ACCIDENT REPORT

Report on the investigation of the

fatal accident to a crewman

on board

the fishing vessel

Starlight Rays PD230

126nm NNE of Aberdeen

on 25 August 2011

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

VERY SERIOUS MARINE CASUALTY REPORT NO 15/2012 June 2012

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

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

NOTE

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

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GLOSSARY OF ABBREVIATIONS, ACRONYMS AND TERMS

AIS	-	Automatic Identification System
ARCC	-	Aeronautical Rescue Co-ordination Centre
BA	-	Breathing apparatus
BP	-	British Petroleum PLC
BST	-	British Summer Time
CCTV	-	Closed circuit television
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
CPR	-	Cardio pulmonary resuscitation
FISG	-	Fishing Industry Safety Group
fv	-	fishing vessel
GRT	-	Gross Registered Tons
IMO	-	International Maritime Organization
km	-	kilometre
kW	-	kilowatt
LOA	-	length overall
m	-	metre
MARPOL	-	Annex I of the International Maritime Organization (IMO)'s International Convention for the Prevention of Pollution from Ships
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MRCC	-	Maritime Rescue Co-ordination Centre
MSN	-	Merchant Shipping Notice
nm	-	nautical miles
OAN	-	Operations Advice Note
OOW	-	Officer of the watch
ppm	-	parts per million
ROV	-	Remotely operated (underwater) vehicle
SCMS	-	Survey & Certification Management System
SFF	-	Scottish Fishermen's Federation

Seafish	-	Sea Fish Industry Authority
SOLAS	-	The International Convention for the Safety of Life at Sea 1974, as amended
STCW	-	The International Convention on Standards of Training Certification and Watchkeeping for Seafarers
UK	-	United Kingdom
UK FVC	-	United Kingdom Fishing Vessel Certificate
UTC	-	Universal Time, Co-ordinated
VHF	-	Very High Frequency

Times: All times used in this report are BST (UTC+1 hour)

Starlight Rays

SYNOPSIS

At about 1450 on 25 August 2011, Artis Sterkis, the engineer on board the fishing vessel *Starlight Rays*, collapsed while attempting to use a portable petrol engine-driven pump to remove oily water from a compartment inside the vessel's fish hold. He was evacuated from the vessel and taken to hospital by rescue helicopter, but never regained consciousness. It was later confirmed that he died from carbon monoxide (CO) poisoning. *Starlight Rays* was engaged on guard vessel duties at the time, operating 126nm north-east of Aberdeen.

Artis Sterkis was attempting to pump overboard into the sea some oily water that had gathered in the vessel's bow thruster space. With assistance from another crewman, he had carried a portable salvage pump down into the fish hold so that it was close to the bow thruster space. The pump's petrol engine ran for a total period of more than an hour in a compartment with no mechanical ventilation and little natural air circulation. This caused very high levels of CO to accumulate within the fish hold because the petrol engine's exhaust gas fed directly into the space.

The crewman who had been assisting Artis Sterkis collapsed in the fish hold while attempting to rescue him. The vessel's watchkeeper managed to rescue the crewman but later needed medical treatment for his exposure to CO. Both the crewman and watchkeeper survived.

The accident demonstrated inadequate consideration and control of hazardous work activities on board *Starlight Rays*. The rescue efforts included a commendable response from the crew of the support vessel *Skandi Carla*, but showed that it is very difficult to rescue a crewman from a compartment with a dangerous atmosphere on board a fishing vessel, without risking the lives of the rescuers.

Petrol engine-driven pumps are commonly carried on board fishing vessels as salvage and emergency fire pumps. The investigation found that, without careful thought and preparation, many of these pumps could be ineffective. This can lead to them being used inappropriately, with lethal consequences.

The MAIB has issued a Safety Flyer to the fishing industry to highlight the dangers identified from this accident. The Maritime and Coastguard Agency (MCA) has updated and reissued a Marine Guidance Note on the hazards of enclosed spaces on fishing vessels. In addition, the MCA has undertaken to discuss the safety issues from this accident with fishing industry bodies via the Fishing Industry Safety Group (FISG) to assess what other action can be taken to improve fishermen's safety. The owner and skippers of *Starlight Rays* have been given recommendations designed to improve the standard of occupational safety and protection for crew working on their vessel.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *STARLIGHT RAYS* PD230 AND ACCIDENT

SHIP PARTICULARS

Vessel's name	*Starlight Rays*
Flag	United Kingdom
Classification society	Not applicable
Official number/fishing numbers	C17103/PD 230
Type	Fishing vessel
Registered owner	Privately owned
Manager(s)	Caley Fisheries Limited
Construction	Steel
Length overall	26.4m
Registered length	23.65m
Gross tonnage	320

VOYAGE PARTICULARS

Port of departure	Peterhead
Port of arrival	Peterhead
Type of voyage	Short International
Manning	4

MARINE CASUALTY INFORMATION

Date and time	25 August 2011 at around 1450
Type of marine casualty or incident	Very Serious Marine Casualty
Location of incident	Devenick Oil Field
Place on board	Fish hold
Injuries/fatalities	1 fatality
Damage/environmental impact	Nil
Environmental conditions	Sea state 4 - moderate Wind force 5 - fresh breeze Weather - clear Natural light - daylight Visibility - moderate
Persons on board	4

1.2 BACKGROUND

Starlight Rays normally operated as one part of a pair trawling partnership. However, its main net drum had been damaged during a previous fishing trip and the equipment had been landed ashore for repair. As the vessel could not fish, the skipper sought guard vessel work with the oil and gas industry in the North Sea.

At the time of the accident, *Starlight Rays* was one of two guard vessels that were protecting the exposed pipe and cable that connected the developing Devenick Field, 126nm north-east of Aberdeen, to the existing East Brae Platform, 18nm to the south of the Devenick Field.

The remotely operated vehicle (ROV) survey and construction support vessel *Skandi Carla* was assigned to co-ordinate the operation of the guard vessels.

1.3 NARRATIVE

1.3.1 Guard vessel duty

At around 0900 on 23 August 2011 *Starlight Rays* left Peterhead and commenced passage towards the Devenick Field.

As *Starlight Rays* approached the Devenick field, the skipper contacted *Skandi Carla* and told the officer of the watch (OOW) that he would soon be arriving to take up his guard vessel duties.

At around 2300, *Starlight Rays* arrived at her designated position and the skipper commenced guard vessel duties. These duties continued throughout the following day.

1.3.2 Pumping out the bow thruster compartment

At about 0400 on 25 August the skipper handed over the watch to the watchkeeper and went to bed. The watchkeeper woke the skipper at around 0930 and the skipper then cooked breakfast for the crew. All four crew members gathered around the mess table, where they ate breakfast and smoked cigarettes.

At around 1015 the skipper went to the wheelhouse and the watchkeeper went to bed. A short time afterwards, the engineer collected the suction and discharge hoses **(Figure 1)** for the portable petrol engine-driven salvage pump (subsequently referred to as 'the pump') from the chain locker and took them to the access hatch into the fish hold on the processing deck. The crewman helped the engineer carry the pump through the small access hatch that was let into the main hatch lid **(Figure 2)** and down the ladder into the fish hold.

The engineer carried the pump over to the access hatch into the bow thruster space that was at the forward end of the fish hold and connected the suction and discharge hoses to the pump. The engineer and crewman then unbolted and removed the bow thruster space access hatch **(Figure 3)** and placed the suction hose into the oily water that was inside. The crewman took the free end of the discharge hose back up the ladder, onto the processing deck and fed the flexible hose out through a tonnage valve[1] on the starboard side.

[1] A tonnage valve is a closable non-return scupper valve fitted to the vessel's side that allows water to drain overboard.

