

MARINE OCCURRENCE REPORT

**COLLISION BETWEEN
THE CANADIAN SAILING VESSEL "MOONGLOW"
AND THE CHILEAN SUBMARINE "THOMSON"
OFF SHERINGHAM POINT, JUAN DE FUCA STRAIT
BRITISH COLUMBIA
11 SEPTEMBER 1994**

REPORT NUMBER M94W0078

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

MARINE OCCURRENCE REPORT

Collision Between the Canadian Sailing Vessel
"MOONGLOW" and the Chilean Submarine "THOMSON"
Off Sheringham Point, Juan de Fuca Strait
British Columbia
11 September 1994

REPORT NUMBER M94W0078

SUMMARY

The "MOONGLOW", on passage from Tofino, B.C. to Victoria, B.C., departed the anchorage at Port San Juan, B.C. at 1500, 11 September 1994.

The "THOMSON" departed Nanoose, B.C. on the morning of 11 September and disembarked her Canadian Navy Coastal Pilot off Victoria at 1805.

The vessel was steaming on the surface in the Juan de Fuca Strait outbound for San Diego, California, U.S.A.

At 2119, in Canadian waters off Sheringham Point, the "THOMSON" and the "MOONGLOW" collided in dense fog.

The "MOONGLOW", holed on the starboard side aft, sank quickly. The operator was rescued from the water by the crew of the submarine and treated for mild hypothermia. The submarine sustained some light damage to the starboard bow.

FACTUAL INFORMATION

Particulars of the Vessels

Name	"THOMSON"	"MOONGLOW"
Naval List	No. 20	-
Licence Number	-	30KA5161
Home Base	Talcahuano Naval Base	-
Licensing Port	-	Campbell River, B.C.
Flag	Chilean	Canadian
Type	"209" Class (Type 1300) submarine	Classic ketch
Displacement	1300	18 tons
Length	59.5 m	49 ft (14.93 m)
Draught	Forward: 5.50 m	(Aft): 1.98 m
	Aft: 5.75 m	
Built	1984, Howaldtswerke, Germany	1939, San Pedro, California, U.S.A.
Propulsion	Diesel electric, 4 MTU 12V-493-AZ80 diesels; Piller alternators: Siemens electric motor, 5000 SHP; one shaft	(Auxiliary) One, four-cylinder Mercedes Benz diesel, driving a single fixed-pitch propeller, 36 BHP
Owners	Chilean Navy, Valparaiso, Chile	Jory Lord West Vancouver, B.C.
Crew	44	One
Others	Two U.S. Navy personnel	

Description of the Vessels

"MOONGLOW"

The "MOONGLOW" was an auxiliary Bermuda-rigged sailing ketch. The vessel was carvel-built with Honduras mahogany on bent oak ribs; she had a full keel of white oak with lead ballast bolted on. The main and mizzen masts and the booms were of spruce, and she was fitted with 16 ft (4.87 m) aluminium spinnaker and trade-wind poles at the main mast (see photographs). The vessel had undergone a private survey on 04 July 1993, at which time it was remarked that the hull, caulking and fastenings were in fair to good condition.

A radar reflector was fitted on the mizzen mast.

The "MOONGLOW" was equipped with the following navigational aids:

- one radar, with remote-control capabilities and on-screen read-out, mounted on a beam at the entrance to the cabin. It was both visible and operable from the cockpit steering position;
- one magnetic steering compass, one hand-held bearing compass and an autopilot;
- one Loran C, with digital read-out, showing courses to steer between waypoints, also visible from the steering position;
- very high frequency (VHF) and single side band (SSB) radiotelephones;
- a video sounder;
- a Stowe electric log; and
- both fixed and portable sound-signalling apparatus.

The vessel was reportedly equipped with the necessary charts and publications for the voyage.

"THOMSON"

The submarine "THOMSON", built for the Chilean Navy, was launched in August 1983, commissioned in September 1984, and refitted in 1990.

She has a single-skinned hull of steel construction (see photographs).

The vessel was navigating on the surface and the following stations were manned:

- the conning tower bridge station;
- the main navigation control station;
- the steering station; and
- the engine control station.

