Report of the investigation of the capsize of a school boat on Fountain Lake, Portsmouth with the loss of one life on 16 September 1999

Marine Accident Investigation Branch
First Floor Carlton House
Carlton Place
Southampton
SO15 2DZ

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CONTENTS

GLOSSARY OF ABBREVIATIONS

AALA	-	Adventure Activities Licensing Authority
DTI	-	Department of Trade and Industry
GRP	-	Glass reinforced plastic
hp	-	Horse power = 0.7457kW
HSE	-	Health and Safety Executive
kW	-	kilowatt
m	-	metre
mm	-	millimetre
MAIB	-	Marine Accident Investigation Branch
MoD	-	Ministry of Defence
RIB	-	Rigid-hulled inflatable boat
RNSC	-	Royal Naval Sailing Centre
RYA	-	Royal Yachting Association
UTC	-	Universal Co-ordinated Time
VHF	-	Very High Frequency

GLOSSARY OF TERMS

Dory	-	a small flat bottomed boat
Freeboard	-	the height of the gunwale above the waterline
Free surface	-	the tendency of a fluid to shift with the motion of a boat, a large free surface can lead to a capsize
Kill switch	-	a cord that is connected to the outboard motor control and the person on the helm
Loll	-	a vessel which is unstable in the upright position will not necessarily capsize, but will settle at an angle of loll
Planing	-	skimming across the surface of the water at high speed
Stem	-	the centre line of the hull at the bow

SYNOPSIS

The accident occurred on 16 September 1999 and was reported to the Marine Accident Investigation Branch (MAIB) the following day. An investigation began immediately.

During the afternoon of 16 September, two teachers, a gap-year student and 18 pupils from Boundary Oak School, Fareham travelled to the Sailing Centre at HMS Excellent, Whale Island, Portsmouth to go sailing.

On arrival the conditions were considered unsuitable for Topper sailing, so rather than disappoint six of the pupils who were making their first outing, an alternative activity was organised. With a teacher in charge the pupils donned lifejackets and boarded a 4.27m (14ft) glass reinforced plastic (GRP) dory type boat owned by the school and propelled by an 18.6kW (25hp) outboard engine. The aim was to give them some practical experience of being afloat.

The wind in the harbour half a mile from where the accident occurred, was force 4 to 5, with a slight sea. The conditions in the lee of naval vessel, HMS *Bristol*, moored nearby, were calmer and the teacher in charge of the dory decided to remain within the shelter provided by her. Shortly after slipping from the pontoon the engine stalled but was restarted. With the teacher at the helm the boat headed towards the sheltered water provided by HMS *Bristol* at a speed of about 3 to 4 knots. While making way, some spray came in over the bows, to the general excitement of the pupils. A large plastic sheet found floating in the harbour was pulled on board. A jellyfish fell out of a bailer and stung one of the children, and a boy fell into the water but was recovered safely.

These events led to a steady increase in the amount of water accumulating in the boat. Throughout this time, the freeboard was slowly decreasing and she began to roll.

The outboard engine stalled a second time but this time, could not be restarted. Without power, four of the pupils were told to start paddling. When still some 75m from the pontoon, the dory capsized and pitched the occupants into the water.

Buoyed by their lifejackets, some pupils managed to climb on to the upturned boat while others, including the teacher, clung to the hull. The crew of a local boat, *Pike II*, saw what had happened and gave immediate assistance. They recovered eight pupils and the teacher, but it wasn't until this rescue was complete that one of the children was found to be missing. *Pike II*'s crew lifted one end of the upturned dory and found a young girl underneath. She was recovered, given first-aid, but died later in hospital.

Following the accident the dory was examined in detail and found to contain a substantial amount of water trapped in the void between the inner and outer hulls below the floor.

The investigation found that uncontrolled movement of seawater in both the boat, and in the void beneath the floor, combined to make it so unstable that she would capsize. It was found that seawater had entered the void through two small holes in the bows where a towing bolt had been fastened and was missing.

This report makes a number of recommendations to prevent anything similar happening again.

Figure 2

Dory after recovery on 16 September 1999

BOAT AND INCIDENT PARTICULARS

Boat Particulars:

Type	:	Wilson Flyer 14 open dory **(Figure 2)**
Year of Build	:	1985
Material of Construction	:	GRP
Length	:	4.27m
Breadth	:	1.70m
Place of Build	:	Bedhampton, Portsmouth, Hampshire
Propulsion	:	Johnson outboard 18.6kW (25hp)
Speed	:	Approximately 3 to 4 knots laden
Owner	:	Boundary Oak School, Fareham, Hampshire
Occupants	:	Teacher and nine pupils

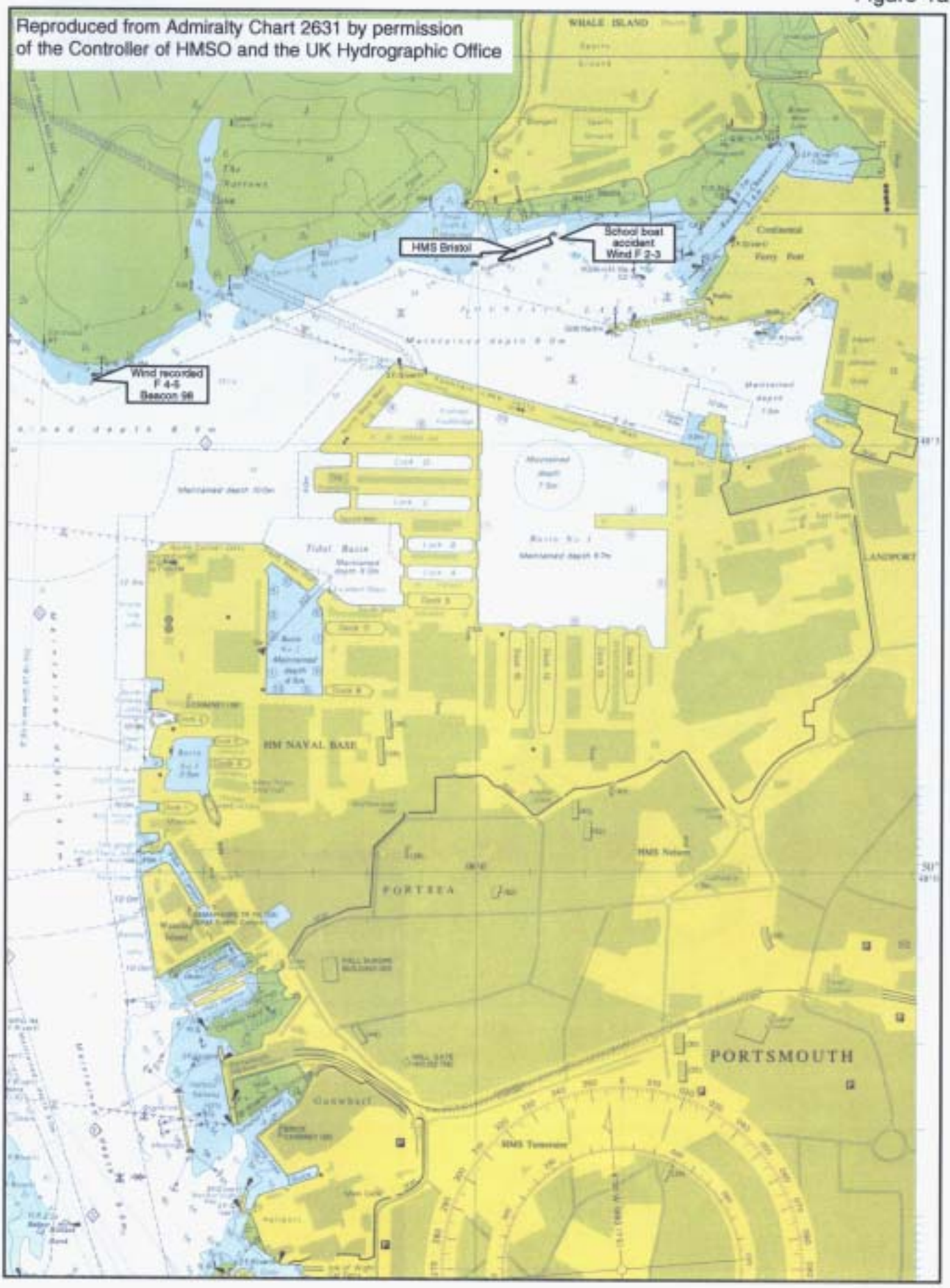
Accident particulars:

Date of Accident	:	16 September 1999
Time of Accident	:	1545 UTC (1645 BST)
Type of Accident	:	Swamping and capsize
Place	:	Fountain Lake about 75m off the pontoon HMS Excellent, Whale Island, Portsmouth, Hampshire **(Figure 1)**
Weather Conditions	:	Beaufort wind force 4 to 5, moderate to fresh breeze
Damage	:	Boat recovered without damage
Injuries	:	One pupil lost her life
Pollution	:	Minimal - from petrol can

Figure 1

General location of the boat's operation

Figure 1a


Reproduced from Admiralty Chart 2631 by permission of the Controller of HMSO and the UK Hydrographic Office
HMS Bristol
School boat accident Wind F 2-3
Wind recorded F 4-5 Beacon 98
RM NAVAL BASE
PORTSEA
PORTSMOUTH
HMS Nelson
HMS Temeraire
WHALE ISLAND
Tidal Basin

SECTION 1 - FACTUAL INFORMATION

1.1 BACKGROUND

Boundary Oak School, Fareham, is an independent school that includes among its outdoor activities, sailing. The school has a sailing club and at the time of the accident owned a rigid inflatable boat, a 4.27m (14ft) open dory and Topper sailing dinghies. Sailing was conducted in the dinghies kept at the Sailing Centre, HMS Excellent, Whale Island, Portsmouth.

All boating activities were supervised by staff, and all those embarking in school organised boats were required to wear lifejackets.