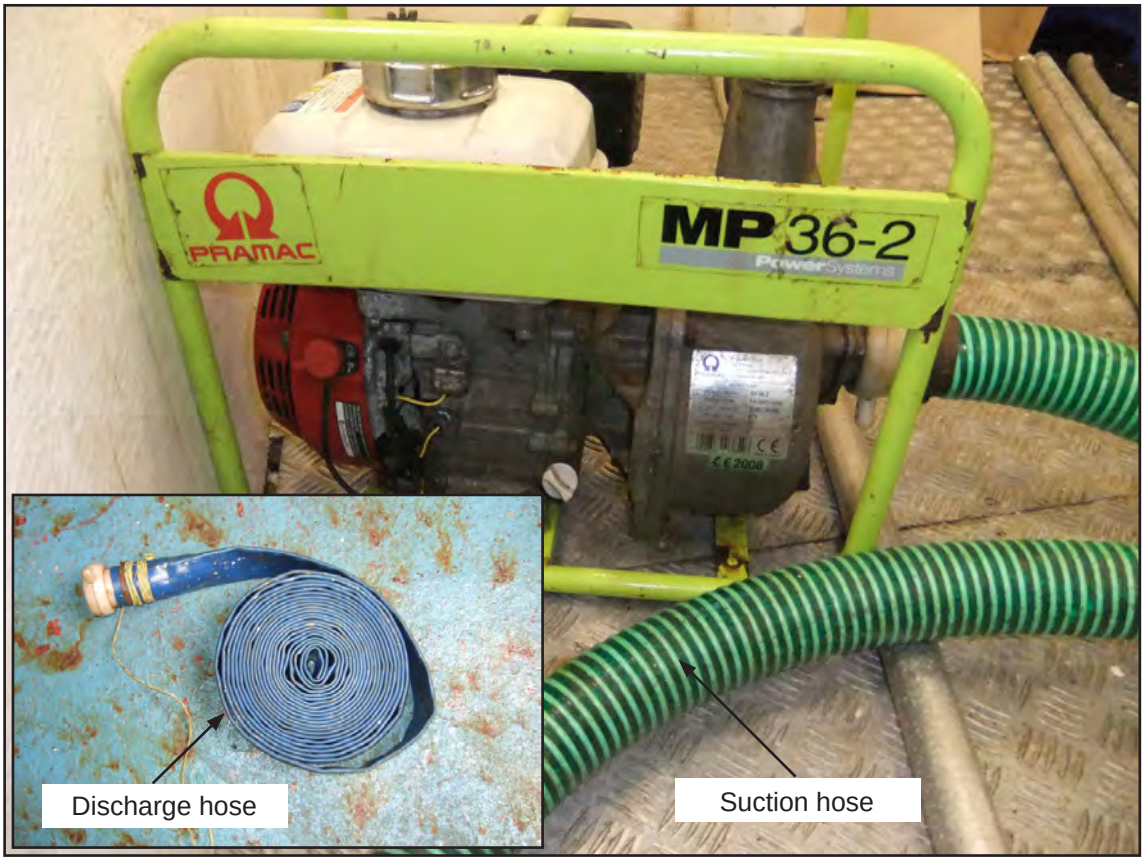


Figure 1: *Starlight Rays*' petrol engine-driven pump and hoses

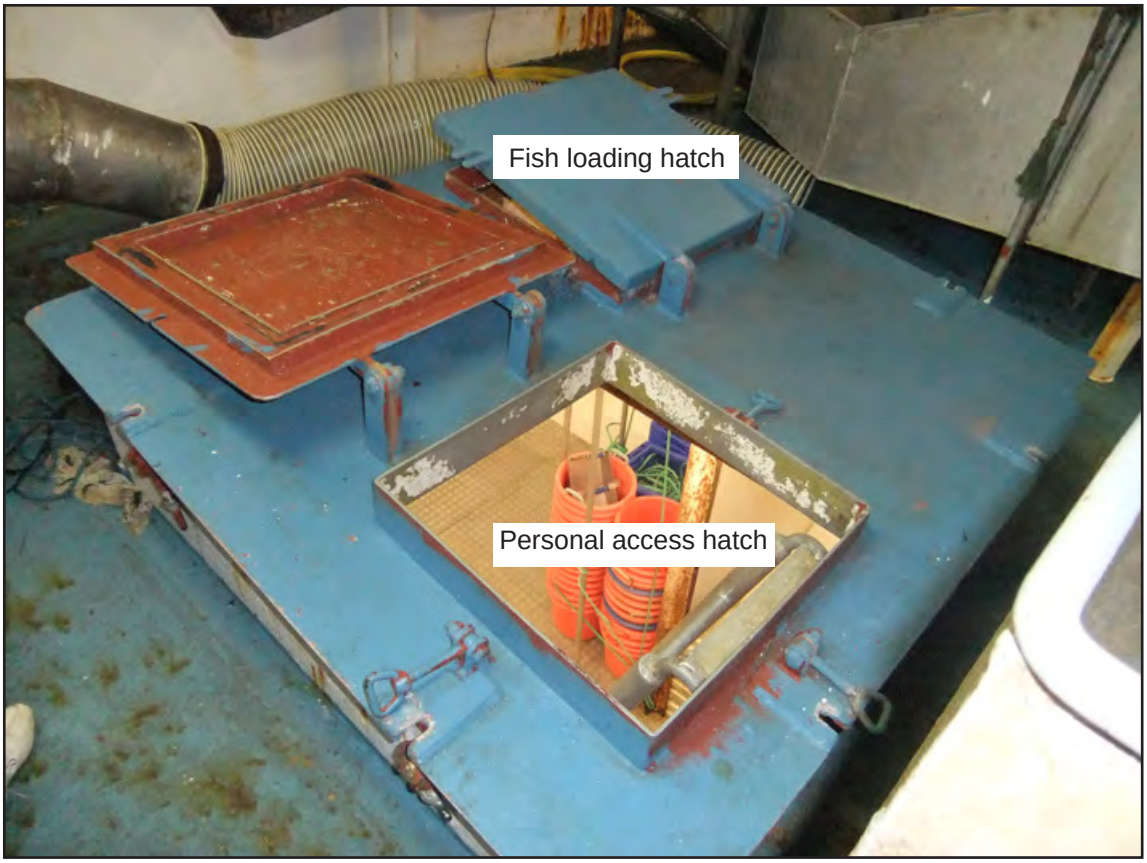


Figure 2: Access hatch from the processing deck to the fish hold

Figure 3: Bow thruster space and cover

The crewman, who survived the accident, was able to describe the sequence and approximate duration of subsequent events, but was not able to recall the times at which they happened.

Once the hoses were set up, the engineer started the pump's petrol engine. The engine then ran for about 20 minutes while the engineer attempted to make the pump draw suction before he shut it down. During this time the crewman climbed down the ladder into the fish hold to help the engineer. The engineer then restarted the engine and the crewman climbed out of the fish hold, ready to tend the discharge hose when pumping started. Again, the pump did not draw suction and, after several minutes, the engineer stopped the engine again. The engineer, assisted by the crewman, lifted the pump out of the fish hold onto the processing deck and started to investigate why the pump was not functioning. The two men then took a break in the mess room.

After their break, the engineer and crewman agreed to try pumping out the bow thruster space again. They carried the pump back into the fish hold; the engineer checked the fuel level, reconnected the two hoses and placed the suction hose back into the bow thruster space. The crewman, who was by now aware of an unusual smell in the hold, took the discharge hose back up the ladder and put the free end overboard. The engineer restarted the engine and tried to get the pump to work by adjusting the throttle control to run the engine at various speeds, including full power at times, for at least the next 30 minutes.

The crewman shouted down to the engineer that no water was being pumped overboard and he then climbed down into the fish hold. The engineer stopped the engine, which was now very hot, told the crewman that the pump did not work, and disconnected the two hoses from the pump. The crewman carried the discharge hose out of the fish hold. He had developed a headache and had difficulty breathing, but rolled up the discharge hose on the processing deck. He did not associate these symptoms with exposure to the exhaust gas and did not understand the danger that he and the engineer were in.

1.3.3 Initial rescue attempts

At about 1450 the crewman looked down through the hatch and saw the engineer shaking, lying on the fish hold deck next to the pump. The crewman climbed down into the fish hold and asked the engineer what was wrong; the engineer told the crewman to tell the skipper what had happened. The crewman ran up to the wheelhouse and told the skipper that the engineer was '*sick*' and then woke the watchkeeper and told him the same information.

The crewman led the skipper and the watchkeeper down into the fish hold. The engineer had lost consciousness and the three men tried to lift him. The engineer was a large man and the three men could not move him. The engineer was still breathing, and the crewmen moved him into the 'recovery position'[2]. The skipper told the watchkeeper to open the main fish hold hatch cover, the unloading hatch cover in the processing deck's shelter and the cod-end hatch cover in order to help ventilate the fish hold. The watchkeeper went to get a cup of hot water for the engineer, collected a dust mask from the wheelhouse and returned to the fish hold. He climbed back down into the fish hold and fitted the dust mask over the engineer's mouth **(Figure 4)**.

At 1500 the skipper went to the wheelhouse and called *Skandi Carla* **(Figure 5)** by very high frequency (VHF) radio. He told *Skandi Carla*'s OOW that he needed medical assistance for the engineer, who had collapsed in the fish hold possibly due to the effects of carbon monoxide (CO).

The watchkeeper left the fish hold and went up to the processing deck; he then connected a fish bin to the hook of the unloading crane. When the bin was ready to lower into the fish hold, the watchkeeper shouted down to the crewman. After hearing no response, the watchkeeper looked down into the hold and saw that the crewman had also collapsed. The watchkeeper called to the skipper, who had arrived back on the processing deck, and told him about the crewman's collapse. The watchkeeper then climbed into the bin and the skipper lowered him into the fish hold **(Figure 6)**.

The crewman was much smaller than the engineer, and the watchkeeper, who now felt light-headed, was able to push him into the fish bin. The skipper hoisted the crewman and the watchkeeper out of the fish hold and lowered them on to the deck. The watchkeeper and the skipper placed the crewman into the recovery position and covered him with a duvet.

[2] The recovery position is one in which an unconscious, but breathing casualty can be placed to prevent their airway from becoming obstructed as part of first-aid treatment.

Figure 4: Dust mask used during rescue

Image courtesy of Fotoflite

Figure 5: *Skandi Carla*

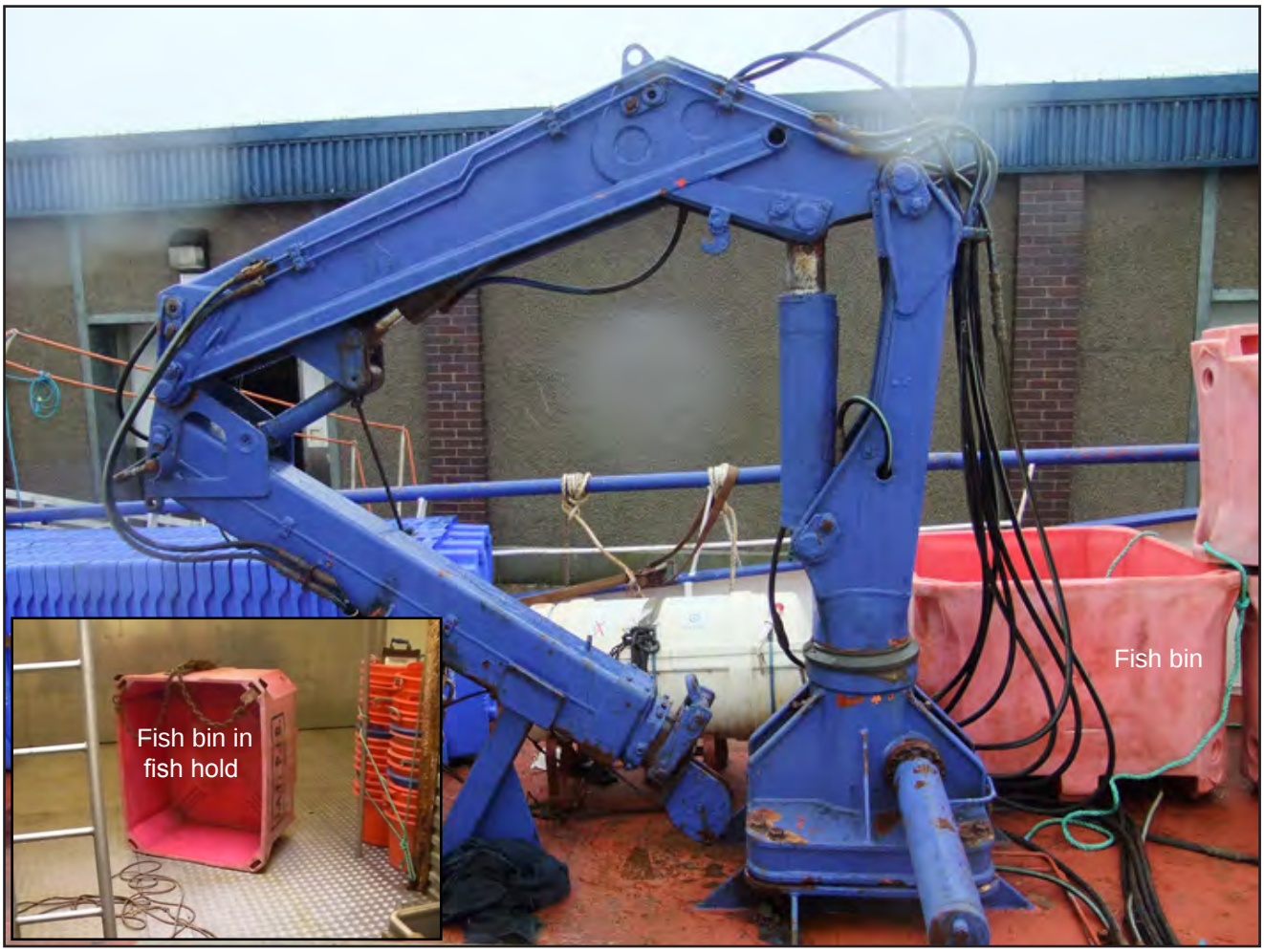


Figure 6: Landing crane and fish bin

1.3.4 Further rescue attempts

At 1510 *Skandi Carla*'s rescue boat was launched with a rescue party consisting of two boats' crew, a medic and an assistant. The medic brought his medical grab-bag, which included an oxygen cylinder. The members of the rescue party were unfamiliar with what safety equipment was carried on fishing vessels and assumed that breathing apparatus (BA) would be available on board. The medic and the assistant boarded *Starlight Rays* by a rope ladder **(Figure 7)**. The medic gave oxygen to the crewman who was lying on the deck.

