Report on the investigation into the fall of a suspended buoy on board the workboat **Annie E**

> resulting in serious injury to a deckhand off the Isle of Muck, Scotland on 3 April 2021





SERIOUS MARINE CASUALTY

REPORT NO 12/2022

DECEMBER 2022

The United Kingdom Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 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."

<u>NOTE</u>

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For all enquiries:

Marine Accident Investigation Branch First Floor, Spring Place 105 Commercial Road Southampton SO15 1GH United Kingdom

Email: <u>maib@dft.gov.uk</u> Telephone: +44 (0)23 8039 5500

Press enquiries during office hours: +44 (0)1932 440015 Press enquiries out of hours: +44 (0)300 7777878

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

SYN	IOPSIS		1
SEC		I - FACTUAL INFORMATION	2
1.1	Particu	lars of Annie E and accident	2 3 3 3 5 7 7 7
1.2	Narrat		3
	1.2.1	Background	3
	1.2.2	The accident	3
1.3	Post-a	ccident	5
1.4	Annie E		
	1.4.1	General	7
	1.4.2	Mallaig Marine Ltd	7 7
		Manning and crew training	
	1.4.4	Work schedule	9
	1.4.5	Lifting equipment	9
1.5	The de	eckhand	9 9 9
	1.5.1	Career and training	9
	1.5.2	Service on board Annie E	9
		Injuries	9
1.6		Scotland Limited	10
	1.6.1	General	10
	1.6.2	Fish farm operation	10
	1.6.3	Muck fish farm	10
	1.6.4	Contractual arrangement with Mallaig Marine Ltd	14
1.7	The gr	id buoy	14
	1.7.1	General	14
	1.7.2	Cipax buoy user manual	16
		Grid buoy operation, maintenance and failures	18
	1.7.4	The grid buoy failure	18
1.8	The gr	id buoy lift	20
	1.8.1	The plan	20
	1.8.2	Method statement and risk assessments	20
	1.8.3	Grid buoy lift reconstruction	21
1.9	Regula	ations and guidance	22
	1.9.1	Guidance to seafarers	22
	1.9.2	Shipboard lifting equipment regulations	23
	1.9.3	Training of workboat crew	23
	1.9.4	•	23
SEC		2 - ANALYSIS	25
2.1	Aim		25
2.2	Overvi	ew	25
2.3		eckhand's injuries	25
2.4		id buoy	25
•	2.4.1	•	25
		Grid buoy failure	26
	2.4.3	Grid buoy installation, maintenance and inspection	27
			_ 1

2.5	The grid buoy lift		
	2.5.1 Grid buoy lifting method	27	
	2.5.2 Method statements and risk assessments	27	
	2.5.3 Estimation of risk	28	
2.6	Experience and training	28	
SEC	TION 3 – CONCLUSIONS	29	
3.1	Safety issues directly contributing to the accident that have been addressed or resulted in recommendations		
3.2	2 Other safety issues not directly contributing to the accident		
SECTION 4 - ACTION TAKEN 3			
4.1	Actions taken by other organisations	30	
SECTION 5 - RECOMMENDATIONS			

FIGURES

Figure 1:	Annie E deck arrangement
Figure 2:	Location of the accident
Figure 3:	Approximate positions of Annie E's crew immediately before the accident
Figure 4:	Annie E general arrangement
Figure 5:	Mowi Scotland Limited fish farm locations
Figure 6a:	Aerial view of Muck fish farm
Figure 6b:	Plan view of Muck fish farm
Figure 7:	Components of Muck fish farm mooring arrangement (pen 4)
Figure 8:	Cipax CB1100 buoy
Figure 9:	Illustration based on the user manual's recommended lifting procedure for grid buoy
Figure 10:	Failed grid buoy components
Figure 11:	Wear mechanism of grid buoy float and tie rod on upper end plate
TABLES	

 Table 1:
 Example of MMLP8 hazards and control measures

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ALB	-	all-weather lifeboat
COSWP	-	Code of Safe Working Practices for Merchant Seafarers
kg	-	kilogram
LOLER	-	The Merchant Shipping Vessels (Lifting Operations and Lifting Equipment) Regulations 2006
m	-	metre
mm	-	millimetre
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
Mowi	-	Mowi Scotland Limited
nm	-	nautical mile
PFD	-	personal flotation device
PPE	-	personal protective equipment
RNLI	-	Royal National Lifeboat Institution
SI	-	Statutory Instrument
SWL	-	safe working load
t	-	tonnes
UTC	-	universal time coordinated
VHF	-	very high frequency
WAH	-	working at height

TIMES: all times used in this report are UTC+1 unless otherwise stated.

SYNOPSIS

At approximately 1315 on 3 April 2021, a deckhand on board the workboat *Annie E* was injured at a fish farm off the Isle of Muck, Scotland. *Annie E*'s crew were using the workboat's forward crane to lift a grid buoy that was connected to the fish farm's network of securing lines. The grid buoy had been lifted about 9m from the water when its structure failed, causing it to fall and strike the deckhand.

First aid was administered to the injured deckhand and *Annie E*'s skipper immediately called for shore assistance. The deckhand was subsequently transferred to hospital by coastguard helicopter and treated for severe injuries that required several operations in the months that followed.

The investigation identified that the grid buoy was not being lifted in accordance with the manufacturer's guidance and that it was not certified as lifting equipment. Examination of the lifted grid buoy showed that it had suffered a mechanical failure to its metal components. The deckhand was injured when the buoy fell because he was momentarily standing under a suspended load, which was contrary to both company risk assessments and industry guidance.

Since the accident *Annie E*'s owner, Mallaig Marine Ltd, has made changes to company risk assessments and method statements on workboat grid buoy lifting operations. The fish farm owner, Mowi Scotland Limited, has issued guidance to Mallaig Marine Ltd on the correct grid buoy lifting method to follow when undertaking maintenance to fish farm infrastructure. Based on these actions, the MAIB has made no recommendations in this report.



Image courtesy of Mallaig Marine Ltd

Annie E

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF ANNIE E AND ACCIDENT

SHIP PARTICULARS

Vessel's name	Annie E
Flag	United Kingdom
Classification society	Bureau Veritas
IMO number	922411
Туре	Workboat
Registered owner and managers	Mallaig Marine Ltd
Construction	Steel
Year of build	2017
Length overall	21.6m
Gross tonnage	90.6
Minimum safe manning	3

VOYAGE PARTICULARS

Port of departure	Tobermory, Scotland
Port of arrival	Mallaig, Scotland
Type of voyage	Commercial

MARINE CASUALTY INFORMATION

Date and time	3 April 2021 at approximately 1315
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Off the Isle of Muck, Scotland. 56°50.6'N 006°12.7'W
Place on board	Main deck forward
Injuries/fatalities	Injury to deckhand
Damage/environmental impact	Buoy rendered unfit for service
Ship operation	Fish farm maintenance
Voyage segment	Moored (to fish farm)
External & internal environment	Fine weather, light winds and good visibility
Persons on board	3

1.2 NARRATIVE

1.2.1 Background

The aquaculture industry farms fish in large offshore nets, known as pens, which are held in a grid that is secured to the seabed by a network of anchors and supported by chains, ropes and buoys. Fish farms are often in locations exposed to prevailing wind and tide and it is common for the grid components to become worn, for anchors to drag, and for buoys to be displaced. Fish farm operators use workboats to conduct fish farm installation, routine inspection, and maintenance tasks.

