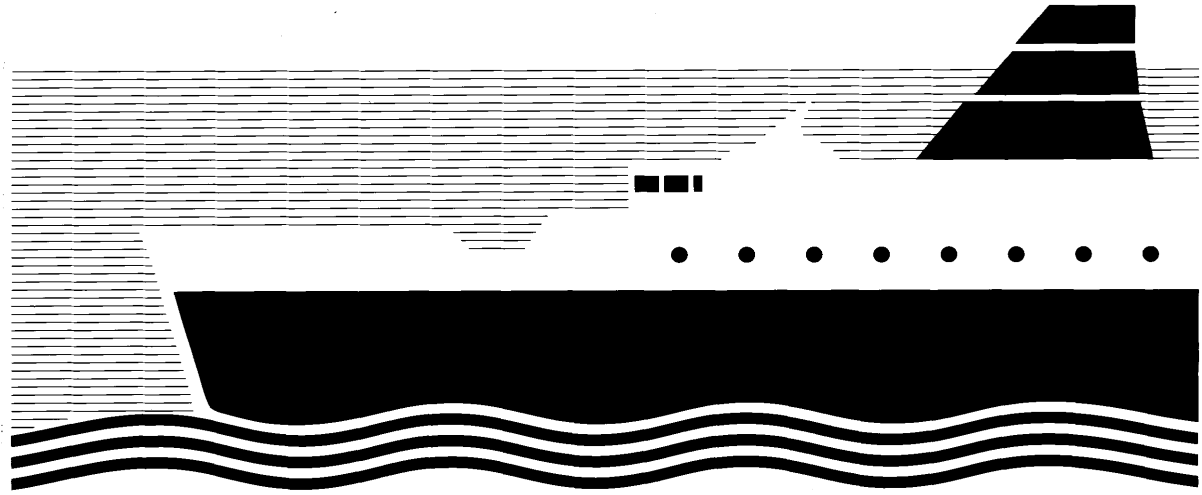


MARINE OCCURRENCE REPORT

05-205 **restricted limit passenger vessel *Black Cat*, control cable failure and collision with rock wall Seal Bay, Akaroa Harbour** **17 April 2005**

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

Report 05-205

restricted limit passenger vessel *Black Cat*

control cable failure and collision with rock wall

Seal Bay, Akaroa Harbour

17 April 2005

Abstract

On Saturday 17 April 2005 at about 1205, the *Black Cat* with a Master, a deckhand and 31 passengers on board was on a cruise around the lower reaches of Akaroa Harbour. As they approached the shore in Seal Bay, the Master put both engines astern, but a control failure caused the starboard engine to go ahead and the boat to collide with the natural rock wall. The impact was such that the bow bounced off, which allowed the boat to continue back into clear water.

Some of the passengers were shaken by the impact; those who were standing were thrown forward and those on the foredeck were knocked to the deck. Seven passengers suffered minor injuries, and there was little damage to the boat, which was able to return safely to Akaroa on one engine without assistance.

The safety issue identified was:

- the unintentional weakening of control cables by the attachment of additional weight to them.

Safety recommendations were made to the Managing Director of TeleflexMorse Australia and to the Commission to address this issue.

The *Black Cat*

Contents

Figures

Abbreviations

ECU	electronic control unit
kW	kilowatt(s)
m	metre(s)
mm	millimetre(s)
nm	nautical mile(s)
UTC	co-ordinated universal time

Glossary

neaps	part of the tidal cycle with the highest low tides and the lowest high tides
potentiometer	an instrument for measuring differences in electric potential
servomotor	a small electric motor whose speed or position is controlled by a closed loop feedback circuit
slipped	a boat being hauled from the water up an inclined track for repair or maintenance
slipping	releasing a mooring or similar
standard port	a port or place for which times and heights of tides have been predicted, which can be used to calculate the time and heights of tides at other ports

Data Summary

Vessel particulars:

Name:	*Black Cat*
Type:	restricted limit passenger
Limits:	restricted inshore – Banks Peninsula
Length:	17.35 m
Breadth:	7.25 m
Gross tonnage:	40
Built:	1993 in Western Australia
Propulsion:	2 Yanmar 6KY ETE diesel engines, each producing 450 kW and driving, through a ZF IRM350 reversing gearbox, a 5-bladed fixed-pitch propeller
Service speed:	18 knots
Owner/operator:	Black Cat Group
Port of registry:	Lyttelton
Crew:	2
Maximum passengers:	99
Date and time:	17 April 2005 at about 1205[1]
Location:	Seal Bay, Akaroa Harbour
Persons on board:	crew: 2 passengers: 31
Injuries:	crew: nil passengers: 7 minor
Damage:	starboard hull dented and holed forward. Starboard propeller damaged and starboard propeller shaft bent
Investigator-in-charge:	Captain Doug Monks

[1] Times in this report are New Zealand Standard Time (UTC + 12 hours) and are expressed in the 24-hour mode.

