[3] Severe vibration caused by the formation of vapour cavities in the water when the propeller stalls due to over-acceleration of the water flow through its blades.

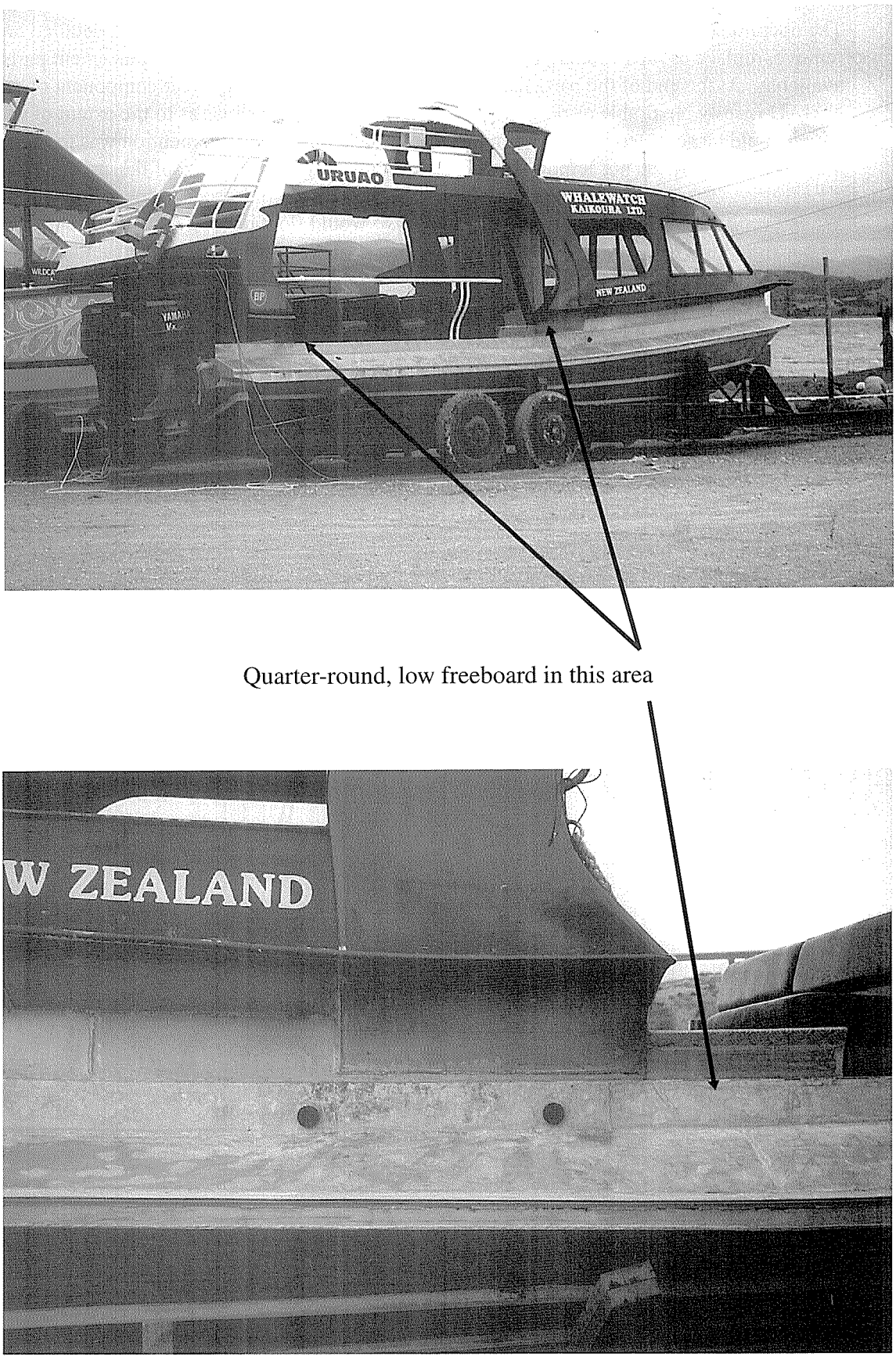

Figure 5
Photographs of *Uruao* without pontoons fitted

1.2.11 Video footage of NAIAD craft operating at high speed in rough conditions showed that they rarely used the pontoons for buoyancy except when the craft was leaning into a tight turn or when the craft's pitching motion was out of synchronisation with the wave period causing the bow to dip excessively into a wave. The latter situation could be avoided by adjusting the craft's speed or angle of attack in relation to the waves. The pontoons were designed to withstand reasonable forces of this nature. NAIAD craft are widely used as rescue craft because of their renowned ability to perform well at high speed in rough conditions.

1.3 Damage to the craft

1.3.1 The bags were torn along the stitched seam where the boltrope secured their bottom edge to the hull. The tear ran the entire length of the bag on both sides of the craft, resulting in it detaching from the hull along that edge. The flotation pontoons also separated from the hull, wrenching out their valves in the process.

