Transportation Safety Board of Canada

Bureau de la sécurité du Canada

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

Marine Occurrence Report

Striking

by the Bulk Carrier "NIRJA" of the Tanker "HAMILTON ENERGY" Hamilton, Ontario 11 December 1993

Report Number M93C0003

Synopsis

On 11 December 1993, the bulk carrier "NIRJA", carrying a partial load of steel, was attempting to berth at a slip in Hamilton Harbour, Ontario. While turning off the entrance to the slip in strong stern winds and with three tugs assisting, the "NIRJA" did not successfully negotiate the turn and struck the tanker "HAMILTON ENERGY" which was moored alongside the oil barge "PROVMAR TERMINAL I" at the entrance to the slip. There was no injury or pollution, but the wharf and the vessels involved sustained some damage.

The Board determined that the "NIRJA", while manoeuvring in strong wind conditions under the conduct of a pilot, did not successfully negotiate the turn into the slip and struck the "HAMILTON ENERGY" because the vessel was not stopped in the available distance. The fact that the tugs were not secured to the vessel, that the anchor was not deployed and that the performance of the pilot was probably less than optimal contributed to the accident.

Ce rapport est également disponible en français.

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1.0 *Factual Information*

1.1 *Particulars of the Vessels*

	"NIRJA" ex-"ERMIS"	"HAMILTON ENERGY"
Official Number	18702-90	307998
Port of Registry	Panama	Halifax, Nova Scotia
Flag	Panamanian	Canadian
Type	Bulk carrier	Tanker
Gross Tons[1]	15,875	982
Length	190 m	59.2 m
Draught (max. at time of occurrence)	F[2]: 6.07 m A: 7.26 m	F: 10 m (estimated) A: 14 m
Built	1972, Tamise, Belgium	1965, Grangemouth, Scotland
Propulsion	ACEC/MAN, type K8Z70/120E, 8,238 kW, driving a fixed-pitch, right-handed propeller	Polar Atlas, 840 kW diesel motor
Owners	JS & S Shipping Ltd., Hong Kong	Provmar Fuels Inc., Toronto, Ontario

1.1.1 Description of the Vessels

"NIRJA"

The "NIRJA" is a conventional bulk carrier with bridge, accommodation and engine-room aft of the six cargo holds. The vessel is fitted with a bulbous bow. On the fore-and-aft centre line, there are three steel masts and six slewing derricks.

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

[2] See Glossary for all abbreviations and acronyms.

"HAMILTON ENERGY"

The "HAMILTON ENERGY" is a small, single-hull tanker used for ship refuelling in the Great Lakes area. At the time of the occurrence, the vessel was double-banked starboard side to the "PROVMAR TERMINAL I" on the north face of Pier 24.

1.2 *Description of the Voyage*

Upon arrival at Hamilton on 07 December 1993, the "NIRJA" anchored inside the harbour breakwater awaiting a berth.

On 11 December at 1100[3], a pilot boarded the "NIRJA" at anchor. Due to strong stern winds, the pilot, in consultation with the master, called for three tugs to assist in berthing the vessel.

At 1220, the port anchor of the "NIRJA" was weighed and the vessel backed out of the anchorage. When her allocated berth became available, the "NIRJA" proceeded toward Pier 23, the southernmost slip of the harbour. The pilot, who had the conduct of the vessel, the master, the officer of the watch (OOW) at the engine telegraph, and a quartermaster at the helm were on the bridge.

Between 1230 and 1240, the three tugs rendezvoused with the "NIRJA" which was off Section 27 (see Appendix A), and were positioned on the port side of the bulk carrier abreast of hatches Nos. 1, 3 and 6, respectively. The vessel was proceeding on the starboard side of the centre channel heading on to a chimney landmark beyond the channel.

At 1235, the OOW noted the vessel's approximate position as being off the knuckle of Pier 21. At 1249, when the vessel was off Section 26 and moving ahead at between three and four knots (kn) in a south-easterly direction, the main engine was stopped. The three tugs began assisting under the direction of the pilot. None was made fast to the "NIRJA".

At 1254, slow astern was ordered, followed about half a minute later by half astern. The tug abreast of hatch No. 6 was ordered to push closer to the bow in way of hatch No. 1 along with the other two tugs. When the bow reached the knuckle of Pier 23, the vessel barely began turning to starboard. At 1255, the engine telegraph was placed on full astern followed about half a minute later by emergency full astern. Subsequently, orders were given to let go the starboard anchor, but the anchor was not dropped. At 1258, the bow of the "NIRJA" came in contact with the "HAMILTON ENERGY" aft of the engine-room bulkhead.

[3] All times are EST (Coordinated Universal Time (UTC) minus five hours) unless otherwise stated.

1.3 *Injuries to Persons*

No one was injured as a result of this occurrence.

1.4 *Damage*

1.4.1 *Damage to the Wharf and Pollution*

The cement wall face of the wharf was cracked and broken over a length of 4 m. There was no pollution.

1.4.2 *Damage to the Vessels*

"NIRJA"

The "NIRJA" sustained indentation of the bulbous bow.

"HAMILTON ENERGY"

The "HAMILTON ENERGY" sustained damage to four strakes of shell plating and associated internals on the port and starboard sides in way of the engine-room. Some auxiliary machinery and piping were also damaged. The supports to the boat deck on the starboard side were also buckled.

"PROVMAR TERMINAL I"

The oil barge "PROVMAR TERMINAL I", moored between the "HAMILTON ENERGY" and the wharf, sustained damage in way of the poop deck area where the boarding ladder access platform was heavily buckled and fractured. The sheer strake plating was set in and the pump-room bulkheads, fore and aft, were buckled.

1.5 *Certification*

1.5.1 *Vessel*

The "NIRJA" was certificated, equipped and manned in accordance with existing regulations.

1.5.2 *Personnel*

The personnel on the bridge, in the engine-room and at forward stations held qualifications appropriate for the class of vessel on which they were serving and for the voyage being undertaken.

The tug masters were appropriately certificated.

The pilot was appropriately licensed for this pilotage area.

1.6 *Personnel History*

1.6.1 *Master*

The master had served in this capacity since 1984. He had been master of the "NIRJA" since April 1992 and had made several trips to the Great Lakes.