Communication between stations is by an intercom (P/A) system, with sound-powered telephones and portable radiotelephones for backup.

At the steering station, located aft of the main navigation control station, there are two steering positions side by side; one for surface navigation and the other for the dived condition.

The helmsman is seated in front of a console on which are:

- an aircraft-type joystick steering control;
- a gyrorepeater;
- a log speed indicator;
- an engine revolutions and helm indicator; and
- a graduated knob to set engine revolutions.

Engine speed orders are relayed to the helmsman in terms of revolutions ahead or astern, and these orders are executed by the helmsman turning the graduated knob to the required setting. The knob is within easy reach on the console in front of him.

Surface speed is 11 knots, and the diesel-electric mode of propulsion allows for instantaneous full-ahead to full-astern engine movements.

Distance travelled when a crash stop is executed at a speed of eight knots is reported to be 275 m.

The "THOMSON" is equipped with the following navigational equipment:

- a number of radar sets of which three were in operation at the time of the collision. One set was for the use of the officer of the watch (OOW) and a second was being used for navigation. One of the weapon systems radars was employed for target-searching and plotting;
- a Global Positioning System (GPS);
- an Inertial Navigational System;
- a Satellite Navigational System;
- VHF radiotelephones, both fixed and hand-held;
- an echo-sounder; and
- sensing devices particular to the vessel's purpose. The

conning tower bridge is equipped with a gyrorepeater and fog horn control. The bridge team is supplied with binoculars when on lookout duty.

Events According to the Owner/Operator of the "MOONGLOW"

The "MOONGLOW" was on passage from Tofino to Victoria and had anchored at Port San Juan in the early morning of 11 September to await improved weather and to allow her operator to rest.

The vessel departed Port San Juan at 1500. The auxiliary engine was shut down after clearing the anchorage. At 1600, in approximate position 48°30.3'N, 124°30.8'W, the vessel set course to 090° Compass (C), about 113° True (T). The full main and genoa sails were set, the wind was from the west. (See sketch of the area.)

The "MOONGLOW" did not participate in the Seattle Traffic (VTS) Reporting System, nor was she required to. The vessel's VHF was tuned to channel 13, which is Seattle Traffic's secondary frequency used primarily for vessels making passing arrangements. The VHF was also tuned to channel 16, the international calling and distress frequency.

At 1900, the vessel was approximately three miles SSW of Jordan River. There was fog in patches, and the visibility was zero to three miles. In accordance with his standard procedure after dark, the operator changed the genoa sail for a trade-wind jib. The smaller trade-wind jib sail does not obstruct other vessels' view of the port and starboard sidelights which were fixed on the main mast stays, about 1.7 m above the deck level. Both sidelights and the stern light were switched on.

The vessel was being kept about three miles offshore because of reduced visibility in fog. Positions were fixed by radar and the Loran C was also in operation.

At about 2130, in a position approximately four miles south of Sheringham Point, the course was altered to 060°(C), about 083°(T), for a position south of Race Rocks to keep to the north of the outbound traffic lane. The vessel was travelling at an estimated speed of four knots and the main sail had just been reefed. The operator was steering the vessel by hand. The last position had been plotted on the chart about 20 minutes previously. Visibility was between zero and 1/16 of a mile. The wind was north-westerly at 15 to 20 knots and a low westerly swell was running.

After course was altered at 2130, with the radar on the four-mile

All times are PDT (Coordinated Universal Time (UTC) minus seven hours) unless otherwise stated.

See "Time of the Collision" Section.

range, an echo was observed 15° to starboard of the heading marker and close to the centre of the PPI screen. When the range was reduced to one mile, the target was estimated to be about 1/16 of a mile distant. The operator then heard a rush of water and saw what appeared to be the bulbous bow of a freighter, but was, in fact, the bow of the "THOMSON".

When the bow was at an estimated distance of 6 to 9 m, the conning tower and both navigation sidelights of the submarine became visible.

The operator instinctively moved to the port side of the cockpit; he did not attempt a collision avoidance manoeuvre in the few seconds before collision. He sent a brief, hurried "MAYDAY" message by VHF radiotelephone immediately after the collision. All lights, radios and electronics on board the "MOONGLOW" then went dead. Although it was reported that a "MAYDAY" position was transmitted, no such position was received by shore stations nor by other traffic in the area.

