MARINE INVESTIGATION REPORT

M98C0082

STRIKING OF A LIGHT STRUCTURE

THE BULK CARRIER "FEDERAL BERGEN"

ST. LAWRENCE SEAWAY, ONTARIO

12 DECEMBER 1998

Marine Investigation Report

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Summary

The "FEDERAL BERGEN" was en route from Duluth, Minnesota, USA, to Montreal, Quebec, with a Canadian pilot on board. While navigating at night and in good visibility, the vessel's course was erroneously altered off Bradford Point Light "71" in the St. Lawrence River, east of Morrisburg. The officer of the watch detected the navigational error and informed the pilot. The pilot investigated the officer's concern and effected remedial measures but it was too late, and the vessel struck Weaver Shoal light structure "68".

Other Factual Information

	"FEDERAL BERGEN"	
Port of Registry	Hong Kong	
Flag	China (Hong Kong)	
Registry Number	HK0356	
Type	Bulk carrier	
Gross Tons[1]	16,983	
Length	180.5 m	
Draught	Forward: 7.80 m	Aft: 7.80 m
Built	1984, Japan	
Propulsion	6988 kW	
Number of Crew	21	
Registered Owner	Thunder Bay Investment Corporation, Monrovia, Liberia	
Managers	Anglo-Eastern Ship Management, Hong Kong	

Description of the Vessel

The "FEDERAL BERGEN" has five cranes along the centre line, with the accommodation and the navigation bridge aft. The vessel, which is designed for Seaway transits, regularly calls at Great Lakes ports, and the crew is familiar with the St. Lawrence Seaway. The navigation equipment in use aboard the vessel included:

- a course recorder,
- one radar on the port side,
- two radars, of which one was fitted with an automatic radar plotting aid (ARPA), on the starboard side,
- very high frequency (VHF) radiotelephones on both the port and starboard sides, and
- two global positioning systems (GPS).

No equipment malfunction was reported.

History of the Voyage

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

On 11 December 1998 the "FEDERAL BERGEN" was en route from Duluth to Montreal. At 2100 a Seaway pilot boarded the vessel at Cape Vincent for the transit to the Snell Lock. The voyage was uneventful and on time. Gyro error, as recorded in the Azimuth Log, was a half degree low. For short segments, however, the pilot applied a gyro error of 2° low on all headings. At about 0330 the vessel cleared the Iroquois Lock.

The vessel's course was altered to 077°G (079°T) as the vessel was passing Crysler Shoal Light "73". Just prior to the course alteration at Crysler Shoal, the pilot, using the VHF on the starboard side of the navigation bridge, reported to Seaway Eisenhower that the vessel was off calling-in point 10. The Seaway traffic control station advised the vessel of the traffic in the area and the sequence in which the vessels were to enter the locks, and shortly thereafter the station advised a change in that sequence. There was one upbound vessel above the Eisenhower lock and one below the Snell lock. In addition, there was one downbound vessel some distance ahead (and scheduled for transit of the Eisenhower lock), and one astern.

The vessel's average speed was 10.8 knots (kn). The weather conditions and visibility were good and favourable. At 0426 the vessel was abeam of Bradford Point light "71" and a course alteration was executed to 071° G (073°T).[2] The OOW was not anticipating a course alteration at this time. After consulting the chart, the OOW looked forward and noticed a red flashing light very fine on the port bow. Concerned by his observations, the OOW reportedly notified the pilot and proceeded to the starboard side to check for buoy "67". Unable to sight light buoy "67", the OOW returned to the port side to double-check light "68", which, by now, was right ahead. He informed the pilot that the red light was now right ahead. The pilot, who was still on the starboard side of the bridge, walked over to the port side to check for himself.

By this time, striking of light structure "68" was imminent and the pilot ordered hard-a-starboard helm. However, this action was initiated too late and about the time the "FEDERAL BERGEN" started responding to the helm, the port bow of the vessel came in contact with light structure "68", some 5 m from the stem at approximately 0430.