1.2.2 The accident

At 0600¹ on 3 April 2021, the workboat *Annie E* (Figure 1), crewed by a skipper and two deckhands, departed Tobermory, Scotland, bound for the Isle of Muck (Figure 2). The weather was fine, with light winds and clear visibility. *Annie E*'s crew spent the morning lifting and inspecting three boat moorings around a fish farm operated by Mowi Scotland Limited (Mowi), approximately 0.5 nautical miles (nm) north-east of the Isle of Muck.

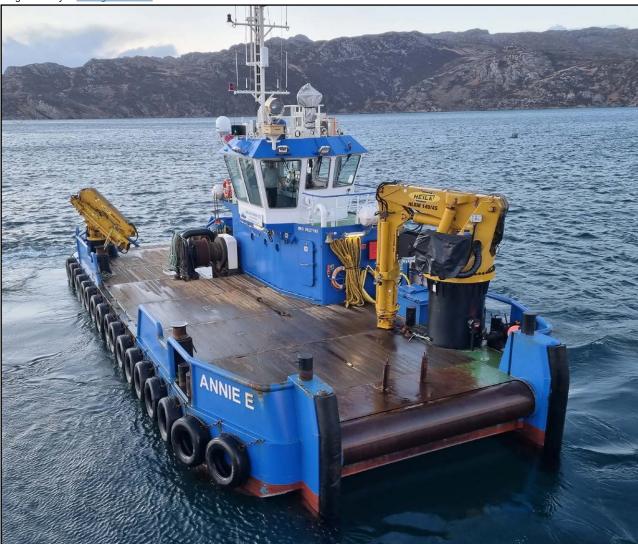


Image courtesy of Mallaig Marine Ltd

Figure 1: Annie E deck arrangement

¹ British summer time (UTC+1).

Reproduced from Admiralty Chart 0002-0 and (inset) 2207-0 by permission of HMSO and the UK Hydrographic Office

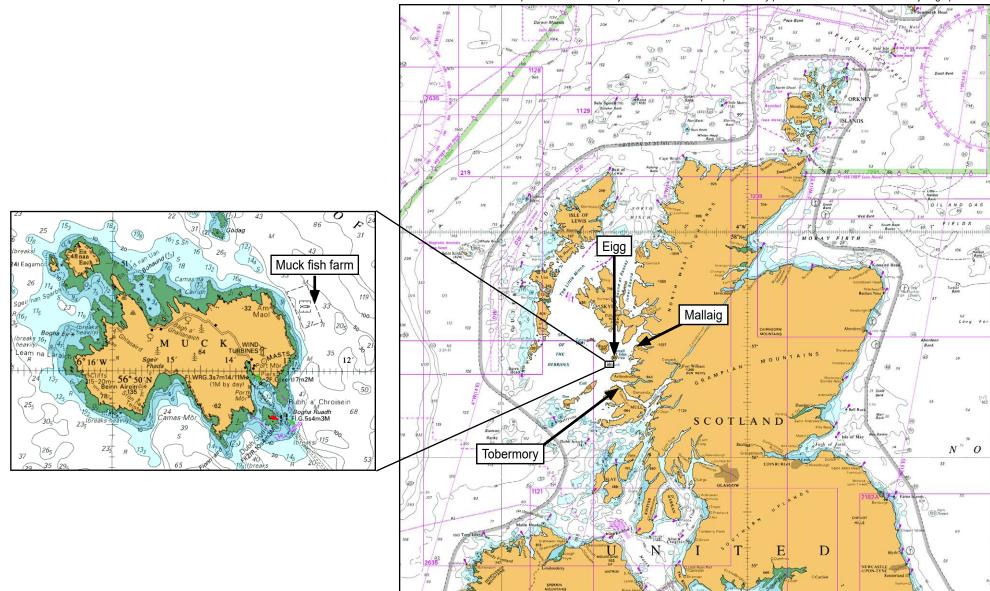


Figure 2: Location of the accident

At 1215, the last mooring buoy inspection was completed and *Annie E*'s skipper set a course to return the vessel to its home port of Mallaig. A short while later, as the vessel passed the Muck fish farm, the skipper saw that one of its grid buoys, known colloquially as grey buoys, was out of position, indicating that its mooring anchor needed to be recovered and re-laid, and he altered course toward the fish farm. Once closer to the grid buoy, he also noticed that the anchor's tripping buoy² was missing.

The skipper stopped the vessel, conducted a tool box talk with the crew and explained that the grid buoy needed lifting to access the anchor line. The skipper then completed a lift plan operations record, and the crew prepared *Annie E*'s forward crane and deck winch in readiness for the planned lifting operation.

At about 1310, the skipper slowly manoeuvred *Annie E* so that the grid buoy was close to the bow roller. One of the deckhands (the crane operator) prepared to lift the grid buoy by moving *Annie E*'s forward crane into position using its remote control unit. The other deckhand laid chest down on the deck and reached out and attached the crane hook to the lug on top of the grid buoy. He then stood up and walked aft to collect the winch wire, shackle and connecting strop. The crane operator raised the crane jib and lifted the grid buoy about 9m above the water until the grid connecting strop, known as a flexi link, was hanging in front of *Annie E*'s bow, clear of the water. The deckhand walked forward and prepared to reach out to thread the connecting strop through the flexi link and attach the winch line shackle **(Figure 3)**.

As the crane operator turned toward *Annie E*'s starboard bulwark to hang the forward crane's remote controller on its hook, he saw the grid buoy float fall and strike the deckhand. The crane operator went immediately to the injured deckhand, who was curled on deck near the bow. The deckhand was semiconscious and his safety helmet was on the deck next to him.

At the time of the accident, the skipper had been looking away to starboard to assess *Annie E*'s position but saw the buoy hit the water in his peripheral vision. He immediately put *Annie E*'s engine astern and stopped the workboat clear of the fish farm. The skipper left the wheelhouse and, as he was descending the ladder to the main deck, the crane operator shouted that the deckhand was severely injured and required assistance. At 1315, having returned to the wheelhouse, the skipper called the coastguard on VHF radio channel 16.

1.3 POST-ACCIDENT

The crane operator lifted the deckhand to his feet and tried to help him walk aft to *Annie E*'s accommodation on the main deck. The deckhand collapsed after a few steps so the crane operator moved him to the shelter of the starboard bulwark. The crane operator supported the deckhand, cut off his personal flotation device (PFD) to enable him to breathe and applied a clean cloth to his head wound. The skipper started to navigate *Annie E* at full speed toward Mallaig, which was 2 hours away.

By 1324, the coastguard had tasked a helicopter and the Mallaig RNLI all-weather lifeboat (ALB) to *Annie E* and advised the skipper to rendezvous with them east of the Isle of Eigg (**Figure 2**).

² The tripping buoy is attached to the grid buoy's anchor and helps locate and recover it.