A portable compressed gas fog horn, used in preference to the vessel's electric fog horn, was used to sound the required fog signal at least within five minutes prior to the collision.

The bow of the "THOMSON" struck the "MOONGLOW" on her starboard side aft about the cockpit at an angle of impact of between 30 to 45° on the bow, and rolled the "MOONGLOW" to port. The ketch sustained extensive damage and water rushed in. The operator estimated that the collision position was 48°18'36"N, 123°55'00"W, some four cables north of the northern limit of the outbound lane.

The operator made a brief unsuccessful attempt to launch the inflatable liferaft but he experienced difficulty in operating the quick-release goose-neck clip. As the ingress of water caused the vessel to sink deeper in the water, the operator abandoned the vessel over the stern. Wearing a floater jacket, he swam clear. The "MOONGLOW" sank bodily in about 180 m of water within one minute of the collision.

The "MAYDAY" transmitted by the "MOONGLOW" was heard by the "THOMSON", by Canadian and US Coast Guard radio stations and VTS stations as well as by other traffic transiting the area.

The operator clung to a floating propane tank until rescued by the submarine about 20 minutes later.

The operator of the "MOONGLOW" had gained experience on small vessels including tugs and workboats. He has sailed his own yachts in B.C. waters since 1991 and is presently employed, in a relieving capacity, as a seaman with the Canadian Coast Guard. He had purchased the "MOONGLOW" in 1993.

Events According to the Crew of the "THOMSON"

The "THOMSON" and her crew were paying their first visit to the West Coast of Canada. The submarine entered Canadian waters on 08 September 1994, arriving at Nanoose on the east coast of Vancouver Island on 09 September. The vessel was then engaged in naval exercises with Canadian and US Navy vessels, in exercise area "WG" off Nanoose.

The submarine departed Nanoose en route for San Diego at 0808, 11 September. A Canadian Navy Coastal Pilot was on board. In addition to the ship's complement, two US Navy personnel were on board; a liaison officer and a communications rating. The rating assisted with English language radiotelephone communications.

The vessel participated in both the Vancouver and Seattle VTS reporting systems as required throughout.

The Canadian Navy Coastal Pilot disembarked off Victoria at 1805, 11 September. Because of reduced visibility ahead, "low visibility navigation stations" was implemented at 1847.

Extra watchkeepers were posted: these included an additional lookout in the conning tower bridge and an extra radar operator to monitor one of the vessel's weapon systems radars in use to detect and plot other vessels.

All five retractable masts, two periscopes, two radar and a navigation light mast were raised to increase radar detectability. The vessel's speed was reduced to eight knots and the navigation lights were switched on. The fog signal, required by the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS), was sounded manually from the conning tower bridge.

A total of 18 officers and men were on watch at "low visibility navigation stations".

In the main navigation control room were the commander, the OOW, a second watch officer, the navigator, the radar man, the magnetic telephone man, the radio man, a sonar man, two periscope men, and a records man.

On the conning tower bridge were the bridge watch officer and two lookouts.

A helmsman was at the steering station.

Three men were on duty in the engine control space.

After disembarking the pilot, the "THOMSON" kept to the outbound traffic lane and rounded Race Rocks at 1909. At 1916, she was steadied on a heading of 279°(T). The vessel was kept approximately

two cables south of the northern limit of the traffic lane to allow larger and faster outbound traffic to keep to the centre of the lane to overtake her safely. Navigation was by radar and GPS.

Between 2006 and 2035 (see sketch of the area), the "THOMSON" crossed the northern limit of the traffic lane to allow the outbound freighter "SEALAND ENTERPRISE" to pass at a safe distance in fog. Ten GPS or radar positions obtained during this period indicated that the vessel was never more than two cables north of the limit.

At 2035, the course was altered to 260°(T) to pass an outbound tug and tow. At 2056, having passed to the south of the tug and tow, the submarine was located near the centre of the traffic lane and course was altered to 282°(T) to follow the outbound lane.