On the afternoon of 16 September, it had been hoped to take a group of pupils sailing, but because the conditions were judged to be unsuitable for dinghies, an alternative activity afloat was proposed. Nine of the pupils were taken out in an open dory with a teacher in charge.

The accident occurred later that afternoon when the dory capsized.

1.2 NARRATIVE (All times are BST (UTC+1))

On Thursday 16 September at 1330, 18 pupils, two teachers and a student met in the Assembly Room at Boundary Oak School to discuss the safety procedures to be used ashore and afloat for an afternoon's sailing that day. The discussion included the behaviour of the pupils, the wearing of lifejackets, dangers of working on deck, logistics for the day, rigging the boat and, because the weather forecast was poor, the prospects for sailing in the Toppers.

The party arrived at the Whale Island Sailing Centre at 1430 where the conditions were still not that good. Two helpers (a parent and an ex-parent) would normally have been present, but were not so on this occasion. One of the teachers, Mr Dove, discussed the conditions for going afloat with a naval officer at the sailing centre, Lt Cdr Rothwell. He told Mr Dove that in view of the weather, sailing might be possible in the more sheltered water at the eastern end of the basin. Further dialogue revealed that although the conditions had been too gusty for dinghies earlier that day, they were alright for the afternoon. In the event sailing was cancelled because the pupils had not completed "dinghy rigging training" and "the safety boat would not start".

Because some of the pupils had not previously been afloat with the school, and the organisers were anxious not to disappoint them, a boat trip was quickly organised. The pupils were split into two groups of nine, with six of those who had not previously been out before allocated to go afloat with Mr Dove in the dory.

Attempts were made to ready the RIB, but its outboard engine failed to start.

The dory, meanwhile, was being prepared and all those embarking donned lifejackets. It is understood they were briefed about them. Some of the pupils were wearing wet suits while others wore normal clothing.

The dory left the pontoon some time between 1600 and 1630 with ten people embarked. Mr Dove was at the aft end and standing next to the outboard motor. The children were distributed three to a seat. The wind in the exposed front of the harbour was recorded as being between 15 to 20 knots (force 4 to 5) from the west, but was estimated to be force 2 to 3 in the shelter of HMS *Bristol*, a destroyer moored to a jetty nearby.

Shortly after getting underway the outboard motor stalled, but was restarted successfully.

Mr Dove headed for the relative shelter of HMS *Bristol* at between 3 and 4 knots, and began manoeuvring up and down in her lee making lazy figure-of-eight turns. Four or five pupils had by now moved forward, and were laying face down at the bow. To the children's excitement spray had begun to come inboard. Mr Dove told one of the pupils to move further aft. During this time water from both the spray and from waves coming in over the gunwale was beginning to accumulate inside the boat.

A large plastic sheet, which had blown off some scaffolding, was seen floating by and was recovered as a training exercise. Two pupils pulled it on board and, under Mr Dove's guidance, tucked it away beneath the middle seat.

Shortly after this, a boy positioned forward went overboard. He was quickly and easily recovered by the teacher and suffered no ill effects, but some additional water was shipped during the recovery.

Soon afterwards the outboard motor cut-out again. It was reported that Mr Dove instructed the pupils sitting on the aft bench to move forward to give him room to restart the outboard motor. However, it was also reported that this was unnecessary. He turned to try and restart the motor, but was unsuccessful. Without power, the boat came beam on to the waves and the rolling increased. Four pupils were instructed to move to the starboard side and start paddling. At about this time two people ashore were watching the boat. The accounts differ, with one reporting the dory as having little freeboard and rolling heavily while lying beam on to the westerly swell. The other recalls seeing the dory as level and only being splashed by its own passing wash.

At some stage a jellyfish fell out of a bailer aft. As it slid across the floor it stung one of the pupil's legs and caused quite a commotion, which added to the movement of, by now, a rolling boat. The time was about 1645.

Moments later, and when some 75m from the pontoon, the dory rolled to port and capsized **(see Figure 1)**. The occupants were pitched into the water.

The dory had inverted and was now floating upside down. The weight of the outboard engine meant that the aft end was well below the surface. Four or five pupils climbed on top of the upturned hull while the others held on to the lifeline attached to its sides.

The teacher was thrown some distance away from the boat and his attention was focused on getting back to the boat. He couldn't see everyone from where he was, but assumed from the assurances he received that everyone was either on top of the boat or hanging on to the lifelines. He did not carry out a head count.

The lifejackets worn by the pupils had whistles attached to them, and these were used together with shouting to attract the attention of the person on the jetty.

1.3 RESCUE AND RECOVERY

The two-man crew (Mr David Baker and Mr Colin Hill), of a harbour vessel *Pike II* working nearby, noticed the capsized boat and saw the pupils waving. They did not hear the whistles or shouting. They stopped what they were doing immediately and motored across to provide what assistance they could. It took them about 4 minutes to arrive and having done so, started to rescue those they could see in the water and from the upturned boat.

Once the survivors had been embarked in *Pike II*, one of the pupils, Victoria Bee, realised her sister, Elizabeth, was missing and called her. With no-one else left in the water and suspecting she might still be underneath the upturned hull, the crew of *Pike II* lifted the forward end of the dory. Their fears were justified. The young girl was lifted from the water unconscious, and taken onboard *Pike II* where one of the crew, Colin Hill, an experienced fisherman with first-aid training, attempted to revive her.

A group of people on the sailing centre jetty had in the meantime also heard the shouting and whistles, and some embarked in a boat to provide whatever assistance they could. Sailing centre instructor, Mrs Monkham, joined Mr Hill on *Pike II* and began heart massage and mouth-to-mouth resuscitation until they were relieved first by an RN CPO, then by the ambulance crew. Lt Cdr Rothwell had called the emergency services but, because there was no direct telephone line to them, had to go through the base telephone exchange and the quartermaster.

Some 15 minutes after the accident *Pike II* returned to the sailing centre pontoon with the survivors and the unconscious girl.

The ambulance arrived with a police escort 22 minutes after it was called. Elizabeth Bee was taken to Queen Alexandra hospital where she was pronounced dead. A postmortem later determined she died from drowning.

A rope was secured to the capsized dory and it was towed by an RNSC searider to the launching slip. There, the boat was righted, lines attached and taken to its berth on the pontoon **(see Figure 2)**. Later that day it was towed to the Ministry of Defence (MoD) police berth on Fountain Lake pontoon.

1.4 ENVIRONMENTAL CONDITIONS

The wind strength in Portsmouth harbour on the day of the accident was reported to have been gusty. During the morning the weather had been described as "awful", and unsuitable for dinghy sailing by young children.

At 1545 on 16 September the wind at No 98 beacon, some half a mile west of where the incident occurred, was recording between 15 to 20 knots from a westerly direction. This equates force 4 to 5 or a moderate to fresh breeze on the Beaufort scale. The weather was fine.

The sea state in the harbour was reported as moderate but, by all accounts, the conditions in Fountain Lake by HMS *Bristol* were less, and some shelter was provided. One witness recalls the wind as being force 2 to 3, but all the evidence indicates that outside the shelter provided by HMS *Bristol* the sea state was slightly higher. High water was at 1600 and the accident occurred during slack water.

Sea temperature was about 18°C.

1.5 DESCRIPTION AND HISTORY OF THE BOAT

The dory owned and used by Boundary Oak School was built in about 1985 by Wilson Flyers, to a specification agreed by the first owner, Mr James Butcher. It was an open boat, 4.27m (14ft) long with a hull made of glass reinforced plastic (GRP). It had an inner floor, three transverse bench seats, and a heavy wooden gunwale, **(Annex B)**. There was a relatively large foredeck with a substantial bow overhang. Beneath this foredeck the bow assumed a conventional shape.

Foam was inserted in the void under the floor and forward. A drain fitting was added in the transom with an inboard wooden bung that could be removed to drain water from the floor when the boat was planing.

The boat was propelled by a Johnson 18.6kW (25hp) two cylinder, two-stroke petrol outboard engine (Model No 25R75B/C20762).

While in the ownership of Mr Butcher, the boat was used mainly for leisure and

family trips and, very occasionally, for general workboat duties. The 18.6kW (25hp) Johnson outboard engine allowed planing at a speed of about 15 knots with two or three people embarked. With five or six people onboard she did not lift, but handled well in the displacement mode and could make way at about 5 or 6 knots.

In all loaded conditions prior to the accident there were no known problems with her stability.

Following the death of the original owner in 1995, the boat was rarely used. It was kept ashore in the winter and afloat during the summer months.

In August 1997 the boat, together with its outboard motor and trailer, was sold to Boundary Oak School for £475. Although the outboard motor had not been started for a while and the trailer was in a poor state, the school considered the boat itself to be in good condition. It was purchased as a support boat and a back-up to the RIB safety boat.

During the winter of 1997/98 it was stored in a container at the school, but when rocked during this time water was heard sloshing in the void space beneath the floor. The boat builder was approached to resolve the problem, and, on his advice, drain holes were drilled in the floor by the team who maintained the boat. About two gallons of water were seen to drain from the void. The boat was left to dry out before the holes were filled and the hull repaired.

Before the 1998 sailing season got underway, the 18.6kW (25hp) Johnson outboard motor was serviced, and the boat given a coat of anti-fouling. It functioned successfully throughout the season and was involved in the annual sailing camp at Newtown Creek, Isle of Wight. It was used to carry stores to the camp, and while there it transferred people and stores between boats and the shore, as well as performing its normal duties.

During the winter of 1998/1999 the boat was once again rocked to determine if the void contained any water. Nothing was heard. In March 1999, and before the sailing season started, the outboard engine was serviced by Fairweather Marine Ltd and spark plugs and gear oil replaced.

In April the boat was taken to the pontoon at Whale Island in preparation for the summer season which lasted until June. When used on activity days it carried six pupils and two adults, while other pupils sailed in the Toppers. The boat, loaded with stores, was again towed to the Isle of Wight for the summer camp. The cleat on the foredeck was pulled out during this trip.