For illustrative purposes only: not to scale

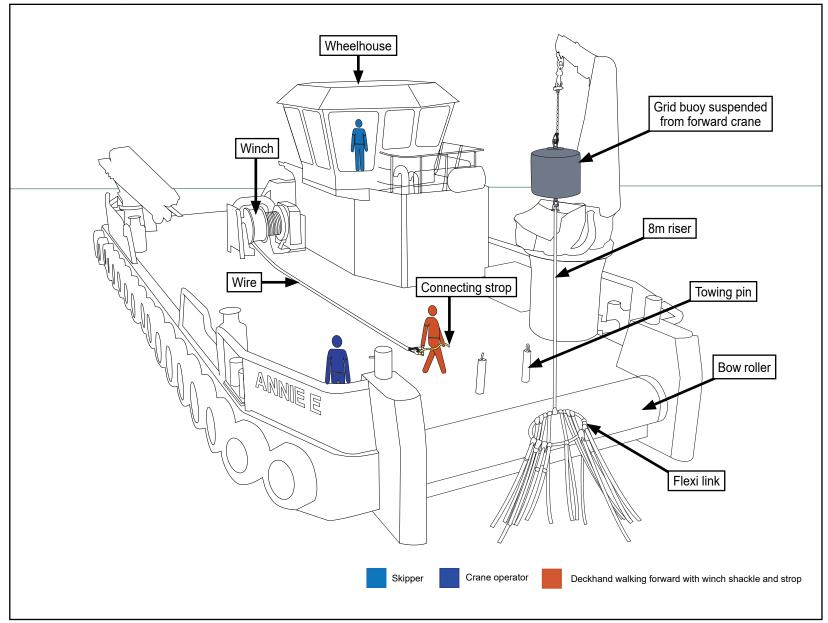


Figure 3: Approximate positions of *Annie E*'s crew immediately before the accident

At 1404, the ALB was on scene. At 1418, the helicopter arrived and lowered the winchman onto the ALB, which then went alongside *Annie E*. The winchman and two lifeboat crew transferred across to attend to the deckhand and, following medical assessment and first aid treatment, the deckhand was put on a stretcher and winched into the helicopter. At 1515, the helicopter departed and, at 1627, it arrived at Queen Elizabeth University Hospital, Glasgow. At 1645, *Annie E* berthed at Mallaig.

1.4 ANNIE E

1.4.1 General

Annie E was a 21.6m steel hulled workboat, built in 2017 for Mallaig Marine Ltd. On the main deck was a raised wheelhouse, a crew mess and a deck store. Below the main deck was the engine room and crew accommodation. The main deck had a 25.10t safe working load (SWL) hydraulic crane to forward and an 8t SWL hydraulic crane to aft. A 50t towing winch and a 10t tugger winch were used to haul anchors and buoys onto the main deck over the bow and stern transverse rollers; the opening at the stern was fitted with safety wires. Two steel towing pins were welded to the main deck, adjacent to the forward bow roller (**Figure 4**).

1.4.2 Mallaig Marine Ltd

The owner of Mallaig Marine Ltd had worked in the fish farming industry for 15 years, carrying out and supervising fish farm installation and maintenance for Mowi on board owned and subcontracted workboats. In 2010, he started Mallaig Marine Ltd with the 20m landing craft *Emma C* and was contracted to carry out fish farm installation and maintenance on behalf of Mowi. As the number and size of Mowi's fish farms increased, *Annie E* was added to the fleet to cope with the additional workload. The vessel was used for towing, new fish farm infrastructure installation, in service maintenance of fish farms, and to remove equipment when fish farms were decommissioned at the end of their service life. Mallaig Marine Ltd had used *Emma C* to install the Muck fish farm and *Annie E* to extend it.

1.4.3 Manning and crew training

The owner of Mallaig Marine Ltd had worked as skipper on board both *Emma C* and *Annie E* and later employed full-time skippers to operate the two workboats as the company grew. He developed company health and safety policies, operational procedures, risk assessments and method statements for use on board both vessels.

Annie *E* was crewed by a skipper and two deckhands. The crew operated a rota of 2 weeks on, 2 weeks off, and lived on board during their working period. The skipper piloted the workboat, planned the daily operations, carried out crew training and completed risk assessments in accordance with the Mallaig Marine Ltd templates. A signed record of individual crew training was attached to each operational method statement and risk assessment.

Image courtesy of Mallaig Marine Ltd

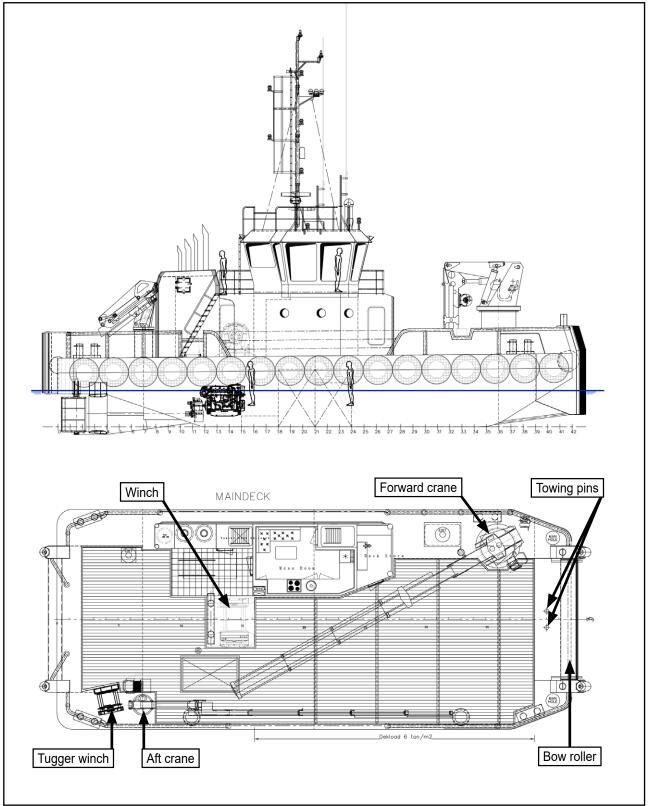


Figure 4: Annie E general arrangement

1.4.4 Work schedule

Mowi supplied its fish farm site staff and *Annie E*'s skipper with a workboat plan, which listed a schedule of work to be carried out at the various fish farm locations. The skipper planned daily work activities for *Annie E* based upon the state of tide and weather conditions at the specified locations. Typical jobs included lifting, inspecting and servicing mooring buoys, resetting fish farm anchors and replacing grid link buoys that had become detached and drifted away. *Annie E*'s skipper reported any observed fish farm infrastructure defects back to Mowi for inclusion into future workboat plans. Replacement equipment required for the maintenance of the fish farms, such as grid link buoys, chains and shackles, were ordered by *Annie E*'s skipper and supplied by Mowi.

1.4.5 Lifting equipment

Annie E's cranes and loose lifting equipment were tested and certified in accordance with MGN 332 (M+F) Amendment 1 The Merchant Shipping and Fishing Vessels (Lifting Operations and Lifting Equipment) Regulations 2006 (LOLER). Records of inspections and tests of lifting plant and loose lifting equipment were kept on board Annie E.

1.5 THE DECKHAND

1.5.1 Career and training

From 2011, for approximately two and a half years, the deckhand worked for Mallaig Marine Ltd on board *Emma C*. He then left and worked as a rope access technician and later trained to become a marine engineer. In 2019, he qualified as an STCW³ engineer officer of the watch and served as third engineer on board a standby vessel and a superyacht. In March 2021, he returned to Mallaig Marine Ltd.