The rescue team requested further assistance from *Skandi Carla* when they realised that the engineer could not be rescued from the fish hold due to his size and the toxic atmosphere. At 1515, *Skandi Carla*'s master called the Maritime Rescue Co-ordination Centre (MRCC) Aberdeen by satellite telephone, advised them of the situation and requested helicopter assistance. The rescue boat returned to *Skandi Carla* and embarked three more crewmen, and one BA set. The rescue boat then went back to *Starlight Rays* and two of the men climbed back up the rope ladder to board the fishing vessel.

One of the rescuers from *Skandi Carla* donned the BA set, entered *Starlight Rays*' fish hold and attempted to push the unconscious engineer into the fish bin. He was not successful as the engineer was too heavy to be moved by one person.

Figure 7: *Skandi Carla*'s rescue team boarding *Starlight Rays*

1.3.5 Evacuation

At 1526 the Aeronautical Rescue Co-ordination Centre (ARCC) at Kinloss requested that the Bond Super Puma rescue helicopter R11, which was part of the offshore rescue network, be launched to assist; R11 was reported as being airborne at 1530.

R11 arrived at *Starlight Rays* at 1550 and a paramedic was winched down onto the deck. The helicopter's two-man rescue strop was disconnected from the winch wire, connected to *Starlight Rays*' unloading crane hook and lowered into the hold. The rescuer wearing BA placed the engineer into the rescue strop, but as the engineer was lifted he slipped out of the strop. The BA wearer attached the rescue strop to himself and the engineer and held the engineer's arms to secure him in the strop as both men were lifted from the hold and landed on deck. The paramedic gave the engineer oxygen and then began Cardio Pulmonary Resuscitation (CPR).

At around 1610 the BA wearer spoke with the coastguard at MRCC Aberdeen via radio and reported the situation to them. The BA wearer advised the coastguard that, due to the odour and its location, he suspected that gas leaking from the refrigeration system was the more likely cause of the accident.

At 1613 the unconscious engineer was hoisted from *Starlight Rays* into R11. By then, the crewman had regained consciousness, and he was hoisted on board R11 at 1618 **(Figure 8)**. The two men were then transferred by R11 to Aberdeen Royal Infirmary. The skipper and the watchkeeper told the rescue party that they felt well, and the rescue party returned to *Skandi Carla* in their boat.

At 1650, *Skandi Carla*'s master advised *Starlight Rays*' skipper that he was released from guard vessel duties and could return to port. *Starlight Rays* departed from the Devenick Field at 1805.

Figure 8: Bond rescue helicopter R11

At 1820 *Starlight Rays'* watchkeeper told the skipper that he felt unwell. The skipper immediately contacted the master of *Skandi Carla,* advised him of the situation, and altered course to return to the Devenick Field. At 1823 *Skandi Carla*'s master contacted MRCC Aberdeen to ask for a helicopter to evacuate the watchkeeper. The watch-officer at MRCC Aberdeen advised *Skandi Carla*'s master that the rescue helicopter based in the Shetland Islands (callsign R102) would be sent and that the estimated time of arrival was 1938. At 1835 *Skandi Carla*'s rescue boat transferred a medic and an assistant on to *Starlight Rays*. The medic gave oxygen to the watchkeeper, who remained conscious and responsive.

R102 arrived on scene at 1940; the watchkeeper was lifted from *Starlight Rays* at 1957 and transferred to a hospital in the Shetland Islands.

At 2001 the rescue boat made a further trip back to *Skandi Carla* and returned to *Starlight Rays* with two BA sets and an oxygen meter. *Skandi Carla*'s chief engineer checked the oxygen levels in the wheelhouse, accommodation and the fish hold and found the levels to be at normal atmospheric levels. This information reinforced the rescuers' theory that the noxious atmosphere had been caused by a leak of refrigerant gas. The rescue party remained on board *Starlight Rays* until two crewmen were transferred from the guard vessel *Guide Us* to assist in returning *Starlight Rays* to port. At 2215, the stand by vessel *Vos Ranger* supplied *Starlight Ray*'s skipper with a gas detector that could monitor Oxygen, CO and carbon dioxide (CO_2) levels. This gas detector was not used.

At 2220 *Starlight Rays,* escorted by *Guide Us,* departed from the Devenick field; they both arrived alongside in Peterhead at 1430 the following day, 26 August. During the passage back, *Starlight Rays*' weather deck hatch and processing deck hatch had remained open.

1.4 TEST OF THE ATMOSPHERE IN THE FISH HOLD

At 1631 on 26 August 2011, the atmosphere in *Starlight Rays*' fish hold was tested by independent contractors engaged by the MAIB. The oxygen content was measured at 20.9%. The CO level was found to be 600 parts per million (ppm), with a safe level for people to enter the space considered, by the tester, to be 5ppm. Two electrically-powered air fans were placed on deck with flexible trunking placed into the bottom of the hold. One fan blew air into the fish hold while the other sucked air from it. At 1735, an hour after ventilation had started, the CO level was recorded at 189ppm. The fans were left running overnight; at 0745 the following day, with zero CO found, the hold was confirmed as being safe to enter.

1.5 GUARD VESSELS

Guard vessels help to prevent damage to subsea equipment by ensuring that other vessels do not enter into a 500m radius 'Exclusion Zone' placed around the equipment. Guard vessels stay within designated patrol areas and use radar, automated identification system (AIS) and a visual watch to identify and warn vessels, particularly trawlers, approaching the Exclusion Zone. In addition to routine broadcasts of the location of the Exclusion Zone, guard vessels' watchkeepers can call an approaching vessel by VHF radio and advise them to alter their course.

1.6 KEY PERSONNEL

1.6.1 Overview

The skipper worked a 6 hours on, 6 hours off, watch pattern with the watchkeeper. The engineer and the crewman worked only during the day.

All of the crew had completed the mandatory Seafish Industry Authority's (Seafish) safety courses, which included a course on '*Safety Awareness and Risk Assessment'*.

There was no requirement for the engineer to have any engineering qualifications to operate on board fishing vessels of *Starlight Rays*' size.

1.6.2 The skipper/owner

The skipper was British and aged 52. He was *Starlight Rays*' sole owner and had financial control of the boat and its operation. He held a Class II fishing certificate of competency. With other business interests abroad, he worked as skipper for around 4 or 5 months of the year.

1.6.3 The watchkeeper

The 18 year old watchkeeper was the owner's younger son. He held a navigational watch certificate issued after completing the 5 day course provided by Seafish.

1.6.4 The engineer

The engineer, Artis Sterkis, was Latvian and aged 37. He had worked on board *Starlight Rays* for 6 years, the last three as the vessel's engineer. Artis Sterkis had gained an unrestricted STCW[3] III/ 1 certificate as Engineering Officer of the Watch in 1993, but had not revalidated his certificate. He was a larger than average man, approximately 1.88m tall and weighing about 110kg.

Toxicology tests carried out after the postmortem examination confirmed that he died from '*carbon monoxide poisoning'*.

1.6.5 The crewman

The 36 year old Filipino crewman was an experienced seaman and fisherman who had completed 3 months of his year long contract on board *Starlight Rays*. He held an STCW qualification in basic safety training.

1.6.6 The main skipper

The owner's elder son was *Starlight Rays*' skipper for most of the year, but was not on board at the time of the accident. He operated and maintained the boat, requiring only major financial decisions to be made by his father.

1.6.7 Superintendent engineer

In exchange for a percentage of the price achieved for fish sales, Caley Fisheries Limited provided *Starlight Rays*' owner with its services as a fish selling and settling agent. Caley Fisheries Limited also provided the services of a superintendent engineer who helped arrange and co-ordinate technical aspects of the boat's maintenance. There was no written agreement between the two parties that described the technical superintendent's role or his responsibilities.

1.7 WEATHER CONDITIONS

The weather conditions on the day of the accident **(Figure 8)** were:

- Wind - south-easterly, 18 knots
- Visibility - 10nm
- Sea - slight to moderate
- Swell - moderate
- Weather - overcast

1.8 *STARLIGHT RAYS*

1.8.1 General arrangement

Starlight Rays was a 26.4m length overall (LOA) fishing boat fitted out for pair trawling. The fish processing deck was enclosed by a weathertight shelter that was fitted with a deck head hatch through to the open air for landing fish, and a starboard side hatch for bringing the net's cod end inboard **(Figure 9)**. The hatch in the shelter was positioned above the processing deck hatch which provided the only access to the fish hold **(Figure 2)**.