The occurrence was reported to Seaway Eisenhower and the vessel proceeded to the anchorage east of Weaver Shoal for inspection. The crew were called and tank and hold soundings were taken. Part of the cargo in Nos. 1 and 2 holds was transferred to minimize the ingress of water and to assess the damage. The vessel sustained extensive underwater damage from the stem to No. 1 hold, caused by the submerged steel base of the light structure.

Approaches to Weaver Shoal

The Crysler Shoal and the Weaver Shoal are between Iroquois Lock and Eisenhower Lock, with some 1.3 miles separating the shoals. Proceeding eastbound along the channel, a vessel passes north of the Crysler Shoal and Bradford Island and south of the Weaver Shoal. The Seaway channel in the area is about 425 m across at its narrowest point. Weaver Shoal leading lights are on the Canadian shore about 2.4 miles west-southwest of Cooks Point; these lights are in line bearing 262°T. Three lights, the Crysler Shoal Light "73", the Bradford

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[2] The times used in the report are those from the course recorder trace. These times are three minutes behind the ship's clock and the times entered in the ship's log. The trace provides a true and accurate depiction of the courses steered by the vessel.

Point Light "71" and light buoy "67" mark the south edge of the channel, all displaying flash green (*Fl G*) characteristics. A radar beacon, identified by Morse code "M" (— —), is operated from the Crysler Shoal Light structure. The north edge of the channel is marked as follows: light buoy "72" displaying quick flash red (*QR*) characteristics; light "70", shown at an elevation of 8.8 m, displaying flash red (*Fl R*) characteristics; and light "68", shown at an elevation of 14 m from a white circular tower marked "68" on a red cylindrical base and displaying *QR* characteristics.

Method of Navigation

Prior to the occurrence, the pilot was, for the most part, stationed on the starboard side of the bridge. The navigation was primarily conducted by visual aids and the pilot made only cursory reference to the radar. The pilot used neither a course book nor an *aide-mémoire*. Further, the pilot recorded neither the estimated time of arrival for way points nor the actual time of course alterations, nor did he keep any other record of the vessel's progress. The pilot had to rely solely on his memory and observations to keep track of the vessel's progress.

Prior to the course alteration to 071°G (073°T), the pilot reportedly observed on the radar that the vessel was 0.25 mile from Bradford Point.

The OOW verified the vessel's position at 5-minute intervals, both visually and through the use of radar, and ensured that the pilot's orders were executed.

Course Recorder

A review of the course recorder trace revealed the following:

0420.5–0421 : A/C 063°G
0421– 0423.5 : 063°G
0423.5– 0424 : A/C 077°G
0424– 0426 : 077°G
0426–0426.5 : A/C 071°G
0426.5–0430 : 071°G
0430 : hard-a-starboard helm

Conflicting Information Respecting Course Alteration

There is conflicting information with respect to the orders given by the pilot to alter the vessel's course to 071°G (073°T) at 0426. According to the pilot, he gave orders to alter the vessel's course to 080°G (082°T). This is at variance with the information provided by the ship's complement forming the bridge team, who indicated that the pilot ordered a course alteration to 071°G (073°T). In any event, the vessel's course was altered to 071°G (073°T).

This vessel was not equipped with a Marine Voyage Data Recorder(VDR) nor was it required to be.

Communication

Between the time the Crysler Shoal course alteration commenced and around the time of the course alteration to 071°G (073°T), the pilot was in communication with Seaway Eisenhower twice, in order to receive updates on the vessel traffic. He was advised that the vessel was not slated for immediate lock transit. During this period the pilot also informed the OOW that the vessel's speed might have to be reduced. The starboard anchor had been walked back earlier.

Modification to the Pilot's Plan

Following communication with Seaway Eisenhower, the pilot modified his navigational plan to take into account other traffic. In order to arrive at the entrance to Eisenhower Lock at around 0600, he planned to reduce the vessel's speed on passing Weaver Shoal Light "68" and then to hold the vessel at Wilson Hill Anchorage. The pilot did not communicate the details of his revised navigational plan to the OOW.

