MARINE INVESTIGATION REPORT

M99W0145

GROUNDING

BULK CARRIER “MANDARIN ARROW”

DUNCAN BAY, BRITISH COLUMBIA

17 AUGUST 1999

Marine Investigation Report

Grounding

Bulk Carrier "MANDARIN ARROW"
Duncan Bay, British Columbia
17 August 1999

Report Number M99W0145

Summary

The "MANDARIN ARROW" was en route from Kitimat, British Columbia, to Duncan Bay, British Columbia, under the conduct of a British Columbia coast pilot. During the approach to a wharf in Duncan Bay, with two tugboats assisting, the vessel grounded approximately 25 metres from shore. The pilot notified the authorities, while the master and crew carried out damage assessment. Approximately 55 minutes later, the vessel refloated on a rising tide and was berthed at the wharf without further incident. The vessel remained alongside the berth while temporary repairs were completed. No injury or pollution was reported as a result of this occurrence. However, the "MANDARIN ARROW" sustained extensive damage to her shell plating.

Ce rapport est également disponible en français.

Other Factual Information

Particulars of the Vessel

	"MANDARIN ARROW"
Official Number	728077
Port of Registry	Nassau, Bahamas
Flag	Bahamas
Type	Bulk Carrier
Gross Tonnage[1]	35 998
Length	199.7 m
Draught	Forward: 8.00 m Aft: 9.65 m
Cargo	Forest products and soda ash
Built	1996, Dalian, China
Propulsion	Diesel engine, 11 520 kilowatt; one fixed-pitch propeller
Crew	21
Owner(s)	Kristian Gerhard Jebsen, Bergen, Norway

Description of the Vessel

The "MANDARIN ARROW" is a general cargo vessel with 10 cargo hatches and two moveable gantry cranes. The wheelhouse, machinery, and accommodations are all housed in one superstructure located at the after end of the vessel. The distances from the superstructure to the vessel's bow and stern are approximately 170 m and 30 m, respectively.

The wheelhouse has an open layout, with the steering console recessed in the middle and the chart table behind the steering console. A gyro repeater with azimuth mirror is located on each bridge wing and a third is mounted in the wheelhouse, on the forward bulkhead, in the centre line. Two radars and consoles with various controls are located next to the forward bulkhead. One radar is mounted to the left, and the second radar and pulpit with engine controls is to the right of the wheelhouse gyro repeater.

The clock and the vessel's speed and revolutions per minute (r/min) indicators are mounted on the forward bulkhead in front of the steering console. The rudder indicator is located on the deckhead in front of the steering column and is easily visible from every position inside or outside the wheelhouse.

[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.

The propulsion machinery of the "MANDARIN ARROW" consists of one reversible main engine driving one right-handed, fixed-pitch propeller. It may be controlled either from the engine control room or directly from the wheelhouse or from either bridge-wing. At the time of the occurrence, the wheelhouse-control mode was in use.

The vessel is fitted with a 2040 brake horsepower bow thruster and Schilling rudder; the latter, when fully deflected, renders the effect of a stern thruster. Reportedly, both were used by the bridge team prior to and during the occurrence.

Description of the Site

Duncan Bay is a body of water in Johnstone Strait lying approximately four miles south of Seymour Narrows. It is bounded by Vancouver Island to the west and open to the northeast. Located in Duncan Bay is a large pulp and paper mill which owns and manages three wharves: a pulp wharf, a paper wharf, and a barge-loading facility. The pulp wharf, to which the "MANDARIN ARROW" was allocated, is 152 m long and extends into the bay at 15 degrees True (°T), almost parallel to the shore; it has a mooring dolphin located at its north end (see Appendix A).

History of the Voyage

The "MANDARIN ARROW" departed Kitimat partially loaded on 16 August 1999 at 0200. Her deadweight was 28 685 tonnes (t); her total displacement was 43 510 t. With two British Columbia (B.C.) coast pilots on board, the vessel proceeded to Duncan Bay. The trip along the B.C. coast was uneventful; the pilots took turns conning the vessel while the master and crew performed their normal duties.

On August 17, shortly after 0400, she transited Seymour Narrows. After passing Race Point at 0436, the pilot began slow-steaming the vessel in order to approach the berth not sooner than 0600 (as the shore linesmen were not available before this time). The quartermaster was hand-steering; the master and officer of the watch (OOW) were also in the wheelhouse.