[3] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

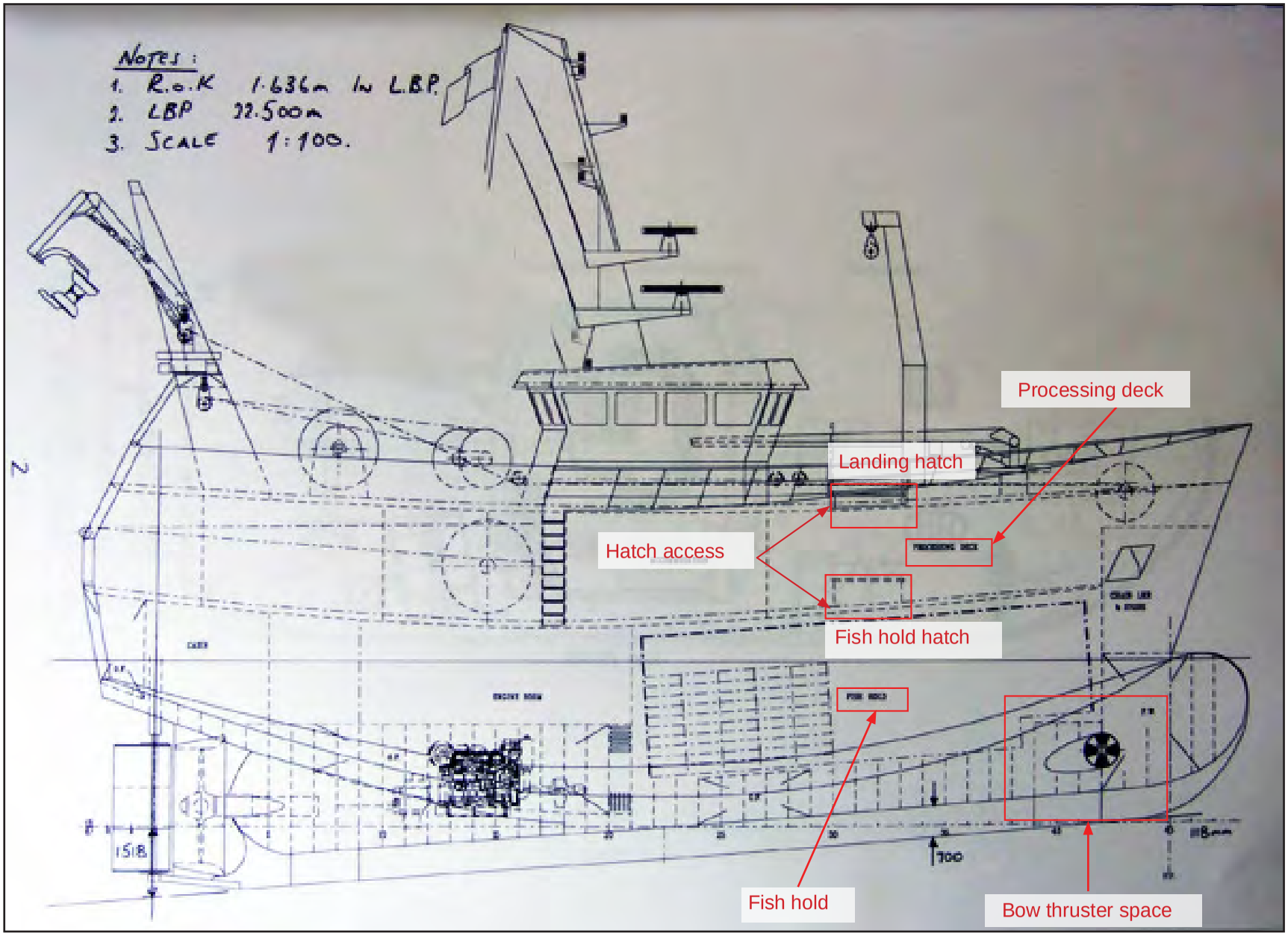


Figure 9: *Starlight Rays'* general arrangement drawing

1.8.2 Operation

Starlight Rays usually fished as a pair trawler with another Peterhead based vessel, *Starlight*. When one of the vessels was unable to fish, such as due to a failure of the fishing gear, the owners would make the boats available for guard vessel duties. There were usually six crew on board when fishing; when employed as a guard vessel, the size of the crew was reduced to either four or five.

1.8.3 Watchkeeping

When working as a guard vessel either the skipper or watchkeeper usually kept watch alone in the wheelhouse. Whoever was on watch generally sat in the starboard chair so that he could maintain a visual lookout and keep a radar watch using the screen mounted at the starboard side of the deck head displays **(Figure 10)**. While *Starlight Rays* was at sea, the CCTV monitor, located on the port side of the same deck head display as the radar, showed alternately the fish gutting belt and the aft end of the fish hold and its access ladder **(Figure 10** inset**)**.

Figure 10: Wheelhouse watchkeeping chair, radar and inset, CCTV monitor display

1.8.4 The fish hold

The refrigerated fish hold had an internal volume of 167m^3. The hold had no forced ventilation system and its only natural ventilation was via the hatch opening(s). The main hatch cover contained two smaller hatches: one for loading fish and the other for crew access **(Figure 2)**. At the time of the accident, the hold contained refrigeration pipework, a seawater slush ice tank, an ice storage bay and empty fish boxes **(Figure 11)**. The fish hold had a bilge well at the aft end that connected to the fixed bilge pumping system. The bow thruster space was accessed via a hatch at the forward end of the hold.

Forward Aft

Figure 11: Fish hold forward and aft view

1.8.5 Enclosed space hazards

With no provision for forced ventilation and the hatches closed, or, with only a small hatch open, the space had the potential to become a dangerous enclosed space as defined by the MCA. *Marine Guidance Note (MGN) 309 (F) Fishing Vessel – The Dangers of Enclosed Spaces* **(Annex A)** defines a dangerous enclosed space as:

- *One that is poorly ventilated or sealed with the oxygen reduced to low levels; or*
- *Where toxic and/or flammable gases have built up to dangerous levels.*

The MGN also stated:

> *'Many forms of chemical reaction can cause low oxygen levels or dangerous gases to build up, for example the decay of waste material or the exhaust from machinery… All enclosed spaces therefore need to be treated with caution before opening or entering'.*

1.8.6 The bow thruster space

The bow thruster's hydraulic motor was located in an otherwise void space at the forward end of the fish hold. The space had an internal volume of around $3m^3$. At the time of the accident it contained $1.8m^3$ of water mixed with about $0.25m^3$ of hydraulic oil **(Figure 12)**. The space had been fitted with suction pipework at build that enabled the space to be pumped out using *Starlight Rays*' main bilge pumping system. However, the crew on board at the time of the accident did not know this. The oil had leaked from the bow thruster's hydraulic system and accumulated from several separate hydraulic system failures. Water, from the melting ice from the stowed fish boxes and the water used to wash down the hold once the fish had been landed, had entered the space through leaks around the hatch cover.

Figure 12: Bow thruster space and contents

If the oily water overflowed into the fish hold it would spoil any fish stored on the deck. Consequently, the crew pumped out the bow thruster space about once or twice a year. This had been done by a variety of different methods in the past, including at least one attempt using a petrol engine-driven pump positioned in the fish hold. This had been done while the vessel was in port, with all the hatches open. The oily water was discharged into drums on the quayside and it was reported that it only took around 20 minutes for the pump to empty the space.

1.8.7 The salvage pump

Starlight Rays' petrol engine-driven salvage pump was a Pramac model MP 36-2 **(Figure 13a)**; the petrol engine was a Honda model GX120 that produced 2.6kW of power. The pump was capable of producing a maximum flow of 600 litres per minute when not pumping against a pressure head. It was theoretically capable of pumping against a total head of 30m through a 50.8mm (2") outlet hose.

The pump was purchased new and placed on board, along with a 5m length of semi rigid suction hose and a 15m length of flexible discharge hose **(Figure 1)**, in June 2009. The crew last operated the pump to remove sea water from the fish hold around 4 days before the accident.

Figure 13a: Pramac MP 36-2 petrol engine-powered pump

Figure 13b: Warning notice on the petrol tank

The pump had a warning notice placed on the petrol tank, immediately next to the filling cap **(Figure 13b)** stating:

> *'The engine emits toxic carbon monoxide. Do not run in an enclosed area'.*

The danger of operating the pump in an enclosed space was also clearly stated in the instruction manual that was supplied with the pump. The engine's exhaust manifold was mounted inside a casing, and there was no means of attaching an extension hose to carry the exhaust gases outside an internal compartment.

MGN 165 (F) Fishing Vessels: The Risk of Flooding **(Annex B)** carries the following advice that a skipper or owner should consider, inter alia:

> *'Carry a portable salvage pump. Extremely positive feedback has been received from skippers who have sailed with this type of pump, which may "double-up" as a fire fighting pump in a "dead ship" situation. However, a recent investigation attributed the death of one crew member to such a salvage pump. Unfortunately, he received fatal carbon monoxide poisoning whilst operating the pump inside the engine room.*
>
> *Such pumps should be:-*
>
> *i)Used in a well-ventilated space, preferably on deck, where the exhaust fumes will be released to outside the vessel.*

ii)Permanently rigged, or readily available, with direct attachment to permanent suction lines (to prevent the need for hoses to be fed through open hatches/ doors).

iii)Given due consideration concerning the storage of fuel, particularly petrol driven versions (i.e. adequate ventilation provided, fit for purpose storage canisters and away from sources of ignition).'

1.9 TECHNICAL INVESTIGATIONS

1.9.1 Refrigeration systems

*Starlight Ray*s was fitted with three refrigeration systems: a fish hold cooling system; a freshwater flake ice machine and a seawater slush ice machine. The three refrigeration systems were tested by a refrigeration engineer after the accident and the systems were found to be intact and fully charged **(Annex C)**.

1.9.2 Analysis of the effect of the pump's exhaust gas on the fish hold atmosphere

A technical investigation of the effect of the petrol engine-driven pump's exhaust on the atmosphere inside the unventilated fish hold was carried out on 23 August 2011 by analysts from the School of Engineering at the University of Aberdeen **(Annex D)**.

To test the pump under realistic load conditions, the analysts attempted to make the unit pump water, however the pump could not be made to prime. The analysis found that:

- The engine, when set at realistic speed for pumping water, produced about 3 litres of exhaust gas each second.

- The exhaust gas contained around 10% CO_2 and around 2.2% CO.

An assumption was made that, due to the static conditions inside the fish hold and the exhaust gases being denser than air, the CO in the exhaust gas would mix with about half the total volume of gas (air) in the fish hold. This allowed the following estimates to be made:

- After an initial 30 minutes of operation, a CO concentration of around 2800ppm would have been reached in the vicinity of the pump.

- After a further 30 minutes (i.e. a total of 60 minutes), it is likely that a CO level of around 3400ppm would have been reached in the vicinity of the pump.

The analysis concluded that:

'Operating the pump in the fish hold without an appropriate exhaust duct led to a rapid CO and CO_2 build up. The CO level after 30 minutes can be considered as harmful to health, the level after 60 minutes can be considered lethal when exposure lasts several minutes.'

1.9.3 Symptoms of carbon monoxide poisoning

The symptoms of CO poisoning on the human body are shown in the table below:

Concentration	Symptoms
35ppm (0.0035%)	Headache and dizziness within six to eight hours of constant exposure
100ppm (0.01%)	Slight headache in two to three hours
200ppm (0.02%)	Slight headache within two to three hours; loss of judgment
400ppm (0.04%)	Frontal headache within one to two hours
800ppm (0.08%)	Dizziness, nausea, and convulsions within 45 minutes; insensible within 2 hours
1,600ppm (0.16%)	Headache, tachycardia, dizziness, and nausea within 20 minutes; death in less than 2 hours
3,200ppm (0.32%)	Headache, dizziness and nausea in five to ten minutes. Death within 30 minutes.
6,400ppm (0.64%)	Headache and dizziness in one to two minutes. Convulsions, respiratory arrest, and death in less than 20 minutes.
12,800ppm (1.28%)	Unconsciousness after 2-3 breaths. Death in less than three minutes.

