MARINE OCCURRENCE REPORT

M97W0197

GROUNDING

THE BULK CARRIER "RAVEN ARROW"
JOHNSTONE STRAIT, BRITISH COLUMBIA
24 SEPTEMBER 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.

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Synopsis

While in Johnstone Strait en route from Vancouver to Kitimat, British Columbia, via the inside passage, the "RAVEN ARROW" ran aground in Boat Bay on the south side of West Cracroft Island when the pilot, who had the conduct of the vessel, ordered an alteration of course.

The Board determined that the "RAVEN ARROW" grounded in fog when the pilot lost situational awareness and prematurely altered course to enter Blackney Passage after having elected to conduct the navigation of the vessel without assistance from the ship's complement. Contributing to the occurrence were the following factors: the pilot was probably fatigued; sound navigational principles were not implemented by the bridge team; the exchange of information between the pilot and the officer of the watch was minimal and imprecise; and the officer of the watch did not effectively monitor the pilot's communication with Marine Communications and Traffic Services.

Ce rapport est également disponible en français.

5.0 Appendix

Figures

1.0 Factual Information

1.1 Particulars of the Vessel

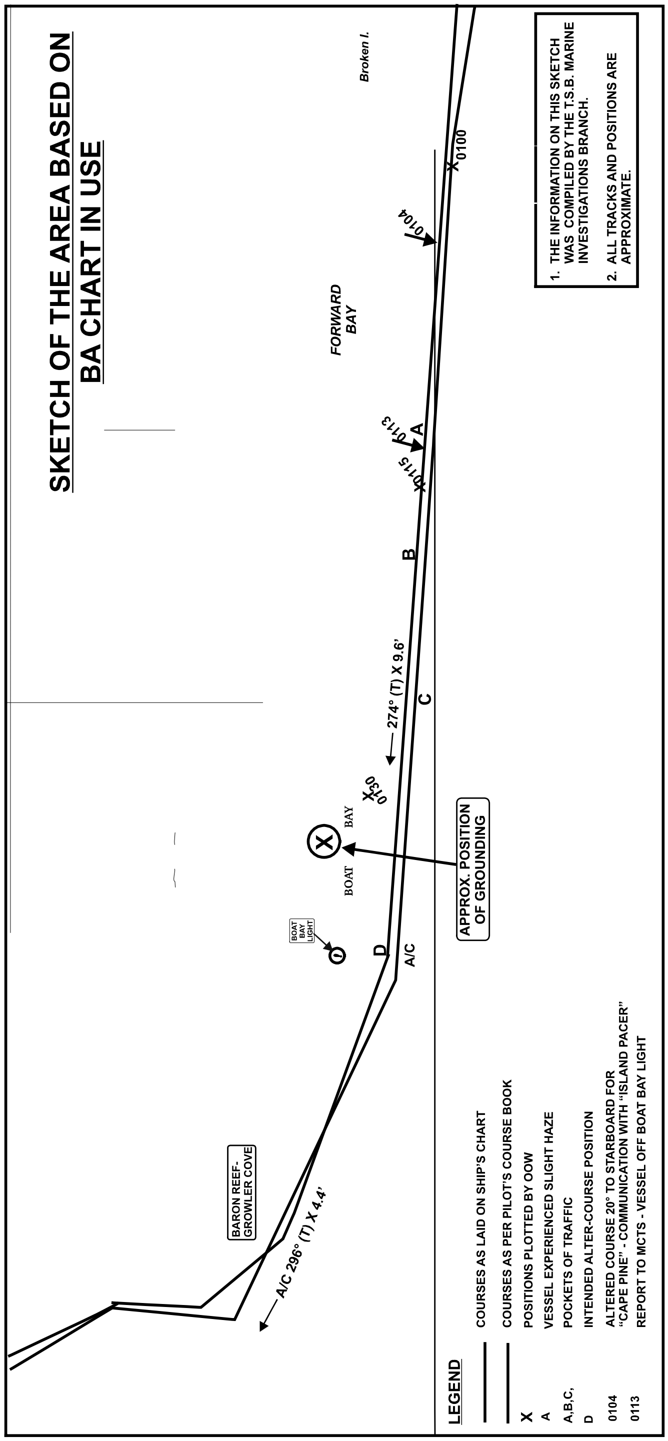
	"RAVEN ARROW"
Official Number	399426
Port of Registry	Nassau, Bahamas
Flag	Bahamas
Type	Forest Product Carrier
Gross Tons[1]	25,063
Length	182 m
Draught	Forward: 7.85 m Aft: 9.58 m
Built	1981, Japan
Propulsion	Mitsui B&W marine diesel engine, 13,100 b.h.p.[2], driving a fixed-pitch propeller
Cargo	19,629 tonnes of pulp and lumber; 1,960 tonnes of ballast
Crew	24
Owners	Gearbulk Shipowning Ltd., Hamilton, Bermuda
Managers—Operations	Kristian Gerhard Jebsen Skipsrederi A.S. Bergen, Norway
Managers—Day-to-Day Operations	United Ship Management Ltd., Hong Kong

1.1.1 Description of the Vessel

The vessel is a forest product carrier, with the bridge, accommodation and engine-room aft of the five cargo holds. She is fitted with two gantry cranes.

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 at Appendix A for all abbreviations and acronyms.


SKETCH OF THE AREA BASED ON
BA CHART IN USE
Broken I.
FORWARD BAY
BARON REEF-GROWLER COVE
BOAT BAY LIGHT
BOAT BAY
APPROX. POSITION OF GROUNDING
A/C 296° (T) X 4.4'
274° (T) X 9.6'
A/C
D
C
B
A
0100
0104
0113
0115
0130
1. THE INFORMATION ON THIS SKETCH WAS COMPILED BY THE T.S.B. MARINE INVESTIGATIONS BRANCH.
2. ALL TRACKS AND POSITIONS ARE APPROXIMATE.
LEGEND
COURSES AS LAID ON SHIP'S CHART
COURSES AS PER PILOT'S COURSE BOOK
X POSITIONS PLOTTED BY OOW
A VESSEL EXPERIENCED SLIGHT HAZE
A,B,C, POCKETS OF TRAFFIC
D INTENDED ALTER-COURSE POSITION
0104 ALTERED COURSE 20° TO STARBOARD FOR "CAPE PINE" - COMMUNICATION WITH "ISLAND PACER"
0113 REPORT TO MCTS - VESSEL OFF BOAT BAY LIGHT

1.2 History of the Voyage

At 1300 Pacific daylight saving time (PDT) on 23 September 1997 the partly loaded "RAVEN ARROW" departed Vancouver, bound for Kitimat, B.C., with two B.C. coast pilots on board.[3] Pilots alternate their shifts while on board. Pilot No. 1 had the conduct of the vessel upon departure at 1300 until 1800, and pilot No. 2 from 1800 to 2300. The voyage until Johnstone Strait was uneventful, but the pilot was occupied with concentrations of fishing vessels encountered. The pilot exchange took place at 2300, with the vessel off Knox Bay in position 50°22.5' N, 125°36.8' W, in Johnstone Strait.

After the change in watches at 0000, September 24, personnel on the bridge comprised the second officer, who was the officer of the watch (OOW), pilot No.1, who had the conduct of the vessel, and the quartermaster, who was at the helm, engaged in steering. At 0002 the pilot reported to Marine Communications and Traffic Services (MCTS) Vancouver that the vessel was around Fanny Island and her estimated time of arrival (ETA) at Boat Bay Light was 0135. MCTS advised the vessel of the upcoming traffic.

In the vicinity of Stimpson Reef the visibility was good as the vessel encountered traffic, including a few fishing vessels. On passing Broken Island, at the eastern end of West Cracroft Island, the vessel's course was altered to 274°, to head for a point some 0.5 nautical mile (M) off Boat Bay Light. At 0100, Broken Island Light bore 058°, distance 1.9 M, and around this time the vessel began to experience a slight haze. Targets were picked up on the vessel's radar on the 12-mile range. Approaching Forward Bay, the vessel entered fog. By 0120–0125 the visibility had decreased to about 150 m and the master was not informed. No dedicated look-out was posted.

Between 0100 and 0130 the vessel encountered traffic (for which primarily port-to-port passing arrangements were made); some of which were MCTS participants, while others were not. At 0103 a port-to-port passing arrangement was made with the "CAPE PINE," for which a course alteration of some 20 degrees to starboard was carried out (between 0104 and 0107). Upon clearing the "CAPE PINE", port-to-port passing arrangements were made with two other fishing vessels. At 0113 a report was made to MCTS that the vessel was off Boat Bay Light and that her ETA at Lizard Point was 0240.

The last position, as plotted on the chart by the OOW, was at 0115: 50°30.2' N, 126°26.32' W, some 5.5 M east of Boat Bay Light. Between the 0045 and 0115 positions the average speed of the vessel was 14.92 knots (kn). At approximately 0130 the pilot saw on the radar what he believed was the entrance to Blackney Passage and commenced a course alteration to starboard. He did not verify the vessel's position prior to the course alteration nor did he request the OOW to plot the vessel's position. Shortly after reaching the new heading of 320°, the pilot realized that the vessel was not at the alter-course position and ordered hard-a-starboard helm, in the hopes of bringing her around, but this was unsuccessful and the vessel grounded in position 50°31.4' N, 126°32.4' W, on a heading of 056°. The time of the grounding as recorded in the log books was 0133, while the course recorder trace showed that the grounding occurred at 0136.

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[3] All times are PDT (coordinated universal time (UTC) minus seven hours) unless otherwise noted.

1.2.1 Events Following the Grounding

At 0138 the pilot reported the grounding to MCTS. The grounding position was initially reported to be off Cracroft Point in Blackney Passage. The master, who had retired to his cabin, was alerted by the grounding. He immediately proceeded to the bridge to assess the situation. The vessel's position was plotted and a revised and accurate grounding position was reported. MCTS issued an advisory requesting all vessels transiting that area to proceed with caution.

The crew were called and tank and hold soundings were taken. Depth soundings were also taken in the area of the grounding and it was found that the bow was firmly aground and the stern was afloat in deeper waters. After determining that it was safe to refloat the vessel, the ballast was redistributed and with the assistance of three tugs the vessel was refloated some eight hours later, at 0930.

1.3 Injuries to Persons

There were no injuries.

1.4 Damage to the Vessel

The vessel sustained extensive damage to the shell plating and internals in way of the stem to the No. 3 double-bottom tanks, but there was no pollution.

1.5 Certification

1.5.1 Vessel

The vessel was crewed, equipped and operated in accordance with existing regulations. The vessel was in the process of obtaining International Ship Management (ISM) certification. The system was introduced on board in February 1997; the vessel was due for internal and external audits about two months after the occurrence.

1.5.2 Personnel

The master held a Master Foreign Going Certificate of Competency, which carried an *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW) endorsement and a Global Maritime Distress Safety System (GMDSS) General Operator's Certificate.

The second officer was in possession of a Second Mate Foreign Going Certificate of Competency, which carried an STCW endorsement and a tanker (Tankerman [Petroleum] Person-in-Charge) endorsement. He also held a GMDSS General Operator's Certificate.

The quartermaster on duty at the time of the occurrence held an Able Seaman/Helmsman Certificate, which carried an STCW endorsement.

Pilot No. 1 held an Ocean Navigator 1 (ON1) Certificate of Competency, issued in February 1991. He had completed a six-month apprenticeship period and, like all British Columbia Coast Pilots (BCCP) pilots, he had received ship-handling training at a facility in France and had been to a ship-handling simulator in Rhode Island, U.S.A. Recently, he had received bridge resource management (BRM) training specifically designed for pilots. He had received a Class I Pilotage License issued by the Pacific Pilotage Authority (PPA) in June 1997.

1.6 Personnel History

The master has some twenty years' sea service. He had served as a master since 1990 and with the owners since 1994.

The second officer had some eleven years' experience as an officer, of which eight years were as a second officer, during which period he had served on very large crude carriers (VLCCs), bulk carriers, and tankers. This was his first vessel with this company and he had joined the vessel on September 17, seven days before the occurrence. He was conducting his first inside passage routing of the B.C. coast.