Vessel and Personnel Certification

The vessel was International Safety Management certified and was crewed, equipped and operated in accordance with existing regulations.

The pilot held a Canadian Master Home Trade Steamship Certificate of Competency and appropriate pilot licence for the area of operation. He had some 30 years' sea service, of which the last 19 years were as a pilot for the area.

Visibility from the Bridge

The vessel has five cranes forward, which were in the housed position. These cranes partially restricted the view forward such that a person stationed on the starboard side of the bridge could not see across the bow to the port side.

Analysis

Navigation Plan

Orders Given by the Pilot

The distance between Weaver Shoal light and the lock entrance is about 9.5 miles, including some 5 miles in the Wiley-Dondero Canal. The vessel was not slated for lock transit until 0600. This meant that the vessel's speed would have to be reduced to some six knots, assuming that the vessels scheduled to transit the lock before the "FEDERAL BERGEN" did not encounter any delay. The reduction in speed was to take place upon passing Weaver Shoal light. The pilot's intention then was to hold the vessel at the Wilson Hill Anchorage on the north side of the channel.

An alteration to 080°G (082°T) would have kept the vessel on the south side of the channel, and a subsequent northerly alteration for Wilson Hill Anchorage could then have been made as/when convenient to avoid upbound traffic. Alternatively, an immediate course alteration to the north, passing the Weaver Shoal light at close range, would place the vessel on the north side of the channel, on a course to enter the Wilson Hill Anchorage directly and clear of upbound traffic.

Regardless of whether the pilot ordered a course alteration to 080°G (082°T) or to 071°G (073°T), the vessel's course was altered to 071°G (073°T).

The pilot had extensive experience navigating in this area, and had taken this vessel in-bound. He had a good understanding of where he was and how the vessel would respond. When the pilot gave the command to adjust course, he thought he gave the command to alter course from 077° (G) to 080°(G), and believed he heard the call-back to that effect. This led him to expect that the vessel was turning to 080°; in other words, his mental model was that the vessel was turning toward 080°. It is at this point that the pilot's mental model diverged from the ensuing situation, and he lost situational awareness, since the vessel was actually turning to 071°. The pilot did not ensure that the vessel had turned to 080°, because he was talking with Seaway Eisenhower and planning the trip to the next lock.

It can be difficult to simultaneously perform two similar tasks, such as listening to a steering call-back while talking and listening to the traffic control station. Furthermore, expectancies can play a big role in the process of communication.[3] In this instance, if it is accepted that the pilot had given the command of 080°(G), he would have expected to hear back the same information. In performing multiple tasks he was less likely to pick up on his own command error. Furthermore, from the pilot's location on the starboard side of the bridge, the limited visual cues available to him were not compelling enough for him to update/change his mental model and realize that the vessel was not at a heading of 080°.
It could not be determined with certainty what course alteration the pilot ordered. The next course alteration, according to the chart, was 068° (T), off light "68." Given the probable mental model of the pilot, it is unlikely

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[3] E.L. Weiner and D.C. Nagel, eds., *Human Factors in Aviation* (Los Angeles: Academic Press Inc., 1988), p. 284.)

that the pilot ordered starboard course alteration to 080°(G). In any event, the vessel's course was altered to 071°(G). If it is accepted that this alteration was contrary to the pilot's orders, it would suggest that the pilot did not ensure that the course alteration was correctly executed according to his normal practice, as the course alteration to 071° (G) had been effected for some four minutes at the time of striking.

Limitations Imposed by Navigational Practices

Work Load

Key elements of bridge resource management (BRM) include team building and maintenance, communication processes and decision making, workload management, and situational awareness. Because pilots have to work with ships' complements whose competency, language skills and workload vary substantially from vessel to vessel, a reluctance to utilize the ships' complement has become part of pilot culture.[4] This has resulted in some pilots taking on additional workload which, in certain circumstances, may be beyond their ability to handle. This is contrary to the principles of BRM and safe operation of a vessel.