Table 1: Symptoms of carbon monoxide poisoning[4]

1.9.4 Treatment for CO poisoning

The standard treatment for CO poisoning is to give the injured person 100% oxygen through a tight fitting mask[5].

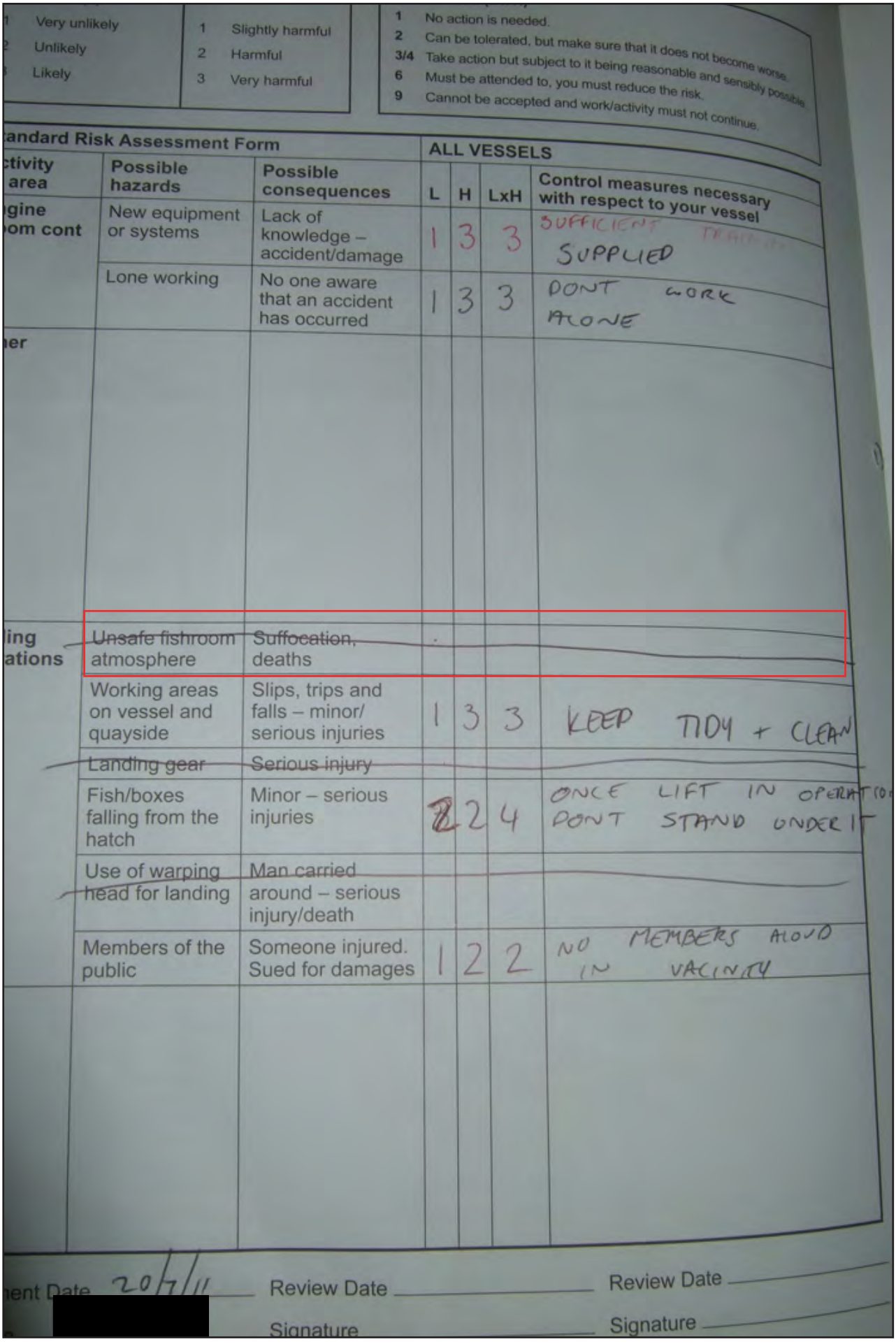
1.10 RISK ASSESSMENT

Starlight Rays' main skipper (the owner's son) had carried out risk assessments using the templates provided in the current edition of the Seafish 'Fishing Vessel Safety Folder'. The standard risk assessment template included the possible hazard of '*unsafe fishroom atmosphere*' with the possible consequence of '*suffocation, death*'. This section had been crossed out as not being applicable on board *Starlight Rays* **(Figure 14a)**.

The standard risk assessment template also included the possible hazard of *'Fumes from paints and other processes'* with the possible consequence being *'Respiratory problems, suffocation'*. The main skipper had considered the consequences from this risk to be '*can be tolerated, but make sure that it does not become worse*'. The control measures that were put in place to mitigate this risk were stated as, *'masks found in wheel house'* **(Figure 14b)**. The masks that were supplied on board (and were found in the fish hold after the accident) **(Figure 4)** were JSP Martcare FFP2 moulded respiratory masks. These masks offered '*protection from solid and liquid aerosol variants*'; they did not provide any protection from oxygen depletion or noxious gases.

[4] Goldstein M (December 2008). "Carbon monoxide poisoning". Journal of Emergency Nursing: JEN: Official Publication of the Emergency Department Nurses association / Struttmann T, Scheerer A, Prince TS, Goldstein LA (Nov 1998). "Unintentional carbon monoxide poisoning from an unlikely source". The Journal of the American Board of Family Practice

[5] www.nhs.uk/conditions/Carbon-monoxide-poisoning/pages/treatment.aspx



1	Very unlikely
2	Unlikely
	Likely

1	Slightly harmful
2	Harmful
3	Very harmful

1	No action is needed.
2	Can be tolerated, but make sure that it does not become worse.
3/4	Take action but subject to it being reasonable and sensibly possible
6	Must be attended to, you must reduce the risk.
9	Cannot be accepted and work/activity must not continue.

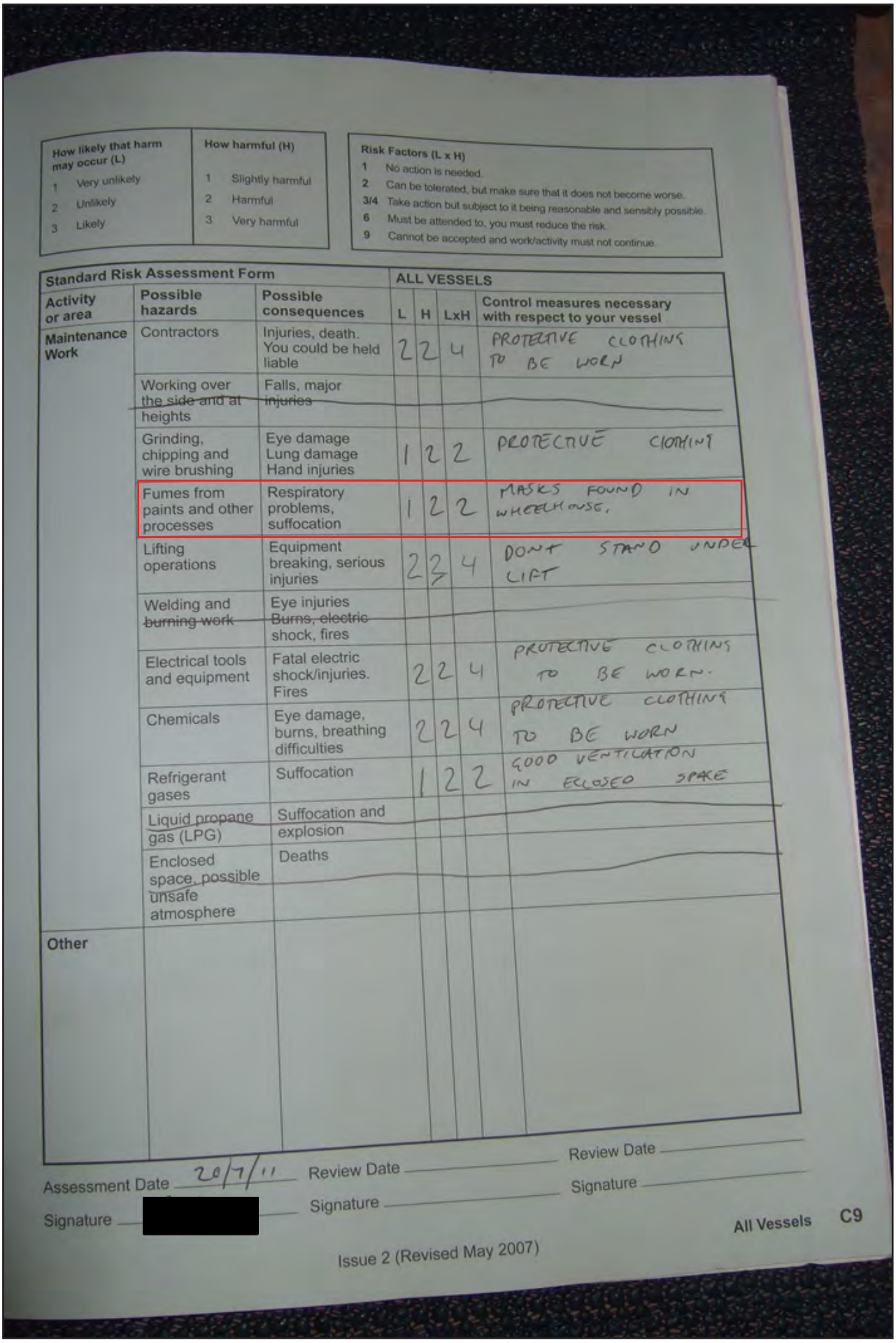
andard Risk Assessment Form — ALL VESSELS

ctivity area	Possible hazards	Possible consequences	L	H	LxH	Control measures necessary with respect to your vessel
gine om cont	New equipment or systems	Lack of knowledge – accident/damage	1	3	3	SUFFICIENT TRAINED SUPPLIED
	Lone working	No one aware that an accident has occurred	1	3	3	DONT WORK ALONE
ner						
ing ations	~~Unsafe fishroom atmosphere~~	~~Suffocation, deaths~~				
	Working areas on vessel and quayside	Slips, trips and falls – minor/ serious injuries	1	3	3	KEEP TIDY + CLEAN
	~~Landing gear~~	~~Serious injury~~				
	Fish/boxes falling from the hatch	Minor – serious injuries	2	2	4	ONCE LIFT IN OPERATION DONT STAND UNDER IT
	Use of warping head for landing	Man carried around – serious injury/death				
	Members of the public	Someone injured. Sued for damages	1	2	2	NO MEMBERS ALOUD IN VACINITY

ent Date 20/7/11 [redacted] Review Date _____ Review Date _____

Signature _____ Signature _____

Figure 14a: Seafish risk assessment extract



How likely that harm may occur (L)	How harmful (H)
1 Very unlikely	1 Slightly harmful
2 Unlikely	2 Harmful
3 Likely	3 Very harmful

Risk Factors (L x H)

1 No action is needed.
2 Can be tolerated, but make sure that it does not become worse.
3/4 Take action but subject to it being reasonable and sensibly possible.
6 Must be attended to, you must reduce the risk.
9 Cannot be accepted and work/activity must not continue.

