Report of the investigation of
the flooding and
foundering of

mfv *Sharona (PD185)*

80 miles north-east of Peterhead
on 3 August 1999

Marine Accident Investigation Branch
First Floor, Carlton House
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Report No 25/2000

Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

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GLOSSARY OF ABBREVIATIONS

CCTV	Close Circuit Television
CO_2	Carbon Dioxide
EPIRB	Emergency Position Indicating Radio Beacon
FRC	Fast Rescue Craft
kW	kilowatt
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
UK	United Kingdom
UTC	Universal Co-ordinated Time
VHF	Very high frequency

SYNOPSIS

On 3 August 1999 the Marine Accident Investigation Branch (MAIB) was notified of the flooding and foundering of the trawler *Sharona* 80 miles north-east of Peterhead. An investigation conducted by an MAIB inspector began that day.

Sharona had been fishing 80 miles north-east of Peterhead when the crew discovered flooding in the engine room.

A sequence of events on board led to further flooding of the engine room until eventually all electrical power was lost. The skipper then requested assistance from the coastguard in the form of a tow.

While the vessel was under tow, the flooding continued, eventually leading to her loss. There were no injuries and all the crew were transferred to the towing vessel, which arrived in Aberdeen the following day.

The cause of the accident was uncontrolled flooding to the engine room through a fractured copper main engine cooling water outlet pipe.

Contributory causes were: The decision to haul the fishing gear, which resulted in a failure to stop the main engine immediately and thereby, prevent further flooding; the failure of the engine room bilge alarm; and the failure to detect defective pipework.

The investigation has resulted in a recommendation to the Maritime and Coastguard Agency (MCA) to consider updating its advice given in *Merchant Shipping Notice M631*, and to include a reference on the work-hardening of copper piping.

VESSEL AND ACCIDENT PARTICULARS

Name	:	*Sharona*
Type	:	Trawler (Twin Rig)
Port of Registry	:	Peterhead
Fishing Number	:	PD 185
Built	:	1974 Buckie
Construction	:	Wood
Owner	:	Mr J Strachan Stroma, Mile End, Peterhead, AB42 2GG
Gross Tonnage	:	45.25
Length Overall	:	19.72m
Length Registered	:	18.75m
Breadth	:	6.64m
Depth	:	2.29m
Propulsion	:	Kelvin Diesel (336kW) Single Screw Shaft
Crew	:	Five
Position of Accident	:	58°10.5'N 000°22.2'W
Date and Time	:	3 August 1999 2313 (UTC)
Injuries	:	None
Damage	:	Total Loss

