Report on the investigation of

two people being thrown from a

high-speed rigid inflatable boat

with the loss of their lives

in Milarrochy Bay, Loch Lomond, UK

on 13 March 2005

Marine Accident Investigation Branch
Carlton House
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Report No 24/2005
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Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purpose is to attribute or apportion liability or blame.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

C	–	Centigrade
CB	–	Citizen Band
cc	–	cubic centimetres
CCTV	–	Closed circuit television
CSPUSU	–	Central Scotland Police Underwater Search Unit
EEA	–	European Economic Association
GPS	–	Global positioning system
GRP	–	Glass reinforced plastic
hp	–	Horse power
kW	–	kiloWatt
m	–	metre
mph	–	miles per hour
RIB	–	Rigid inflatable boat
RNLI	–	The Royal National Lifeboat Institution
RYA	–	Royal Yachting Association
UTC	–	Universal Coordinated Time
VHF	–	Very high frequency

SYNOPSIS

At about 1345 on 13 March 2005, Angus Buchanan and his daughter Holly were thrown overboard from their rigid inflatable boat (RIB) while travelling at high speed on Loch Lomond. Despite extensive surface and underwater searches, their bodies have not been found at the time of publication.

On the day of the accident, the father and his two teenage daughters launched their 6.4m RIB from the Loch Lomond and the Trossachs National Park Authority's slipway at Balloch. The RIB was fitted with a 150 hp outboard engine, giving a top speed of 50 knots.

The water temperature was 3°C, the air temperature was about 5°C and the strength of the wind was force 4 from the west, which produced waves of about 30cm in height. They were all wearing warm clothing, but were not dressed for entering the water and were not wearing lifejackets, as these had been accidentally left at home.

While on passage to one of the islands in Loch Lomond, the father allowed his elder daughter to steer. However, she found this task difficult and the father took over again. After they had a picnic on the island, they re-boarded the RIB to return to Balloch.

The father was sitting at the steering wheel on the forward of two fore and aft seats, the younger daughter was sitting directly behind him and the elder daughter was standing behind her sister holding on to a back rest. Soon after leaving the island, at the request of his daughters, the father weaved the boat from side to side, after which he steadied the RIB on a course for Balloch and set the throttle at full speed. Soon afterwards, the RIB unexpectedly lurched to port, throwing the father and younger daughter overboard into the water.

Because the outboard engine ignition cut-out kill cord had not been attached, the RIB carried on travelling away from the two people in the water. The elder daughter, who had been thrown to the bottom of the RIB, managed to reach the engine throttle control and to stop the boat. Then, despite problems steering the RIB, she was able to drive it back to the area where her father and sister had been thrown into the water.

A passing cruiser had seen the RIB at a distance and saw the elder daughter raise an arm. However, the people on the cruiser mistook this gesture as a greeting, and not one of alarm, and they continued on passage, oblivious to the emergency.

The elder daughter manoeuvred the RIB close to her sister and then entered the water. However, despite courageous attempts to rescue her sister, the effects of cold water forced the elder daughter to re-board the RIB, after which she lost sight of both her younger sister and her father. She then drove the RIB over to two fishermen in a boat in Milarrochy Bay to seek help, and they called the emergency services. On-water and shoreline searches began and these were later joined by two helicopters. However, the father and the younger daughter were not seen again.

The report concludes that:

- The condition of the hull, tubes and outboard engine was not a causal or contributory factor to the accident.
- The steering system was in poor condition and in need of maintenance or replacement.
- The cause of the accident was the loss of a significant quantity of hydraulic oil from the steering system.
- The effects of loss of hydraulic oil, the introduction of air into the steering system and damaged non-return valve springs combined to cause a sudden uncontrolled movement of the outboard engine, with the result that the RIB lurched violently to port.
- An in-water test showed that the steering system functioned satisfactorily when it had been topped up with hydraulic oil.
- Cold water shock severely reduces a person's ability to stay afloat, so the wearing of a lifejacket is essential to extend survival time and hence improve the chances of being rescued.
- It was essential for the father and his younger daughter to be rescued quickly before the debilitating symptoms of cold water shock took effect. Had any or all of a number of safety items been in place (kill cord, lifejackets and means of alerting others to an emergency), their chances of survival would have been greatly enhanced.
- Attendance on an RYA powerboat course would provide boat owners with the practical skills required for operating a RIB. It would also educate them on the safety issues relating to powerboats.
- Waterway authorities can assess the general risks caused by leisure craft activities, and they have the powers to put in place control measures to reduce those risks.

This report recommends that:

- The RYA extensively promulgates the lessons learnt from this tragic accident, both to its instructors and trainees.
- The Waterway Authorities ensure that procedures are put in place to establish and/or regularly review the general risks posed by the various leisure activities on their waters, and identify and then implement appropriate control measures, if required, that will reduce such risks to an acceptable level.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF THE RIGID INFLATABLE BOAT AND ACCIDENT

(All times are UTC)

Vessel details

Owner	:	Angus Buchanan
Type	:	Rigid inflatable boat
Built	:	1989/1995 by Northcraft of Pattrington, East Yorkshire
Construction	:	GRP hull and hypalon buoyancy tubes
Length overall	:	6.4m
Engine power and/or type	:	Mariner V6 OptiMax 112kW (150hp)
Fuel	:	Petrol
Maximum speed	:	50 knots
Gears	:	Forward, neutral, reverse

Accident details

Time and date	:	At 1445 on 13 March 2005
Location of incident	:	Milarrochy Bay, Loch Lomond, Scotland
Persons on board	:	3
Fatalities	:	2
Damage to boat	:	None

Photograph 1

Police officers from Cental Scotland's Underwater Search Unit testing the RIB in the Firth of Forth

1.2 BACKGROUND

Angus Buchanan, the owner of the boat, was an experienced offshore yachtsman. He had sailed in challenging sea conditions and was known by those who sailed with him to be a safety conscious sailor who always wore his lifejacket. However, his experience with Rigid Inflatable Boats (RIBs) was less extensive, spanning a period of only about the previous 2 years. During that time he had owned one RIB then replaced it with a larger one, which he had fitted with a much more powerful outboard engine.