The quartermaster on duty at the time of the occurrence had some twenty years' sea service, of which the last seven years were as a helmsman.

Pilot No.1 joined the Department of Fisheries and Oceans in the early 1980s and had served on their vessels for some seven years. He then served in the towing and fishing industry and on the fast ferry in Kitimat before joining the pilotage services.

1.7 Weather, Current and Geographical Information

1.7.1 Weather—Forecast and Experienced

The weather experienced by the vessel was consistent with the marine weather forecast for the area. Winds were light and seas calm. Between 0120 and 0125 fog rolled in and the visibility at the time of the grounding was reported to have been about 150 m.

1.7.2 Current Information

The current and tidal information for the Johnstone Strait area is contained in the *Tide and Current Tables*, Vol 6. The tidal differences are referenced to Port Harvey and the secondary current stations referenced in the Johnstone Strait are given for Forward Bay.

On September 23 high water was at 1921, with a height of 3.93 m (13.0 ft) above chart datum and low water was at 0236, September 24, with a height of 1.48 m (4.9 ft) above chart datum. The flood was weak and variable (general direction of 100°). The ebb was 280°, reaching a maximum velocity of 1.0 kn at 0200. The current was ebbing and the rate was about 1.0 kn at the time of the occurrence.[4]

1.7.3 Geographical Information

Johnstone Strait extends along the NE coast of Vancouver Island from Chatham Point at its east end to Blinkhorn Peninsula at its west end, a distance of about 54 M.[5] West Cracroft Island forms the north shore at the western end of Johnstone Strait; Cracroft Point is at the western tip of the island. Boat Bay, on the south shore of the island, is some 6 M east of Cracroft Point. The channel in the vicinity of Boat Bay is 1.85 M wide. Boat Bay Light, with a nominal range of 10.7 M and quick flash red (QR) characteristics, is obscured by high land northward of 102°.[6] The light was functioning satisfactorily at the time of the grounding.

1.8 Main Engine Operation and Engine-Room Personnel

Personnel were stationed in the engine-room and the main engine was on bridge control at the time of the occurrence. The engine was on 30-minute stand-by, and was available for immediate use in an emergency.

1.9 Visibility from the Bridge

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4 Information provided by the Canadian Hydrographic Service.

5 *Sailing Directions - British Columbia Coast (South Portion).*

6 *Pacific Coast - List of lights, buoys and fog signals* - TP397E.

Neither the masts nor the gantry cranes interfered with the navigational visibility from the bridge.

1.10 Communication

1.10.1 Communication with Marine Communications and Traffic Services

The vessel was operating in Johnstone Strait, a Vancouver Traffic Zone area for which MCTS has no radar coverage. Communications in the area are handled by the Comox MCTS centre. The very high frequency (VHF) designated frequency for the area is channel 71, and all conversations are recorded. As per the general practice, the pilot handled all communication with MCTS, communication that the OOW reportedly monitored but only casually when it came to reporting at call-in points. The "RAVEN ARROW" participated in the MCTS reporting system; the salient features of the recorded communication were as follows:

Table 1
Excerpts of Recorded Communications

Time	From	To	Text
0002	RA	MCTS	Vessel off Fanny Island Light. ETA Boat Bay Light 0135.
	MCTS	RA	Southbound from Boat Bay are three fishing vessels which are reporting into the system. Fish packer “CAPE PINE” with barge by Boat Bay. Followed by “TOTEM” with tow and, later, “SILVER BAY 6” with a log barge in tow ETA Boat Bay Light 0100.
0103	CP	RA	CP requests passing arrangement. RA agrees to red-to-red passing arrangement.
0104	IP	RA	Coming through Blackney Passage, no fog.
	RA	IP	Approaching Boat Bay, just starting to get into fog patches - clear until now.
0109	RA	SB6	RA makes red-to-red passing arrangement.
0110	IP	RA	IP is in Blackney Passage, fog is starting to settle here but no traffic in sight.
0110	TOT	RA	TOT makes red-to-red passing arrangement.
0113	RA	MCTS	RA off Boat Bay Light. ETA Lizard Point 0240. MCTS provided traffic information and ETA of vessels at Lizard Point.
0138	RA	MCTS	RA reported grounding position as being just across from Cracroft Point.
0141	MCTS	All Traffic Broadcast	Vessels transiting Blackney Passage to proceed with caution.
0147	RA	MCTS	RA updated grounding position as being 0.5 M east of Boat Bay Light.

RA	“RAVEN ARROW”
MCTS	Comox Marine Communications and Traffic Services
CP	“CAPE PINE”
IP	“ISLAND PACER”
SB6	“SILVER BAY 6”
TOT	“TOTEM”

1.10.2 Shipboard Communication

Communication between the pilot and the OOW was conducted in English. Communication respecting navigation of the vessel was minimal but there was no language barrier between them.

1.11 Navigation Equipment

The vessel's navigation equipment included:

- Two radar sets, one X-band and one S-band, both fitted with automatic radar plotting aid (ARPA) capabilities. The information displayed on the radar included ship's heading, speed of the vessel, global positioning system (GPS) position, way point number, distance to go. The radar is fitted with auto-clutter, which will allow the clutter to automatically adjust to sea conditions;
- two GPS systems;
- a gyro compass with four repeaters;
- a course recorder;
- a speed log, two depth sounders, and a GMDSS comprising two VHF digital select calling controllers and receivers, an MF digital select calling controller and receiver, and an HF radio system; and
- British Admiralty (BA) chart No. 3387 (in use at the time of the grounding).

No equipment malfunction was reported.

1.12 Navigation with Pilot on Board

Compulsory pilotage areas have been established by pilotage authorities to ensure safe and efficient navigation of vessels in Canadian waters where local knowledge is essential. For the west coast of Canada, these areas have been defined in the *Pacific Pilotage Regulations.* The "RAVEN ARROW" was in compulsory pilotage waters when she grounded.

Under the *Pilotage Act,* a licensed pilot who has the conduct of a ship is responsible to the master for the safe navigation of the ship.[7]

[7] *Pilotage Act,* s 25(2)

1.12.1 Established Navigational Practices

The STCW 1978 as amended in 1995, the *IMO Code of Nautical Procedures and Practices,*[8] the *Bridge Procedures Guide* by the International Chamber of Shipping and established navigational practices all emphasize that:

- the master and/or the OOW must cooperate closely with the pilot and maintain an accurate check of the ship's position and movement;
- the pilot's presence on board does not relieve the master and the OOW from their duties and obligations for the safety of the ship; and
- if in any doubt as to the pilot's actions or intentions, the OOW must seek clarification from the pilot and, if doubt still exists, notify the master immediately and take whatever action is necessary before the master arrives.

1.12.2 Navigational Practices on the "RAVEN ARROW"

The master's standing orders included the following:

- All *Rules of the Road* to be strictly observed. Do not hesitate to use whistle/engines/helm as and when required.
- Pilot's presence on the bridge does not relieve the OOW of his duties; and that the OOW [should] plot vessel's position every 15 minutes.
- OOW shall, at all times, execute and monitor the passage plan.
- Call the master at any time the OOW is in doubt, or if visibility deteriorates to three miles or less.

1.13 Conduct of Navigation

1.13.1 Use of Course Book

During the transit, the OOW plotted the vessel's position at about 15-minute intervals, on the chart in use. The pilot did not refer to those positions nor did he refer to the chart to refresh his memory. The pilot carried a personal course book, which he used to facilitate his navigation of the vessel. Included in the course book was a sequential listing of courses to steer, distances between course-alteration positions, reference to navigational aids, and pilotage remarks. The course book had no provision for the recording of ETA or the actual time of course alteration, nor was the pilot keeping any other record of the vessel's progress. The pilot had to rely solely on his memory to keep track of the vessel's position.

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[8] The *Code* was adopted by Canada and distributed by Transport Canada as TP1018.

1.13.2 Method of Navigation and Monitoring Vessel's Progress

The pilot referred only to the radar to monitor the vessel's progress whereas, on this watch, the OOW used the GPS (except for the 0130 position, which was taken from the radar). Also, on this watch neither the pilot nor the OOW made a practice of using more than one method of monitoring the vessel's position.

A review of the course recorder trace[9] revealed the following:

Time	Heading
0055-0107	277°
0107-0110	altered course 20° to starboard for vessel (red-to-red passing)
0110-0113	282°
0113-0114.5	altered course to 277°
0114.5-0122	277°
0122-0123	282°
0123-0131	285°
0131-0133	altered course to 320°
0133-0134	320°
0134-0136	altered course, helm hard-a-starboard
0136	056°

According to the OOW, shortly before 0130 he asked the pilot to confirm that 0800 was the vessel's ETA at Pine Island (a prominent position further down the vessel's track at the entrance to Queen Charlotte Sound). This drew a response from the pilot to the effect that he hoped the vessel had not overshot the alter-course position. After they both checked the radar display, the OOW sought confirmation from the pilot that the vessel had reached alteration point, to which the pilot responded in the affirmative. The OOW took a range and bearing of a point of land and noted these values on the chart. Before the OOW had time to plot the vessel's position on the chart, the pilot began a course alteration. The OOW returned to the conning position and ensured that the pilot's orders were promptly executed by the helmsman. The vessel's position was plotted on the chart following grounding.

1.14 Bridge Resource Management (BMR)

[9] Times on the course recorder trace are three minutes ahead of log book entries, which were referenced to the ship's clock.

The essence of BRM is the effective utilization of all available resources to ensure the safe completion of the operation. BRM addresses the management of attention, operational tasks, stress, attitudes, and risk. BRM recognizes that there are multiple determinants of mission effectiveness and safety, such as individual, organizational, and regulatory factors. Optimizing the management of these elements will have a direct effect on four factors critical to the successful outcome of any operation, namely, recognizing and defining the nature of the problem encountered (situational awareness); reflecting on and regulating one's own judgements or decisions (metacognition); involvement of others in the problem solving (shared mental models); and understanding what must be done, in what priority, and what resources are required and available (resource management).

There are several key areas that are addressed in successful BRM programs. These include team building and maintenance, communication processes and decision making, workload management and situational awareness.

1.14.1 Team Building and Maintenance

While the characteristics of individual team members are important, a team—in contrast to an individual—can share work, perform a task in a more timely and effective way, and achieve a higher level of performance than could the best individual working alone. Research has demonstrated that there is a formation process for teams during which patterns of communication and interaction are established.[10] Once established, the process continues and leads to activities that can maintain patterns of effective (or ineffective) group communication.

1.14.2 Communication Processes and Crew Decision Making

Crew decision making is managed decision making. The pilot is responsible for making the decisions but is supported by input from the crew, both on the bridge and from shore (e.g., traffic control). This requires a group climate that encourages participation and the exchange of information. Poor communication can result in crews not sharing a common understanding of a situation, or in a misunderstanding of the pilot's intentions.

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10 Robert L. Helmreich and Clayton H. Foushee, "Why crew resource management? Empirical and theoretical bases of human factors training in aviation," in E. Weiner, B. Kanki, and R. Helmreich, eds., *Crew Resource Management* (San Diego: Academic Press).

1.14.3 Workload Management

The tasks essential for safe navigation of the vessel are allocated to different persons best equipped/experienced to carry them out so that no members of the bridge team, including the pilot, carry a workload that is beyond their capabilities to handle.

1.14.4 Situational Awareness

Situational awareness is the accurate perception of the factors and conditions that affect a vessel and crew during a defined period of time.[11] More simply stated, it is "knowing what is going on around you."

At the level of the individual, situational awareness can be thought of as the mental model that an individual has of a given situation and time. Mental models develop from cues in the immediate situation and environment, e.g., location, speed, presence of hazard, as well as information from education, training and experience. In the absence of a complete set of cues for a given situation, fragmentary information is sometimes combined with mental expectations and integrated into the mental model.

A bridge team, a well-defined group of individuals, combines to create a unique blend of personalities, attitudes and shared responsibilities. They include the people that constitute the group and the operational structure in which they function. As the mental models of each member of the group will vary, so each may have a unique awareness of the situation.