1.5.2 Service on board Annie E

The deckhand was on his second shift rotation at the time of the accident, having rejoined *Annie E* on 30 March with the skipper and the other deckhand. Mallaig Marine Ltd had issued the deckhand with personal protective equipment (PPE), including a PFD, oilskins, a safety helmet and steel toe cap rubber work boots, all of which he was wearing at the time of the accident.

The crew had shown the deckhand around *Annie E* during his first shift rotation and he had carried out some lifting operations, including grid buoy lifts. He was asked by the skipper to read the company's method statements and risk assessments.

1.5.3 Injuries

The deckhand suffered memory loss during the accident and had no recollection of the event up to 10 weeks afterwards. He sustained the following injuries:

- ruptured spleen
- shattered collarbone

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

- damaged pelvis
- punctured lung
- broken rib
- fractured skull
- kidney damage
- broken left arm
- nerve damage to his left arm and fingers
- broken left thumb

The deckhand underwent ongoing surgery, physiotherapy, and treatment for mental trauma for several months after the accident. His injuries were so severe that he is unlikely to return to sea service.

1.6 MOWI SCOTLAND LIMITED

1.6.1 General

Mowi was the UK's largest salmon farmer and annually produced 68,000t of salmon from 46 seawater fish farm sites around north-west Scotland (Figure 5).

1.6.2 Fish farm operation

Fish farming was a 24-hour operation and Mowi serviced its sites using a variety of company-owned and subcontracted vessels. Fish farm installation and maintenance was subcontracted to Mallaig Marine Ltd.

1.6.3 Muck fish farm

The Muck site was a salmon farm designed by Aqua Knowledge AS, a subdivision of Mørenot Aquaculture AS, which was an international supplier of equipment and services to the fishing industry. The fish farm was installed in 2014 and originally consisted of 10 pens. In 2019, pens 6 and 12 (Figures 6a and 6b) were added to its southern end. Each pen comprised an upper buoyant ring and a lower sinker ring with a 120m circumference mesh net between them and was supported by a 75m x 75m grid line system, submerged to a 7m water depth. A network of 21 grid buoys provided additional buoyancy to the grid and pens. Each grid buoy was connected to a flexi link by an 8m riser line. Grid lines were attached to each flexi link to interconnect adjacent pens. The grid line system was held in position by mooring lines connected at each flexi link to an anchor on the seabed, the water depth of which was between 15m and 35m. A tripping line and buoy was connected to each anchor to enable its recovery (Figure 7).

The equipment used in Muck fish farm and its extension was supplied by Mørenot Aquaculture AS via Mowi and the installed system was inspected by a diver to check the position and security of the anchoring system.

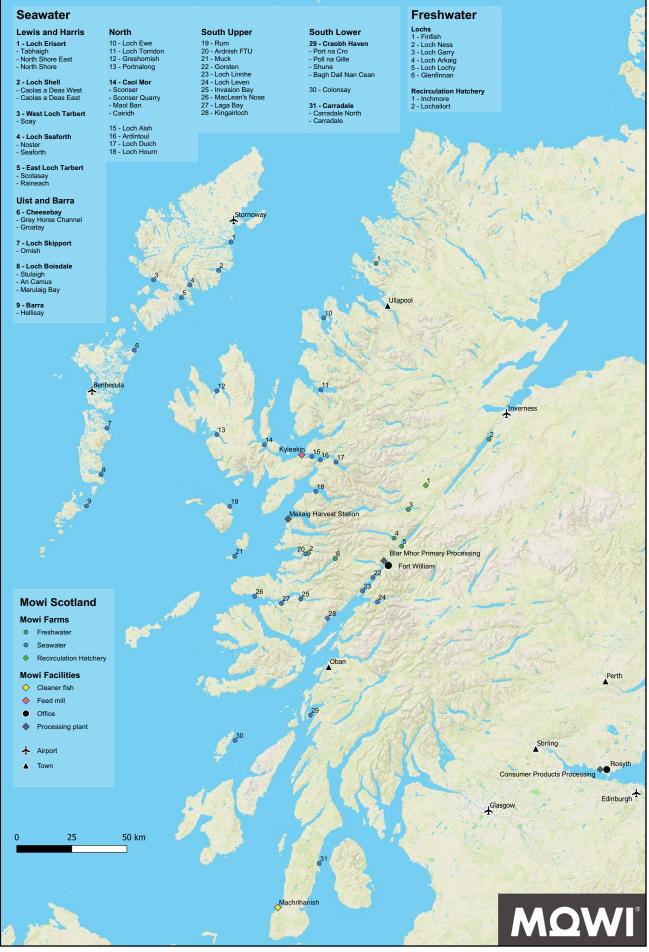


Figure 5: Mowi Scotland Limited fish farm locations



Figure 6a: Aerial view of Muck fish farm

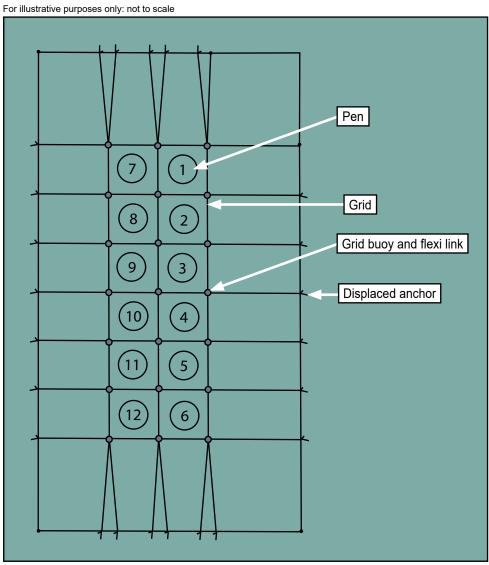


Figure 6b: Plan view of Muck fish farm

For illustrative purposes only: not to scale

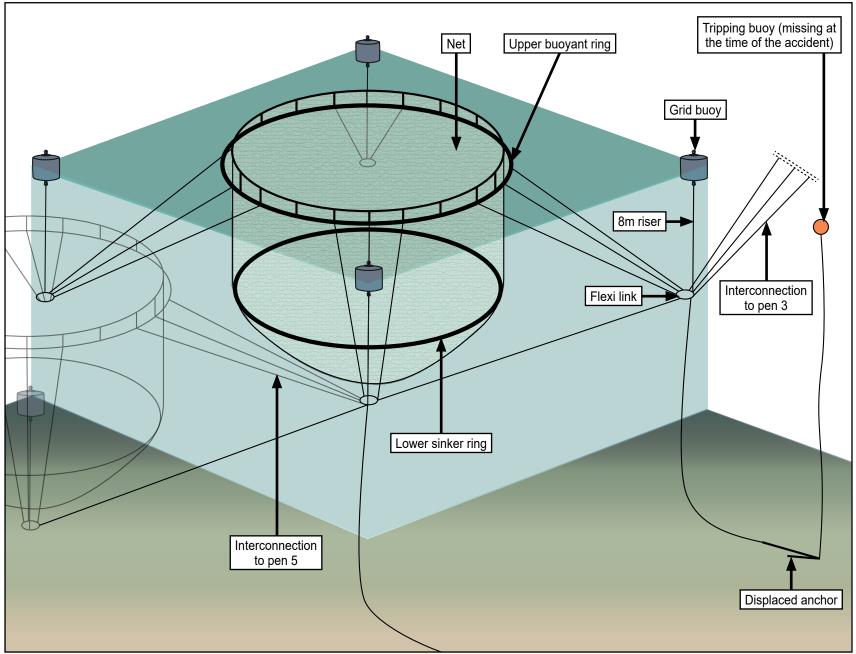


Figure 7: Components of Muck fish farm mooring arrangement (pen 4)

Muck fish farm contained approximately half a million salmon; the service life span of the Muck fish farm was nominally 6 years, which had been extended. Divers inspected the Muck fish farm mooring infrastructure every 18 months, at the end of the seawater phase of the fish farming cycle.