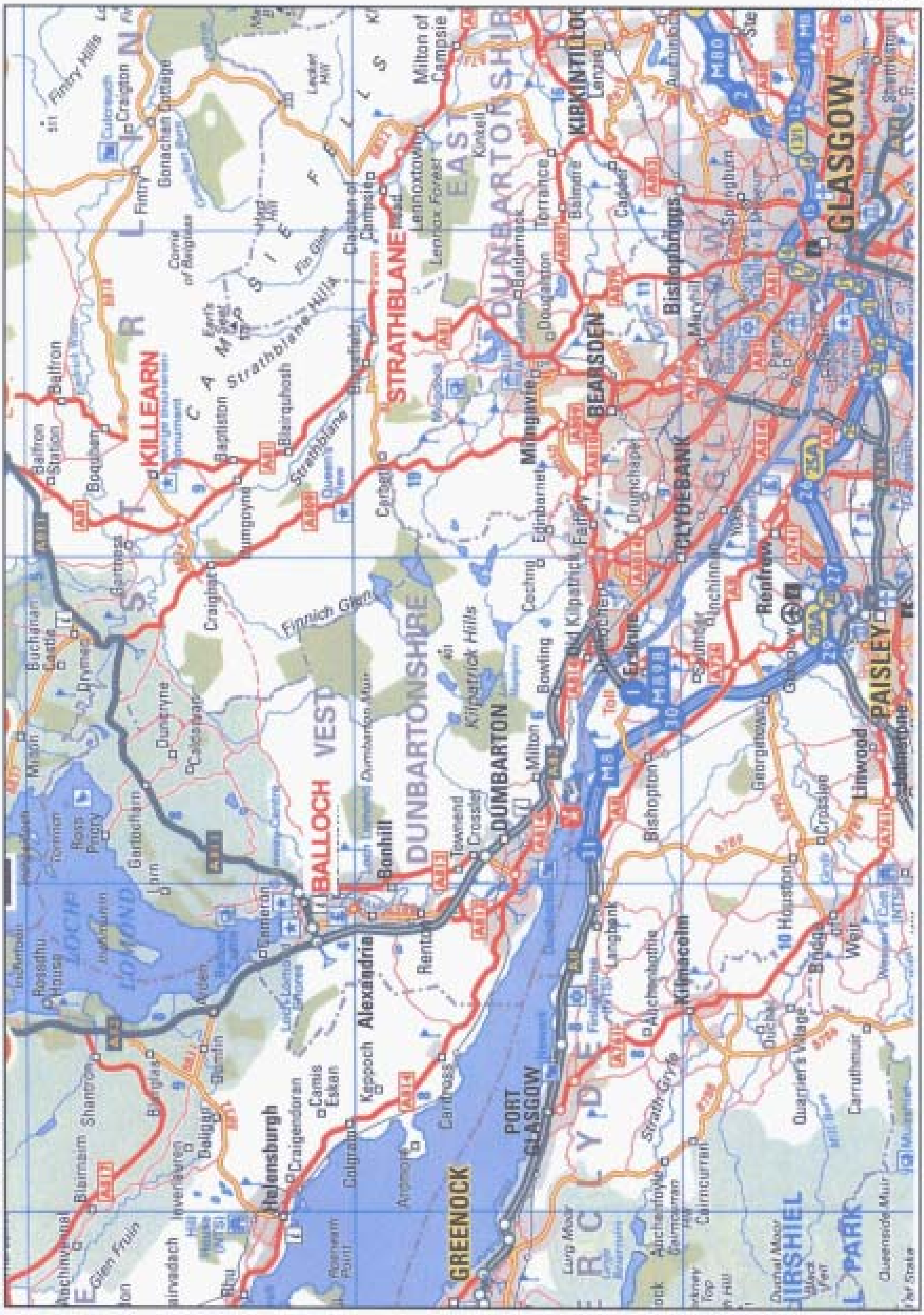
1.3 NARRATIVE

On the morning of Sunday 13 March 2005, Angus Buchanan and his 15 year old daughter drove from Glasgow to his parent's house in Strathblane, to collect his RIB, which had been stored there over the winter. The RIB was on a trailer, which they hitched to the back of his car. The RIB was fitted with a 112 kW (150hp) Mariner outboard engine mounted on the transom. They also collected a flag, a tool box and a pair of oars.

The father and daughter then travelled to Killearn to collect his 13 year old daughter Holly, after which they carried on to Balloch (see Figure 1). At Balloch, they intended to launch the boat at the slipway into Loch Lomond, and have a picnic on one of the islands at the southern part of the loch.

During the journey to Balloch, they realised that they had forgotten their lifejackets. However, it was decided to continue with the outing without this equipment.

Figure 1



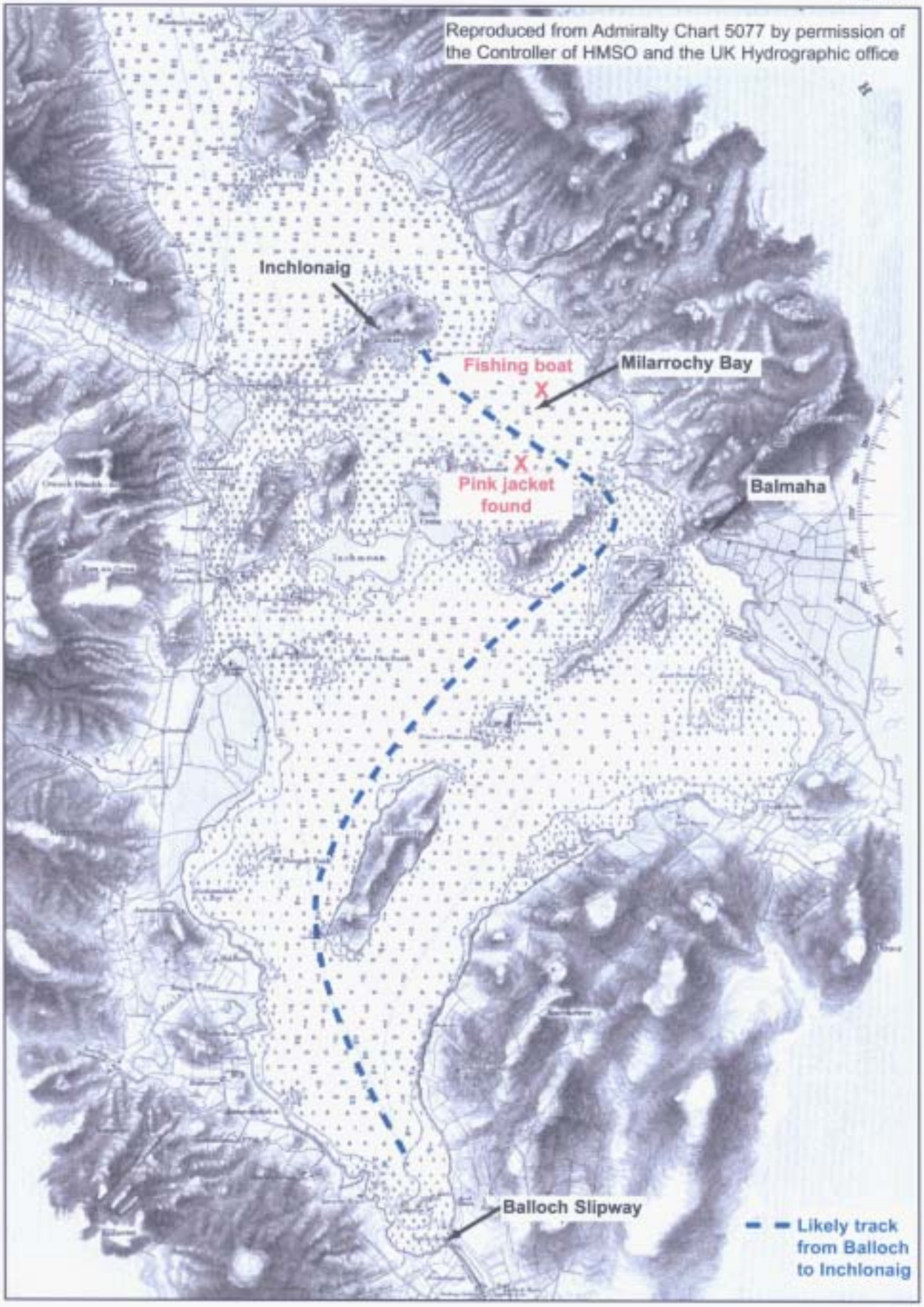
The slipway at Balloch was managed by the Loch Lomond and Trossachs National Park Authority (hereafter the National Park Authority), and CCTV coverage showed the family arrived there at 1240.

At 1243, they were joined by two members of the public and by one of the National Park Authority's rangers. At 1256 the elder daughter walked to the slipway **(see Photograph** 2) and, at 1257, the father reversed his car and trailer down the slipway, with the younger daughter sitting in the RIB.

The younger daughter was wearing jeans with jogging trousers over them and then waterproof trousers, a bright *Musto* sailing jacket, skiing goggles and a woolly hat. The father was wearing cream trousers, an old green heavy jacket, a white and red hat and skiing goggles. The elder daughter was wearing similar clothing to her sister except for a pink padded jacket.

After the boat was launched, the father and his two daughters travelled towards the island of Inchlonaig **(see Figure 2),** which took about 20 minutes. During the passage to the island, the father allowed his elder daughter to steer the RIB. However, she found this task difficult because she had to turn the wheel a disproportionate number of times to turn the outboard engine and hence steer the RIB. Because of the effort required, she was able to steer the boat for only a short period of time, after which her father took over again.

