MARINE INVESTIGATION REPORT
M97L0030

GROUNDINGS

BULK CARRIER "VENUS"
BÉCANCOUR HARBOUR
ST. LAWRENCE RIVER, QUEBEC
17 AND 18 APRIL 1997

Transportation Safety Board of Canada

Bureau de la scurit des transports du Canada

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 Investigation Report

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Synopsis

On 17 April 1997, the Liberian bulk carrier “VENUS” was proceeding up the St. Lawrence River on a voyage originating from Uquan Bay, China. Under the conduct of a pilot, the vessel commenced her approach to Bécancour Harbour, Quebec, assisted by two tugs.

While drifting laterally during the approach, the “VENUS” suddenly swung to port and grounded on a shoal at the downstream limit of the turning basin off the entrance to the harbour. The compartments were sounded and no leak was found. During the evening, the bulk carrier was refloated with the assistance of four tugs, but the vessel could not stem the current, and on 18 April 1997, she grounded again on the north shore of the river.

The Board determined that the “VENUS” grounded because an order to increase speed was not transmitted to the engine-room by the navigation personnel, and the pilot did not confirm that it was. The vessel's speed was insufficient to allow her to stem the current, and she was set toward the downstream limit of the turning basin, where she struck an obstruction. Following bottom contact, the vessel suddenly swung to port. The heavy spring current set the vessel toward the edge of the basin and the vessel grounded. The heavy concentration of shoals surveyed would seem to indicate that the obstruction was formed by silting.

Ce rapport est également disponible en français.

1.0 Factual Information

1.1 Particulars of the Vessel

	"VENUS"
Official Number	5893
Port of Registry	Monrovia, Liberia
Flag	Liberia
Type	Bulk carrier
Gross Tonnage[1]	31,791
Length	199.789 m
Draught	F[2]: 11.19 m A: 11.42 m
Cargo	43,536 tonnes of magnesite
Crew	30
Built	1977, Chita, Japan
Propulsion	One Sulzer diesel engine, RND76, 10,444 kW
Owners	World Wide Shipping Co. S.A.

1.1.1 Description of the Vessel

The "VENUS" is a bulk carrier with bridge, accommodation and engine-room aft of the seven cargo holds. Cargo is handled by four slewing derricks mounted on the fore-and-aft centreline of the vessel.

1.2 History of the Voyage

On 17 April 1997, around 0405 eastern daylight time (EDT)[3], off the pilot station at Québec Harbour, Quebec, the pilot boarded the "VENUS", bound for Bécancour Harbour, Quebec.

During manoeuvres, to avoid delays in changing speeds, the main engine runs on diesel fuel. After the vessel passed Champlain, Quebec, at 1018, speed was reduced. Abreast of buoys C20 and C21, in the ship channel off

1 Units of measurement in this report conform to International Maritime Organization (IMO) standards or, where there is no such standard, are expressed in the International System (SI) of units.

2 See Glossary for all abbreviations and acronyms.

3 All times are EDT (Coordinated Universal Time (UTC) minus four hours) unless otherwise stated.

Bécancour Harbour, speed was reduced to “dead slow ahead.” Around 1050, the tug “ROBERT H.” was secured by the bow forward of the accommodation on the port side. The tug “DUGA” stood by the vessel’s starboard shoulder. The pilot gave the order to steer 220°(G) and the vessel entered the turning basin off Bécancour Harbour.

The vessel proceeded toward the upstream limit of the turning basin, and at 1053, the main engine was stopped. The helmsman was ordered to keep the vessel on a heading of 220°(G), but the vessel had difficulty staying on that heading. At 1058, “dead slow ahead” was ordered and the “ROBERT H.” was ordered “half astern.” The vessel continued moving sideways toward the wharf, while also drifting toward the downstream limit of the basin. The pilot ordered the “ROBERT H.” to stop pulling and ordered the navigation personnel to increase engine speed to “slow ahead.” The vessel seemed to slow down, but then suddenly swung to port. At 1107, “half ahead” was ordered, then “full ahead.” However, the vessel continued to swing to port. At 1108, “full astern” was ordered, and the vessel came to rest on the shoal in position 46°24'34"N, 072°22'27"W, on a heading of 196°(G) at the downstream limit of the turning basin. At 1109, the main engine was stopped.

At 1126, the pilot reported the grounding to the Marine Communications and Traffic Services (MCTS) Centre at Québec.

After an inspection of the compartments revealed no leak, an initial attempt was made to refloat the vessel with the tugs “ROBERT H.” and “DUGA”, but to no avail. The shipowners’ representatives called for two tugs with high bollard pull. The tugs “OCEAN FOXTROT” and “CAPT. IOANNIS S.” were dispatched from Québec Harbour in the late afternoon. When these two additional tugs arrived at Bécancour that evening, three tugs, the “CAPT. IOANNIS S.”, the “ANDRÉ H.” and the “DUGA” were positioned downstream of the “VENUS” against the aft port side. The “OCEAN FOXTROT” was secured by the stern to the stern of the “VENUS”.

Using the vessel’s main engine for astern propulsion and with the assistance of the four tugs, the “VENUS” was refloated at approximately 2333. The vessel drifted north along the shoal on which she had grounded. At 2338, the “VENUS” entered the ship channel and the starboard anchor was dropped, but the vessel continued to drift toward the north shore. On April 18 at about 0002, the “VENUS” grounded again off Pointe-à-Bigot, Quebec, in approximate position 46°25'04"N, 072°22'36"W, on a heading of 070°(G).

An inspection of the compartments again revealed no leak, and it was decided to refloat the “VENUS” again. With the assistance of the tugs “CAPT. IOANNIS S.”, “DUGA” and “OCEAN FOXTROT”, the “VENUS” was again refloated around 0225. Downstream of buoy C20, the vessel swung into the ship channel on her starboard anchor; then, at 0237, the anchor was weighed. The "VENUS" proceeded toward Bécancour Harbour, and around 0250, she anchored in the upstream part of the turning basin. After it was confirmed that the anchor was not dragging, the main engine was stopped at 0344.

At 0418, the pilot ended his assignment and was replaced by a relief pilot. At 0453, the anchor was weighed, and at 0555, under the conduct of the relief pilot, the vessel berthed without incident at berth B3 in Bécancour Harbour.