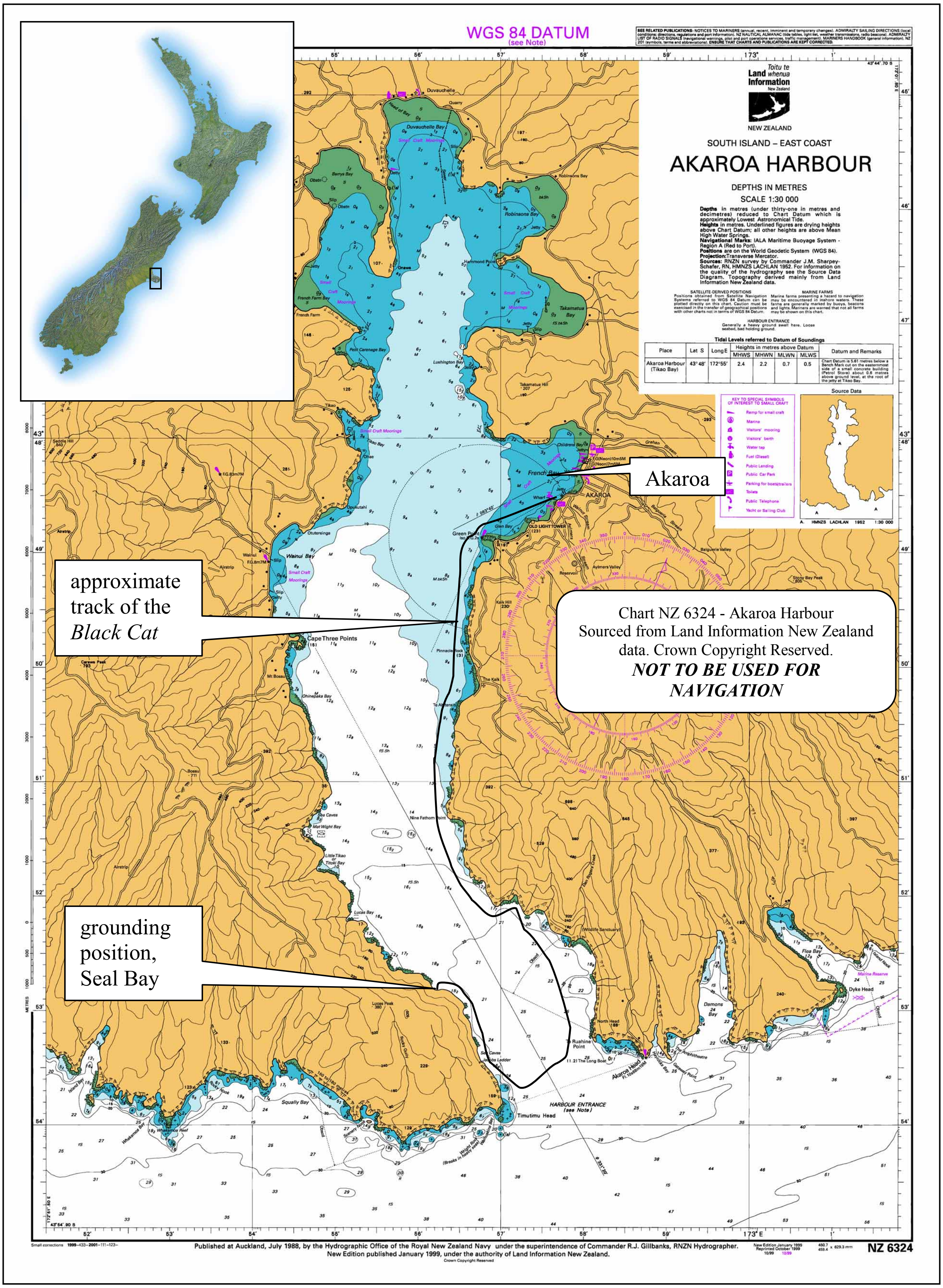


Figure 1
Chart of Akaroa Harbour

1 Factual Information

1.1 Narrative

1.1.1 On 17 April 2005 at about 1000, the Master and deckhand of the restricted limit passenger vessel *Black Cat* boarded the boat on its mooring at Akaroa. They completed the pre-start checks before slipping the mooring and bringing the boat alongside the wharf in readiness to embark passengers for a harbour cruise.

1.1.2 At about 1105, with 31 passengers and 2 crew on board, the boat left the wharf and headed down the eastern side of Akaroa Harbour. The Master gave a commentary on the history of the area and general information about the dolphins and whales.

1.1.3 When they were near the mouth of the harbour, they encountered a pod of Hector's dolphins, so the Master stopped the boat and they stayed with the dolphins for about 20 minutes. At the entrance, there was a swell running from the south-west, so the Master decided to stay inside the harbour and crossed to the western shore. He then started to head up the western side of the harbour, continuing to give a commentary to the passengers.