Standard Risk Assessment Form — **ALL VESSELS**

Activity or area	Possible hazards	Possible consequences	L	H	LxH	Control measures necessary with respect to your vessel
Maintenance Work	Contractors	Injuries, death. You could be held liable	2	2	4	PROTECTIVE CLOTHING TO BE WORN
	Working over the side and at heights	Falls, major injuries				
	Grinding, chipping and wire brushing	Eye damage Lung damage Hand injuries	1	2	2	PROTECTIVE CLOTHING
	Fumes from paints and other processes	Respiratory problems, suffocation	1	2	2	MASKS FOUND IN WHEELHOUSE.
	Lifting operations	Equipment breaking, serious injuries	2	3	4	DONT STAND UNDER LIFT
	Welding and burning work	Eye injuries Burns, electric shock, fires				
	Electrical tools and equipment	Fatal electric shock/injuries. Fires	2	2	4	PROTECTIVE CLOTHING TO BE WORN.
	Chemicals	Eye damage, burns, breathing difficulties	2	2	4	PROTECTIVE CLOTHING TO BE WORN
	Refrigerant gases	Suffocation	1	2	2	GOOD VENTILATION IN ECLOSED SPACE
	Liquid propane gas (LPG)	Suffocation and explosion				
	Enclosed space, possible unsafe atmosphere	Deaths				
Other						

Assessment Date 20/7/11 Review Date _____ Review Date _____

Signature [redacted] Signature _____ Signature _____

All Vessels C9

Issue 2 (Revised May 2007)

Figure 14b: Seafish risk assessment extract

1.11 THE MCA'S 15 TO 24 METRE FISHING VESSEL CODE

The MCA's *'Fishing vessels (Safety of 15-24 Metre Vessels) Regulations 2002'* give statutory force to MSN 1770 (F) *'The Fishing Vessel Code of Safe Working Practice for the Construction and Use of 15 metre length overall (LOA) to less than 24 metre registered length (L) Fishing vessels'* (the code). The code applied to *Starlight Rays* at the time of the accident.

1.11.1 Salvage pumps

The code **(Annex E)** required that on existing vessels, at least one salvage pump should be power-driven and the second may take the form of:

- *a power-driven pump, (powered by separate means to the first pump); or*
- *a portable salvage pump; or*
- *a submersible pump, powered by separate means to the first pump; or*
- *a hand-operated bilge pumping system.*

The code stated that '*A portable salvage pump may also be used as an emergency fire pump and it is recommended that existing vessels… carry such a pump in addition to the minimum requirements*.'

Pumps used for this purpose are most commonly petrol-driven due to their relatively low cost and simplicity. They could alternatively be diesel-driven or electrically-powered from an independent battery supply. Salvage pumps are typically of the centrifugal type. This type of pump needs to have its suction line and the pump casing flooded with liquid before it can generate any discharge pressure. This is often achieved by ensuring that the suction line is under pressure – for example, by lowering the pump inlet to below the level of the fluid to be pumped. Where this cannot be done, the suction line can be fitted with a foot valve[6] to allow the pump casing and suction line to be filled with fluid so that the pump produces a discharge pressure as soon as it is started.

There is no requirement or guidance in the code for portable salvage pumps to be capable of being connected to the vessel's fire main system, to a fire nozzle, or that the suction is connected to an appropriate foot valve arrangement to minimise priming problems **(Figure 15)**.

1.11.2 BA and rescue equipment

There is no requirement for a fishing vessel of *Starlight Rays*' size to carry BA or dedicated rescue equipment. Neither of these was carried on board *Starlight Rays*.

[6] Foot, or check valves, are non return valves installed at the bottom of a pump suction line to prevent the line from draining and ensures that the pump can be primed.

Pump suction pipe - not fitted with foot valve

Starlight Rays' pump discharge hose

Fixed fire fighting arrangement

Figure 15: Portable pump hoses and the fixed fire system

1.11.3 Petrol storage

Following the accident, two empty plastic petrol containers were found outside *Starlight Rays*' mess room, at the entrance to the weather deck **(Figure 16)**. Prior to the accident the petrol was stored in a locker close to the crew accommodation. Storing petrol on board in this way introduces several possible hazards. The vapours from a leaking canister are flammable and can be ignited when exposed to an ignition source, the fire is then provided with the readily available fuel source from the petrol stored inside the containers. If a fire has already started for some other reason in a compartment where petrol is stored, it adds a considerable amount of fuel and creates a significant risk of an explosion. When the petrol is contained in a plastic, rather than a metal, container this risk is exacerbated. In larger, SOLAS[7] sized vessels there is a requirement to store petrol in containers in a location where they can be easily jettisoned over the side in an emergency.

There is no regulation or guidance for the storage of petrol on board fishing vessels. The MCA advises its fishing vessel surveyors and inspectors to provide skippers with guidance on suitable places to store petrol during their visits on board if this is required.

Figure 16: Petrol cans located inside the accommodation

[7] The International Convention on the Safety of Life at Sea (SOLAS) applies to vessels greater than 500 Gross Registered Tons (GRT)

1.12 RISK OF POLLUTION

Annex I of the International Maritime Organization's (IMO) International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL), prohibits the discharge of oil or oily mixture (except in an emergency) from all ships, including all fishing vessels.

1.13 SURVEY AND INSPECTION

1.13.1 MCA inspections

When engaged in work other than fishing, *Starlight Rays* was required to be surveyed annually by the MCA in order to be issued with a load line exemption certificate. This had been carried out most recently on 24 June 2011 **(Annex F)**. The survey report listed 15 deficiencies, most of which were required to be rectified before the vessel returned to sea. Among the deficiencies was a requirement that the emergency salvage pump should be run and witnessed by the crew within 2 weeks from the survey date. On 27 June 2011, following a request from the skipper, the superintendent engineer from Caley Fisheries Limited sent a facsimile letter to the MCA stating that all the deficiencies on *Starlight Rays* had been *'attended to'* **(Annex G)**.

Following the accident, on 30 August, a further survey was carried out by an MCA surveyor; the survey report identified 25 deficiencies in total **(Annex H)**. Of the original 15 deficiencies that were recorded during the 24 June 2011 survey, 10 had not been rectified or had been allowed to re-occur.

Due to limited resources, the MCA has a policy of not revisiting fishing vessels to check that deficiencies have been rectified. MCA surveyors provide deficiency reports to skippers, and rely on them to report in writing that the required improvements have been made.

1.14 PREPARATIONS FOR GUARD VESSEL DUTIES

1.14.1 Preparation and briefing

SFF Services Limited, a commercial company wholly owned by the Scottish Fishermen's Federation (SFF), nominated *Starlight Rays* as a suitable guard vessel to protect the BP Devenick field on Friday 19 August 2011. A Seacroft marine surveyor, on behalf of BP, had previously inspected the vessel on 27 June 2011 prior to earlier guard vessel work, and therefore no further inspection was required to be carried out before the contract was agreed.

On 22 August an SFF Services Limited representative carried out a Vessel Project Briefing on board *Starlight Rays*. This briefing guided the skipper through a pack of materials relating to the work, reporting forms, procedures and contact details for the other vessels and installations involved in the project. Contained in this pack of materials was an A3 sized poster of 'BP's golden rules of safety' **(Annex I)** that included their safety rules for, among others, confined (enclosed) space entry and the use of permits to work. The pack also contained a copy of the combined Technip and BP Devenick QHSE[8] Charter **(Annex J)** stating that '*Technip and BP are jointly*

[8] Quality, Health, Safety and Environment

committed to operations where QHSE is a core value'. Guidance provided from both organisations included leaflets on the following topics: *'Make it safe'* including *'Know and follow procedures'* and *'Follow BP Golden Rules'*.

1.14.2 Guard vessel contract

The contract for the guard vessel work was between SFF Services Limited and the owners of the mv *Starlight Rays* PD230, care of Caley Fisheries Limited. The contract hired the vessel for 18 days starting at 2400 on 23 August 2011 *'to provide protection for the Devenick Crossings and a section of the 34km of vulnerable pipeline being laid between the East Brae Platform and the Devenick Manifold and Wells…'* **(Annex K)**.

1.15 *SKANDI CARLA*

Skandi Carla, a purpose built ROV survey and construction support vessel **(Figure 5)**, was chartered by Technip for the BP Devenick Field project. There was no requirement for *Skandi Carla* to remain at the Devenick Field throughout the whole of the project, and there was no arrangement in place that *Skandi Carla*, or any other vessel, would provide emergency support to guard vessels. *Skandi Carla*'s rescue response was provided as required by international convention, as it would have been to any other vessel in distress.

SECTION 2 - ANALYSIS

2.1 AIM

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

2.2 THE ACCIDENT

2.2.1 CO poisoning

The engineer, Artis Sterkis, died of carbon monoxide poisoning from the petrol engine-driven pump's exhaust gas. The fish hold was not ventilated and the CO was able to accumulate. From the technical analysis conducted after the accident, it is considered likely that the concentration of CO close to the engine reached lethal levels after the engine had been running for between 30 and 60 minutes.

With no provision for forced ventilation, and only limited natural ventilation for long periods, the fish hold had the potential to become a dangerous enclosed space.

Tests on the pump after the accident showed that it would not prime and was incapable of pumping the contents of the bow thrust space. Had the pump worked as designed, it is estimated that the oily water could have been pumped out in a few minutes.

Why the engineer decided to use the pump, despite the warning signs that showed that the engine exhaust was poisonous and that it should not be used in enclosed spaces, will never be known for certain. Similarly, why the engineer persevered with running the engine despite his professional engineering knowledge and his experience on board fishing vessels is unknown. It is possible that when Artis Sterkis started the engine he thought that the task would be done quickly and that the effect of the exhaust fumes would be minimal. If this was so, it would explain why he chose to use the pump and why he did not open more hatches to increase the natural ventilation.