1.3 Damage to the Vessel

Sounding around the vessel after the first grounding revealed that the vessel was resting on a shoal between frames 191 and 65. After each grounding, a sounding of the compartments revealed no leak. On 22 April 1997, during unloading at Bécancour, the classification society, Bureau Veritas, sounded the compartments again and found no leak. Because of reduced underwater visibility, no underwater inspection was carried out at Bécancour. However, in its inspection report, the classification society indicated that an underwater inspection had to be performed before the next loading or by 30 April 1997 at the latest.

1.4 Certification

1.4.1 Vessel

The "VENUS" was certificated, equipped and crewed in accordance with existing regulations.

1.4.2 Personnel

The master and officers of the watch of the "VENUS" held qualifications appropriate for the class of vessel on which they were serving and for the intended voyage.

1.4.3 Pilot

The pilot held a valid pilot licence for a vessel of the tonnage of the "VENUS" and for the district of the St. Lawrence River in which he served.

1.5 Personnel History

1.5.1 Master

The master had 17 years' sea service and had been master of the "VENUS" since 11 March 1997.

1.5.2 Pilot

The pilot had some 40 years' sea service and had been serving as a pilot since 1967. In 1997, he had had the conduct of two vessels in Bécancour Harbour, the "FEDERAL BAFFIN" and the "UVIKEN", as first and second pilot. This was his first assignment on the "VENUS".

1.5.2.1 Pilot's Medical Requirements

The pilot takes medication for hypertension, but it has no effect on his duties. He undergoes an annual medical examination at a family medicine clinic. His most recent medical examination had been done in March 1995 by a medical examiner appointed by the Laurentian Pilotage Authority (LPA) in accordance with the *General Pilotage Regulations.*

1.6 Weather and Current Information

1.6.1 Weather Forecast

On 17 April 1997, the weather conditions recorded in the bridge log of the "VENUS" were as follows: wind from the south-west, Beaufort wind force 3[4], visibility six, and sky overcast. On April 18 at 0400, the crew noted that the wind had turned into a light breeze (four to six knots) from the north-east. Visibility had increased to seven miles.

1.6.2 Currents

The *Canadian Tide and Current Tables* indicate that, at the time of the first grounding, the current in the turning basin was probably 2.7 knots and 055°(T). The Tables also indicate that the direction of the current off Bécancour was relatively independent of the tide. These parameters are based on average climatic conditions and do not take into account the winds or the spring run-off. The rate of flow in the St. Lawrence varies according to the season; e.g., the current during spring run-off likely exceeds the mean value shown in the Tables. The pilot estimated the current at approximately four knots.

1.6.3 Tide Forecast

The first grounding occurred at 1110. Since three hours and five minutes had elapsed between high tide and the first grounding, the tide had fallen 0.5 m to a forecast 2.4 m above chart datum. The difference of 0.5 m between high tide and the time of the grounding was calculated using the *Canadian Tide and Current Tables* instead of the tide gauge for the area.

1.6.4 Water Level

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[4] The Beaufort scale is a table indicating approximate wind speed. Force 3 represents a speed of 7 to 10 knots.

The depth of water as plotted by the Bécancour tide gauge recorder for April 17, around 1108, is 2 m above chart datum.

1.6.5 Silting

The harbour approaches are subject to silting, and at the time of this occurrence, four Notices to Shipping (Notship) (L0587/97, L0595/97, L0596/97 and L0597/97) were in effect concerning silting off the harbour. Canadian Hydrographic Service (CHS) marine chart No. 1313 contains a remark regarding silting. The silting reported had reduced the depth of water in the approaches by 0.3 to 0.5 m. One week after the groundings, on 24 April 1997, the area was sounded and Notship L1871/97 was broadcast starting 08 August 1997. This sounding revealed that the water depth had dropped to 9.7 m above chart datum at the entrance to the turning basin.

1.7 Under-keel Clearance

The ship channel and turning basin off Bécancour Harbour are dredged to a depth of 11 m and 10.6 m, respectively. Based on the water level at the time of the first grounding, the usable depth of water in the turning basin was 12.6 m.

While proceeding upriver, the navigation personnel of the "VENUS" reported to the MCTS an after draught of 11.6 m. In view of the vessel's deep draught, the MCTS calculated the under-keel clearance and advised the Pilotage Dispatch Office of the transit prohibition windows for the "VENUS" at Neuville and Portneuf. Before boarding the "VENUS", the pilot had requested that the Dispatch Office fax the information from the MCTS regarding the restrictions placed on the vessel to the waiting room of the Québec pilot station. While the pilot boat was catching up to the "VENUS" in Québec Harbour, the pilot observed that the after draught of the vessel was approximately 11.65 m.

According to the Canadian Coast Guard's (CCG) Estimated Squat Table for transits between Montreal and Québec, a 32 m-wide vessel (the "VENUS" was 32.2 m wide) making six knots (the vessel was stemming a four-knot current) squats by about 0.21 m. Thus, with a usable water depth of 12.6 m, a draught of 11.65 m and a squat of 0.21 m, the "VENUS" had an under-keel clearance of approximately 0.74 m in the turning basin.

1.8 Navigation

1.8.1 Navigation Equipment

It was determined that the vessel's navigation equipment was serviceable. The navigation personnel had noted a gyrocompass error of +1 degree.

1.8.2 Aids to Navigation

The *Sailing Directions* published by Fisheries and Oceans Canada contain the following note regarding the unidirectional range light at Bécancour Harbour:

> An "optical guidance system", in line bearing 167½°, is used as **leading lights** for the basin approach. This system, located near the shore, SE of Berth No. 5, consists of a guidance panel showing illuminated directional arrows which become vertical lines when the ship is on the indicated course.

According to some pilots, using the unidirectional range light requires some training, but when one gets used to it, it is effective. However, according to the pilot of the "VENUS", the unidirectional range light requires constant attention. Since it is a private aid to navigation, it is not inspected by the CCG Technical Services or the CHS.

The pilot chose instead to use the silos of the Bécancour aluminium refinery and the two derricks at their berth on wharf B5 as landmarks because there was a shoal in the upstream portion of the turning basin and a vessel was moored at berth B1. Seen from the turning basin, the space between the two derricks and the silos in the background forms a space for the approach manoeuvre. The middle silo of the Bécancour aluminium refinery and the upstream side of the building on the wharf at berth B5 provide an approximate range that reaches out to the middle of the manoeuvring space.