1.1.4 Just to the south of Seal Bay (see Figure 1), they stopped for a few minutes to observe a small pod of dolphins, before they slowly approached the shore with the dolphins continuing to play in the bow wave. When they were about 50 to 60 m from the rocky shore the Master, who was controlling the boat from the port bridge wing, put both engines astern with the intention of stopping the boat so that the passengers could observe the fur seals that were basking on the rocks.

1.1.5 Instead of the boat stopping as the Master intended, it started to turn to port and continue towards the shore. The Master increased the throttle on both engines to try to stop the boat, but the additional throttle caused the starboard engine to thrust the boat ahead and continue its turn to port.

1.1.6 Realising there was a fault on the starboard engine, the Master put it into neutral and applied full astern on the port engine. By this time they were so close that the starboard bow of the still turning boat made contact with the rock face. The boat bounced off at the bow, continuing to turn to port and away from the rock face. The Master ran into the wheelhouse, to the main conning position on the central console, from where he was able to stop the starboard engine. He continued to use the port engine and was able to manoeuvre the boat clear of the shore. He also activated the bilge pumps in all the spaces.

1.1.7 When the boat was about 100 m from the shore the Master put the port engine into neutral and inspected the damage. The deckhand assisted the passengers to don lifejackets, and tended to one passenger who was feeling faint. The Master went through each of the void spaces and did not find any ingress of water or discharge of diesel oil.

1.1.8 After reassuring the passengers that they were not in any immediate danger, the Master headed towards Akaroa on the port engine. On the journey, he tried the starboard engine and found that it was stuck in forward gear, so he again stopped it, preferring to manoeuvre on the port engine alone.

1.1.9 At about 1315, the Master berthed the boat at the wharf in Akaroa and the passengers who required medical attention were taken to the Akaroa Medical Centre, where they were examined. None required hospitalisation.

1.1.10 The next day, after engineers had assessed the damage, the boat was taken to Lyttelton, on the port engine alone, where it was slipped and repaired.

1.2 Vessel information

1.2.1 The *Black Cat* was built in 1993 to a standard Sabre Catamarans (Australia) Proprietary Limited design for a 17 m aluminium catamaran. The Black Cat Group purchased the boat in October 1999. When it arrived in New Zealand, it was used as a cruise vessel on Lyttelton Harbour. In October 2004 it was sent to Akaroa to operate harbour and dolphin-watching cruises there.

1.2.2 Maritime Management Services issued the boat with a Safe Ship Management certificate on 1 October 2003 that, subject to regular inspections and audits, would remain valid until 28 August 2007. The boat was licensed to carry 99 passengers in the restricted inshore area of Banks Peninsula.

1.2.3 In 2003, the boat's original 2 Caterpillar engines were replaced by 2 Yanmar 6KY ETE diesel engines. Each engine produced 450 kW [600 horsepower] and drove, through a ZF IRM350 reversing gearbox, a 5-bladed fixed-pitch propeller.

1.2.4 Each of the 2 propulsion engines was controlled by a single lever that selected forward or reverse gear and also varied the engine speed. The control system was a combination of electronic and cable control (see Figure 2). The bridge control stations were electrically linked to the 2 electronic control units (ECUs), which were linked by cables to each engine and transmission. The electrically linked control heads allowed any one of several individual control stations to be used. The *Black Cat* had 4 control stations: in the wheelhouse, on each bridge wing and one in the forecastle hatch. The last was used when the vessel was being secured to its mooring. Control was switched between each of the control stations by setting the lever on the active station to neutral then pressing the "station select" button on the head unit at the new control station. An indicator light on each head unit showed when that station was active (see Figure 3).