1.3.2 The three outboard motors were running when the craft capsized and they sustained internal salt-water damage, as did the electronic navigation equipment.

1.4 Weather information

1.4.1 The weather conditions reported varied considerably between observers. Reported wave/swell heights ranged from one metre, northerly, to three metre, north-easterly.

1.4.2 At the Kaikoura Automatic Weather Station (AWS), which is located on the Peninsula close to the highest point, the winds on 2 March 1996 were light and variable during the morning, but settled down to a 15 knot north-easterly in the afternoon. The AWS, despite its elevated site, is sheltered in northerly flows by the northern part of South Island, and is not representative of the conditions offshore.

1.4.3 When a northerly flow covers central New Zealand the flow is concentrated as it passes through Cook Strait and tends to continue southward parallel to the South Island east coast with only a slight diminution. At Kaikoura the winds, light close inshore, increase rapidly to seaward reaching full strength approximately one mile offshore.

1.4.4 At 1200 hours on 2 March the winds in mid-Cook Strait were 30 to 35 knots from the north. The winds offshore at Kaikoura were probably 25 to 30 knots. These winds would generate locally rough seas together with a short, two-metre swell. They would then give a combined sea of approximately three metres, with an occasional wave in excess of four metres.

1.4.5 Further inshore the seas generated by the offshore conditions would have diminished slightly and changed direction toward the coast; however, an occasional larger set of waves/swells could be expected to pass through the area south and south-east of Kaikoura Peninsula where most of the whale-watching activity was located.

1.4.6 The area off Kaikoura Peninsula is one of conflicting currents and tidal streams causing unpredictable sea conditions that can vary dramatically over a short distance and/or short period of time.

1.4.7 The conditions experienced off Kaikoura Peninsula at the time and location of the accident were likely to have been a 10 knot north-east wind with a short one to two metre confused swell, predominantly from the north-east, occasional swells up to 2.5 metres and localised areas of turbulence where tidal streams opposed the wave direction. The skies were cloudy, but with a high cloud base and no precipitation. Visibility was good. The sea conditions described should have been within *Uruao's* safe operating limits.

1.7 Maintenance procedures

1.7.1 Little is known about the maintenance procedures for Uruao prior to 1994, other than those recalled by the manufacturer and previous employees. New systems which were put into place in January 1994 were monitored and refined with time in operation.

1.7.2 A Daily Check List was used by Masters to record information and comments about the condition of the craft and her equipment. Maintenance was carried out on *Uruao* on a daily basis as the need was seen by the operator. *Uruao* could make several trips in any one day, often with different Masters and crew rostered on.

1.7.3 The Master in command of the first trip each day carried out a pre-trip inspection of the craft, filling out and signing the check list. The check list was left on board for other Masters to fill in performance details for their respective trips. The Master on the last trip carried out a post-trip inspection, signed the form and passed it on to the maintenance staff.

1.7.4 The maintenance staff would carry out their own complete checks and attend to any deficiencies noted on the list. Servicing of the outboard motors was carried out under warranty by a recognised Yamaha service centre. Any maintenance carried out would be noted in the craft's log book. The log book and check lists would remain on board for subsequent Masters to refer back to, the check lists being collected weekly and filed for future reference.

1.7.5 The daily check list contained sections for the Master, maintenance staff and guides to fill out and sign for their area of responsibility. Company policy stated that the craft would not be allowed to proceed to sea unless the check list had been completed and signed by the relevant personnel. Recognising the impracticability of this it was left up to the Masters and maintenance personnel to co-ordinate, the final confirmation that everything had been checked being a radio call from the Master to the base prior to departing on each trip.

1.7.6 The craft's log book and the check lists for the previous 10 days were lost during the capsize. Inspection of check lists for the previous two years showed that they were completed but rarely signed by the Masters.

1.7.7 The check list included as a check item "Pontoons" without specifying what aspects of the pontoons were to be checked. Damage to the rubber pontoons was usually repaired by the operator's maintenance staff, but damaged bags were sent to NAIAD for repair. The bags were not manufactured by NAIAD, but were made under licence at a different location. On occasions the operator would send the bags direct to the manufacturer.

1.7.8 It was reported by the manufacturer that bags would occasionally arrive damaged, with no instruction for repair, or explanation of how the damage occurred. On one occasion the bags had been cut to assist in their removal from the craft, requiring additional repair to that which would normally have been required. When bags arrived for specific repairs, the manufacturer would usually check the complete set and make any additional repairs necessary.

1.7.9 Most repairs to the bags were around the stern region; however, in July 1994, major reconstruction of the bow section was required. The wooden fender at the front of *Uruao*'s trailer had fallen off exposing the steel framework of the bow support, causing the bags to chafe on the steel each time *Uruao* was retrieved. The aluminium bowsprit, where the tongue of the bags was supposed to be secured, had suffered small dents and gouges as a result.