1.8.3 Marine Chart

The navigation personnel of the "VENUS" were using the 18th edition of the American marine chart entitled "Champlain, Lac St. Pierre" published by the Defence Mapping Agency on 15 July 1995. The most recent correction to the chart was NM 13/97. There is no inset showing Bécancour Harbour or the unidirectional range light on this chart.

The inset on CHS marine chart No. 1313 shows two private buoys marking the east limit of the turning basin and the entrance to the harbour. These buoys had been removed for the winter, but since they are optional, they had not been redeployed in the spring. The Bécancour Harbour authorities were planning to replace them with a landmark during the summer of 1997.

1.8.4 Bridge Resource Management

Before arriving at Bécancour, the pilot and master discussed preparations for securing the vessel to the tug and to berth B3 at the Bécancour wharf. However, the discussion did not include helm orders, main engine orders, or tug manoeuvring. There were three radars on board, one of which was equipped with an automatic radar plotting aid (ARPA), but neither the navigation personnel nor the pilot used any of the radars to navigate by parallel indexing. The master neither requested nor received any information concerning the unidirectional range light.

Under the *Pilotage Act*, a licensed pilot who has the conduct of a vessel is responsible to the master for the safe navigation of the ship.[5] The master is responsible for the overall safety of the vessel and the crew. While the pilot has the local knowledge to analyse local cues more readily and take rapid action as necessary, the ship's crew has a greater understanding of the ship's handling characteristics. It is essential that the skills of each be combined in the working relationship of a bridge team. The Board, recognizing the need for teamwork and greater cooperation between the master/watchkeeping officers and the pilots, made several bridge resource management-related recommendations in its report No. SM9501 entitled *A Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots*. In this instance, the master considered that the approach and berthing manoeuvres were the sole responsibility of the pilot, despite the requirements of the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW) that set out certain principles for keeping a navigation watch with a pilot on board. Irrespective of the duties and obligations of the pilot, his presence on board does not relieve the master or the officer of the watch of their duties and obligations with respect to the safety of the ship.

1.9 Communications

1.9.1 Communication Between Pilot and Tugs

There were two very high frequency radiotelephones (VHF R/T) on the bridge, each mounted on a side bulkhead in way of one of the doors leading to the wings. The pilot, at the centre of the bridge, used his portable VHF R/T to communicate with the MCTS and the tugs.

1.9.2 Communication Between Vessel and Nearby Traffic

It was not anticipated that the "VENUS" would leave the turning basin after being refloated the first time. However, the "CANMAR ENDEAVOUR" and the "FERBEC", which were transiting the area, obtained from the pilots of the "VENUS" and the "CAPT. IOANNIS S." information concerning the position and heading of the "VENUS" so they could pass the bulk carrier safely in the ship channel. The "VENUS" did not impede the passage of traffic in the ship channel.

1.9.3 Communication Between Pilot and Navigation Personnel

Between 1058 and 1107, the pilot considered that the vessel was too close to the downstream limit of the turning basin, and he ordered the "ROBERT H." to stop her engine and directed the navigation personnel on the bridge to increase the main engine speed of the "VENUS" to "slow ahead."

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[5] *Pilotage Act*, section 25(2)

Occurrences resulting in situations like this depend on the ability of the operator to interpret and process information which, in certain cases, can be limited. The operator picks up bits of information that he retains for later use if he considers the information relevant, significant or useful. However, some crucial information might go unnoticed if the operator is concentrating specifically on other information or on the performance of a specific task. The pilot focussed partly on visual observation of the landmarks to keep the vessel within the manoeuvring space, and partly on giving helm and engine orders to correct the drift. The officer of the watch, who controlled the engine telegraph and entered the pilot's orders in the engine log book on the bridge, did not carry out the order to increase speed to "slow ahead," and the pilot did not confirm that his orders had been carried out.

The data recorder for the main engine shows the following speed changes:

Speed	Time
STOP	1050[6]
DEAD SLOW AHEAD	1051.5
STOP	1053.5
DEAD SLOW AHEAD	1058.5
HALF AHEAD	1107
FULL AHEAD	1107
STOP	1107.5
FULL ASTERN	1108
STOP	1109

[6] The data recorder clock was set to local time.

1.10 Vessel Manoeuvrability

1.10.1 Vessel Speed

Orders are transmitted from the bridge to the engine-room via the engine telegraph. In the loaded condition, the vessel makes the following speeds at the following settings:

Setting	Speed (in knots)
Full ahead (manoeuvring)	12
Half ahead	10
Slow ahead	7.5
Dead slow ahead	5

1.10.2 Visibility from the Bridge

The derricks on the main deck did not interfere with visibility from the bridge.

1.11 Approach and Berthing Manoeuvres

1.11.1 Possible Approach Manoeuvres in the Turning Basin

Steering approximately 220°(G) in the ship channel, the vessel proceeded toward the turning basin assisted by two tugs. There are other ways to manoeuvre a vessel in the turning basin; two are presented here.

One way is to execute the approach by keeping the vessel's head on a landmark and using propeller thrust to stem the current. Rather than being secured to the vessel, the two tugs push against the starboard side, one forward and one aft, to push the vessel toward the harbour entrance.

Another way to manoeuvre in the turning basin is to secure one tug by the bow to the aft port side of the vessel forward of the accommodation with the other tug, not secured, standing by on the starboard shoulder. Upon entering the turning basin, the vessel is turned slightly toward the harbour so that the fore-and-aft centreline is at a slight angle to the current. This causes the vessel to drift sideways southward toward the harbour entrance. To arrest the vessel's drift downstream, the secured tug applies astern power while the vessel's main engine is operated ahead.

Some pilots use the unidirectional range light, while others choose to use the harbour structures, such as the silos of the Bécancour aluminium refinery and the derricks on wharf B5, as landmarks.

When off the harbour entrance, the forward tug pushes against the starboard shoulder and the vessel swings to port until she is headed on the harbour entrance. The vessel enters the harbour without assistance from the tugs, then the main engine is operated astern to stop the vessel off berth B3. The manoeuvre is completed by the two tugs pushing against the port side until the vessel comes alongside the wharf.

1.11.2 Selecting a Manoeuvre

Pilots teach the approach and berthing manoeuvres to apprentices during training. There is more than one way to execute approach and berthing manoeuvres in a given harbour. While training on the St. Lawrence River, apprentices have the opportunity to accompany most of the serving pilots and to learn the different manoeuvres. Apprentices adopt the manoeuvre that best suits them and allows them to do their job safely. Pilots may use the same method throughout their careers.