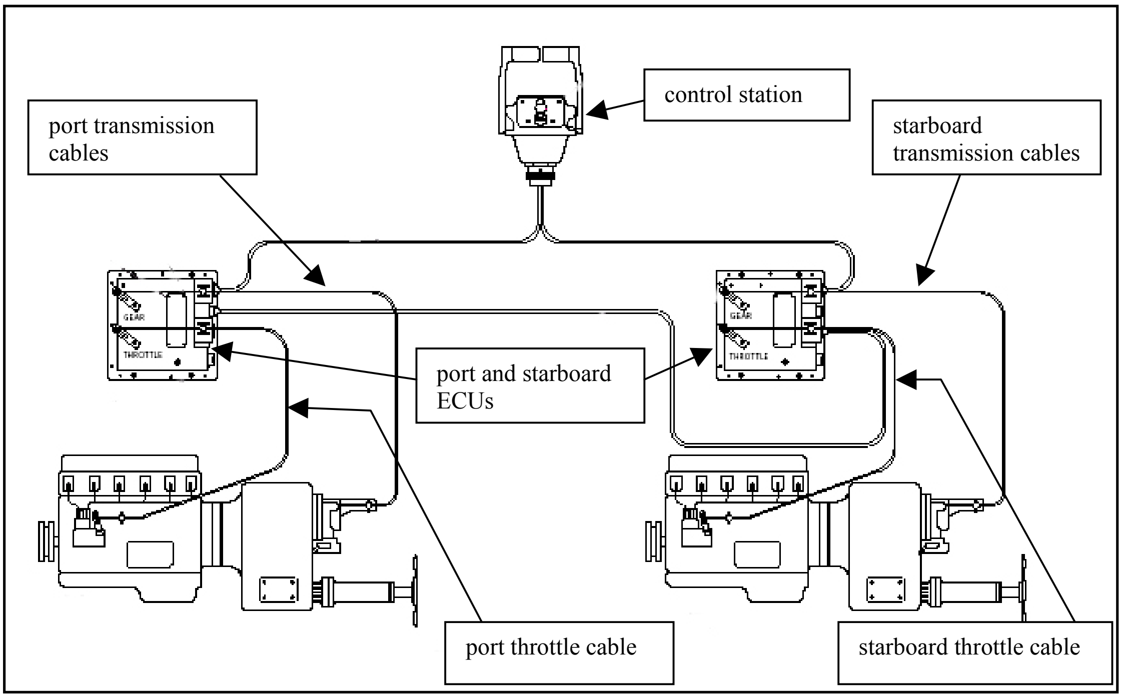


Figure 2
Diagram of the engine and transmission control system

Figure 3
Port bridge wing and wheelhouse engine control stations

1.2.5 The interface between the electronic and cable controls took place in the ECUs. Each cable actuator was moved by a small servomotor, which was regulated by a potentiometer. The control system for the Yanmar engines differed from that of the Caterpillars, so the ECU part of the Twindisc control system was replaced with one that had separate throttle and transmission actuators (see Figure 4).

1.2.6 The ECUs were mounted in the port and starboard void compartments forward of the engine rooms, and watertight grommets were used where the control cables passed through the bulkhead into the engine room. The control cables in the starboard side curved downwards from the ECU before recurving upwards to pass through the bulkhead. In an attempt to improve tidiness, electrical cables passing between the void space and the engine room had been attached with cable ties to the control cables (see Figure 5).

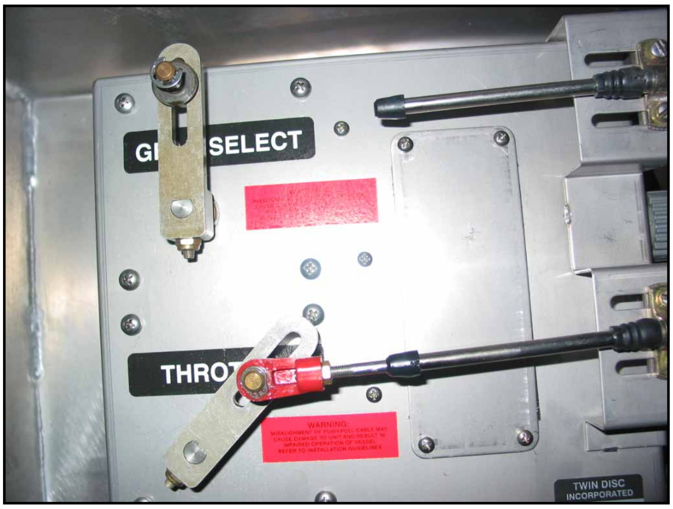


Figure 4
Electronic control unit with transmission cable removed

1.2.7 The boat was provided with a fixed bilge pumping system capable of pumping every space through a bilge pump mounted on and driven by the port main engine. A manual bilge pump capable of drawing water through the main bilge piping system was also fitted. This system and pumps could also be used as the fire main. In addition, there were 8, 4 in each hull, independent submersible bilge pumps that pumped directly over the side. Bilge alarms in each of the individual spaces registered in the wheelhouse.