Photograph 2


Reproduced from Admiralty Chart 5077 by permission of the Controller of HMSO and the UK Hydrographic office
Inchlonaig
Fishing boat
Milarrochy Bay
Pink jacket found
Balmaha
Balloch Slipway
Likely track from Balloch to Inchlonaig

When the RIB arrived at the island, the elder daughter went ashore and took photographs of the RIB with her father and sister aboard as he manoeuvred the boat at speed clear of the beach **(see Photograph 3)**. He then brought the boat onto the beach and they had a picnic lunch. While they were having lunch on the beach it began to snow.

After lunch, they boarded the RIB to return to Balloch. The father was sitting at the helm, the younger daughter was sitting on the seat behind him, and her elder sister was standing directly behind her and holding onto the backrest **(see Photograph 4)**.

At the request of his daughters, the father weaved the boat from side to side several times at speed. Then he steadied the RIB and set the engine throttle control at or near full speed, which was about 50 knots.

Unexpectedly, the RIB lurched heavily to port and the elder daughter saw her sister and father thrown out of the boat and into the water, while she was thrown to the bottom of the boat. The RIB carried on travelling at speed; the elder daughter managed to crawl forward and reach the engine throttle control lever. She pulled the lever back, initially into reverse, before she was able to move it to the neutral position. She noticed that the loose items in the boat had been disturbed by the severity of the RIB's movement. She also saw that her father and sister were in the water some distance away from and behind the RIB.

At this time, a south-bound white cabin cruiser was travelling from Ardlui, at the northern end of the loch, to Balmaha **(see Figure 2)**. As the cabin cruiser passed Strathcashell Point, the crew saw a RIB ahead of them travelling at speed in Milarrochy Bay. They slowed the cabin cruiser in case the RIB turned back, as this would bring it too close to their own boat. They saw the RIB stop and a person in the boat raise an arm (it was too far away for the cabin cruiser's crew to establish whether the person in the RIB was male or female). It appeared to the crew of the cabin cruiser that this was a gesture of greeting by the occupant of the RIB, and it did not occur to them that the boat might require assistance. They therefore continued with their passage to Balmaha.

The elder daughter began shouting to her father and sister from the time she regained control of the boat. She turned the RIB around and started to head back towards them. She saw the white cabin cruiser pass between the RIB and her father and sister and then continue on passage. She could see both of their heads above the surface of the water about 2 to 4 metres apart, and she could hear her father shouting. She continued to shout to her father to help her sister, but her father, by that time, failed to respond.

Photograph 3

A view of the RIB manoeuvring off Inchlonaig

Photograph 4

The elder daughter arrived at her father's and sister's position, but had difficulty in manoeuvring the RIB close enough to reach out to them. She shouted for her father and sister to swim to the boat, but they did not do so. She manoeuvred the RIB closer to her sister and reached out to her with an oar, but her sister did not respond. She then decided to enter the water to help her sister get back into the RIB. When she reached her, she placed her hands under her sister's arms and attempted to keep her head above the surface of the water. She then tried to lift her sister up and onto the RIB, but could not do so.

The elder daughter then began to suffer from the effects of the cold water. She tried to climb back on board the RIB, but found it difficult. She took her jacket off and swam to the rear of the boat where she was able to climb on board over the transom stern. Once on board, she looked for her father's mobile telephone, but could not find it. She looked around the loch, but was unable to locate her father and sister. However, she saw a small fishing boat in Milarrochy Bay, so she re-started the engine and drove the RIB towards the fishing boat, which had two fishermen on board.

It was clear to the fishermen that the girl was very upset. She was shouting to them that her father and sister were in the water, and was asking whether they had a mobile telephone.

Earlier, the fishermen had seen the RIB pass them, heading south, with three people on board. Now, as the RIB approached them, they noted there was only one girl on board. One of the fishermen dialled 999 on his mobile telephone and was connected to the police at Dumbarton. He relayed to the police what the girl had told him, and was told to keep his mobile telephone switched on and to stay with her.

As one of the fishermen boarded the RIB, the elder daughter told him she believed there was something wrong with the steering. At the same time, the other fisherman took his boat out further onto the loch to search for the girl's father and sister.

At 1456, the Dumbarton police contacted Clyde Coastguard and informed them of the situation. The coastguard alerted four of their search and rescue units, and tasked them to search the loch for the two missing people. They also alerted the Royal Navy rescue helicopter R177 from *HMS Gannet* at Prestwick airport. A police helicopter VM70 was also scrambled and, at about 1522, both helicopters arrived at the search area. The search effort was augmented by the National Park Authority and the Luss rescue boats, the Loch Lomond rangers, the police and members of a local sailing club.

Leaving the search to the other vessels, the fishing boat returned to the RIB and began towing it to the National Park Authority's slipway in Milarrochy Bay. On the way, the fishing boat and the RIB were joined by rangers on board the National Park Authority's rescue boat. Since the fishing boat was struggling with

the tow, two of the rangers boarded the RIB and drove it back to Milarrochy Bay slipway under its own power. On arrival, the elder daughter was taken ashore to the National Park Authority's facilities and, after being treated for hypothermia, she was taken to Stirling Royal Infirmary.

On boarding the RIB, the rangers had found one end of the kill cord in the ignition, enabling them to simply turn the ignition key to start the engine. Later, while returning the RIB to Balloch, they drove the boat cautiously, as the elder daughter had told them of the steering problem. During the return passage, they had to stop a number of times to physically re-position the outboard engine to make it head in the correct direction, as it was not responding to the helm and would periodically flip to port or starboard.

At about 1806, the police helicopter saw a pink jacket in the water, and it was picked up by the R177 helicopter at 1812. The jacket was found about 350m due east of Ceardach Island **(see Figure 2)**.

The search of the loch and shore was called off at about 2000 because of the failing light. Search teams were re-deployed the following morning and were supplemented by divers from the Central Scotland Police Underwater Search Unit (CSPUSU). However, the search was unsuccessful and the teams were stood down again at about 1830 that evening.

The coastguard search continued during the next few days, but without success. The search was officially closed on 21 March 2005.

When weather permitted, the police Underwater Search Unit continued its divers' search of the loch bed. They also carried out a search using sonar equipment with assistance from military and commercial specialists. Their searches continued until 19 April 2005, when the Unit abandoned the search without finding the bodies of Angus or Holly Buchanan.

1.4 ENVIRONMENTAL CONDITIONS ON LOCH LOMOND

At 1500 on 13 March 2005, the wind was 10 – 15 mph from the west, the air temperature was +5°C falling to +2°C and there had been snow showers. A few hours after the accident, the water temperature was recorded as 3°C.

Sunset was at 1815.

1.5 INSPECTIONS OF THE RIB AND THE OUTBOARD ENGINE

1.5.1 General description

The RIB was built by Northcraft of East Yorkshire. It had a glass reinforced plastic (GRP) shallow "V" shaped hull, with buoyancy tubes down the sides of the top of the hull, except for the transom stern. A grab line on each side of the hull was integral to the tubes **(see Photograph 4)**.

The steering wheel, the hydraulic steering pump and three gauges were fitted to a console which was positioned about one third of the RIB's length from its bow. The gauges provided information on the RIB's speed through the water, the contents of the fuel tank and engine revolutions **(see Photograph 5)**. There was a storage compartment in the forward part of the consol fitted with an access hatch. Aft of the consol were two fore and aft seats, both of which had backrests as shown in **Photograph 4**. A fuel tank was stored under the forward seat.

Photograph 5

A stainless steel "A" frame was fitted over the transom stern, to which were fixed the navigation lights along with two of the National Park Authority's registration number plates. These were attached to either side of the frame as shown in **Photograph 4**.

The RIB was capable of carrying 12 persons. The EU Recreational Craft Directive normally class this size of RIB as "category B", which means that it was capable of travelling 30 miles offshore in mean wave heights of up to 4m. However, this particular RIB did not have to comply with the EU RCD because it was built before 16 June 1998.

1.5.2 Inspections

On 17 March 2005, MAIB inspectors and the CSPUSU's diving supervisor made an initial inspection of the RIB at the unit's storage shed in Maddiston, near Edinburgh.

