Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

MARINE TRANSPORTATION SAFETY INVESTIGATION REPORT M21A0041

CATASTROPHIC FAILURE OF MACHINERY, SUBSEQUENT FIRE, AND SINKING

Fishing vessel *Atlantic Destiny*
120 nautical miles south of Yarmouth, Nova Scotia
02 March 2021

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Summary

On 02 March 2021, the fishing vessel *Atlantic Destiny*, with 31 persons on board, sustained a catastrophic engine failure while the vessel was about 120 nautical miles south of Yarmouth, Nova Scotia. The shaft generators exploded, causing a fire and damage that led to flooding in the engine room. All persons on board were evacuated by search and rescue authorities. Minor injuries were reported. On 03 March 2021, the *Atlantic Destiny* sank.

1.0 FACTUAL INFORMATION

1.1 Particulars of the vessel

Table 1. Particulars of the vessel

Name of vessel	*Atlantic Destiny*
Official number	824202
Fisheries and Oceans Canada vessel registration number	105736
Port of registry	Halifax, NS
Flag	Canada
Type	Fishing, factory
Gross tonnage	1113
Length overall	39.2 m
Breadth	12 m
Draft at time of occurrence	6.3 m
Propulsion	1 9-cylinder inline 2500 brake horsepower diesel engine, 1 single controllable-pitch propeller.
Crew capacity	32
Built	2002, Skagen, Denmark

Registered owner and authorized representative	55104 Newfoundland & Labrador Inc., St. John's, Newfoundland and Labrador
Operator	Ocean Choice International (OCI), Head office, St. John's, Newfoundland and Labrador
Recognized organization	DNV

1.2 Description of the vessel

The *Atlantic Destiny* was a single-screw stern trawler (Figure 1) built in Denmark in 2002 to DNV[1] rules for the construction of fishing vessels. The vessel was of all-welded steel construction and was equipped for processing, freezing, and storing scallop catches.

Figure 1. The Atlantic Destiny (Source: TSB)

The bridge was equipped with a global maritime distress and safety system, including a very high frequency radio with digital selective calling (VHF-DSC). The vessel was equipped with a closed-circuit television system that monitored the engine room, the scallop-processing factory, and the main deck.

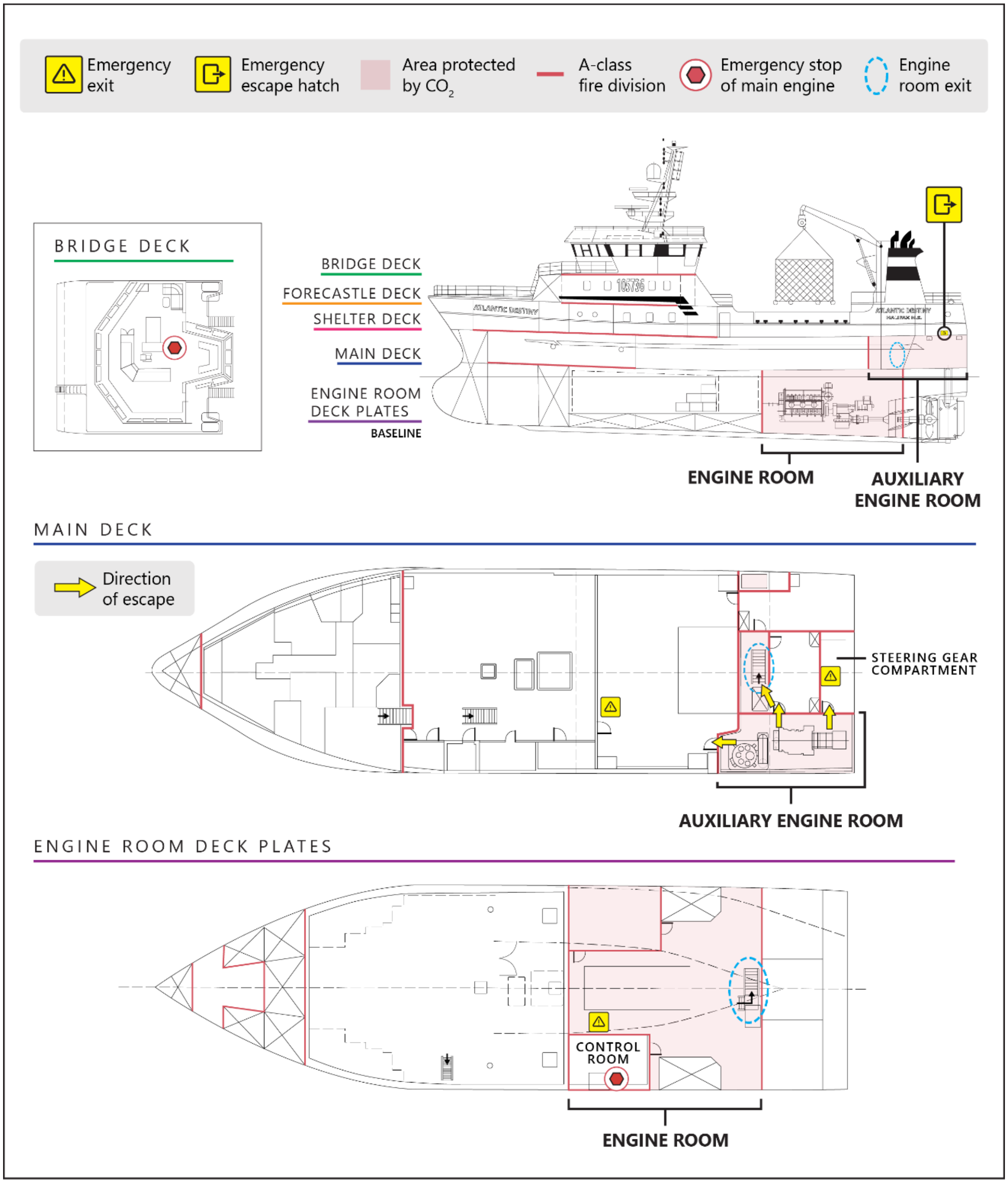
The accommodations were located forward and spanned 3 deck levels: the main deck, shelter deck, and forecastle deck. The vessel's processing factory was located on the main deck above a refrigerated fish hold around midship.

The engine room was located aft below the main deck and was accessed via a stairwell from the main deck. The auxiliary engine room was located aft on the port side of the main deck and was accessed from the workshop or from the processing factory on the main deck. The

1 DNV has changed its name 3 times since it was established in 1864. Originally known as Det Norske Veritas, it merged with Germanischer-Lloyd in 2013 to become DNV-GL and, in 2021, was renamed DNV. All references to the company in this report will use the name DNV.

deck of the auxiliary engine room had an opening around the exhaust stack, making the 2 rooms into a single category A space. The engine control room (ECR) was located on the forward port side of the engine room and was accessed from the engine room but was in its own category A space. The steering gear compartment was on the main deck and accessed from the auxiliary engine room or from a hatch on the shelter deck but was in a different category A space (Figure 2).

Figure 2. Port-side cross-section view and top view of the main deck and engine room deck plates of the vessel showing that the engine room and auxiliary engine room formed a single category A space on 2 levels (Source: TSB, based on the Atlantic Destiny fire and safety plan)



The vessel's life-saving equipment included 1 rescue boat at the vessel's stern and 4 inflatable life rafts, 2 on each side of the wheelhouse.

1.2.1 Emergency escapes

The *Large Fishing Vessel Inspection Regulations* require that, "[w]here a single entrance only is provided to a crew space, an emergency escape hatch shall be fitted."[2] The regulations do not contain specific provisions concerning hatch design, such as being able to be opened from both sides. Some hatches are equipped with a spring and a wheel, which makes them easier to open in difficult conditions such as rough weather or darkness.

Other jurisdictions have more detailed requirements. For example, the U.S. regulations state the following:

> Each door, hatch, or scuttle, used as a means of escape, must be capable of being opened by one person, from either side, in both light and dark conditions. The method of opening a means of escape must be obvious, rapid, and of adequate strength.[3]

The *Atlantic Destiny* was constructed with the required number of emergency exits. One exit from the engine room provided an escape route to the vessel's processing factory on the deck above. This emergency exit was located on the port side between the ECR and the engine. The exit consisted of a vertical ladder and a hinged hatch with a locking mechanism comprising 3 independent latches. To open the hatch, it was necessary to balance on the steps holding on to the ladder with 1 hand, turn each of the 3 latches to the open position with the other hand, and then push the hatch open.

Escape hatches are not required to be tested or used in drills. They may be inspected in annual inspections by the recognized organization.

1.3 History of the voyage

On 17 February 2021, the *Atlantic Destiny* left Riverport, Nova Scotia, for a 21-day scallop-fishing trip, with 31 people on board. On 02 March, the 13th day of the trip, the vessel was situated at the fishing grounds near Georges Bank, Nova Scotia (Figure 3). Fishing operations were suspended due to the weather, and most of the crew were off duty. The vessel was proceeding at reduced speed, with the controllable-pitch propeller set to approximately 40%.

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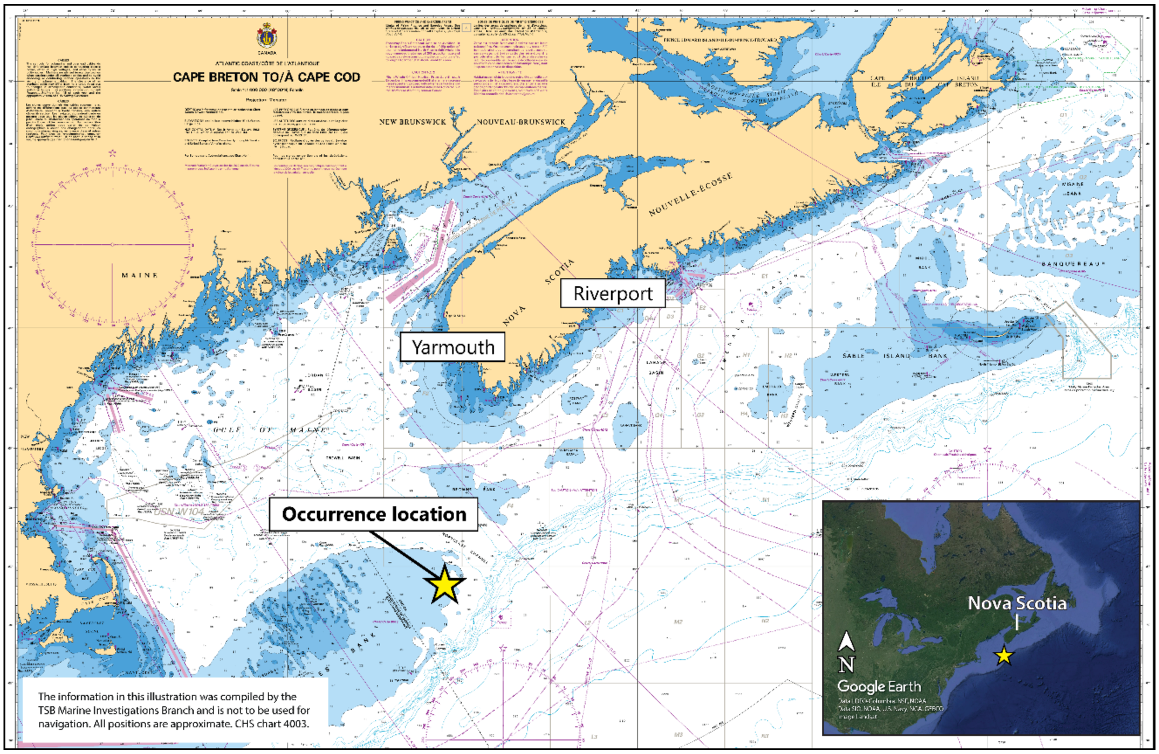
2 Transport Canada, C.R.C., c. 1435, *Large Fishing Vessel Inspection Regulations* (amended 23 June 2021), section 22, subsection 9.

3 U.S. *Code of Federal Regulations*, Title 46, Chapter I, Subchapter T, Part 177, Subpart E, Section 177.500, Subsection h: Means of escape, at https://www.ecfr.gov/current/title-46/chapter-I/subchapter-T/part-177/subpart-E/section-177.500 (last accessed 24 November 2023). Similar descriptions exist in *International Convention for the Safety of Life at Sea* and International Association of Classification Societies documents.

Figure 3. The Atlantic Destiny was fishing near Georges Bank, Nova Scotia (Source: Canadian Hydrographic Service chart 4003 and Google Earth inset, with TSB annotations)



At 1800,[4] the master took over the watch on the bridge, accompanied by a deckhand. At the same time, the second engineer took over the watch in the engine room and the chief engineer went to his cabin.

At about 1930, the second engineer, who was in the ECR, observed that 1 of the shaft generators was offline. He called the bridge to verify with the master that no changes had been made to the equipment or gear being used. The master assured him no changes had been made. The second engineer went to investigate and observed no visual indication of a problem at the shaft generator; he then returned to the ECR.

At approximately 1940, the second shaft generator went offline, causing a blackout throughout the vessel and the battery-powered emergency lights to come on. Alarms indicating loss of power to non-essential equipment began to sound. The auxiliary generator started automatically and provided electrical power to the vessel. The engine continued to run at approximately 600 rpm.

Shortly after, the chief engineer entered the ECR. As both engineers were trying to determine why both shaft generators had gone offline, they heard the engine starting to increase in rpm and the shaft generators making a whining sound. The second engineer pushed the emergency stop button in the ECR in an attempt to stop the engine; however, the engine continued to run.

4 All times are Atlantic Standard Time (Coordinated Universal Time minus 4 hours).

Less than a minute later, the 2 shaft generators and associated machinery shattered, projecting hydraulic fluid and multiple hot metal fragments at high speed throughout the engine room. This caused a fire that produced dense smoke in the engine room and stopped the engine. From the ECR, the engineers witnessed the catastrophic failure and saw a ball of flame and black smoke. The fire alarm began to sound. The fire alarm continued to sound and all attempts to silence the alarm were unsuccessful.

When the fire alarm sounded, crew members (other than those in the engine room and bridge) mustered on the stern, and all were accounted for. Some of the crew were tasked to rig fire hoses for boundary cooling and to bring spare bottles for the self-contained breathing apparatuses (SCBAs) and fire extinguishers to the muster station. The second mate and assigned deckhands closed the fire dampers. Other assigned crew members retrieved the 2 firefighter outfits and an extra SCBA. The deckhand who was assigned as a firefighter donned a firefighter outfit but did not act as a firefighter.

When the master saw the explosion on the closed-circuit television system, he briefly pushed the distress button on the vessel's VHF-DSC radio to send an automatic distress call.[5] He then took a fire extinguisher and proceeded to the engine room entrance. A few steps below the entrance, he observed a burning fragment of metal machinery measuring about 60 by 60 cm.