1.7.10 Following this repair, the operator procured a second set of bags to reduce down-time over the forthcoming summer season. The new bags were placed in service in September 1994 and the old set kept as spare. Over the ensuing 14 months the bags were exchanged on several occasions when the need for repairs arose.

1.7.11 It was not practicable to ascertain the "in-service" time of each set of bags over the 14-month period as the original set was not provided with an identification tag. The new bags had an identification number printed on a label; however, this was not quoted in the operator's maintenance records, nor the manufacturer's job records.

1.7.12 In late December 1995 the newer set of bags was sent to NAIAD for repairs to the stern and the old set was put into service. The bags were lost in transit and this, combined with the holiday period, resulted in delays in effecting the necessary repairs.

1.7.13 The summer holiday period was a busy time for the operator and around Christmas the original set of bags in use began to deteriorate around the stern. To minimise down-time the bags were air-freighted direct to the manufacturer, repaired, air-freighted back the same day and put back into service. Several days later the newer set was located, repaired and sent back to the operator who kept them in storage, opting to continue using the old set of bags. After the accident the operator used the newer set of bags for post-accident testing and analysis. According to the operator the newer set of bags required additional repairs to the stitched seam that enclosed one of the boltropes into the edge of the bag.

1.7.14 During the first year of operation the Managing Director and Designer for NAIAD had made several visits to Kaikoura to discuss the performance of *Uruao* and instruct the maintenance staff on various issues relating to the maintenance, care and fitting of the pontoons and bags. During one of the initial visits the maintenance staff were advised of the need to secure the tongue at the bow on each of the NAIADS (the company also operated several smaller NAIADS); however, this information was not passed on when maintenance staff changed in 1994, with the result that the tongues were not secured.

1.7.15 Few problems were encountered with the bags over the first two years of operation; however, over the summer of 1993/94 there was some concern from both the company and the manufacturer over the frequency and type of repairs compared with those by other operators using the same hull. The type of operation and high working hours accounted for a high proportion of the wear and tear. Some changes in practice resulted in a reduction in the damage experienced.

1.7.16 None of the maintenance staff and Masters interviewed could remember the tongues having been secured on any of the NAIADS. The *Uruao's* Master on the accident trip was not aware that there was a facility for securing the tongue.

1.8 Inspection and test results

1.8.1 After salvage the damaged bags were removed from the craft. Inspection revealed deformation of the fibre reinforcing in the PVC consistent with it having been torn from the bow towards the stern. The tear started within the repaired bow section of the bag on both sides of the bowsprit where the aluminium extrusion ended. From this point it progressed aft following the weakest path, the stitched seam holding the boltrope in the PVC bag, and continued along this seam until it was arrested by the stitched and glued cone-ends at the back of the bags.

1.8.2 The repair to the bow section of the bags consisted of two, or three, layers of PVC glued and stitched over the worn and frayed original fabric. After the repair had been performed the rope ends did not continue under the securing tongue, but stopped on both sides at the point where the bag edge entered the aluminium extrusion. Removal of the outer PVC layer showed that the rope had originally extended almost to the seam under the securing tongue. The tongue was not secured at the time of the failure. The fabric and rope ends at the beginning of each tear were frayed and weathered. (See Figures 6 and 7.)