The following items were found in the RIB:

- a kill cord attached to a ring holding ignition, tow bar and other keys;
- a starter battery for the engine;
- a spare fuel container;
- a white plastic canister containing 2 stroke oil;
- two oars;
- a holdall containing clothing;
- a tool box containing various tools; and
- plastic containers and baskets with food and soft drinks.

The RIB and engine were in good condition. For comments on the condition of the steering system **see Section 1.6.3**.

On 5 April 2005, police officers of the Underwater Search Unit, MAIB inspectors and a representative from Northcraft (the manufacturer of the RIB), made a further inspection of the RIB at the storage shed in Maddiston.

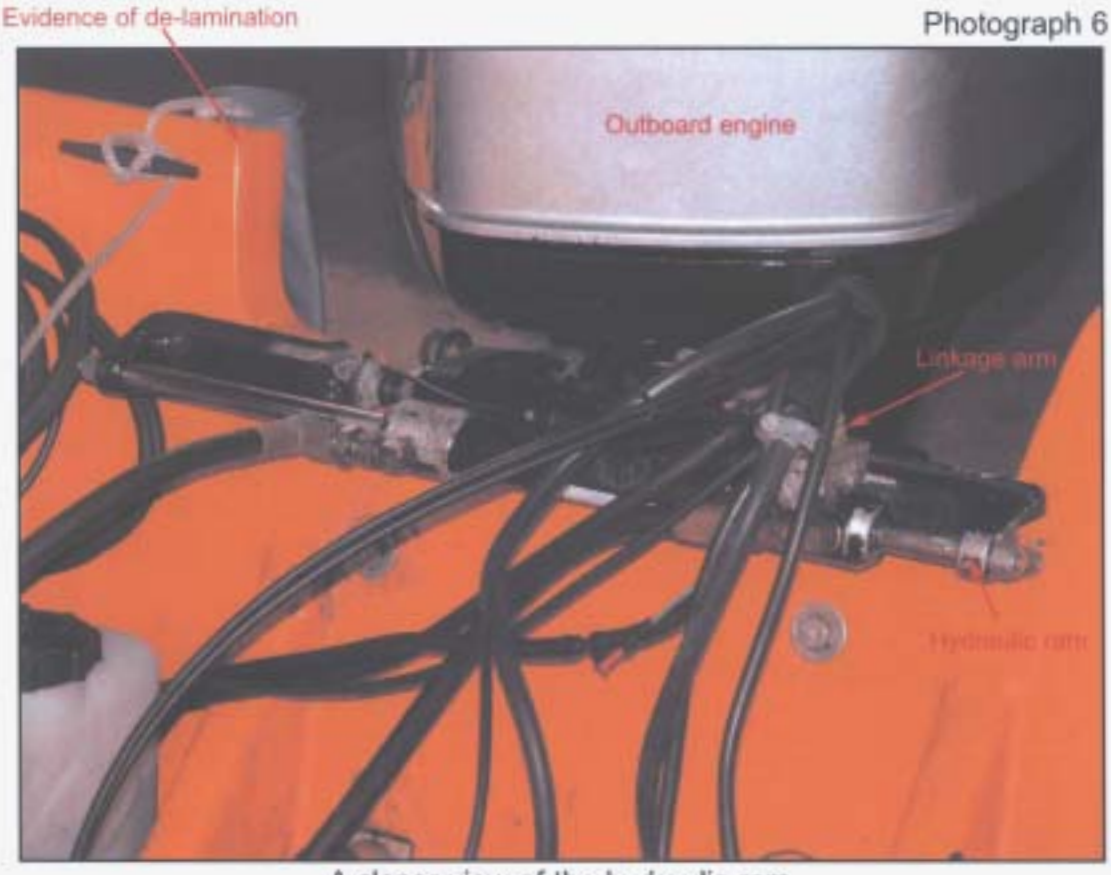
The manufacturer's identification marks for this particular RIB had been originally stamped inside the tubes, but, because it had been re-tubed, the marks were lost and it was not possible to determine the exact date of manufacture. However, the Northcraft representative recognised that the RIB's particular style of hull form had been in production between 1989 and 1995, after which it had been discontinued.

The representative also noted that the cut-away section of the transom stern had been deepened at some time in the past. However, the edges of the transom stern were cracked, showing that it was beginning to de-laminate **(see Photograph 6)**.

The consensus of those present at the inspection was that the RIB was generally in good condition, with evidence of only minor repairs to the GRP hull.

For a more detailed account of the steering system and tests, **see Section 1.6.4**.

Photograph 6



A closer view of the hydraulic ram

1.5.3 The buoyancy tubes

The original buoyancy tubes had been changed between June and July 2003 by Eurocraft of Leyland in Lancashire, and the cost had been invoiced to a person from Northampton. The Northcraft representative noted that the new tubes on either side of the transom stern did not project as far aft of the transom as the original design, and that, as a consequence, the RIB's overall length had been shortened by 0.1m. The original tubes had been made of polyurethane, but the new tubes were made of Hypalon and were of 0.5m diameter.

The buoyancy tubes were in good condition, showing little wear, and they were fully inflated.

1.5.4 The engine

The outboard engine was a ***Mariner*** V6 ***OptiMax*** and had a power output of 112 kW (150hp), at a maximum of between 5250 and 5750 rpm. The engine had been bought by Angus Buchanan from Bill Higham Marine of Worsley near Manchester on 17 August 2004.

This type of two stroke Mariner outboard engine was designed to be fuel efficient, with an electronic management system to adjust the engine and lubrication to maintain peak performance throughout its range and to reduce exhaust emissions. The engine is noted for its acceleration and top speed.

For this size of RIB, the manufacturer's upper limits for outboard engine power and weight were 149 kW (200hp) and 400kgs respectively.

Instead of the usual trim tab near the propeller, the outboard engine had been offset to starboard of the centre line by 6cm to compensate for propeller torque.

The outboard engine was in good condition, apart from the cowling being cracked at one corner. It functioned well during the in-water tests – **see 1.6.3 and 1.6.5 below**.

On 21 April 2005, an engineer from Forth Yacht Marina attached a diagnostic terminal to the engine electronic management system, and downloaded the following historical engine rpm range and time data:

0 – 749 rpm	5.1 hours
750 – 1499 rpm	2.1 hours
1500 – 2999 rpm	3.9 hours
3000 – 3999 rpm	5.3 hours
4000 – 4499 rpm	0.9 hours
4500 – 4999 rpm	0.5 hours
5000+ rpm	nil

The total recorded running time for the engine was 17.8 hours.

1.5.5 Toe straps

There were no toe straps fitted to the deck of the RIB. Where fitted, toe straps are provided to help the crew stabilise themselves when travelling in a seaway. Toe straps are not provided for the purpose of preventing people from being thrown overboard. They are normally fixed to the deck close to either side of the base of the seats. However, in some RIBs, where there is limited deck space between the seats and the tubes, they pose a trip hazard for people moving around.

Toe straps are particularly useful for RIBs' crews travelling through waves at sea, but in the relatively calmer waters of inland waterways they do not normally serve any practical purpose.