The pilots who were aboard the tugs "CAPT. IOANNIS S." and "OCEAN FOXTROT" prefer to use the unidirectional range light and not secure the tugs to the vessel on the approach. On the other hand, the pilot on the "VENUS" chose to use the silos and derricks as landmarks for the approach manoeuvre. However, all three pilots involved in the accident said they use the same berthing manoeuvre.

A pilot might have the conduct of a vessel to berth at or depart from Bécancour Harbour several times a year. In 1997, the MCTS recorded 4,798 vessel movements[7] under the conduct of a pilot between Québec and Montreal, including 618 vessel movements in Bécancour Harbour. Of the 16 marine occurrences recorded at this location since 1976, 4 were groundings, and 2 of those occurred during the approach.

1.12 Marine Salvage

1.12.1 Marine Salvage Service

When the representatives of the "VENUS" requested the assistance of two tugs, Groupe Océan offered the services of a marine salvage specialist. The offer was declined.

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[7] A movement on the St. Lawrence River is defined as either an outbound or inbound passage, and a harbour movement is either a berthing or departure.

1.12.2 Intended Refloating Manoeuvre

The intended manoeuvre was to move the port quarter of the "VENUS" away from the downstream limit of the turning basin to avoid damaging the propeller and rudder, and to tow the "VENUS" astern to the upstream part of the turning basin and then drop anchor. The "VENUS" would then swing on the anchor and stem the current again, ready to resume the berthing manoeuvre.

1.12.3 Assistance to the Vessel

When the vessel came to rest on a heading of 196°(G) on the first grounding, the current running approximately 055°(T) was pushing against the hull at an angle of about 50 degrees. Since it was feared that the vessel would dig further into the shoal, the tug "ANDRÉ H." was ordered to push against the port side.

During the afternoon, the stern of the vessel moved a short distance away from the shoal and came to rest again, on a heading of 180°(G). The pilot, the shipowners' representatives and the navigation personnel took part in the preparations for refloating.

Upon arriving on the scene, the "CAPT. IOANNIS S." was ordered to push against the port side of the "VENUS" with the "DUGA" and the "ANDRÉ H." Pushing together, the three tugs were able to swing the vessel around to 170°(G); none of the tugs were made fast to the "VENUS". The "OCEAN FOXTROT", however, was secured by the stern to the stern of the "VENUS".

The refloating manoeuvre commenced with the main engine being ordered "half astern" at 2308. With the four tugs assisting, the main engine was operated astern and ahead to clear the hull from the shoal. The vessel swung to starboard to about 150°(G), then slightly back to port, and came clear from the shoal at approximately 2333. When the "VENUS" was refloated, the "OCEAN FOXTROT" steered upstream, but the "VENUS" drifted along the downstream limit of the turning basin while lying crosswise to the current. At about 2338, the "VENUS" drifted over buoy C21. The vessel entered the ship channel stern first, and the anchor was dropped while the engine-room was given a series of orders for ahead power to arrest the drift toward the north shore. The vessel nonetheless continued to drift north, with the "OCEAN FOXTROT" pulling crosswise to the ship channel until the bottom of the "VENUS" contacted the bank off Pointe-à-Bigot.

After allowing traffic in the area to pass the "VENUS", a second tug, the "DUGA", was secured to the aft starboard side of the vessel to pull her away from the north bank. The vessel then drifted north of buoy C20. The vessel swung on the anchor into the ship channel, and the anchor was weighed.

1.12.4 Tug Particulars

The particulars of the tugs assisting the “VENUS” for the approach and refloating manoeuvres are as follows:

Name	Power	Gross tonnage	Bollard pull
ANDRÉ H.*	2,200 hp	317	28 tonnes
CAPT. IOANNIS S.	5,600 hp	722	73 tonnes
DUGA*	4,200 hp	382	55 tonnes
OCEAN FOXTROT	5,200 hp	700	63 tonnes
ROBERT H.*	1,000 hp	257	15 tonnes

* Tugs normally used by Bécancour Harbour.

1.13 Performance Degradation

1.13.1 Rest prior to the Assignment

The Corporation des pilotes du Saint-Laurent central inc. provides the LPA with a supplementary list of pilots once a year. During his vacation from 04 to 17 April 1997, the pilot completed two assignments as relief pilot (on 05 and 12 April 1997), as his name was on the supplementary list. The pilot spent the three nights preceding his assignment on the “VENUS” at home, and his sleep was not disturbed. On April 16, he was in bed by about 2130 and fell asleep around midnight. He reported having difficulty falling asleep because, during his vacation, he had gotten out of the habit of retiring early. The “VENUS” was his first pilotage assignment after his vacation.

1.13.2 Duration of the Assignment

An assignment starts when a pilot receives his notice to board. The pilot is required to remain on board until the pilotage mission is completed and the vessel is secure or until he is relieved by another pilot. At 0315 on April 17, the Dispatch Office called the pilot to inform him that he was assigned to the “VENUS” and that the vessel would be off the Québec pilot station at about 0415. The pilot boarded the vessel around 0405. The two groundings of the vessel considerably prolonged the pilot’s assignment, but he continued to have the conduct of the “VENUS” during both refloating operations and until the anchor was dropped in the turning basin. The pilot disembarked at 0418 on April 18.

In an occurrence in Hamilton Harbour, Ontario, on 11 December 1993, the bulk carrier “NIRJA” did not successfully negotiate the turn into the slip and struck the “HAMILTON ENERGY” because she was not stopped in the available distance (TSB report No. M93C0003). The fact that the tugs were not secured to the vessel, that the anchor was not dropped, that this was the pilot's third consecutive assignment in 24 hours and that he had not had adequate rest periods between these assignments probably adversely affected his performance. It was determined that fatigue, among others, was a contributing factor to that occurrence.

The Board had two safety concerns arising out of that occurrence. First, current pilotage assignment practices permit extended duty days such that significant performance degradation can occur. Secondly, both the pilotage authority and the pilots themselves apparently do not fully appreciate the adverse effects of fatigue on performance and they are not aware of the strategies that can be used to mitigate those effects.