While still in the ECR, the second engineer donned an emergency escape breathing device (EEBD).[6] He left the ECR and tried to escape through the emergency escape hatch that led to the vessel's processing factory. He could not open the emergency escape hatch and returned to the ECR, took a fire extinguisher, and escaped through the engine room entrance, putting out fires on his way. In the meantime, the chief engineer assembled and donned the second EEBD.[7] On the stairs leading to the auxiliary engine room, the second engineer met the master and the chief mate. He asked them to open the engine room emergency escape hatch from the processing factory and then returned to the engine room. The master and the chief mate opened the emergency escape hatch from above and the chief engineer escaped the engine room. As the second engineer followed the chief engineer out, the sound of water sloshing was heard.

The master returned to the bridge. Using the VHF-DSC radio, the master broadcast a message to nearby fishing vessels asking them to confirm that the distress call from the *Atlantic Destiny* had been received. When he heard that the distress call had not been received, he asked the others to send a distress call for him. At that time, the fishing vessel *Cape Lahave* was close and the fishing vessels *Atlantic Preserver*, *Atlantic Protector*, and *Maude Adams* were approximately 1 nautical mile (NM) from the *Atlantic Destiny*.

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5 VHF-DSC radios typically require the distress key to be held down for 3 to 5 seconds. For the model of radio on board the *Atlantic Destiny*, the manual instructs users to press the key for 4 seconds continuously.

6 EEBDs supply approximately 10 to 15 minutes of breathing time.

7 The second EEBD required assembly because it was expired and ready for disposal.

At 2008, the *Atlantic Preserver* relayed the distress call to the Canadian Coast Guard (CCG) Marine Communications and Traffic Services Centre in Halifax, Nova Scotia.

The chief mate, the second engineer, and the chief engineer donned SCBAs and proceeded to the main engine room to fight the fire and assess the situation. They fought the fire from the engine room entrance using fire extinguishers. Once it became evident that the fire extinguishers were not sufficient to control the fire, they threw 1 of 2 portable dry sprinkler powder aerosol (DSPA) extinguishers into the engine room and closed the engine room door. The sound of water was heard again, coming from under the engine room deck plates.

At about 2015, after a short discussion, the master, the chief engineer, and the second engineer decided to use the engine room's carbon dioxide (CO_2) fixed fire suppression system. The second engineer then went to the emergency control station on the shelter deck. From the emergency control station, he operated the 4 quick-closing valves shutting off the fuel valves supplying the engine, the auxiliary generator, the fuel oil separator and oil-fired boiler, and the fuel oil storage tanks.

A short time later, the chief engineer obtained permission from the master and entered the engine room to investigate the source of the water that had been heard. The chief engineer wore an SCBA and used a fire extinguisher to put out fires in the hot spots. When the low air pressure alarm on his SCBA sounded, he was forced to retreat from the engine room before he had established the source of the water ingress.

At about 2100, the chief engineer and the second engineer entered the engine room, planning to stop the water ingress by closing the sea bay valves (see Section 1.14.1 *Sea bay valves*). The second engineer used an SCBA and the chief engineer covered his face with a rag for protection. The chief engineer proceeded along the port side of the engine room and the second engineer along the starboard side. The chief engineer observed that the water had reached the engine room deck plates. Because the chief engineer had difficulty breathing, he was unable to reach the port-side sea bay valves and left the engine room. The second engineer observed that many pipes were smashed or broken. He tried to access the starboard sea bay valves to close them but was unable to do so because of limited space and because he was hampered by the SCBA. He then left the engine room, took off the SCBA, covered his face with a rag, and returned to the engine room to try again. By this time, the sea bay valves were already under water and to reach them he had to reach under pipes that were also submerged. After an unsuccessful attempt to reach 1 of the sea bay valves, he left the engine room.

While the engineers were attempting to close the sea bay valves, the second mate was ordered by the master to start the emergency fire pump. Wearing an SCBA, the second mate entered the steering gear compartment through the auxiliary engine room and tried twice unsuccessfully to start the emergency fire pump using the electrical starter. Shortly after, the chief engineer joined him, entering through the shelter deck hatch. They tried to start the emergency fire pump once again using the electrical starter and confirmed that the batteries were depleted. The second mate and the chief engineer tried to start the pump manually using the crank handle. When the pump still did not start, the second mate and the chief engineer abandoned their attempts to start the emergency fire pump and decided to restart the auxiliary generator to be able to use the bilge pumps.

The engineers, without SCBAs, and the second mate, with an SCBA, attempted to restart the auxiliary generator. At this point, they saw fire in the engine room below through the opening around the exhaust stack. They put out the fire using the second portable DSPA extinguisher and then resumed their attempts to start the auxiliary generator. They started the auxiliary generator several times before they were able to keep it running. The chief engineer went to the ECR by himself to attempt to close the breaker on the main panel to bring the auxiliary generator online but was not able to close the breaker. The chief engineer and the second engineer made a subsequent unsuccessful attempt together. The second engineer became trapped in the ECR when the door was obstructed by debris moving across the engine room because of the vessel's movement. The chief engineer helped the second engineer to exit from the ECR and together they left the engine room. The fire was out at this point.

At about 2204, a Royal Canadian Air Force (RCAF) search and rescue (SAR) airplane arrived on the scene. At approximately 2210, after several passes, it dropped a gasoline-powered SAR pump to the sea. Due to adverse wind and sea conditions, the kit could not be retrieved and drifted away. Another pump kit was prepared and after 3 passes it was dropped and successfully recovered by the crew.

Shortly after, the crew prepared the pump for operation. The discharge hose was not long enough to reach through the stairs and over the side so the crew extended the discharge hose by connecting the vessel's fire hoses to it. The pump regularly lost suction because the strainer was clogged with debris that was floating in the engine room.

At 2317, an RCAF SAR helicopter arrived on the scene with 2 SAR technicians. After discussion with the SAR commander, the master decided to evacuate all crew not essential to the operation of the vessel. The chief mate coordinated the evacuation and maintained communication with the CCG. The rescue helicopter experienced a problem with its hydraulic system and was forced to leave the scene urgently with only 6 crew members. The 2 SAR technicians remained on board to assist the crew.

On 03 March 2021 at 0031, a United States Coast Guard helicopter delivered another pump kit and evacuated 8 more crew members.

At 0235, another United States Coast Guard helicopter delivered 1 more pump kit and evacuated 13 more crew members, including the chief mate.

The 27 crew members were evacuated to Yarmouth, Nova Scotia. The remaining 4 crew members (the master, the chief engineer, the second engineer, and the second mate) and the 2 SAR technicians remained on board to try to control the water level by keeping all 3 SAR pumps running. However, the pumps experienced issues with suction and the water level in the engine room continued to rise.

At approximately 0530, pumping operations were abandoned. The second mate and the second engineer closed all doors and went to the bridge. The crew prepared 3 Jacob's ladders: 1 on each side of the vessel on the bridge deck and 1 at the starboard cargo door on the shelter deck. Two life rafts were deployed so the crew could be ready to abandon the vessel.

By about 0537, the vessel had developed a considerable list to port, sufficient to raise a concern about the vessel's stability and eventual capsizing.

At about 0600, another RCAF helicopter arrived on the scene to evacuate the 4 crew members and 2 SAR technicians still on board the *Atlantic Destiny*. During this operation, the helicopter's 2 hoist cables became entangled in the vessel's rigging. The helicopter was not able to complete the operation and left the scene.

At approximately 0700, the CCG vessel *Cape Roger* arrived on the scene. At approximately 0719, the 4 crew members and 2 SAR technicians were transferred to the *Cape Roger* on its fast rescue craft, completing the rescue of the 31 crew members.

On 03 March 2021 at 1036, the *Atlantic Destiny* sank at position 41°51' N, 066°12' W.

1.4 Injuries

Two crew members sustained minor injuries. The second engineer injured his arm while escaping the ECR, and another crew member injured his shoulder when he hit the rail during evacuation from the vessel.

1.5 Environmental conditions

During the occurrence, the winds were from the northwest at 40 to 45 knots gusting up to 55 knots with wave heights of 5 to 8 m. The water temperature was approximately 5 °C and the air temperature was 0 °C. The visibility was moderate (2 – 5 NM).

1.6 Vessel certification

From 2002, when the *Atlantic Destiny* was built, until March 2019, inspection and certification were carried out by Transport Canada (TC).

In March 2019, based on the Delegated Statutory Inspection program, TC authorized DNV to inspect and certify the vessel on its behalf. Inspections for certification were conducted annually.

The inspection certificate allowed the *Atlantic Destiny* to operate on an Unlimited Voyage, restricted to Near Coastal Voyage, Class 1, with a crew of 32 persons.

1.7 Crew certification, experience, and training

The master held a Fishing Master, Third Class certificate of competency, which limited him to serving as a master on fishing vessels engaged on near coastal voyages. He had sailed as a master on various fishing vessels since 1976 and had been sailing on the *Atlantic Destiny* since it was acquired by Ocean Choice International (OCI) in 2002. He completed Marine Emergency Duties (MED) Basic Safety (MED A1) training in 1984, 1994, and 1997, and MED Firefighting (MED B2) training in 1984.

The chief mate held a Fishing Master, Fourth Class certificate of competency. He had been sailing on the *Atlantic Destiny* since 2010. He completed MED A1 training in 2011.

The second mate held a Fishing Master, Third Class certificate of competency. He had been sailing on the *Atlantic Destiny* since 2010. He completed MED A1 training in 2010.

The chief engineer held a Third-Class Engineer, Motor Ship certificate of competency. He had been employed as a chief engineer on board the *Atlantic Destiny* since May 2017. He completed MED A1 in 2002, MED for Senior Officers (MED D) training in 2011, and *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW) MED Advanced Firefighting training in 2011. He completed STCW refresher training in basic safety and advanced fire fighting in 2016.

The second engineer held a Fourth-Class Engineer, Motor Ship certificate of competency. He had 11 years of experience at sea working on different types of vessels and had been working on the *Atlantic Destiny* for the last 4 years. He completed STCW Basic Safety training and STCW MED Advanced Firefighting training in 2016. He completed MED D training in 2014.

1.8 Ocean Choice International safety management system

A safety management system (SMS) is an internationally recognized framework that allows companies to identify hazards, manage risks, and make operations safer—ideally before an accident occurs. An SMS should describe individual responsibilities and roles at all levels of the company. It should also describe written policies and procedures for safety records and communication; education, drills, and training; risk assessment and risk mitigation; emergency preparedness and responses; and safe working procedures. When an SMS is required by regulation, it must be externally audited and certified. When an SMS is voluntary, there is no requirement for an external audit or certification.

In 2008, OCI voluntarily implemented an SMS for all the vessels in its fleet.[8] In 2019, the SMS was updated. At the time of the occurrence, the OCI SMS had not been externally audited or certified.

The OCI SMS is documented in an SMS manual, a copy of which was available on the *Atlantic Destiny*. The SMS is described in the manual as follows:

> The purpose of the SMS is to protect the safety and health of our employees (hereon referred to as crewmembers), to assist in preventing accidents and injuries, to increase efficiency of operations, and to reduce the costs associated with

[8] The Ocean Choice International fleet consisted of 1 vessel based in Nova Scotia (the *Atlantic Destiny*) and 5 vessels based in Newfoundland and Labrador.

> occupational accidents and illnesses. OCI is committed to the health and safety of all crewmembers and the prevention of occupational injury and illness. The program is intended to support the Occupational Health and Safety (OH&S) Policy by detailing the roles and responsibilities of the various stakeholders in the company, i.e., Senior Management, Operations Management, crewmembers, OH&S Committees, and contractors. The OH&S duties of each workplace party are interrelated and thus the successful implementation of OH&S practices and procedures is dependent on the cooperation of all individuals in the Company.[9]

The OCI SMS manual contains sections about roles and responsibilities including for those working on board, occupational health and safety (OHS) requirements, education and training, safe work practices, ship inspection procedures, accident and incident investigation, hazard assessment and reporting, emergency preparedness and responses, and return-to-work management. At the time of the occurrence, the SMS manual stated that the operations manager was responsible for verifying that engine room instructions were on board and readily accessible. However, in practice, the operations manager depended on the master and crew to determine that everything was in place.

The accident and incident investigation section of the manual applied to both the crew and the vessel. In practice, however, only accidents and incidents related to OHS requirements for crew were handled using the SMS. OCI provided the TSB with all accident reports (2) that were documented for the *Atlantic Destiny* for the period from 2017 to the date of the occurrence. These accident reports were related to injuries or risk of injury.

Maintenance resulting from accidents and incidents related to the vessel machinery was handled outside the SMS. During the period from 2017 to the date of the occurrence, 3 occurrences were reported to the TSB.[10] These occurrences were documented within OCI using service reports.

1.9 Developing, documenting, and reviewing testing procedures

Procedures contribute to safety when they are specific to the operations to which they apply, take both activities and operating conditions into account, and are used by their intended audience. Procedures should be reviewed regularly to ensure they still reflect the activities they describe and that they are being used effectively.

Developing procedures requires an understanding of and experience with the context, goals, risks, and activities of the operations. For engine operations, this includes a complete understanding of how the engine components interact, such as the engine management system and the engine safety system, and an understanding of the vessel and its limitations.

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9 Ocean Choice International Fleet Division (Nova Scotia), *Safety Management System* (Revision 3), section 1: Introduction, p. 5.

10 TSB Marine Investigation Report M17A0039 and TSB marine transportation safety occurrences M18A0092 and M17A0216.

According to the *Canada Shipping Act*, *2001*, the authorized representative of a vessel is responsible for providing written procedures to the crew.[11] The authorized representative of the *Atlantic Destiny* was 55104 Newfoundland & Labrador Inc. As part of the TC delegation process, OCI's operations manager was identified as the authorized delegated operator[12] of the vessel. The operations manager had a background in fish processing.

1.10 Vessel engine

The engine of the *Atlantic Destiny* was a 9-cylinder turbocharged, intercooled, 4-stroke diesel engine with a displacement of 114 L and a power rating of approximately 2500 brake horsepower (1865 kW). The engine was built in 2001 and had accumulated more than 136 840 running hours at the time of the occurrence. The engine provided both the vessel's propulsion and its electrical power supply. Under normal operating conditions, with the controllable-pitch propeller system and both shaft generators online, it maintained a constant speed of 900 rpm.

The engine was connected to a combination gearbox via a flexible coupling (Figure 4). There were 3 output shafts from the combination gearbox: the lower output shaft at a 5.52:1 reduction for the propeller shaft, and 2 upper output shafts with fluid couplings, at a 1:2 increase, to drive the shaft generators. The design limit for the fluid couplings was 1800 rpm. At the normal engine operating speed of 900 rpm, the propeller shaft turned at 163 rpm and the generators turned at 1800 rpm.