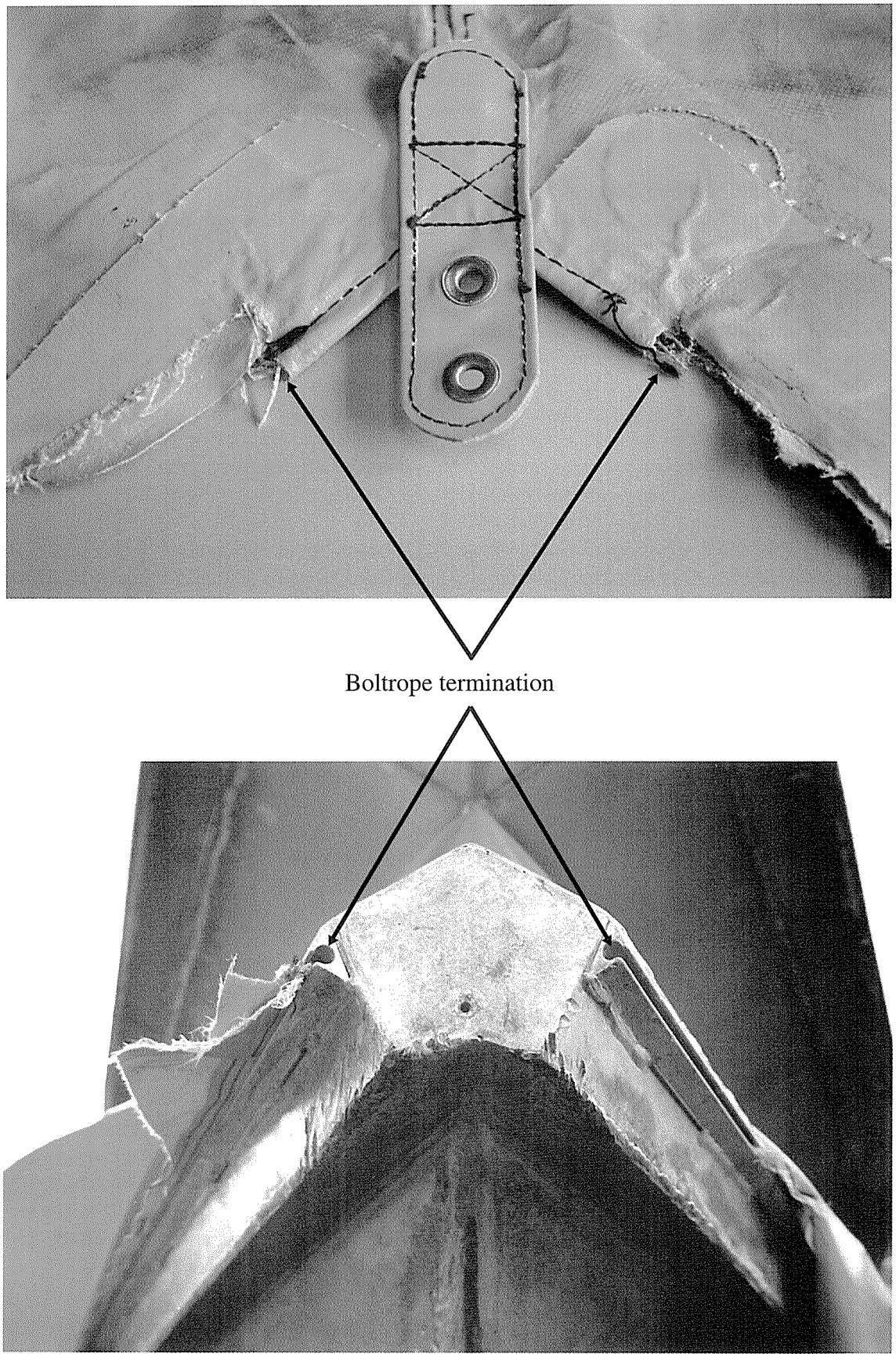

Figure 6
Photographs showing *Uruao's* bowsprit and points of initial failure of the bags

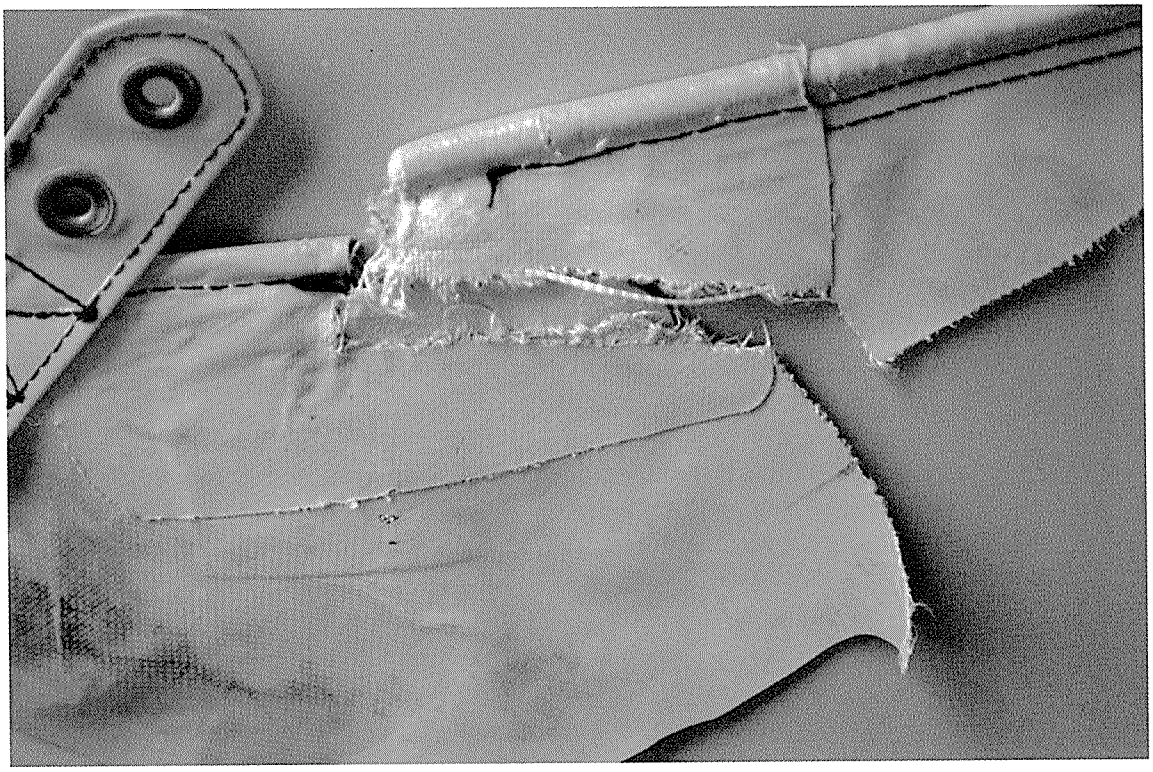

Figure 7
In situ photograph of boltrope on one side of the securing tongue

1.8.3 An "exposure to light" test was conducted on new samples of the same PVC fabric from which the bags were constructed. Results showed that the material had an excellent resistance to light. Warp and weft tear tests were carried out on samples of fabric taken from the damaged bags, and on the repaired, multi-layered front section of the bags. The following results were obtained:

Tear test	Single layer	Repaired section	Specifications (new)
Warp	814 Newtons	1364 Newtons	550 Newtons
Weft	698 Newtons	*	500 Newtons

* Repaired section was large enough to test in only one direction

1.8.4 The test results show that the fabric used for the construction of the bags still exceeded the manufacturer's guaranteed minimum strength after four years. The results also show that the strength in the main body of the repaired section, due to the added layers of fabric, was more than double that of the rest of the bags.

1.8.5 The inner inflatable pontoons had their inflation valves wrenched out as they departed the hull. Salvage divers had to cut free the remaining pontoon that was trailing in the water to effect the tow. Other than that, the pontoons sustained no damage.

1.8.6 The flexible PVC duct attached to the freeing port on the port side was found to be in a deteriorated condition, with holes worn in the fabric around the sealing edge and the main body split. The device, in the condition found, reduced the flow of water on to the main deck but did not prevent it.

2. Analysis

2.1 The high number of *Uruao's* daily running hours, particularly in the summer season, and the harsh working environment in which she operated, meant that she required more frequent maintenance than NAIADs with other operators. Most of the maintenance required on her flotation pontoons was due to "fair wear and tear"; however, some was due to incorrect procedures in caring for, removing and fitting the bags, particularly during the 1993/94 summer period of operation.

2.2 It would have been prudent for *Uruao*'s builder to have referred to the securing of the tongue onto the bowsprit in the instruction manual for the craft. Notwithstanding this, given its existence, and the close proximity of the threaded bolt hole, it should have been obvious to a prudent Master, Surveyor or maintenance person that the tongue had a purpose, and how it should be attached.

2.3 That the July 1994 repair fabric on the bow section was of a suitable strength was evidenced by the post-accident test results. However, during the course of the repair the securing rope appeared to have been cut, probably due to the tapered part being damaged, and stopped on both sides at the point where the boltrope channel entered the aluminium extrusion. The lack of the securing tongue, the end of the extrusion, and the change in the hull geometry combined to create a weak point. The rope was designed to add extra stiffening and strength across the weak point. Its absence caused the fabric to be "worked" more heavily at the weak point until the fabric split at this point on both sides of the bowsprit. This was exacerbated by the fact that the tongue was not secure, enabling the bag to creep forward allowing still more play in the fabric.

2.4 Once split, further working of the fabric in this area caused a tear to progress back through the reinforced repair for approximately 11 centimetres. The progress of the tear would have accelerated as the failing fabric allowed itself more play and opened a bigger gap for wave action to invade the space inside the bags. It could not be determined conclusively for how long the tears on both sides of the bowsprit had been present; however, the frayed and weathered end of the rope and fabric at the origin of the tear indicated that the bow region of the bags had been torn for some time, awaiting only a moderate force to initiate total failure of the craft's inflated buoyancy system.

2.5 Witness accounts of events indicate that as *Uruao* proceeded with the following sea and swell in pursuit of the sighted whale, her bow slammed into a smaller secondary wave, causing the weakened bags to part at the bow. The craft's momentum carried her past this wave, burying her bow into the trough between the two larger waves. The hydraulic effect of sea-water being driven inside the securing bags by the craft's forward momentum, combined with the outward pressure from the inflated pontoons as they "peeled" back from the hull probably caused the fabric of the bags to fail along their weakest point, the stitched seam. With only their air valves securing them to the hull, the inner pontoons were torn from the hull by the wave action and deflated.

2.6 On seeing the port forward pontoon "flash" past in his peripheral vision, and hearing the guide crying "stop stop!" over the public address system, the Master instinctively stopped his craft. Given the benefit of hindsight, and the fact that *Uruao* was more stable when planing, it may have been more appropriate for the Master to have kept *Uruao* on the plane and head directly for shore; however, in that instant the Master did not, and could not, fully appreciate the magnitude of the problem. His action in stopping the craft was therefore understandable if not appropriate. The stability of the craft would have been finely balanced at this stage.

2.7 After discussion with the *Whahia's* Master the decision was made to proceed back to South Bay. The *Uruao's* Master engaged all three engines ahead and began to apply power to them but cavitation from one or more of the propellers, and the heel to port caused by propeller torque, prevented him from doing so. Some cavitation was normally experienced when powering up on to the plane. The effect would have been worse due to all three propellers rotating in the same direction, and the drag of the damaged bags and trailing pontoon in the water.