Studies have shown that sleep-deprived individuals tend to underestimate their level of fatigue. Given the susceptibility of individuals in safety-sensitive positions to making significant errors in judgement when fatigued, and given the potential consequences of such errors, the Board believes that mandatory rest provisions should be strictly enforced in the assignment of marine pilots. Therefore, the Board recommended that:

> The Department of Transport and the Great Lakes Pilotage Authority implement a policy and procedures for allocating pilotage assignments, such that pilots receive sufficient rest to minimize the adverse effects of fatigue on performance.
>
> (M96-17, issued December 1996)

Further, the Board recognizes that strict enforcement of mandatory rest periods will not in itself ensure that no pilot will suffer the adverse effects of fatigue. Many factors beyond pilot scheduling can affect a pilot's performance while on duty. The pilots themselves have control over many of these in terms of personal lifestyle modifications; e.g. off-duty activities, eating and drinking habits, sleep scheduling and sleep environment, exercise, etc. Very relevant literature is available to assist employees in developing personal strategies for coping with the natural physiological effects of shift work, irregular work schedules, circadian dysrhythmia, or extended duty hours.

To assist pilots in coping with the natural stresses of operating in a "24-7" industry, the Board recommended that:

> The Great Lakes Pilotage Authority develop and implement an awareness program to provide guidance to dispatching staff and pilots on reducing the adverse effects of fatigue on job performance.
>
> (M96-18, issued December 1996)

1.13.3 Possible Performance Degradation Factors

The work environment of pilots requires them to work irregular schedules that are sometimes demanding and can involve work in adverse weather conditions. Sleep loss and sleepiness resulting from extended duty hours or altered work/rest schedules have been identified as contributing factors in many industrial accidents[8]. Under

[8] Mark R. Rosekind, Philippa H. Gander, Linda J. Connell, and Elizabeth L. Co, *Crew Factors in Flight*

the *Pilotage Act*, licensed pilots are prohibited from having the conduct of a vessel or from being on duty aboard a vessel when their abilities are impaired.

Research into circadian rhythms and sleep indicates that there are maximum sleepiness times and maximum wakefulness times during each 24-hour period. Under normal conditions, for most people, maximum sleepiness occurs between 0300 and 0500, and a second natural period of sleepiness occurs between 1500 and 1700. Similarly, there are maximum wakefulness periods when people find it difficult to sleep, and any sleep they do achieve at these times will not have the same restorative value.

Research also suggests that it is not possible to store sleep. As a person remains awake, a sleep need develops, notwithstanding how well rested the individual was at the beginning of the wake cycle. The sleep need continues building until a person goes to sleep. On average, people need 7.5 to 8.5 hours of sleep per day. A person obtaining less than his/her required sleep develops a sleep debt and will be subject to performance degradation. Performance on cognitive and vigilance tasks is particularly impaired and there is an increased propensity for risk-taking by fatigued persons. Cumulative sleep loss and circadian disruption can lead to decreased waking alertness, impaired performance, and worsened mood[9].

Researchers at the Defence and Civil Institute of Environmental Medicine found that a 30 per cent decrement in performance on cognitive tasks can be expected after 18 hours of wakefulness[10]. Breaks or periods of low workload had no effect on performance levels. The only intervention which maintained or restored levels of performance was sleep.

Operations X: Alertness Management in Flight Operations. NASA Technical Memorandum, DOT/FAA/RD-93/18. NASA Ames Research Center, 1994.

9 Mark R. Rosekind, Philippa H. Gander, et al., "Fatigue in Operational Settings: Examples from the Aviation Environment," *Human Factors*, vol. 36, No. 2, page 328.

10 R.G. Angus, R.A. Pigeau, and R.J. Heslegrave, "Sustained Operations Studies: from the Field to the Laboratory," *Why We Nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep*. ed. C. Stampi. Boston: Birkhauser.

Sleep quality and duration are negatively affected by many factors, including time of day, light, environment, and use of stimulants such as caffeine. People tend to experience poor sleep in surroundings different than their normal place of rest[11]; e.g., aboard a ship, on a different mattress, with a different noise level and tone, vibration, temperature, and humidity. During the day of April 17, the pilot had two 15-minute naps on the vessel.

People are poor judges of their own levels of fatigue and alertness. Caffeine, physical activity, or interesting conversation can mask the effects of sleep debt and fatigue. It has been demonstrated that individuals (especially sleepy individuals) do not reliably estimate their alertness and performance[12].

1.13.4 Number of Pilots on Board

In a compulsory pilotage area, normally only one pilot is required on a vessel. The *Laurentian Pilotage Authority Regulations* state, however, that two licensed pilots are required if the assignment is to last over 11 consecutive hours or if the conditions or nature of the voyage are such that more than one pilot is required to carry out the pilotage duties.

Under the pilotage services contract between the LPA and the Corporation des pilotes du Saint-Laurent central inc., where an unexpected situation requires an immediate solution, consultations are held between the operations assistant and his representative and a member of the Board of the LPA. The grounding was reported on the alert network at 1155 on April 17, but it was not until 15 hours after the first grounding that a second pilot was assigned to the vessel, and then only because the pilot on duty requested it.

The pilot of the "VENUS" first requested a replacement only after the second grounding. The computer database in the Dispatch Office indicates that, at 0158, further to a request, a second pilot was assigned to the "VENUS" for 0400. A licensed pilot can be replaced, where possible, if he gives the Dispatch Office 12 hours' notice and then confirms his request at least 4 hours before. Approximately one hour after the pilot's first request for relief, the Dispatch Office advised the pilot on duty that no pilot from the regular list was available, but that a pilot from the supplementary list had agreed to take over.

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11 Richard M. Coleman, *Wide Awake at 3:00 AM.* Stanford, CA: Stanford Alumni Association, 1986.

12 Mark R. Rosekind, Philippa H. Gander et al., *Crew Factors in Flight Operations X: Alertness Management in Flight Operations.* NASA Technical Memorandum, DOT/FAA/RD-93/18. NASA Ames Research Center, 1994.

2.0 Analysis

2.1 Selecting an Aid to Navigation

Since the unidirectional range light was not shown on the American marine chart used on the "VENUS", the navigation personnel were not inclined to use that aid to navigation when planning the approach manoeuvre or to mention it to the pilot before or during the approach.

The unidirectional range light projects over the middle of the turning basin and allows the entire surface of the turning basin to be used as a manoeuvring area. Unlike the unidirectional range light, the landmarks used by the pilot tend to restrict the vessel to the downstream portion of the turning basin. When these landmarks are used, the approach manoeuvre must be executed closer to the shoal along the downstream limit, which considerably increases the risk of grounding.