The safety of the voyage depends upon the level of situational awareness that the group is able to attain together and is limited by the situational awareness of the individual who has the conduct of the vessel, in this case the pilot. A fundamental factor in maintaining optimal situational awareness is the ease and effectiveness of communication. The ideal working environment includes a situation where:

- the pilot encourages a climate in which bridge team members can comfortably provide inputs and there is an expectation that the input will be considered;
- each member of the bridge team does everything feasible to support the pilot to maximize the latter's level of situational awareness; and
- the pilot recognizes the contribution that each member of the bridge team can make to the group and objectively considers input from those who exhibit competency in the navigation task at hand, recognizing the individual's area of expertise.

1.15 BRM Training

11 Geiss-Alvarado Associates, *Human Error Accident Training*, U.S. Coast Guard training manual (July 1991).

The Board, concerned that the lack of BRM training among pilots and ships' officers increases the chances for accidents in compulsory pilotage waters, recommended to Transport Canada (TC) that BRM training be made a prerequisite to the granting/renewal of proficiency certificates/pilotage licenses.[12] In response to the recommendations, Transport Canada Marine Safety (TCMS), in consultation with industry representatives, was in the process of finalizing a BRM training syllabus. At the time of this occurrence BRM courses were not mandatory. However, TCMS encourages shipping companies to take the initiative in implementing BRM concepts on their vessels.

Recognizing the international scope of the marine industry, the Board further recommended that TC use the IMO forum to promote international support for the provision of formal BRM training requirements worldwide.[13] The IMO (through the STCW Convention 1978, as amended in 1995, Chapter VIII, Part 3-1 of the non-mandatory "Code B") provides guidance on keeping a navigational watch, and suggests that shipping companies take the initiative in implementing BRM concepts on their vessels.

1.16 BRM Application

1.16.1 Master–Pilot Exchange of Information

On boarding, the pilots were presented with a pilot information card and the exchange of information included the following:

- the vessel's forward and aft draughts;
- engine manoeuvring speeds data;
- vessel manoeuvring data; and
- advice that the navigational equipment and main engine were functioning satisfactorily.

1.16.2 Working Relationships—Pilots and Ship's Personnel

The rapport among master, pilots and OOW on the "RAVEN ARROW" was good. The master and the OOW had confidence in the pilots, and the performance of the pilots was never an issue.

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12 TSB Report No. SM9501, *A Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots,* Recommendations M95-09, M95-10, and M95-11.

13 Ibid., Recommendation M95-12.

Investigation also revealed that the pilots sometimes encounter a ship's complement who lack communication skills in English, who take a passive approach to navigation with a pilot on board, and who have been subjected to a heavy workload when the vessel is on the coast.
The pilots indicated that these factors can, and in some instances did, lead to them taking on the full workload.

1.16.3 Passage Planning and Pilotage

There were only minor differences between the courses laid by the ship's complement and those contained in the pilot's course book for the area covering Fanny Island to Cracroft Point. However, there was a significant difference in the plan to round Cracroft Point. On the vessel's proposed route an alteration of some 70 degrees was required, whereas the pilot intended to make two alterations, of some
30 degrees and 40 degrees respectively, over a mile apart (see Figure 2). The pilot had not informed the OOW of this plan nor had he indicated to the OOW the minimum safe distance from the shore he intended to keep.

According to the International Chamber of Shipping *Bridge Procedures Guide,* information, which may include courses to steer, headings, leading lines, parallel index distances, distances between way points, and important navigational marks that would be used to identify major course alteration points, should be presented on a suitable chart or a chart sketch in a format that can be accommodated at the conning position or radar display. There was no such plan aboard the "RAVEN ARROW".

The Board has been concerned that the lack of an appropriate exchange of information on a pilot's intended passage precludes effective monitoring—by the ship's officers—of a vessel's progress in compulsory pilotage waters and increases the chances of accidents, e.g., grounding/striking, in the ecologically sensitive marine environment. Accordingly, the Board has recommended that:

The Department of Transport require that pilots, as part of their initial hand-over briefing:

- obtain the master's agreement to the intended passage plan; and
- invite the bridge team's support by having the officer of the watch plot and monitor the

> vessel's position at regular intervals and report the position to the pilot with respect to the agreed passage plan.[14]

In response to the recommendation, the TSB was advised that TC and the pilotage authorities will promote procedures that clarify the understanding of the pilot and ship's officers as to the passage to be undertaken and their respective obligations in ensuring its successful completion. Reportedly, the institution of safe corridors is currently being considered as one of the alternatives to address this issue.

The International Maritime Pilots' Association also recognizes that effective communication and information exchange, and a general agreement on plans and procedures for the anticipated pilotage passage (with the understanding that the passage plan is a basic indication of the pilot's preferred intention) are essential elements for effective pilotage.[15]

1.16.4 BRM During Voyage

In this instance, pilot No.1 had received BRM training but did not opt to use the services of the OOW to advantage in the navigation of the vessel because the latter was new to the area and the vessel. However, during the 1300–1600 watch, September 23, the second officer, who was the OOW with pilot No.1, had observed that the vessel was north of the course as laid on the chart for the vessel in the Strait of Georgia. The OOW requested routing information from the pilot and was informed that the vessel would be taking the alternative route via
Sabine Channel. During the 0000–0400 watch, September 24, in conversation with the OOW, the pilot had remarked on the similarity between the courses pre-plotted on the chart and those he would normally take in that area.

1.17 Pilot Scheduling

Since 1996 the pilotage company has employed a total of 112 pilots—including 10 seasonal pilots and 2 half-time pilots—to meet the pilotage demands. The seasonal pilots work full time during the peak season and half time during the slack season and have a minimum of eight years'

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14 TSB Report No. SM9501, *A Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots,* Recommendation M95-08.

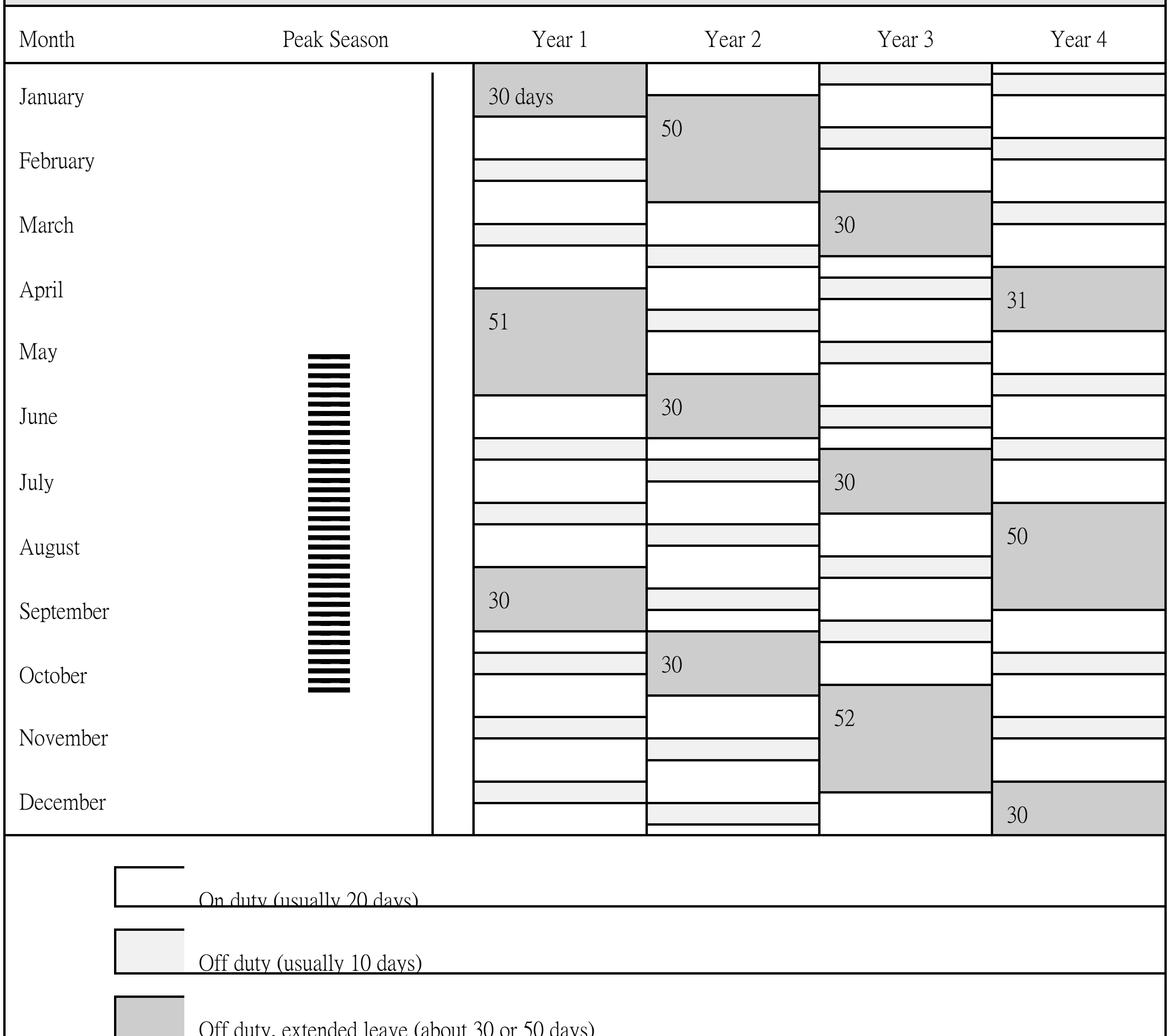
15 MSC 69/20/2, dated 11 December 1997, *Operational Procedures for Maritime Pilots - Note by the International Maritime Pilots' Association.*

experience. The half-time pilots work half time throughout the year and have a minimum of 15 years' experience. The current scheduling system was designed and implemented prior to the cruise ship boom of recent years.

1.17.1 British Columbia Coast Pilots (BCCP) Scheduling System

Following BCCP policy, the basic building block of a pilot's schedule (with some modification) consists of 20 days on duty followed by 10 days off duty, with a pilot receiving an extended leave upon completion of the third consecutive work cycle (80-day block). In any given year, pilots receive a total of three extended leave periods, two of which are about 30 days long, and the other about 50 days (see Table 2). The pilots have a four-year scheduling cycle, which ensures equitable rotation of duty periods and extended rest periods over the slow and peak traffic seasons.

Table 2
Schematic of Pilot's Time on, Time off, and Extended Leave over the Four-year Cycle



On average, annual totals for on-duty and off-duty days are about equal (~180–185 each).

Source: BCCP

1.17.2 Pilotage Assignments

During the peak season, from mid-May to the end of September, the pilots have a full workload during their 20-day on-duty period.[16] They carry out between 14 and 21 assignments in the 20-day cycle; on average, between 14 and 17 assignments, most of which are long trips.[17] In the rest of the year, the pilots average 10 to 12 assignments in the same period, most of which are short trips. BCCP has received complaints from some pilots that they tend to become fatigued towards the end of their 80-day cycle during the periods of increased workload associated with the peak season.

1.17.3 Pilot's Recent Assignments

Pilot No.1 was near the end of his 80-day cycle at the time of the occurrence and was scheduled to proceed on leave from September 27 to October 27. His most recent assignments, from September 18 to the time of the occurrence, were as follows:

Table 3

Vessel Name	Dispatch		Disembarked	
	Date	Time	Date	Time
"STAR HOSAN"	18 Sept.	1900	19 Sept.	0450
"ASIA STAR"	19 Sept.	2030	20 Sept.	0659
"ASIA STAR"	20 Sept.	1200	20 Sept.	2220
"MERLION AC"[18]	21 Sept.	1630	22 Sept.	0630
"RAVEN ARROW"	23 Sept.	0700	24 Sept.	0133 (time of occurrence)

16 Expansion of the cruise ship operation has resulted in the extension of the peak season from the first week in May until the middle of October.

17 Varying lengths of short and long trips are carried out by BCCP pilots. The average length of all trips is 6.1 hours. Short trips are primarily Vancouver Harbour movements. Medium trips are between 5 and 10 hours' duration. Long trips are over 10 hours, and average 27.1 hours.

18 This assignment, from Seattle to Sandheads, involves a three-hour pilotage in Canadian pilotage waters.

The information as recorded by the pilot shows that he had five hours of sleep between 0700 and 1200 during his back-to-back assignments on "ASIA STAR". No other sleep was recorded.