1.6.4 Contractual arrangement with Mallaig Marine Ltd

Mowi's Moorings and Facility Policy stated that Mallaig Marine Ltd, identified as MML in the contract, was a *specialist aquaculture moorings installation company, with over 21 years' experience in moorings installation and maintenance.*

In 2017, a contract was signed between Mallaig Marine Ltd and Mowi, formerly Marine Harvest Scotland, which stated that Mallaig Marine Ltd should carry out:

installation of and maintenance of moorings, nets and pens at relevant Marine Harvest sites; and

routine maintenance checks on all Marine Harvest mooring installations.

The contract also stated that Marine Harvest (MH) Ltd:

shall provide to MML in a timely manner all documents, information, items and materials in any form (whether owned by Marine Harvest or third party) reasonably required by MML in connection with the provision of the Services and ensure that they are accurate and complete in all material respects including, without limitation the MH Equipment; and

shall ensure that all of the MH Equipment is in reasonable working order and suitable for the purposes for which it is to be used in relation to the Services and conforms to all relevant United Kingdom standards or requirements or where applicable the standards or requirements applicable in the jurisdiction in which the Vessel is required to be located in connection with the provision of the Services and in which the MH Equipment may be used; [sic]

1.7 THE GRID BUOY

1.7.1 General

The grid buoy being lifted at the time of the accident was a Cipax CB1100 (Figure 8). Its dimensions were height 1580mm, diameter 1160mm and weight 69kg and it had an 1100kg net buoyancy when new. The buoy's foam-filled plastic float was compressed between two steel end plates connected via a central 28mm steel tie rod, secured with a nut and washer at the upper end plate. Each end plate was located to the float by means of a stub pipe, and the connection to the float was sealed by means of a rubber gasket. The tie rod threads above the securing nut were deformed at the time of original assembly to prevent the nut from loosening. A 28mm round section steel lug was welded to the upper and lower end plates. All the steel components were galvanised. The breaking load of the steel components was 14.8t and the Cipax user manual for the buoy stated that the steelwork was *not to be used as lifting equipment*.



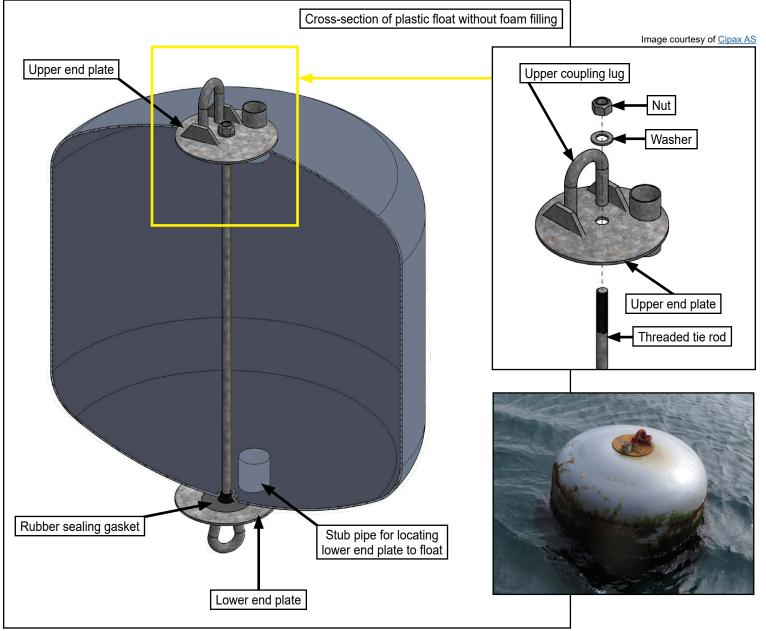


Figure 8: Cipax CB1100 buoy

1.7.2 Cipax buoy user manual

The Cipax buoy user manual stated recommended procedures for the use of Cipax fish farm buoys. The manual was supplied to Mowi but not to Mallaig Marine Ltd. It contained limitations for the use of Cipax buoys, which included:

The buoy is not made for lifting. When lifting the mooring plate, please use the procedure described further down in this document.

The Preparation before installation section stated:

Make sure the steelwork is proper prestressed/tightened. This can be controlled by checking that the end plates lie tight against the plastic shell, and that the washer is locked between the nut and the end plate. If the end plates have come loose, the steelwork must be tightened with a wrench or other suitable tool. [sic]

The user manual recommended that asymmetric equipment with a short lifting chain and a long lifting chain was used **(Figure 9)**.

The Personnel safety section stated:

The lifting eye on the buoys is only intended to lift the buoy clear of water. The buoy shall in no circumstances be a part of the lifting system during control, installation, service and similar. We recommend the use of an asymmetrical lifting gear when checking the buoy/Plant.

It went on to specify that:

This procedure is always to be used, due to the lack of possibility to inspect the condition of the steelwork inside the buoy.

The Final inspection after installation affirmed:

The plant is to be inspected by an accredited inspection organ, which is to verify that the buoys are installed according to the manual.

There are to be made a visual inspection of:

- Securing and positioning of the shackle/coupling loop.
- Correct installation direction.
- Correct pre-load/submersion of the buoy.
- Corrosion damage
- Wear [sic]

The user manual stated that the steel components of the buoy should be inspected for damage and wear and checked for correct pretension twice a year and after foul weather.

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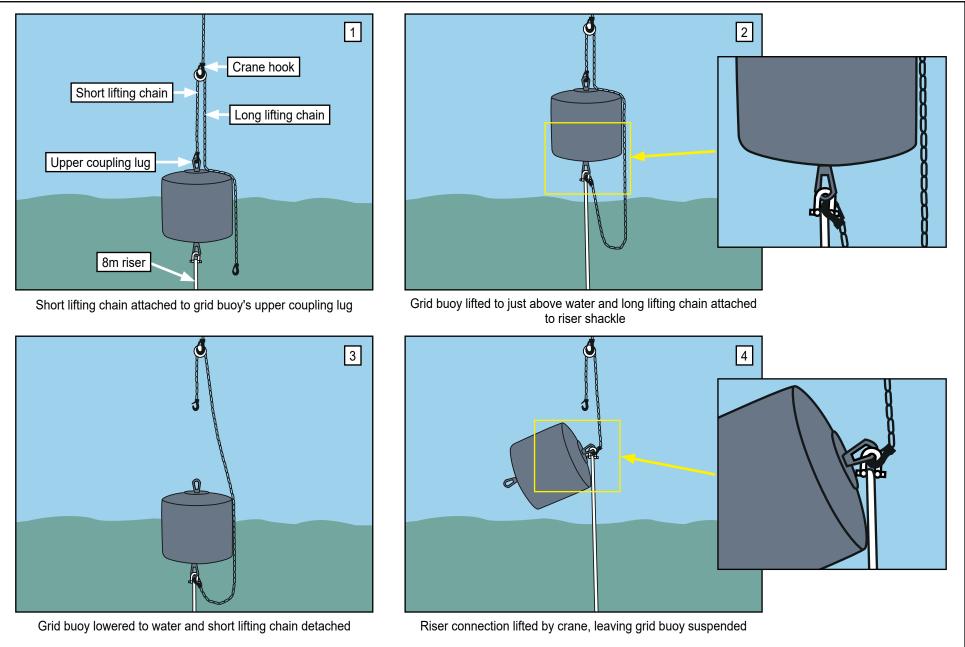


Figure 9: Illustration based on the user manual's recommended lifting procedure for grid buoy

1.7.3 Grid buoy operation, maintenance and failures

The Muck fish farm grid buoys were not identified by individual serial numbers. Some of the buoys had been changed by Mallaig Marine Ltd workboats during the fish farm's lifetime. The failed grid buoy was a different type to that specified in the Muck fish farm design document prepared by Aqua Knowledge AS, although it had the correct buoyancy.