Figure 1 - *Sharona*

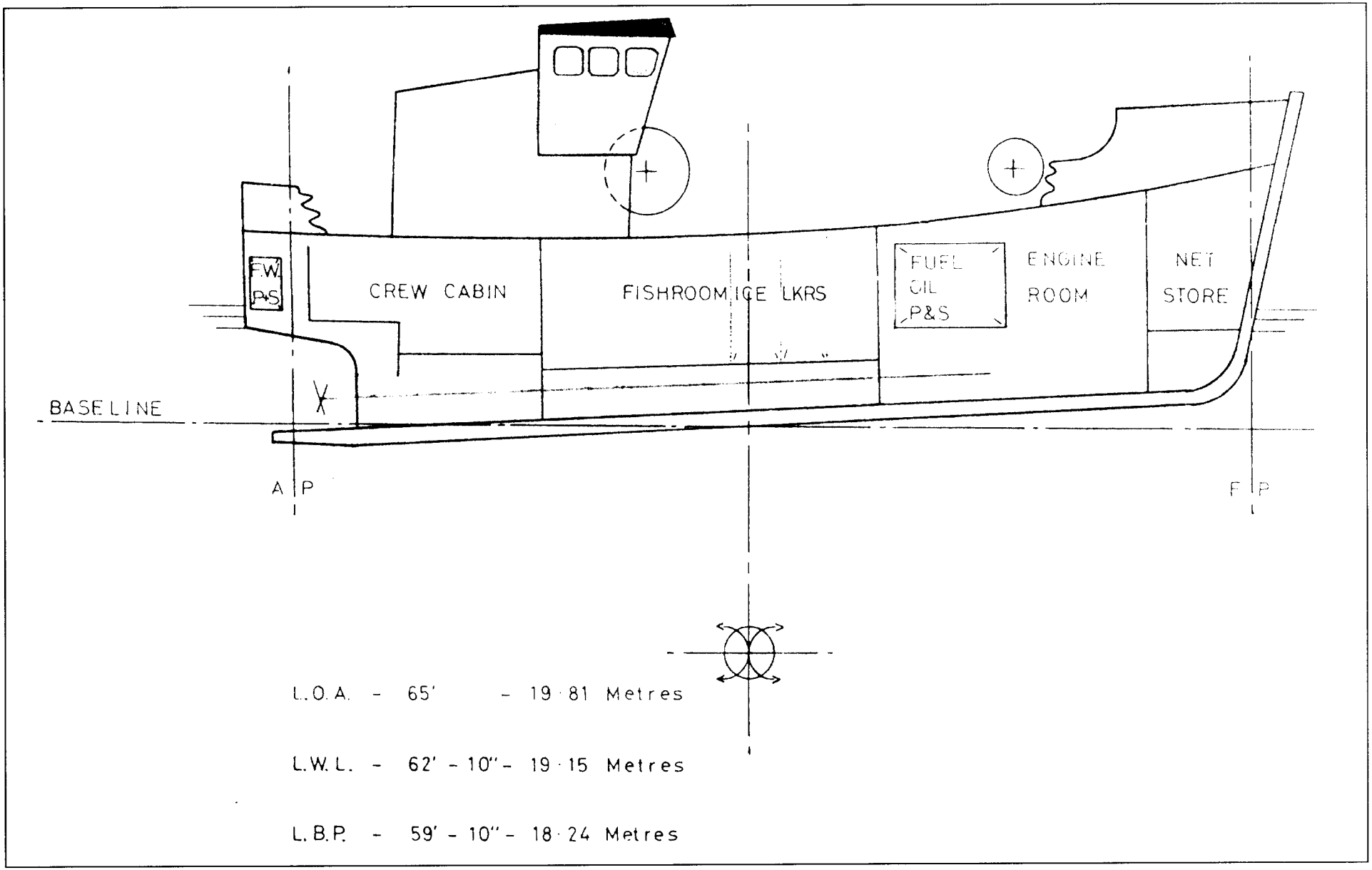

Figure 2 - General arrangement

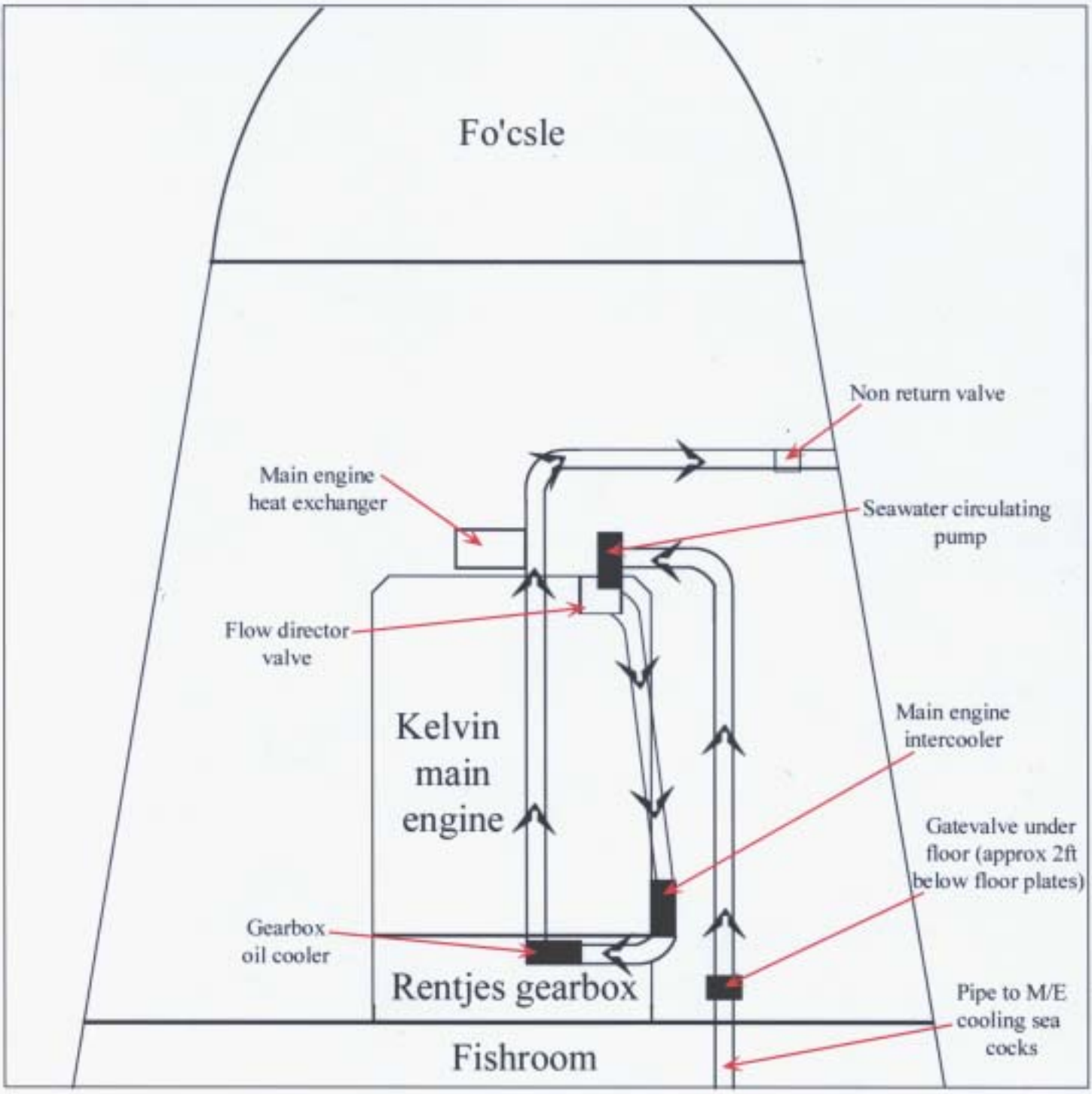

Figure 3 - Main engine and gearbox cooling system

SECTION 1 - FACTUAL INFORMATION

1.1 Background

Sharona was purchased by her owner in 1985. Since then, she was engaged in single and twin rig bottom trawling, working mainly from Mallaig on the west coast of Scotland, and periodically from her home port of Peterhead.

The vessel normally spent four to five days at sea followed by a period in harbour where her catch was landed and she was re-supplied for her next voyage.

1.2 The crew

Sharona carried a crew of five: the skipper, a mate and three deckhands. The skipper and the mate were the sons of the owner.

Under *The Fishing Vessel (Certification of Deck Officers and Engineer Officers) Regulations 1984* the vessel was required to carry at least one holder of a Deck Officer Certificate of Competency (Fishing Vessel) Class 2.

The skipper was the holder of a Deck Officer Certificate of Competency (Fishing Vessel) Class 2. He was also the holder of an Engineer Officer Certificate of Competency (Fishing Vessel) Class 2. He had several years experience in the fishing industry, all of which was mainly spent aboard *Sharona* while his father was skipper of the vessel. He first took command of the vessel three months before the accident.

The mate did not hold a Certificate of Competency, nor was he required to do so. He had three years experience in the fishing industry since leaving school, all of which had been spent aboard *Sharona.*

The remainder of the crew's experience varied. One deckhand had 13 years experience, and another was on his first fishing trip.

The skipper, mate and two of the deckhands had undergone training in Basic Sea Survival, Fire-Fighting and First-Aid.

1.3 Description of vessel

Sharona was built at Buckie in 1974 and was constructed of wood.