1.6.2 *Pilot*

The pilot had been with the Great Lakes Pilotage Authority since 1978. His responsibilities were primarily in the region of the Great Lakes and the St. Lawrence River District No. 2 area above Cornwall, Ontario. He had piloted several vessels in and out of Hamilton Harbour in stronger wind conditions, and had piloted the "NIRJA" on several occasions in the past.

1.6.2.1 *Pilot's Medical Requirements*

In accordance with existing regulations, the pilot had undergone his annual medical examination the previous year. Reportedly, he was not taking any medication at the time of the occurrence nor did he have any disability.

1.7 *Weather Information*

The Burlington Bridge registered northerly winds at 22 kn gusting to 28 kn. According to the pilot, the wind as reported by the Burlington Bridge operator was northerly at 20 to 21 mph (17 to 18 kn). The tug masters and the vessel's complement reported that winds were north-westerly at 25 kn, gusting to 30 kn and that, at the time of the occurrence, the winds were gusting.

1.8 *Navigation Equipment*

There was a full range of navigation equipment on board, adequate for the safe operation of the vessel. No equipment malfunction was reported and the appropriate navigation chart was in use at the time of the occurrence.

1.9 *Main Engine Operation and Manoeuvring*

The main engine is operated from the control room located in the engine-room, and orders are transmitted from the bridge by telegraph. The telegraph is fitted with an audible alarm that rings until the telegraph orders have been acknowledged. The vessel is also fitted with bridge controls for the main engine, but the use of the system had been discontinued for some time.

Astern power is generally 75 per cent of ahead power. The engine response times are as follows:

- from stop to either ahead or astern propulsion: approximately 9 seconds; and
- 25 to 35 seconds for the propeller to reach the maximum of 90 rpm from stop.

The pilot acknowledged that, while departing the anchorage, it had taken the engine nine seconds to respond. He did not complain about the main engine efficiency until after the astern movement had been ordered off the slip. He then complained that the requested astern power was not available. Several ahead and astern movements had been executed following the occurrence, and no problem was reported.

According to the pilot, the maximum rpm astern attained during manoeuvring was 90 rpm at both full astern and emergency full astern. According to the crew, the maximum rpm reached during emergency full astern was 95 to 96 as per the engine performance characteristics.

1.9.1 *Engine-room Manning*

A change of engine-room watch personnel had taken place shortly before the occurrence. There were five engineering staff in the control room at the time of the occurrence: the chief engineer (at the main engine controls), the second engineer, the third engineer, the fourth engineer and the electrician. The chief engineer was carrying out the manoeuvring, the electrician was making entries in the engine-room movement book, and the three other engineers were standing by.

1.10 *Vessel Manoeuvrability*

In the loaded condition, the vessel's speed at dead slow ahead and slow ahead is 4 kn and 6 kn, respectively, and in the ballast condition, her speed increases by 1 kn. Steerageway can be maintained at a minimum speed of 4.2 kn in the loaded condition and 4.6 kn in the ballast condition. With the engine at slow ahead and a crash stop manoeuvre executed, the vessel will travel a distance of 1.4 nautical miles (M) and take some 6 minutes to come to a stop in the loaded condition, and 0.7 M and 4 minutes 40 seconds, respectively, in the ballast condition (see Appendix B).

1.10.1 *Visibility from the Bridge*

Neither the disposition of the masts nor the derricks interfered with the navigational visibility from the bridge.

1.11 *Depth of Water and Vessel Draught*

The height of water was 0.59 m above the International Great Lakes Datum 1955, and the depth of water as depicted on Canadian Hydrographic Service (CHS) chart No. 2067 is 8.2 m. The depth of water at the time of the occurrence was therefore 8.79 m. The deepest reported draught of the vessel was 7.26 m. Sounding checks carried out after the accident confirmed the charted water depths.

1.12 *Deployment of Tugs*

Three tugs were used to assist the vessel in manoeuvring/berthing:

Name	Length	BHP
"ARGUE MARTIN"	19.51 m	800
"LAC MANITOBA"	18.56 m	800
"THE PAUL E. NO. 1"	22.28 m	1,000

None of the tugs was secured to the vessel because the pilot wanted the freedom to move the tugs along the length of the vessel as required and to avoid the tugs being caught between the "NIRJA" and any fixed structures in the area.

1.13 Communication

1.13.1 Pilot/Tug Communication

The pilot communicated with the tugs by portable very high frequency (VHF) radiotelephone. Reportedly, no communication problem was experienced.

1.13.2 On-board Communication

1.13.2.1 Helm Orders and Execution

Helm orders were given in English and, although not conversant in English, the helmsman had a complete understanding of helm orders.

According to the pilot, when the vessel was headed on to a chimney, he ordered "steady as she goes." The pilot indicated that the ship's head was going to starboard. Consequently, he ordered hard-a-port helm and dead slow ahead on the engine. Once the vessel was steadied, hard-a-port helm was maintained under the direction of the pilot, and the helm was ordered amidships when the engine was ordered astern. The pilot also indicated that execution of helm orders was not a factor in this occurrence.

1.13.2.2 Bridge/Forecastle Communication

Communication between the chief officer positioned at the bow and the master on the bridge was by means of a portable radio.

1.14 Master/Pilot Exchange of Information

The pilot was presented with the "Pilot Card" on boarding, and the exchange of information between the master and the pilot included the following:

- the ship's propeller was fixed-pitch and right-handed;
- astern propulsion would result in the bow going to starboard;
- astern propulsion was 75 per cent of ahead propulsion; and
- the engine response time was about nine seconds.

The master discussed the securing of the tugs to the vessel with the pilot and suggested to the pilot the effectiveness of using the pier knuckle to swing the vessel into the slip under the prevailing wind conditions. However, the pilot felt it would be risky to secure the tugs or to make use of the unfendered knuckle. He indicated that he would carry out his normal approach of swinging the vessel directly into the slip without securing the tugs to the vessel.

1.15 *Master/Pilot Rapport*

The rapport between the master and the pilot was reportedly good. According to the master, the pilot seemed confident; however, following the accident, he was a lot more careful. At no time did the master take over the conduct of the vessel from the pilot. As the pilot had in-depth local knowledge and as the tugs were under his control, the master allowed the pilot to continue having the conduct of the vessel. The master considered that taking over the conduct of the vessel from the pilot at a crucial stage in the manoeuvre would only have led to disruption and further compromised safety.