Between 2053 and 2126, a total of seven positions were plotted on the submarine's navigation chart; three obtained by radar and four by GPS.

At this time, winds were west to west-north-westerly at about six knots, the sea was slight and visibility was approximately 100 m.

At 2126, with the vessel in position 48°18'00"N, 123°58'13"W by GPS, the conning tower bridge officer reported to the main navigation control room that he had sighted a green light 15° on the port bow. The other vessel was approximately 20 m from the bow and showed no mast lights. No fog signal was heard. The "MOONGLOW" had not been detected by any of the submarine's radar sets, nor had she been seen by either of the periscopes.

When the other vessel was sighted, the conning tower bridge officer immediately ordered port full rudder, stop motors and full astern motors. The "THOMSON" started to swing to port but was unable to clear the "MOONGLOW". The starboard bow of the submarine struck the "MOONGLOW" on the starboard quarter at an angle of impact of approximately 30°. The speed of impact is unknown, but it was less than eight knots because the submarine's astern propulsion had engaged prior to the collision. The "MOONGLOW" was not seen to take avoiding action nor were her sails seen to be set.

The "MOONGLOW" slid down the starboard side of the "THOMSON" and her stern light was seen to disappear in the fog off the starboard quarter.

The submarine commander heard the sighting report. He ordered the crew to man emergency stations and to prepare for an imminent collision by the bow. These orders were relayed over the P/A system. The alarm bells were also sounded. He hurriedly climbed the conning

See "Time of the Collision" Section.

tower ladder but arrived on the bridge just after the collision occurred. The commander ordered the crew to stand by for a "man overboard procedure" and manoeuvred the vessel around to starboard to retrace her track. He then stopped engines to listen for sounds.

About six to eight minutes after the collision, the watch heard the operator of the "MOONGLOW" shouting. He was sighted, clinging to a propane tank, in the beam of an aldis lamp. He was recovered by a crew member who donned a wetsuit and swam over to him with a line.

He was then pulled alongside and helped on board by crew members positioned on the small expanse of fore deck.

The operator of the "MOONGLOW" was treated for mild hypothermia, given dry clothing and served a meal. He was later transferred to a US Coast Guard vessel and then to a Canadian Coast Guard vessel and landed in Sooke, B.C.

The commander of the "THOMSON" is qualified as a submarine commander with both the Chilean and the Royal Navy. He had 25 years' experience in the Chilean Navy, 15 years of which were on submarines. He had been in command of the "THOMSON" for two years. Both the bridge watch officer and the main control room officer were fully qualified and experienced submarine officers.

Vessel Traffic Services, Tracking and Communications

The Juan de Fuca Strait routing system has been adopted by the International Maritime Organization (IMO). It is listed in Notice No. 10 of the 1994 Annual Edition of Notices to Mariners. Vessels which are not required to participate in the Seattle Traffic Reporting System are still obliged to comply with the requirements for using traffic lanes as found in Rule 10 of the COLREGS.

The assigned VHF reporting frequency for vessels participating in the Seattle Traffic Reporting System for the Juan de Fuca Strait is 5A. The "MOONGLOW" did not maintain a listening watch on this frequency.

VTS Seattle tracked the outbound "THOMSON" by radar. The vessel participated fully in the Seattle VTS Reporting System prior to the collision. At the time of the collision, the VTS Sector Operator reported that the submarine was tracking near the centre of the outbound traffic lane.

The Sector Operator also reported that, at no time during his tracking of the "THOMSON", did he observe the vessel outside (to the north) of the outbound traffic lane.

Neither before nor after hearing the "MAYDAY" broadcast by the "MOONGLOW" did the Sector Operator observe that vessel's radar echo by VTS radar.

Due to frequency interference, radiotelephone communications between the "THOMSON" and Seattle VTS were bad after the collision. It took some minutes for VTS to make contact with the submarine. At first, the "THOMSON" did not respond when asked if she had been involved in a collision. The submarine indicated that, while she was passing through the area, calls for help had been heard and that she was attempting to rescue a person from the water. In answer to further inquiries from VTS Seattle at about 2140, the submarine denied having been in a collision.