2.8 The Master turned the craft in the general direction of South Bay and applied low power to all three engines. This action placed the craft in a situation where all influencing factors favoured a capsize to port. Wind from the starboard quarter and torque from the propellers was heeling the craft to port while the sea and swell coming from the starboard quarter caused the craft to wallow, favouring a roll to port. In addition, the deteriorated condition of the non-return device on the port side was allowing water to back-flow through the freeing port. Waves coming from the craft's starboard quarter would have had the repeated effect of turning the vessel to starboard, necessitating the application of corrective port helm. The application of port helm creates a port heeling moment.

2.9 It would have been more appropriate for the Master to turn *Uruao* head-to-wind under minimum power to give him more time to assess the situation and consider his options. Had he been more familiar with the stability characteristics of *Uruao*, he may have chosen this option.

2.10 When the craft teetered over to port on the face of a wave, water poured into the main deck over the low sill where the inflated pontoons had previously provided freeboard in this area. The majority of the passengers falling down to the port side would have contributed to the capsizing motion. At this stage the situation was irretrievable.

2.11 The deceased was described by friends and relatives as a strong swimmer. The position in which she was found indicated that she had almost managed to swim free of the craft. It is probable that she was making her way towards the open-sided part of the craft which would have appeared to offer the easiest route for escape. In doing so she would have passed the smaller opening immediately aft of the forward enclosed cabin. Her life jacket would have hindered her attempts to escape, forcing her to have to pull down against its buoyancy in order to progress aft.

2.12 On reaching the open-sided part of the craft the deceased was probably washed inboard by the surface swell and became stuck between the seat backs, where she was found.

2.13 The operator's procedures for the operation and maintenance of *Uruao*, if followed, should have been adequate to detect the tear in the bags. It could not be established whether the intended cross-checking between Masters and maintenance staff was taking place as signatures were missing from the check lists. This alone, according to documented procedures, should have been enough to stop *Uruao* entering service on any one day where the signatures were missing; however, the checklists had been filled in and were said to have been confirmed by a radio call to the office prior to each trip.

2.14 Regular changes in maintenance staff resulted in inadequate flow of information relating to past problems and procedures. If regular inspections of the bags were being conducted then such inspections were either not thorough enough, or the persons carrying out such inspections were not aware of the importance of the tongue and the securing of the bags to the hull. A thorough inspection would have revealed that:

- the tongue was not attached; and
- the fabric either side of the tongue was torn.

2.15 There was no mention on past check lists of either deficiency. When the tongue is not attached, it tends to hang down in full view. It is likely that this was noticed regularly and was accepted as being normal and of no consequence.

2.16 There did not appear to be any routine for checking repairs made to the bags when they were returned. While they could reasonably expect a bag returning from the manufacturer to be in a seaworthy condition, the ultimate responsibility for ensuring that the craft was seaworthy rested with the operator and the crew. It may have been difficult to detect that the rope on the old set of bags did not extend under the tongue when first fitted, but the tears would have become evident once the bags had been in service long enough for them to develop.

2.17 Under normal circumstances where damage has occurred, or modifications are made to a craft that could affect her conditions of class and survey, such modifications or damage are required to be notified to the Surveyor. None of the repairs to *Uruao*'s bags were notified to the Surveyor, nor was he notified when the bags were exchanged. As the bags were considered to be a wearable item, and instructions were given by the builder on how to carry out repairs to them, it is considered that the operator acted appropriately in not informing the Surveyor each time repairs were carried out. However, when the condition of the old bags deteriorated to a point where the operator opted to purchase a new set, the Surveyor should have been informed. Had he been informed he may well have condemned the old bags as being unfit for further use.

2.18 When the Surveyor inspected *Uruao* 12 days before the accident for renewal of her Certificate of Survey, he gave little attention to the condition of the bags. The Surveyor was not aware that the bags had been changed on occasions over the preceding two years and was unaware at the time as to what extent the flotation pontoons had contributed to the craft's stability when the original tests were conducted. Had he been aware of these factors he may have included the bags in his thorough hull survey and may have noticed the tear in the bags near the bow.

2.19 Notwithstanding the considerations in paragraph 2.18 it should have been readily apparent to a prudent mariner who had a reasonable knowledge of craft stability that the flotation pontoons played a significant role in *Uruao*'s stability and handling characteristics. If such persons had any doubt they could have sought the advice of the builder or a naval architect.

3. Findings

3.1 *Uruao* was crewed and certificated as required for a craft of her assigned class.

3.2 Sea and weather conditions were within normal operating limits for which *Uruao* was designed provided that she was being operated with due diligence.

3.3 There was no evidence to suggest that the Master was not operating *Uruao* with due diligence at the time of the accident.

3.4 *Uruao* suffered a catastrophic failure of the securing bags which resulted in the loss of all four buoyancy pontoons.

3.5 The shortened boltrope and failure to attach the tongue to the hull resulted in a weakening of the bags to a point where they could not sustain normal working loads.