Between June and September the uncovered boat was moored to the pontoon at Whale Island and not used by the school. At the beginning of the autumn sailing season in September a large amount of water had, nonetheless, accumulated on the floor of the boat and was removed.

The boat was used again by one of the regular users, Mr Clover, and a teacher during sailing activities on 9 September. No pupils were embarked and it appeared to handle normally. There were no incidents, and on completion it was left afloat and secured to the sailing centre pontoon as normal.

The accident occurred shortly after the third anniversary of the dory's purchase.

1.6 PEOPLE ON BOARD

At the time of the accident there were ten people on board, one adult and nine pupils.

The person in charge was a 64 year old teacher at Boundary Oak School, Mr Dove. He was an experienced sailor and held a Yacht Master (Ocean) Certificate (No 3535 - qualified on 2 September 1974). He was an average swimmer, but not trained to the standards of the Adventure Activities Licensing Authority.

He was the normal operator of the RIB safety boat, and had previously used the dory for routine jobs such as putting out marker buoys. He was not one of the regular users, but had taken her out on previous occasions to gain experience.

The nine children embarked, all aged about 9, were pupils at Boundary Oak School and in Year 6. Six of them had been afloat with the school before, but a number had been sailing with their families. They could all swim and some were wearing wet suits. Mr Dove had taught six of the nine in Year 5 and some in Year 4.

1.7 LIFESAVING EQUIPMENT

The pupils and teacher were wearing lifejackets and, with one reported exception, they functioned as designed. It is understood that Mr Dove's lifejacket did not inflate automatically when he entered the water, and he had to inflate it by mouth.

Elizabeth Bee was wearing a Seasafe LJ4 lifejacket.

The dory was fitted with lifelines on both sides. They had been fitted by Mr Clover after the boat was purchased and before any pupils were embarked **(see Figure 2)**. These enabled all those who did not climb onto the upturned hull to cling to something.

Four paddles were carried.

There was no radio or other means of communicating with the shore other than by using manual means including whistles on the lifejackets.

1.8 SCHOOL SAILING ACTIVITY

Sailing was an approved activity at Boundary Oak School, and a risk assessment had been carried out. This covered all sailing activities, but not the situation that prevailed on the afternoon of 16 September.

The key requirement for the school was to have a craft that was both robust and stable. The Wilson Flyer 14 dory fulfilled this need.

The school also owned a RIB that was used as a safety boat, but on the day of the accident it was unavailable; the engine would not start.

Two helpers, a parent and an ex-parent were not, as was usual, present, and the decision to go afloat with one teacher and nine pupils embarked was made without any review being taken of the risks involved in the changed situation.

The Hampshire County Council provides guidance for such activities in a document called *Safety in Hazardous Pursuits.* This document contains sound advice on marine activities, including staffing ratios, and was most recently updated in 1997. It is issued to 'all schools' in Hampshire but not, apparently, to those in the independent sector. Boundary Oak School is independent and did not have a copy.

In the document's introduction reference is made to planning. It states that '*Thorough planning and preparation are essential for the safety and welfare of all participants in any visit or activity'.*

The document goes on to cover individual activities including powerboats. The section on boat suitability states:

All outboards must be fitted with a 'Kill' switch with a pull cord attached to the helmsperson.

Petrol and two stroke outboard engines should normally be replaced every three years. Each time a power boat is used the skipper will check that all safety equipment is on board and that the boat is in a fit condition for use.

All defects must be reported and rectified at the earliest opportunity.

The document goes on to say that '*When passengers under the age of eighteen are carried, in addition to the skipper, there will be another adult on board who will be responsible for the children's behaviour and in particular the compliance with safety rules and emergency action.'*

It is understood that any exception to these regulations would only apply where there is a safety boat in the immediate vicinity.

A week after the accident, on 22 September, the school suspended all sailing

activities until the cause was known.

At their meetings on 21 June and 28 June 2000 the school governors proposed that all sailing activities operated by the school would cease. The proposal was agreed.

1.9 INSPECTION AND TESTS

On the day following the accident, 17 September, an MAIB inspector examined both boat and outboard motor at the MoD police pontoon in the Navy Base, Portsmouth. The boat was still afloat and contained water which was pumped out. The outboard engine was still in place, but the fuel tank was missing.

When boarded during this inspection the boat adopted an unusually large angle of heel. When unloaded with just the outboard motor attached, a small angle of loll calculated to be about 2.5° was found.

A large white plastic sheet, approximately 15m in length, was also examined.

1.9.1 Static tests

The boat was measured and found to be 4.19m (13ft 9ins) long, and 1.70m (5ft 7ins) in breadth.

Various measurements were taken to obtain some idea of the freeboard that would have featured at the time of the accident. These measurements were taken from the waterline to the top of the 51mm (2ins) thick gunwale.

The freeboards with the boat empty were found to be:

aft port = 0.51m (1ft 8ins), forward port = 0.40m (1ft 4ins).

To simulate the loaded condition with nine pupils and a teacher on board, four police officers with a total weight of 377.8kg (59.5 stone) sat on the centre line of the boat. The freeboards were measured as:

aft port = 0.47m (1ft 6½ins), forward port = 0.318m (1ft 0½ins).

The four police officers moved to port, which resulted in the following freeboards **(see Figure 3)**:

aft port = 0.20m (8ins), forward port = zero (the water was lapping at the top of the gunwale).

With two officers on the centre line and the other two on the port side, the freeboards were:

aft port = 0.29m (11½ins), forward port = 0.178m (7ins).

Figure 3

Static test with boat loaded with 380kg on 17 September 1999

Enlargement showing holes to locate U-bolt

1.9.2 Reconstruction

To reconstruct the incident, and see how the boat behaved in the prevailing conditions at about 1600 on the day of the accident, the MoD police vessel Endeavour towed the dory to the approximate position of the accident in Fountain Lake. At the time this was done it was thought the accident had occurred some 200-250 metres from the pontoon. An experienced marine unit police officer weighing about 105kg (16½ stone) and wearing a dry suit was on board.

At the time of the test, the wind at No 98 beacon was recorded as 20 knots from the west-south-west. The strength was similar to that prevailing on 16 September at No 98 beacon, but the direction had changed slightly; it had

backed from the west which meant that HMS *Bristol* provided less shelter. Although the conditions were not necessarily identical to those prevailing the previous day, they gave a useful idea of those that had existed at the time of the accident.

Once in position the boat was set adrift with the police officer on board. He started to move around and soon became concerned for his safety. He found that when seated on the port gunwale the boat was on the verge of capsizing **(see Figure** 4).

Figure 4

Reconstruction of incident

1.9.3 Further inspections

On Saturday 18 September, the MAIB inspector visited Wilson Flyer boats to examine the construction of the Flyer 14. The owner, Mr Wilson, gave a full explanation about the construction of the GRP boat, and offered to assist with the next inspection. It emerged that Wilson Flyer boats were no longer building the Flyer 14 to the same specification as the Boundary Oak School dory. Unless a customer specified otherwise, foam was now fitted under the floor.

On 23 September a further inspection of the boat was carried out by an MAIB inspector in the company of Mr Wilson, who recognised it as one he had built for Mr Butcher in 1985.

With the dory still afloat, holes were cut in the floor to determine whether, and

how much, water was actually present in the void between the outer GRP hull and the floor. Any water found might have accounted for the lack of stability experienced during the reconstruction.

The void was found to be partially filled with open cell foam that had become saturated and was breaking up. 56.8 litres (12.5 gallons) of frothy water containing bits of foam was pumped out. In the opinion of those watching, the water gave the appearance of having been there a long time, but it was not possible to measure the amount that had been absorbed by the foam.

With this excess water now removed, the freeboards were measured again. The freeboard aft on the port side was found to be 0.56m (1ft 10ins) and forward port 0.57m (1ft 10½ins).

The hull was examined in greater detail.

A wooden bung was fitted from the outboard side in the transom at the waterline.

There were two 7mm-diameter holes vertically above each other in the stem and would have accommodated the stainless steel towing eye/U-bolt **(see Figure 5)**. The position of this through-hull fitting was 254mm (10ins) below the top of the gunwale and clear of the waterline **(see Figure 3)**. There was no sign of the towing eye that should have been secured through these holes.