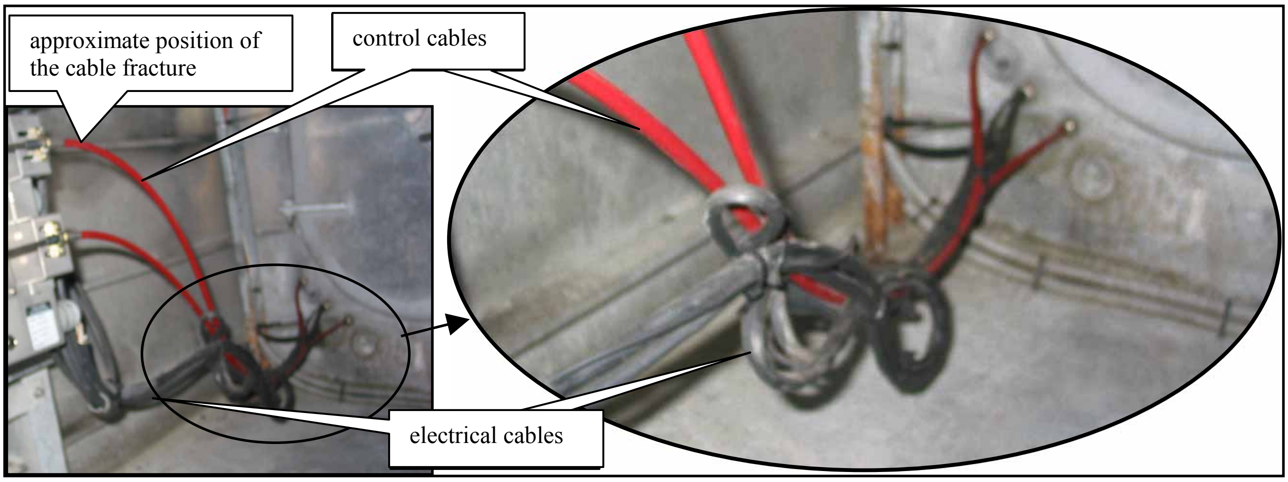


Figure 5
Control cables with electrical wires attached

1.2.8 The boat was fitted with the following navigational and communications equipment:

- a JRC JLU 121 GPS/plotter
- a JRC JMA 2143 radar
- a TMG autopilot
- 2 JRC very high frequency radios.

1.3 Personnel information

1.3.1 The Master had been working at sea for about 4 years, entirely with the Black Cat Group. He had gained a Local Launch Operator's certificate in 2002 and had been sailing as Master ever since. He had gained an Inshore Launchmaster's certificate in 2004.

1.3.2 The deckhand had worked for the Black Cat Group for 9 years. She spent 3 days per week working in the office and 2 days a week working on the boats. She had no maritime qualifications, but had undergone basic on-the-job training on the boat when she had joined the company.

1.3.3 The Master worked 5 days on and 2 days off. He, along with the other 4 company masters, rotated between the 3 vessels of the fleet, which included the *Black Cat*, a Naiad with 2 outboard motors and a catamaran driven by jet units.

1.4 Climatic conditions

1.4.1 The weather in the harbour was fair with light south-westerly winds. Outside the harbour the wind was stronger with a slight to moderate sea and swell.

1.4.2 For the purpose of calculating the tide Lyttelton was the standard port for Akaroa. On 17 April a high water of 2.0 m was at 1031 and the low water was 0.9 m at 1638. The tidal cycle was neaps. The tidal streams in the harbour were weak.

1.5 Injuries and damage

1.5.1 The 7 injured passengers were examined at the Akaroa Medical Centre. The injuries mostly consisted of slight bruising and sprains caused when the people fell against the boat's superstructure and fittings, however one passenger was suspected of having a cracked rib and another had a sprained knee.

1.5.2 The bow of the starboard hull was dented and there was a small tear in the hull plating in way of the stem (see Figure 6). Although above the waterline, the tear allowed the slow ingress of water into the forward void space when the boat was moving. However, the bilge pumps were capable of handling the amount of water entering the space. The starboard side of the hull had scrapes along its length, but none of those penetrated the hull. There was a crack in the hull above the starboard propeller. Two of the blades on the starboard propeller had lost about 25 mm off their tips; a third blade had a small nick out of its outer edge (see Figure 7).

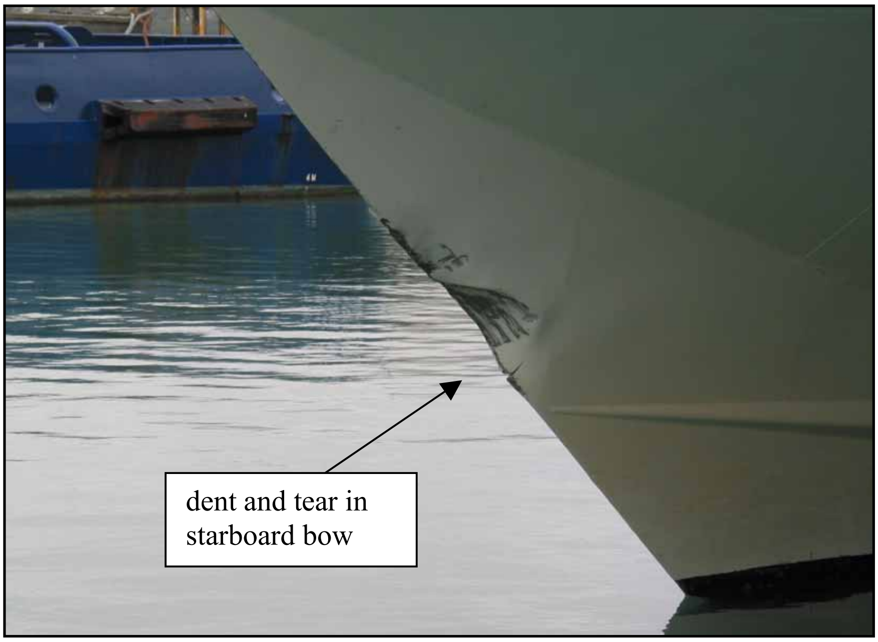


Figure 6
Damage to the starboard bow

1.5.3 The owner's contracted engineer inspected the boat at Akaroa. He found that the inner part of the starboard transmission control cable was broken a short distance from where it connected to the ECU.