Although the crewman was aware of a strange smell, he did not intervene to stop the pump being used because he did not understand the dangers that were involved.

In persevering to get the pump to work, the engineer ran the engine for sufficient time for the CO level in the fish hold to rise to a dangerous level that was capable of causing death if the victim was exposed to it for enough time. Artis Sterkis's exposure to CO would have been relatively high as he was working close to the pump, trying to make it prime, while it was running. It is likely that his decision-making ability was adversely affected as the levels of CO in his body increased; this could account for his perseverance with the task despite the increasing personal risk.

This tragic accident serves as a reminder to the fishing industry of the significant risks of operating petrol or diesel engine-driven portable pumps in enclosed spaces, and particularly in fish holds.

Portable engine-driven pumps must only be operated in the open air, unless a proven method of supplying air and ventilating exhaust gases is in place. These lessons must be spread throughout the fishing industry to help prevent a similar accident from happening again.

2.2.2 On board management

Starlight Rays' owner, who was skipper at the time of the accident, was responsible for the overall safety of his crew and responsible for assessing, and mitigating, the risks that they faced.

Pumping out the bow thruster space while *Starlight Rays* was at sea had the potential to be a very hazardous activity: it involved opening up the watertight bow thruster space; operating a petrol-driven pump below decks; and, discharging contaminated water overboard. It was, therefore, the type of activity that should not have been conducted without the full awareness and prior approval of the skipper. Because of the hazards involved, approval to commence the task should only have been given once all the relevant risks had been identified and adequate control measures put in place. None of this appears to have occurred before the engineer and crewman started work on this occasion.

At the time of the accident in the fish hold, the skipper was carrying out his guard vessel watch. The CCTV display was located next to the radar in the wheelhouse and would have been clearly visible to him. The picture was set up to show the fish room and the access ladder; it is very hard to understand how the skipper did not see the engineer and the crewman as they went in and out of the fish room, carrying the pump and hoses, throughout the course of the morning and early afternoon. Had he seen the two men, he should immediately have queried their activity as no maintenance or other tasks had been planned for the day.

All skippers need to be vigilant in order to identify when their crew are working dangerously. They must then take immediate action to stop the work and find a safer way of completing the task.

2.2.3 Assessing risks

A risk assessment had been completed by *Starlight Rays*' main skipper. The risk assessment had not considered the risks of operating the petrol-driven pump on board. Similarly, the risk assessment did not consider the risks of toxic fumes building in a fish hold that had no forced ventilation. Consequently, there was nothing in place to prevent this hazard from occurring, to detect if a dangerous atmosphere existed, or to make the atmosphere safe.

With no BA or gas detectors available on board *Starlight Rays*, there was no means of rescuing an unconscious person from the noxious atmosphere in the fish hold without placing the other crewmen in danger. The risk assessment's control measure of using dust masks to limit the effects of toxic fumes was flawed, and potentially provided a false sense of security for the crew. With no medical oxygen on board, there were limited means of treating a crewman with CO poisoning.

The crew had not thought enough about the risks they faced when attempting to pump out the oily water from the bow thruster space. This could have been done either by reviewing the existing risk assessment, or by the crew talking through what they intended to do before starting work. An opportunity to do this had occurred when the crew gathered for breakfast at 0930. Crew on fishing vessels need to think more methodically about the risks they face, both when completing their risk assessments and before a task is started. Efforts then need to be made to reduce the identified hazards to an acceptable level, or a decision made to postpone the work until a safer way of doing it can be found. The crew should also plan how best to respond if something goes wrong with the task and someone needs help.

It is particularly tragic that the use of the petrol-driven pump could have been avoided completely. Proper inspection and maintenance of the bow thruster space hatch lid would have shown that the seal was not effective; if this had been replaced, water would not have accumulated in the space. There was also a fixed bilge suction line in the bow thruster space. If the crew had understood the system properly and been able to arrange the discharge into a storage tank, the oily water could have been disposed of safely and in accordance with MARPOL.

Hazardous tasks on board fishing vessels, including those not directly related to fishing, need to be considered carefully. Risk assessments, such as those based on the templates provided by Seafish, work only when they are used properly. However, the principles are straightforward: work out what needs to be done, think about what could go wrong, do something either to reduce the chance of the task going wrong, or, to make sure that no-one gets hurt if it does. Finally, think about what actions should be taken if somebody is injured and needs help.

2.3 OTHER SAFETY ISSUES

2.3.1 Credibility of emergency portable salvage pumps

The MCA encourages owners of 15m to 24m fishing vessels to carry on board their vessels independently powered pumps, for use as a salvage pump and an emergency fire pump, as they are generally more effective than the hand-powered pumps that were traditionally fitted. Petrol engine-driven pumps are the most popular type found on fishing vessels due to their low cost and relative simplicity. However, this accident shows that petrol-driven pumps may not work as intended and introduce new hazards on board fishing vessels.

The closer a salvage pump is positioned to the water, the more easily it can be primed because the suction head is reduced. This introduces the temptation for crew to take a pump down into an internal space so that they can prime the pump. This might be acceptable if there is good ventilation and the exhaust gases are carried away through an extension hose but, if not, the exhaust gases can accumulate in the compartment, with fatal consequences.

Starlight Rays' salvage pump's suction hose was not fitted with a foot valve; there is no requirement or recommendation for one to be used. Fitting a foot valve to the suction hose enables a salvage pump to be primed higher above the water level, therefore reducing the need for crewmen to take the pump into internal spaces.

As an emergency fire pump, a portable engine-driven pump would take its suction from the sea. Without a foot valve, the pump would need to be close to the waterline before it could be primed. On fishing vessels such as *Starlight Rays* this might be achieved from the lower freeboard after decks. It would be much more difficult from the higher forward decks.

The flexible discharge hose on *Starlight Rays*' pump was not suitable for fitting to a fire nozzle and, with its open flexible end, it would have been difficult to make it form a jet of water that could be directed onto a fire. It was not possible to connect the portable pump's discharge hose to the fire main on *Starlight Ray*s so that existing fire hoses and nozzles could be used if the main pump or the power supply failed. There is no requirement or recommendation for this simple capability to be provided on 15-24m fishing vessels.

While an independently powered pump could make a difference in saving a vessel in distress, it is clear that portable engine-driven pumps have their limitations and introduce new hazards on board. The pump on *Starlight Rays* was deadly when used as a salvage pump and would have been no use as an emergency fire pump. However, the simple fact that it was on board satisfied the code. The MCA surveyor's requirement that the pump should be demonstrated with all the crew present within 2 weeks of his inspection, was not enforced and, consequently, was not done. In order to prevent a false sense of security and avoid future tragedies, fishing vessel operators and the MCA must consider in detail the practicalities of how portable engine-driven pumps are to be used for both salvage and fire-fighting purposes. Written guidance, enforced by a requirement in the code would help; however, this will only be effective if the MCA introduces a policy of verifying that these pumps are fit for their intended purpose when conducting their scheduled surveys and targeted inspections on fishing vessels. Fishermen must be made more aware of the limitations of portable pumps and the potential dangers if they are used incorrectly.

2.3.2 Pollution

Of the 1.8m^3 of oily water in the bow thruster space, around 0.25m^3 was found to be hydraulic oil. It might have been possible, if the water and oil had sufficiently separated, to have pumped only the water overboard and left the oil in the bow thruster space. However, the only method of detecting when the oil level in the bow thruster space had been reached would have been when oil was pumped overboard and seen in the sea. Although the amount of oil would have been relatively small, it would have caused some pollution and would have contravened the IMO's MARPOL convention and UK law.

While not directly related to the accident, the crew's disregard for the MARPOL convention and UK law was evident on board *Starlight Rays*. Any pollution could have had a negative effect on the crew's own livelihood, and the attempt to dispose of pollutants while at sea was an extremely poor reflection on the crew's personal and professional standards.

2.4 EMERGENCY RESPONSE

2.4.1 On board response

The skipper and the watchkeeper responded to the accident by following the crewman, who was already affected by CO, into the poisonous atmosphere of the fish hold in an attempt to rescue the engineer.

The skipper realised that the engineer had been overcome by the effects of the engine exhaust and instructed the watchkeeper to open the hatches to allow more natural ventilation into the fish hold. The crew expected the effects of this natural ventilation to act quickly, but the fish hold atmosphere remained highly toxic. Both the crewman and the watchkeeper suffered from CO poisoning during the subsequent rescue, and both required medical treatment and evacuation by helicopter. The crew had no gas monitors to detect the presence of the toxic gas in the fish hold and no BA to enable them to enter the compartment safely; they could not rescue the engineer without risking their own lives.

The time it takes to ventilate a large space, such as a fish hold, to make its atmosphere safe to breathe, must not be underestimated. The hatches from the weather deck into the processing deck and from the processing deck into the fish hold remained open throughout the vessel's return voyage. Yet the test of the atmosphere in the fish hold, carried out once *Starlight Rays* was alongside her berth in Peterhead 24 hours after the accident, showed that the CO level was still dangerously high. Ventilation fans then forced fresh air into the fish hold for about 1 hour. The atmosphere in the fish hold was retested, but it was still too hazardous to permit entry. The fish hold was finally declared to be safe to enter the following morning, over 36 hours after the accident.

The unconscious engineer was exposed to toxic CO gas throughout the rescue, and his condition would have continued to deteriorate. In an attempt to assist the engineer, the crew used a dust mask to cover his mouth. However, this mask provided no protection from the toxic gas as it was not designed for this purpose. Without oxygen or a supply of fresh air from a BA set there was no means of treating the engineer until external assistance arrived.

Starlight Rays' crew did not have the skills or equipment to be able to rescue the engineer without additional help. They had to wait for *Skandi Carla*'s rescue team and the rescue helicopter's crew before the engineer could be lifted out and treated. Sadly, their attempts to help achieved nothing other than to risk their own lives. That a second member of the crew collapsed at the scene, and a third later suffered the effects of CO poisoning, indicates how close this accident came to resulting in multiple deaths.

The desire to enter a dangerous atmosphere in an enclosed space to rescue another crewman, and friend, can be overwhelming; however, this response can make the situation far worse, and the dangers of entering enclosed spaces must be emphasised to fishermen.

2.4.2 *Skandi Carla*'s response

Starlight Rays' skipper asked the crew of *Skandi Carla* for assistance, and four volunteers boarded the rescue boat and transferred over to *Starlight Rays* to help. The volunteers, two boat's crew and a two-man rescue team, had no experience of fishing vessels. They were not aware of the safety equipment that was carried and anticipated that there would be BA sets on board. One of the rescuers was a medic and took oxygen with him, which he used to treat the crewman who was lying unconscious on the deck. As soon as they found out that *Starlight Rays* had no BA sets on board, they asked for BA to be sent over from *Skandi Carla*.