On the inbound passage, the OOW was on watch with the same pilot in the same section of the Seaway. The pilot considered the OOW to be knowledgeable and competent. The OOW had demonstrated to the pilot that he could effectively participate in the safe navigation of the vessel, in that he monitored the progress of the vessel and communicated in English. Although the pilot was preoccupied in communication with the Seaway traffic control station, assimilating information, and in planning ahead and assessing the developing navigational situation, he did not communicate the details of his revised navigation plan to the OOW. Nor did he request the OOW's assistance or communicate his intention for the helm order (i.e. course alteration/adjustment), at a critical juncture in the vessel's transit. Thus, the pilot did not take full advantage of the potential for the OOW to assist in the safe navigation of the vessel. This occurrence highlights the need for appropriate distribution of the workload within the limits of individual expertise and capacity.

Weak Link in Pilotage Operations

Pilotage is mentally demanding and, consequently, pilots often implement practices to facilitate pilotage operations, including the use of tools such as a pilot course book. In this instance the pilot did not use a course book as a passage plan, nor did he use an *aide-mémoire* to assist him in navigation. By not communicating the details of the revised navigation plan to the OOW, the pilot could not use the services of the OOW to advantage. Instead, the pilot relied solely on his own observations, memory and his optimal performance to safely navigate the narrow channel. As such, navigation and the decisions associated therewith rested with the pilot alone, who was without the full benefit of an informed supporting team. This then became a weak link in a system prone to a single-point failure.

Loss of Situational Awareness

In the period leading to the approach to Bradford Point Light "71" the pilot's workload had increased as he was engaged in communicating with Seaway Eisenhower, taking mental note of traffic, assimilating information and

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[4] TSB Report No. M97W0197 - "RAVEN ARROW".

planning ahead for the lock entry; in so doing he may have lost track of time. Being positioned on the starboard side, the visibility from the bridge precluded the pilot from sighting light "68". The pilot did not monitor the execution of the helm order nor had he monitored the vessel's progress for some three and a half minutes—this at a critical time in the transit. Consequently, the pilot lost situational awareness and he became aware of the danger only after the OOW drew his attention to it.

Marine Voyage Data Recorders

If it is accepted that the vessel's position was on the recommended track and, had the vessel's course of 077° been maintained, she would have cleared light "68" by some 120 m; the distance according to the recommended track on the chart is 150 m. An alteration to 080° would have placed the vessel some 30 m further south and at the recommended distance for normal downbound transits.

There is conflicting information as to whether the pilot ordered course alteration to 071°G (073°T), or to 080°G (082°T). Reliable voice data would have allowed the TSB to determine with certainty which course alteration was ordered and to examine in-depth what operational and human factors led to the erroneous course alteration.

The availability of recorded information after an accident increases the objectivity of the Board's investigations by providing reliable information about what happened. Objective data is most valuable to investigators in understanding the sequence of events and voice data in particular, and assists in the identification of operational problems and human factors, which are elements in the majority of accidents. VDRs which will record both voice and operating data are available, and the International Maritime Organization is working on setting standards for these devices. These devices will become mandatory for all passenger vessels, including Ro-Ro passenger ships, constructed on or after 1 July 2002 and engaged in international trade.

Also, a VDR is an invaluable operational tool for ship operators in analysing hazardous incidents and bridge team procedures and has the potential to enhance safety in that it can assist in:

- identifying training needs, and developing and implementing a training validation system;
- assessment of response to safety and environmental emergencies; and
- promoting best practices and accident prevention.[5]

Limited Use of Navigational Equipment

The configuration of the coast and the special navigational aids in the area provide good radar responses, and information obtained therefrom is conducive to safe navigation. Prior to the course alteration of 071°G (073°T), the pilot reportedly made an observation on the radar and noted that Bradford Point was 0.25 mile away. However, the pilot used the radar only occasionally, and the parallel indexing technique was not used. Also, following a change in course, the Weaver Shoal Leading Lights, which were astern of the vessel, were not used to advantage. This precluded the pilot from effectively monitoring the vessel's progress. After the