1.16 *Vessel Speed/Engine Response*

The pilot maintained that, while en route to the slip, the master had commented that the vessel was proceeding slowly. However, the pilot explained to the master that he would be increasing the vessel's speed from dead slow ahead to slow ahead for an additional couple of minutes (the period in question being from 1240 to 1242). Furthermore, the pilot reportedly ordered full astern four times, then emergency full astern, and subsequently ordered to let go the anchor. Although he confirmed that the telegraph in the wheel-house had been set to full astern, the pilot reported that he had not received adequate astern power. It seemed to him that the "NIRJA" was like a "dead ship" and that there were no usual indicators of progressive astern power, such as vibration or black smoke from the funnel, which led him to believe that there was some operational delay in executing the engine manoeuvre. The pilot further indicated that the engine response time was about 10 seconds from stop to slow astern, and a further 15 to 20 seconds to attain 90 rpm astern.

The deck movement book recorded the following sequence of engine movements:

1229: Slow Ahead
1236: Dead Slow Ahead
1240: Slow Ahead
1242: Dead Slow Ahead
1249: Stop
1254: Slow Astern
1254.5: Half Astern
1255: Full Astern
1255.5: Double Ring (Emergency) Full Astern

According to the pilot's recollection of events, following the recorded 1242 entry in the movement book, he ordered stop engine and steady as she goes. As the vessel's head did not steady, the pilot ordered dead slow ahead for a few moments and the helm hard-a-port before ordering stop engine.

The ship's bridge personnel indicated that there was no abnormal delay in engine response. The master reportedly expressed his concerns to the pilot and maintained that he had considered the vessel's headway to be considerable for the stern wind conditions. His concerns went unaddressed and, by 1255, he deemed it necessary to "countermand the pilot's order of Full Astern." He personally took over the telegraph from the OOW and rang "Emergency Full Astern." He then reinforced the urgency by telephoning the control room and asking for maximum astern power.

According to the engineering staff, there was no mechanical problem before, during or after the accident, and there was sufficient starting air for the main engine. All engine movements were promptly executed and the main engine responded appropriately.

One of the tug masters indicated to the pilot that the "NIRJA" was rapidly closing with the "HAMILTON ENERGY". From that tug, no propeller wash was observed until the vessel was within 60 m (200 feet) of the "HAMILTON ENERGY".

1.17 Deployment of Anchor

While the vessel was proceeding toward the berth, the boatswain was on the forecastle engaged in berthing preparations. When orders were given to let go the anchor, the chief officer was near the windlass and the boatswain was in the vicinity, but his precise position is not known. The chief officer ran forward and, after looking over the side, informed the bridge that the vessel was too close to the "HAMILTON ENERGY" and that it was unsafe to drop the anchor. There is conflicting evidence as to whether or not the master conveyed this information to the pilot. While the pilot maintained that the anchor was not ready to let go, the crew maintained that it was. The pilot based his conclusion on the fact that he did not see anyone move on the forecastle. He nonetheless also indicated that, in his preplanning for emergencies, he always ensures that the anchor is ready for immediate deployment.

The vessel's planned manoeuvre did not call for the deployment of the starboard anchor or the use of the unfendered knuckle to negotiate the turn into the slip.

1.18 Reporting of Clearances

The clearances between the vessel's bow and objects ahead were conveyed by the chief officer to the master. There is conflicting evidence as to whether or not the master relayed this information to the pilot. The pilot maintained that the tugs kept him apprised of the distances. He further commented that it is difficult to get ship personnel to keep him informed of the distances ahead. However, the pilot did not indicate having made such a request to the "NIRJA".

1.19 Collective Agreement and Hours of Work

Under the collective agreement between the Great Lakes Pilotage Authority and The Pilots' Corporation, Lake Ontario and Harbours, pilots in this region work 20 days then are off for 8 days. When on duty, the pilots must have a 12-hour rest period after each trans-lake assignment.

Pilots may, during periods of heavy traffic, volunteer their services and take on additional assignments on their designated days off.

According to the pilot, following a trans-lake assignment, the dispatcher may allocate another assignment if no other pilot is available. Pilots must ensure that they are well rested, able and willing to carry out the assignment, and decide whether or not to take on such additional assignments. The pilot indicated that he had taken on additional assignments because he was well rested.

1.19.1 Pilot's Scheduled Assignments

The pilot commenced his tour of duty on 09 December 1993 after eight days off. He had no assignment on that day. The following day, 10 December, he boarded a vessel at Port Weller, Ontario, at approximately 1530 and piloted her to Cape Vincent, Lake Ontario, arriving there around midnight. He then boarded an upbound freighter at about 0230 on 11 December and piloted her to Port Weller, arriving there at approximately 1030. He then went to the pilot office and was asked to take on another assignment in Hamilton. The ship's agent drove him to Hamilton where he boarded the "NIRJA" at about 1100. The pilot maintained that, on each of the two trans-lake assignments, he had had about five hours' sleep and was consequently rested. He also indicated that he had had to get up at Mid-Lake Ontario calling-in point (CIP) to make a report to the Vessel Traffic Centre (VTC). The accident occurred at 1300 on 11 December, some 22 hours from the time of his first assignment.

Following the "NIRJA" assignment, the pilot returned to the pilot station where he was asked to take on another (fourth) assignment which he declined.

1.20 Demand for Pilotage Services

Near the end of the Seaway navigation season, there is a demand to move a large number of foreign vessels out of the system. The pilot, therefore, responded to the increased demand for pilotage services.

1.21 *Pilotage Requirements*

To ensure safe and efficient navigation in Canadian waters where local knowledge is essential, compulsory pilotage areas have been established by the pilotage authorities and are defined in the Great Lakes Pilotage Regulations.

Under the *Pilotage Act*, a licensed pilot who has the conduct of the ship is responsible to the master for the safe navigation of the ship. Should the master, who has the command of the vessel, feel that the safety of his vessel is compromised, he may take over the conduct of the vessel from the pilot. In such an eventuality, the master is required to file an official report with the pilotage authority.