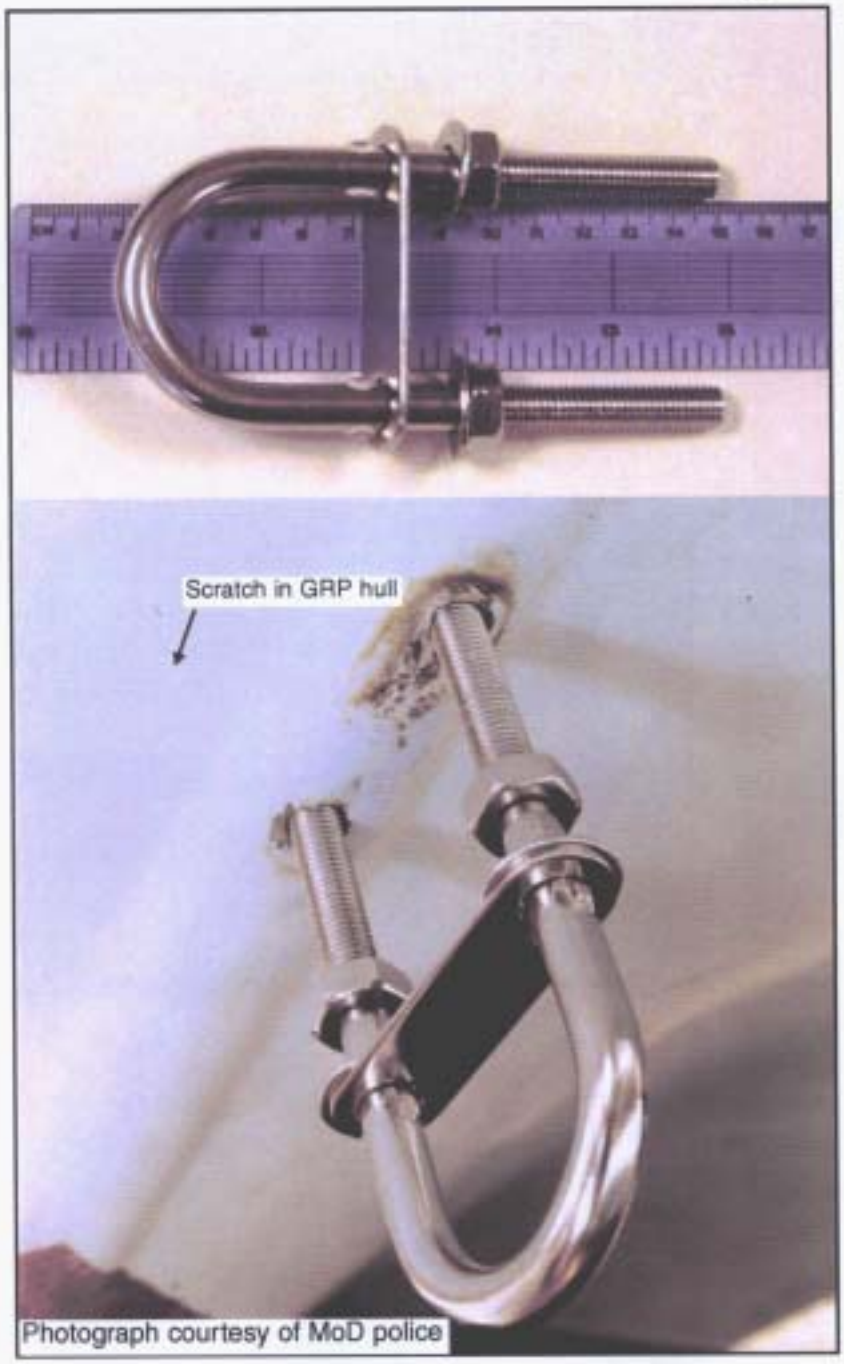
On completion of the in-water inspection, the boat was lifted on to the quay for examination ashore and future preservation. Two small drain holes were drilled in the hull aft, and two more buckets of water were drained out. This meant that a total of 79 litres (17.5 gallons) of water had been removed from the void. A large amount of water remained in the saturated foam inside the void space.

Further holes were cut in the fore deck to examine the space beneath it that included the buoyancy box. To test the possible flooding route to the void under the floor, a hose was placed over the holes in the stem and the tap was turned on. Moments later water began to pour out of the small hole drilled in the port side of the hull **(see Figure 6)**.

The angle of the outboard motor's cavitation plate to the underside of the boat was found to be at an angle of about [15°] **(see Figure 7)**.

Two months later, further holes were cut in the foredeck, giving access to the inner part of the stem. Two nuts and a washer were recovered from the foam at the base of the stem. They were in good condition.

Figure 5

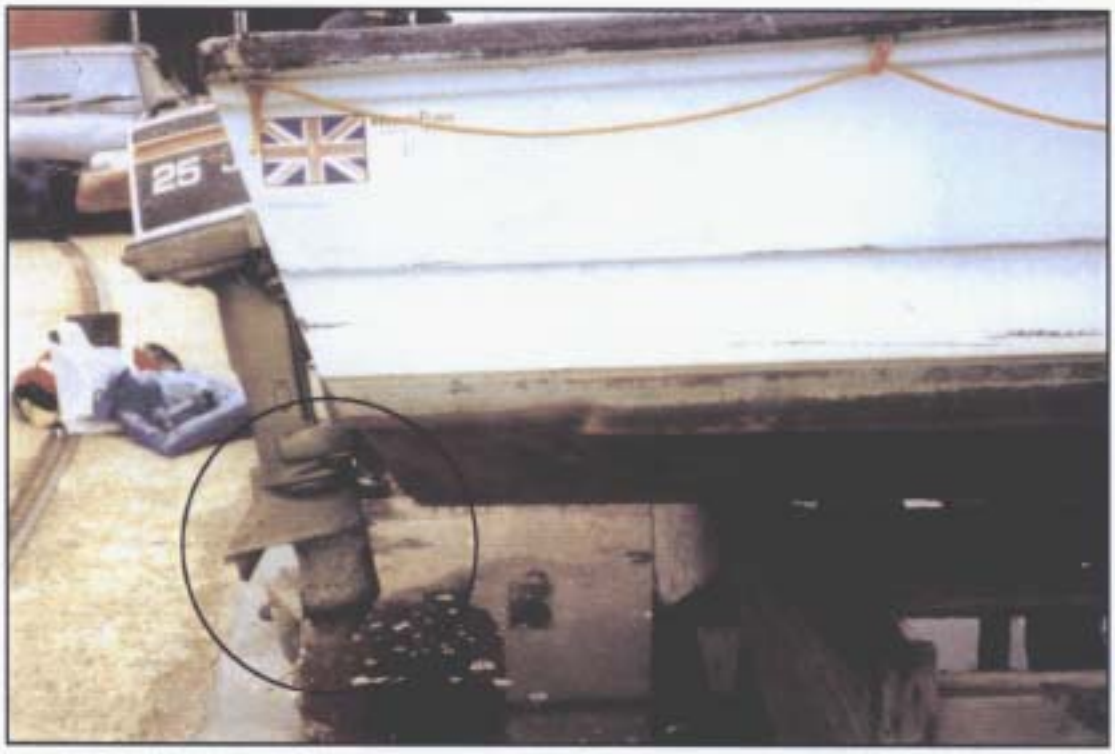


Typical U-bolts used as a towing eye

Figure 6

Boat lifted ashore - water draining from the void
through a hole which had been drilled in the hull aft

Figure 7



Boat ashore - aft end, note the angle of the cavitation plate on the
outboard motor is not in-line with underside of the boat
(The starboard lifeline can be seen)

1.10 FLOODING TEST

A simple test was carried out to estimate how long it would take water to pass through two holes similar to the holes in the stem. The test was repeated three times, and each time it took 3.25 minutes for 9 litres (2 gallons) of fresh water to pass through the holes.

SECTION 2 - ANALYSIS

The investigation set out to establish what caused the dory to capsize, why a young pupil died, and whether there was anything that occurred either before, or on, 16 September that contributed to this tragic accident.

The scope of the investigation and its findings is primarily concerned with establishing the causes. It does not embrace, except as so far as it is relevant, the question of school activity supervision. The sole purpose of the investigation was to make safety recommendations to prevent something similar happening again and to identify any lessons that could be learned.

2.1 ENVIRONMENTAL CONDITIONS (WIND, SEA STATE AND TIDE)

The weather on the day of the accident had been poor during the forenoon, and there was a moderate breeze blowing in the harbour at the time the decision was taken to cancel the sailing. Although accounts vary, there is a general consensus that the conditions in the lee of HMS *Bristol* were sufficiently calm to permit safe activities afloat. The wind force was probably force 2 to 3 with a slight sea running while in sheltered water. What is not in dispute is that the dory was rolling in the moments leading up to the capsize, although it was reported that when making way there was far less rolling than when stopped. A dory is, under normal conditions, a remarkably stable boat in calm conditions.

The investigation concludes that regardless of the actual wind strength and direction at the time of the accident, the sea conditions were such that at various times it resulted in water being shipped, and that the dory was rolling prior to the capsize. Some of the waves encountered were from the prevailing sea conditions, others were created by the craft's own wash.

When the reconstruction took place a day after the accident and in the same general location, the wind was just south of west, and recording at No 98 beacon about 20 knots. These wind speeds at the beacon were similar to those on 16 September, although the shelter offered by HMS *Bristol* was probably less.

In the opinion of MAIB inspectors, the conditions on 16 September were safe for a seaworthy, and properly handled, 4.27m (14ft) dory in the area selected.

2.2 CONDITION OF BOAT

The boat had been stored ashore the previous winter without any reported difficulty, and the engine had been serviced before the 1999 season commenced.

By all accounts the boat had operated successfully during the summer sailing season and the only reported difficulty was the outboard engine's tendency to stall when set at low power. She remained in the water throughout but was little used, if at all, during the summer holidays. She was found to be full of water in early September. This was removed, and there is no evidence of water being on board when the teacher and pupils embarked at about 1600 on 16 September.

When examined after the accident the boat was found to be in reasonable condition for her 15 years. The GRP hull and deck showed signs of wear, and there was some minor damage to the wooden gunwale. The only items found to be missing were a deck cleat, the stainless steel towing eye and the fuel tank. The fuel tank had been lost at the time the dory capsized.

One of the aims of the detailed inspection of the boat following the accident was to establish why the empty boat was listing, and to find out if there was any water trapped in the void between the inner and outer hulls. If so, the investigation wanted to establish whether this contributed to any lack of stability.

When holes were drilled in the hull a substantial quantity (17.5 gallons) of water drained from the void. This confirmed that water had been trapped, but did not indicate how it had got there, or for how long. Several possibilities were considered.

The first of these was that the void had been collecting water over a lengthy period and had saturated the foam. Alternatively, water had somehow entered the void on the day of the accident and before the capsize. A third possibility was that water had entered the void as a result of events after the accident and before the tests were conducted. And finally it was possible that all three explanations played a part. This is discussed further in more detail in section 2.4.

2.3 THE MISSING TOWING U-BOLT

Mr Clover, one of the normal operators of the boat, states that a week before the accident the towing eye on the stem was in place. He had moored the boat to the pontoon using the polypropylene painter that had been attached to the towing eye. It is therefore reasonable to assume it was still there on 16 September and, indeed, Mr Dove recollects having seen the painter onboard once he was underway. There is no evidence to show, or suggest, the U-bolt was missing when the pupils embarked.

How and when it became detached is not known. The two nuts and a washer recovered from inside the foam in the bow void were in good condition, and the nuts had clear threads. This indicated they had dropped from the U-bolt by means other than excessive force or corrosion.