1.17.4 Pilot Work/Rest Allowances and Call-backs

The Agreement between the PPA and the BCCP states, in part, that ". . . the Company [BCCP] will assure that an adequate work force will be provided to handle the normal workload." It also lays out the minimum rest period of eight hours following any assignment (excluding short trips), with an additional allowance for travel time.

1.17.5 Pilot Watches

There is no set standard for pilot watches. They vary from vessel to vessel and are arrived at by mutual consent between pilots. Some prefer a six hours on/off watch schedule while others prefer a five hours on/off schedule. Aboard this vessel, the pilots worked a five hours on/off schedule, with the last segment to be equally shared between them.

Pilot No. 1 was on watch from 1300–1800. After having his dinner, he returned to the bridge at about 1900 to watch traffic off Cape Mudge. While on the bridge, pilot No. 2 observed that pilot No. 1 looked tired, that he leaned over with his head bowed, was less talkative and that his speech was slow.

At about 2130 pilot No. 1 returned to his cabin, where he lay down. It was the intention of pilot No. 2 to allow pilot No. 1 to obtain additional sleep. However, at about 2240 pilot No. 1 was called to the bridge for his tour of duty, where he arrived at 2300.

1.17.6 Sleep History

Pilot No. 1 indicated that he has no problem sleeping. He went to bed at 2200, September 22, the night before the "RAVEN ARROW" assignment, and woke up the following morning at 0600 having had what he considered to be a satisfactory night's sleep. While aboard the "RAVEN ARROW", the pilot had lain down for about an hour to an hour and a half but did not sleep during the entire period. At the time of the occurrence, the pilot had been awake for over 19.5 hours and would have been required to be on watch for a further 1.5 hours.

1.18 Officer of the Watch (OOW) Work/Rest History

During the 72 hours prior to the occurrence, the OOW's work/rest periods were as follows:

Table 4

Date	Time	Activity
20 Sept.	0000-0600	cargo watch and chart work
	1200-1800	cargo watch
21 Sept.	0000-0600	cargo watch and chart work
	1200-2000	Departure Stations, bridge watch, supper and chart work
22 Sept.	0400-1200	bridge watch, administrative work and arrival stations
	1200-1800	cargo watch
	2200-2400	chart work
23 Sept.	0000-0600	cargo watch
	1200-1730	Departure Stations, bridge watch and chart work
24 Sept.	0000-0130	bridge watch

According to the OOW, he slept well on the night of September 23 and was well rested before his watch on the morning of September 24.

1.19 Demand for Pilotage Service

Over the last three years there has been a steady increase in the number of foreign vessels calling at west coast ports and/or transiting the west coast pilotage waters, the result of which has been an increase in coastal pilot assignments. This period has also seen a boom in cruise ship operations. The summary of annual pilotage assignments for the west coast is as follows:

Table 5			
	1995	1996	1997
Coastal assignments	12,497	12,713	13,278
Pilots	108	112	112
Call-backs	270	219	263
Source: PPA			

1.19.1 Pilotage Characteristics—Pacific Region

A review of the 1996 statistics for pilotage assignments revealed the following:[19]

- The assignments varied from a minimum of 854 trips in January to a maximum of 1,152 in August.
- The busiest 30-day period was from July 24 to August 23, with 1,309 trips, 157 trips more than the busiest calendar month.
- The least busy 30-day period was from March 9 to April 8, with 839 recorded trips, 15 trips fewer than the least busy month.

1.19.2 Call-backs

The seasonal peak demand for pilotage services results in pilots who, although scheduled to be off duty or on their extended leave periods, are recalled to handle assignments. The BCCP makes every effort to recall first those pilots who are on their extended leave periods. If none are available—as is often the case—pilots on their 10 days' off-duty period are called. Generally pilots receive between 6 and 12 hours' notice for a call-back assignment; however, sometimes, the notice period can be as short as 2 or 3 hours. Individually, each pilot has the option to take or to refuse any particular additional assignment, but the (pilot) population as a whole is contractually obligated to handle these assignments. The pilot who undertakes these assignments is compensated with future time off, to be taken at any time, which may include the peak season.

[19] Source: TSB review of PPA data

1.20 Pilot Work Environment and Safety

The work environment of pilots requires them to work irregular schedules that are sometimes demanding and involve work in adverse weather conditions. Currently, while some information is disseminated to pilots by the BCCP, there is no formal training program in place to help pilots better mitigate the adverse effects of irregular work schedules on their performance. The lack of such training across all pilotage authorities is an ongoing concern for the Board.

Given the vulnerability of individuals (in safety-sensitive positions) to significant errors in judgement when fatigued, and given that many factors are controllable by the pilots themselves (in terms of personal lifestyle modifications), the Board recommended that:

> The Great Lakes Pilotage Authority [GLPA] develop and implement an awareness program to provide guidance to dispatching staff and pilots on reducing the adverse effects of fatigue on job performance.[20]

In response to the recommendation, the TSB was informed that the GLPA is committed to ensuring that all operational employees are provided with information to help them reduce the adverse effects of fatigue on job performance. Reference materials have been gathered from specialists in this field and distributed to the pilots. In early 1998, the program was offered as part of pilot training curriculum, and no further courses are planned.

In the last few years the BCCP and the pilots have become aware of fatigue-related issues through the in-house distribution of information. The BCCP is exploring the possibility of a formalized training programme to help pilots mitigate the adverse effects of an irregular work schedule on performance.

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[20] TSB Report No. M93C0003, “NIRJA” - Recommendation M96-18.

2.0 Analysis

2.1 Vessel Operation in Pilotage Waters

Problems associated with shipboard practices in pilotage waters continue to be of concern in the maritime industry. The IMO has put forward measures to improve training that, over a period of time, will lead to higher standards and greater safety. Meanwhile, occurrences involving vessels operating in pilotage waters continue to draw the attention of the Board. The analysis of what happened in this occurrence, and why, is presented within the framework of BRM-related issues, and fatigue-related issues.

2.2 BRM-related Issues

2.2.1 Marine Culture and Team Work

Navigation with a pilot on board creates a situation where a relative stranger, the pilot, is teamed with an existing crew to carry out a coordinated job together. While the pilot has the local navigational 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. Because pilots, masters and officers of vessels have different areas of experience and training, it is essential that the skills of each be combined in the working relationship of a bridge team.

Pilots have to work with ships' complements whose competency, proficiency, language skills and workload vary substantially from vessel to vessel. This has resulted in some pilots generalizing that they cannot rely on the ship's complement to assist in navigation. While these issues are being addressed through the introduction of STCW and ISM, the reluctance to utilize the ship's complement has become part of the culture of the pilot.[21] Furthermore, in many cases a ship's complement will adopt a passive approach to the navigation of a vessel under pilotage. The result is that some pilots may feel it necessary to take on an additional workload which, in certain circumstances, may be beyond their ability to handle. This is contrary to the principles of BRM and the safe operation of a vessel.

In this instance, the fact that the OOW was new to both the vessel and the area did not diminish his ability to plot the vessel's position, monitor her progress and meaningfully participate in her safe navigation. The OOW, by querying the pilot and plotting the vessel's position at regular intervals, demonstrated that he could effectively participate in the navigation of the vessel. Despite this, the pilot did not take full advantage of the potential for the OOW to assist in the navigation of the vessel. The master was not aware that the pilot's workload was increased due to traffic, nor that he had elected not to enlist the services of the other pilot or to effectively use the OOW in the essential tasks of position fixing and/or collision avoidance. The pilot's decision to take on the additional workload may have been based on generalized assumptions regarding the OOW's capabilities, rather than on an informed assessment. This decision left the pilot relying solely on his own

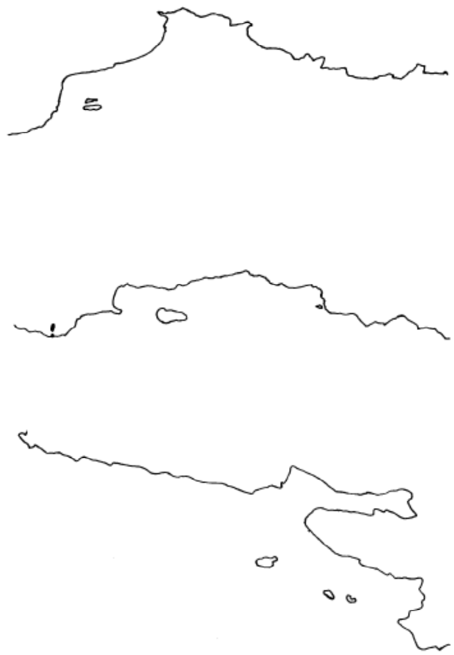
[21] TSB Report No. SM9501, *A Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots.*

performance, foregoing the potential for team work, and leaving little room for error.

2.2.2 Situational Awareness

Similarity of Forward Bay, Boat Bay and Baron Reef-Growler Cove Area

Proceeding westbound along the south shore of West Cracroft Island and before reaching the Baron Reef-Growler Cove area where the course alteration into Blackney Passage is effected, a vessel passes Forward Bay and Boat Bay. A review of the chart for the south shore of West Cracroft Island reveals similar shoreline indentations in the Forward Bay, Boat Bay and Baron Reef-Growler Cove areas (6 M and 4 M apart, respectively). To an observer on a vessel proceeding eastward or westward along the shore, a cursory radar observation could result in improper identification of the three areas.



Pilot's Loss of Situational Awareness

At 0113 the pilot reported being off Boat Bay Light, located on the western headland of Boat Bay (Swaine Point), when the vessel was in fact passing the western headland of Forward Bay. When the vessel was approaching Boat Bay, the pilot initiated the course alteration which was to have taken place off Baron Reef. The grounding position reported by the pilot to MCTS was in the vicinity of Blackney Passage, which is consistent with a mental model in which the vessel's course had been altered to enter Blackney Passage. This suggests that although the pilot was viewing the radar, his interpretation of the radar presentation was at variance with the actual radar display and that he did not make effective use of the radar.

Between 0100 and 0130 the pilot's workload increased as he was engaged in collision avoidance manoeuvres with southbound vessels. To effectively monitor traffic for collision avoidance, the radar used by the pilot was switched to shorter ranges. The use of shorter ranges hindered continuous monitoring of the shoreline, and the increased workload associated with collision avoidance may have interfered with navigation. In dealing with the cumulative effect of the increased workload, the pilot was apparently unable to process all the navigational cues and information available to him. As a result, the pilot transposed his position from Forward Bay to off Boat Bay Light.

There were a number of cues that could have alerted, but did not alert, either the pilot or the OOW to the navigation error. These included:

- the unique characteristics that differentiated Forward Bay and Boat Bay. These include the absence of a navigational light on the headland west of Forward Bay; however, given the deteriorating visibility, an assumption was made that the light was obscured by fog;
- the mismatch between the 0113 position report to MCTS and the OOW's 0115 plotted position. The OOW did not detect the pilot's error in reporting the 0113 position to MCTS;
- the vessel would have had to average a speed of some 19 kn to have been off Boat Bay Light at 0113 instead of 0135. This is an unrealistic speed in the given circumstances. Neither the pilot nor the OOW used the vessel's estimated steaming time between course alteration points as a means to cross-check whether the vessel had reached the alter-course position.

OOW and Situational Awareness

The OOW was new to the area and did not possess the necessary local knowledge; the only member of the bridge team who had local experience of the area was the pilot. Further, the pilot did not specifically indicate to the OOW that the vessel's course was being altered to enter Blackney Passage. In the absence of complete information, the OOW could not be expected to have, nor did he have full situational awareness and he was only generally following the vessel's progress. Because the pilot had not passed all relevant information to the OOW, the latter's mental model had been developed on fragmentary information. Consequently, it was readily influenced after the pilot indicated to the OOW that the vessel had reached the alter- course position. The subsequent rapid progression of events precluded the OOW from plotting the vessel's position and upgrading his mental model—which is essential in a course alteration situation—as by now the OOW's emphasis had shifted to ensure that the mechanics of the course alteration were properly executed. It is likely that incorporating new information—which became available from the pilot—was made more difficult by the increased workload of the rapidly developing situation.