The design incorporated one deck above the waterline. Above deck the wheelhouse was positioned aft, and a whaleback was fitted forward. A half shelterdeck, incorporating an enclosed fish hopper, was situated forward of the wheelhouse which left an open deck area between the shelter and whaleback.

Under deck, the accommodation was situated aft. Forward of the accommodation was the fish room, and forward of this was the engine room. They were separated by a non-watertight bulkhead. A CCTV camera was located in the engine room with a monitor in the wheelhouse. This enabled the watchkeeper to keep a constant view of the engine room.

1.4 Main engine and gearbox cooling system

The main engine, a 336kW Kelvin diesel was sea water cooled by means of a fresh water heat exchanger. Cooling water was supplied through one of two main sea water valves situated in the fish room. The sea water was fed into the engine room and pumped via a two-way valve into the main engine heat exchanger and into an inter-cooler for the main engine gearbox. The sea cooling water was then pumped overboard through a 50mm diameter copper pipe. This pipe was approximately 2 to 3mm thick. The discharge outlet, which was fitted with a non-return valve, was situated 0.6m above the waterline forward on the starboard side of the hull.

1.5 Bilge pumping arrangements

Sharona was fitted with a Desmi 50mm main engine belt-driven bilge pump. The pump suction was inter-changeable between engine room, fish room and cabin by means of a valve chest located in the engine room.

The vessel was also fitted with two 100mm hand Whale Gusher bilge pumps. One served the engine room bilge, the other, the fish room bilge. A petrol-driven portable salvage pump was also carried on board.

In addition to the bilge pumps, the engine room and cabin were fitted with high level bilge alarms.

1.6 Environmental conditions

The weather reported throughout the incident was a south-easterly wind of force 3 to 4 with a slight swell. The visibility was good.

1.7 Narrative of events

Sharona sailed from Peterhead at 1330 on 2 August 1999, bound for fishing grounds 80 miles to the north-east.

At 2200 she arrived at the grounds and, after shooting the fishing gear started trawling. The first haul was taken aboard early the following morning, without incident. This was the last time a member of the crew visited the engine room before the flooding was discovered.

At 1550 the next day, in preparation for the second haul, two crew members went forward to the engine room to clutch-in the drive for the hydraulic winch, an operation which was carried out routinely before every haul.

As the first crewman climbed down the ladder to the engine room, he noticed the engine room bilges had flooded to a height which was level with the floor plates, approximately 1.6m. He immediately called for the skipper who was on watch in the wheelhouse. The skipper hurried forward, then climbed down into the engine room to investigate further. He was surprised to see the water level so high, having fully expected the high water level bilge alarm to have been activated, which would have given advance warning of the flooding.

Once in the engine room, he discovered that the overboard discharge pipe for the main engine cooling water, on the starboard side of the engine room, was fractured. The cooling water pump, driven by the main engine, was pumping cooling water into the bilges instead of overboard, while the main engine was running.

In an attempt to reduce the water level in the engine room, the skipper engaged the main engine-driven bilge pump. However, the bilge pump was unable to cope with the flooding. Water was being pumped into the bilges quicker than it was being pumped out.

The crew made no attempt to use the two hand bilge pumps which had never been used before by the crew to pump the bilges. In addition, they did not try at that time to use the portable salvage pump which was carried on board.

The skipper then instructed a deckhand who had followed him into the engine room, to ease back on the main engine revolutions. This enabled him to clutch-in the winch so the crew could haul the fishing gear. He also tried to realign the fractured section of pipe in an attempt to stem the ingress of water. However, this was unsuccessful.

Back on deck, the crew began to haul the fishing gear. While the gear was being hauled, all crew donned their lifejackets as a precaution. When the clump weight was hauled on board, leaving the nets outboard, the skipper stopped the main engine to halt the ingress of water into the engine room. At 1630 he called the coastguard for assistance in getting a tow from another vessel. He then instructed the crew to put the portable salvage pump into the engine room bilges, and, using that pump, the water level in the engine room bilge was gradually reduced. However, at that time, all electrical power onboard was lost.