The nuts had, almost certainly, worked loose with vibration, with the lower nut falling off first. There was a score mark on the hull in line with the lower hole, to indicate that the lower part of the bolt became free first, leaving an exposed hole. For the nuts to work free, the process would have taken a long time, perhaps a year, as there was about 45mm of clear thread on a typical U-bolt **(see Figure 5)**. To prevent the nuts working loose a nylon locknut or double nuts should have been fitted, but no evidence has been produced to show that this was done. On some GRP boats, this has been achieved by laminating over the nuts.

With the U-bolt missing, or just secured by one nut, the exposed holes or hole in the stem meant the hull was no longer watertight.

2.4 WATER ACCUMULATION

To determine why the water was present in the void, several lines of inquiry were pursued.

2.4.1 Long term accumulation in the void space

The first explanation to account for the presence of the water was that it had been accumulating in the void over a period of time, and had saturated the foam without being noticed. The boat's history was therefore examined.

There were no adverse reports by the dory's owners and operators on its handling characteristics before Boundary Oak School purchased it in 1997. It could plane with two or three people embarked when it reached a speed of about 15 knots. With five or six people on board it would not lift, but would operate well in the displacement mode and make way at about 5 or 6 knots.

While collecting evidence however, several people with recent operating experience said this boat was very heavy for her size, and with the reduced power of the old 18.6kW (25hp) outboard motor, it was not possible to make her plane. With just him on board, one of the regular operators found he could make it plane in smooth water. This contrasts with the performance reported by the previous owner. There is therefore circumstantial evidence that the boat was heavier in 1999 than when first used. One possible explanation is that over a period of time, probably over several years, water had been steadily accumulating in the void space to saturate the foam within it.

One of the discoveries made during the post-accident inspection was that this foam crumbled easily. This is symptomatic of long term degradation.

It is known that at least one of the regular users of the dory hadn't noticed anything untoward when using it during the 1999 sailing season. Had the foam become saturated, it suggests it might have done so over such a long time that

nobody noticed it. If this was in fact the case, only someone with an intimate knowledge of this particular craft might have noticed she was floating more deeply than designed. There was no specific waterline mark on the hull to indicate the correct afloat configuration, and there was very little information, if any, to draw attention to the possibility of foam saturation.

In the opinion of the MAIB, the balance of probability is that the foam inside the void was at least partially, and probably totally, saturated prior to being used on 16 September, and had been like that for a long time. There might have been free water in the void if one of the stem holes had been exposed, and not noticed.

2.4.2 Short term accumulation in the void space

It is known that water had accumulated in the void before the dory was laid up at the end of the 1997 sailing season. About two gallons was drained. The reason for the ingress of water was the damage to the hull.

When it was laid up a year later, a check for internal water was made, but none was detected. It can reasonably be assumed that no matter whether the foam was saturated or not, there was no additional water in the void when she was put back in the water at the start of the 1999 sailing season. But when the boat was examined after the accident, some 17.5 gallons of water was drained from it. The question was when, and how, it had managed to get there.

If water had been in the void before the dory was used on 16 September, nobody was aware of it. It would have been extremely difficult to detect, and only someone with intimate knowledge of the type of boat might have noticed she was lying deeper in the water than she should have been. The chances are that anyone looking at her on 16 September would have judged her trim and freeboard against what he or she would have normally seen. Although water might have been present there is no firm evidence to support this, except that the U-bolt would have taken a long time to work loose. However, the water that drained from the void after the accident gave the appearance of having been there for a long time. The balance of probability suggests that some surplus water at least was already present in the void.

Even if an assumption is made that the void was empty when the group embarked on 16 September, there had to be some explanation to account for so much water being present when the boat was inspected. There must have been a leak somewhere.

The detailed examination of the boat after the accident failed to reveal any damage or cracks in the GRP hull or floor, and there were no fittings in the floor through which water might pass. In the opinion of the MAIB, the floor was watertight, and any water that had accumulated inboard during the summer months could not have drained into the void.

The only possible way that water could enter the void was through the two small holes discovered on the stem where the missing U-bolt had been fastened.

The distance between the holes and the waterline when stationary was between three and six inches (76mm and 152mm) depending on the loading configuration **(see Figure 3)**. When underway on the day of the accident these holes would have been submerged by the bow wave and, when heading into either a sea or the dory's own wash, they would have been even further under water. It is known that four of the pupils were lying up in the bows during the early manoeuvres, and their collective weight would have tended to trim the boat down by the head. The freeboard forward would have been reduced further.

Because the U-bolt position was obscured from anyone's view, nobody on board would have been aware what was happening. It is impossible to gauge how much water actually entered the boat by this means before the accident. It is thought very unlikely that any water seeped in after the event. Although it cannot be proved when the flooding actually started, or at what rate, the MAIB is in no doubt that water did enter the void by this means in the time between getting underway and the capsize.

When the police carried out a reconstruction of the event after the accident, there was an instinctive feeling that the boat was unstable. This sensation had not, apparently, been noticed by those on board the dory when they set off on 16 September, but there is evidence to indicate that by the time the outboard engine stalled the second time, the accounts of rolling were very similar. The experience of the police when the boat adopted a large angle of heel was probably very similar to the conditions on board immediately before the accident.

It was confirmed later that the boat's loll was caused by the weight of water that had penetrated the void under the floor. When the dory was examined on 23 September, this void was nearly full of water, and the foam was completely saturated. This additional water added weight to the boat and reduced its freeboard. In turn this made her more vulnerable to taking water over the gunwale. Water trapped would, furthermore, have created a free surface and reduced the reserve of buoyancy. Both these effects made her more vulnerable to capsize. (Free surface effect can best be demonstrated with a tray of water. Once tilted, water rushes to the low side, further increasing the tilt or heel.) The free surface effect created by on-board liquids is a well-known danger and contributed to the capsize of the *Herald of Free Enterprise* and many other vessels.

The findings so far have been concerned about water entering the void. No consideration has yet been given to the second source of additional weight, water shipped over the side and into the boat.

2.4.3 Onboard accumulation of water

By all accounts spray came over the bows whenever a wave, from whatever source, was met in the early stages of the activity. Additional water also came over the gunwale when a large plastic sheet was recovered and later when a boy 'fell' overboard and was recovered safely.

A rough estimate on the quantity of water that was actually shipped, was based on one witness report that the water covered the teacher's shoe. Evidence indicates it was sloshing around inside the boat.

The conclusion drawn was that in the moments before the capsize, the extra water she was carrying, and its free surface effect, contributed to the dory being dangerously unstable. The teacher did not appear to have been aware of the very dangerous situation that had developed.

2.5 OUTBOARD MOTOR

Very few accidents are caused by a single event. In nearly every case they result from an accumulation of seemingly unconnected circumstances which, when grouped together, lead to whatever happened. The inquiry looked at other possible contributing factors to this tragedy. It focused attention on the outboard engine.

When the boat was purchased, the 1985 built outboard engine had not been used for some time. While in the ownership of Boundary Oak School it was regularly serviced but, according to Mr Clover who was familiar with the engine, it had a habit of stalling at low speeds when the throttle was closed.

It was therefore a relatively old engine and had a history of stalling despite regular servicing.

In its *Safety in Hazardous Pursuits* document, the Hampshire County Council says of petrol and two stroke outboard engines that they should normally be replaced every three years. The MAIB has no grounds to disagree with this sensible advice. The accident occurred just over three years after the outboard engine had been purchased second hand.

On the day of the accident the outboard engine failed twice, the first as the dory got underway. Despite the known problems with the engine, the activity was allowed to proceed although the safety boat was not available to stand by. It too had an engine that would not start.

When the boat and its engine were inspected after the accident, the outboard motor's cavitation plate was not, as is normal practice, set at an angle in line with the underside of the boat **(see Figure 7)**. The plate was angled downwards, which would tend to generate a bow-down attitude when under

power. This, in turn, would have produced a larger than normal bow wave. This phenomenon had not, however, been previously noted, but would have been an additional factor in explaining why water had entered the two small holes in the stem.

When the engine failed a second time it could not be restarted, and the decision was taken to resort to paddles. The safety boat was unavailable.

The only people available to use them were young inexperienced pupils. There is conflicting evidence on the weight distribution within the boat at this time, but all are agreed she was rolling. The movement of the paddlers, and perhaps among the pupils, would have been just sufficient to provide a very small tilting moment. Given the unstable nature of the boat at that time, it was all that was needed to capsize her.

It is therefore concluded that the failure of the outboard engine was a contributing factor in this accident. It was an old engine with a history of unreliability. It had already failed at the start of the fateful trip, and although it was known the safety boat was unavailable in the event of anything going wrong, the decision was taken to proceed on the afternoon of 16 September.

The petrol container on board the dory should have been secured to the floor, but was not. As a result, it was dislodged when the boat capsized, and its contents spilled out.

It was also noticed that this particular engine did not have a kill switch fitted. Although its absence had nothing to do with the cause of the accident, it contributed to the impression that the standards accepted by Boundary Oak School in its boating activity were not as good as they should have been.

2.6 THE CAPSIZE

With an overloaded boat that was rolling, it isn't clear whether the teacher was aware of how dangerous a situation he was in. He would have been aware that water was sloshing around on the floor, but would not have known about the water in the void. Given his overall experience he should have been aware that the boat was not, however, handling normally.

When the engine failed, and he could not restart it, he took the decision to start paddling. It is not known whether he had any doubts about the boat's stability, but probably felt that paddling was the only option open to him. Except by using hand signals he had no means of contacting those ashore to alert them to his predicament. It is not known what instructions he gave to the children about movement, but it is known that the distribution of the pupils on board was not uniform, having told four of them to move over to starboard to paddle. Had they been evenly distributed the boat would have been safer.

Shortly after the paddling started the dory finally lost what residual stability it had, and capsized.