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[5] International Maritime Organization MSC72/10/15, dated 28 March 2000, *Safety of Navigation - The benefits of Voyage Data Recorders (VDRs)* submitted by the United Kingdom.

vessel had reached the new heading of 071°G (073°T), the vessel continued on that course for some three minutes before action was taken to avert a striking. This would suggest that the pilot did not effectively monitor the vessel's progress by visual means, nor make effective use of radar at a critical point in the vessel's transit. Close monitoring of the vessel's progress, including effective use of the radar, would have better enabled the pilot to recognize the navigational error (that the vessel was headed dangerously close to the Weaver Shoal light) in ample time to initiate remedial measures.

Selective Use of Navigational Aids

The pilot deviated from the normal practice of using the Weaver Shoal leading lights in that the lights were not effectively monitored to ensure that the vessel was on the intended track. Instead, he used other visual aids to transit the area between Bradford Point Light "71" and light buoy "67". It was at the time of course alteration that the OOW recognized the potential error in navigation. After a quick reference to the chart, the OOW saw light "68" very fine on the port bow and brought this observation to the attention of the pilot. During the subsequent short delay the master was not called. It was not until after the communication with the Seaway traffic control station had been completed that the pilot responded to the OOW's information. By the time hard-a-starboard helm was ordered, it was too late, and the vessel struck the light structure.

The pilot made selective use of navigational aids on this leg and elected not to use the prominent Weaver Shoal Light "68" as a navigational marker. When the vessel's course was altered to 077°G (079°T), the pilot was aware that the next course alteration was to port (according to the chart it was 068°(T)). Instead of positioning himself on the port side, which would have allowed for a better appreciation of the visual navigational aids, the pilot remained on the starboard side. Although the VHF was readily available on the port side, on this occasion the pilot elected to navigate from the starboard side, as he found that the VHF available there was easier to use. This positioning was contrary to his normal practice, and, in conjunction with the selective use of navigational aids, deprived the pilot of some of the cues essential for maintaining situational awareness; cues which, in this instance, were critical for safe transit.

Findings

1. The pilot was engaged in several tasks and did not take full advantage of the potential for the OOW to assist in the safe navigation of the vessel. Specifically, he did not communicate the details of his revised navigation plan to the OOW.

2. The pilot's work load was such that he did not monitor execution of the helm order to ensure that it had the desired effect, nor did he monitor the vessel's subsequent progress for about three and a half minutes.

3. The pilot relied solely on his own observations and memory for navigation and to keep track of the vessel's progress. This became a weak link in a system prone to single point failure.

4. The pilot made selective/limited use of navigational aids and, by electing to navigate from the starboard side of the bridge, deprived himself of some of the cues essential for maintaining situational awareness; cues that were critical for safe transit.

5. The cumulative effect of workload associated with Seaway communication, planning and assessing the developing navigational situation, and cursory observation of the navigational aids resulted in the pilot's loss of situational awareness.

6. There was a short delay between the time the OOW became aware of the navigational error and the action initiated by the pilot.

7. The "FEDERAL BERGEN"was not equipped with a Marine Voyage Data Recorder and consequently, it could not be determined whether the pilot ordered a course alteration to 071°G (073°T), or to 080°G (082°T).

Causes and Contributing Factors

The "FEDERAL BERGEN" struck Weaver Shoal light structure "68" following an erroneous course alteration. The pilot, who was engaged in several tasks including Seaway communication, monitored neither the course alteration nor the vessel's progress. Contributing to the occurrence were the following: sound navigational practices were not followed; the pilot did not make optimal use of the navigation equipment and navigation aids; the details of the revised navigation plan was not communicated to the OOW; and the potential for the OOW to assist in the navigation was not optimized.