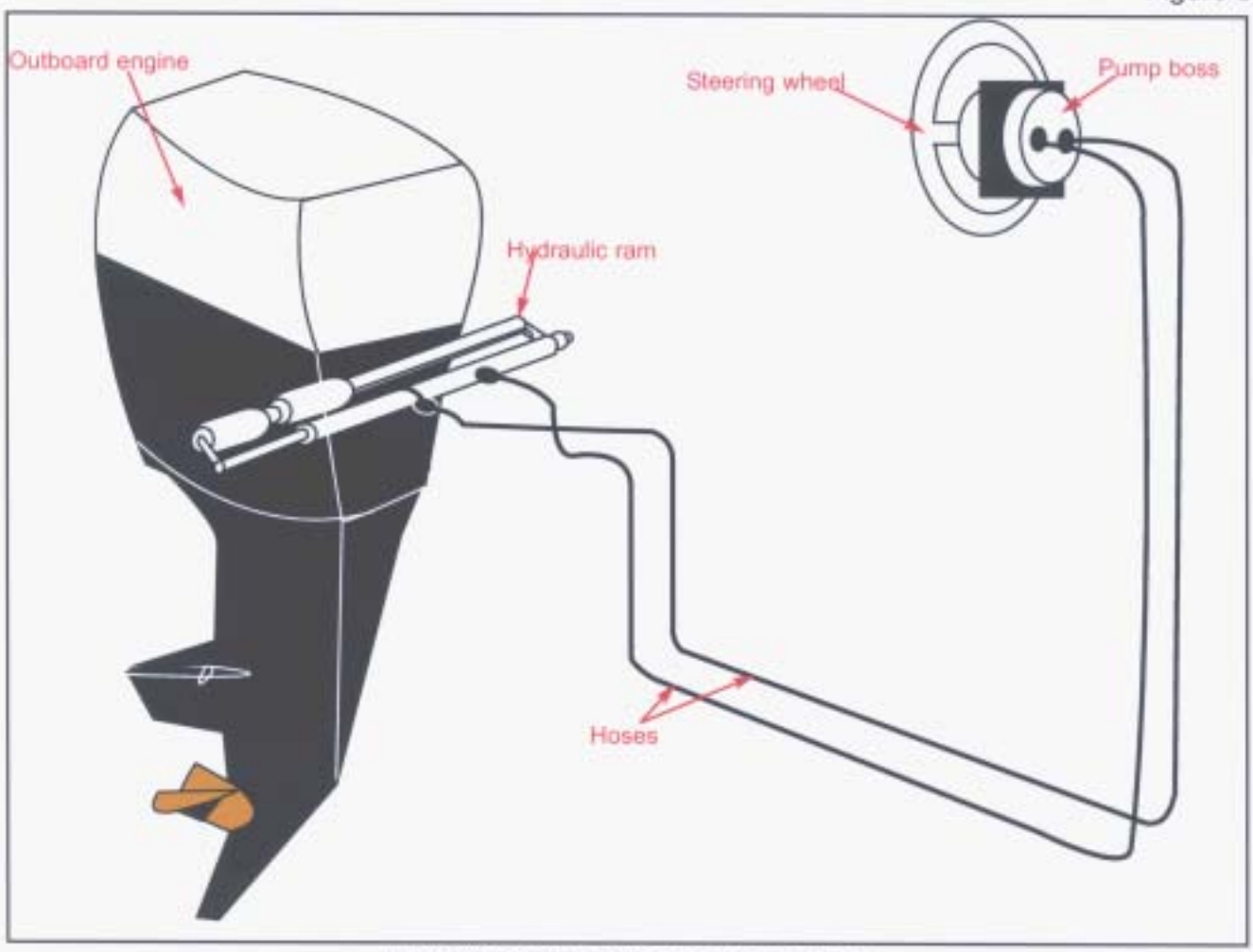
1.6 THE STEERING SYSTEM

A detailed examination of the steering system was made because of the reported difficulties both the elder daughter and the Loch Lomond rangers had experienced when trying to steer the RIB.

1.6.1 Description of the steering system

The hydraulic steering system was manufactured by the Italian company Hydraflex. It consisted of the steering wheel which was directly coupled to a hydraulic pump. There were two hydraulic hoses connecting the pump to a hydraulic ram, which controlled the steering by moving the outboard engine. A similar system is shown in Figure 3.

Figure 3



Layout of a hydraulic steering system

This type of hydraulic steering system uses fluid pressure to transfer the movement from the steering wheel to the outboard engine through pipes or hoses containing hydraulic oil. When the wheel is turned to port or starboard, the pump moves a quantity of oil round the system to the appropriate side of a two-way hydraulic ram, causing the ram to move transversely across the transom. The moving part of the ram is connected, by a mechanical linkage arm, to the outboard engine **(see Photograph 6)**.

The mechanical advantage provided by hydraulic steering systems allows large, powerful outboard motors to be steered with much less effort than would be required by a direct linkage system which uses cables or wires to move the engine. The hydraulic pump fitted to the RIB displaced 35cc of hydraulic oil with every complete turn of the steering wheel. The manufacturer's manual stated that it required 3.8 turns of the steering wheel to move the engine from port lock to starboard lock.

The hydraulic steering system fitted to the RIB was suitable for outboard engines of up to 224 kW (300hp) and speeds of up to 54 knots.

As with all hydraulic systems, it is essential that the correct oil is used, and levels are maintained to prevent water and air ingress, which causes corrosion and poor pressure transfer respectively.

No maintenance schedules were available for the Hydraflex steering system fitted to the RIB. However, a very similar system is manufactured by SeaStar Systems. This manufacturer's maintenance requirements for its hydraulic steering system can be seen at **Annex 3**.

1.6.2 Observations on the condition of the steering system

The inspections conducted on 17 March and 5 April 2005 (see 1.5.2 above), found the steering system to be old, with paint missing from the helm pump boss and from the ram to the engine. There was evidence of hydraulic oil leakage from between the steering wheel shaft and the pump boss, and this had produced a film of oil extending down the console in front of the driver's seat **(see Photograph 7)**.

There was another film of oil in the well just forward of the transom stern underneath the ram, indicating further possible leakage from the hydraulic steering ram assembly.

Although there was evidence of, what appeared to be, minor leakage in the system, there were no signs that it had suffered any major rupture.

The manufacture's code *LD35 HY9306* was stamped on the pump boss. *LD35* was the model type relating to the pump capacity. This was the larger model of two (the other was LD25) and was designed to require fewer turns of the wheel than the smaller model to move the engine from lock-to-lock, but required more physical effort to do so.

The system was not fitted with bleed nipples at any point. These are normally fitted to hydraulic systems to enable any air to be purged from the system (see **Annex 3).** Since hydraulic systems work on the basis that the oil used cannot be compressed, so that any movement of the wheel is directly transferred to the outboard engine, any air in the system (air is compressible), will detrimentally affect this energy transfer, reducing the effectiveness of the steering.

The refilling plug used in the top of the pump boss was not original **(see** Photograph 7). It appeared that the original nylon or metal plug had been substituted by a rubber grommet which was neither watertight nor airtight. Inspection of the inside of the pump boss filler hole revealed no sign of hydraulic oil, and when the wheel was turned it made noises consistent with the pump continually drawing in air. This would have been a direct result of there being insufficient fluid in the system.

Photograph 7

A view looking up from underneath the helm pump boss, showing leakage of hydraulic oil

1.6.3 First in-water test

On 5 April 2005, the RIB was taken to a slipway and launched into the Firth of Forth. One of the CSPUSU officers took it out into a sheltered bay off the slipway and drove it around slowly. He found that he had to turn the steering wheel many times to turn the outboard engine and hence to steer the RIB.

After the initial run, two officers from the CSPUSU took the RIB out into the main channel of the Firth of Forth. They drove the RIB in a steady direction up to 3,200rpm, giving a speed of about 27 knots, which was measured by the officer's hand-held GPS. At the end of each run, they reduced speed considerably, turned the RIB around and then accelerated to 3,200rpm in the opposite direction.

After a number of runs, they returned to the slipway. The police officer who had control of the RIB reported that he had very little response from the steering when travelling at 3,200rpm.

1.6.4 Measurement of the hydraulic oil

On 21 April 2005, engineers from Forth Yacht Marina drained off the oil from the RIB's steering system. 0.45 litre of oil was recovered. However, it is likely that a quantity of oil remained in the system as it could not be completely drained without being fully dismantled. The system was then refilled with new oil until full. 1.0 litre of oil was replaced. From this, it can be concluded that, at the time of the accident, the RIB's hydraulic steering system contained approximately 0.5 litre of oil less than it should have done.

A 100ml sample of the original hydraulic oil, and a control sample of new unused oil were taken to *Analytical Data Services* of Southampton for analysis, the results of which are at **Annex 2**.