Everyone was pitched into the water. The teacher and eight of the nine pupils found themselves clear of the upturned boat but the ninth child, Elizabeth Bee who had been sitting in the centre of the middle seat, was trapped when it toppled over. Nobody noticed.

It is impossible to speculate about what happened, but it can be assumed that the upturned hull pushed her under water. At the same time the buoyancy from her lifejacket would have made it very difficult for her to swim out from under the boat or into a void, where air might have been present. The essential requirement at that stage was for someone to recognise that one pupil was missing. Nobody did, and it appears that no thought was given to the possibility that one or more pupils might have been trapped beneath the inverted craft which, by now, would have been even more deeply submerged with children lying on top of it.

Shortly after the capsize the teacher, Mr Dove, made his way to the aft end of the boat, and held on. He was not a strong swimmer, and because his lifejacket failed to inflate automatically, he was initially preoccupied with inflating it by mouth. The reasons for this failure are not known. He asked if everyone was safe, and hearing calls from the pupils assumed they were all right. At no stage did he conduct a roll call or head count.

Research into such incidents shows that when no previous thought has been given to how a situation such as a capsize might be handled, the chances of the correct actions being taken are much reduced. It is also known that when suddenly thrown into cold water, many people's ability to think coherently is adversely affected. There is no evidence to indicate what Mr Dove was thinking in the immediate aftermath of the capsize, but his preoccupation with blowing up his lifejacket, and the failure to have a contingency plan for such an unexpected event, contributed to the outcome. According to more than one witness he was also in a state of shock. It is well known that in any emergency, people tend to fall back on their training. When such training has not been undertaken, many people will revert to actions that, with the benefit of hindsight, were probably not very sensible. Mr Dove was not trained to the standards expected by the AALA.

2.7 THE RESCUE

Although the sea temperature was about 18°C and some of the pupils were wearing wet suits, a basic requirement in such situations is to recover people from the water as soon as possible. The rate of loss of body heat in children is much faster than that of adults, and speed of recovery is essential.

The survivors were able to hang onto the lifelines fitted to the boat or climb onto

the upturned hull. The means of support provided by the inverted boat and its fitted lifelines served three purposes: they provided a means of additional buoyancy, it meant that body heat could be preserved by not having to move around, and it provided a focus for a rescue attempt. The fitting of lifelines to the dory played a crucial part in ensuring there were no additional casualties.

Raising the alarm was by manual means: by waving, shouting or by using the whistles attached to the lifejackets. Shouting and whistles have limited scope for attracting attention in conditions other than when calm, but were in this instance heard by those positioned down wind at the sailing centre. Waving is the only other alternative, but is highly dependent on someone looking in the right direction.

Fortunately the crew of *Pike II* did see what had happened, and went to provide what assistance they could without delay. They took approximately four minutes to arrive at the scene of the accident, and then experienced some difficulty making fast to the boat. It took about another five minutes to recover the four or five pupils from the upturned boat, and those in the water.

During the rescue, *Pike II*'s crew were totally unaware that there should have been one adult and nine pupils in the water. The teacher did not convey this vital information. When it was discovered that one child was missing, the forward end of the boat was lifted, and the 9 year old was seen and recovered from a position about mid-length along the boat. There was also a strong smell of petrol.

The crew of *Pike II* carried out this prompt and efficient rescue in about 10 - 15 minutes.

This accident occurred sufficiently close to others ashore to enable them to observe what had happened fairly soon after the event. In other circumstances the survivors may not have been so lucky, and the capsize might have occurred without anyone being aware of it. Alerting people to problems is a fundamental component of safety afloat. In this instance the teacher had virtually no means of raising the alarm. While flares, a VHF radio or even a mobile phone would have been useful had there been a problem while still floating the right way up, the sudden capsize would almost certainly have prevented any of these being used. A watertight VHF radio attached in some way to the teacher might have provided a suitable means to alert attention.

It cannot be proved that such a radio would have made any difference to the outcome of this particular incident, but it might have prompted two actions that could have helped. On the assumption that any transmission would have been made on Channel 16, the coastguard (or other recipient) would have been in a position to alert the emergency services far more rapidly than occurred on this occasion. Secondly, the very first amplifying information likely to have been sought by the coastguard would have been a check to establish how many

people were on board. They would have followed this up by asking whether everyone had been accounted for. This could have been the trigger for a positive headcount to be made.

The crucial, and missing, element in this entire affair was the failure to establish if everyone had survived the capsize. For someone with even basic training in this or similar small craft, it is normally comparatively straightforward to locate and recover someone from underneath an upturned hull of this type. Had this been done, and one person was found to be missing, alerting the emergency services as soon as possible would have been essential.

In the event, there was an unquantifiable delay in contacting the emergency services because it was not possible to make a call direct to an outside line from the sailing centre. It is not known what the time delay was, or whether it had any influence on the final outcome, but the authorities at Whale Island are recommended to review their emergency callout procedures to see what steps can be taken to ensure that delays of any sort are eliminated.

2.8 MARINE ACTIVITIES

The decision to provide sailing opportunities as an extra curricular activity at a school lies with the school authorities. It is not part of the MAIB's task to comment on such decisions. Provided the craft and the equipment used are sound, that those in charge are properly qualified and trained, that proper safety precautions have been taken and that due account is taken of the weather and sea conditions, such activities are however, perfectly safe. They do much to encourage a sense of responsibility and develop confidence.

Boundary Oak School governors and staff had taken the decision to include sailing as an outdoor activity. Suitable precautions had been taken and appropriate risk assessments had been made. The school owned a safety RIB and the decision to purchase a second-hand dory was sound. Dories have a reputation for robustness, are stable, very versatile and can be handled by one person with ease. There is nothing fundamentally wrong with the Wilson Flyer 14.

Any second-hand craft presents a potential risk to a new owner. There may be hidden flaws or latent defects that only a qualified surveyor can detect. At the time of this accident, the dory involved had been owned by Boundary Oak School for just over three years and, so far as can be established, was never professionally surveyed either before it was purchased or at any time thereafter. There is no means of establishing its true condition when it was purchased but, by all accounts, it had served the school well. It is however very strongly recommended that any second-hand craft being purchased by a school for use in embarking children, is professionally surveyed before it is ever used for that purpose. If purchased and any safety defects are found, these must be rectified

before it is put into service.

For reasons that cannot be satisfactorily explained, the U-bolt towing eye became detached. In the opinion of the MAIB it had been working loose for some time, but nobody had noticed it. Any check of a boat, and especially one being used to take school children afloat, should be meticulously checked at regular intervals. Any defect, no matter how trivial, can have potentially serious consequences. A well maintained boat is a safe boat, and any defect should be made good as soon as possible, and preferably before being used again.

Similar precautions should be taken with a second-hand engine. Provided they are regularly used, meticulously maintained, regularly serviced and laid up sensibly, such engines can give many years of reliable service. If any of these ingredients is missing, reliability becomes suspect. Any engine being used by a school must be reliable, and the advice contained in the Hampshire County Council's document *Safety in Hazardous Pursuits* about replacing such engines at intervals of three years, is sensible. Boundary Oak was unaware of this advice, and did not come to a similar conclusion. An old engine, with a history of stalling, was in use on the day of the accident and its failure to restart for a second time was a contributory cause to what had happened. The MAIB supports the recommendation that outboard engines used in school activities should normally be replaced every three years.

A risk assessment of sailing activities had been undertaken. On 16 September, all normal precautions had been taken and due consideration had been given to the weather conditions. There were two adults and a student in charge of 18 children, and all were dressed suitably. Lifejackets were worn. The only variation to established practice was that two other adults who normally helped were absent that day.

The decision to abandon sailing on 16 September was responsible and sensible.

Those in charge were then faced with deciding on an alternative activity. There was a perfectly understandable reluctance to avoid disappointing the pupils. This very human predicament resulted in the decision to take nine of them out in the dory with a single teacher in charge. There was nothing wrong with contemplating this as an option, but there is no evidence whatsoever that any of those in charge carried out a risk assessment of what was being proposed other than to make sure that those embarking were properly dressed, were wearing lifejackets and were briefed. To many this would be seen as being sufficient. It was, quite demonstrably, not.

The most fundamental safety checks to be made in any craft, no matter what the size, are to ensure that the skipper is competent, that the alarm can be raised if anything goes wrong, and to ensure that everyone on board has the means to survive. To an extent this criteria was met, but the means of

communicating with the shore was inadequate.

Any risk assessment should have addressed such matters as the provision of a safety boat, a suitable means of alternative propulsion and the ability of those embarked to handle the unforeseen. In this the competence of the person in charge is critical.

It is not up to the MAIB to comment on the degree of supervision to be provided for school activities afloat but, once again, the Branch agrees with the advice contained in the *Safety in Hazardous Pursuits* handbook. '*When passengers under the age of eighteen are carried, in addition to the skipper, there will be another adult on board who will be responsible for the children's behaviour and in particular the compliance with safety rules and emergency action.*'

It is not known precisely what checks of the boat were made before anyone embarked. Nobody noticed if there was anything wrong with the U-bolt in the stem. Had the dory sailed without the U-bolt in place, the hull would not have been watertight and the boat would have been unsafe. There was no evidence to indicate this was the case; but when the boat was examined after the accident, it was missing. In the opinion of the MAIB, it almost certainly came off soon after getting underway as a result of it having been working loose for a long time beforehand. There was sufficient time from the moment of slipping, to the actual capsize, for water to enter the void through the two holes provided they were submerged.

The sole teacher on board was 64 years old and a qualified yacht master. Although he had acquired some experience handling the dory, he was not as familiar with it as were others. Any risk assessment carried out that afternoon should have considered the number of people that could be safely embarked and the sensible staff/pupil ratio needed to handle the planned activity and any emergency that might arise.