In this instance, the master did not take over the conduct of the vessel and no report was filed with the Great Lakes Pilotage Authority.

1.21.1 *Decision to Depart Anchorage*

Neither the pilot nor the master had reservations respecting berthing of the vessel in the prevailing weather conditions.

1.22 *Performance Degradation Factors*

Sleep loss and sleepiness resulting from extended duty or altered work/rest schedules have been identified as contributory factors in many industrial accidents[4].

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

Research also suggests that it is not possible to store sleep. As a person remains awake, a sleep need develops, notwithstanding how well rested the individual was at the beginning of the wake cycle. The sleep need continues building until a person goes to sleep. On average, people need 7.5 to 8.5 hours of sleep per day. A person obtaining less than his/her required sleep develops a sleep debt and will be subject to performance degradation. Performance on cognitive and vigilance tasks is particularly impaired and there is an increased propensity for

[4] Rosekind, Mark R., 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.

risk-taking by fatigued persons. "Cumulative sleep loss and circadian disruption can lead to decreased waking alertness, impaired performance, and worsened mood"[5].

Researchers at the Defence and Civil Institute of Environmental Medicine found that a 30 per cent decrement in performance on cognitive tasks can be expected after 18 hours of wakefulness[6]. Breaks or periods of low workload had no effect on performance levels. The only intervention which maintained or restored levels of performance was sleep.

People are poor judges of their own levels of fatigue and alertness. Caffeine, physical activity, or interesting conversation can mask the effects of sleep debt and fatigue. It has been demonstrated that "individuals (especially sleepy individuals) do not reliably estimate their alertness and performance"[7].

Sleep quality and duration are negatively affected by many factors, including use of stimulants, such as caffeine, time of day, light, and environment. "People tend to experience poor sleep in surroundings different than their normal place of rest"[8]; (e.g. aboard a ship on a different mattress with a different noise level and tone, vibration, temperature, and humidity).

1.22.1 *Pilot Training and Safety*

The work environment of pilots requires them to work irregular schedules which are sometimes demanding and involve work in adverse weather conditions.

The negative effects of shift work and irregular work schedules can, however, be mitigated by 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.

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

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

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

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

Material is available on work-related stress, fatigue and performance maximization for people with irregular work schedules. However, the Great Lakes Pilotage Authority has neither a directive nor an educational program in place to provide guidance to pilots.

1.23 Operational Pressures - "NIRJA"

Reportedly, there was no pressure from the owners or charterers to proceed to the slip and, during the master/pilot exchange of information, weather was not considered a factor preventing the vessel from berthing.

2.0 *Analysis*

2.1 *Non-deployment of Anchor*

Even if the boatswain was not necessarily in the immediate area at the time orders were given to let go the starboard anchor, the chief officer, after ensuring that it was safe to drop the anchor, could have returned to the windlass and executed the order, albeit with a delay of a few seconds.

As both the pilot and the master were on the bridge at the time the vessel's port anchor had previously been weighed, both should have been aware of the state of readiness of the anchor for immediate deployment. As immediate deployment of an anchor is a pre-requisite for handling emergency situations in confined spaces, both the master and the pilot should have ensured that the anchor was ready and the station appropriately manned, especially since berthing was to take place in stern wind conditions and without the tugs secured to the vessel.

The time at which orders should have been given to let go the starboard anchor would vary depending on the assessment and realization of the developing situation. If the engine did not respond appropriately and in a timely manner, the orders to let go the anchor should have been given when this was realized. The pilot's normal practice was to initiate the turn to starboard when the vessel was a ship's length away from the knuckle of Pier 23. However, on this occasion, the first astern movement had reportedly been given earlier owing to the strong stern winds, but the vessel barely started swinging to starboard when the bow was in line with the knuckle of Pier 23. Hence, the need for deployment of the anchor should have been realized well before the vessel reached the knuckle. In such a case, the anchor could have been deployed. However, if the engine responded promptly and appropriately, the order to drop the anchor should have been given when it was realized that the headway could not be stopped in time, which would be later in the manoeuvre. The evidence from the ship's personnel and the pilot is consistent with their respective positions. Thus, in the absence of an entry in the bridge movement book of the time that "let go starboard anchor" was ordered, the precise timing of the order in relation to the complete manoeuvre cannot be established nor is it possible to ascertain the precise impact that the deployment of the anchor would have had on the outcome of the occurrence.

As the pilot had the conduct of the vessel and the master was monitoring the vessel's progress, both had to have witnessed the situation developing. In any event, the anchor was not deployed in a timely manner, and the "NIRJA" struck the "HAMILTON ENERGY" because she did not successfully negotiate the turn to starboard nor was she stopped in the available distance.

2.2 *Speed of Approach*

There was conflicting evidence regarding the speed of the vessel during approach. On the one hand, the pilot maintained that the master wanted him to go faster. Since he considered this request to be reasonable, he explained that he would go from dead slow ahead to slow ahead for some two minutes (1240 to 1242) and then revert to dead slow ahead. On the other hand, the master indicated to the pilot that he considered the vessel's speed to be considerable for the conditions. In this case, any increase in speed would obviously have exacerbated the situation. However, it is known that the vessel proceeded on dead slow ahead for the major portion of the seven minutes (1242 to 1249) before the main engine was stopped prior to the astern movement. It should be noted that the manoeuvring characteristics of the vessel show that a consistent dead slow ahead movement can give a speed of 4 to 5 kn. As the master's preference was at variance with the pilot's approach, the master was well aware of the limitations/difficulties of the manoeuvre. Consequently, it is unlikely that the master would have requested the pilot to proceed faster.

Of the nine minutes before the striking, the main engine was stopped for the first five minutes, between 1249 and 1254. During the following four minutes, between 1254 and 1258, astern movements were ordered, the last three minutes of which (between 1255 and 1258) for full astern, followed by emergency full astern. The pilot provided contradictory evidence with respect to the vessel's position when full astern was ordered. While he indicated that it was given when the vessel was some two ship's lengths from the knuckle of Pier 23, the position he indicated on the chart placed the vessel one ship's length away; the latter is consistent with his normal approach practice. He also indicated that he had asked for full astern at least three times whereas the ship recorded that slow astern and half astern had been ordered before full astern. The "NIRJA" nonetheless struck the tanker. This would suggest that either the vessel's engine did not respond in a timely manner or that the vessel's headway was such that, despite timely and appropriate engine response, the vessel could not be stopped within the available distance.