Figure 7
Propeller damage

1.5.4 The broken transmission control cable resulted in the gearbox remaining in the direction it was prior to the breakage, irrespective of the position of the control lever. However, the throttle remained active and the engine speed would change in line with the position of the lever.

1.6 Morse control cables and post-accident testing

1.6.1 Control cables are manufactured in many different sizes and types depending on the application for which they are intended. Those specified to connect the ECU with the engine and transmission were Morse 33C Red Jacket cables, which comprised a polyethylene outer case and a stainless steel inner wire. Those for the transmission were 4.25 m long. The throttle cables were of the same type but were 5.0 m in length.

1.6.2 The specifications of the cable issued by the manufacturer, TeleflexMorse, recommended that a minimum bend radius of 127 mm [5 inches] would give a 30 series control cable, such as those fitted on the *Black Cat*, optimum life. The manufacturer specified that other variables, such as output loads, cable length and the total degrees of cable bend in the installation could affect the life of a cable. Where the minimum specifications of a cable were met or exceeded, its minimum life should be 150 000 cycles. A cycle was one movement from neutral to either ahead or astern.

1.6.3 Although not measured, the cables appeared to have bend radii of more than the minimum 127 mm, so the cable should have had an expected life cycle of a minimum 150 000 cycles. The engineering company that installed the new Yanmar main engines in July 2003 produced a receipt from that date for 2 new Morse 33C Red Jacket cables each 4.25 m long.

1.6.4 The owner estimated that during each cruise the transmission control cable would go through up to 45 cycles. When the *Black Cat* was in Lyttelton, it did one trip per day and when it moved to Akaroa it did 2 trips during the summer and one during the winter. Allowing a conservative 1.5 trips per day, for the 630 days since the new cables had been fitted with the new engines, the cable would have completed in the order of 42 500 cycles.

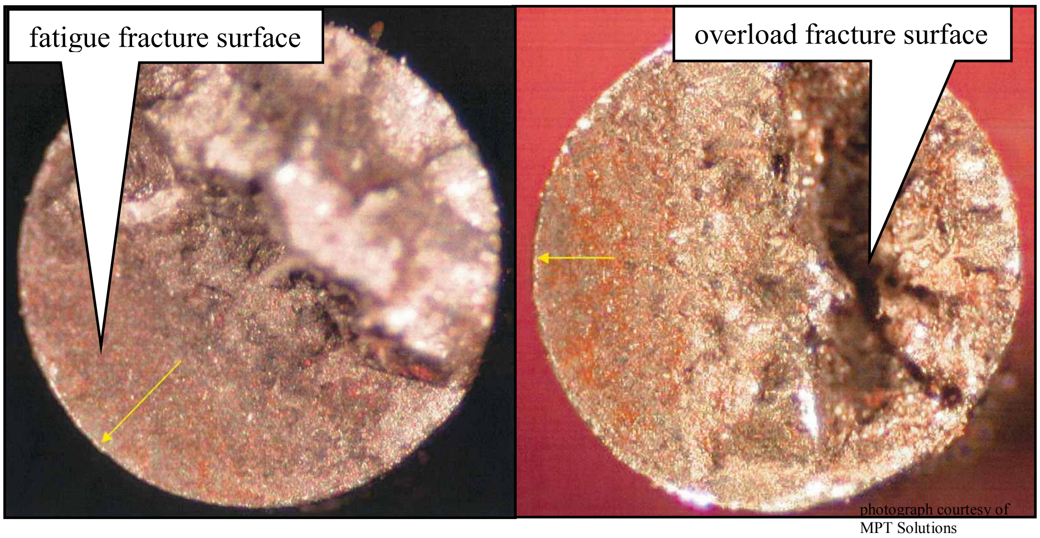
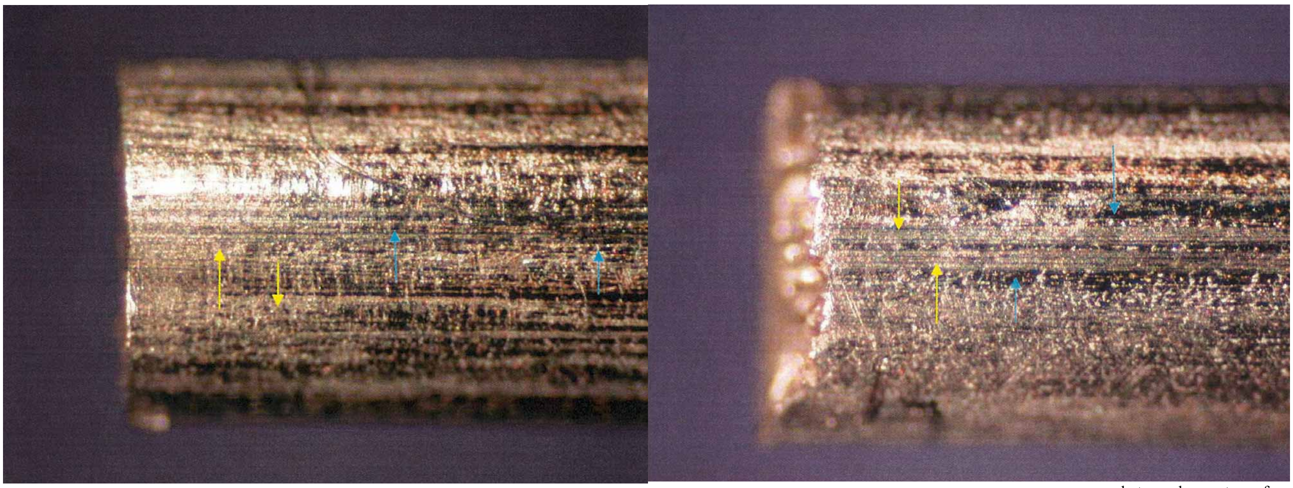