As the distance to go was only about two and a half miles, the speed was reduced substantially, and the engines were stopped occasionally. To maintain steerage at this low speed, the bridge team used the bow thruster. This was handled by the OOW, while the master oversaw the performance of both the vessel and bridge team. While it was slow-steaming, the vessel reportedly remained to the west of the wharf's axis, and the pilot observed that the current, which had just turned to flood, was setting slightly in a southwesterly direction.

At 0520 two tugboats, the "REGENT" and the "SEYMOUR CROWN", arrived to assist the "MANDARIN ARROW" in the final approach to the pulp wharf. Neither the "REGENT" nor the "SEYMOUR CROWN" are dedicated docking tugs. They perform this task when available and when not engaged in other regular towing duties. Reportedly, the pilot receiving information from one of the tugboats that the current set near the wharf's outer end was not significant. He ordered the "SEYMOUR CROWN" to the vessel's port quarter and the "REGENT" to stand-by off the starboard bow and await orders—with both being ready to push. The crew on the bow was instructed to walk out the starboard anchor to above the water level and leave it in gear. The master considered both these orders to be standard precautionary measures.

When the "MANDARIN ARROW" was approximately four cables from the dolphin, on a heading of about 120°T, the pilot initiated a starboard turn towards the berth. At the same time, the current began to set the vessel southward.

When the "MANDARIN ARROW" was almost parallel to the wharf with the bow approximately 100 m from the dolphin, the pilot attempted to stop the turn but the starboard swing continued. Simultaneously, the vessel was rapidly setting bodily towards the rocky shoal on her port side. It appeared that the hull was pivoting clockwise around the bow. The pilot ordered the stand-by tug to go to the port quarter and both tugs to push on the vessel's port side. The bow thruster was set to thrust the bow to starboard with full power and the starboard anchor was let go with approximately 25 m of cable.

The rudder was moved hard to port which, with the propeller working ahead, was intended to arrest the swing and move the stern away from danger. When these countermeasures were observed to be having no effect, both the master and the pilot decided to abort the approach and reversed the engine to withdraw the vessel, stern first. The engine was reversed, first at 51 r/min and then, gradually over the following two minutes, this was increased to 85 r/min. However, before the vessel could begin to move astern, she swung to approximately 268°T, touched the ground, and then swung back and stopped on a heading of 233°T.

Immediately after the vessel went aground, the pilot notified the authorities and ordered an additional tugboat sent to the site of the grounding. The master and the crew began implementing damage assessment and pollution control measures. All tanks and bilges were checked. It was established that the contact with the bottom was made by the vessel's port side hull in the vicinity of holds Nos. 2 and 3.

At approximately 0552 the requested third tugboat arrived and, after some ballast water was pumped out, the vessel was fully refloated at 0630 on a rising tide. The subsequent berthing operation was uneventful, and the "MANDARIN ARROW" berthed port side to the pulp wharf at 0742.

Course Recorder, Event Log, and Compass

The vessel's course recorder interfaced with gyrocompass shows that the course steered between approximately 0438 and 0520 oscillated about the heading of 150°T. From 0520 till 0524, the vessel turned to port until the heading reached 128°T, thence she momentarily veered to starboard. At approximately 0536, the heading reached 268°T. Subsequently she swung back to port until the heading steadied at 233°T at 0540 for approximately 55 minutes while the vessel was grounded.

The vessel's event log shows the following engine movements:

Time	Main engine r/min
0500 – 0533	Changed from astern 40 to ahead 44, with frequent stops
0533:11	Ahead 55

0538:05	Stop
0538:21	Astern 51
0538:39	Astern 70
0539:07	Astern 79
0540:33	Astern 85
0540:57	Stop
0540:57 – 0622:27	No engine movement recorded

The *Bell Book* contains the following pertinent entries:

0413	Separation Hd @ 0.59' off
0419	Plumper Pt. @ 0.39' off
0426	Maud Is. @ 0.20' off
0436	Race Pt. @ 0.38' off
0500	Middle Pt. (Brg) 293°T @ 0.8' off
0540	Vessel aground
0552	Tug Ballantyne Straits arrived
0629	Vessel start moving astern

Damage

Shortly after berthing, a team of divers, surveyors, and owners' representatives began damage assessment, and an underwater video was taken. Bottom plating indentations were found along port side wing water ballast tanks Nos. 1, 2, and 3. The port side bilge keel was bent and the bilge strake between frames 162 and 163 was found fractured, with rocks inserted in the crack.