At 2215, when the rescue vessel USCG 41315 from Neah Bay, Washington, U.S.A., was alongside the submarine, it was communicated to them that the transfer of the operator of the "MOONGLOW" would not take place until after statements were made. At 2317, the submarine's US Navy liaison officer communicated that, contrary to earlier reports, a collision had occurred. The operator of the "MOONGLOW" was transferred to the USCG vessel at 0040, 12 September.

Other Vessels in the Area

The Canadian tug "SEASPAN CAVALIER" responded to the "MAYDAY" message sent by the "MOONGLOW". The tug was towing two loaded lumber scows and, at 2120, was in approximate position 48°19.00'N, 123°49.3'W, some six miles ENE of the collision position. The tug was eastbound on a course of 103°(T) at a speed of 7.3 knots, and was keeping to the north of the traffic lane.

The "SEASPAN CAVALIER" would have passed the outbound submarine shortly after 2100. The tug reported that particular attention would have been paid to any vessel north of the traffic lane limit, that VTS Seattle would have informed the tug had this been the case, and that, had there been such a vessel north of the lane, the tug would have detected her by radar "for sure".

The Canadian yacht "ARDENT" was steering on Otter Point, B.C., eastbound for Sooke. When responding to the "MAYDAY", she reported that her position by GPS was 48°22.2'N, 124°02.9'W. The vessel reported that, prior to the collision, there was a radar target about four miles ahead of her, on a similar course and proceeding at about the same speed. It was believed that this target was the "MOONGLOW".

Since the reported track of the "ARDENT", when projected ahead, is much further inshore than the collision position reported by either the "MOONGLOW" or the "THOMSON", the echo observed by the "ARDENT" could not have been that of the "MOONGLOW".

ANALYSIS

Communications

The "MOONGLOW" did not keep a listening watch on VHF channel 5A. Although it is not mandatory for a vessel of the size and type of the "MOONGLOW" to participate in the VTS reporting system, had she been participating, she would have been aware of the movements of other vessels in the area, including those of the submarine. Additionally, as a result of the non-participation of the "MOONGLOW", the submarine and other vessels were not aware of her presence nor of her movements.

Compass Courses

The operator of the "MOONGLOW" was steering by magnetic compass. Although the compass had been purchased new less than one year before, the vessel had not been swung to determine the deviation of the compass. The value of deviation on compass headings was unknown as was the accuracy of the courses reported to have been steered.

The practice on board was to compare the course shown by the uncompensated magnetic steering compass to the true course to steer displayed by the Loran C. The course to steer displayed by the Loran C is electronically calculated from the vessel's current position and the next previously determined waypoint; in this case, a position south of Race Rocks.

The operator of the "MOONGLOW" reported that, at about 2130, he altered course to 060°(C), about 083°(T), for a position north of the traffic lane and south of Race Rocks. If this course to steer is laid off on the chart from the intended waypoint back toward a position off Sheringham Point, it would indicate that the vessel was considerably further to the south than the operator stated; south of the outbound traffic lane in US Navy Exercise Area 2. Conversely, if the vessel followed this course when laid off from the 2130 estimated position, the course would not lead to the intended waypoint but on to the shore north of Beechey Head.

Position of the Collision

The operator of the "MOONGLOW" reported that the collision took place north of the traffic lane because:

- the approximate track of the vessel took her to about four cables north of the limits of the outbound traffic lane at her course alteration south of Sheringham Point; and
- the radar was on the four-mile range and Sheringham Point was showing just inside the edge of the screen.

The operator of the vessel had not, however, plotted a position on the chart for some 20 minutes prior to the time of the collision.

The collision position given by the "MOONGLOW" cannot be reconciled

either with that given by the "THOMSON" or with the evidence of Seattle Traffic.

The collision position recorded by the submarine is about five miles SSW of Sheringham Point. In the half-hour preceeding the collision, the submarine had obtained eight positions by GPS or by radar. These positions place the submarine at or near the centre of the traffic lane.