2.2.3 Limitations Imposed by Navigational Practices

This occurrence highlights the need for appropriate distribution of the workload within the limits of individual expertise and capacity. Pilotage is mentally demanding and, consequently, pilots often implement tools and practices to facilitate pilotage operations. The pilot's course book is an example of such a tool. Relying solely on his course book as a passage plan, and without the use of an additional *aide-mémoire,* the pilot became confused as to which leg of the passage the vessel was on. It was his belief that the vessel was approaching the course-alteration point in Blackney Passage after having inaccurately reported passing Boat Bay Light some 20 minutes prior to the time he would have passed it. His belief could have been influenced, in part, by the fact that:

- having made several course alterations to starboard for traffic, the last heading prior to course alteration was 285°, close to the 290° heading which the course book indicated was the intended course to steer to arrive at Blackney Passage;
- the content of his radio communication with the "ISLAND PACER" both in terms of that vessel's geographical location and the weather being experienced by her did not contradict his mental model that the "RAVEN ARROW" was approaching Blackney Passage, but instead could have reinforced this belief.

Once a hypothesis or a certain way of thinking about a problem is adopted, it is very resistant to change. Consequently, one becomes susceptible to what has been termed "confirmation bias" or "hypothesis locking," where one may selectively attend to information that confirms one's mental model, and disregard other—equally valid—information that would disprove one's hypothesis.[22] The effect of hypothesis locking is so great that it may take the intervention of another person with contradictory information to overcome it.

2.2.4 Communication between Pilot and OOW

It is possible that when the pilot began the course alteration to 320°, under the mistaken impression that the vessel had reached Blackney Passage, the OOW may initially have been under the impression that the pilot intended to alter course to 290°(having reached the Boat Bay Light). However, it would appear that the OOW had some doubt with respect to course alteration and he questioned the pilot as to whether the vessel had reached the alteration point. The OOW readily acquiesced when the pilot responded in the affirmative. Because communication between the pilot and the OOW was minimal and imprecise and because the pilot had not used the services of the OOW to advantage in the navigation of the vessel, a barrier likely had been created that left the OOW less likely to challenge the pilot's decision, especially at a critical time of course alteration. This could have been reinforced by the tendency of OOWs generally not to distract or interfere with pilots. On the other hand, effective monitoring of the vessel's progress would have heightened the OOW's situational awareness such that he could have sought clarification from the pilot with regard to the course alteration. However, this was not done.

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[22] R.G. Green et al., *Human Factors for Pilots* (Aldershot, 1991), p. 60.

The pilot's specific plan was not explained to the OOW, which precluded the latter from effectively participating in the navigation. Although the OOW plotted the vessel's position at 15-minute intervals, this information was not used by the pilot. On the other hand, the OOW did not effectively monitor the pilot's communication with MCTS, in that he was not alerted to the pilot's error in reporting the 0113 position. Thus, the first opportunity to take remedial measures, some 20 minutes prior to the grounding, was lost. Subsequently, when the OOW became aware of the pilot's intention to alter course, he took the bearing and distance from the radar to establish the vessel's position. However, because the pilot commenced the course alteration before the vessel's position could be plotted on the chart, another opportunity to verify the position and remedy the error was lost as the focus now shifted to prompt execution of the pilot's orders.

For the OOW to carry out his responsibilities as the master's representative, it is essential that all communication with MCTS be monitored, be it merely position reporting or traffic-related. Further, improper monitoring of MCTS communication has the potential to jeopardize the safe navigation of the vessel. In this instance, the OOW only casually monitored the pilot's communication with the MCTS. This would suggest that the necessity to effectively monitor the pilot's communication with the MCTS was not fully appreciated by the OOW.

The use of sound navigational practices to monitor the vessel's progress, i.e., communication and sharing of information, and the use of more than one method of ascertaining the vessel's position, would have better enabled both the pilot and the OOW to realize the error in ample time to initiate remedial measures.

2.2.5 BRM, Pilotage and Safety

In an era of rapid change, with increasingly large ships and decreasing crew sizes, and commercial pressures becoming part of everyday operations, the services provided by the pilots should reflect this reality.

As the pilot has the conduct of the vessel and possesses local knowledge, and as complete support of other members of the bridge team, especially the OOW, is essential for the safe navigation of the vessel, good seamanship practices dictate that a passage plan—approved by the master and the pilot, and containing all pertinent information—be suitably displayed at the conning position or radar display. The absence of such a plan prevents the ship's personnel from effectively monitoring the vessel's progress, and results in inopportune communication—to seek clarification—that has the potential to interfere with pilotage at a critical time in a manoeuvre. In this instance there was no agreed-upon passage plan aboard the "RAVEN ARROW", and the courses as laid on the ship's chart differed from the pilot's approach to rounding Cracroft Point.

Although the pilot had taken BRM training, on this passage he did not put the associated techniques into practice. Neither the pilotage authorities nor the BCCP have a regime in place to monitor how BRM principles are being implemented in practice. The absence of such a monitoring regime permits the old culture to continue, thereby effectively negating the benefits of such training (to the detriment of safety), as was the case aboard the "RAVEN ARROW". This occurrence reinforces the need for implementation of TSB recommendation No. M95-08, which called for:

- an agreed-upon (approved) passage plan prior to the commencement of passage in pilotage waters, and
- for the pilot to encourage a climate whereby bridge team members can comfortably provide input.

While the pilot has the conduct of the vessel, the master retains command of the vessel. In order to retain effective command of the vessel (by the master or, in his absence, the OOW), masters need to hold objective discussions with pilots who are less inclined to team work.

This need has been widely recognized by a number of non-governmental maritime organizations including the International Association of Independent Tanker Owners (INTERTANKO) and the International Chamber of Shipping. While the intent of the aforementioned TSB recommendation had been accepted by TC, and discussions have taken place between TC officials and pilotage authorities, concrete agreed-upon measures have not yet been established.

2.3 Emergency Action

At the time of the course alteration, the vessel was four cables off shore. In a partly loaded condition, the vessel's turning circle is 3.3 cables. The course recorder trace shows that the vessel's swing was arrested on a heading of about 320° for a short period before the pilot realized his error. The pilot, in order to extricate the vessel from this situation, had the option to either come around over 120 degrees to starboard or over 60 degrees to port to clear the area. The pilot considered that the vessel was still four cables off shore and ordered hard-a-starboard. However, the distance off land was less than the turning circle of the vessel and the vessel grounded. Sea room was available to go to port with a greater chance of extricating the vessel, though the alteration of course to port would have required some adjustment for traffic. The pilot's assessment that the vessel was still four cables off shore is consistent with his thinking that the vessel was in Blackney Passage where such a manoeuvre might have been possible. The grounding position initially reported to MCTS by the pilot was in Blackney Passage. As part of the attempted clearing manoeuvre, the engine could have been put to emergency full astern, but the pilot was reluctant to use the engine because it was on a 30-minute standby. Although the main engine was available, it was not used.

2.4 Pilot Scheduling and Safety

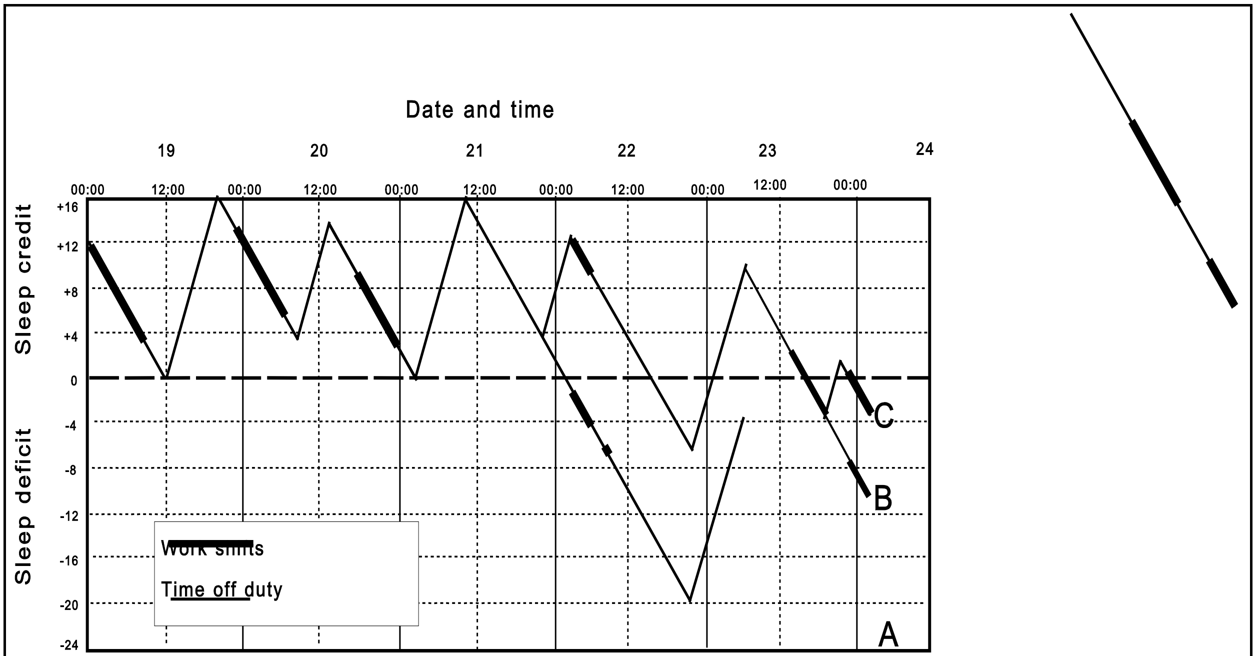
2.4.1 Fatigue and the Pilot's Performance

Fatigue is a physiological state characterized by impaired performance and diminished alertness. Two causes of fatigue are inadequate quantity or quality of sleep, and disruption of circadian rhythm. These can result from irregular work schedules, extended duty, or altered work/rest schedules, and have been identified as contributory factors in many industrial accidents.[23]

Research 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. Most people need between 7.5 to 8.5 hours of sleep per day. A person who does not obtain required sleep will develop a sleep debt and will be subject to performance degradation. A rough calculation of sleep debt can be determined by allowing two hours of credit for every hour of sleep up to a maximum of 16 hours credit and one hour of debit for every hour awake.

Figure 4 shows pilot No.1's sleep history and accumulated sleep debt prior to the occurrence. Work shifts are represented by a thick black line, while time off duty is represented by a thin black line. Line "A" on the graph represents the pilot's sleep credits/deficits based on the recorded information as provided by the pilot. From this diagram, it is evident that the pilot had accumulated a sleep debt equivalent to having missed approximately 10 hours of sleep—or just over one full night's sleep—over the three days preceding the accident. At the time of the grounding the pilot had been awake for 19.5 hours and would have been awake for 21 hours upon completion of the planned watch. The need for sleep typically recurs after about 15 or 16 hours of being awake, even for someone who is well rested.

[23] Mark R. Rosekind, Philippa H. Gander, Linda J. Connell, and Elizabeth L. Co, *Crew Factors in Flight Operations X: Alertness Management in Flight Operations*, NASA Technical Memorandum DOT/FAA/RD-93/18 (NASA Ames Research Center, 1994).



A Based on recorded time on assignment (work/rest) figures provided by pilot No. 1.
B Based on recorded time on assignment (work/rest) provided by pilot No. 1, but allowing for a four-hour sleep on board the MERLION AC in the evening of September 21.
C Based on assumptions of **B**, and allowing for a two-hour nap taken during transit on September 23.

On September 21 the pilot's assignment aboard the "MERLION AC" lasted for 13.5 to 14 hours, of which some 3 hours were spent on pilotage duties in Canadian waters. After allowing for dispatch, transportation, vessel boarding and formalities, it is reported that the pilot could have had an opportunity to obtain sleep for some four hours on this assignment. The impact of such sleep is depicted by line "B", and shows that his sleep debt at the time of the occurrence would have been drastically reduced. This sleep debt could then have been further mitigated by the pilot having obtained sleep between 1800 and 2300 on September 23 while off-duty, as shown by line "C". Consequently, the pilot's schedule over a short period of six days was not a factor in this occurrence.