At 1632 *Maersk Challenger* responded to the call and set course for *Sharona*'s position. Communications between *Sharona* and *Maersk Challenger* were maintained by hand-held VHF radio.

When the level of water in the engine room bilge was below the floor plates the skipper told the crew to stop pumping and run the fishing gear off on to the seabed in preparation for being towed.

At 1800 *Maersk Challenger* arrived alongside *Sharona*. Lloyd's Open Form was agreed between master and skipper, and a tow line was transferred from *Maersk Challenger* to *Sharona*. Three deckhands from *Sharona* were then transferred to *Maersk Challenger* leaving the skipper and mate on board.

Both men tried again to reduce the bilge water level in the engine room using the portable pump again. However, when the tow started, *Sharona*'s bow was pulled down by the forward momentum. When this happened, water started to back-flood into the engine room from the aft bilges. At about the same time, the skipper, who was in the engine room with the suction end of the pump, noticed some sparks and a strong smell of smoke. He immediately left the engine room, battened down the hatch, closed the vents and operated the CO_2 smothering system. He then called *Maersk Challenger*, informed them of the situation and requested immediate evacuation. The skipper and mate then inflated one of the liferafts alongside *Sharona* as a precautionary measure.

At 1845, a safety stand-by vessel, *Aberdonian*, which had also responded to *Sharona*'s call for assistance, used her fast rescue craft (FRC) to transfer both the skipper and mate to *Maersk Challenger*.

At 1849, the tow restarted. However, an hour later the tow parted, and *Maersk Challenger* went alongside *Sharona* to reconnect the tow. While alongside, the skipper and mate were transferred back on board to assess the situation. On examining the engine room, they found the water level had risen to a depth of approximately 3m and was well above the main engine casing. Water was also back-flooding into the engine room through the fractured overboard discharge outlet. *Maersk Challenger* was banging heavily alongside.

A portable pump was transferred from *Maersk Challenger* and the skipper and mate made a further attempt to reduce the water level. They only managed to pump sufficient water from the engine room to prevent the back-flooding through the discharge outlet, because the reach of the pump was insufficient. Once the back-flooding was stopped, the skipper tried to put a bung in the discharge outlet, but was unsuccessful.

With the ingress of water temporarily stopped, both crew were transferred back to *Maersk Challenger*, and at 2115 the tow recommenced.

At 2130, *Maersk Challenger*'s officer of the watch recorded a reduction in *Sharona*'s freeboard. The tow was shortened and a quick release arrangement introduced.

At 0013 on 4 August, while under tow, *Sharona* listed to port, completely immersing her gunwales. The quick release system was activated on board *Maersk Challenger*, and *Sharona* sank in position 58° 10.5' N 000° 22.2' W.

Aberdeen Coastguard was informed of the situation. Under instructions from the coastguard one of *Sharona*'s liferafts and her EPIRB were recovered from the sea. Her crew were taken back to Aberdeen where they arrived safely the following day.

1.8 Previous flooding

On 12 November 1997, in position 56° 48' N 007° 08' W, 15 miles south-east of Barra, *Sharona* suffered a similar flooding incident in the engine room. On that occasion the flooding was contained, and she was towed into Barra Harbour by another vessel, while Barra Lifeboat stood by.

Flooding of the engine room in that incident was caused by a failure to the main engine cooling pipework in way of the inter-cooler.

The crew estimated that there were approximately 2.5m of water in the engine room bilges before the flooding was discovered. A high level bilge alarm sensor was fitted in the engine room, but failed to operate.

To prevent a recurrence, the pipework was repaired, a new bilge alarm system was fitted, and a CCTV camera was installed in the engine room with a monitor in the wheelhouse.