A rescuer wearing BA entered the fish hold and tried to move the unconscious engineer into the fish bin. The engineer was a large man and the rescuer could not move him on his own. Nevertheless, the rescuer persisted and held the unconscious engineer in the helicopter rescue strop so that he could be lifted out.

The rescue party responded quickly to a difficult situation in an unfamiliar environment of which they had little knowledge or training. Their willingness to put themselves at risk to go to the aid of other seafarers was commendable.

However, and without detracting from the rescue party's efforts, there are always lessons that can be learnt following an accident such as this.

In any situation that requires BA to be worn, it is always better not to work alone, as there is no support should something go wrong. When working in BA, and particularly in an emergency situation, there should be at least one other person standing by in BA ready to help if needed.

The engineer was still breathing when the rescue began. His condition might have been stabilised by giving him air from a BA set or medical oxygen while arrangements were made to lift him out of the fish hold. As there was only one BA set and the only oxygen cylinder was being used to treat the crewman, this was not possible.

The accident on *Starlight Rays* also reinforces the difficulty of lifting an unconscious person out of a compartment. An improvised rescue harness, made by suitable knots tied in a mooring line, might have allowed the rescuers to have lifted the engineer out of the fish hold before the rescue helicopter arrived. There was a risk of the engineer slipping from an improvised harness, but this risk could have been balanced against the danger of his continued exposure to the toxic atmosphere.

The rescue team questioned the cause of the noxious atmosphere and considered that it was more likely that the men had collapsed due to the release of refrigerant gas rather than CO. Refrigerant gas would not have had a toxic effect, but would have displaced the air from the bottom of the fish hold. If this had been the case, testing the oxygen available in the fish hold could have been misleading unless the test was repeated at different levels from the hatch down to the deck.

However, measuring the oxygen level alone can not be relied on to confirm if the atmosphere in a compartment is safe to breathe. Dangerous levels of CO can exist in the air without affecting the amount of oxygen that is available. High levels of CO remained in *Starlight Rays*' fish hold even after it returned to Peterhead, reinforcing the need for extreme caution when dealing with accidents in enclosed spaces. The crew of *Vos Ranger* lent their multigas meter to those on *Starlight Rays*. This

meter was capable of measuring concentrations of oxygen, CO, CO_2 and potentially explosive hydrocarbon gases. Had it been used, it would have shown the extent of the contamination from the exhaust gases.

2.5 INSPECTION REGIME

2.5.1 MCA

The MCA's annual load line exemption survey of *Starlight Rays*, carried out 2 months prior to the accident, highlighted numerous deficiencies that were to be rectified either prior to returning to sea, or within the following 2 weeks. The obligation to demonstrate, within 2 weeks, how the portable pump could be used as an emergency fire pump with all the crew present was one of these requirements and was not done. This simple test would have highlighted the dangers of operating the pump between decks to all the crew and would have shown that the pump would not have been effective in fighting a fire.

It is the MCA's policy for its surveyors to trust skippers and owners to report that deficiencies have been rectified without checking for themselves. This reduces their workload by avoiding the need to return to the vessel and confirm that it will return to sea in a safe condition. When MCA surveyors inspected the boat after the accident, the majority of the previously identified deficiencies remained, and even more deficiencies were found.

The skipper, responsible for the safety of the vessel and the crew, was aware that the MCA's surveyors were very unlikely to revisit the vessel for some time and did not pay sufficient attention to rectifying many of the deficiencies that the survey had identified. The skipper's decision to return to sea without rectifying the deficiencies properly, showed contempt for the MCA's survey process and blatant disregard for the safety of his crew.

This accident is a reminder to skippers of fishing vessels that, by leaving known deficiencies uncorrected, they may expose their vessel and crew to unnecessary risk.

2.5.2 Caley Fisheries Limited

The engineering superintendent from Caley Fisheries Limited sent a signed declaration to the MCA stating that all the deficiencies that were identified during the load line survey had been '*attended to*', when this was not true. The superintendent did not check that the corrective actions that were required had been carried out. Rather than declaring this important information on behalf of the skipper, he took personal responsibility for its accuracy.

Superintendents, and others, representing fishing vessel operators should take actions as necessary to ensure that any declarations that they make to the MCA, or other official bodies, are true.

2.5.3 Petrol storage

There is no regulation or guidance on the storage of petrol on fishing vessels. The MCA has recommended that independently powered salvage pumps should be carried on 15 to 24m LOA fishing vessels; the most cost effective means of complying with the recommendation is the use of a petrol engine-driven pump. The carriage of petrol on board vessels of this size is therefore highly likely.

The MCA should provide guidance and advice to encourage safer stowage of petrol on board fishing vessels.

2.6 FATIGUE

There is no evidence that any of the crew were suffering from fatigue and, therefore, it is not considered to be a contributing factor to this accident.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. The engineer, Artis Sterkis, died of carbon monoxide (CO) poisoning from the petrol engine-driven pump's exhaust gas. *Starlight Rays*' fish hold was not ventilated and the CO was able to accumulate until it reached lethal levels. [2.2.1]

2. With no forced ventilation and limited natural ventilation the fish hold had the potential to become a dangerous enclosed space. [2.2.1]

3. The salvage pump would not prime, and it is likely that the engine ran for longer than the engineer anticipated while he attempted to make it draw suction. As the CO levels in the fish hold rose, the engineer's judgment and perception of the danger he was in was likely to have been affected. [2.2.1]

4. The crewman did not stop the pump being used in the fish room because he did not understand the dangers that were involved. [2.2.1]

5. It is difficult to understand how the skipper did not see the engineer and crewman on his CCTV monitor as they attempted to use the pump. All skippers need to be vigilant in order to identify when their crew are working dangerously. They must then take immediate action to stop the work and find a safer way of completing the task. [2.2.2]

6. The crew had not considered the risks of pumping out the bow thruster space. Hazardous tasks on board fishing vessels need to be effectively considered. Risk assessments, when properly used, should help crew identify and mitigate the hazards they face. Additionally, the most appropriate emergency response to potentially hazardous tasks needs to be assessed. [2.2.3]

7. It is clear that portable engine-driven pumps have their limitations, and introduce new hazards on board. The pump on *Starlight Rays* was deadly when used as a salvage pump, and would have been of little use as an emergency fire pump. [2.3.1]

8. *Starlight Rays*' crew did not have the skills or equipment to be able to rescue the engineer without additional help. They had to wait for *Skandi Carla*'s rescue team and the rescue helicopter's crew before the engineer could be lifted out and treated. Sadly, their attempts to help achieved nothing other than risk their own lives. [2.4.1]

3.2 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE BEEN ADDRESSED OR HAVE NOT RESULTED IN RECOMMENDATIONS

1. It is possible that when Artis Sterkis started the salvage pump's engine he thought that the task would be done quickly and that the effect of the exhaust fumes would be minimal. If this was so, it would explain why he chose to use the pump inside the fish hold and why he did not open more hatches to increase the natural ventilation. [2.2.1]

2. In order to prevent a false sense of security and avoid future tragedies, fishing vessel operators and the MCA must consider in detail the practicalities of how portable engine-driven pumps are to be used for both salvage and fire-fighting purposes. [2.3.1]

3. Fishermen must be made more aware of the limitations of portable pumps and the potential dangers if they are used incorrectly. [2.3.1]

4. The time it will take to ventilate a large space, such as a fish hold, to make it safe for entry, should not be underestimated. [2.4.1]

5. The engineer's condition might have been stabilised by giving him air from a BA set or medical oxygen while arrangements were made to lift him out of the fish hold. As there was only one BA set, and the only oxygen cylinder was being used to treat the crewman, this was not possible. [2.4.2]

6. The rescue party's assessment, following the evacuation of the watchkeeper, that the atmosphere was safe because the oxygen levels were acceptable, was not correct. Dangerously high levels of CO remained in the fish hold. Oxygen levels alone cannot be used to confirm that an enclosed space is safe to enter. [2.4.2]

7. This case demonstrates the flaws in the MCA's policy of trusting fishing vessel owners to rectify deficiencies without surveyors checking that the work has been completed satisfactorily. [2.5.1]

8. This accident is a reminder to skippers of fishing vessels that uncorrected deficiencies may significantly increase the risk to their vessels and their crews. [2.5.1]

9. Superintendents, and others, representing fishing vessel operators should take actions as necessary to ensure that any declarations that they make to the MCA, or other official bodies, are true. [2.5.2]

10. The MCA should provide guidance and advice to encourage safer stowage of petrol on board fishing vessels. [2.5.3]

SECTION 4 - ACTION TAKEN

The **MAIB** has issued a Safety Flyer to the fishing industry **(Annex L)**.

The **MCA** has undertaken to:

- Update MGN 309 to include the dangers of enclosed spaces in general.
- Provide more detailed guidance on salvage pumps in Guidance to Surveyors and the Code of Practice documents.
- Embolden existing guidance on fuel being stowed in containers that can be easily jettisoned.
- Arrange for their fishing vessel surveyors to:
  - Make the dangers of enclosed spaces one of their discussion topics with fishermen when conducting surveys and inspections.
  - Check that the portable salvage pumps are fitted with foot valves on a reinforced suction pipe.
  - Check that pumps operate effectively during drills.
- Request that Seafish:
  - Ensures that the dangers of enclosed spaces and the difficulties of rescuing injured crewmen are in the syllabi and discussed in the fire-fighting and safety awareness courses.
  - Ensure that, when they are supervising the construction of a fishing vessel, all void spaces are fitted with a bilge suction line.
- Submit the following issues for discussion at Fishing Industry Safety Group:
  - Ensure that the Communications Sub Committee discusses the lessons learnt from this investigation and transmits these lessons to fishermen.
  - Ensure that the Operations Sub Committee discusses the safety problems of enclosed and unventilated spaces and agrees appropriate actions.

The **owner (and skipper) of *Starlight Rays*** has:

- Supplied an electrical semi-submersible pump on board, in addition to the stand-alone petrol engine-driven pump.
- Completed, with external support, a review of the vessel's risk assessments.
- Rectified all outstanding deficiencies to the satisfaction of the Maritime and Coastguard Agency.

SECTION 5 - RECOMMENDATIONS

The **owner** and **skippers of *Starlight Rays*** are recommended to:

2012/120 Improve the standard of occupational safety and protection for crew working on their vessel by:

- Ensuring that the use on board of any portable engine-driven pumps is in accordance with the guidance provided by the MCA.
- Educating and supervising crew to prevent them from using dangerous working practices.

Marine Accident Investigation Branch
June 2012

Marine Accident Report