VTS Seattle radar placed the submarine in the traffic lane, i.e. more than 4.4 miles from Sheringham Point. While there is no VTS record of the submarine's positions in this period, the vessel presented a good radar target to VTS and the vessel was closely monitored. Had the vessel left the traffic lane, it would have been evident on VTS radar. It is the Sector Operator's duty to warn a vessel if she leaves a traffic lane. No such warning was necessary or given. The traffic lane limits are superimposed electronically on the VTS radar screens and these lines are accurate to within 200 to 300 yards (182 to 274 m). The Sector Operator would not call another vessel if she were close to the line as in the case of the "THOMSON".

There can be little doubt that the submarine was at or near the centre of the outbound traffic lane when the collision occurred. The vessel plotted her position on the chart almost continuously.

The relative positions of the ketch and the submarine before the collision also tend to confirm that the "MOONGLOW" was further to the south than her operator believed. Because the submarine, while steering 282°(T), sighted the ketch's green light to port, it follows that the ketch, steering a course of about 083°(T), must have been in the traffic lane. The relative position is substantiated by the fact that the "MOONGLOW" sighted the submarine 15° on her starboard bow.

Time of the Collision

Reportedly, the operator of the "MOONGLOW" sent the "MAYDAY" immediately after the collision. Because both Canadian and US Coast Guard radio stations recorded this time as 2119, it is most likely to be correct.

Although this time is not the same as the times reported by both vessels, it does not appreciably change the collision position as recorded by the "THOMSON" because the submarine's GPS position of 2126 and a position recorded at 2117 by radar were very close. Both were near the centre line of the traffic lane.

The collision occurred 3 hours and 30 minutes before the predicted time of high water at Sooke, and 15 minutes before the predicted time at which the current turned to ebb. The rate of the tidal current

was zero.

Radar Visibility

Since departing Nanoose, the submarine was tracked on radar first by Vancouver VTS and then by Seattle VTS, both of which reported that the "THOMSON" presented a good radar target. The submarine had no anti-radar detection devices on board. The raising of the masts reportedly increased her reflective surface by 50 per cent.

The operator of the "MOONGLOW" did not see the radar echo of the submarine until she was approximately 1/16 of a mile off, in spite of the fact that the radar was readily in view from the cockpit steering position. However, because the operator was reefing the sails and out of the cockpit for at least part of the submarine's approach, the echo may have been detected by radar but not seen by the operator. While reefing the sail and carrying out other duties requiring his absence from the cockpit, the operator engaged the autopilot.

The reason why the "MOONGLOW" was not detected by the "THOMSON" nor by Seattle VTS is unknown; the ketch was equipped with a radar reflector and, although constructed of wood, had other reflective surfaces on her rigging.

Navigating in the Vicinity of Submarines

The yearly edition of the Canadian Notices to Mariners warns that, in restricted waters, submarines should be passed with caution observing their limited manoeuvrability on the surface, deep draught and vulnerability to collision.

The bridge watch officer on the "THOMSON" came hard-to-port in an attempt to avoid collision. With a collision imminent, it is imperative for a submarine of the type of the "THOMSON", with a single-skinned hull, to take the impact on the bow to avoid pressure hull damage amidships which could prove fatal to the vessel and her crew.

Sound Signals

The operator of the "MOONGLOW" did not hear the fog signals sounded by the submarine and the submarine did not hear a signal from the ketch.

The operator of the "MOONGLOW" stated that he would have sounded the fog horn at least within five minutes prior to the collision. This testimony differs from his declaration to the commander of the "THOMSON". At that time, the operator of the "MOONGLOW" stated that he only emitted sound signals when passing vessels and that he was not doing so at the time of the collision. The COLREGS require that a sailing vessel sound three blasts in succession, namely one

prolonged followed by two short blasts, at intervals of not more than two minutes.

Because the "MOONGLOW" was not detected by other means, the sound signal was the only means by which she could have been identified as a vessel in some way restricted in her ability to manoeuvre.

"MOONGLOW"--Under Power or Sail

The difference in testimony regarding whether the "MOONGLOW" was under power or under sail cannot be resolved.

As there can be little doubt concerning the submarine's position, the collision occurred in the outbound traffic lane.