1.9 Loss of fishing vessels through flooding

Marine Guidance Note MGN 49(F) published by the Maritime and Coastguard Agency and entitled *Losses of Fishing Vessels through Flooding,* states in part:

Introduction

Inquiries into the losses of fishing vessels due to flooding have shown that:

- *in many cases not even the most basic action was taken to prevent further flooding;*

- *bilge level alarms were either not fitted or failed to give the intended warning.*

During operation

DO *regularly (preferably daily) test bilge level alarms by moving the float by hand to check that the visual and audible alarms actually work.*

DO *check that all non-return valves are clear of debris and in good condition each time the vessel is slipped, dry docked or otherwise out of the water.*

In an emergency

DO *try using the bilge pump or ejector and hand pumps when provided.*

1.10 Corrosion of copper pipes in engine cooling systems

Merchant Shipping Notice M631 published by the Maritime and Coastguard Agency and entitled *Corrosion of Copper Pipes in the Engine Cooling Systems of Inshore Fishing Vessels* states in part:

There has been a high incidence of failure in copper pipes of cooling systems in inshore fishing vessels. Investigations show the probable causes to be:

(a) Corrosion / Erosion
(b) Electrolic Corrosion

The majority of the evidence suggests corrosion/erosion to be the main cause of unusually rapid pipe failures. This is the result of turbulence associated with internal obstructions or changes in geometry of pipes together with water speeds above 1metre/sec - copper being known to suffer from this defect and, being a comparatively, soft material, wastage can be very rapid.

An alternative may be to fit cupro-nickel piping in the effected areas. While this material may similarly suffer wastage, the acceptable water speed is higher, eg 3 to 4 metres/sec and the rate of deterioration is slower. Aluminium-brass and stainless steel pipes are also more resistant to corrosion.

In order to combat electrolyic corrosion, owners should ensure that the proper special earthing plates for electronic equipment are fitted and used, avoid the attachment of earth connections to machinery parts and ship side fittings and prevent short circuits by the regular testing and maintenance of electric wiring systems.

1.11 Work-hardening of copper pipes

Work-hardening of copper pipes can be caused by vibration.

Work-hardening (or Cold Working) is a modification of the properties of copper by plastic deformation at room temperatures or moderate temperatures below that which would cause recrystallisation. Such working results in an increase in strength and hardness with general loss of ductility.

As deformation proceeds, the copper becomes harder and stronger and a stage is reached when further deformation is impossible. Any increase in stress will lead only to a fracture. At this stage, when tensile strength and hardness are at a maximum and ductility is at a minimum, the copper is said to be work-hardened. Further plastic deformation can only be carried out if the copper is annealed.

In order to combat the effects of work-hardening, stresses should be kept to a minimum. This can be achieved by avoiding wherever possible unsupported lengths of copper piping subject to any form of vibration.

1.12 Condition and safety surveys

Sharona underwent a UK fishing vessel safety survey in April 1996. The survey, which is mandatory, is carried out every four years by the MCA. On completion of the survey *Sharona* was issued with a UK Fishing Vessel Safety Certificate.

On 13 July 1999, three weeks before the accident, a local firm of ship surveyors, Pirie and Smith, carried out a condition survey on behalf of *Sharona*'s insurers. Before the commencement or renewal of cover, the insurers normally require a condition survey report.

The survey covered the complete vessel including the lifesaving, fire-fighting and navigation equipment carried on board the vessel.

It was noted that bilge alarms, where fitted, were fully operational and were tested satisfactorily on the day of the survey.

A comment made on the condition of the 50mm copper pipework in the engine room, was that it was in order where seen. It was not a condition of the survey by the insurers that certain sections of pipework were to be examined, rather a general overall condition survey.

It was also noted the vessel was in a generally well-used condition. The hard working life and the age of the vessel reflected this.

The report recommended the owner to have a few minor defects repaired before returning to sea. The survey did not highlight any major defects.

1.13 Fishing Vessel (Safety Provision) Rules 1975

Part II, Rule 2 of the *Fishing Vessel (Safety Provision) Rules 1975*, states in part:

Every such vessel shall be provided with a watertight collision bulkhead in the fore part of the vessel, and main and auxiliary machinery essential for the propulsion and safety of the vessel shall be situated in a watertight machinery compartment, except that vessels constructed substantially of wood may be provided with a wooden bulkhead or bulkheads of solid and substantial construction separating the fish hold from the rest of the vessel.