2.2.1 *Timeliness of Main Engine Response*

According to the pilot, the engine response time was about 10 seconds from stop to slow astern, and another 15 to 20 seconds to attain 90 rpm astern. This is consistent with the engine operating characteristics in that it takes the engine some 25 to 35 seconds to reach full astern (90 rpm) from stop.

If it is accepted that the engine performed satisfactorily, the engine was effectively going astern for a total of about 3.5 minutes. Within this period, the engine could have been producing maximum astern rpm for less than three minutes. According to the pilot, as the vessel travelled a distance of some 1,330 m in about 25 minutes, her average speed was about 1.75 kn between 1230 and 1255. The tug master's observation placed the vessel some 60 m from the "HAMILTON ENERGY" when wash from the propeller and smoke emitting from

the vessel's stack were seen. This would suggest that the vessel covered a distance of about 60 m in some three minutes, giving her an average speed of about 0.6 kn. This corroborates both the pilot's and the master's assessments that the vessel was barely making headway at the time of the striking, and is consistent with the damage sustained by the "HAMILTON ENERGY". However, as the three tugs were positioned abreast of hatch No. 1, a considerable distance from the vessel's stern, some time had to have elapsed between the time the engine went astern and the wash of the propeller was observed from the tug. Hence no conclusion can be drawn from this observation to determine at what time the vessel's engine responded to the astern order(s). In any event, the strong wind acting on the vessel's starboard quarter in conjunction with the three tugs pushing abreast of hatch No. 1 (forward) would account for the resultant motion being maintained at the time of the striking.

2.3 *Pilot/Master Relationship and Safety*

As indicated by the master, his preferred approach to the berthing manoeuvre would have been to secure the tugs for optimal performance and to use the knuckle to pivot the vessel. He had discussed this with the pilot. However, the pilot opted, instead, to use his normal approach of making a direct turn into the slip without securing the tugs to the vessel. As the vessel had advanced too far into the berthing manoeuvre and only the pilot could communicate directly with the tugs, the master was reluctant to take over the conduct of the vessel, particularly since his preferred approach was at variance with that of the pilot. It is well known that masters are reluctant to take over the conduct of the vessel from pilots. This occurrence once again highlights the need for both the master and the pilot to concur on the overall berthing procedure/manoeuvre before commencing such a manoeuvre. The planned manoeuvre must take into consideration, among other things, the need for additional safeguards when berthing in adverse weather conditions. Such an agreement is a pre-requisite for the safe conduct of a vessel.

2.4 *Berthing Manoeuvre Considerations*

As the depth of the water was 8.79 m and the deepest draught of the vessel was 7.29 m, the vessel had an underkeel clearance of 1.5 m. As such, the underkeel clearance is not considered to have been a factor in this occurrence.

A review of the chart indicates that the width of the channel in the vicinity of the slip is about 240 m and following the turn, at slip 23, it is about 83 m. The beam of the vessel is 23 m and that of the tugs is about 6 m. The tugs could have been secured ready for immediate release without compromising their safety. As the tugs were not secured, their assistance was limited to pushing. Consequently, the tugs were not deployed for optimal performance.

Although the pilot was aware of the stern wind conditions and the limitations imposed by not securing the tugs, his planned manoeuvre did not call for the deployment of the starboard anchor or for the use of the unfendered knuckle to assist in negotiating the vessel's turn. Instead, he elected to berth the vessel without this assistance. The consequences of possible main-engine-related operational problems were not fully appreciated.

To counteract the effect of the vessel's head swinging to starboard after the main engine had been stopped, the vessel's helm, under the direction of the pilot, had been maintained at hard-a-port. The bringing of the helm to amidships earlier, before the astern movement was requested, could have initiated the vessel's swing to starboard; however, this was not done at an early stage. Further, as the tugs had not been secured to the vessel, they could not be used effectively to retard the vessel's forward motion. Since the anchor was not deployed in a timely manner, it could not be used to accelerate the vessel's swing to starboard and to retard/control the vessel's forward motion at a critical time in the manoeuvre. Thus, the pilot was left with little option but to rely on the optimal performance of the main engine and the steering in conjunction with his own optimal performance, leaving no room for error. This, however, proved unsuccessful, which would suggest that there was no contingency plan taking all pertinent factors into consideration to respond effectively to an emergency situation.

2.5 *Effect of Pilot's Rest on Performance*

At the time of the striking, the pilot was on his third assignment in a 24-hour period; the previous two had been trans-lake assignments.

The pilot departed Port Weller at approximately 1530 the day before the occurrence on his first assignment, and his opportunity to sleep on that passage would have occurred during a period of maximum wakefulness. Any sleep obtained during this time probably would not have been restorative.

Notwithstanding the requirement for a 12-hour rest period following a trans-lake assignment, the pilot boarded another vessel between 0200 and 0300, and his earliest opportunity to go to sleep would have been some time between 0400 and 0500, which is near the end of the period when he would likely obtain restful sleep.

On each of these two trans-lake passages, the pilot reportedly had five hours of sleep, but he had to wake up at Mid-Lake Ontario CIP to make a report to the VTC.

In view of the above, it is unlikely that the pilot had achieved five consecutive hours of restorative sleep and, consequently, he was likely accruing a sleep debt.

Manoeuvres such as those carried out by the "NIRJA" are demanding and require high levels of concentration, good judgement, close monitoring and immediate response to a developing situation. The pilot was familiar with the "NIRJA" and her manoeuvring characteristics, he had extensive experience which included docking vessels in stronger wind conditions than on this occasion, and three tugs were assisting in manoeuvring the vessel, but he was unable to turn the "NIRJA" successfully or to avert the striking. This would suggest that the pilot, who had the conduct of the vessel, misjudged the developing situation and did not take effective action in ample time. Judgemental errors of this type are typical of the performance of a fatigued person.