Mowi staff routinely inspected the Muck fish farm. The most recent inspection was completed at the end of March 2021. Their checklist included a weekly inspection of the grid buoy's position and the float for damage as well as a 6-monthly lift of each buoy to inspect the riser and connecting shackle. Records provided during the accident investigation indicated that the 6-monthly buoy lift and inspection was not undertaken. Fish farm staff reported that grid buoys could sometimes experience wear to their lower lifting lug, causing them to break and detach and the buoy to drift away. Sometimes, grid buoys became holed and filled with water, causing them to sink. There had been no recorded incidence of grid buoys failing while being lifted on any Mowi Scotland fish farm. Damaged grid buoys were removed from service by the crews of either *Annie E* or *Emma C* and replaced with new grid buoys supplied via Mowi. It was usual for Mowi fish farm staff to scrap any damaged grid buoys after they had been changed out.

1.7.4 The grid buoy failure

Before the accident, the grid buoy was lifted and suspended approximately 9m above the water by *Annie E*'s forward crane with the fish farm grid connected to the lower coupling lug via the riser and flexi link. *Annie E*'s skipper had estimated and noted a system load of less than 2.5t on the lift plan operations record.

After the accident, the grid buoy's upper end plate was left hanging on the crane hook, the tie rod had sunk but remained attached to the riser and the float had fallen into the water and drifted away. All components of the grid buoy were later recovered and examination of these showed that (Figure 10):

- the tie rod had pulled through the upper end plate and the float
- the tie rod nut was fitted, and the tie rod threads adjacent to and above the nut were deformed as per the manufacturer's instructions
- the tie rod washer was not retained
- the metal components at the top of the grid buoy were lightly corroded
- the metal components at the lower part of the grid buoy were heavily corroded
- when reassembled, the measured distance between the upper and lower end plates was 9mm greater than the height of the grid buoy float
- the tie rod threads just below the nut were worn
- the metal around the central hole in the top plate was deformed and the tie rod and nut had pulled through the central hole
- the grid buoy's plastic float was not holed and did not contain water.



Figure 10: Failed grid buoy components

1.8 THE GRID BUOY LIFT

1.8.1 The plan

The intention was to lift the grid buoy to recover and secure the flexi link on *Annie E*, then detach the anchor line and winch the anchor on board. The anchor was to be fitted with a new tripping line and buoy, then re-laid and reattached to the flexi link.

1.8.2 Method statement and risk assessments

The Mallaig Marine Ltd lift plan operations record that *Annie E*'s skipper completed before lifting the grid buoy referenced *Method Statement 008 Grid Operations*, which covered:

lifting operations while carrying out grid work to facilitate essential maintenance and repair, and installation or extraction of fish farm grids.

The method statement specified that the skipper or crane operator was to complete a lift plan and carry out a toolbox talk before work started and stated that:

the tool box talk for the lift should ensure that all personnel are aware that the load may be suspended over the water until the repairs/maintenance have been completed. They are to be reminded to avoid standing near or on the main ring whilst ropes / chains are being tensioned. [sic]

The method statement also required personnel to use appropriate PPE.

The procedure for fish farm grid maintenance instructed operators to:

Secure the vessel to the grid at a point where the maintenance is to be completed. This is done by using the crane to lift the fish farm marker buoy clear of the water using an appropriately rated lifting chain at either the front or side of the vessel. Remove any mussels or seaweed if required, continue lifting until the main ring is lifted and secured to the vessel or secure point.

The stated purpose of Mallaig Marine Ltd MMLP8 *Lifting plan: Annie E & Emma C – Fish Farm Grid Operations* was:

To ensure safe operations whilst carrying out grid works that involve lifting to facilitate essential maintenance and repair, installation or extraction of fish farm grids.

It identified the lifting point for buoys as:

Lifting eye on top of grey buoys or lifting eye on riser rope from buoy to main ring.

The MMLP8 included several hazards and control measures associated with lifting operations during fish farm grid works **(Table 1)**.

Hazard	Control Measure
Working over water	All appropriate PPE is worn by personnel
Risk to personnel of contact with equipment and or load	No persons to stand below the grey buoys when the lift is in motion
Risk of equipment/accessory failure	Ensure all lifting accessories are rated in safe working condition for the lift which is to be undertaken All equipment must be visually inspected prior to use
Untrained personnel undertaking intermediate operation	Only trained personnel to undertake the operation

 Table 1: Example of MMLP8 hazards and control measures

The Mallaig Marine Ltd *Use of Hydraulic Cranes* risk assessment identified several hazards such as *load separates from lifting gear* that could result in *Major/minor injury to personnel*. The control measures for this hazard included:

- All lifts to be carried out by competent trained personnel.
- Stand well clear during lifting operations.
- Appropriate PPE to be worn at all times.

The Mallaig Marine Ltd *Working on water* risk assessment, which detailed *working on open deck when stationary*, identified the following control measures for a *fall through open railings/open areas at bow and stern of vessel* [sic]:

- Only authorised personnel permitted to work on deck.
- Appropriate PPE including life jacket, work boots and hard hats to be worn at all times.
- Good communication system established between crew throughout works.

Safety harnesses and fall prevention tethers were provided on board *Annie E* for the crew to use as part of their PPE.

1.8.3 Grid buoy lift reconstruction

During the accident investigation, a similar grid buoy to the one that failed at the Muck fish farm was connected by its upper end plate lug to *Annie E*'s forward crane, raised to 9m and suspended clear of the workboat above open water. A calibrated load cell⁴ was fitted between the crane hook and the grid buoy and recorded a 1.5t maximum load.

⁴ The load cell converted tension force into an electrical signal, which sent output to a digital display that showed force in tonnes.

1.9 REGULATIONS AND GUIDANCE

1.9.1 Guidance to seafarers

The Code of Safe Working Practices for Merchant Seafarers 2015 edition – Amendment 5, October 2020 (COSWP), published by the Maritime and Coastguard Agency (MCA) provided *best practice guidance for improving health and safety on board ship* and *was intended primarily for merchant seafarers on UK registered ships.*

Section 18.9.2 of chapter 18 – Provision, Care and Use of Work Equipment – stated that:

All seafarers and any managers or supervisors who use work equipment should have access to all necessary health and safety information and written instructions, including manufacturers' instructions, relating to the use of that equipment.

Chapter 19 provided guidance on shipboard lifting equipment and operations, which included:

'Lifting equipment' means work equipment used for lifting or lowering loads and includes the attachments used for anchoring, fixing or supporting it.