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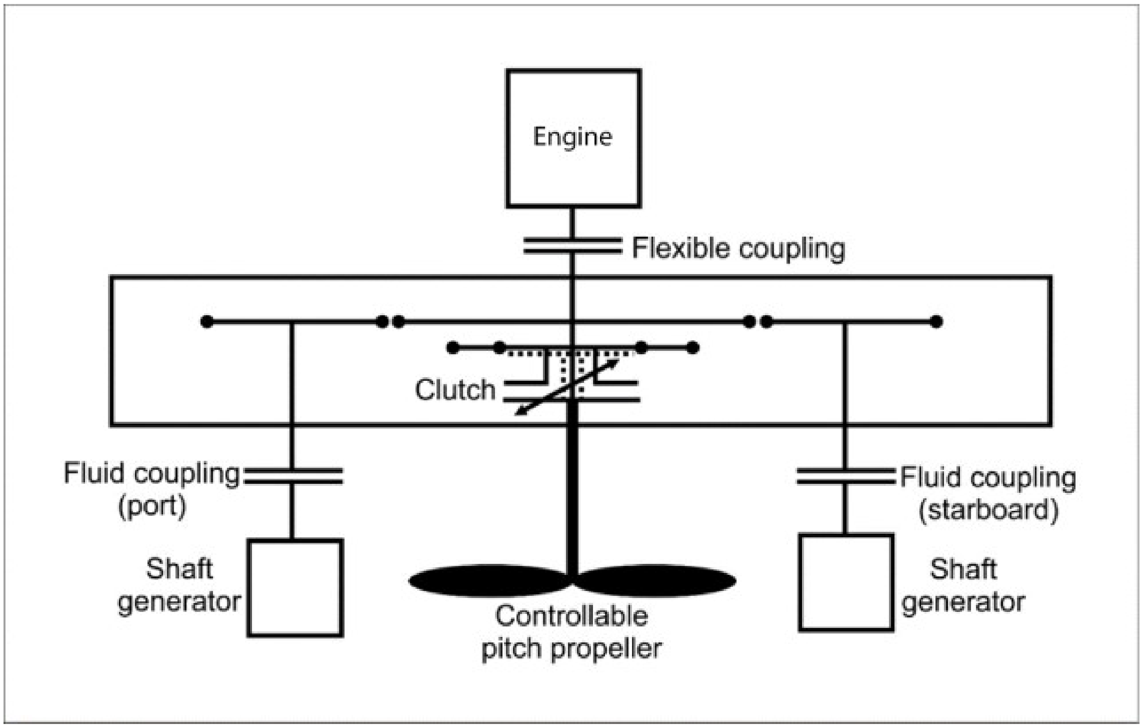
[11] Government of Canada, S.C. 2001, c. 26, *Canada Shipping Act, 2001* (as amended 30 July 2019), paragraph 106(1)(b).

[12] As part of the Delegated Statutory Inspection Program, the authorized representative of a vessel can name an authorized delegated operator.

Figure 4. The configuration of the engine, shaft generators, and controllable-pitch propeller (Source: TSB)



The *Atlantic Destiny* was equipped with an engine management system to control the speed of the engine. The vessel was also equipped with an engine safety system designed to protect the engine and gearbox from damage.

1.10.1 Engine management system

The engine management system (Figure 5) controlled the speed of the engine on board the vessel to ensure it maintained the required speed for all modes of operation including start-up, clutch-in, and operating at sea with shaft generators online. The system was installed in October 2017 as an upgrade to the system previously in use on the vessel.[13]

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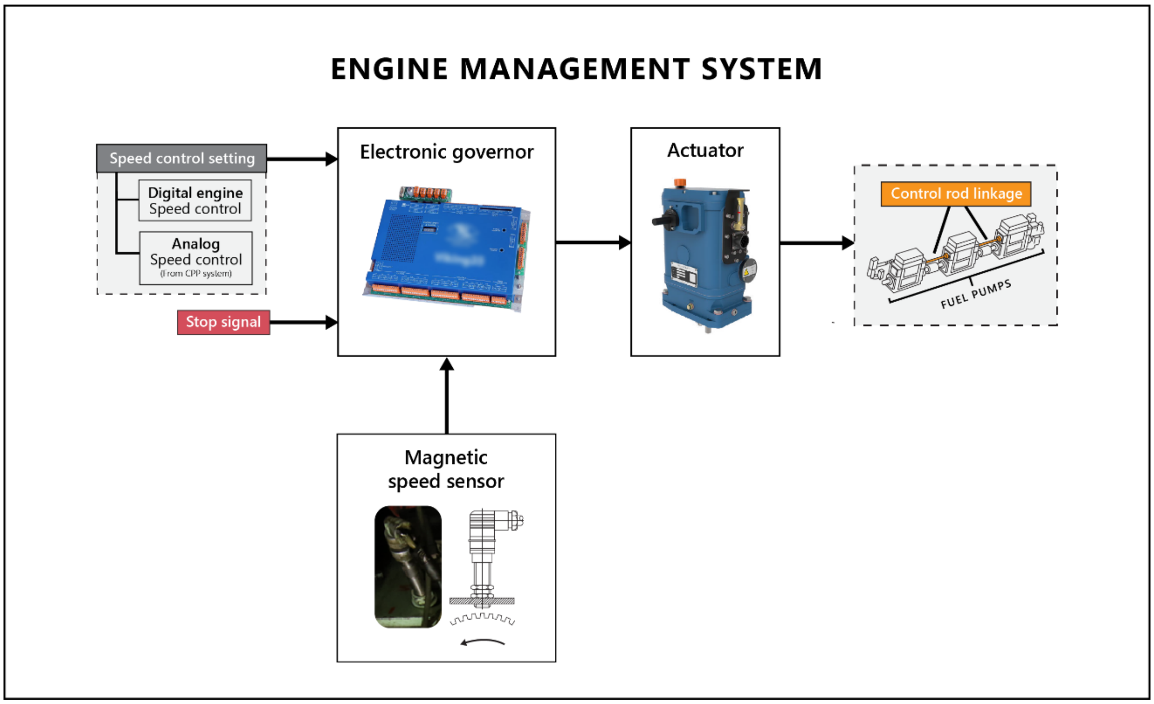
13 The vessel returned to service after an engine failure in April 2017 (TSB Marine Investigation Report M17A0039). The electronic governor was upgraded in October 2017.

Figure 5. Diagram of the engine management system showing how the components are related (Source: TSB; photos of electronic governor and magnetic speed sensor from Deutz; photo of actuator from Europa)



The engine management system had 3 main components: the electronic governor, the magnetic speed sensor, and the actuator. The electronic governor used output from the magnetic speed sensor to provide a signal to the actuator, which governed the amount of fuel supplied to the engine and maintained a constant speed.

The electronic governor was located in the ECR and maintained the engine's speed. During operation, the engine speed was set to be maintained at 900 rpm. The engine speed could also be controlled directly, either in the ECR using an analogue rpm control or at the engine using a digital rpm control. The electronic governor required a continuous signal from the magnetic speed sensor to monitor the engine speed. The electronic governor also received input from the controllable-pitch propeller system.

The magnetic speed sensor was a magnetic frequency generator and was mounted on the starboard aft side of the engine near the engine flywheel. This sensor provided electrical impulses proportional to the speed of the engine.

The actuator was mounted on the engine and governed the amount of fuel to each engine cylinder via a mechanical linkage to the engine's fuel rack. The fuel pumps for each of the 9 engine cylinders were assembled into 3 fuel pump assemblies consisting of 3 fuel pumps each; the fuel rack connected the vessel's 3 fuel pump assemblies so that any movement from the actuator moved all fuel pumps at the same time. When the engine load changed, the electronic governor signalled the actuator to move the fuel rack.

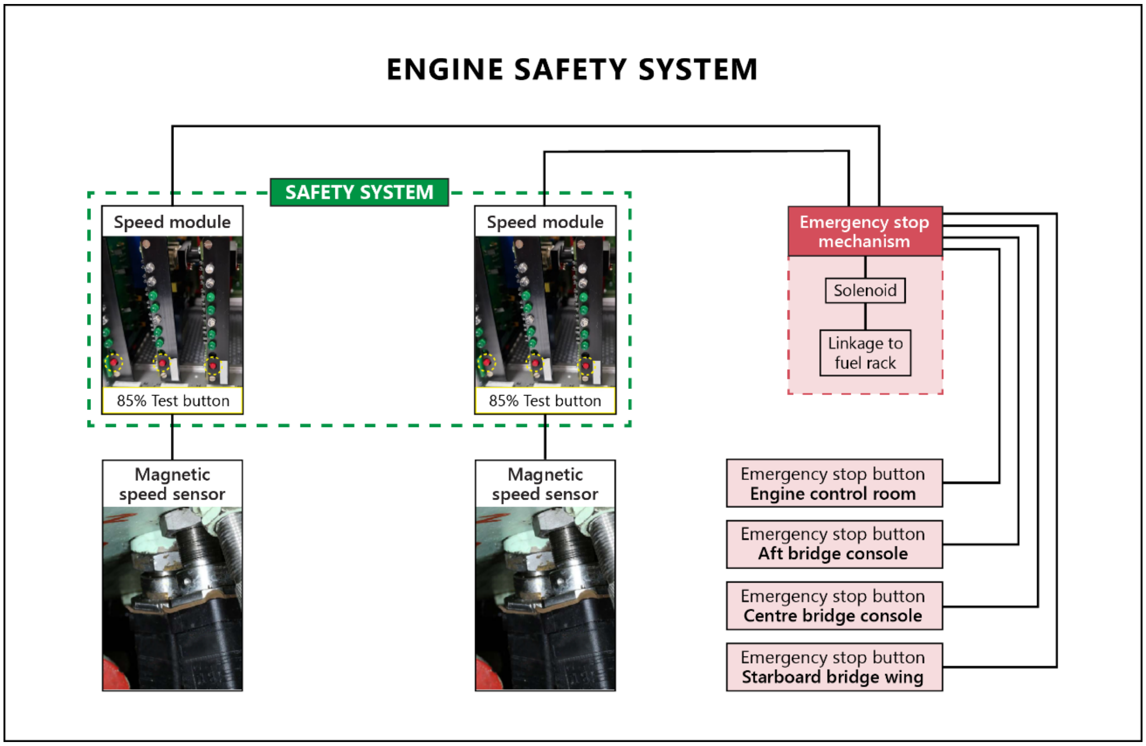
Engine management systems are designed for the weather conditions that a vessel will operate in. In adverse weather conditions, vessel motions can cause the propeller to be subjected to varying loads as the hull moves up and down faster than it would in better weather. The varying loads will cause the propeller speed to change, and if the engine management system is not able to respond to the change quickly enough, the engine can overspeed. In this occurrence, the *Atlantic Destiny* had suspended fishing operations due to adverse weather conditions, and the controllable-pitch propeller was set to approximately 40%.

1.10.2 Engine safety system

The engine safety system (Figure 6) provided monitoring and protection of the *Atlantic Destiny*'s engine and gearbox. The safety system shut the engine down automatically via the emergency stop mechanism when preset engine parameter limits were met. Engine parameters monitored by the safety system include excessive engine speed, low lubricating oil pressure in the engine, or low gearbox oil pressure. In addition to this automatic safety system, the engine could be shut down by an operator manually by depressing any 1 of 4 emergency buttons. Three emergency buttons were located on the bridge: 1 at each navigation console and 1 in the ECR.

An unsafe condition in any of the monitored parameters sends an electric signal to the emergency stop mechanism, causing the fuel rack to be set to zero, cutting off the fuel supply, and causing the engine to stop. The emergency stop arrangement comprised a solenoid and a mechanical linkage connected to the fuel rack. When the solenoid was activated, it contacted the mechanical linkage, causing it to disconnect the fuel rack control rod from the engine management system actuator, thereby cutting off the flow of fuel despite the set point of the governor.

Figure 6. Diagram of the engine safety system showing the components of the overspeed protection system (Source: TSB)



1.10.3 Overspeed protection system

As a component of an engine safety system, an overspeed protection system constantly measures the rpm of an engine, senses when the engine reaches a predetermined speed, and immediately stops the engine to prevent damage. If the fuel supply for a diesel engine becomes uncontrolled, and the overspeed protection system does not work, the engine speed will accelerate to speeds above the design parameters for the engine, causing engine damage.

The overspeed protection of the engine safety system on board the *Atlantic Destiny* consisted of 2 magnetic speed sensors fitted in the same location as the sensor for the engine management system, and 2 speed modules to send a signal to the emergency stop mechanism when an overspeed condition was detected. These sensors and modules were arranged in loops such that they acted independently of each other, providing redundancy, and shutting down the engine if only 1 loop signalled a speed in excess of the set parameter.

For the *Atlantic Destiny*, the manufacturer recommended an overspeed protection setting of 110% of the engine operating speed, meaning that the stop mechanism should be activated when the engine speed was 990 rpm.[14] DNV recommended an overspeed protection setting of 115% above the engine operating speed for diesel engine driven generators, or

14 Deutz AG, *Operation manual S/BV6/8/9M628: Medium-sized and large engines,* 3rd Edition (10/2001), section 3.3.3: Setting data for monitoring equipment.

1035 rpm.[15] The recorded value of the overspeed shutdown for the *Atlantic Destiny* engine was 1035 rpm or 115% of the engine speed for normal operating conditions. TC requires verification of safety monitoring devices[16] but does not give specific numbers.

1.10.4 Testing of the overspeed protection system

Safety systems should be tested at regular intervals as recommended by the manufacturer and must be tested annually as part of the inspections for certification. Safety systems should also be tested after maintenance on any of the components of the system. All components of the safety system should be tested.

For the engine safety system on the *Atlantic Destiny,* the manual recommended testing every 1500 hours,[17] and the preventive maintenance system showed this time period for testing the overspeed protection and lubricating oil pressure shutdowns.

A complete test of the overspeed protection component of the engine safety system tests both safety module loops. This could be accomplished as follows:

- **Speed module test button.** Each speed module is fitted with a test button to allow for testing at 85% of the preset overspeed shutdown rpm. This allows testing of the emergency stop mechanism without creating an actual physical overspeed of the engine. One person, in the ECR, pushes the test button and a second person, at the engine, notes the rpm when the engine shuts down. From this rpm, the actual shutdown rpm can be calculated.

  To confirm that each safety module loop is able to shut down the engine independently, each loop needs to be tested separately. This method ensures that all components of the overspeed protection component of the engine safety system are functioning for each safety module loop.