1.6.5 Second in-water test

On 23 May 2005, the RIB was returned to the Firth of Forth for a second in-water test, however, on this occasion the hydraulic oil in the steering system was at the correct level. The police officers from the CSPUSU were able to take the RIB up to a speed of about 43 knots (80 kilometres per hour) and found that the steering system operated satisfactorily.

Following the second in-water test, Forth Yacht Marina's engineers once again drained the system before removing the entire steering system from the RIB. The system was then sent to Hypro Marine of Lymington for a detailed technical examination and disassembly to assess its condition. Hypro Marine's report is at **Annex 1**.

1.7 RYA TRAINING AND ADVICE FOR POWERBOATS

1.7.1 The RYA

The RYA was founded in 1875 as the Yacht Racing Association. Its purpose was to standardise the rules governing the measurement of racing yachts. The establishment of the General Purposes Committee gave the YRA a forum for power and sail cruising boats, and in 1953 the YRA became the [Royal Yachting Association] RYA.

The RYA has had a role in the national organisation of powerboat racing since 1961 and, in 1967, it set up a committee to oversee powerboat training activities. By 1968, 72 schools had applied for RYA recognition.

1.7.2 Training

The RYA's National Powerboat Scheme is applicable to sports boats, RIBs, dories and launches. The powerboat courses have a number of levels:

Level 1 provides a practical introduction to boat-handling skills.

Level 2 provides the skills and background knowledge needed by the competent powerboat driver, and is a basis of the International Certificate of Competence.

Intermediate Day Cruising covers practical use of pilotage and passage planning by day on coastal waters, using both traditional and electronic navigational techniques.

Advanced Day and Night provides skills and background knowledge needed by powerboat drivers operating by day or night in known or unfamiliar waters, the skipper's role, and boat-handling in more demanding conditions.

1.7.3 RYA's Powerboat Handbook

Published in 2005, RYA's *Powerboat Handbook* gives advice on travelling at speed, boat equipment, engine checks, kill cords, lifejackets and buoyancy aids, summoning assistance and flares **(see Annex 4)**.

1.8 RNLI SAFETY CHECKS

As part of its Safety Equipment Advisory Check, the RNLI offers free impartial advice and safety guidance on all aspects of water safety, including a free survey of any leisure boat. This is delivered by a nationwide team of volunteer safety advisors.

The RNLI also urges leisure boat owners to carry out crucial checks before they go back on the water at the start of the boating season, recommending that, as a minimum, they complete the following checks (relevant to this case):

- Lifejackets – gas canisters for corrosion and webbing for wear
- Carry out a VHF radio check
- Ensure all safety equipment, such as flares, are within expiry dates.

1.9 COLD WATER SURVIVAL TIMES

The MAIB commissioned QinetiQ to produce a model for the survival times of Angus and Holly Buchanan, given their physical descriptions. QinetiQ's report is at **Annex 5**.

In *Essentials of Sea Survival* by F Golden and M Tipton published in 2002, it states that survival time in water will significantly decrease in water temperatures below 15°C. The temperature of the water in Loch Lomond was only 3°C, which is colder than sea water temperatures; the mean sea surface temperature for the west coast of Scotland for February is about 8°C.

A report was prepared by Professor M J Tipton for a previous MAIB investigation on the likely survival times of individuals in a boating accident. He made the following comments:

> *Survival time in cold water can range from minutes to many hours depending on the circumstances. A significant proportion of individuals die from drowning or cardiac related problems during the first minutes of immersion as a result of "cold shock", caused by sudden cooling of the skin. With continued cooling superficial muscles and nerves are cooled and their function deteriorates. The resulting impairment of such things as grip strength, manual dexterity and swimming ability can result in problems, chief amongst which is incapacitation and drowning as victims become unable to keep their airway clear of the water. A properly donned and functioning lifejacket is an essential piece of lifesaving equipment at this time.*

1.10 THE LOCH LOMOND AND THE TROSSACHS NATIONAL PARK AUTHORITY

1.10.1 The byelaws

The Loch Lomond Registration and Navigation Byelaws were drawn up jointly by Dumbarton and Stirling District Councils and came into force on 1 February 1996. Since July 2002, the National Park Authority has had responsibility for the Loch Lomond Byelaws and has the power to draw up byelaws in its own right.

At the time of the accident, the byelaws included a speed limit of 11 kilometres per hour (6 knots) within 150m of the shore and in other restricted waters between the islands at the southern end of the loch. (On 5 June 2004, Angus Buchanan had been given a verbal warning for breaking the 6 knots speed limit.) Outside these restricted areas, the speed limit was 90 kilometres per hour (49 knots).

Under the section in the byelaws titled *General rules relating to boat,* it states:

> *3.11 (1) No persons shall navigate or cause to be navigated any boat, which, by reason of its construction, or fitting out, could be liable to cause a hindrance to free navigation or danger to persons, other boats or property.*

A team of dedicated National Park Authority's rangers operate a patrol boat every day to encourage compliance with the byelaws, especially with regard to speed enforcement. Police officers regularly accompany rangers to support their work. However, no specific checks are made by the rangers on the sea-worthiness or safety equipment of powerboats.

1.10.2 Registration of power-driven boats

Under the byelaws, all power-driven craft have to be registered with the National Park Authority. Application for registration, or renewal of registration, is made to the National Park Authority. On receipt of the application, the National Park Authority allocates a number to the individual boat. The applicant is required to display the number on both sides of the boat **(see Photograph 4)**.

Angus Buchanan registered his first Humber RIB, which was 5m in length and had a 63.5kW (85hp) outboard engine, on 13 February 2004. On the registration form **(see Annex 6)** under the *Other Information* section, he had ticked the "*No*" to all boxes asking whether the boat had a VHF radio; whether he had a recognised certificate of competency to drive a motor boat; whether the boat was insured; whether he was a member of a Loch Lomond based boating club; and whether he was a member of a governing body controlling the sport in which he participated.

After buying the Northcraft RIB, he transferred the registration numbers from the Humber RIB to the new boat on 21 August 2004. The only difference in the *Other Information* section was that he had ticked the *Yes* box for having a certificate of competence, but he did not signify the type of qualification held.

1.10.3 Risk assessment

Under the Health and Safety at Work Act 1977, employers have a duty to ensure the health and safety at work of their employees, and persons not in their employment who may be affected by their work. This means that the National Park Authority has to carry out risk assessments on the activities of its rangers, and the general public using its facilities and slipways. However, the National Park Authority is not required to extend its risk assessments to the general public while they are on the water, because it does not own the loch.

A search on the National Park's database showed that, in 2005, there was a total of 6711 registered powerboats. However, at the time of the search, only 4067 of the total had renewed their registration, of which 400 had VHF radios, 60 had CB radios, 951 had certificates of competence and 4042 had third party insurance.

1.10.4 Revision of the byelaws

At the time of the investigation of the accident and publication of this report, the National Park Authority is undertaking a comprehensive review of the byelaws. Formal consultation exercises began in January 2005, and questionnaires have been distributed to over 6,000 interested parties, the relevant questions of which were:

- *Do you think rules relating to personal safety should be part of the bylaws, for example, the compulsory use of lifejackets?*
- *What are your views on whether some form of competency scheme for driving a boat should be required?*
- *Should we consider the introduction of a boat standard and safety scheme to cover issues such as structural integrity, gas stove maintenance etc?*

The responses to the consultation process will go through a formal legal process and final confirmation by the Scottish Executive. Proposals for any change to the byelaws should be with the Minister by December 2005, with the intention of implementing these by the summer of 2006.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 THE RIB AND STEERING SYSTEM

2.2.1 General

The RIB's hull and inflatable side tubes were generally in good condition, and the boat was considered to be seaworthy. The outboard engine was also in good condition and functioned correctly during the in-water tests.

Therefore, the condition of the hull, tubes and outboard engine were neither causal nor contributory factors to the accident.