3.6 The tear in the securing bags, their improper securing to the hull and the deteriorated condition of the freeing port, should have been detected by the operator's inspection and maintenance system. The Surveyor should also have detected them during his inspection of *Uruao*'s hull less than two weeks before the accident.

3.7 The weakened state of the bags and the manner in which they were fitted rendered *Uruao* unseaworthy at the time of the accident.

3.8 The loss of the buoyancy pontoons caused a loss of stability sufficient to cause *Uruao* to capsize under the influencing conditions at the time.

3.9 The *Uruao's* loss of stability was caused by the subsequent reduction in freeboard, loss of reserve buoyancy and free fluid surface effect of sea-water on the main deck, after the pontoons had departed the craft.

3.10 Torque from the three right-hand turning propellers, failure of the non-return device on the freeing port and the Master's decision to place the wind, sea and swell on the starboard quarter, were contributing factors which coincided to cause the *Uruao*'s capsize.

3.11 Although the *Uruao* complied with the stability requirements assigned to her at the time of commissioning into service, she was capable of capsizing with only one of her aft pontoons deflated during the stability tests.

3.12 The stability requirements with which *Uruao* had to comply were inadequate for a craft where inflatable buoyancy pontoons contributed to the craft's stability.

3.13 The quick response to the Mayday, the efficient manner in which the rescue operation was conducted and the post-accident care given to the passengers and crew by the operator, probably prevented further serious injury.

4. Safety Recommendations

4.1 It was recommended to the Chief Executive of Whale Watch that he:

4.1.1 Critically review and, where necessary, upgrade the company's inspection and maintenance procedures to prevent similar lapses in the future. (051/96)

4.1.2 Review the stability characteristics of all company craft and include relevant instruction on each in the company procedures manual. (052/96)

4.1.3 Produce a safety card that, with the aid of pictures, conveys the main points of the safety briefing given at the start of each trip. The text on the card should be repeated in several of the main languages. (053/96)

4.2 The Chief Executive for Whale Watch responded inter alia as follows:

4.2.1 (051/96) - This recommendation should be withdrawn. No "lapses" occurred of any nature that has any bearing whatsoever on this incident.

4.2.2 (052/96) - No "relevant" instruction can be incorporated in the company's procedures manual as this incident was directly caused by the inherent design defect which manifested itself upon catastrophic failure of the bags (in turn caused by substandard repairs). No stability issues remain for the company to address.

4.2.3 (053/96) - The safety card idea is fine and these steps were in train at the time of the accident; nevertheless, as this has no relevance to this event we seek its removal.

4.3 It was recommended to the General Manager of NAIAD that he:

4.3.1 Review the NAIAD Instruction Manual and expand it to include full fitting instructions for the bags, and guidelines for the user regarding repair or replacement of wearable parts. (054/96)

4.3.2 Consider extending the half-round recess for the full length of the craft to ensure adequate freeboard in the event of deflation or loss of a pontoon on similar craft built in the future. (055/96)

4.3.3 Introduce a system where each set of bags has an identification mark that can be used to trace their movement and repair. (056/96)

4.4 The General Manager of NAIAD responded as follows:

4.4.1 054/96 - Please find attached a brief history on RIBs, the forms of attachments, and points to look for in relation to wear and tear (see Appendix A). It is NAIAD's intention to include paragraphs "Craft Stability", "Inspection And Maintenance", "Outers" and "Maintenance Of Outers" in our future manuals and send a copy to all commercial users.

4.4.2 055/96 - As each boat is built for a particular end use we will consider extending the inwhales up to the level of the top of the air bags where appropriate. In every case for commercial use we will supply stability information in the manual to make owners aware of the stability characteristics that the craft has.

4.4.3 056/96 - Each set of outers are clearly identified with a serial number as well as the date of manufacture and material roll number.

4.4.4 Modifications are made from time to time where improvements are required to overcome perceived deficiencies as they are identified. NAIAD have a policy of constant improvement in design and manufacture. We are also able to retro-fit most of such improvements to our older craft.

4.5 It was recommended to the Director of Maritime Safety that he:

4.5.1 Produce a MSA Circular Letter to surveyors, instructing them, when surveying rigid inflatable craft, to include the inflatable pontoons and their attachments to the hull, as though they were an integral part of the hull. (034/96)

4.5.2 Adapt the appropriate rules to require any rigid inflatable to:

4.5.2.1 Be able to withstand the deflation of any one of its inflatable pontoons and still meet the existing stability criteria.

4.5.2.2 Have explicit instruction manuals and guidelines for maintenance, which must be sighted by the surveyor before a Certificate Of Survey is issued.

4.5.2.3 Have each pontoon numbered for identification and its method of securing recorded on the Certificate Of Survey if the inflatable pontoons are interchangeable.