'Loose gear' means any gear by means of which a load can be attached to lifting equipment but which does not form an integral part of either the lifting equipment or the load

A valid certificate of testing and thorough examination by a competent person should be in force for every item of lifting equipment, accessory for lifting and loose gear. All items should be tested, and then thoroughly examined and certificated for use...

Under no circumstances should personnel stand on, stand below or pass beneath a load that is being lifted.

Annex 1.2 provided guidance on the preparation of risk assessments. It included information on the hierarchy of controlling risks and the order in which these principles should, if possible, be applied:

- try a less risky option (e.g. switch to using a less hazardous chemical);
- prevent access to the hazard (e.g. by guarding);
- organise work to reduce exposure to the hazard (e.g. put barriers between pedestrians and traffic);
- issue personal protective equipment (e.g. clothing, footwear, goggles); and
- provide welfare facilities (e.g. first-aid and washing facilities for removal of contamination). [sic]

1.9.2 Shipboard lifting equipment regulations

The LOLER Regulations applied to UK registered vessels. Guidance and interpretation of these regulations was provided in MGN 332 (M+F). Regulation 10 set out the requirement for the organisation of lifting operations and stated:

The employer shall ensure that every lifting operation involving lifting equipment is -

- a. properly planned;
- b. appropriately supervised; and
- c. carried out in a safe manner.

It further asserted that, *All reasonable measures should be taken to ensure that any load cannot:*

<u>strike and injure someone</u> - the simplest way to achieve this is by ensuring no-one is close enough for this to happen and is prevented by barriers or some other method, from moving into a position where this could happen.

And, that personnel are not positioned beneath suspended loads.

1.9.3 Training of workboat crew

The Workboat Code Edition 2 – Amendment 1, The safety of small Workboats and Pilot Boats - a Code of Practice, applied to UK workboats less than 24m in length. Appendix 3,The Manning of Small Vessels, stated:

All seafarers should be trained or certified or otherwise qualified to perform their duties. Training may include on board training or supervised experience, such that the seafarer is competent to perform their duties safely and without risk to others

Appendix 7, Safety Management System, further affirmed that:

Prior to the first occasion of working on the vessel, each employee must receive appropriate familiarisation training and proper instruction in on board procedures.

1.9.4 Working at height guidance

MGN 410 (M+F) Amendment 1, The Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Work at Height) Regulations 2010, provided guidance on the requirements of the Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Work at Height) Regulations 2010 (SI 2010/332) (the WAH Regulations 2010). The regulations applied to:

...work on every vessel where it is possible and/or proposed that work, of any kind, will be carried out at height. In this context it should be noted that "work at height" does not only encompass working from a ladder or on scaffolding but may also include:

• working alongside an open hatch or other opening in a ship's structure;

Regulation 9 of the WAH Regulations 2010 required employers to take appropriate safety measures to minimise the risk from working at height and to:

include the installation of safeguards of a suitable configuration and strength to prevent, or where that is not possible arrest, falls from a height and as far as possible prevent injury to workers. The form such safeguards should take is primarily for the employer to decide and may vary depending on the equipment being used. However, safeguards could include safety harnesses for workers, guards to prevent falls from scaffolding or towers, or fall arrest equipment.

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 OVERVIEW

The deckhand was injured when he was struck by a fish farm grid buoy that unexpectedly fell after being lifted and suspended from *Annie E*'s forward crane. This section will analyse the factors that caused the buoy to fall, the working practices on board *Annie E*, and why the deckhand was beneath the falling buoy.

2.3 THE DECKHAND'S INJURIES

The deckhand had no memory of the accident up to 10 weeks afterwards but the evidence shows that the grid buoy float struck the deckhand, most likely on his left-hand side.

The grid buoy was under tension due to the weight of the attached fish farm infrastructure. The elevated buoy would have taken less than 1 second to free fall into the water from its 9m height and even less time to fall to the deck under tension, providing little opportunity for the deckhand to get clear.

The falling float dislodged the deckhand's helmet, inflicted blunt force trauma injuries to his head and body and caused him to fall. It is likely that he struck the steel towing pins adjacent to *Annie E*'s bow and punctured his lung and ruptured his spleen as he fell to the deck.

2.4 THE GRID BUOY

2.4.1 General

The distance between the grid buoy's top and bottom end plates, measured after the accident, was greater than the height of the buoy's float, which indicated that the end plates were not compressing the grid buoy float as they were designed to do. The deformation of the tie bolt threads just above the nut had prevented the nut from loosening and it is likely that the nut was insufficiently tightened at the time of the grid buoy's manufacture. It is also unlikely that the tie rod tension was checked when the buoy was installed or while it was in service.

The grid buoy's upper plate was loose in relation to its float and tie rod. When the buoy was in service at the fish farm, the action of the wind and sea against the float caused the loose upper plate to fret against the tie rod threads in way of the central hole (**Figure 11**). The worn threads found below the nut indicated that the cyclic fretting had worn the edges of the upper plate central hole and caused it to enlarge, thereby reducing the amount of steel supporting the nut. Consequently, the upper plate became susceptible to failure due to a load stress less than that of the buoy's steel components' 14.8t design breaking load.

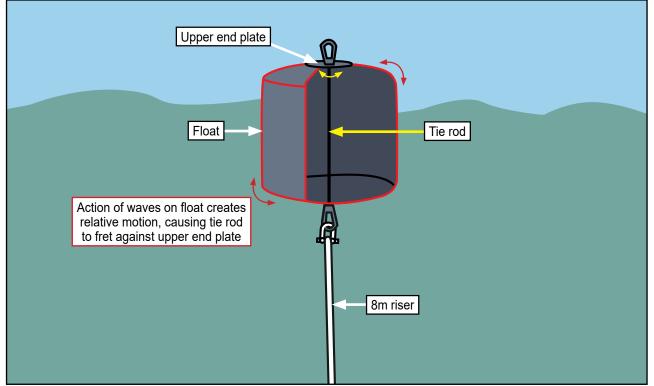


Figure 11: Wear mechanism of grid buoy float and tie rod on upper end plate

No steel washer was found on the grid buoy's tie rod after the accident. The grid buoy's galvanised steel components in way of the top of the buoy were only lightly corroded, therefore it is unlikely that the washer had rusted away during the grid buoy's service at Muck fish farm. It was not normal practice for either Mowi staff or Mallaig Marine Ltd crew to disassemble and repair damaged grid buoys, hence it is unlikely that the washer had been removed during a repair operation. Had a galvanised steel washer been fitted to the grid buoy it would have been retained by the central tie rod at the time of the accident so it is probable that the top plate washer had been missing since the grid buoy's manufacture.

2.4.2 Grid buoy failure

The flexi link and grid connections became tensioned and an estimated 1.5t load was applied to the grid buoy as *Annie E*'s crane lifted them. At the time of its failure, the concentrated load caused the grid buoy's tie rod nut to exert pressure on the metal around the enlarged central hole of the upper end plate. No washer was fitted to spread the load and reduce the stress to the metal around the hole. The metal surrounding the upper end plate's central hole plastically deformed⁵ downwards and then yielded, causing brittle fracture cracks. The mixed mode failure enabled the upper end plate central hole to become sufficiently deformed and enlarged to allow the tie rod and nut to pull through the upper end plate, causing the grid buoy float and tie rod to fall. The float remained at the surface when it hit the water and the tie rod, which was still under tension from the load exerted by the connection to the flexi link, pulled through the float and sank.