2.2.2 The steering system

Examinations of the steering system concluded that it had been installed when the RIB was built (it was date stamped 12/92 on the pump boss), and that it was in poor condition **(see Section 1.6.2)**.

The poor condition of the steering system was evident to Bill Higham Marine's employees when the new outboard engine was mounted onto the RIB in August 2004. They also remembered that the steering linkage arm from the hydraulic ram to the outboard engine was missing, and that there was leakage from the helm boss. They brought both defects to Angus Buchanan's attention. He told them he had possession of the linkage arm, and that he would fit it himself later. He also stated that he would rectify the leak **(see Section 4)**.

Some time after the engine was mounted, the RIB was laid up for the winter. The leakage of hydraulic oil from the region of the helm shaft/pump boss was relatively small, but over a time, a significant amount of oil would have been lost. The loss of even a small amount of oil can expose the operating pistons in the pump boss, and thereby introduce air into the system under operating conditions.

Ideally, the steering system should have been drained of old oil, then refilled with new oil, ensuring that any air was bled from the system before the RIB was used again following the winter lay-up period. However, the investigation revealed that the oil had been in the system for some time, and that there were no means of purging the system of air. Air within the hydraulic system can be compressed, and will consequently expand suddenly with movement of the steering wheel, causing uncontrolled movement of the outboard engine.

Further to the observations from the examinations mentioned above, Hypro Marine's report **(see Annex 1)** also concluded that the overall condition of the steering system was poor. The report further identified that the internal non-return valve springs in the ram were broken as a result of corrosion. This latter condition would have allowed hydraulic oil to pass through the non-return valves, causing feedback between the ram and the steering wheel. Therefore, particularly when the RIB was travelling at high speed, feedback through the non-return valves could allow uncontrolled and unexpected movement of the outboard engine. This situation was aggravated by air in the system which was allowed to freely migrate throughout the non-return valves.

Analytical Data Service's report showed that the hydraulic oil contained a significant amount of water, which would cause corrosion in the system and, in turn, pitting, wear and leakage. The presence of aluminium, copper and iron, which would have come from the steering components, gave further evidence of corrosion and wear. Water in the system could have caused the non-return valve springs to corrode and become brittle, causing distortion and damage.

In conclusion, the examinations and tests by Hypro Marine and Analytical Data Services showed that the steering gear was not correctly fitted to the outboard engine, and the entire system was in need of maintenance or replacement. The examinations also revealed that, in addition to the low oil level, the hoses showed initial signs of perishing, the connections were poorly made, there were no bleed nipples, the operating ram was poorly adjusted and the bolt connecting the steering linkage arm to the outboard engine was wrongly threaded and had been forced into place. While this led to an undesirable degree of slack in the steering, once the hydraulic system was filled with the required quantity of oil, the steering operated in a satisfactory manner. This clearly indicates that the cause of the accident was the lack of hydraulic oil in the steering system.

2.3 THE ACCIDENT

Shortly after the start of the passage to the island, the elder daughter reported that she had difficulties steering the boat. However, on reaching the island, she went ashore and took photographs of the RIB with her father and sister onboard, manoeuvring at speed, just clear of the beach **(see Photograph 3)**. These photographs show that the father was driving the RIB at high speed and making tight turns towards the beach, suggesting that the father did have a certain degree of control of the steering at that time, despite the steering system containing insufficient hydraulic oil. It is therefore possible that any fault or problem with the steering system was intermittent.

There are no records to show when the oil level in the steering system was last checked, but the laboratory analysis of the oil drained from the system is consistent with it having been there for a period of time, certainly since the previous season. Hence the minor leaks seen in the system would have been sufficient to allow a significant quantity of oil to be lost.

On the return passage to Balloch, the father was able to manoeuvre the RIB in Milarrochy Bay when he weaved the boat from side to side. However, when he had finished these manoeuvres and was heading on a straight course, the RIB suddenly lurched to port so violently that it broke his grip on the wheel and threw both him and his younger daughter out of the boat.

In the MAIB's opinion, the most likely cause of the accident was that the high speed manoeuvres caused the air to migrate around the steering system and into the operating ram. This could have caused the outboard engine to turn independently of the steering wheel with small movements of the RIB, especially at high speed. This uncontrolled movement of the outboard engine would have become exaggerated because the effective hydraulic pressure in the whole system was lost due to the damaged non-return valve springs. The result could have caused the outboard engine to suddenly flip over to one side. At high speed, the uncontrolled movement of the outboard engine caused the RIB to lurch violently to port, and to throw the casualties out of the boat and into the water.

This scenario is consistent with the later difficulty experienced by the rangers in driving the vessel back to Balloch, where they regularly had to manhandle the outboard into the ahead position; a procedure that would not have been necessary or possible had the hydraulic system been full of oil. This was borne out during the second in-water test, which showed that the steering system functioned satisfactorily when it had been topped up with hydraulic oil.

In conclusion, the loss of hydraulic oil, the introduction of air into the steering system, and the damaged non-return valve springs, caused sudden uncontrolled movement of the outboard engine and the RIB to lurch violently to port.

2.4 SURVIVAL TIMES

The father and his younger daughter were lost in a relatively short period of time in very cold waters of only 3°C.

The report produced by QinetiQ **(see Annex 5)**, assumes the person has survived the initial shock of cold water immersion, and has not been overcome by exhaustion during the first few minutes of being in the water. The report estimates that, if this had been the case, the father's survival time would have been about 60 minutes; his daughter's would have been about 43 minutes.

The father and his younger daughter succumbed to the debilitating effects of cold water shock and, in a short period of time were unable to swim or react to assistance when it was offered, or help themselves remain afloat. Had they been wearing lifejackets, their airways would have remained above water. Even if they had become unconscious, they could have remained alive for the periods of time estimated by QinetiQ, and would probably have survived.

In conclusion, cold water shock severely reduces a person's ability to stay afloat, so the wearing of a lifejacket is essential to extend survival time and hence improve the chances of being rescued.

2.5 THE LOSS OF THE FATHER AND THE DAUGHTER

As the elder daughter began to return in the RIB to the area where her father and sister had been thrown into the water, she could see their heads above the water's surface and could hear her father shouting. She could see her father quite close to her sister, and called for him to move closer to her. However, it seems that he was unable to do so. As she approached the area, her father had stopped shouting and her sister was unable to reach out to the oar when it was proffered to her. Despite wearing thick clothing, by that time cold water shock would have been taking effect; they were unable to swim to one another or to the RIB, and could not talk. They were probably becoming incapacitated by the effects of cold shock and were quickly unable to keep their airways above water.

The elder daughter made a courageous attempt to rescue her sister by entering the water and trying to lift her onto the RIB. However, this was understandably too much for her, and she had to return to the RIB because she, too, was succumbing to the cold water.

Because of the debilitating effects of cold water shock, it was essential for the father and daughter to be removed from the water within a short period of time if their drowning was to be prevented. However, there were three factors which prevented this from being achieved:

1. The RIB's kill cord was not properly in place on the return passage from the island. Although the elder daughter had seen it in place on the outward-bound passage, for some reason, the father had not attached the free end of the cord to himself on the return passage. The National Park Authority's rangers had found the cord attached to the ignition cut off switch after the accident, but the free end was hanging loose (there was no defect with the cord's attachments) **(see Photograph 8)**. Because the kill cord was not in place, the RIB carried on travelling away from the area in which the father and his daughter were thrown into the water. This caused a significant delay because it took time for the elder daughter to recover from the violent lurch, struggle to reach the controls, stop the RIB, and then return the RIB to her father and sister.

   Had the kill cord been used correctly, the RIB would have stopped very quickly and close to the two people in the water. Assuming they were not injured by the impact with the water, when they were thrown out of the RIB, they could then have swam to the RIB and boarded it before succumbing to cold water shock.

2. They were not wearing lifejackets at the time of the accident. They had realised that they had forgotten their lifejackets on the way to the slipway at Balloch, but had decided to continue with their excursion without them.