Figure 8
The long and the short end fracture surfaces. The yellow arrows indicate the origin of the fatigue fracture

1.6.5 A consulting metallurgical engineer from Materials Performance Technologies examined the broken cable. In his analysis he determined that the inner stainless steel wire had fractured about 75 mm from where it joined the threaded shaft that connected to the actuator. The broken ends of each part of the wire had a slight permanent bend, the shorter end was bent downwards, but the direction of the bend in the longer section could not be determined. The fracture surface on the short length showed a uni-directional bending fatigue extending over about half the cross-sectional area, while the other half showed an irregular pattern, typical of an overload fracture (see Figure 8). A similar pattern was seen on the complementary fracture surface on the long end. The orientation of the fracture was such that the start of the fatigue fracture was at the top or the 12 o'clock position.



photographs courtesy of MPT Solutions

Figure 9
The upper and under sides of the wire showing scratches (yellow arrows) and polishing (blue arrows)

1.6.6 The metallurgical engineer further noted that the external surface of the inner wire exhibited wear consisting of longitudinal scratches and polishing over about 70% of the upper surface from 40 mm along the short end from the fracture to 30 mm along the long end from the fracture (see Figure 9). On the under sides of the wire there were 2 distinct sets of longitudinal scratches plus polishing over a narrow strip up to 20 mm along the short end from the fracture and 65 mm along the long end.

1.6.7 The metallurgical engineer used the dye penetrant method to test the inner wire for further cracks over a length of about 150 mm either side of the fracture. No further cracks were found.

1.7 Topography

1.7.1 Akaroa Harbour lies on the southern side of Banks Peninsula, and is about 9 nm in length and its width varies between one and 2 nm. The Akaroa township lies in French Bay, about midway along the eastern side of the harbour. The shore on both sides of the outer part of the harbour is generally steep to, with cliffs rising from the sea. There are numerous small coves and bays along the shoreline, but few of them provide safe anchoring or landing.

Figure 10
The coast around Seal Bay

1.7.2 In Seal Bay a small rock shelf breaks the steep rise of the shoreline. New Zealand fur seals bask on this rock shelf. From the shelf the rocks fall away sharply, leaving a sheer rock face, and it was with this that the starboard side of the boat collided (see Figures 10 and 11).

Figure 11
Rock shelf in Seal Bay

2 Analysis

2.1 Ecotourism and wildlife-observing cruises are becoming very popular. To give the passengers a worthwhile experience the boats need to approach the shore so that the wildlife can be clearly observed. With fully functioning engines this would not normally be a problem, but the nature of the failure put the driver in a difficult situation from which he was unable to extricate himself.

2.2 The sheer rock wall along the coast, with deep water extending right up to it, allowed boats to safely come within a few metres of the shore.

2.3 The Master did not readily identify the failure of the control cable, but only realised that the boat was not responding to the settings he placed on the controls. His initial response to apply additional astern movement on the lever was an understandable automatic reaction. Humans become accustomed to machinery responding correctly to their commands and when the response differs from that expected, it can take the operator time to analyse what has occurred and to work out the necessary corrective action.

2.4 Even if the Master had been in the wheelhouse rather than on the bridge wing, he would not have noticed the failure any earlier, as none of the engine indicators showed which way the propellers were turning.

2.5 There were no emergency stop buttons on the bridge wing control stations. This was reasonable on a boat that was only 7.25 m in width, where the Master was never more than 4 paces from the emergency stop.