Once underway and before the accident happened, one of the pupils "fell" overboard. Various people providing evidence to the MAIB have inferred that such an event was a normal reflection of high spirits by the young, and therefore acceptable. The chief inspector of marine accidents takes a different view. There is a time and place for such antics; trips in a dory with other children present and a single teacher in charge is not one of them. Safety afloat demands an acceptance of discipline, which includes children behaving sensibly and remaining on board. An event that might have started 'as a bit of fun' can very often finish in tragedy. This event alone demonstrates that supervision of the children onboard was at best lax and, at worst, non-existent. By normal standards of conduct afloat it was unseamanlike.

This tragic accident has highlighted various failings in equipment, maintenance and organisation. Had the school been aware of the advice contained in the Hampshire County Council's handbook and acted upon it, the chances of this

accident ever happening would have been much reduced. The MAIB cannot but help reflect on what appears to be a very unfortunate lack of communication between the state and independent education sectors in the sharing of very sound advice. It is not known whether this is widespread, and no recommendation is made to correct this arrangement, but it is hoped that authorities throughout the country will learn the obvious lessons from this sad affair and take whatever measures are needed to ensure it can never happen again. There should be no barriers when it comes to the safety of young children.

2.9 WEIGHT AND DISTRIBUTION IN BOAT

Following the accident, various calculations were made to assess whether the weights being carried on 16 September exceeded the dory's maximum operating weight.

			kg
Outboard motor - Johnson 25hp		=	30
Fuel tank 2 gallons (9 litres)		=	9
Pupils - nine at 40 kg		=	360
Teacher		=	75
	Subtotal	=	474
Water recovered from void space 7 buckets x 2½ gallons (11.3 litres)		=	79
	Subtotal	=	553
Water on the floor of the boat		=	260
Estimated total weight on board	**Total**	=	**813kg**

The known load on board at the time of departure with nine pupils (360kg) and a teacher (75kg) was approximately 474kg. This is approximately equal to six adults, and, based on previous operations, is considered within the boat's carrying capability. It was understood the boat usually operated safely with two adults and six pupils on board, or about 45kg less than on this occasion.

There is no indication to suggest the boat was knowingly operated in an overloaded condition.

However, when the weight of water removed from the void is added to that of

the occupants, the load rises to at least 553kg, which is equivalent to the weight of about seven men. In this condition the boat becomes overloaded. It cannot be proved that all the water drained from the void was actually present before the accident, but the MAIB concludes that most of it was, because the bow was out of the water.

If the foam had absorbed just 20% of its volume, the weight would have increased by 74kg. The combined weight of this, the water drained from the void, and the water on the floor, is over 400kg. With this very large quantity of water on board, free to move in the void and on the floor, the boat was unstable.

The calculations confirm that the boat was in a grossly overloaded and dangerous condition immediately before the accident. It only required a very small tilting moment to initiate the capsize.

2.10 LOADING TESTS

The loading test on the boat with four policemen (381kg) on the port side in calm water, showed the boat's gunwale was in the water. In this condition the boat was at a dangerous angle of heel, as illustrated by the way the officers are holding on to the pontoon **(see Figure 3)**. This test might have been similar to the condition of the boat before she capsized, but without the extra water on the floor.

It is not possible to make an assessment of the amount of water that would have entered the void after the capsize, but there is no doubt in the mind of the MAIB that most of the water was present beforehand. The tests were a reasonable representation of the condition prevailing at the time she capsized, and can be relied upon. The weight of water on the floor would have made the situation much worse with the total weight and the free surface effect making it even less safe. The dangerously large angle of heel that resulted indicated that the boat had poor stability, and that a further increase or movement of weight during the reconstruction could have capsized it.

This would have been very similar to the conditions prevailing as the pupils started to paddle. The precise force that caused the boat to capsize cannot be determined, but the dory was so sensitive that it needed only the slightest shift in weight to initiate it.

In another test, the boat was taken to sea with one person of 105kg on the port side. The angle of heel was still unsafe, with a strong possibility of the boat capsizing **(see Figure 4)**.

In neither test was water present on the floor.

2.11 FLOODING TIME

It took approximately 28.5 minutes to flood the void with 79 litres of water **(section 1.10)** through the holes in the stem. This is roughly the length of the trip on the day of the accident. However, if the water absorbed by the foam is taken to be just 20% of its volume, this amounts to a further 74 litres of water, and this water would have taken another 26.5 minutes to come on board through the holes in the stem. As the flooding conditions cannot be accurately modelled, because there are so many unknowns, the above times are only estimates. Nevertheless there is an indication that there was water in the void, up to about 74 litres, before the start of the trip on 16 September 1999.

2.12 FREEBOARD

After 59kg of water had been removed from the void under the floor, the static freeboards were re-measured, and increases of 50mm aft and 152mm forward were recorded. The freeboard at the stem below the holes for the U-bolt increased to about 230mm in the unloaded condition. The angle of loll also reduced.

A further 20kg of water was drained from the void when the boat was on the quay. The hull had holes drilled in it at this stage, and hence the boat could not be put back into the water, but a further increase in the freeboard would have been recorded had this been possible. This is estimated as a third of the earlier increase, resulting in total freeboard increases of: aft 13% from 510mm to 580mm, and forward 50%, from 400mm to about 600mm.

A 50% increase of forward freeboard when the 79kg of water was removed is significant, and critical in a boat of her size. Had the water from the saturated foam been removed, the freeboard would have increased further and resulted in a safer boat.

As the boat was loaded on the day of the accident, the freeboard was such that the holes for the U-bolt might have been under water, and allowing water into the void when the boat was making way. The weight of the pupils leaning over the foredeck reduced the freeboard and increased the bow down attitude caused by the setting on the outboard motor. All these factors contributed to producing a very small forward freeboard. A witness working on the pontoon who saw the dory shortly before the accident said the boat was running level, but all the other evidence supports the bow down attitude version of events and a craft that was rolling heavily.

It is not possible to estimate the freeboard with an extra weight of 260kg of water on the floor, but in that condition the boat would probably have been lost.

2.13 OTHER ACCIDENTS INVOLVING DORY TYPE BOATS

As part of the investigation, steps were taken to find out whether there had been any similar accidents involving dories. There had:

- *Hunkey Dory* - capsized in 1989 - one life lost
- *Cigi* - capsized in 1996 - two lives lost
- *Morwennol* - capsized in 1998 - one life lost
- *Flying Fisher* - capsized - crewman was rescued
- *Fleet Wing* - capsized in 1999
- *Fisher Lad* - capsized in 1999
- *Unnamed boat on Loch Awe* - capsized in 1999 - three lives lost.

As a result of all these accidents, including this one, the MAIB published a *Safety Bulletin* in November 1999. The aim was to inform the boat building, fishing and recreational industries of the potential dangers of water being trapped in the void space on board dories. Safety recommendations were made **(Annex A)**.

The information contained in this Safety Bulletin would not have been known to anyone involved in arranging the boating activity on the afternoon of 16 September 1999.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

1. The boat capsized at about 1645 on 16 September 1999 and resulted in the loss of one life. [1.2]

2. The conditions on 16 September were safe for a seaworthy, and properly handled 4.27m (14ft) dory. [2.1]

3. No safety assessment had been carried out for the boating activities carried out on 16 September. [2.2, 2.3]

4. Sound advice for the conduct of activities afloat has been produced by the Hampshire Education Authority, but staff at Boundary Oak School, Fareham, were not, apparently, aware of it. [2.8]

5. Given its age, the dory was in a reasonable condition, but two small holes in the stem allowed water to enter the void. It is not known when the U-bolt became detached. [2.2 and 2.3]

6. The U-bolt had probably vibrated free over a long time, but this had not been detected by any of the regular users. [2.3]

7. When the boat was inspected before leaving for the trip, there was no evidence to indicate the U-bolt was missing or loose. [2.6]

8. With a loose or missing U-bolt, and given the exposed hole or holes in the stem, the hull was not watertight. [2.3]

9. Foam within the void space had been saturated, or near saturated, over a long time. [2.4.1]

10. Once underway, water would flood into the void space through the holes exposed at the stem. [2.4.2]

11. Once underway on 16 September, water began accumulating inside the boat through spray, being shipped over the gunwale, and from the activities of those on board. [2.4.3]

12. With water both in the void and on the floor, and with free surface effect and the accumulated weight of those onboard, the dory was unstable. [2.2]

13. The 18.6kW (25hp) outboard motor stalled twice during the trip. [2.3]

14. A kill switch cord was not fitted to the 18.6kW (25hp) outboard motor, and the fuel tank was not secured. [2.5]

15. With the boat in a grossly overloaded and unstable condition immediately before the capsize, it only required a very small tilting moment to initiate the process. [2,8]

16. When someone sat on the port gunwale during a test after the accident, the boat assumed an unsafe angle of heel, making capsize very likely. [1.9.2]

17. When 79kg of water was removed from the void space, a 50% increase in forward freeboard resulted. [2.11]

18. The pupils and teacher were all wearing lifejackets. [2.8]

19. The teacher was an average swimmer, but was not trained to the standard expected by the AALA. [2.6]

20. The dory had not been professionally surveyed while owned by Boundary Oak School. [2.8]

21. The lifelines fitted to the boat provided the survivors with handholds. [2.7]

22. There was no VHF radio or mobile phone on board with which the teacher in charge could communicate with the shore. [2.7]

23. No head count of the survivors was made after the capsize. [1.3]

24. The crew of *Pike II* responded promptly and efficiently in rescuing the survivors. [2.7]

25. MAIB published a Safety Bulletin 4/99 in November 1999, highlighting the dangers of water trapped in the void spaces of dories. [2.13]

26. The cause of death for the one victim was drowning. [1.3]

3.2 CAUSES

Immediate cause of the accident

1. The dory capsized because she was unstable. This was caused by an excess of water inside the boat and in the void beneath the floor, and by its free and uncontrolled movement when underway.

Contributory factors

2. The decision to take nine children out in a dory as an alternative to sailing, without carrying out an appropriate risk assessment.

3. The decision to embark nine children with only one adult on board to supervise them.

4. The failure to notice the state of the U-bolt on the stem.

5. The hull of the boat was not watertight because of a loose or missing through-hull fitting U-bolt in the stem, which allowed water to accumulate in the void undetected.