In today's workplace, the loss of performance associated with alcohol is not tolerated, while that associated with fatigue—with similar results—*is* tolerated. Researchers at the Defence and Civil Institute of Environmental Medicine found that after 18 hours awake, people showed a 30 per cent decrement in performance on cognitive and vigilance tasks, and after 48 hours the impairment averaged 60 per cent. Researchers at the Centre for Sleep Research at the University of South Australia found that after 18 hours without sleep, students performed as poorly on performance tests as they had with a blood alcohol concentration of 0.05 per cent. After 24 hours without sleep, their performance dropped to that of a person with a blood alcohol concentration of 0.096 per cent.[24]

That pilot No.1 may have been fatigued is corroborated by the observation of the second pilot, that the demeanor of pilot No.1 was suggestive of his being tired. It is likely that pilot No.1 underestimated his tiredness, as people are poor judges of their own levels of fatigue and alertness. It has been demonstrated that "individuals (especially sleepy individuals) do not reliably estimate their alertness and performance."[25]

Fatigue can lead to forgetting or ignoring normal checks or procedures, reversion to old habits, and inaccurate recall of operational events. Fatigue can also reduce attention, the effects of which are that people overlook or misplace sequential task elements, become preoccupied with a single task, and are less vigilant. When alertness is impaired, people may fix their focus on a minor problem (even when there is risk of a major one), they may fail to anticipate danger and they may display automatic behaviour syndrome. Problem solving can also be affected and flawed logic may culminate in the application of inappropriate actions.

In this occurrence, pilot No. 1 appears to have demonstrated several errors involving reduced attention and memory typical of the fatigued state:

- the pilot jumped a line in the course book following the course alterations taken to avoid fishing vessels;
- the pilot transposed his position from Boat Bay to Blackney Passage subsequent to receiving radio traffic from another vessel which was entering Blackney Passage;
- the pilot interpreted the radar image to be that of a position further along his route;
- the pilot became preoccupied with altering course to enter Blackney Passage, and only made use of confirmatory information;
- the pilot altered course to starboard although there was ample sea room available to swing the vessel around to port and make a fresh approach (overshooting the alter-course position to enter Blackney Passage would not have placed the vessel in danger of grounding); and
- the pilot was unable to alter his erroneous mental model even after the vessel grounded, as is evidenced by his reporting the vessel's position incorrectly.

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24 Research conducted by Dr. Drew Dawson of the Centre for Sleep Research, University of South Australia and reported in *The NSF Connection*, 4, 1 (1997) p. 1.

25 Rosekind, et al., *Crew Factors in Flight Operations X.*

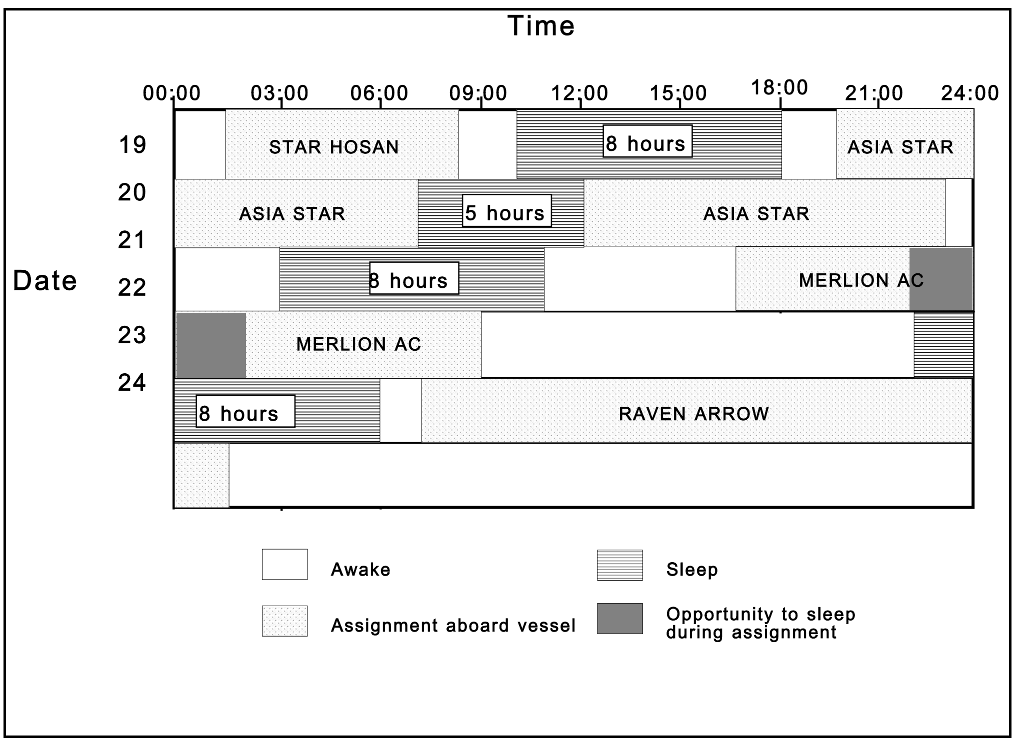
While fatigue is not necessary to explain these forms of error, they are consistent with those expected to be made by a fatigued individual. Hence it is probable that fatigue was a contributory factor in this occurrence.

A review of the OOW's work/rest schedule revealed that September 22 was a day in which he had a relatively full workload. Despite this, his fatigue is not considered to have been a factor in this occurrence.

2.4.2 Pilot Scheduling Issues

Acknowledging that operational considerations will influence scheduling, a preliminary review of the pilotage schedule suggests that the following factors merit further consideration:

- irregularity of the pilot's schedule;
- special conditions affecting midnight shift workers;
- work/rest cycles; and
- off-duty recovery periods.



2.4.2.1 Irregularity of the Pilot's Schedule

Figure 5 presents pilot No.1's schedule for the period September 19 to September 24. The irregularity of the pilot's schedule is evidenced by the fact that the pilot had worked three midnight shifts in six days, and that interspersed with these midnight shifts were an evening shift and a day shift. Over the six days, off-duty periods between the shifts vary in length from about 5 hours to about 21 hours. Studies of marine watchkeepers who work odd shifts have shown that shorter/poor-quality sleep and poorer performance are associated with irregular work/rest cycles.[26]

2.4.2.2 Special Conditions Affecting Midnight Shift Workers

Even small reductions in sleep—of as little as two hours—can result in measurable changes in performance on tests of vigilance. Many studies of shift workers link sleep loss with the time of day that sleep is taken.[27] Sleep taken during the day is shorter and of poorer quality than sleep taken at night. Studies have shown that pilots who conduct pilotage around midnight produce high levels of adrenaline (up to seven times that of a normal person, sleeping) and it can take as long as two days for adrenaline levels to return to normal.[28] For such a pilot, sleep will be very difficult. Hence, working at night cannot be taken as equivalent to working during the day. Sleep is poor if it is taken at times of day when the body is physiologically alert, and sleep loss exacerbates the normal drop in alertness and performance found at circadian low points in the day.[29]

Statistics for 1996 show that assignments with a pilot "order time" between 2200 and 0600 numbered some 4,650 assignments and accounted for 38 per cent of total assignments (Figure 6).

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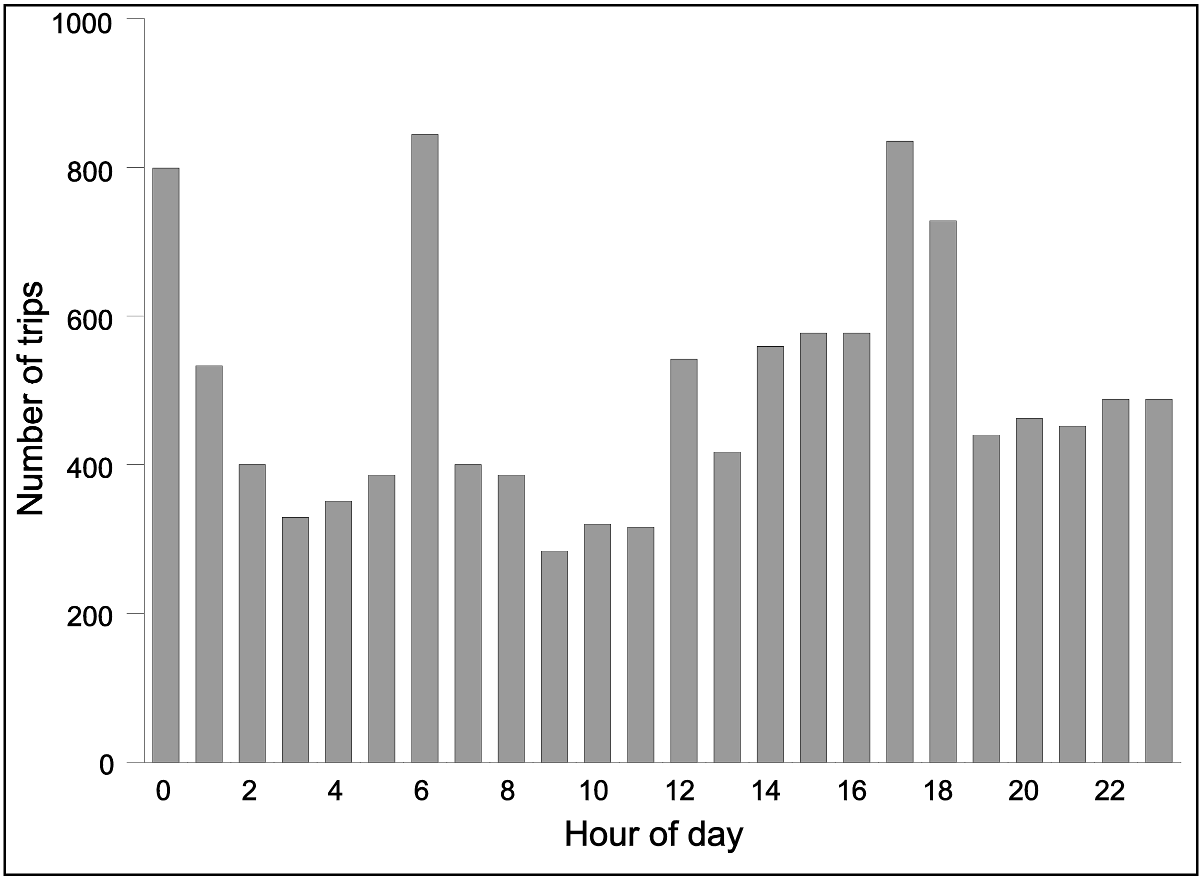
26 J. Rutenfranz, J. Aschoff and H. Mann, "The effects of cumulative sleep deficit, duration of preceding sleep period and body temperature on multiple-choice reaction time," *Aspects of Human Efficiency, Diurnal Rhythm and Loss of Sleep,* W.P. Colquhoun, ed. (The English Universities Press Limited,1972), 217-228.

27 F. Lille, "Le sommeil de jour d'un groupe de travailleurs de nuit," *Travail Humain*, 30 (1967): 85-97.

28 Yossi Breger, *Port Phillip Sea Pilots* (Melbourne: La Trobe University,1984).

29 National Transportation Safety Board (1995) *Safety study: Factors that affect fatigue in heavy truck accidents*. NTSB, SS—95-01 / NTIS, PB95-917001.



2.4.2.3 Work/Rest Cycles

A pilot may work for many consecutive days, at various times of day, and for as long as eight hours per shift if working alone (and up to six hours per shift if working in conjunction with another pilot). A pilot might work for up to eight hours, be off duty for eight hours plus travel time, and then return to work at the end of this period (multiple shorter shifts may have abbreviated off-duty time associated with them). Moreover, such a pattern could continue for many days, so that the individual's work/rest schedule would never develop a consistent circadian pattern.

2.4.2.4 Off-duty Recovery Periods

Recovery from an acute sleep deficit, cumulative sleep debt, prolonged performance requirement, or extended hours of continuous wakefulness is another important consideration. Operational requirements can engender each of these factors and it is important that a recovery period provide an opportunity to acquire recovery sleep and to re-establish normal levels of performance and alertness.