As the pilot had been on duty continuously for the last 22 hours, it is most likely that more than 24 hours had passed since his last significant sleep episode. Further, after 18 hours of wakefulness, a 30 per cent decrement in the performance of cognitive tasks can be expected. Although the pilot had obtained some sleep during his trans-lake assignments, it is probable that he was operating with a sleep debt which could compromise his ability to perform precise monitoring, control and decision-making tasks. Since the pilot's condition was not assessed on site immediately following the accident, the extent to which his performance may have been degraded by sleep debt cannot be established. However, degradation of the pilot's performance, as manifested in impaired judgement, probably contributed to the occurrence.

As people are poor judges of their own fatigue and alertness levels, it is unlikely that the pilot's self-assessment in accepting a second and a third assignment was objective, more so as continuing to work involved personal financial benefit.

The negative effects of shift work and irregular work schedules can be mitigated by a combination of sleep schedules and control of one's environment and diet. In this instance, the pilot had control over sleep but limited control of his environment and diet. The fact that the pilot did not avail himself of a 12-hour rest period after each trans-lake assignment, but instead opted to carry out two trans-lake assignments followed by the berthing of the "NIRJA" within a period of 22 hours without restorative sleep, suggests that he did not fully appreciate the negative effects of shift work and irregular work schedules on his performance.

2.6 *Pilot Assignments and Safety*

As the Seaway navigation season draws to an end and vessels attempt to clear the Seaway, additional demands are placed on pilots. This is reflected in the pilot having been given, and carrying out, three assignments over a 22-hour period and having been asked to take on another (fourth) local assignment after he had been involved in the striking. While the collective agreement allows off-duty pilots to volunteer their services and take on additional assignments, nothing in the rules allows on-duty pilots to volunteer their services and take on additional assignments. On-duty pilots cannot take on additional assignments (following a trans-lake assignment) without having 12 hours of rest, except in extenuating circumstances. Nonetheless, evidence indicates that, following a trans-lake assignment, the dispatcher may allocate another assignment if no other pilot is available. However, before taking on the assignment, it is incumbent upon the pilot to ensure that he is well rested, and able and willing to carry out the additional assignment. The pilot maintained that he was well rested. In the absence of any training program to help pilots better appreciate the negative effects of their work environment, the decision to take on additional assignments can, in part, be influenced by other considerations, such as personal financial benefit, to the detriment of vessel safety.

3.0 Conclusions

3.1 Findings

1. The vessel attempted to berth in strong stern wind conditions.

2. The vessel did not successfully negotiate the turn to starboard and her approach speed was such that she was not stopped in the available distance.

3. The anchor was not deployed in sufficient time to ensure its desired effect; i.e., to successfully negotiate the turn or avert the striking.

4. The tugs were not effectively deployed for optimal performance and could not be used to retard the forward motion of the vessel at a critical point in the manoeuvre.

5. At a critical stage in the vessel's manoeuvre, the pilot was limited to the use of the main engine to retard/control the vessel's forward motion.

6. It is possible that the vessel's engine did not respond to the full astern movement(s) in a timely manner or that the orders were given too late to stop the vessel before the striking.

7. The cumulative effect of the strong stern winds and of the tugs pushing at the forward end of the vessel would account for the resultant motion at the time of the striking.

8. Following two trans-lake assignments, the "NIRJA" was the pilot's third continuous assignment allocated by the dispatcher.

9. The pilot was required to rest for 12 hours following a trans-lake assignment, but he did not.

10. The pilot had been on duty for some 22 hours without restorative sleep and this probably adversely affected his performance.

11. The demands to clear large numbers of vessels from the Seaway system before its closure was, in part, responsible for the pilot being given additional assignments.

12. Research indicates that persons suffering from sleep debt may not be capable of objectively assessing the negative effect of their irregular work schedules on their performance.

13. There is neither a directive nor an educational program in place to provide guidance to pilots regarding work-related stress, fatigue and performance maximization associated with work schedules/environment.

14. Although the master raised some concerns regarding the manoeuvre, he relied on the pilot's local knowledge and experience.

3.2 *Causes*

The "NIRJA", while manoeuvring in strong wind conditions under the conduct of a pilot, did not successfully negotiate the turn into the slip and struck the "HAMILTON ENERGY" because the vessel was not stopped in the available distance. The fact that the tugs were not secured to the vessel, that the anchor was not deployed and that the performance of the pilot was probably less than optimal contributed to the accident.

4.0 *Safety Action*

4.1 *Action Required*

4.1.1 *Pilot Assignments*

The Board has two specific concerns arising out of this occurrence. First, current pilotage assignment practices permit extended duty days such that significant performance degradation can occur. Secondly, both the Great Lakes Pilotage Authority and the pilots themselves apparently do not fully appreciate the negative effects of fatigue on performance and the strategies for mitigating those effects.

In the marine transportation industry, work schedules and working conditions are often conducive to fatigue-induced degradation of performance. Implicitly, the pilots' collective agreement does recognize the need for a fixed period of rest following trans-lake assignments. However, as evidenced by this occurrence, this rest requirement is not rigorously applied. It is understood that the American Pilotage Authority does enforce a "10-hour bridge-to-bridge"[9] rest period following trans-lake assignments.

The Board recognizes that seasonal peaks in Seaway traffic, such as at the close of the navigation season, create increased demand for pilotage services. Flexibility in scheduling is provided by allowing pilots to take extra assignments on their scheduled days off. However, the current practice for allocating extra pilotage assignments puts the onus on the pilots to decide if they are sufficiently rested to accept the additional work. Yet, studies have shown that sleep-deprived individuals tend to underestimate their level of fatigue. Further, the Board believes that pilots are being put in the difficult position of making a safe decision, while standing to gain personal financial benefit from accepting the extra assignment.

Given the vulnerability of individuals in safety-sensitive positions to significant errors in judgement when fatigued, and given the potential consequences of such errors, the Board believes that mandatory rest provisions should be strictly enforced in the assignment of marine pilots. Therefore, the Board recommends that:

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

[9] Period between the end of one assignment and the beginning of the next one.