  This method is described in the manufacturer's manual.[18]
- **Frequency generator.** A frequency generator inputs a frequency corresponding to the overspeed shutdown rpm into first one and then the other speed module of the engine safety system while the engine is shut down. This simulation causes the engine safety system to activate the emergency stop mechanism at the overspeed shutdown rpm. This method ensures that all components of the overspeed protection portion of the engine safety system are functioning for each safety module loop.

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15 Det Norske Veritas, DNV-RU-SHIP, *Rules for classification: Ships* (July 2016), Part 4, Chapter 3, section 2, subsection 3.2.4: Overspeed.

16 Transport Canada, SOR/90-264, *Marine Machinery Regulations* (as amended 23 June 2021), Part IV, Division 1, section 19.

17 Deutz AG, *Operation manual S/BV6/8/9M628, Medium-sized and large engines,* 3rd Edition (10/2001), section 8.1.3: Periodic maintenance jobs for engines running in continuous operation.

18 Noris Tachometerwerk GmbH & Co., *Safety System KN2100* (26 January 2000), section 2.1.7.1: Overspeed test with engine running.

This method was used by service providers. The service providers' technicians recommended they be present for future tests.

Contractors who worked on the *Atlantic Destiny* during annual periods of shore maintenance sometimes tested the overspeed protection system using either the test buttons or the frequency generator. Records show that the tasks in the 1500-hour test of the preventive maintenance system were closed by referring to the annual tests.

When demonstrating the functionality of the engine overspeed protection system for annual inspections, a third test method, physical overspeed, was most commonly used. The mechanical linkage between the actuator and the fuel rack is physically adjusted with a wrench to cause the rpm to rise to the overspeed shutdown rpm. This causes the magnetic speed sensor to send a signal to the speed modules that cause the engine safety system to activate the emergency stop mechanism. This method only confirms that 1 loop of the overspeed protection system is working, not both.

The physical overspeed method was used by crew and shore staff, as well as some contractors, not all of whom were aware that they were testing only 1 loop of the overspeed protection system.

1.10.5 Oversight and inspection of engine tests

Part of an inspection is to ensure that an engine safety system has been adjusted correctly and is operational. For both TC[19] and DNV[20] inspections, the person conducting the inspection can witness these tests or choose to accept the report of the third-party service provider who conducted the test. In all cases, the person conducting the inspection must ensure that all components of the engine safety system are tested.

In 2017, TC witnessed the tests of the engine safety system, for which the physical overspeed test was used. In later inspections, it accepted the reports from third-party service providers. When the inspections were delegated to DNV in March 2019, the engine safety system was tested by a third-party service provider and the chief engineer, and these tests were accepted by DNV. In January 2020, the engine safety system was tested by a third-party service provider and the chief engineer, using the physical overspeed test method. These tests were accepted by DNV for the annual survey conducted in March 2020. In January 2021, the engine safety system was tested in the same way by a different third-party service provider.

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19 At the time of the inspections between 2017 and 2021, the *Marine Machinery Regulations* were in force. General requirements state that tests for safety devices must be witnessed, but a more specific requirement states that for speed-regulating governors and other complex systems, maintenance records and test results are acceptable. (Source: Transport Canada, SOR/90-264, *Marine Machinery Regulations* [as amended 03 February 2017], Division II, subsection 20(1), item 11; and Division I, section 19, item 3).

20 DNV, *Rules for classification: Ships,* DNV-RU-SHIP (July 2020), Part 7, Chapter 1, section 7, subsection 3.1: General.

1.11 Maintenance

The *Atlantic Destiny* was the only OCI vessel based in Nova Scotia and was managed by the operations manager there, who worked with the fleet maintenance manager in Newfoundland and Labrador. The operations manager came from a background in fish processing, and he depended on the engineers of both crew rotations for input when setting priorities for operational and maintenance spending.

The vessel's maintenance history, which includes crew reports, incident and accident reports, and other reports produced by the maintenance system, helps identify problems, potential hazards, and possible solutions.

Maintenance was managed differently, depending on the source of the maintenance request. Maintenance resulting from accidents and incidents related to the vessel machinery was handled by the chief engineers, who reported the accident or incident to the operations manager. The operations manager then called a third-party service provider who investigated the problem, repaired the damaged components, and then documented the issue and the work that was done in a service report. Routine maintenance was usually managed using the preventive maintenance system software. Unscheduled maintenance requests from the engineers on each 3-week shift were managed informally.

When the vessel was at sea, maintenance was conducted by the vessel's engine room crew, which consisted of the chief and second engineers. The engineers worked a 2-watch system with each watch consisting of 12 hours per day and with 1 engineer on watch at a time. The engineering crew also maintained the vessel's processing factory. The crew worked rotations of 3 weeks on and 3 weeks off.

As the engineers conducted maintenance at sea during a 3-week trip, they created a work request list for maintenance to be conducted in port. This list was sent to the operations manager who coordinated third-party contractors and OCI maintenance personnel to conduct work while the vessel was in port for a crew change. The amount of time spent in port was usually 1 to 2 days. To reduce the risk of transmission of COVID-19, the engineers' handovers consisted of short meetings and notes instead of periods of overlapping work.

During the January 2021 maintenance period, the 12 000-hour maintenance on the engine was due. The maintenance was originally scheduled to be completed by the regular third-party contractor, but the contractor was changed due to availability and COVID-19 protocols. The task list for the 12 000-hour engine maintenance was modified because not all parts had been ordered or delivered to the vessel. Instead, when the job started, the contractor had to compile a list of the additional parts required to complete the maintenance. For example, all 3 fuel injection pump assemblies were due to be changed during the maintenance period, but only 1 new pump assembly was available. In addition, there were no parts available to overhaul the main air start valve.

At the end of the maintenance period, the engine was test run at 50% of load. The overspeed protection system was tested using the physical overspeed method and it activated at 1035 rpm, 115% of the engine operating speed. The lubricating oil pressure shutdown was tested. The contractor made recommendations for additional work on the engine. It also reported having observed issues with the emergency stop arrangement (wear in the mechanical linkage and travel of the solenoid).

One fuel injection pump assembly for cylinders 1, 2, and 3 (aft fuel injection pump assembly) was replaced during the maintenance period. The mechanical linkage between the fuel rack and the actuator was calibrated and the fuel injection pump assemblies were set up according to the manual on board the vessel. The contractor initially began to remove the centre fuel injection pump assembly for cylinders 4, 5, and 6. It then realized that the only spare pump available to be installed was for cylinders 1, 2, and 3 and so reinstalled the centre fuel injection pump assembly.

When the vessel returned to sea after the maintenance period, the trip had to be cut short and the vessel had to return to port due to issues with the engine: the engine had low power and had difficulty maintaining a constant speed, crankcase gases were escaping at the aft fuel injection pump assembly, and heavy black smoke was coming from the exhaust.

When the engine was examined during the unplanned return to port between 28 and 31 January, the contractor found resistance in the actuator movement. The contractor reinstalled the old fuel injection pump assembly that had been removed during the maintenance period and replaced the actuator with a spare used actuator. In addition, the magnetic speed sensor for the governor feedback was found to be providing a weak signal and a new magnetic speed sensor was ordered. The contractor subcontracted a marine electronics specialist, who was working on the *Atlantic Destiny* for the first time, to help with the work on the engine management system.[21] On 31 January, the vessel returned to sea.

On 16 February, when the vessel returned to port for a crew change, the contractor and subcontractor came on board. The new magnetic speed sensor was installed to eliminate the problem with the engine failing to maintain a constant speed. The contractor also changed the settings for the mechanical linkage between the fuel rack and the actuator to correspond better to the movement of the actuator. On 17 February, the vessel returned to sea.

1.12 Electrical power sources

When the vessel was running on its engine, electrical power was supplied by 2 independent 704 kW shaft generators. The main gearbox, which was driven by the engine, had 2 output shafts driving the shaft generators via separate fluid couplings.

When the engine was not running and the vessel was not on shore power, the vessel's source of electrical power was via a 910 kW diesel-driven generator. This generator unit

21 During the initial visit and the follow-up visit, the specialist was learning the electronic control system on board the *Atlantic Destiny* through troubleshooting.

was identified as the "auxiliary generator"[22] on the plans. It had a dedicated fuel tank located inside the auxiliary engine room. As a normal practice, when the vessel was at sea and the engine was running, the auxiliary generator was shut down and placed in standby mode. In standby mode, the auxiliary generator automatically started and provided electrical power to the vessel if the electrical power from the shaft generators was interrupted.

The main switchboard, located in the ECR, contained the control panels for both the shaft generators, the auxiliary generator, and the 2 shore-power connections, and also contained various breaker panels for the electrical distribution system. The 450 V/60 Hz distribution system supplied 115 V power throughout the vessel. The distribution system could supply power either via a motor generator set to a 450 to 115 V transformer or via a 450 to 115 V transformer alone. In this occurrence, when the auxiliary generator was brought online, the engineers closed the breakers to supply power to the lights via the motor generator set to a transformer. When the auxiliary generator was restarted after the CO_2 release, the engineers were not able to close the breaker that connected the auxiliary generator to the 450 V distribution system.

Large fishing vessels such as the *Atlantic Destiny* (group 5A) are required to have an emergency power source provided either by an emergency generator or batteries.[23] The emergency power source must be capable of supplying at least 3 hours of power for the alarm and communication systems, emergency lighting, and navigation lights.[24] On the *Atlantic Destiny*, the emergency power source was provided by batteries.

The 115 V distribution system supplied the chargers for the six 24 V emergency battery systems that supplied 24 V DC power to the following:

- The emergency lighting switchboard in the wheelhouse
- The switchboard in the wheelhouse (this system supplied the navigation lights, bow thruster, telephone, and CO_2 system and could supply the alarm system, fire alarm system, engine, and steering gear power)
- The emergency radios
- The switchboard in the engine room for the alarm system, fire alarm system, engine controls, controllable-pitch propeller system, navigation lights back up, and steering gear
- 2 independent systems for the 24 V DC starter for the auxiliary generator

[22] To be classified as an emergency generator for this class of vessel, requirements for fuel supply, generator location, and distribution system must be met (Source: Transport Canada, TP 127E, *Ships Electrical Standards,* Revision 3 [May 2018], part A, section 1.7.2).

[23] Ibid., section 1.6.2.

[24] Ibid., section 1.7.1.

In comparison, vessels of group 4 (Convention cargo vessels), which operate at distances from shore similar to group 5A vessels, are required to be capable of supplying all services essential for safety in an emergency for a period of 18 hours, to have a location for the emergency power source that is not affected by a fire or other casualty in the machinery space, and to have a separate emergency switchboard.[25]

1.13 Firefighting appliances

A large fishing vessel such as the *Atlantic Destiny* must meet the emergency equipment requirements of the *Large Fishing Vessel Inspection Regulations*[26] and the *Fire and Boat Drills Regulations.*[27] The vessel carried all the firefighting equipment required for this type of vessel. The vessel also carried equipment beyond the minimum requirements, such as the DSPAs and the EEBDs.[28] These EEBDs and DSPAs were not indicated on the vessel's fire and safety plan or mentioned in the monthly safety inspection checklist and action report.

Finding: Other

Although the 2 EEBDs and the 2 portable DSPA extinguishers were not required to be carried on board the *Atlantic Destiny*, the EEBDs were useful for escaping the engine room and the DSPAs were useful in extinguishing the engine room fire.

1.13.1 Fire main line

The *Atlantic Destiny's* fire main line was supplied by two 50 m³/h electrically-driven fire pumps located in the engine room and connected to the electrical distribution panel. These pumps could be run only when the shaft generators or the auxiliary generator were running.

The fire main line could also be supplied by a 25 m³/h emergency diesel-driven centrifugal pump. The emergency fire pump was located in the steering gear compartment on the starboard side of the steering gear and could only be started from this location. The engine driving the pump was equipped with an independent fuel supply tank and a 12-volt battery bank to facilitate starting the engine with an electrical starter. In addition to the electrical starter, the engine could be started manually with a crank handle inserted into the engine flywheel. A decompression lever allowed the operator to crank the engine with the crank handle, bring the engine up to sufficient speed and then, upon releasing the decompression lever, cause the engine to start. In the design of the vessel, the engine and pump arrangement

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25 Ibid., section 1.5.1.

26 Transport Canada, C.R.C., c. 1435, *Large Fishing Vessel Inspection Regulations* (as amended June 2021), section 25: Fire protection arrangements.

27 Transport Canada, SOR/2010-83, *Fire and Boat Drills Regulations* (as amended 23 June 2021).

28 This equipment is required for vessels that are similar to the *Atlantic Destiny* and on similar voyages but that are not fishing vessels. (Transport Canada, SOR/2017-14, *Vessel Fire Safety Regulations* [as amended 23 June 2021]).

was installed such that there was only 30 cm between the adjacent bulkhead and the engine, which made cranking the engine difficult.

The investigation revealed that no instructions for starting the emergency fire pump, either electrically or manually, were posted at the pump location.

1.13.2 Carbon dioxide fixed fire suppression system

CO_2 is a colourless, odourless inert gas. It is non-flammable and non-conductive and is often used for fire suppression in category A spaces[29] such as engine rooms, and other confined spaces such as cargo holds.

When applied to a fire, CO_2 provides a heavy blanket of gas that displaces air and reduces the oxygen level to a point where combustion cannot occur. Proper sealing of the engine room is essential to extinguish the fire effectively. If a space is re-entered too early, the fire may re-ignite and backdrafts may occur.[30]

To operate a CO_2 fixed fire suppression system, the space must be evacuated and then sealed, quick-closing valves for the affected area must be activated, the CO_2 must be released, and then the space must remain sealed. Proper sealing of the space is essential to extinguish the fire effectively. However, because CO_2 is less efficient at cooling than water, ventilation of the engine room should not be started until it has been established both that the fire has been extinguished completely and that conditions are no longer sufficient for the fire to restart, a process that takes hours.

On the *Atlantic Destiny*, the quick-closing fuel valves included a valve fitted to the dedicated tank for the auxiliary generator, which, when closed, would stop the fuel supply to the auxiliary generator.

The *Atlantic Destiny* had a CO_2 fixed fire suppression system for the engine room and auxiliary engine room. The system consisted of six 53-kilogram cylinders and 2 CO_2 release stations. The cylinders were stored in the CO_2 room, located midship on the starboard side of the shelter deck. One release station was located in a compartment beside the CO_2 room and the second release station was located aft, on the starboard side of the shelter deck beside the scallop sorting area.