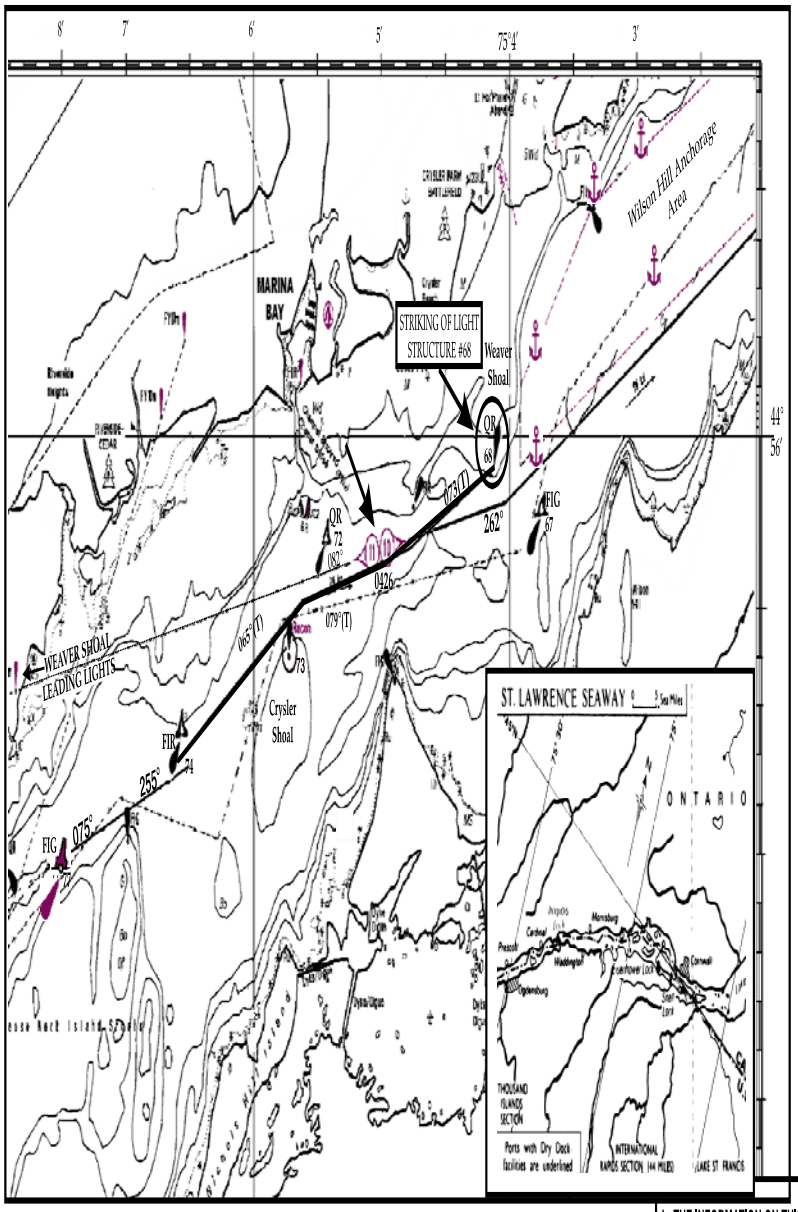
Safety Action Taken

As a result of similar occurrences, the Board has already addressed deficiencies and issued recommendations regarding bridge resource management training and demonstration of relevant skills (M95-09,10,11,12, Report SM9501) as well as for pilotage authorities to implement a safety management quality assurance system (M99-06, Report M97W0197).

The Board continues to believe that increased emphasis on information exchange, coordination and quality assurance monitoring would reduce deficiencies, improve bridge team management and advance marine safety.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 26 July 2000.

Appendix A - Sketch of the Occurrence Area



1. THE INFORMATION ON THIS SKETCH WAS COMPILED BY THE T.S.B. MARINE INVESTIGATIONS BRANCH.

2. ALL TRACKS AND POSITIONS ARE APPROXIMATE.

BASED ON ELECTRONIC NAVIGATION CHART (ENC) PROVIDED BY THE CANADIAN HYDROGRAPHIC SERVICE (CHART No 1434) AND NAUTICAL DATA INTERNATIONAL, INC.