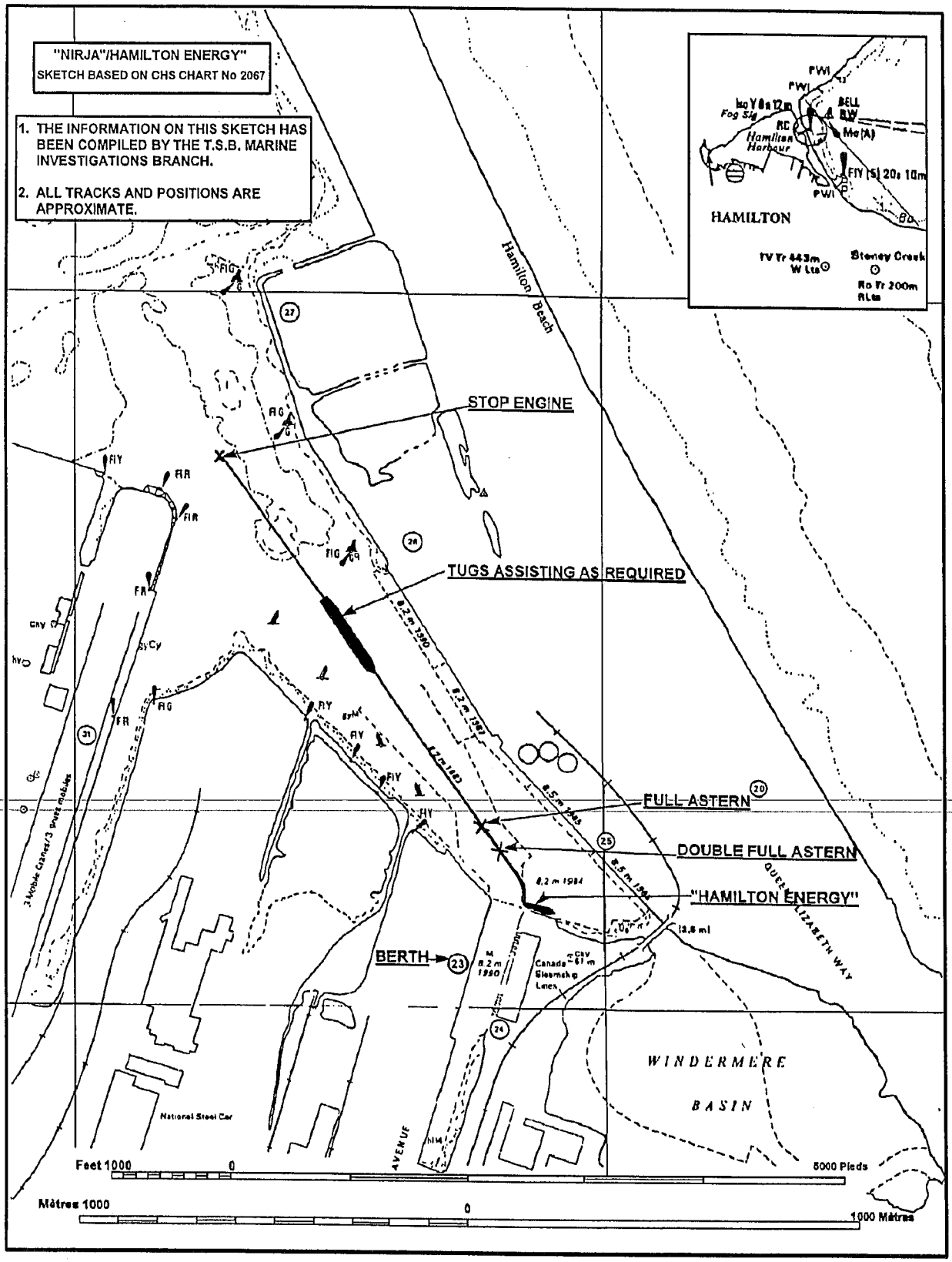
The Board recognizes that strict enforcement of mandatory rest periods will not in itself ensure that no pilot will suffer the adverse effects of fatigue. Many factors beyond pilot scheduling can affect a pilot's performance while on duty. Many of these are controllable by the pilots themselves in terms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

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

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

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 December 1996.

Appendix A - Sketch of the Area of the Occurrence



Appendix B - Manoeuvring Characteristics of the "NIRJA"

Note: *The manoeuvring characteristics are based on calm weather, no current, and water depth twice the vessel's draught or greater.*

(1) **Main Engine Manoeuvrability**

Speed	rpm	Speed when Loaded	Speed when in Ballast
Full Sea	118		
Full Manoeuvring	90	10 kn	11 kn
Half Ahead	75	8 kn	9 kn
Slow Ahead	65	6 kn	7 kn
Dead Slow Ahead	50	4 kn	5 kn
Dead Slow Astern	50		
Slow Astern	65		
Half Astern	75		
Full Astern	90		
Emergency Full Astern	95-100		

(2) **Vessel Manoeuvrability**

Condition	Speed	Advance	Transfer
Loaded	Half Ahead	592 m	563 m
Ballast	Half Ahead	612 m	588 m