The vessel's SMS manual contained only information about the certification of the CO_2 fixed fire suppression system. The investigation determined that the master and chief engineer

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29 Category A machinery spaces of are "spaces and trunks to such spaces that contain internal combustion machinery used for main propulsion, internal combustion machinery for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW, or any oil-fired boiler or oil-fuel unit." (Source: Transport Canada, TP 11469E, *Guide to Structural Fire Protection* (1993), Part 1: Definitions, at https://tc.canada.ca/en/marine-transportation/marine-safety/guide-structural-fire-protection-1993-tp-11469-e#wb1 (last accessed on 08 December 2023).

30 United Kingdom Marine Accident Investigation Branch, *Safety Digest: Lessons from Marine Accident Reports,* Volume 2 (2017), pp. 12–13, at https://assets.publishing.service.gov.uk/media/5e81e5d2e90e0706fba5421d/2017-SD2-MAIBSafetyDigest.pdf (last accessed on 08 December 2023).

thought that a period of 20 to 60 minutes was enough time to wait before re-entering a space where CO_2 had been released.

1.13.3 Fire detection system and other firefighting appliances

The *Atlantic Destiny's* fire detection system consisted of 53 smoke detectors and 6 heat detectors. The *Atlantic Destiny* carried the following firefighting appliances:

- 1 45 L foam extinguisher
- 1 foam applicator with two 25 L foam containers
- 4 portable 5 kg CO_2 fire extinguishers
- 1 fixed 2 kg CO_2 fire extinguisher for the galley exhaust duct
- 1 fixed 4 L wet chemical fire extinguisher for the deep fat fryer
- 11 portable 9 kg powder extinguishers
- 2 portable DSPA extinguishers

1.13.4 Personal protective equipment

1.13.4.1 Firefighter outfits

The *Atlantic Destiny* firefighter outfits consisted of a fire protection suit with boots and gloves, an SCBA, a fire helmet with neck shield, a safety lamp, a fire axe, a fireproof safety line, and a signalling line.

The *Atlantic Destiny* had 2 firefighter outfits stored in the firefighter equipment locker located inside the deck store compartment on the shelter deck. One additional SCBA was kept on the bridge.

1.13.4.2 Emergency escape breathing devices

An EEBD is a self-contained breathing apparatus for escape from a hazardous area due to smoke, fire, or poisonous gases. It consists of a face mask and a small compressed air cylinder ready for use, with a capacity of 10 to 15 minutes of breathing time. EEBDs are compact, light, and easy to use.

The *Atlantic Destiny* had 2 EEBDs on board, both located in the ECR. One of the EEBDs was expired and had been taken apart.

1.13.5 Fire alarms

The purpose of a fire alarm system is to detect the presence of fire or smoke and alert the occupants of the vessel, allowing them to evacuate to safety and facilitating a quick response to the fire emergency. The *International Code for Fire Safety Systems*[31] specifies

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[31] International Maritime Organization, *International Code for Fire Safety Systems* (2015 Edition), chapter 9: Fixed fire detection and fire alarm systems, section 2.5.1: Visual and audible fire signals.

that "Means to manually acknowledge all alarm and fault signals shall be provided at the control panel. The audible alarm sounders on the control panel and indicating units may be manually silenced."

Finding: Other

In this occurrence, the fire alarm sounded continuously, distracting the crew during the emergency response.

1.13.6 Maintenance and verification

All shipboard firefighting appliances, detection, and suppression systems were inspected and certified annually by a class-approved shore technician. The last inspection was carried out on 04 March 2020.

One of the crew members, designated as a safety officer, was responsible for inspecting the firefighting equipment monthly. After each inspection, the safety officer filled out and signed a Safety Inspection Checklist & Action Report and sent it to the company. The last inspection was carried out on 16 February 2021.

According to the OCI SMS for the *Atlantic Destiny,* during each fire drill, the appropriate fire hose was to be run out, examined, and pressure tested; fog nozzles and other spray equipment were to be tested and the crew instructed in their use. Every hose was to be used in a drill at least once every 2 months.

The vessel's maintenance schedule required that the operation of the emergency fire pump be tested weekly, every Sunday. The investigation revealed that the engine crew started the emergency fire pump using the electrical starter but not using the manual crank.

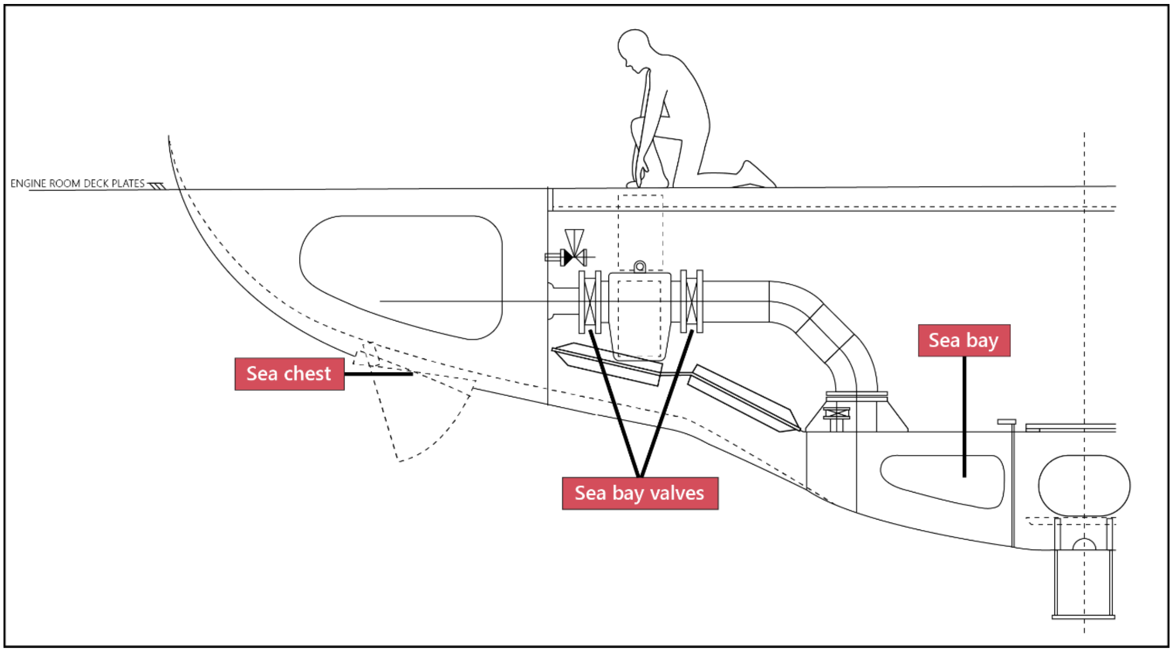
1.14 Control of water ingress

Water ingress is controlled by closing off the source of ingress and by removing the water from the vessel.

1.14.1 Sea bay valves

The *Atlantic Destiny* was equipped with a seawater system (Figure 7) that provided the vessel with seawater for cooling the engines, ballast water, firefighting, and fresh water generation. The system was composed of a port and starboard sea chest (a tank-like part of the ship's structure whose exterior hull plating allows for seawater to enter). Each sea chest was connected to the single interior tank inside the vessel, called the sea bay, via piping consisting of 2 valves, a strainer, and pipe sections inside the engine room. The piping allowed for the port and starboard sea chests to be isolated so that 1 sea chest supplied the sea bay at a time. The sea bay was an independent internal tank located in the bottom of the vessel, with seawater suctions for the various systems that it supplied. The sea chests and sea bay on the *Atlantic Destiny* were located between frames 23 and 25, which corresponded to the forward part of the vessel's engine room.

Figure 7. Diagram of sea bay valves in the engine room cross-section, showing the access point used in the occurrence. The TSB also added a human figure for scale. (Source: Ocean Choice International, Atlantic Destiny drawing No. 1-6577 Sea Chest and Inlet Grids, with TSB annotations)



The valves connecting the sea chests to the sea bay were replaced during the drydocking of the *Atlantic Destiny* in January 2019. The engineers reported that the sea bay valves were operated at the end of each trip when the strainers were alternated from port to starboard and cleaned.

1.14.2 Vessel pumps

According to the bilge and ballast plan, the vessel was equipped with several means to remove water from the machinery spaces. Three pumps were powered from the main electrical distribution system:

- 1 dedicated bilge pump with a capacity of 30 m^3/h
- 1 dual-purpose bilge and ballast pump with a capacity of 30 m^3/h
- 1 emergency bilge suction connected to the seawater cooling pump on the engine

The drawing also showed 2 other means of removing water:

- 1 portable electrical submersible pump with a capacity of 35 m^3/h
- 1 portable bilge ejector that could be connected to the fire main line

In this occurrence, none of these pumps were used to control the water ingress in the engine room.

1.14.3 Search and rescue pumps

As part of its mandate, the Canadian Armed Forces provides aeronautical SAR services while also supporting the CCG in providing maritime SAR. RCAF squadrons responsible for

SAR have a minimum of 3 air-droppable pump kits for use in response to maritime occurrences. The single type of pump and kit elements that the RCAF employs is of a size and weight that can fit on board SAR aircraft and be easily handled by aircrew, as well as recovered by the crew on the distressed vessel and put to use. The pump kit is designed to perform in a variety of situations and is intended to provide additional time for other operations related to the emergency response. The choice to use a single type of pump minimizes the financial, personnel-related, and logistical pressures that may be associated with the acquisition, maintenance, and training on multiple pumping systems.

The Canadian and U.S. pump kits that were used in this occurrence were similar. The pumps were powered by a gasoline engine. The output rates were 454 to 568 L per minute at a 3 m suction lift. The suction hose was non-collapsible, 7.6 cm in diameter, and between 4.6 and 4.8 m in length, with a metal strainer. The discharge hose was approximately 6 m in length.

In this occurrence, the SAR pumps were set up at the top part of the engine room. The discharge hoses were not long enough. The crew cut the vessel's fire hose and connected sections to the SAR pump hoses using a short steel pipe fixed with tape and clamps.

The SAR pumps lost suction multiple times because the strainers became clogged with debris floating in the engine room. Each time a pump lost suction, the crew members had to enter the engine room and work in the cold water to unclog the strainer and prime the pump to get it running again.

In 2016, the TSB investigated an occurrence involving the fishing vessel *Saputi*.[32] On 21 February 2016, the *Saputi*, with 30 people on board, was fishing turbot in the Davis Strait, 167 NM east-northeast of Resolution Island, Nunavut, and 220 NM west-southwest of Nuuk, Greenland. At 1935 Atlantic Standard Time, the vessel struck a piece of ice and was holed in the shell plating on the starboard side at the forward end of the cargo hold. After pumping operations failed to keep up with the ingress of water, the cargo hold was sealed, and it subsequently flooded. During the occurrence, SAR resources provided the vessel with additional pumps. The investigation found that, despite the use of the vessel's pumps as well as those provided by assisting SAR resources, the crew was unable to stem the ingress of water as the mixing of the cargo with the water clogged the pump suctions and prevented them from working at full capacity. As well, the investigation found that if equipment provided by SAR resources is not adaptable to a vessel's size or condition, the maximum benefit of that equipment is not realized, and there is a risk that the assistance to the vessel and its crew will be ineffective.

1.15 Crew emergency preparedness

When faced with an uncertain situation, particularly when there is an element of time pressure and the potential consequences are serious, individuals will often focus on responding to, rather than evaluating, the situation. For this reason, it is important for crew

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[32] TSB Marine Investigation Report M16C0016.

members to have had sufficient training and to have practised different emergency situations and tasks. With practice, tasks can be performed automatically, with minimal demand on working memory, which can be vulnerable to external stressors such as emergency events and associated distractions. .[33]

Training and practice are particularly important because, in the event of an emergency, there is no time to learn how to use firefighting equipment and the stressful nature of an emergency makes it more difficult to remember the procedures or techniques to respond quickly.

When task performance is required as part of a team, it is important for procedural knowledge and skill development to occur in this context. This optimizes the probability that the team can respond in the most effective and efficient manner.

Knowledge, rules, and skills can be developed and maintained for both individuals and teams through formal emergency training, including recurrent training; through vessel-specific familiarization; and by performing regular emergency drills. Performing complex and realistic drills that use different scenarios increases preparedness and enables participants to practise making decisions in emergency situations. In particular, senior officers on board a vessel who are required to make emergency decisions should have a full awareness of the appropriate use of emergency systems.[34]

1.15.1 Safe manning documents

The *Marine Personnel Regulations* (MPR) specify that a vessel must obtain a safe manning document before being operated. A safe manning document lists the minimum number of crew members and qualifications required to operate the vessel and respond to emergencies on the voyages that the vessel is authorized to engage in.[35] The MPR also specify which certificates are required for roles on the vessel, depending on its type, size, and voyage. Lastly, the regulations define the qualifications needed to obtain the required certificates.

To obtain or renew a safe manning document, the authorized representative sends a proposal for the safe crewing of their vessel to TC. TC evaluates the proposal to ensure that the vessel's complement meets the MPR and contains the number and capacities of personnel to fulfill the tasks, duties, and responsibilities required for the safe operation of the vessel, for the protection of the marine environment, and for dealing with emergency

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33 C. D. Wickens and J. G. Hollands, *Engineering Psychology and Human Performance*, 3rd Edition (Pearson, 1999), Chapter 12: Stress and Human Error, pp. 483–484).

34 United Kingdom Marine Accident Investigation Branch, *Safety Digest: Lessons from Marine Accident Reports,* Volume 2 (2017), pp. 12-13, at https://assets.publishing.service.gov.uk/media/5e81e5d2e90e0706fba5421d/2017-SD2-MAIBSafetyDigest.pdf (last accessed on 14 November 2023).

35 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (as amended 23 June 2021), sections 202-207.

situations. Also, TC ensures that the master, officers, and other crew members are not required to work more than the requirements for work and rest hours specified in Canadian regulations.[36]

Table 2. Specifications of the safe manning document for the Atlantic Destiny

Grade/capacity*	Certificate
Master	Fishing Master, Third Class
Chief mate	Fishing Master, Third Class
Second mate	Fishing Master, Fourth Class
Chief engineer	Third-class Engineer, Motor Ship
Second engineer	Watchkeeping Engineer, Motor-driven Fishing Vessel
2 deckhands	Bridge Watch Rating
4 deckhands	Basic Safety (MED A1) training

* In the safe manning document, the second mate is called a watchkeeping mate and the deckhands are called ratings.

The TSB compared the safe manning document for the *Atlantic Destiny*, as a large fishing vessel certified for Near Coastal, Class 1 voyages, with those of 3 non-fishing vessels of similar size and certified for the same class of voyage. The investigation determined that the officers on the non-fishing vessels are required to follow more advanced training for multiple areas, such as more advanced MED training and ship management.