Items 4.5.2.2 and 4.5.2.3 should be made to apply retrospectively. (035/96)

4.6 The Director of Maritime Safety responded as follows:

4.6.1 034/96: We have asked the management at M & I to undertake a study into the special nature of NAIAD craft compared to conventional vessels. We have asked then to issue appropriate instructions to their surveyors to take the difference into account. The M & I surveyor who surveyed Uruao shortly before the accident has been reminded that the pontoon is an integral part of the hull and that its condition and means of attachment to the hull requires particular attention.

4.6.2 035/96: The inclusion of your suggestions that such craft be able to withstand the deflation of any one of its pontoons and still meet the existing criteria has been forwarded to our Rules section for consideration.

4.6.2.1 MSA is collaborating with the manufacturer to produce precautionary operational measures which will be forwarded to all known NAIAD owners in order to avoid a recurrence of this magnitude. The manufacturer has also been asked to supply guidelines for maintenance to new owners. He has also agreed to conduct training courses for new owners, prior to them putting their craft into operation.

4.6.2.2 Your suggestion that the pontoon identification numbers be recorded on each vessel's Certificate of Survey will be forwarded to the surveyors.

3. Double skinned, glued and sewn construction;

- check all seams for peel or wear on the stitching;
- look for cuts and chafing. If right through the outer then it must be repaired;
- look at attachment points at the beginning and ends especially.

Assessment can be made on the strain on the bonding to the hull. If the bonding is protected by a stepped chine so that the chine takes the primary impact then less strain needs to be absorbed by the air tubes. The way the tubes are supported by the hull will indicate the potential strain on the attachment system e.g. if the air tubes are supported half way round or partially on top then some strain is reduced at the points of attachment.

Craft Stability

The inflatable pontoons add significantly to the stability of the craft. Losing one section or side will alter the stability, in some cases significantly. All commercial craft will have stability data included in the manual. Contact the manufacturer if clarification is required. Generally craft with a taller superstructure and consequently a higher centre of gravity will be more dependent on the extra stability the inflatable tubes provide. It is therefore very important to maintain and care for the pontoons and ensure they are fitted correctly.

Inspection and Maintenance

The correct operating pressure is 2.5 to 3.0 lb./sq inch. At pressures below 2 lbs/sq inch for light duty the possible strain on the attachment points is increased by deformation of the buoyancy tubes by impacting waves. Buoyancy tubes at the correct pressure reduce the movement at those points and will therefore increase the life.

Check the condition of the bolt rope where it exits the bolt rope track forward and aft. Minor repairs should be carried out if the coating is badly damaged and the base fabric is showing through. If the fabric is torn at that point then a more substantial repair is required.

The outers are constructed using sewing and gluing. All glue seams should be checked periodically for lifting or slipping. All exposed sewing threads to be checked for chafing or other damage.

The retaining tag at the bow should be fitted correctly to the hull on all models being used commercially and on all models 5.8 metre and bigger on pleasure craft. This tag prevents the bags from creeping forward and keeps the gap between the hull and the outer to a minimum. A recent change in design of the aluminium inwhale has improved the fitting at the bow.

The lower boltrope must be pulled in as hard as possible to reduce the gap. There are two holes in the tag, one is a spare in case of damage to the other. If the other is used a new hole must be drilled and tapped to suit.

Outers

Bow tie-down tag. Two tags are sewn into the outers at the bow, one at the top boltrope and one at the bottom boltrope. All models have these tags. Though design changes have meant that it is not necessary to fix these in models 5.8XL and smaller it is most important that the 5.8 offshore and larger models have the lower tag attached to the bow. The tag prevents the outer from sliding forward during inflation and deflation and ensures that the gap between the lower bag rails and the outers is kept to a minimum to prevent water entering between the outer and the inner.

Maintenance of Outers

Cleaning: Do not use chemical solvents, bleaches, acids, or strong alkaline. Do wash with plain water. Stains or dirty spots can be rubbed with fine liquid abrasives such as "Jif" but this must be thoroughly washed off with clean water. PVC restorers may be used but they do tend to make the outers slippery.

Visual inspections should be carried out frequently depending on use. Part of the construction is stitched; this should be checked for damage to the threads. Part is glued; these joins should be checked for damage and peel. Small cuts should be patched as in extreme situations these can allow water to enter between the inner and outer and cause the cut to enlarge to a dangerous extent where major damage to the outer could result.

Glossary of Marine Abbreviations and Terms

AC	alternating current
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
bus	an arrangement of copper conductors (Bus bars) within a switchboard, from which the circuits are supplied
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"
DC	direct current
deckhead	nautical term for roof
dog	cleat or device for securing water-tight openings
draft	depth of the vessel in the water
EPIRB	Emergency Position Indicating Radio Beacon
even keel	draft forward equals the draft aft
freeboard	distance from the waterline to the deck edge
free surface	effect where liquids are free to flow within its compartment
freshet	term used to describe an increase of water level in the river due to rain in the mountains
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
GS	general service
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
V	volts
VHF	very high frequency
windlass	winch used to raise a vessels anchor