(3) **Crash Stop**

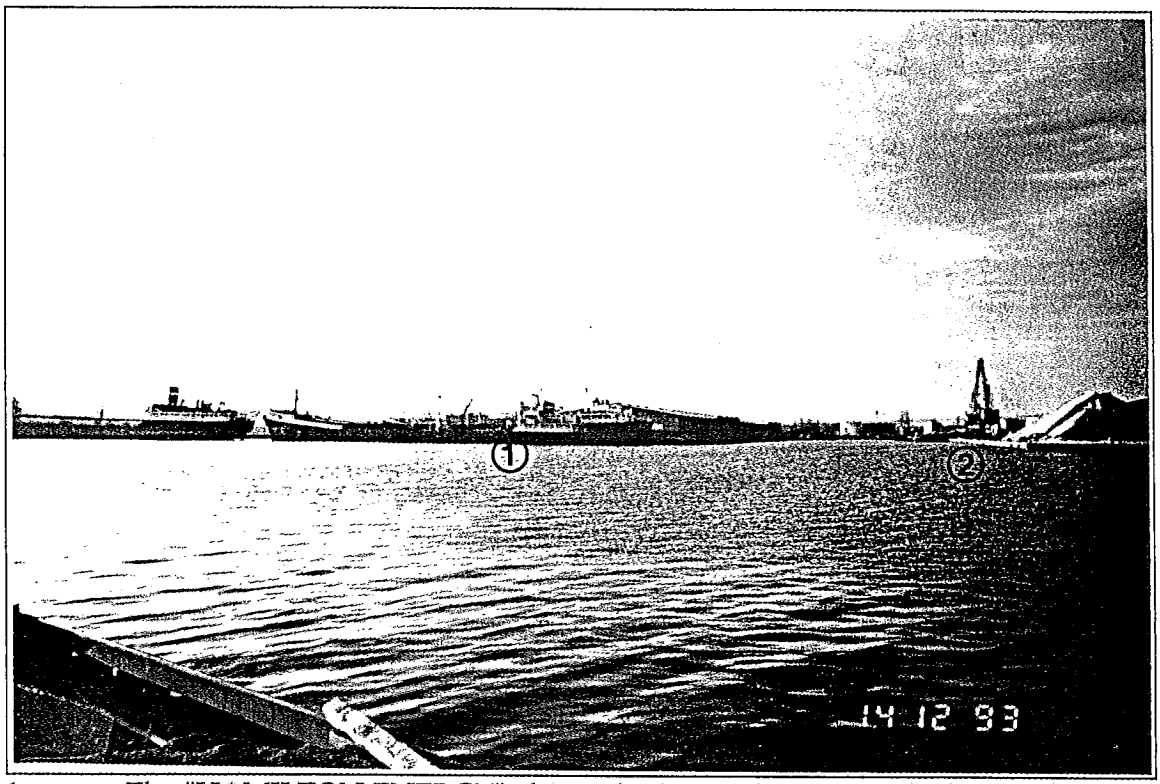
Speed	Loaded		Ballast	
	Time	Distance	Time	Distance
Full (sea)	7'50"	2.3 M	6'05"	1.30 M
Full (manoeuvring)	7'25"	1.9 M	5'00"	0.95 M
Half	6'55"	1.6 M	4'45"	0.65 M
Slow	6'00"	1.4 M	4'40"	0.70 M

(4) **Minimum Steering Speed**

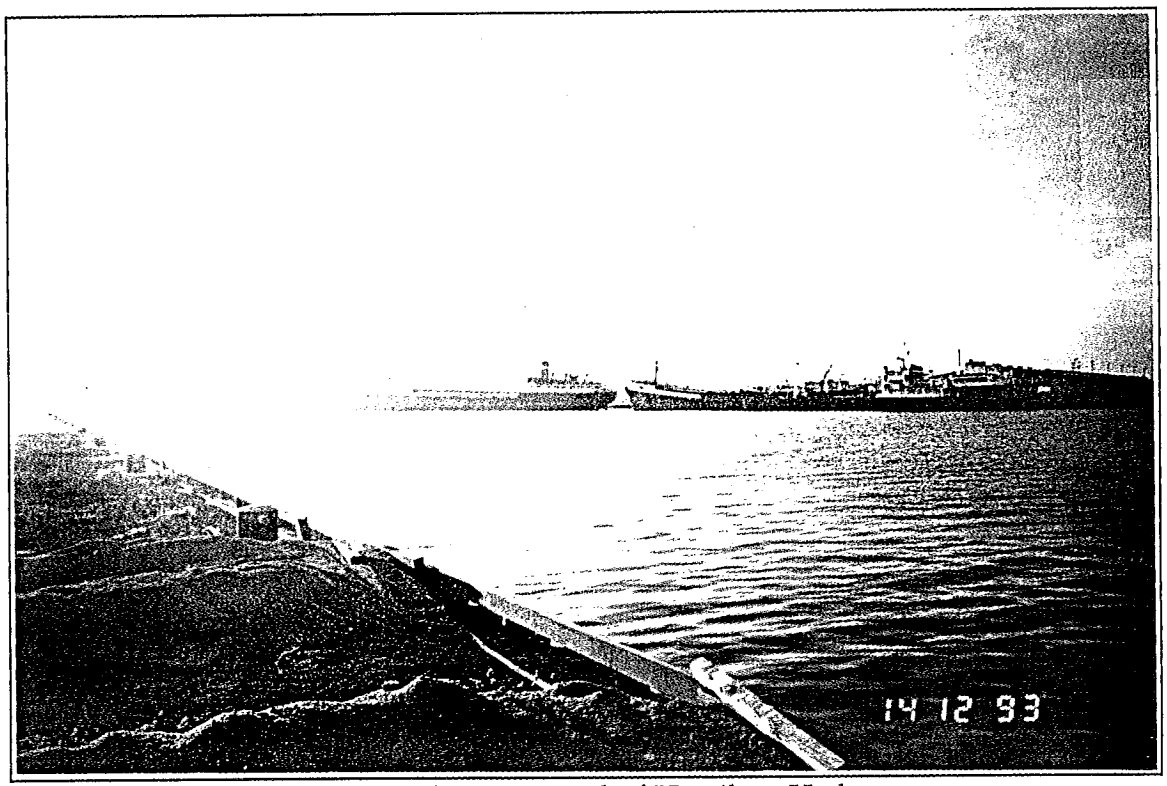
Normal Loaded Condition	4.2 kn
Normal Ballast Condition	4.6 kn

Note: *Being partially loaded on this occasion, the vessel required approximately one mile to carry out a crash stop as she proceeded at slow speed.*

Appendix C - Photographs



1. The "HAMILTON ENERGY" alongside the "PROVMAR TERMINAL I".
2. Crane at the right side of the slipway shows berthing location for the "NIRJA" (at Pier 23).



Narrow south-eastern end of Hamilton Harbour.

Appendix D - Glossary

A	aft
BHP	brake horsepower
CIP	calling-in point
CHS	Canadian Hydrographic Service
EST	eastern standard time
F	forward
IMO	International Maritime Organization
kn	knot(s): nautical mile(s) per hour
kW	kilowatt(s)
M	nautical mile(s)
m	metre(s)
mph	mile(s) per hour
OOW	officer of the watch
rpm	revolution(s) per minute
SI	International System (of units)
TSB	Transportation Safety Board of Canada
UTC	Coordinated Universal Time
VHF	very high frequency
VTC	Vessel Traffic Centre
′	minute(s)
"	second(s)