Although the safe manning documents met the requirements of the MPR, they specified different qualifications for the navigating officers:

- On the *Atlantic Destiny*, the master and the chief mate required a Fishing Master, Third Class certificate. This certificate requires the holder to complete training for MED with respect to basic safety (MED A1).
- On the non-fishing vessels, the masters needed a Master 3000 Gross Tonnage, Near Coastal certificate, and the chief mates needed a Chief Mate, Near Coastal certificate. Both of these certificates require the holder to complete MED Basic Safety (STCW), MED Advanced Firefighting (STCW) and MED for Senior Officers (MED D) training.

Finding: Other

The chief mate of the *Atlantic Destiny* held a Fishing Master, Fourth Class certificate of competency, whereas the vessel's safe manning document required the chief mate to have a Fishing Master, Third Class certificate.

1.15.2 Marine Emergency Duties training

The goals of Marine Emergency Duties training courses include the following:

> 1) To help seafarers understand the hazards associated with the marine environment and with their vessel.

36 Ibid., section 319.

> 2) To provide, through approved shore-based courses, training in the skills that seafarers require to cope with such hazards, to an extent appropriate to their functions on board.[37]

The hazards associated with the marine environment depend in part on the nature of the voyage. For Canadian vessels and vessels in Canadian waters, voyages are classed according to factors such as the distance from shore. For example, on Near Coastal voyages, Class 1, the vessel can operate up to 200 NM from shore.[38]

Requirements for MED training in basic safety, advanced firefighting, and duties for senior officers vary depending on the certificate of competency.[39]

The course syllabi[40] specify topics related to firefighting, providing drills and familiarization and leading emergency responses as follows:

- MED Basic Safety (MED A1) includes 3 hours of theory and 3 hours of practical exercises related to firefighting. The practical exercises involve the correct use of portable fire extinguishers to extinguish class A, B, and C fires and basic work with fire hoses and nozzles.
- STCW basic safety training includes 9.5 hours of theory and 16 hours of practical exercises related to firefighting, including onboard training. The theory covers firefighting theory, fire control aboard vessels, and the shipboard organization of firefighting responses. The practical exercises involve the correct use of portable and mobile extinguishers, the use of fixed fire suppression equipment, how to don firefighter outfits, starting emergency fire pumps, moving through spaces in firefighter outfits and using breathing apparatus in low visibility, conducting rescues, participating in a team to fight fires in a simulated ship structure, using a firehose and nozzles, and taking care of firefighting equipment.
- MED Advanced Firefighting includes 19 hours of theory and 18.5 hours of practical exercises, including 2.5 hours for the on-scene leaders' plan of attack, 10 hours for the coordination of shipboard firefighting, and 4 hours for fixed fire detection and extinguishing facilities including CO_2 fixed fire suppression systems.
- MED for Senior Officers (MED D)[41] includes 10 hours of theory and 5 hours of practical exercises, including contingency plans, orientation and emergency training

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37 Transport Canada, TP 4957E, *Marine Emergency Duties Training Courses*, Revision 2 (July 2021), section 1.3.

38 For a detailed definition of voyage classes, see Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (as amended 23 June 2021), Interpretation.

39 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (as amended 23 June 2021).

40 Transport Canada, TP 4957E, *Marine Emergency Duties Training Courses,* Revision 1 (June 2007) and Revision 2 (July 2021).

41 Based on the amendments to the 2010 STCW Convention, the competencies addressed in Marine Emergency Duties (MED) for senior officers (MED D) were integrated into MED with respect to STCW Basic Safety and STCW Advanced Fire-Fighting courses. Revision 2 of TP 4957 (July 2021) was approved in January 2023 and no longer includes a reference or syllabus for MED D.

of crew members, emergency management, damage control, abandon vessel decisions, SAR, and the organization and management of medical care on board.

MED refresher training is not required for those employed on fishing vessels; however, it is compulsory for those employed on other types of vessels engaged in Near Coastal, Class 1 voyages, such as the voyages the *Atlantic Destiny* was certified for.[42]

Table 3. Comparison of Marine Emergency Duties training requirements for selected certificates of competency

Certificate of competency	MED A1	MED Basic Safety (STCW)	MED Advanced Firefighting (STCW)	MED D
Fishing Master, Class 1 and 2	Not needed	Required	Required	Required
Fishing Master, Class 3 and 4	Required	Not needed	Not needed	Not needed
Engineer, Classes 1, 2, and 3	Not needed	Required	Required	Required
Engineer, Class 4	Not needed	Required	Required	Not needed
Watchkeeping Engineer, Motor-driven Fishing Vessel	Not needed	Required	Not needed	Not needed
Bridge watch Rating	Not needed	Required	Not needed	Not needed

1.15.2.1 International standards of training, certification, and watchkeeping for fishing personnel

The International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F) [43] was adopted by the International Maritime Organization in 1995. STCW-F sets certification and minimum training requirements for crews of seagoing fishing vessels with the aim to promote the safety of life at sea and the protection of the marine environment, taking in account the unique nature of the fishing industry and the fishing working environment. STCW-F generally applies to personnel of seagoing fishing vessels and, in particular, to skippers (masters) and deck officers of fishing vessels of 24 metres in length and over, and engine room officers of fishing vessels powered by main propulsion machinery of 750 kW propulsion power or more.

STCW-F came into force on 29 September 2012, and Canada became a party to the Convention on 29 September 2017. TC is developing regulations to ensure full compliance with STCW-F. Until these regulations come into force, TC encourages holders of fishing vessel certificates of competency to take steps to ensure the validity of their certificates under STCW-F. According to the interim measure published in Ship Safety Bulletin

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42 Transport Canada, Ship Safety Bulletin 09/2017: *Update on How to Meet STCW 2010 Manila Convention Requirements* (27 November 2017), at https://tc.canada.ca/en/marine-transportation/marine-safety/ship-safety-bulletins/update-how-meet-stcw-2010-manila-convention-requirements-ssb-no-09-2017 (last accessed 11 December 2023).

43 International Maritime Organization, *International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel* (1995), chapter II: Certification of skippers, officers, engineer officers and radio operators.

10/2018,[44] existing Fishing Master, Third Class certificates will be equivalent to Skipper, Limited waters or Officer, Unlimited waters certificates valid for any fishing vessel, where "Limited waters" means

> waters within 200 nautical miles from shore or above the continental shelf, limited to the waters contiguous to Canada, United States (except Hawaii) and St-Pierre and Miquelon including on the west coast of Canada the waters up to Cobb-Eickelberg seamount chain at not more than 260 nautical miles from shore.[45]

Among the requirements for obtaining this certificate of competency, the candidate will have to complete MED Basic Safety (STCW) and MED Advanced Firefighting (STCW).

1.15.3 Emergency drills and the muster list

Vessels such as the *Atlantic Destiny* are required to carry out fire and abandon ship drills at intervals of not more than 1 month or within 24 hours of leaving a port if more than 25% of the crew has been replaced at that port.[46]

The SMS manual contained general information about the expected frequency and content of drills. The master of the *Atlantic Destiny* was designated by the company as responsible for coordinating and implementing onboard drills.

The SMS manual specifies that in the event of an engine room fire,

> the engine room crew shall be exercised in their special duties in case of fire, putting the fire pumps into operation and manning the stations allotted to them for the purpose of fighting fire in the engine and boiler rooms, or elsewhere, as required.[47]

Drill records were sent to OCI head office at the end of every trip. For trips in 2020 and 2021, drills typically involved more than 1 scenario, such as a fire drill followed by an abandon ship drill due to an out-of-control fire scenario.

The muster list on the *Atlantic Destiny* specified the emergency tasks and duties to be performed by each crew member in fire, person overboard, and abandon ship emergencies.

This muster list was developed for 24 crew members, divided into 4 teams:

- the command team, made up of the master, the quality assurance person, and the second mate, with the chief mate as the alternate for the master. The command team

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44 Transport Canada, Ship Safety Bulletin 10/2018: *Interim measure for holders of a Canadian fishing master Certificate of Competency who seeks recognition under the STCW-F* (24 July 2018) at https://tc.canada.ca/en/marine-transportation/marine-safety/ship-safety-bulletins/interim-measure-holders-canadian-fishing-master-certificate-competency-who-seeks-recognition-under-stcw-f-ssb-no-10-2018 (last accessed 11 December 2023).

45 Ibid.

46 Transport Canada, SOR/2010-83 *Fire and Boat Drills Regulations* (as amended 23 June 2021), subsection 20(1).

47 Ocean Choice International Fleet Division (Nova Scotia), Safety Management System (revision 3), section 10: Emergency Preparedness & Response, p. 35.

was responsible for directing the emergency, navigational and crew safety, coast guard communication, and recording of events.[48]

- the machinery control team, made up of the chief engineer, the second engineer, and 1 deckhand, with the second engineer as the alternate for the chief engineer. The machinery control team was responsible for emergency procedures in the engine room, closing watertight doors, starting the emergency fire pump and the auxiliary generator, and shutting down the electrical system.
- the primary emergency team, made up of the chief mate and 9 deckhands. The alternate for the chief mate was the second mate. This team was responsible for bringing firefighting equipment to the appropriate location, rigging fire hoses, and watching for persons overboard.
- the support emergency team, made up of the factory leader and 7 deckhands. The alternate for the factory leader was deckhand number 2. This team was responsible for ensuring that all persons on board were accounted for, preparing life rafts and other life-saving equipment, rigging fire hoses, cooling boundaries, starving the fire, closing vents and watertight doors, and assisting the primary emergency team as directed.

According to the muster list, in case of a fire on board, 2 deckhands were required to don firefighter outfits and SCBAs. In the case of a fire in the engine room, the second engineer was required to don a firefighter outfit and an SCBA.

1.15.4 Realistic drill scenarios

Emergency drills that include realistic scenarios increase a crew's preparedness, readiness, and effectiveness in the event of an emergency. Realistic scenarios might include different conditions, such as darkness, noise, missing crew members, or damaged equipment, or combinations of individual scenarios.

1.16 Previous occurrences

1.16.1 Previous occurrences with a fire on board a fishing vessel

Between 2011 and March 2021, the TSB was informed of 177[49] fires on board commercial fishing vessels in Canadian waters; 174 of the vessels were Canadian. In at least 57 cases, a fire in the engine room was reported. In 14 cases, the crews abandoned their vessels.

Other than the *Atlantic Destiny* investigations, the TSB conducted 2 Class 3 investigations[50] and 1 Class 4 investigation.[51]

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48 Transport Canada, SOR/2007-115, *Marine Personnel Regulations* (as amended 23 June 2021), paragraph 340(1)(i).

49 This data does not include this occurrence.

50 TSB marine investigation reports M11W0063 and M15C0045.

51 TSB Marine Transportation Safety Investigation Report M20A0003.

M11W0063 – On 09 May 2011, a fire broke out in the engine room of the small fishing vessel *Neptune II*. After their attempt to fight the fire was unsuccessful, the 2 crew members abandoned the vessel into their dive tender and issued a distress call. The *Neptune II* burned to the waterline and subsequently sank east of the Broken Islands in Johnstone Strait, British Columbia. There were no injuries.

M15C0045 – On 28 April 2015, the fishing vessel *Frederike. C-2* caught on fire off Rimouski, Quebec. The crew abandoned the vessel into a life raft and was later rescued by the fishing vessel *Marie-Karine D*. The CCG vessel *Cap Perce* was dispatched to assist. The vessel later sank. No injuries were reported.

M20A0003 – On 29 January 2020, the fishing vessel *Newfoundland Lynx* reported a fire on board. The fishing vessel *Sivuliq*, 2 RCAF aircraft, and the CCG vessels *Terry Fox* and *Henry Larsen* were tasked to assist. The fire was located in the sauna and the vessel's crew managed to extinguish the fire. The fishing vessel *Sivuliq* escorted the vessel to St. Anthony, Newfoundland and Labrador, where the local fire department went on board to confirm the fire was out. The vessel sustained major damage. No injuries or pollution were reported.

1.16.2 Previous occurrences involving the *Atlantic Destiny*

In 2017, the TSB investigated the Class 3 occurrence M17A0039 involving the *Atlantic Destiny*.

M17A0039 – On 14 March 2017, the fishing vessel *Atlantic Destiny*, with 31 people on board, sustained a breakdown in its engine, as well as damage to its shaft alternators and machinery spaces, 200 NM southwest of Halifax, Nova Scotia. The vessel was subsequently towed to port. The TSB found that the engine overspeed protection was compromised by the 2 speed sensors, which were either installed incorrectly or functioning intermittently due to electrical shorting. Also, the engine safety system was not periodically tested in accordance with manufacturers' recommended schedules and repaired accordingly to ensure its readiness.

Also, the TSB obtained information that on 17 May 2017, the *Atlantic Destiny* experienced an electrical malfunction that led to the loss of propulsion. The vessel proceeded to Riverport, Nova Scotia, to carry out repairs.

Additionally, the TSB registered 2 class 5 occurrences concerning engine failures on the *Atlantic Destiny*.

M17A0216 – On 07 June 2017, the fishing vessel *Atlantic Destiny*, with 32 people on board, was reported as disabled due to an engine failure. The vessel anchored, the crew carried out repairs, and the vessel proceeded to Riverport, Nova Scotia.

M18A0092 – On 16 April 2018, the fishing vessel *Atlantic Destiny*, with 31 people on board, reported being disabled due to engine problems 98 NM southwest of Cape Sable Island, Nova Scotia. The vessel was subsequently towed to port by another fishing vessel.

1.17 TSB Watchlist

The TSB Watchlist identifies the key safety issues that need to be addressed to make Canada's transportation system even safer. The issues on this list are supported by a combination of investigation reports, Board safety concerns, and Board recommendations. All of them, however, require a concerted effort from the regulator and industry stakeholders.

Commercial fishing safety is a Watchlist 2022 issue. The TSB has long sought to improve commercial fishing safety. The TSB has been monitoring commercial fishing safety since 1999 and this issue has been on the TSB Watchlist since 2010. Every year, the same safety deficiencies on board fishing vessels continue to put at risk the lives of thousands of Canadian fish harvesters and the livelihoods of their families and communities.

As seen in this occurrence, the MPR do not require the same level of training and qualifications for the crew on large fishing vessels as are required for the crew on other vessels of similar sizes on similar voyages.

ACTION REQUIRED

Commercial fishing safety will remain on the Watchlist until there are sufficient indications that a sound safety culture has taken root throughout the industry and in fishing communities across the country, namely:

- TC and Fisheries and Oceans Canada work together to ensure that fish harvesters meet all requirements before they operate commercially.
- Federal and provincial authorities coordinate regulatory oversight of commercial fisheries.
- TC, provincial workplace safety authorities, and fish harvester associations promote existing and user-friendly guidelines on vessel stability designed to reduce unsafe practices.
- Spurred by the leadership of industry and safety advocates, there is marked and widespread evidence that harvesters are taking ownership of safety, specifically with respect to the use of stability guidelines, personal flotation devices, immersion suits, emergency signalling devices, and safe work practices.