   Professor Tipton (see Section 1.9) commented that lifejackets are essential in keeping people afloat and keeping their airways above the surface of the water when they are suffering from cold water shock. Even when people are unconscious, the wearing of lifejackets will assist in preventing them from drowning.

3. The craft was not carrying a VHF radio or flares. Although the RIB had travelled some distance away from the father and the younger daughter in the water, the surviving daughter could have used the radio to call the emergency rescue services and/or the flares to alert other nearby craft. By alerting nearby craft to the emergency, an early rescue attempt of the two people in the water could have been initiated, possibly before they were lost.

In conclusion, it was essential that the father and his younger daughter were rescued quickly, before the debilitating symptoms of cold water shock took effect. Had any or all of the above safety items been in place, their chances of survival would have been greatly enhanced.

Photograph 8

The kill-cord in place in the ignition

2.6 TRAINING

Although the father had been an experienced yachtsman for many years, he was relatively inexperienced with powerboats, having owned two RIBs over about 2 years. Inquiries showed that there was no indication that he had undertaken a powerboat course with the RYA.

By undertaking any of the RYA powerboat courses, not only do boat owners become more skilled in the operation of RIBs, but also they become more aware of the generic safety issues relating to powerboats. Training and good experience enables a person to foresee problems or unsafe conditions, and to make informed decisions on the appropriate control measures. This would not always be the case where a person is self-taught in the operation and maintenance of powerboats.

A further advantage of training is that it raises awareness of the availability of advice from other competent bodies such as the RNLI, who offer a free service to check the condition of the craft and its safety equipment: in effect, a form of voluntary MOT for boats. Had the RIB been subject to such a survey, perhaps annually at the start of each season, it is very likely that the poor condition of the steering system, and the lack of safety equipment on board would have been highlighted.

The number of people undertaking RYA powerboat courses has risen from 18,000 to over 28,000 per annum in the past 2 years, and reflects the growth area in this part of the leisure industry. The RYA is therefore perhaps uniquely placed to promulgate the lessons learned from this tragic accident both to its instructors and trainees.

2.7 MONITORING AND CONTROL OF LEISURE CRAFT

Under the Health and Safety at Work Act 1977, the National Park Authority had an obligation to carry out risk assessments for its employees and members of the general public when using its facilities. However, the National Park Authority is not obliged to carry out risk assessments on the activity of boat users on the loch. Risk assessments identify control measures to take to prevent unsafe conditions. The only control measures that the National Park Authority has imposed on the activities of boat users, is the establishment and enforcement of speed limits. It does not take an active role in enforcing the seaworthiness of craft using the loch, or the level of safety equipment carried by these vessels.

By way of comparison, competent harbour authorities carry out generic risk assessments on the consequences of accidents to vessels within their port limits. They also implement control measures to prevent accidents occurring, and to reduce the consequences when they do take place. However, they do not carry out risk assessments on the vessels themselves, since that is the responsibility of the owner under international law. In the case of waterway

authorities, they are not required to carry out risk assessments on the craft that ply their waters. However, they do have rescue boats to assist craft when they get into difficulties, enforce speed restrictions and give safety advice and information to owners of craft.

Unlike a commercial vessel, where the owner is required to carry out risk assessments, there is no such requirement for non-commercial vessels. In the absence of enforcement by waterway authorities of private craft plying their waters, there are no controls over the seaworthiness of boats, the competence of operators or the safety equipment carried aboard them.

There is no national legislation providing standards on licensing/registration of powerboats, training of drivers, insurance and the carriage and use of safety equipment. However, the RIB market is expanding. These boats are becoming increasingly more sophisticated, larger in size, with bigger and more powerful engines, with attendant increased speed. Notwithstanding the above, the safety of non commercial leisure craft in general is largely unregulated.

In 2003, Loch Lomond's Rescue Boat Operational (annual) Report shows that there were 56 mechanical faults to powerboats, 10 vessels grounded, 4 searches for missing persons, 4 capsizings/founderings, 4 bodies were recovered (none related to boating), 1 fire and 1 collision between 2 craft in which a woman was injured. It was only this latter accident which involved personal injury. Therefore, the majority of boating incidents on the loch were minor in nature, being mostly mechanical failures.

However, the level of risk to craft varies greatly between one waterway authority's area and another. Some areas are small and/or not so frequented by craft, while other areas have large expanses of water and are very popular with leisure craft owners. Therefore, the hazards on some waterways are less severe, needing fewer control measures than others, and waterway authorities can decide on, and exercise, an appropriate level of control through powers of direction or through byelaws.

In conclusion, waterway authorities can assess the general risks created by leisure craft activities, and they have the powers to put in place control measures to reduce those risks.

It would therefore seem incumbent on Waterway Authorities to ensure that procedures are put in place to establish and/or regularly review the general risks posed by various leisure activities on their waters, and identify, then implement, appropriate control measures, if required, that will reduce such risks to an acceptable level.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES

1. The condition of the hull, buoyancy tubes and outboard engine was neither causal nor a contributory factor to the accident. [2.2.1]

2. The condition of the steering system was poor and in need of maintenance or replacement. [2.2.2]

3. The cause of the accident was the loss of a significant quantity of hydraulic oil from the steering system. [2.2.2]

4. The effects of loss of hydraulic oil, the introduction of air into the steering system, and damaged non-return valve springs, combined to cause a sudden uncontrolled movement of the outboard engine and resulted in the RIB lurching violently to port. [2.3]

5. An in-water test showed that the steering system functioned satisfactorily when it had been topped up with hydraulic oil. [2.3]

6. Cold water shock severely reduces a person's ability to stay afloat, so the wearing of a lifejacket is essential to extend survival time and hence improve the chances of being rescued. [2.4]

7. Because of the debilitating effects of cold water shock, it was essential for the father and daughter to be recovered from the water within a short period of time if their drowning was to be prevented. However, had any, or all of a number of safety items been in place (kill cord, lifejackets and means of alerting others to an emergency), their chances of survival would have been greatly enhanced. [2.5]

8. By undertaking any of the RYA powerboat courses, not only do boat owners become more skilled in the operation of RIBs, but also they become more aware of the generic safety issues relating to powerboats. [2.6]

9. Waterway authorities can assess the general risks caused by leisure craft activities, and they have the powers to put in place control measures to reduce those risks. [2.7]

SECTION 4 - ACTIONS TAKEN

The **MAIB** has:

- Published Safety Bulletin 2/2005 on 23 May 2005 **(see Annex 7)**.
- Sent a copy of this report to the editors of powerboat specialist press, together with an accompanying letter which requests the promotion of RYA powerboat courses as a means of enhancing boat users' safety awareness.

The **Loch Lomond and The Trossachs National Park Authority** has:

- Promulgated MAIB's Safety Bulletin to loch users at its Milarrochy Bay and at Balloch slipways, and made all of the registered owners aware of its existence. The Authority also notified the local media of the Safety Bulletin and answered their questions for further clarification.
- Is reviewing its current byelaws with the intention of including the following provision by the summer of 2006:

  Lifejackets – all boats

  It shall be the responsibility of every individual liable to wear a lifejacket in the circumstances and of the type prescribed by byelaw 3.5(6) to comply with that obligation. It shall be the duty of every master to ensure that each person on board complies with that obligation while the boat is on the loch.

Bill Higham Marine:

- Will annotate its customers' invoices with details of any deficiencies it has identified to the boat itself, the steering system and safety equipment.

SECTION 5 - RECOMMENDATIONS

The RYA is recommended to:

2005/224 Draw on the safety issues identified in this report to enhance the recognition by RYA instructors and trainees of the importance of adhering to the safety lessons contained within the syllabi of its recognised power boat courses. [2.6]

All inland navigation and/or harbour authorities are recommended to:

2005/225 Ensure that procedures are put in place to establish and/or regularly review the general risks posed by the various leisure activities on their waters, and identify and then implement appropriate control measures, if required, that will reduce such risks to an acceptable level. [2.7]

Marine Accident Investigation Branch
December 2005