2.2 Approach Manoeuvre

In this instance, the pilot decided to manoeuvre in the downstream portion of the turning basin because of the silt deposits in the upstream portion of the entrance to the turning basin and because a vessel was moored at berth B1. He chose this approach manoeuvre because he wanted to keep the vessel away from the potential hazards in the upstream portion of the basin. With a water level of 2 m above chart datum, the vessel had an under-keel clearance of about 1 m over the 10.6 m shoal in the upstream portion of the turning basin. Also, the vessel moored at berth B1 was not encroaching on the harbour entrance.

To carry out his task, the pilot used his usual approach manoeuvre. By choosing a proven method, he avoided surprises and increased his chances of success. Given the number of vessel movements in the area and the low rate of accidents in Bécancour Harbour, the manoeuvre chosen and used by the pilot many times in the past would appear to have been the right choice, but it provided a smaller margin of error than the manoeuvre based on the use of the unidirectional range light.

The vessel apparently swung to port suddenly and unexpectedly. This reaction is similar to that of a long narrow object that is moving sideways when one end strikes a fixed object. Although the after section of the ship's bottom was not damaged, this dynamic behaviour suggests that the vessel's stern struck an obstruction that was probably formed by silting.

2.3 Bottom Contact

The spring run-off was conducive to silting. The silt deposits at several locations on the approaches show that Bécancour Harbour is subject to silting. In fact, silting is mentioned in a remark on the CHS marine chart for the area.
The low manoeuvring speed of the "VENUS" in the turning basin had a slight effect on the squat. The vessel's deep draught (11.6 m) and considerable breadth (32.2 m) likely contributed to a more pronounced reduction in

under-keel clearance. As a result, with an under-keel clearance of less than 0.74 m, the vessel was at risk of striking any shoal formed by silting.

Since the vessel swung suddenly after contacting the bottom, the shoal found at the entrance to the turning basin after the grounding cannot be taken into account. If the vessel had contacted bottom at the entrance to the basin, the heavy spring current would not have set the vessel toward the bottom portion of the basin where she grounded but rather on the rocky downstream limit along the 7.3 m and 6.4 m soundings. The vessel, following the pilot's chosen approach at the entrance to the basin, would have avoided the 9.7 m shoal. Nonetheless, unreported silt deposits along the downstream limit of the turning basin in way of the grounding position cannot be ruled out as a contributing factor to this occurrence.

The current off the harbour entrance tends to set vessels toward the downstream limit of the turning basin. Regardless of the approach manoeuvre selected to enter the harbour, if the vessel is to stem the current, the approach must include helm and engine manoeuvres with or without the assistance of tugs. Consequently, the timing of the changes in engine speeds is critical to the success of any manoeuvre.

Because the vessel drifted toward the downstream limit, the pilot was unable to confirm with the navigation personnel that his orders had been carried out. When the pilot ordered the tug's engine stopped and the speed of the "VENUS" increased, he wanted to arrest the drift and move the vessel to the upstream portion of the basin, or at least to stem the current. The pilot did not ascertain that the "slow ahead" order he had given was carried out, and some time elapsed before he realized that the vessel was slowing down. To ensure the successful completion of the approach manoeuvre planned by the pilot, the master and the officer of the watch had to make sure that they clearly understood the pilot's orders.

Thus, the possibility that the subsequent engine orders came too late and the vessel drifted to the downstream limit of the basin cannot be ruled out. The vessel would have struck the shoal along the edge and would have started swinging to port. Even at "full ahead," the propeller thrust could not overcome the effect of the current against the starboard side. The vessel swung to port until the bottom came to rest against the shoal.

2.4 Bridge Resource Management

Because there was little exchange of information and a lack of support between the navigation personnel and the pilot, a proper watch could not be maintained. As the navigation personnel did not keep an adequate radar watch, they were unable to inform the pilot of the proximity of the downstream limit of the turning basin during the approach manoeuvre. Therefore, the pilot had to perform a number of tasks by himself. For example, he had to keep a lookout as well as give helm and engine orders to the navigation personnel of the "VENUS" and the "ROBERT H." There was no buoy or landmark in place along the downstream limit of the turning basin, which made lateral observation more difficult.

Crews navigating in foreign waters are usually unfamiliar with local waterways. If the pilotage assignment is extended, as in this occurrence, conduct of the vessel can be difficult; consequently, in most cases, the navigation personnel tend to rely completely on the local pilot for the conduct of the vessel. The navigation personnel did not use parallel indexing on any of the three available radars to determine the limits of the turning basin. Nothing prevented them from determining for themselves the available manoeuvring space in the turning basin and from offering that information to assist the pilot. Since the navigation personnel were using a marine chart that did not show the unidirectional range light and since they did not discuss the approach manoeuvre with the pilot, they were not fully aware of all available aids to navigation.

The LPA prescribes the circumstances in which vessels are required to have a pilot on board and the minimum number of licensed pilots that must be on board. However, when a marine accident occurs, only the contract between the LPA and the Corporation des pilotes du Saint-Laurent central inc. indicates how the situation should be assessed. Even if there are provisions for assessing marine occurrences, there are no regulations requiring the parties to dispatch a second pilot to the scene to relieve or assist the pilot already on board. Unless a conflict arises between the pilot and the navigation personnel, a pilot involved in a marine incident or accident must wait at least 12 hours to be relieved.

2.5 Knowledge of Marine Salvage Operations

The information collected indicates that the effect of the current during the spring run-off was underestimated. When the vessel moved astern after being refloated, three of the tugs were unable to push against the side because they were not made fast to the vessel. The one tug that was secured to the vessel had insufficient bollard pull. Instead of swinging in the turning basin, the vessel drifted toward the north shore, where she came to rest for the second time. This time, unlike the first grounding, the vessel was not crosswise to the current. Therefore, two tugs had to be secured to the vessel's stern to pull her clear of the bank.

Over the course of their careers, pilots gain extensive experience in ship handling, but they very seldom have to deal with a grounding. Like pilotage, marine salvage is a field where experience is acquired over time. It is possible that the second grounding happened because the shipowners' representatives, the navigation personnel and the pilots involved in the refloating lacked experience in marine salvage techniques.

2.6 Duration of the Pilotage Assignment and Pilot Performance

When the first grounding occurred, the pilot had had the conduct of the vessel continuously for over seven hours. He was on duty for approximately 24 hours in all.