Safety management is a Watchlist 2022 issue. Some transportation operators in the air, marine, and rail sectors are not managing their safety risks effectively, and many are still not required to have formal safety management processes in place. Moreover, those operators that have implemented a formal SMS are not always able to demonstrate that it is working and producing the expected safety improvements.

As seen in this occurrence, even though OCI voluntarily implemented an SMS for its fleet, the SMS was mostly focused on OHS. For maintenance issues, OCI used its preventive maintenance system, and the SMS did not provide clear procedures for testing the engine safety system, particularly testing of the overspeed protection component. Also, even though regulatory requirements for MED training were met, the OCI SMS did not prompt a risk assessment of the roles assigned to crew members in the muster list.

ACTION REQUIRED

Safety management will remain on the Watchlist for the **marine** transportation sector until

- TC implements regulations requiring all commercial operators to have formal safety management processes; and
- operators that do have an SMS demonstrate to TC that it is working—that hazards are being identified and effective risk mitigation measures are being implemented.

2.0 ANALYSIS

The investigation examined the causes and contributing factors leading to the engine overspeed and the explosion of the shaft generators, the subsequent fire and its reignition, and the engine room flooding. The analysis will look at the effectiveness of the firefighting and emergency equipment, maintenance management, and crew emergency preparedness and training.

2.1 Failure of the engine management system and of the engine safety system

Engines such as the engine on the *Atlantic Destiny* are designed to operate at a constant speed, using an engine management system that controls the flow of fuel to adjust the speed. These engines are protected by a safety system that will cut off the fuel supply if the speed exceeds the specified operating speed. On the *Atlantic Destiny,* both systems had been the cause of both planned and unplanned maintenance, repairs, and troubleshooting work since before the 2017 occurrence of catastrophic engine failure. For example, there was an unplanned return from sea after the January 2021 maintenance period and problems continued even after the most recent work on 16 February 2021.

The sea conditions at the time of the occurrence were rough. Under such conditions, any deficiencies in the engine management system may be magnified due to varying loads on the propeller. In the period leading up to the occurrence, the electronic governor had been unreliable in maintaining a constant engine speed. In this occurrence, both shaft generators went offline unexpectedly and the engine reduced speed to 600 rpm. However, the engine began to increase speed almost immediately, likely as a result of the engine management system applying a signal to increase the fuel to the engine without feedback. The engine continued to overspeed until the shaft generators exceeded the design limit and exploded.

Finding as to causes and contributing factors

One or more components of the engine management system failed and caused it to continually increase the engine fuel supply, which caused the engine to overspeed.

In such a situation, the 2 independent safety loops of the engine safety system are supposed to sense the overspeed and signal the emergency shutdown arrangement to disconnect the fuel rack from the actuator. When the automatic overspeed protection does not work, pushing the engine’s emergency stop button in the engine control room (ECR) disconnects the fuel rack.

In this occurrence, overspeed protection did not automatically work. Then, when the second engineer attempted to shut down the engine by pushing the emergency stop button, it is likely that either the solenoid did not extend to trip the mechanical linkage and disconnect the fuel rack from the actuator, or the mechanical linkage was not functioning correctly.

Finding as to causes and contributing factors

Both the automatic and manual activation of the engine safety system failed to prevent the engine speed from increasing beyond the design limits of the engine, causing a catastrophic failure and significant damage to the engine and the shaft generators.

2.2 Fire and flooding

The explosion of the shaft generators and associated machinery projected multiple hot metal fragments and hydraulic fluid throughout the engine room and started a fire. The metal fragments also damaged the seawater cooling system piping, resulting in an uncontrolled ingress of water.

Finding as to causes and contributing factors

The explosion of the shaft generators and associated machinery caused the fire and a breach in the seawater piping.

Shortly after the initial attempt to control the fire with extinguishers and the release of carbon dioxide (CO_2), the crew considered how to deal with the water ingress. The CO_2 release included the auxiliary engine room and required that the quick closing valves be activated, stopping the auxiliary generator; therefore, no power for the 3 bilge pumps was available. The portable electrical submersible pump shown on the bilge and ballast plan was not used.

The chief engineer and the second engineer tried to access the sea bay valves. The chief engineer had to turn around as he was not wearing fire protection gear. The second engineer was unable to access the valves as they were located under the deck plates and there were space constraints in the engine room. The second engineer returned to the engine without fire protection gear, but with the amount of water already in the engine room, he was unable to reach the valves and close them.

The 3 search and rescue (SAR) pumps were ineffective for the *Atlantic Destiny* because the hose lengths were insufficient and because the strainers became blocked repeatedly; therefore, it was not possible to keep up with the rate of water ingress.

Finding as to causes and contributing factors

Crew were unable to access the sea bay valves and onboard bilge pumps were unavailable. As a result, the flooding of the engine room could not be controlled, leading to the sinking of the vessel.

Finding as to risk

Pump kits provided by air SAR resources may not be effective for all sizes of vessels and operating conditions. If the conditions on a vessel in distress are outside the design parameters of a pump kit, there is a risk that the pump kit will not control water ingress at the expected rate, reducing the time available for the rescue operation.

2.3 Emergency sources of power

Transport Canada (TC) regulations governing vessels not included in the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW)* such as the *Atlantic Destiny* (large fishing vessels, group 5A)[52] require either batteries or an emergency generator for navigation, communication, and lighting. On the *Atlantic Destiny,* power for emergencies was provided by 6 battery systems instead of an emergency generator, which met regulatory requirements. However, Convention vessels of the same size (Convention cargo vessels, group 4)[53] are required to have an emergency power source that is sufficient to supply all those services that are essential for safety in an emergency. They are also required to have a separate emergency switchboard.

On the *Atlantic Destiny*, the bilge pumps could not be used because they were not powered by the vessel's source of emergency power. The auxiliary generator stopped because the quick-closing valve for the auxiliary generator was activated to stop the flow of fuel before the CO_2 release. Although access to the auxiliary generator was complicated by the CO_2 release, the re-ignited fire, and smoke, the engineers were able to restart the auxiliary generator. However, it could not be brought online, likely because of damage to the electrical distribution system.

The *Atlantic Destiny* was certified as a non-Convention vessel operating on Near Coastal, Class 1 voyages. The regulations required the vessel to have emergency power capable of supplying at least 3 hours of power for the alarm and communication systems, emergency lighting, and navigation lights. These systems are designed to keep lights and communications active while the vessel is abandoned or help arrives; however, they do not have the power to run essential equipment such as fire and bilge pumps during an emergency. Without power from the engine or the auxiliary generator, the vessel could not power the fire and bilge pumps.

Finding as to causes and contributing factors

The auxiliary generator could not be brought online, likely because of damage to the electrical distribution system, leaving the vessel without a pumping system.

52 Transport Canada, TP 127E, *Ships Electrical Standards,* Revision 3 (May 2018), part A, section 1.6.2.

53 Ibid., sections 1.5.1 and 1.5.2.

Finding as to risk

If vessels are not required to have emergency power sources that can supply power for essential equipment such as fire and bilge pumps, there is a risk that this equipment will be unavailable in an emergency.

2.4 Effectiveness of the emergency equipment

Given that shipboard fires can threaten life and cause severe damage to the vessel and the environment, it is important that the emergency equipment on board be usable. In this occurrence, the emergency escape hatch from the engine room and the emergency fire pump did not function as expected.

A functioning emergency escape hatch is essential for crew to escape from an engine room or other enclosed compartment on a vessel. The emergency escape hatch in the *Atlantic Destiny*'s engine room was opened by turning 3 independent latches and then pushing the hatch up. In the dark engine room that was on fire and filled with smoke, and with the vessel rolling heavily, it was extremely difficult for the second engineer to hold on to the ladder with 1 hand and open the hatch with the other.

The engineers were not able to open the emergency escape hatch from the engine room and had to wait for it to be opened from the deck above the engine room.

Finding as to risk

If crew members cannot use an emergency escape hatch in an emergency, there is a risk that they will not be able to evacuate a vessel's compartment safely.

When the vessel power failed, the remaining means to supply water to the fire main line was the emergency fire pump, which was located in the steering gear compartment. The second mate accessed the steering gear compartment by going through the auxiliary engine room instead of using the hatch on the shelter deck. Because the auxiliary engine room was part of the space where the CO_2 was released, the second mate needed to wear a self-contained breathing apparatus (SCBA). As well, the second mate had never started the emergency fire pump before, and the battery was depleted by multiple attempts to start the pump. Without battery power, the pump could still be started manually using the crank handle. However, a manual start was extremely difficult in the limited space and in the conditions during the occurrence, and the second mate was unable to start the pump.

It is common to use emergency fire pumps during drills and familiarization training. On the *Atlantic Destiny*, the engineers checked the emergency fire pump weekly but did not test the manual start.

Finding as to risk

If the manual starter of an emergency fire pump is not routinely verified, there is a risk that it will not function in an emergency.

2.5 Maintenance and management of recurrent problems

When a problem occurs, it must be analyzed, the underlying causes must be determined, and effective corrective actions to prevent recurrence must be established. The vessel's maintenance history, which includes crew reports, incident and accident reports, and other reports produced by the maintenance system, helps identify problems, potential hazards, and possible solutions. Lastly, an analysis of the maintenance history helps the crew, company management, and the shore maintenance staff, including contractors, to plan and carry out corrective and preventive maintenance.

Ocean Choice International (OCI), the operator of the *Atlantic Destiny*, had a voluntary safety management system (SMS) that included a section on investigation. That is, OCI had a system in place to investigate incidents and accidents, determine their causes, and implement controls to reduce the chances of a repeat occurrence. The *Atlantic Destiny* had a history of engine and propulsion problems. However, the TSB investigation found only records of accident investigations where injuries had occurred or where there had been a risk of injury. The TSB investigation of this occurrence identified at least 3 earlier occurrences related to engine failures that were serious enough to warrant an SMS investigation by OCI, including a previous engine explosion in 2017 that was investigated by the TSB. However, there were no records of any accident or incident investigations related to vessel maintenance or equipment, likely because vessel maintenance was handled outside the SMS.

Finding: Other

The SMS in use on the *Atlantic Destiny* was established to comply with OHS regulations. Although the accident and investigation section covered both vessel and crew, in practice, the SMS was used only for OHS accidents and incidents.

Following the catastrophic engine failure in 2017 and the subsequent TSB investigation, OCI took some corrective action. For example, shielding was installed around the flexible couplings of the shaft generators and the magnetic speed sensors were replaced. OCI reported that all repairs were completed to the satisfaction of TC. However, there is no record that OCI analyzed the occurrence for underlying causes and corrective action. The routine testing method for the engine safety system remained inconsistent and incomplete, and not all contractors or vessel crew had the knowledge to test the engine safety system correctly.

Finding as to risk

If maintenance records, risk assessments, accident and incident reports, and similar information are not used to learn from experience or if effective corrective actions are not implemented, risks related to vessel safety are likely to persist.

At OCI, the practice was to perform maintenance at sea when possible, do other tasks in the day or two between crew changes, and schedule all other maintenance during the winter maintenance period; the priority was to keep the vessel fishing as much as possible. For example, in the period before the occurrence, the vessel was sent back to sea with known problems with controlling the engine speed, and the remaining maintenance was scheduled for the next crew change.

The vessel was staffed at the level specified in the safe manning document, which required a minimum of 2 engineers to keep the vessel's engine room safely operating at sea. The 2 engineers worked on a 2-watch system. Unlike the other roles defined in the safe manning document, the 2 engineers were also responsible for maintaining all processing factory equipment for a 24-hour operation. This high workload and watch system meant that the engineers generally worked alone and usually had limited time for proactive maintenance and planning. Communication between the vessel's crews at shift changes had also been restricted by COVID-19 protocols.

When a vessel is operated to maximize the time spent fishing and contractors are used for many shore maintenance tasks, then maintenance work must be prioritized carefully for the brief periods in port. As well, requirements for work must be communicated clearly. For the *Atlantic Destiny,* essential tasks were completed, but non-urgent work was often postponed to a later crew change or to the winter maintenance period without assessing the associated risks. As well, if parts were not available during maintenance periods, parts would not be replaced according to manufacturers' recommended schedules. For example, the fuel pumps were not replaced during the most recent winter maintenance period because they did not arrive in time.

Finding as to risk

If scheduled maintenance tasks are frequently postponed so that operations can continue and the risks of deferring the maintenance are not assessed and mitigated, there is a risk that equipment can deteriorate to a point that it affects the safety of the vessel and the crew.

2.5.1 Periodic testing of the engine safety system

Engine systems are complex arrangements of multiple interacting components, sometimes from different manufacturers. Detailed written procedures that integrate instructions from various manufacturers are essential to ensure that the correct method of testing is used and that the same standard is applied.

The OCI SMS manual stated that the operations manager was responsible for verifying that engine room instructions were on board and readily accessible. However, he depended on the master and crew to determine everything was in place. As well, the authorized representative of a vessel is responsible for providing written procedures to the crew. The *Atlantic Destiny* was the only OCI vessel based in Nova Scotia, and was managed by the operations manager there, who worked with the fleet maintenance manager in Newfoundland and Labrador. The operations manager came from a background in fish processing and he depended on the engineers of both crew rotations for input when setting priorities for operational and maintenance spending.

The engine safety system, including its engine overspeed protection system, was tested periodically by engineers on the vessel and by contractors to confirm that the overspeed protection was working. However, the testing did not always follow the manufacturer's recommended schedule and many of the tests did not verify all components of the system because of the testing method used. As well, many of the people performing these tests did not necessarily understand that they were not testing all components of the system, and those with the necessary expertise were not always available to do the tests. The investigation found no written procedures for testing the engine safety system.

TC marine inspectors and recognized organization surveyors observed tests or accepted testing reports. Both TC and the recognized organization accepted tests demonstrating that the engine would shut down, but inspectors and surveyors did not require a demonstration to show that all components of the overspeed protection system were tested. Inspectors must deal with a wide range of vessels and marine sectors and inspections are snapshots. For both these reasons, inspectors rely on the expertise of vessel and shore staff for vessel-specific knowledge, which should be documented in testing procedures and described in an SMS. Therefore, it is important to ensure that a vessel's crew and shore staff have the specific knowledge needed to understand, test, and maintain the vessel's systems.

Finding as to risk

If testing procedures for all elements of engine safety systems are not well developed, documented, followed, and monitored, there is a risk that these systems will be inconsistently maintained and may not work as required.