Frequent recovery periods are important. More-frequent recovery periods reduce cumulative fatigue more effectively than less-frequent ones. For example, weekly recovery periods afford a higher likelihood of relieving acute and cumulative fatigue than monthly or yearly recovery periods.[30] The current schedule adopted by the BCCP makes use of monthly recovery periods, through the use of a 20-days-on and 10-days-off cycle followed by an extended leave period of 30 or 50 days off, at the end of the 80-day cycle. However, the opportunity to rest and recuperate during the 10-days-off period is diminished by call-backs. The adverse effects of the schedule are reflected in some pilots' complaints to the BCCP that they tend to become fatigued towards the end of their 80-day cycle during the peak season.

2.4.3 Increased Demand for Pilotage Services, Pilot Fatigue and Effects on Schedule

Over the last few years there has been a steady increase in the demand for pilotage services by ships calling at west coast ports or transiting coastal pilotage waters. The increase is primarily associated with the growth of cruise ship operations—one of the growing industries on the west coast of Canada—and most of the extra assignments are long trips requiring two pilots. The current scheduling practices were set up before this recent boom. Despite the employment of ten seasonal pilots and two half-time pilots to supplement the full-time pilots, the workload is substantially higher in the peak season than in the rest of the year. The 1996 statistics show that the increase in pilotage assignments varied by some 35 per cent between the months of January and August, but the increase was some 56 per cent when the least-busy and the most-busy thirty-day periods are compared.[31] Thirty-day period figures have been used in this report.

Information provided by BCCP indicates that during the peak season pilots are kept very busy during their 20 days on duty, and that the pilots' average 20-day workload of
8 to 10 assignments in the off season rose to 14 to 21 assignments in the peak season. Although the greater part of the increase involved longer trips, to which two pilots are allotted, there is still a significant increase in work hours per assignment for each pilot, as the long trips range to over 27 hours while the short trips are typically a couple of hours in length. With pilots spending longer periods away from their home base on these long assignments, there are fewer pilots available to carry out other assignments that arise during their absence. The situation is further aggravated by the short rest periods associated with the watch system the pilots must adopt on long trips.

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30 D.F. Dinges, R.C. Graeber, M.R. Rosekind, A. Samei and H.M. Wegmann, *Principles and Guidelines for Duty and Rest Scheduling in Commercial Aviation* (NASA Technical Memorandum 110404, 1996).

31 Statistics compiled by TSB from data provided by the PPA.

Pilotage operation requires high levels of concentration which, when combined with a heavy workload, can result in high levels of fatigue.[32] Some significant factors that adversely affect pilot performance and contribute to pilot fatigue include the following:

- The inherently irregular work/rest schedule associated with pilotage duties, which prevents a pilot from developing a consistent sleep pattern.
- That 38 per cent of BCCP assignments are carried out between 2200 and 0600, where rest must be in the form of daytime sleep. The quality of sleep taken during the day is poor, compared to that taken during the night, but time off between assignments is not adjusted to reflect this.
- Off-duty recovery periods are linked to a 30-day cycle, whereas more-frequent recovery periods would reduce the chance of cumulative fatigue.
- The opportunity to rest and recuperate during the pilot's 10-days-off period is diminished by call-backs, a situation exacerbated in the peak season. This annual increase in demand on the pilots' services is not recognized by any adjustment in the overall pilots' work schedule. No regime has been instituted by which more pilots would be on duty during the peak season, either through an adjustment to the 30-day cycle or an adjustment to the number of pilots on extended leave.

It would appear that there is a tendency for a pilot following the present schedule to suffer from cumulative fatigue towards the end of the 80-day cycle during the peak season. This is substantiated by complaints to this effect that the BCCP has received from pilots.

There are a large number of pilot call-backs to meet the additional demands placed on pilotage services in the peak season and for some of these the pilot gets as little as two to three hours' notice. Every effort is made to recall, first, those pilots who are on their extended leave periods, but if none is available (as is often the case), pilots on their 10-days-off period are called. The onus is on the individual pilot either to accept or decline the call-back assignment. However, as pilots on extended leave are often unavailable, those on their 10-days-off period have little option but to accept these additional assignments; the pilot population as a whole is contractually obliged to handle these assignments.

A review of current scheduling practices shows that an effort is being made by the PPA and the BCCP to reduce work-related fatigue over the 20-day duty period by introducing policies on mandatory rest periods between assignments and on the sequence in which pilots are recalled. These policies need to be expanded to meet longer-term requirements and address the factors leading to cumulative fatigue in the 80-day cycle, especially in the peak season. An overview of the existing structure suggests that the only way the current scheduling system can meet peak-season demands on the pilots is to increase the number of pilot call-backs, which are already at over 260 per year. Call-backs are unscheduled and disruptive to the pilots, and the scheduling system needs to be more flexible to meet periods of high demand.

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[32] Rob Lovell, *Managing Pilot Fatigue - A Question of Safety* (Queensland, Australia)

Although the yearly increase in the demand for pilotage services is somewhat predictable, prudence dictates that this increasing demand not be considered an ongoing phenomenon that must necessarily translate into an increase in staff; competition between ports has the potential to produce wide fluctuations in vessel calls at B.C. ports. Consequently, the fluctuating demands in annual pilotage services, especially those associated with peak periods, need to be met by a flexibility that does not exist in the present work schedule.

The Board, concerned about the effects of fatigue on pilots' performance associated with pilot scheduling, recommended in TSB Report No. M93C0003 that the GLPA implement measures to address work-related fatigue.[33] Typical of measures introduced to address this issue is an amendment in the Collective Agreements that a pilot having worked two consecutive nights may ask to be not dispatched before 0600 the following morning.[34]

2.4.4 Awareness of the Effects of Fatigue and the Impact of Scheduling Practices

There are many factors likely to affect the level of fatigue and alertness that a pilot will experience. The pilots can be subjected to two types of fatigue; one is work-related and the other is general fatigue brought about by their lifestyles. Neither the PPA, nor the BCCP, nor the pilot has full control over all of these factors. The PPA and the BCCP do not have control over what a pilot does during time off. Conversely, the pilot does not formulate the work schedule. Neither has control over delays between the pilot "order time" and a vessel's readiness to begin pilotage. Mitigation of fatigue, therefore, has to be a joint enterprise among all involved.

Time off permits a pilot to take a break from work-related stress and to recuperate before the next call of duty. There is no regime in place, be it self-monitoring or otherwise, to ensure that the pilots are sufficiently rested to carry out their assignments. A fatigue management plan that sets out operating rules and procedures, with well-defined responsibilities, would greatly assist in addressing fatigue-related issues.

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[33] TSB Recommendation No. M96-17.

[34] Working nights means to be ordered for a vessel or transfer between 1600 and 0600 or an assignment ending between 0001 and 0800.

In this instance, although pilot No. 1 had some 21 hours for rest and sleep between assignments, prior to boarding "RAVEN ARROW", he showed signs of fatigue at the time of the occurrence as observed by pilot No. 2. While recognizing the symptoms of fatigue, pilot No. 2 did not fully appreciate the impact of such a state, highlighting the need for more formalized education and training to help pilots and management better appreciate the negative effects of shift work on performance. Knowledge of such factors can influence how pilots acknowledge and deal with problems of fatigue and alertness.

2.5 Quality Control and Pilotage

The need to have clearly defined responsibilities in the safe management and operation of ships has been recognized by the IMO, and the *International Safety Management* (ISM) *Code* is intended to address this issue. As neither the owner, nor the agent, nor master has in-depth knowledge of the pilot's history of assignments—and sleep history—they have no way of knowing the minimum level of service the pilot would provide. Nonetheless, the master assumes full responsibility for the pilot's performance.

As the prime purpose of pilotage is safety and, as compulsory pilotage areas are established for the benefit of the community to protect the environment and the port infrastructure from marine accidents, there is an expectation that the pilot's performance and operational procedures are of a standard that is internationally recognized and accepted.[35] Thus, in an era when shipowners have made a commitment to quality control, safe operation of a vessel in compulsory pilotage waters can be assured through an established, well-documented quality assurance program adopted by pilotage authorities, such as ISO 9002. This occurrence highlights the need for a safety management system that incorporates a fatigue management plan with clearly defined responsibilities.

[35] Standard procedures are not a set of instructions that tell pilots how to pilot a vessel, rather they are a set of procedures to be followed in the discharge of one's duties.

3.0 Conclusions

3.1 Findings

1. Pilot No. 1 elected to conduct the navigation of the vessel without assistance from the officer of the watch (OOW) or from pilot No. 2.

2. Traffic in Johnstone Strait necessitated some collision avoidance course alterations.

3. Other than sequentially following his course book, the pilot relied solely on his memory to monitor the vessel's progress and he did not make effective use of the radar.

4. Sound navigational practices were not implemented by the bridge team and this culminated in the vessel's grounding.

5. The visibility began to deteriorate as the vessel approached Forward Bay and had diminished to some 150 m in fog at the time of the occurrence.

6. The pilot lost situational awareness and prematurely altered course off Boat Bay believing that the vessel was off Cracroft Point in Blackney Passage.

7. The pilot's loss of situational awareness is attributable to the cumulative effects of:

   - the pilot's sole reliance on the course book, without an additional *aide-mémoire*, resulting in confusion as to which leg the vessel was on;
   - the pilot losing track of time; and
   - cursory radar observation, unduly influenced by traffic communication.

8. The cumulative effects of the workload associated with collision avoidance, and the changing of the range on the radar, resulted in the pilot not being alerted by some of the available cues.

9. The OOW plotted the vessel's position at frequent intervals but the pilot elected not to utilize the information.

10. Still under the impression that the vessel was in Blackney Passage, the pilot attempted corrective action to starboard when he realized that the vessel was not at the alter-course position.

11. The OOW did not effectively monitor the pilot's communication with Marine Communications and Traffic Services (MCTS) and was not alerted when the pilot erroneously reported the vessel's position to MCTS some 20 minutes prior to the grounding.

Bridge Resource Management in Pilotage Waters

12. The pilot had received bridge resource management (BRM) training but he did not put into practice all relevant BRM elements.

13. Neither the Pacific Pilotage Authority (PPA) nor the British Columbia Coast Pilots (BCCP) has a regime in place to monitor the application by the pilots of sound BRM practices.

14. The pilot culture tends to lead some pilots to generalize that the ship's complement will provide minimal support in the navigation of the vessel, without assessing individuals on their merits.

15. The ship's passage plan had not been agreed upon and this precluded the ship's personnel from effectively monitoring the vessel's progress.

16. The pilot's lack of communication with the OOW created a climate on the bridge that made the OOW less likely to participate in the navigation of the vessel.

17. The lack of effective communication between the pilot and the OOW initially resulted in the mental model of the OOW being at variance with that of the pilot.

18. The OOW did not fully appreciate the need to effectively monitor the pilot's communication with the MCTS.

19. As effective monitoring of the vessel's progress was not carried out by the OOW, he did not have full situational awareness and he did not seek clarification from the pilot with regard to course alteration.

20. The OOW's mental model was based on fragmentary information and would account for the OOW being readily influenced by the pilot's actions/decisions.

Fatigue in Pilotage Waters

21. Time off between on-board watches and between assignments was not effectively used for sleep by pilot No. 1, and he was probably fatigued at the time of the occurrence.
22. Pilot No. 1 may not have fully appreciated the negative effects that irregular work

schedule and sleep debt can have on performance.

23. There is no formalized education/training program in place for BCCP pilots and management that would provide guidance to pilots regarding conditions conducive to fatigue and the impact of scheduling on fatigue.

24. Neither the PPA nor the BCCP have a regime in place to monitor pilot fatigue.

Pilot Scheduling

25. The demand for pilotage services increases about 56 per cent during the peak season, compared with the rest of the year.

26. Despite the use of additional part-time/seasonal pilots to complement full-time pilots, there are a large number of call-backs to meet pilotage demand during the peak season.

27. Call-backs, which are primarily in the peak season, increase workload.

28. The current scheduling system lacks the flexibility necessary to deal with peak season pilotage demands, and pilots who follow the schedule suffer from fatigue towards the end of the 80-day cycle.