SECTION 2 - ANALYSIS

2.1 General

What could have been considered as a controllable flooding incident on board *Sharona* eventually led to her loss.

Had the owner, skipper and crew adopted some basic flooding prevention measures and taken a different course of action after discovering the flooding, *Sharona* might not have foundered.

2.2 Previous flooding

When *Sharona* suffered flooding to the engine room some 21 months before her loss, the main cause was a failure to the main engine cooling water pipework, the same pipework which fractured on this occasion.

In addition, during the previous flooding incident and on this occasion also, the bilge alarm failed to operate. This raises concern as to whether the high level bilge alarm was regularly checked and maintained in accordance with the advice given in *Marine Guidance Note MGN 49(F)*.

Repairs to the pipework, the fitting of a new bilge alarm and the installation of a CCTV camera were measures taken to prevent a recurrence of flooding in the engine room. The measures taken would certainly, if fully operational, give early warning to any future flooding in the engine room. However, considering the age of the main engine cooling water pipework, originally installed in 1974, a more effective measure would have been a complete test, overhaul and replacement of any defective pipework in accordance with *Merchant Shipping Notice M631*. This would probably have prevented the flooding which led to the eventual loss of the vessel.

2.3 Initial flooding

When flooding was first discovered in the engine room, the skipper tried to reduce the level of water in the bilges by operating the main engine-driven bilge pump. No attempt was made to stop the source of flooding, cooling water was being pumped into the bilges more quickly than it was being pumped out.

It would have been a simple matter to stop the main engine which, in turn, would have stopped the cooling water being pumped into the bilges. Once this had been done the bilges could have been pumped out with either the hand bilge pumps or the portable salvage pump.

The fishing gear would have had to be left on the seabed, as with the main engine not running it would not have been possible to operate the winch. Although this meant there would be a possibility of the gear fouling, it could have been hauled later, once

the emergency was over. It might even have resulted in the loss of the fishing gear, but this would have been a better option than the eventual loss of the vessel.

It can only be assumed that the skipper thought it more important to haul the fishing gear, than to stop the main engine, or was under the impression that *Sharona* was in no immediate danger and hauling the gear would have made little or no difference to the level of flooding in the bilges.

No attempt was made to use the hand bilge pumps in accordance with *Marine Guidance Note MGN 49(F)*; for some reason these pumps were never used by the crew. It's quite possible that with the pumps never having been used, they had (inadvertently) forgotten about their existence during the emergency.

Only when the clump weight was hauled on board did the skipper decide to stop the main engine, but by that time the flooding in the bilges had increased.

Carrying a portable salvage pump on board was commendable. With its use the crew managed to reduce the level of flooding. However, because the decision to use the pump was delayed, they were unable to prevent the loss of electrical power, leaving the skipper no other option than to call for assistance in the form of a tow.

2.4 Final flooding

Despite everything, the level of flooding had been reduced before the skipper and mate were evacuated. When they were transferred back on board, after the tow parted, flooding in the engine room had risen to a depth of approximately 3m.

Further flooding while under tow had occurred due to back-flooding through the fractured overboard discharge outlet. The skipper confirmed this when he inspected the engine room.

The non-return valve fitted behind the discharge outlet failed to prevent back-flooding. Unfortunately this valve was not checked during the recent condition survey carried out by the vessel's insurers. This again raises concerns as to whether non-return valves fitted on *Sharona* had been regularly checked and maintained in accordance with *Marine Guidance Note MGN 49(F)*. Had the non-return valve been fully operational, it would have prevented further flooding into the engine room and the vessel could have been saved.

An unsuccessful attempt was made to stop the ingress of water. The level of flooding was also reduced, which temporarily prevented back-flooding through the discharge outlet. However, with *Maersk Challenger* banging heavily alongside *Sharona*, caulking and planking could have been dislodged or damaged. When the tow was resumed, it would have only been a matter of time before further back-flooding through the discharge outlet and damaged hull caused *Sharona* to sink.

2.5 Fishing vessel surveys

The MCA carried out safety surveys on board *Sharona* some 18 months before the first flooding incident, and more than 3 years before the final flooding incident. She was due another one in April 2000.