2.6 No tight bends were formed in the control cables when they were installed, and the minimum bend radius of 127 mm was exceeded throughout. There was sufficient flex in the cables to allow them to move with the motion of the boat. However, once the control cables were in place, some heavy electrical cables had been attached to them at the bottom of the loop between the ECU and the engine room bulkhead. The additional weight of the electrical cables would have accentuated the stress on the control cables with the movement of the boat and probably induced a bending moment on the supporting control cables, particularly on the upper one, the transmission control cable. The permanent slight bend in the internal cable near the fracture was probably the result of the additional weight of the electrical cables on the control cable.

2.7 Attaching the electrical cables to the control cable, while almost certainly responsible for its failure, was understandable of someone wishing to maintain a tidy boat, and a mistake that many mariners or installers of machinery could and do make.

2.8 When the new ECUs were fitted for the Yanmar engines, additional transmission control cables were needed, but the throttle cables were compatible and so were reused. Consequently, it is probable that the cable that failed was one of those fitted in July 2003, but this could not be confirmed due to the absence of identifying marks on the cables.

2.9 The minimum life of Morse cables was considered to be at least 150 000 cycles. On this occasion, even though the minimum bend radius had not been breached, the cable broke at less than a third of the expected life, most likely because of the extra stress, and particularly the movement that was unwittingly placed on the cables by the attachment of the electrical cables. The cables were sealed and so were unable to be inspected, so areas of wear could not be readily identified during routine maintenance. Control cables were usually replaced as part of a planned maintenance programme.

2.10 The metallurgical engineer concluded that the fracture in the stainless steel inner wire was initiated by a uni-directional bending fatigue, before the final overload fracture completed the failure. The fatigue fracture probably occurred because of the higher than normal bending stresses imposed on the transmission control cable by the additional weight of the electrical cables being tied to them.

2.11 The combination of electronic and manual control system was common, particularly where multiple control stations were required. The cables used were those specified by the manufacturer of the control system.

2.12 Had the failure occurred at almost any other time, for example 5 minutes before when the Master had stopped to observe the dolphins, he should have been able to stop the starboard engine and safely make his way back to Akaroa on the port engine alone. But in Seal Bay he was so close to the shore that the ahead movement of the starboard engine resulted in the boat hitting the shore within seconds and before he could take avoiding action.

2.13 The starboard propeller damage being limited to 2 blades suggests that it hit the rock hard, but either at or about the same time as that engine was put in neutral or stopped. Alternatively, and less likely, was that the propeller hit sufficiently hard to cause the engine to stall instantly.

2.14 The Master was giving a tour commentary at the time of the incident, but this probably did not contribute to the cause or the outcome of the cable failure and the resulting collision with the rock wall.

3 Findings

Findings are listed in order of development, not in order of priority.

3.1 The boat collided with a sheer rock wall after the starboard transmission Morse control cable broke, resulting in the starboard engine going ahead when the Master put the control astern.

3.2 The control cable suffered bending fatigue, which propagated a fracture over about half of its cross-sectional area before the remaining intact area of the control cable was overloaded and ultimately failed during normal operation.

3.3 Bending fatigue failure was caused by the additional weight of electrical cables that were attached to the control cable.

3.4 It is probable that the control cable failed in less than a third of its expected minimum life due to the stress caused by the additional weight of the electrical cables.

3.5 The action of whoever attached the electrical cable to the control cable was flawed, but was an error that is probably quite common.

3.6 The Master was unable to react to the failure in sufficient time to prevent the boat colliding with the rock wall.

3.7 The nature of the eco tour required that the boat approach close to the shore so that the passengers could see the wildlife clearly.

3.8 The area was rugged and had the damage to the boat been such that it took on more water than the bilge pumps could handle, it may have been difficult to reach a safe haven.

3.9 Following the accident, the Master and deckhand capably carried out damage assessment and cared for the passengers.

3.10 The boat and the crew were correctly certificated.

4 Safety Actions

4.1 Following the accident, the owner fitted a complete set of new control cables to the *Black Cat*. The control cables were separated from the electrical cables and were supported on a wooden block (see Figure 12).

Figure 12
Control cable support as fitted after repairs

4.2 Whilst not directly influenced by this accident, TeleflexMorse Australia advised that since early 2003 it had marked each cable with a date stamp showing the year and day of manufacture. It did point out that the date of manufacture might differ considerably from the date of installation.

5 Safety Recommendations

Safety recommendations are listed in order of development, not in order of priority.

5.1 On 25 October 2005 the Commission recommended to the Managing Director of TeleflexMorse Australia that he:

092/05 Include with new cables general instructions on their care and the precautions necessary to optimise their life. Such information may also indicate how and when the cable should be inspected, and when it should be replaced.

5.2 On 7 November 2005, the Managing Director of TeleflexMorse Australia replied:

> We acknowledge the recommendation but need to consider it further before we can determine as to whether it is feasible or not to implement it.

5.3 On 19 October 2005 the Commission charged itself to publicise the findings of this report in boating magazines and journals in New Zealand, to warn owners and operators of the possible dangers of attaching additional items to critical control cables. (094/05)

Approved on 27 October 2005 for Publication

Hon W P Jeffries
Chief Commissioner

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