Refloating a vessel is a very demanding manoeuvre that requires high levels of concentration, good judgement, alertness, and immediate response to a developing situation. As the pilot of the "VENUS" was not assisted by another pilot, he was probably fatigued, and his fatigue most probably contributed to the degradation of his ability to perform monitoring and decision-making tasks. Since no medical assessment of the pilot was performed following the two groundings, the extent to which his performance may have been degraded by sleep debt could not be established.

As fatigued people are poor judges of their own fatigue and alertness levels, it is unlikely that the pilot's self-assessment was objective when he decided to retain the conduct of the vessel; in doing so, he delayed calling for a replacement. Pilots should not assess their level of fatigue on their own. There are no provisions in the regulations nor in the service contract that provide for another pilot to be dispatched immediately; this suggests that those concerned do not fully appreciate the adverse effects of sleep debt on performance. When a pilotage assignment is extended due to a marine accident or incident, there is no program under which the pilot can request to be assisted or relieved, and the safety of the vessel may be jeopardized.

3.0 Conclusions

3.1 Findings

1. The navigation personnel relied on the pilot, on his knowledge of the area and on his ability to conduct the vessel.

2. The navigation personnel were using a marine chart that did not show the unidirectional range light.

3. The navigation personnel did not take part in planning the approach manoeuvre in the turning basin.

4. The pilot and the navigation personnel did not discuss the manoeuvre to be performed in the turning basin.

5. The navigation personnel did not monitor closely the progress of the "VENUS".

6. Neither the pilot nor the navigation personnel used radar to navigate by parallel indexing.

7. There was no buoy or landmark in place to mark the downstream limit of the turning basin and to facilitate lateral observation.

8. The pilot used landmarks that required him to execute the approach manoeuvre near the shoal along the downstream limit of the turning basin.

9. The navigation personnel did not increase main engine speed to "slow ahead" and the pilot did not look to see if his orders had been carried out.

10. The current off the harbour entrance set the vessel toward the shoal at the downstream limit of the turning basin.

11. The spring run-off was conducive to silting in the harbour approaches.

12. The vessel struck an obstruction that probably consisted of unreported silt deposits in the turning basin or along the shoal at the downstream limit of the turning basin.

13. The orders to further increase speed were given too late.

14. The vessel was swung round by the current and grounded.

15. The effect of the current on the vessel's hull was underestimated on the first refloating manoeuvre.

16. It is possible that the second grounding is attributable to a lack of marine salvage experience on the part of the shipowners' representatives, the navigation personnel and the pilots involved in the refloating manoeuvre.

17. The pilot was on duty for approximately 24 hours.

18. Pilots should not assess their level of fatigue on their own.

19. There are no provisions in the regulations nor in the service contract for the immediate assignment of another pilot to assist or relieve a pilot involved in a marine occurrence.

20. When a pilotage assignment is extended due to a marine occurrence, the pilot's performance may be degraded and the safety of the vessel may be jeopardized.

3.2 Causes

The "VENUS" grounded because an order to increase speed was not transmitted to the engine-room by the navigation personnel, and the pilot did not confirm that it was. The vessel's speed was insufficient to allow her to stem the current, and she was set toward the downstream limit of the turning basin, where she struck an obstruction. Following bottom contact, the vessel suddenly swung to port. The heavy spring current set the vessel toward the edge of the basin and the vessel grounded. The heavy concentration of shoals surveyed would seem to indicate that the obstruction was formed by silting.