6. The undetected accumulation of water within the void had saturated the foam over a long period.

7. The steady accumulation of water inside the boat, resulting from spray coming over the gunwale during the recovery activities.

8. The failure of the outboard engine, and the inability to restart it.

9. Insufficient pupil supervision allowed them to move about on board.

SECTION 4 - RECOMMENDATIONS

Boundary Oak School's headmaster and governors are recommended to:

1. Consider introducing the regulations and guidance notes set out by Hampshire County Council for *Safety in Hazardous Pursuits* before undertaking any further marine activities. [3.1.4]

2. Ensure that any future second-hand craft being considered for use to embark children is professionally surveyed. [3.1.20]

3. Ensure that any member of staff put in charge of children afloat is trained to the standards expected by the AALA before taking on that responsibility. [3.1.19]

The Royal Yachting Association and the **Adventure Activities Licensing Authority** are jointly recommended to draw the attention of schools and others involved in youth projects afloat to:

4. The benefits of fitting lifelines to any small craft used as rescue or support boats. [3.1.21]

5. The importance of anyone in charge of children having a reliable means of communicating ashore in the event of an emergency arising. [3.1.22]

SECTION 5 - GENERAL OBSERVATION

The fundamental objective of the Marine Accident Investigation Branch is to investigate accidents with a view to preventing them happening again. This does not necessarily result in recommendations being made, as very often the lessons to be learned are just as relevant. In this instance the Chief Inspector could not help but reflect that some very sound advice for ensuring the safety of children afloat had been produced by the Hampshire Education Authority but, for reasons that have not been looked into, were not known to Boundary Oak School. It is to be hoped that throughout the country, those responsible for arranging outdoor activities will do everything they possibly can to share sound practices, and to ensure that good information is exchanged and made available to all concerned.

The Chief Inspector of Marine Accidents strongly upholds the right of school governors to make decisions on whether sailing and boating activities should feature as a school activity. He is in no doubt, however, that provided sensible precautions are taken, and the equipment used is sound, it is among the most rewarding, enjoyable and challenging activities that children can participate in. He very much hopes that this very tragic accident will not deter schools from including such activities in the future.

The Head of Inspection Services of the AALA supports the Chief Inspector's viewpoints.

Marine Accident Investigation Branch

March 2001

Safety Bulletin

DETR
ENVIRONMENT TRANSPORT REGIONS

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

MAIB SAFETY BULLETIN 4/99

Unstable Dories

Flooded Void Space

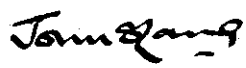
Issued November 1999

MAIB SAFETY BULLETIN 4/99

This document, containing Safety Recommendations, has been produced for marine safety purposes only on the basis of information available to date.

The Merchant Shipping (Accident Reporting and Investigation) Regulations 1999 provide for the Chief Inspector of Marine Accidents to make recommendations at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so.

The Marine Accident Investigation Branch (MAIB) has carried out a number of investigations into the capsize and sinking of several dory-type boats. Some of these craft were later recovered but, when refloated, did so with a noticeable list. It was discovered that this was caused by water trapped in the void space between the deck and main hull. The loss of both freeboard and buoyancy, and the free surface effect were the principle factors in why the dories capsized. In one accident, three of the six people on board lost their lives. This incident is described to demonstrate the nature of the problem.



J S Lang
Rear Admiral
Chief Inspector of Marine Accidents

Press Enquiries: 0171 890 4691 / 3387; out of hours: 0171 873 1985
Public Enquiries: 0171 271 5000
INTERNET ADDRESS FOR DETR PRESS NOTICES:
http://www.coi.gov.uk/coi/depts/GTE/GTE.html

SAFETY RECOMMENDATIONS

Background

A privately owned sea angling dory capsized and sank on Loch Awe near Ardanaiseig, Scotland, with the loss of three lives on 29 May 1999. She was returning to a camp site in bad weather when she encountered some large waves and shipped water over the bow. Shortly afterwards she lost stability and capsized. She briefly remained upside down on the surface before sinking by the stern. Although only about 100 metre from the shore, three of the six anglers onboard lost their lives. None were wearing lifejackets.

Inspection of the recovered boat showed that water had, without anyone being aware of it, penetrated the void between the main hull and the deck. This had two serious effects: the boat sat lower in the water making her more prone to swamping; and the sloshing of the trapped water reduced its stability making it more vulnerable to capsize. It was seen to be low in the water just before the accident, confirming she was carrying a greater weight than could be attributed to those embarked. This additional weight was found to be water in the void space and, because it is enclosed, the crew were unaware of the water's presence. It had accumulated over a period of time and had progressively reduced the freeboard. Nobody had noticed this on 29 May.

Water can enter the void if the hull becomes damaged or if hull/deck fittings are removed. Some voids are foam injected, but this is not a guarantee of safety as some foam absorbs water. In some cases voids are only partially filled with foam, leaving a space on top of the foam where water can accumulate.

Over the last five years, six people have died in a number of serious accidents involving older dory-type boats that are commonly used for commercial fishing, sea angling, and pleasure. Some of these craft were recovered and when righted, floated with a list. In each case it was found the list was caused by water trapped in the void between the deck and main hull.

A well constructed dory which is properly maintained and undamaged, with full buoyancy both in the void space and up the sides, will still stay afloat in the upright position and be able to support her crew when swamped.

A dory with water in the void space is potentially unstable.

Safety Recommendations

Owners and operators of dory-type boats are recommended to:

1. Check for any unexplained changes in freeboard or heeling angles, as these might be the result of water entering the void between the inner and outer hull.

2. Check carefully for any damage to hull and decks.

3. Check for water leaking from the void space when the dory is beached, slipped or put on a trailer, and at the same time listen for water sloshing in the void space when rocking the dory.

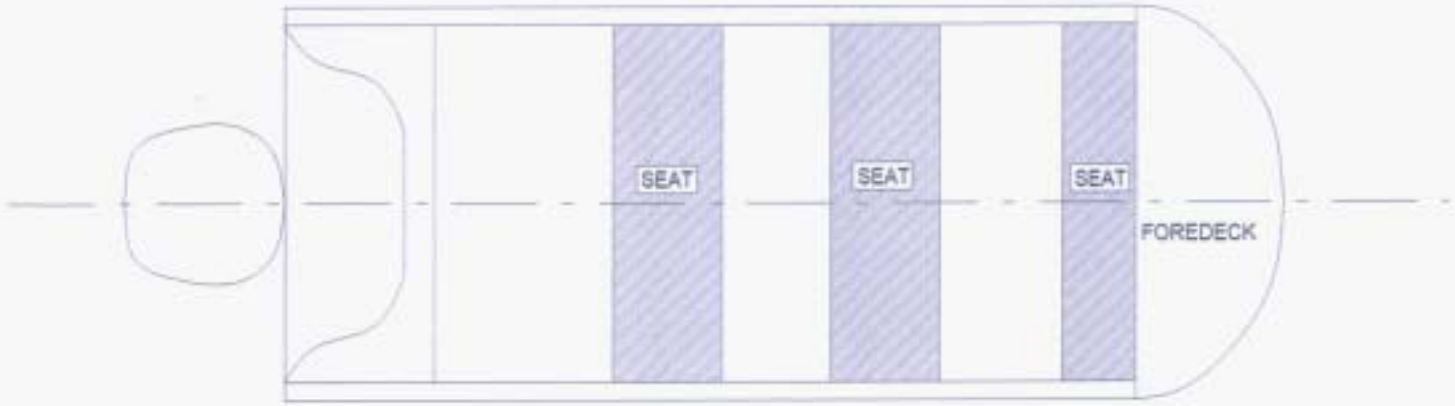
4. Ensure that the boat is properly maintained.

5. If there is reason to believe that water is present in the void space, seek expert advice before attempting to use the craft.

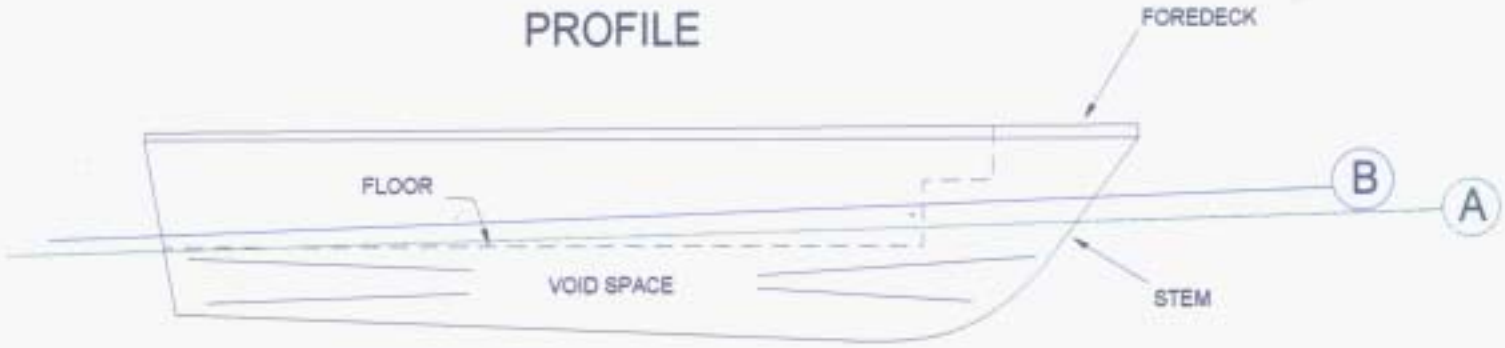
6. Ensure lifejackets are worn by everyone on board in bad weather. The MAIB strongly recommends that they are worn at other times as well. They should **ALWAYS** be carried.

DORY TYPE BOAT - WILSON FLYER 14

PLAN



PROFILE



WATERLINE (A) IS STATIC UNLOADED

WATERLINE (B) IS STATIC WITH LOADED

Annex B