29. The use of monthly recovery periods in the current scheduling system, instead of more-frequent recovery periods, reduces the chance that a pilot will fully recover from fatigue.

3.2 Causes

The "RAVEN ARROW" grounded in fog when the pilot lost situational awareness and prematurely altered course to enter Blackney Passage after having elected to conduct the navigation of the vessel without assistance from the ship's complement. Contributing to the occurrence were the following factors: the pilot was probably fatigued; sound navigational principles were not implemented by the bridge team; the exchange of information between the pilot and the OOW was minimal and imprecise; and the OOW did not effectively monitor the pilot's communication with Marine Communications and Traffic Services.

4.0 Safety Action

4.1 Action Taken

4.1.1 BRM Training Requirement for Pilots

Following the occurrence, all four Canadian pilotage authorities have recognized the need for BRM training and recommended that it be compulsory for their pilots. Further, Transport Canada is proposing amendments to the *General Pilotage Regulations* to include a requirement for pilots to be trained in BRM.

4.2 Action Required

4.2.1 Pilot Fatigue

In the marine transportation industry, work schedules and working conditions are often conducive to degradation of performance due to fatigue. With respect to pilots, the irregular work/rest schedule, the high number of night assignments, the additional workload associated with seasonal fluctuations in demand for pilotage services, and diminished opportunity to rest/recuperate (as highlighted in this occurrence) all have the potential to adversely affect pilot performance.

On the west coast, the BCCP determines the number of pilots available at a given time, while the PPA administers the scheduling of the pilots. During the seasonal peak periods, there is an increase in demand for pilotage services that places additional workload on pilots. The number of pilots on duty and their overall schedule are not adjusted to reflect the seasonal fluctuations in demand for their services. Although part-time and seasonal pilots are used, the heavy demand in peak periods still results in a large number of call-backs of off-duty pilots. This heavy demand causes some pilots to suffer from cumulative fatigue during the peak season. Indeed, pilots have made complaints to the BCCP to this effect. While the Board recognizes the efforts made by the PPA and the BCCP to address work-related fatigue over the short-term single on-off cycle period, it is concerned that the issue of chronic fatigue over the long term, which involves multiple work cycles between the pilot's extended leave periods during the peak season, remains unaddressed.

This is not an isolated occurrence where fatigue has been recorded as a factor contributing to an accident involving a pilot. In a previous occurrence involving the striking of a bulk carrier and a Canadian tanker, the report attributed degradation in the pilot's performance to work-related fatigue due to insufficient rest (TSB Report No. M93C0003). In its report, the Board had expressed concern that the system places pilots in the difficult position of making a safe decision, while standing to gain financial benefit from accepting the extra assignment. Consequently, the Board recommended that TC and the Great Lakes Pilotage Authority (GLPA) implement policies and procedures for allocating pilotage assignments so as to minimize the adverse effects of fatigue on performance and provide training to pilots on managing fatigue.[36] It is understood that the GLPA now has formalized training on fatigue management for its pilots.

[36] TSB Report No. M93C0003—Recommendation Nos. M96-17 and M96-18.

In a 1997 occurrence, a Liberian bulk carrier went aground twice in the St. Lawrence River under the conduct of a pilot. (The investigation, M97L0030, is ongoing.) When the first grounding occurred, the pilot had had the conduct of the vessel continuously for over seven hours. More than 12 hours later, the vessel grounded a second time under the conduct of the same pilot. By the time of the second grounding, the pilot had been on duty continuously for over 19 hours. It was not until some 15 hours after the first grounding that a relief pilot was assigned to the vessel and 24 hours had elapsed on this assignment before the first pilot was relieved. The information gathered to date indicates that the pilot's fatigue probably contributed to a degradation in his ability to perform monitoring and decision-making tasks.

The issue of pilot fatigue, therefore, is not limited to a single region but is widespread throughout Canada. By nature, the work environment of pilots requires them to work irregular schedules that are sometimes demanding and involve work in adverse weather conditions. In addition, pilotage regions in Canada have peak periods, when the demand for pilotage services is substantially higher than average. During such peak periods, an inadequate supply of pilots on duty, and/or work-rest schedules, may result in work-related stress and fatigue in some pilots. Sleep loss and sleepiness resulting from extended duty or altered work/rest schedules have been identified as contributory factors in many industrial accidents.[37] Studies have shown that a sleep-deprived individual tends to be a poor judge of his/her level of fatigue. Researchers at the Defence and Civil Institute of Environmental Medicine found that after 18 hours awake, people showed a 30 per cent decrement in performance on cognitive and vigilance tasks and after 48 hours the impairment averaged 60 per cent.[38]

The Board believes that a flexible pilot work schedule that ensures sufficient pilots are on duty to meet the workload requirement at all times, particularly during peak periods, could alleviate performance degradation due to fatigue. Given the vulnerability of individuals in safety-sensitive positions to significant error in judgement when fatigued, and given the potential consequences of such errors, the Board recommends that:

> Canadian pilotage authorities adopt pilotage assignment policies and practices that both reflect the workload associated with the seasonal fluctuation in demand for pilotage services and help ensure pilots are well rested between assignments, so as to minimize the adverse effects of short-term and/or chronic fatigue on their performance.

M99-03

There are several ways to mitigate the negative effects of shift work and irregular work schedules. Some of the factors that affect pilot performance while on duty are controlled by the pilots themselves, in terms of

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37 Mark R. Rosekind 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.

38 R.G. Angus et al., "Sustained-operations Studies: From the Field to the Laboratory," *Why We Nap: Evolution, Chronobiology, and Functions of Polyphasic and Ultrashort Sleep*, C. Stampi, ed., (Boston: Birkhauser, 1992), 217-241.

modifications to their personal lifestyle, such as a combination of sleep schedules and control of one's environment and diet. Training and educational programs to help workers maintain optimum performance despite irregular work/rest schedules have been developed and can be customized to meet specific needs. The Board believes that such a fatigue management training program will assist pilots in coping with work-related stresses and fatigue. Therefore, the Board recommends that:

> The Department of Transport and the Canadian pilotage authorities develop and implement an awareness program to provide guidance to operational employees, including pilots, on reducing the adverse effects of fatigue on job performance.

M99-04

4.2.2 BRM Training Validation

On the issue of BRM training, the Board commends the action by TC and all four Canadian pilotage authorities in proposing amendments to the *General Pilotage Regulations* to include a requirement for pilots to be trained in BRM. The BRM training program in Canada was jointly developed by industry and the Canadian maritime educational institutions and has now been approved by TC. The objective of the training is to facilitate the effective utilization of all available resources, the exchange of vital information, and the decision-making process, through enhanced crew-pilot interaction. However, to achieve these objectives, training precepts must be effectively put into practice. In this occurrence, although the pilot had received BRM training, the elements of BRM—such as effective communication and distribution of workload based on individual expertise—which are critical to the safe operation of vessels, were not put into practice. This is not an isolated incident; at least one other recent occurrence under investigation has revealed a similar deficiency.

Indeed, these BRM-related failures are found in many occurrences in the pilotage waters of Canada. Navigation with a pilot on board is a unique situation where a complete stranger, the pilot, is added to an often diverse mix of crew and they are required to function as a homogeneous team under stressful conditions and often in complex operational situations. The passive approach taken by some ships' complements and the reluctance to use the ship's complement on the part of pilots are not conducive to creating a climate whereby bridge team members can comfortably provide input to the pilot. As a result, the reluctance of pilots to include the ship's complement in the navigation process has become a norm in the pilots' culture. Consequently, pilot decision-making can become a weak link in a system prone to single-point failure. BRM training is intended to address these deficiencies. Research done into the success or failure of crew resource management training emphasizes the need for training validation to determine the effectiveness of training objectives.[39]

The Board is encouraged that Canadian pilotage authorities and the majority of pilots are endorsing BRM training. However, the Board believes that BRM-related failures and deficiencies will persist if the training's precepts are not effectively transferred from the classroom to the operation front. This requires a change in attitude, culture and job behaviour. The Board believes that recurrent training, coupled with an appropriate

[39] R.L. Helmreich, C.M. Ashleigh, and J.A. Wilhelm, "The Evolution of Crew Resource Management Training in Commercial Aviation," *International Journal of Aviation Psychology*, (in press).

regime to help ensure the application of learned skills and knowledge to reinforce their practice, can bring about the desired changes in existing pilot culture and behaviour. The Board, therefore, recommends that:

> The Department of Transport and the Canadian pilotage authorities develop and implement a Bridge Resource Management (BRM) training validation system to help ensure the principles of BRM are being put into operational practice.

M99-05

4.2.3 Safety Management of Pilotage Operations

Over the years, the TSB has investigated marine occurrences involving vessels operating in Canadian pilotage waters. Also, the unique nature of the master/pilot relationship was the subject of the TSB special study entitled: *A Safety Study of the Operational Relationship Between Ship Masters/Watchkeeping Officers and Marine Pilots* (TSB Report No. SM9501).

TSB investigations revealed safety deficiencies for which recommendations were made. The safety issues that the recommendations address identify factors that affect pilot performance. These include the following:

- pilot/master information exchange,
- pilot performance degradation due to fatigue,
- pilot skill upgrading, training and training validation,
- pilot bridge resource management training and practices, and
- pilot fitness for duty.

Investigations have also revealed that a systematic approach to fatigue management and periodic audits to evaluate pilot proficiency and skills are usually absent from pilotage organization regimes.[40]

The IMO is currently identifying training needs and reviewing pilot operational procedures, aimed at setting a global common standard for pilotage expertise. In addition, at least one classification society, in conjunction with the tanker owners' organization INTERTANKO, pilotage organizations and the Norwegian coastal directorate, has introduced a certification program for the operation of pilotage organizations. The program addresses operations and management factors vital to safety and quality, including passage planning, pilot/master information exchange and definition of quality levels for such matters as training and qualifications of pilots. The Board believes that such a system will go a long way to ensuring that a pilot assigned to a vessel is fit for duty and has the necessary skills and knowledge to complete the assignment safely.

Safe operation of a vessel in pilotage waters is a joint responsibility of the pilot and the master of the vessel. In recent years the IMO, recognizing the severity of the consequences of marine accidents, has been continuously striving to achieve and maintain higher standards of safety for the operation of vessels. The adoption of the

[40] TSB Report No. M97W0197 - "RAVEN ARROW"; occurrence No. M97L0030 - "VENUS" (investigation ongoing); TSB Report No. M97C0120 - "OLYMPIC MENTOR"; and TSB Report No. M93L0001 - "CANADIAN EXPLORER".

mandatory *International Safety Management* (ISM) *Code* by shipowners is one of the many initiatives taken towards meeting that objective. The Board believes that as shipowners have made a commitment to quality control (through the adoption of the *ISM Code*), safe operation of a vessel in compulsory pilotage waters can be enhanced through a parallel, well-documented safety management/quality assurance programme adopted by pilotage authorities. The Board, therefore, recommends that:

> The pilotage authorities develop and implement a safety management quality assurance system, consistent with maintaining the highest practicable standard of safety, for vessels operating in Canadian pilotage waters.

M99-06

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 23 June 1999.

Appendix A - Glossary

ARPA	automatic radar plotting aid
BA	British Admiralty
B.C.	British Columbia
BCCP	British Columbia Coast Pilots
b.h.p.	brake horse power
BRM	bridge resource management
DSC	digital select calling
ETA	estimated time of arrival
ft	feet
GLPA	Great Lakes Pilotage Authority
GMDSS	Global Maritime Distress Safety System
GPS	global positioning system
HF	high frequency
IMO	International Maritime Organization
INTERTANKO	International Association of Independent Tanker Owners
ISM	International Safety Management
kn	knot
m	metre
M	nautical mile
MCTS	Marine Communications and Traffic Services
MF	medium frequency
N	north
NE	northeast
ON1	Ocean Navigator 1
OOW	officer of the watch
PDT	Pacific daylight saving time
PPA	Pacific Pilotage Authority
QR	quick flashing red
SI	International System (of units)
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978
TC	Transport Canada
TCMS	Transport Canada Marine Safety
U.S.A.	United States of America
UTC	Coordinated Universal Time
VHF	very high frequency
W	west
°	degree
'	minute
"	second