Because the COLREGS require that "a vessel of less than 20 metres in length or a sailing vessel shall not impede the safe passage of a power-driven vessel following a traffic lane", the question of whether the "MOONGLOW" was, or was not, under sail is not an issue.

FINDINGS

1. The collision occurred in dense fog near the centre line of the outward bound traffic lane.
2. Neither vessel was aware of the other's presence until moments before the collision.
3. The "MOONGLOW" was being operated single-handed.
4. It is unknown whether the "MOONGLOW" was proceeding under sail or power.
5. The "MOONGLOW" was not participating in the Seattle Traffic (VTS) Reporting System nor was she required to by regulation.
6. The "MOONGLOW" was not detected by VTS radar.
7. The steering compass on the "MOONGLOW" had not been swung, compass deviation was unknown, and the true courses steered by the ketch are not known with certainty.
8. Reportedly, the operator of the "MOONGLOW" did not plot positions on the chart at regular intervals to monitor the vessel's progress.
9. The "MOONGLOW" inadvertently strayed into the outbound traffic lane and was transiting the traffic lane in the wrong direction at a small angle to the direction of flow.

10. The "MOONGLOW" did not observe the radar echo of the "THOMSON" until she was 1/16 of a mile distant.
11. It is likely that the operator of the "MOONGLOW" did not observe the presence of the submarine on radar earlier because he had been preoccupied with reefing the main sail prior to the collision.
12. The "MOONGLOW" had reportedly sounded the prescribed fog signal within five minutes prior to the collision.
13. The "MOONGLOW" did not hear the sound signals reportedly made by the "THOMSON".
14. Upon sighting the "THOMSON", the operator of the "MOONGLOW" instinctively moved to prevent personal injury and did not attempt an emergency manoeuvre to avoid collision.
15. The "THOMSON" participated fully in the Seattle Traffic Reporting System prior to the collision.
16. The "THOMSON" presented a good radar target to VTS radar during her outward bound passage.
17. VTS radar tracked the "THOMSON" continuously. The VTS Sector Operator reported that, at the time of the collision, the submarine was within the outbound traffic lane.
18. Between 2039 and 2126, the "THOMSON" plotted her position on the chart ten times; at no time during that period was the submarine outside the outbound traffic lane.
19. The "THOMSON" did not hear the sound signal reported to have been made by the "MOONGLOW" within five minutes of the collision.
20. It is unknown why the "THOMSON" did not observe the "MOONGLOW" on any of her three operational and manned radars.
21. The "THOMSON" did not acknowledge that a collision had occurred until almost two hours after the collision.

CAUSES AND CONTRIBUTING FACTORS

The collision occurred because the operator of the "MOONGLOW" did not plot his vessel's position frequently to monitor the vessel's progress along her intended track. As a result, the ketch inadvertently strayed into the outward bound traffic lane in dense fog. The fact that the ketch did not participate in the Seattle Traffic Reporting System, that the "MOONGLOW" was not detected by

radar either by the "THOMSON" or VTS, and that, because her operator was engaged in other tasks, he did not observe the approaching submarine by radar, contributed to this occurrence.

ACTION TAKEN

The investigation into this occurrence did not determine why the "MOONGLOW" was not detected by either the VTS or the "THOMSON" radars. However, it is known that small vessels are generally poor radar targets due to their lack of superstructure. It is essential that small vessels of non-metallic construction, such as the "MOONGLOW", carry radar reflectors with good reflective characteristics to increase their possibility of detection.

As a result of a previous collision between a bulk carrier and a fishing vessel in 1994, the Board recommended that Transport Canada warn fishermen of the detection limits of radar reflectors on small fishing vessels and promote radar reflectors designed to ensure maximum reflective performance. Subsequently, the Canadian Coast Guard (CCG) issued Ship Safety Bulletin No. 11/95, *Radar Reflectors on Small Vessels: Construction, Fitting, and Limitations*. The Ship Safety Bulletin, issued in June 1995, cautions operators of small vessels, in general, of the detection limitation of radar reflectors and emphasizes the importance of keeping a proper lookout and maintaining an efficient radar watch. Plans that meet design and fitting standards to give maximum echoing area are also made available at regional Ship Safety offices for those operators who wish to build effective radar reflectors.