When the surveys were carried out, accessible pipework should have been checked for exterior erosion/corrosion, non-return valves checked for satisfactory operation, and bilge pumps and alarms tested.

However, because of the age of the pipework and fittings, a degree of interior erosion/corrosion or work-hardening could have been present. The fact that the first flooding incident was caused by pipework failure supports this probability.

When the insurers of the vessel carried out a further condition survey about three weeks before the final flooding, they did not detect any deficiencies in the pipework and fittings. Again, it is probable that a greater degree of corrosion/erosion or work-hardening was present at that time, and led to the fracture of the pipework and failure of the non-return valve.

The responsibility for the maintenance of pipework on fishing vessels lies with the skipper and owners. They should be aware of the possibility of copper pipework fracturing due to work-hardening and of the measures required to avoid it, including annealing at periodical intervals.

Had the deficiencies in the pipework been detected at an earlier stage, the flooding incidents might have been avoided.

For this reason a recommendation will be made to the MCA to update its advice given in *Merchant Shipping Notice M 631,* and to include reference on work-hardening of copper piping.

2.6 Watertight bulkheads

Sharona was required under the *Fishing Vessel (Safety Provision) Rules 1975*, to have a bulkhead or bulkheads of solid or substantial construction separating the fish hold from the rest of the vessel.

There was no requirement for these bulkheads to be watertight. The engine room was forward of the fish room, and as the propeller shaft had to pass through the bulkhead between the engine room and fish room, it was difficult to maintain any kind of watertight bulkhead.

With no watertight bulkhead, progressive flooding into the fish room and cabin was unavoidable.

Had a watertight bulkhead been in place, separating the fish room from the engine room, progressive flooding into other spaces would have been avoided and *Sharona* might not have foundered.

SECTION 3 - CONCLUSIONS

3.1 Findings

1. *Sharona* might not have foundered had the crew took a different course of action after flooding was discovered. [2.1]

2. *Sharona* had suffered a previous flooding incident caused by a fracture to the main engine cooling water pipework. [1.8, 2.2]

3. The engine room bilge alarm failed to operate during both flooding incidents. [2.2]

4. The main engine was stopped for 40 minutes after flooding to the engine room was discovered. [2.3]

5. Stopping the main engine immediately could have prevented further flooding to the engine room. [2.3]

6. No attempt was made by the crew to use the available hand bilge pumps. [2.3]

7. Carrying a portable salvage pump on board was commendable. [2.3]

8. The portable salvage pump was not used until the main engine was stopped. [2.3]

9. Further flooding occurred, while under tow, through the overboard discharge outlet. [2.4]

10. The non-return valve fitted behind the discharge outlet failed to prevent back-flooding. [2.4]

11. With damage to the hull and back-flooding through the discharge outlet and no watertight bulkhead, it was only a matter of time before *Sharona* sank. [2.4, 2.6]

12. It is more than likely that *Sharona*'s pipework was subject to a degree of interior corrosion/erosion and work-hardening failure. [2.5]

13. *Merchant Shipping Notice M 631* does not contain any reference to the work-hardening of copper piping. [2.5]

14. A watertight bulkhead separating the engine room from the fish room might well have prevented *Sharona* from foundering. [2.6]

3.2 Causes

Sharona's loss was caused by uncontrolled flooding to the engine room through a fractured main engine cooling water pipe because of erosion/corrosion or work-hardening of the copper pipework.

3.3 Contributory causes

1. The decision to haul the fishing gear, which resulted in a failure to stop the main engine immediately and thereby, prevent further flooding.

2. The failure of the engine room bilge alarm.

3. The failure to detect defective pipework.

4. The lack of a watertight bulkhead between the fish room and engine room.

SECTION 4 - RECOMMENDATIONS

The Maritime and Coastguard Agency is recommended to:

1. Consider updating its advice given in *Merchant Shipping Notice M 631,* and include a reference on the work-hardening of copper piping.

Marine Accident Investigation Branch
July 2000