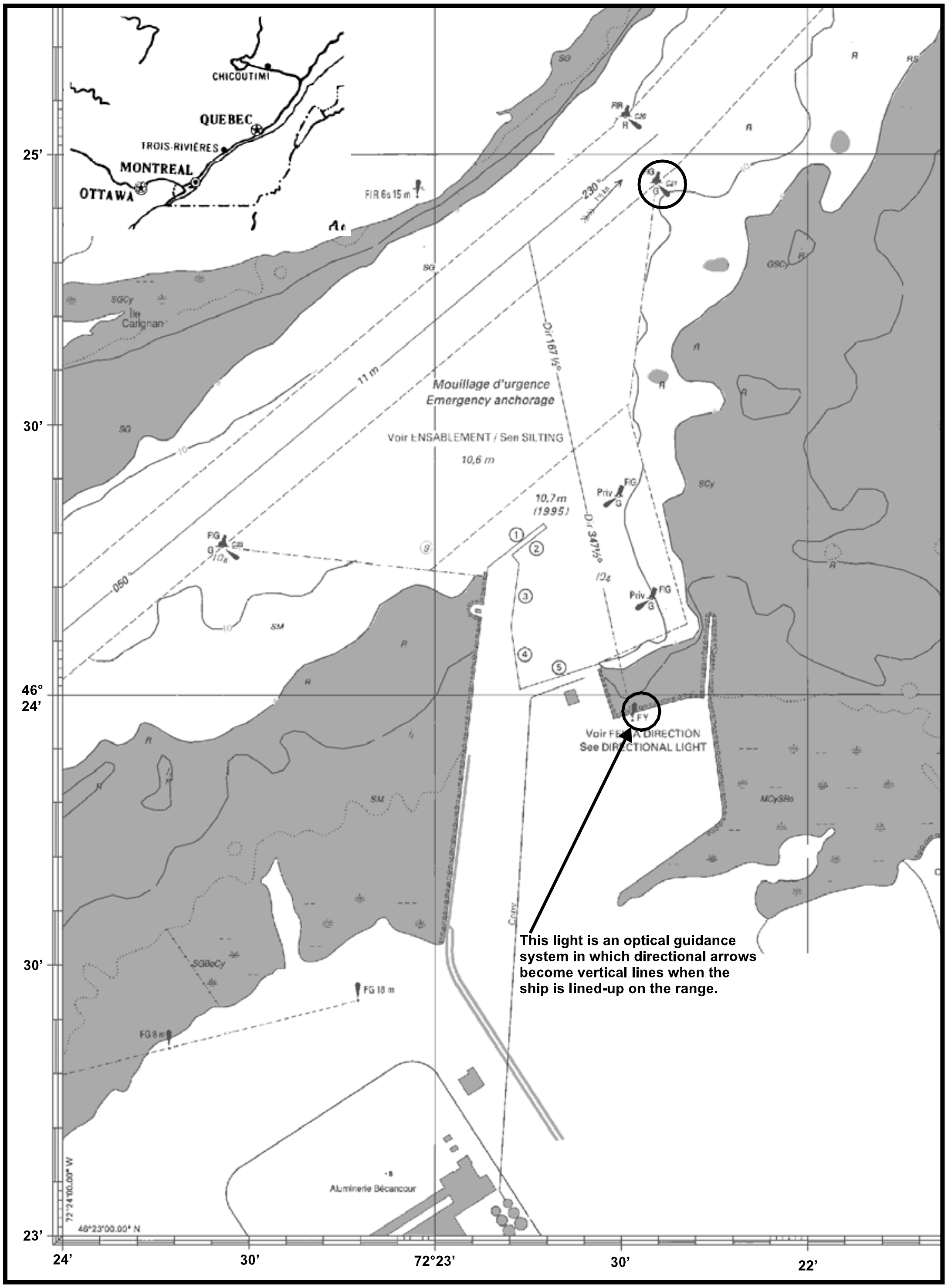
4.0 Safety Action

4.1 Action Being Taken

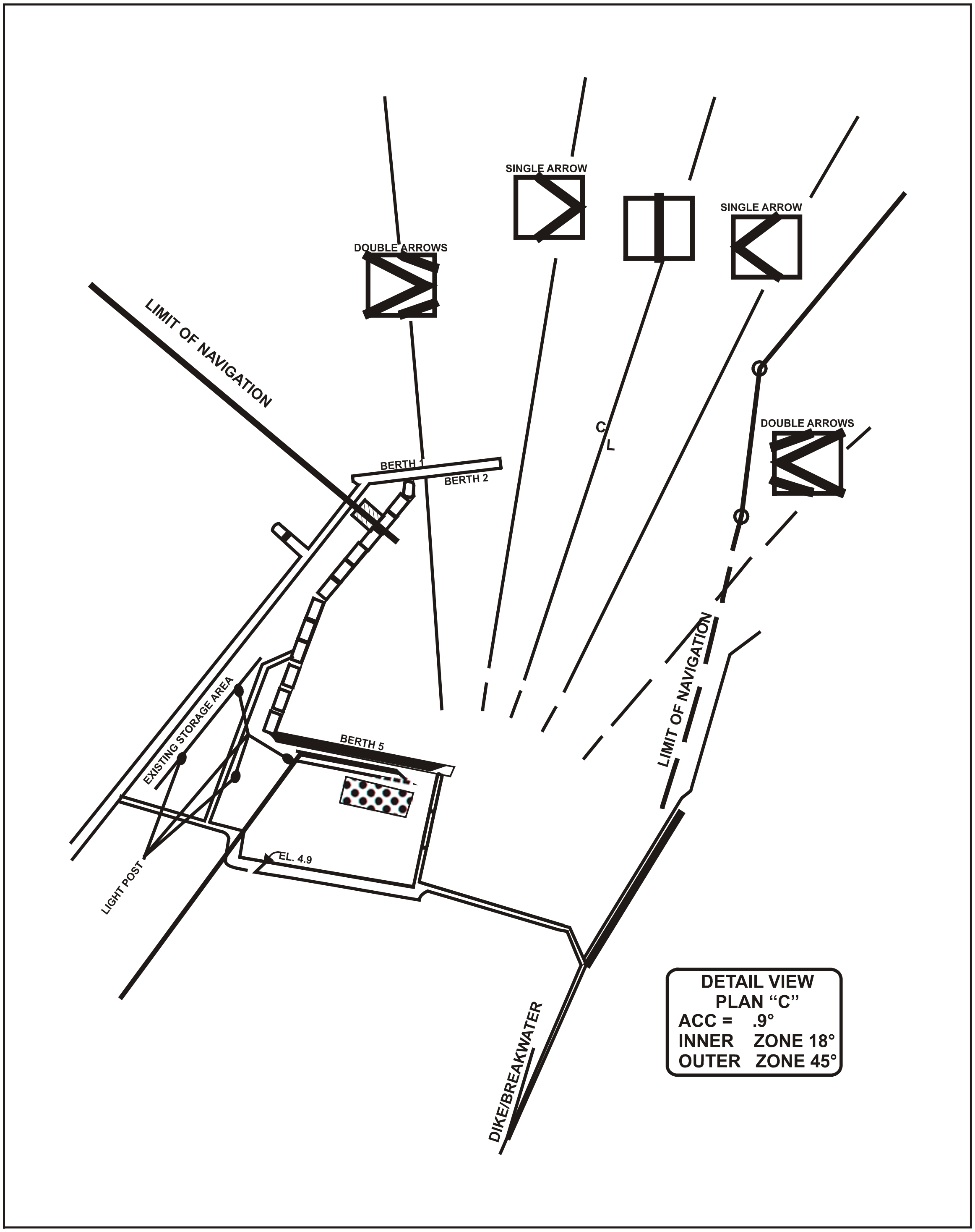
The Great Lakes Pilotage Authority Limited has developed a training package on bridge resource management (BRM) and fatigue awareness and delivered it to all of its pilots. The *General Pilotage Regulations* are currently being amended to make BRM training a mandatory requirement.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 01 March 2000.

Appendix A - Sketch of the Occurrence Area



Appendix B - Photographs



SINGLE ARROW
SINGLE ARROW
DOUBLE ARROWS
DOUBLE ARROWS
LIMIT OF NAVIGATION
C
L
BERTH 1
BERTH 2
BERTH 5
EXISTING STORAGE AREA
LIGHT POST
EL. 4.9
LIMIT OF NAVIGATION
DIKE/BREAKWATER
DETAIL VIEW
PLAN "C"
ACC = .9°
INNER ZONE 18°
OUTER ZONE 45°

Appendix C - Glossary

A	aft
ARPA	automatic radar plotting aid
BRM	bridge resource management
CCG	Canadian Coast Guard
CHS	Canadian Hydrographic Service
EDT	eastern daylight time
F	forward
(G)	gyro (degrees)
hp	horsepower
IMO	International Maritime Organization
kW	kilowatt
LPA	Laurentian Pilotage Authority
m	metre
MCTS	Marine Communications and Traffic Services
N	north
Notship	Notice to Shipping
SE	south-east
SI	International System (of units)
STCW	*International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (1978)
(T)	true (degrees)
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VHF R/T	very high frequency radiotelephone
W	west
°	degree
‘	minute
“	second