⁵ Plastic deformation occurs when a metal is loaded to beyond its ultimate tensile strength.

2.4.3 Grid buoy installation, maintenance and inspection

The failed grid buoy was a different type to that specified in the Muck fish farm design document and no detailed tracking existed for individual grid buoys. Although the grid buoy's length of service at the time of accident is unknown, it is possible that it had been in position for 7 years and was therefore coming to the end of the fish farm's service life. As Mallaig Marine Ltd staff had not been supplied with the Cipax buoy user manual, they were unaware of the maintenance schedule's requirement to check the buoy's tie bar pretension at the time of installation or twice a year thereafter. Further, both the post-installation inspection of Muck fish farm and the inspections carried out at the end of each farming cycle focused on the subsurface mooring equipment; the insufficient tie bar pretension and the absence of the tie bar washer went unnoticed as a result.

Although the Muck fish farm inspection regime carried out by Mowi staff included a check of the grid buoys, the checklist did not include a 6-monthly check of the steelwork in accordance with the Cipax buoy user manual. It is therefore likely that the enlargement of the upper end plate's central hole was not noticed.

2.5 THE GRID BUOY LIFT

2.5.1 Grid buoy lifting method

The grid buoy lifting method involved putting the buoy under tension when it was raised and suspended, making it *lifting equipment* as defined by the LOLER regulations, COSWP and industry guidelines. The Cipax buoy user manual stated that the grid buoy steelwork had no SWL and should not be used for lifting, therefore it had no certification. Although *Annie E*'s crane and lifting equipment were rated for the lift, and the skipper had correctly estimated the lifting load in the lifting plan record, the grid buoy was not identified as *lifting equipment*.

Mowi had not supplied Mallaig Marine Ltd with the Cipax user manual. Thus, *Annie* E 's crew were unaware that the grid buoy was not designated as *lifting equipment* or that the manufacturer had a recommended asymmetric buoy lifting procedure. Consequently, *Annie* E's crew were unable to properly plan and safely carry out the lift in accordance with COSWP and MGN 332 (M+F).

2.5.2 Method statements and risk assessments

The Mallaig Marine Ltd method statements did not detail the procedure for connecting the winch to the flexi link while the grid buoy was suspended. The technique used at the time of the accident involved the deckhand standing close to *Annie E*'s bow roller and reaching a distance of approximately half the diameter of the grid buoy float (0.5m) to thread a connecting strop through the flexi link and attach it to the winch shackle. The deckhand was briefly under a suspended load while threading the connecting strop, which contravened both Mallaig Marine Ltd's lifting plan and hydraulic crane risk assessment and industry guidelines; consequently, he was at risk from an unexpected failure of the grid buoy lift. The deckhand was wearing appropriate PPE; however, although this equipment reduced the effect of being struck by a falling load it did not lessen the likelihood.

The action of attaching the connecting strop to the flexi link involved the deckhand standing adjacent to *Annie E*'s bow roller and thus *working alongside an open hatch or other opening in a ship's structure* and *working in close proximity to a ship's side*, as defined by MGN 410 (M+F). Therefore, the deckhand was effectively working at height without protection from either guard rails or a safety harness with fall prevention tether. His PFD reduced the potential effects of falling overboard but would not prevent him from falling into the sea. COSWP stated in its guidance that it was more effective to prioritise *a less risky option* above the wearing of PPE when preparing risk assessments.

2.5.3 Estimation of risk

The crews of *Annie E* and *Emma C* had used the company procedure to lift Cipax buoys and other buoys numerous times at various Mowi fish farms, including Muck. *Annie E*'s crew were used to carrying out heavy lift operations and using equipment rated to do so. The lifting lug of the grid buoy had a heavy section similar to the shackles used in day-to-day lifting operations. It is possible that *Annie E*'s crew assumed that the lug and tie rod were rated as *lifting equipment* and therefore suitable for the grid buoy lift that was undertaken.

As there was no known instance of other grid buoy lift failures within Mallaig Marine Ltd's area of operations, it is possible that the lifting process had become normalised and deemed safe and that the risk of a buoy failure while briefly standing underneath it had not been considered or discussed during the tool box talk.

2.6 EXPERIENCE AND TRAINING

The deckhand had previous experience of working on workboat *Emma C*, plus industry experience and training as a seagoing engineer. Therefore, he was suitably qualified to work as a deckhand on board *Annie E* in accordance with the Workboat Code Edition 2. The deckhand had served in his new role for 17 days, had sighted the Mallaig Marine Ltd method statements and risk assessment and had carried out some grid buoy lifting operations. The formal induction that the Workboat Code required the deckhand to undertake when he joined *Annie E* had not been completed. Therefore, it is possible that he was not yet sufficiently trained to carry out the grid buoy lifting operation.

SECTION 3 – CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

- 1. The deckhand's injuries were caused by a falling grid buoy that had been lifted and suspended from *Annie E*'s forward crane; the grid buoy had been under tension, which accelerated its descent. [2.3]
- 2. The deckhand was standing near a suspended load contrary to Mallaig Marine Ltd's risk assessments, method statements, lifting plan, and industry guidelines. [2.5.2]
- 3. The method of connecting the winch line to the flexi link required the deckhand to briefly stand below a suspended load. The brief exposure time potentially lowered the crew's perception of risk from the load falling. [2.5.3]
- 4. Mallaig Marine Ltd's risk assessments and method statements did not fully mitigate the risks presented by a suspended load. [2.5.2]
- 5. The deckhand had not carried out formal induction training, in accordance with the Workboat Code Edition 2, when he joined *Annie E*. [2.6]
- 6. The grid buoys were frequently lifted by the same method, and historically without incident, which could have lowered the crew's perception of risk. [2.5.3]
- 7. Mallaig Marine Ltd and *Annie E*'s crew had not been provided with the grid buoy's user manual and were unaware of the recommended lifting procedure. [2.5.1]
- 8. The grid buoy was not certified as lifting equipment and the lifting technique used did not comply with the manufacturer's procedure. [2.5.1]
- 9. The grid buoy's metal components were worn and the top washer was missing, both of which resulted in its failure. [2.4.2]
- 10. There was no record of the grid buoy having been inspected before installation or routinely checked in accordance with manufacturer's guidelines while in service. [2.4.3]

3.2 OTHER SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT⁶

1. The deckhand was working adjacent to water without a safety harness and fall prevention tether during the grid buoy lifting operation and was therefore at risk of falling overboard. [2.5.2]

⁶ These safety issues identify lessons to be learned. They do not merit a safety recommendation based on this investigation alone. However, they may be used for analysing trends in marine accidents or in support of a future safety recommendation.

SECTION 4 - ACTION TAKEN

4.1 ACTIONS TAKEN BY OTHER ORGANISATIONS

Mowi Scotland Limited has issued a safety notice prohibiting the lifting of grid buoys above bulwark height of the vessel carrying out the lift, and provided Mallaig Marine Ltd with a copy of the Cipax buoy user manual.

Mallaig Marine Ltd has revised its lifting procedure for grid boys to reflect the asymmetric lifting procedure recommended in the Cipax user manual.

SECTION 5 - RECOMMENDATIONS

In view of the actions already taken, no recommendations have been made.

Marine Accident Report