2.6 Drills and training for emergency responses

When an emergency such as a fire occurs on a vessel, a prompt and coordinated response is key and must be carried out by trained personnel with appropriate equipment. In this situation, there is an element of time pressure and the potential consequences are serious; cognitive capacity is also reduced and individuals will often focus on responding to, rather than evaluating, the situation. Therefore, training and drills are critical to a successful emergency response.

2.6.1 Marine Emergency Duties training and safe manning documents

The success of any emergency response on board a vessel depends on the officers and crew having the appropriate qualifications and training for the assigned roles, including recent training and practice in leading emergency responses. TC Marine Emergency Duties (MED) training is designed to provide seafarers with an understanding of the hazards associated with the marine environment and with their vessel, and to teach the skills that seafarers require to cope with such hazards. Safe manning documents specify what qualifications are required for the various roles on a vessel and, therefore, what training is required to operate the vessel and manage emergencies. Whatever might be specified on the safe manning document, the authorized representative remains responsible for ensuring that all crew members have the necessary training for the roles they are assigned.

The *Atlantic Destiny* was certified for a complement of 32 and had a fire main system, a CO_2 fixed fire suppression system, and 2 firefighter outfits. The level of certification specified in the safe manning document for the *Atlantic Destiny* required the master and chief mate to have MED A1 Basic Safety training. This meant that they had never been formally trained in shipboard firefighting, including the use of CO_2 fixed fire suppression systems. Only the engineers were required to have MED Basic Safety (STCW) and MED Advanced Firefighting (STCW) training, which they both had. An earlier investigation into a passenger vessel occurrence found that the safe manning assessment process does not consider vessel-specific characteristics.[54]

The TSB compared the safe manning document for the *Atlantic Destiny*, as a large fishing vessel certified for Near Coastal, Class 1 voyages, with those of 3 non-fishing vessels of similar size and certified for the same class of voyage. On these non-fishing vessels, the *Marine Personnel Regulations* (MPR) require more advanced training for masters and chief mates. For the Master 3000 Gross Tonnage and Chief Mate, Near Coastal certificates of competency, MED Basic Safety (STCW), and MED Advanced Firefighting (STCW) training are required.

Muster lists specify who will fill the various roles in an emergency. On the *Atlantic Destiny*'s muster list, 2 deckhands were assigned roles that required them to wear firefighter outfits and self-contained breathing apparatuses, but they were not trained to use this equipment.

Finding as to risk

Vessels of similar tonnage that operate in similar marine environments face similar hazards. If the qualifications that regulations specify for roles on large fishing vessels are less stringent than those for roles on similar vessels, there is a risk that crews of large fishing vessels will not be ready to respond successfully in an emergency.

2.6.2 Drills

In this occurrence, the tasks the crew had practised in routine drills went well. When the fire alarm sounded, crew members mustered at the stern of the vessel with their immersion suits for a head count, according to the drills they had practised. Next, members of the primary and support emergency teams and the second mate on the command team carried

54 TSB Marine Investigation Report M15A0009.

out the preparatory tasks assigned by the muster list, such as preparing the fire hoses and closing the vents. Finally, the evacuation from the vessel was managed without panic and according to the abandon ship drill.

The situation was complex, involving both an engine room fire and water ingress. In such cases, a successful emergency response requires information gathering and decision making to form a situation-specific plan. Routine drills normally focus on training crew members to respond to a single emergency automatically. However, in this occurrence, because there were 2 emergencies unfolding simultaneously, crew members needed more guidance to coordinate their responses. The value of varied, realistic drill scenarios has been discussed with respect to passenger vessels in previous TSB reports and recommendations.[55]

2.6.3 Emergency procedures, training, and familiarization

In this occurrence, the investigation identified the following areas where procedures, familiarization, and training might have affected the outcome.

A distress call on very high frequency radios with digital selective calling (VHF-DSC) requires the operator to press and hold the distress button for at least 3 seconds to alert responders. Because perception of time is unreliable in an emergency, many crew members require familiarization and practice using this distress button. For the model of radio on board the *Atlantic Destiny*, the manual instructs users to press the key for 4 seconds continuously. Recent TSB investigations[56] have found that operators have been unsuccessful in sending an automatic distress call using this feature.

Finding: Other

The master pressed the distress button on the VHF-DSC radio, but the distress call was not successfully transmitted.

The procedures for use of the CO_2 fixed fire suppression system were followed. However, the SMS manual did not contain information about how CO_2 systems work or how long to wait before re-entering a space where CO_2 has been released. In this occurrence, the senior officers decided to release the CO_2 into the engine room and only then proceeded to discuss how to deal with the water ingress, which required re-entering the engine room. Consequently, believing they had waited long enough, when they entered the engine room they inadvertently introduced fresh air into the space less than 1 hour after the CO_2 release, which reignited the fire. A lack of understanding about how CO_2 fixed fire suppression systems work has been a factor in a number of occurrences,[57] and has been highlighted as a

[55] TSB marine investigation reports M13L0067 and M06W0052.

[56] TSB marine transportation safety investigation reports M21A0065 and M20P0229.

[57] TSB marine transportation safety investigation reports M19C0403, M15C0045, and M14C0156.

lesson to be learned from marine accident reports by the United Kingdom's Marine Accident Investigation Board.[58]

The SMS manual described procedures, drills, and familiarization related to fire, but did not contain emergency procedures for flooding. The crew were not familiar with the portable electrical submersible pump and the portable bilge ejector. As well, no instructions on how to start the emergency fire pump were posted at the pump location and only the second engineer was responsible for weekly inspection and starting the pump.

Finding as to risk

If training, familiarization, drills, and procedures do not cover all areas needed for an emergency response, such as the use of CO_2 fixed fire suppression systems, there is a risk the crew will be unable to respond effectively to a shipboard emergency.

58 United Kingdom Marine Accident Investigation Branch, *Safety Digest: Lessons from Marine Accident Reports,* Volume 2, (2017), pp. 12–13, at https://assets.publishing.service.gov.uk/media/5e81e5d2e90e0706fba5421d/2017-SD2-MAIBSafetyDigest.pdf (last accessed on 18 December 2023).

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are conditions, acts or safety deficiencies that were found to have caused or contributed to this occurrence.

1. One or more components of the engine management system failed and caused it to continually increase the engine fuel supply, which caused the engine to overspeed.

2. Both the automatic and manual activation of the engine safety system failed to prevent the engine speed from increasing beyond the design limits of the engine, causing a catastrophic failure and significant damage to the engine and the shaft generators.

3. The explosion of the shaft generators and associated machinery caused the fire and a breach in the seawater piping.

4. Crew were unable to access the sea bay valves and onboard bilge pumps were unavailable. As a result, the flooding of the engine room could not be controlled, leading to the sinking of the vessel.

5. The auxiliary generator could not be brought online, likely because of damage to the electrical distribution system, leaving the vessel without a pumping system.

3.2 Findings as to risk

These are conditions, unsafe acts or safety deficiencies that were found not to be a factor in this occurrence but could have adverse consequences in future occurrences.

1. Pump kits provided by air search and rescue resources may not be effective for all sizes of vessels and operating conditions. If the conditions on a vessel in distress are outside the design parameters of a pump kit, there is a risk that the pump kit will not control water ingress at the expected rate, reducing the time available for the rescue operation.

2. If vessels are not required to have emergency power sources that can supply power for essential equipment such as fire and bilge pumps, there is a risk that this equipment will be unavailable in an emergency.

3. If crew members cannot use an emergency escape hatch in an emergency, there is a risk that they will not be able to evacuate a vessel's compartment safely.

4. If the manual starter of an emergency fire pump is not routinely verified, there is a risk that it will not function in an emergency.

5. If maintenance records, risk assessments, accident and incident reports, and similar information are not used to learn from experience or if effective corrective actions are not implemented, risks related to vessel safety are likely to persist.

6. If scheduled maintenance tasks are frequently postponed so that operations can continue and the risks of deferring the maintenance are not assessed and mitigated, there is a risk that equipment can deteriorate to a point that it affects the safety of the vessel and the crew.

7. If testing procedures for all elements of engine safety systems are not well developed, documented, followed, and monitored, there is a risk that these systems will be inconsistently maintained and may not work as required.

8. Vessels of similar tonnage that operate in similar marine environments face similar hazards. If the qualifications that regulations specify for roles on large fishing vessels are less stringent than those for roles on similar vessels, there is a risk that crews of large fishing vessels will not be ready to respond successfully in an emergency.

9. If training, familiarization, drills, and procedures do not cover all areas needed for an emergency response, such as the use of carbon dioxide fixed fire suppression systems, there is a risk the crew will be unable to respond effectively to a shipboard emergency.

3.3 Other findings

These items could enhance safety, resolve an issue of controversy, or provide a data point for future safety studies.

1. Although the 2 emergency escape breathing devices and the 2 portable dry sprinkler powder aerosol extinguishers were not required to be carried on board the *Atlantic Destiny*, the emergency escape breathing devices were useful for escaping the engine room and the dry sprinkler powder aerosol extinguishers were useful in extinguishing the engine room fire.

2. In this occurrence, the fire alarm sounded continuously, distracting the crew during the emergency response.

3. The chief mate of the *Atlantic Destiny* held a Fishing Master, Fourth Class certificate of competency, whereas the safe manning document required the chief mate to have a Fishing Master, Third Class certificate.

4. The safety management system in use on the *Atlantic Destiny* was established to comply with occupational health and safety regulations. Although the accident and investigation section covered both vessel and crew, in practice, the safety management system was used only for occupational health and safety accidents and incidents.

5. The master pressed the distress button on the very high frequency – digital selective calling radio, but the distress call was not successfully transmitted.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Ocean Choice International

Ocean Choice International (OCI) implemented a safety management system (SMS) that is compliant with the International Safety Management (ISM) Code. In June 2022, upon completion of an audit of OCI's SMS, DNV issued an Interim Document of Compliance, stating that the company's SMS was compliant with the ISM Code.

On the OCI fishing vessels *Calvert* and *Katsheshuk II*, the instructions for starting the emergency fire pump were posted.

4.2 Safety concern

4.2.1 Knowledge of the operation of carbon dioxide fixed fire suppression systems

On 02 March 2021, the fishing vessel *Atlantic Destiny*, with 31 people on board, sustained a catastrophic engine failure while the vessel was about 120 nautical miles south of Yarmouth, Nova Scotia. The shaft generators exploded, causing a fire and damage that led to flooding in the engine room. All crew members were evacuated by search and rescue authorities. Minor injuries were reported. On 03 March 2021, the *Atlantic Destiny* sank.

Crew members used the engine room's carbon dioxide (CO_2) fixed fire suppression system during the fire response. These systems release CO_2 to provide a heavy blanket of gas that displaces air and reduces the oxygen level to a point where combustion cannot occur. Proper sealing of the space is essential to extinguish the fire effectively. Because CO_2 is less efficient at cooling than water, ventilation of the engine room should not be started until it has been established both that the fire has been extinguished completely and that conditions are no longer sufficient for the fire to restart, a process that takes hours. However, the crew heard water in the engine room and re-entered the space after about 30 to 40 minutes to investigate its source. Later, they entered the auxiliary engine room, another part of the sealed space, to access the auxiliary generator. Both actions re-introduced oxygen into the space. Crew members followed documented procedures for use of the CO_2 fixed fire suppression system. However, they were unaware of the need to wait for the space to cool before re-entering.

A lack of understanding of the requirements for using CO_2 fixed fire suppression systems has been a factor in several other occurrences in Canada[59] and worldwide.[60] For example, in the engine room fire on the bulk carrier *Tecumseh*, crew members re-entered the engine room in consultation with vessel- and shore-based management, approximately 2 hours after the CO_2 release and some boundary cooling, and the fire reignited. In an engine room fire on the fishing vessel *Frederike. C-2*, the engine room was not sealed before the CO_2 was released and the fire was not suppressed.

In Canada, the use of fixed fire suppression systems is covered in Marine Emergency Duties Advanced Firefighting training.[61] Transport Canada requires this training for certain certificates of competency. Refresher training is compulsory only for seafarers working on vessels making longer voyages.[62] Although the use of fire suppression systems is covered in Transport Canada training material, this requirement is not applicable to all seafarers, and it is not required for any shore-based personnel who may provide technical support to vessels. If training, familiarization, drills, and procedures do not cover all areas needed for an emergency response, such as the use of CO_2 fixed fire suppression systems, there is a risk the crew will be unable to respond effectively to a shipboard emergency.

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59 TSB marine transportation safety investigation reports M19C0403 and M15C0045. The investigation of an engine room fire on the *MOL Prestige* (TSB Marine Transportation Safety Investigation M18P0014) determined that the crew re-entered the space while the fire was still smouldering. However, the re-entry was not a contributing factor in that occurrence.

60 For example, New Zealand Transport Accident Investigation Commission Report MO-2016-201 and Bahamas Maritime Authority, *Report of the marine safety investigation into an engine room fire which resulted in the death of an Able Body Seaman on 13th August 2014*.

61 The syllabus for the Advanced Firefighting course covers the provisions for the correct operation of water, halon, dry chemical, foam, and CO_2 fixed firefighting systems: pre-activation check and actions, activation, the injection of the agent into the protected area, post-activation check and actions. (Source: Transport Canada, TP 4957, *Marine Emergency Duties Training Courses*, Revision 1 [June 2007], section 12).

62 Ship Safety Bulletin 09/2017 specifies that marine emergency duties refresher training is not required for seafarers when the vessel on which they are working is "making a:

- Voyage in *Sheltered Waters*;
- *Near Coastal, Class 2* voyage;
- *Near Coastal, Class 1* voyage on the Great Lakes;
- Voyage in the waters of the Gulf of St. Lawrence and Cabot Strait, up to 25 nm seaward of a straight line joining Cape Canso at 45° 18.36'N, 60° 56.28'W and Cape Pine at 46° 36.81'N, 53°32.5'W [...]; or,
- Voyage in the areas of Queen Charlotte Sound and Hecate Strait, up to 25 nm seaward of a straight line joining Winifred Island at 50° 39' 40"N, 128° 22' 00" W, and Kunghit Island at 51° 56' 37" N,131°01' 52" W."

(Source: Transport Canada, Ship Safety Bulletin 09/2017: *Update on How to Meet STCW 2010 Manila Convention Requirements* [27 November 2017], at https://tc.canada.ca/en/marine-transportation/marine-safety/ship-safety-bulletins/update-how-meet-stcw-2010-manila-convention-requirements-ssb-no-09-2017 [last accessed on 19 December 2023]).

Given several occurrences during which the effectiveness of CO_2 was compromised during the fire response, the Board is concerned that there is insufficient crew knowledge of the necessary pre- and post-release stages in the use of CO_2 fixed fire suppression systems.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 18 October 2023. It was officially released on 242 January 2024.