As requested by Transport Canada Marine Safety and classification society surveyors, temporary repairs were carried out while the vessel was conducting loading operations alongside the pulp wharf. The most serious damage—fracture of tank No. 3—was provisionally covered with an outside cement box. At 1048 on August 18 the "MANDARIN ARROW" sailed for Nanaimo, B.C. On August 19 she departed Nanaimo and arrived in Vancouver, where the repairs were completed. A steel box was welded inside tank No. 3 to cover the fracture. After the repairs had been completed, the vessel obtained a Seaworthiness Certificate and sailed to her destination in Europe on August 23.

There were no injuries or pollution as a result of this occurrence.

Certification

Vessel

At the time of the occurrence, all the vessel's certificates were valid. A Cargo Ship Safety Certificate was issued by Det Norske Veritas in Oslo, Norway, on 20 November 1998. The last Port State Control Inspection was conducted in China on 5 April 1999; no deficiencies were found. She was last dry-docked in Ulsan, Korea, in April 1999.

Vessel Personnel

The master of the "MANDARIN ARROW" held a Master Foreign Going Certificate of Competency, issued in the United Kingdom in 1979, and renewed in 1998. He had 30 years of sea service on various cargo vessels in worldwide trade, including 18 years as master. Since 1991 he had served as master with the owners of the "MANDARIN ARROW". During the three years previous to this occurrence, he served as master of this vessel on a four-months-on/four-months-off basis.

The Chief Officer, who was performing wheelhouse duties during the occurrence, held a Master Mariner's Certificate of Competency issued in Manila on 4 November 1998. He had accumulated approximately 13 years of sea time, approximately three of which were as Chief Officer.

The two remaining deck officers on board the "MANDARIN ARROW" held competency certificates of appropriate grades.

Pilot

The pilot held a Canadian Master Mariner's Certificate of Competency, issued in 1982, and a Pilot's Licence class 1, issued in 1996. He had attended all the required upgrading courses: automatic radar plotting aid (ARPA); radar; marine emergency duties (MED); and shiphandling. Up to 1995 he accumulated a total sea time of approximately 28 years on various Canadian tugboats and Coast Guard vessels. Since 1995 he had piloted a wide range of cargo vessels through most of the navigable waters of the B.C. coast, including several trips to and from Duncan Bay. He completed a bridge resource management (BRM) course in June 1997. Prior to becoming a pilot, for a number of years he had operated a fleet of fish packers from Brown Bay (six miles to the north) and was in and out of Duncan Bay on a regular basis.

Fatigue

The "MANDARIN ARROW" arrived Kitimat at 0214, August 11, and departed August 16 at 0200. After departure, the watch standing officers of the "MANDARIN ARROW" performed their normal shipboard duties.

During the five days in port the master was afforded the time to rest. After the departure from Kitimat, due to intermittent fog experienced during the passage, he was required several times on the bridge in addition to conducting his other duties. He slept between 0400 and 0700 on August 16, and again between 1300 and 1500.

He was called to the bridge from 1900 until 2030 with a further rest between 2030 and 2200. After 2200 he was on the bridge until arrival at Duncan Bay on the morning of August 17, giving a total of 6½ hours sleep in the 28-hour period from departing Kitimat.

Although the master's circadian rhythm had been disrupted, and the accident happened at 0540, less than eight hours had elapsed since his last rest and his 72-hour sleep history does not suggest a sleep debt.

The pilotage during the passage was shared equally between the two pilots, each of whom rested when not conning.

Weather and Current Information

The weather throughout the passage from Kitimat to Duncan Bay was described as cloudy with occasional fog patches. During the approach to the berth, there was a very light wind, a calm sea surface, and very good visibility.

Duncan Bay is subject to large mixed-type tides that generate strong reversible currents. The Canadian *Sailing Directions for B.C. Coast, Southern Portion* warns mariners:

> In navigating the coast where the tidal range is considerable, caution is always necessary . . . . Arrows on charts show the usual or the mean direction of a tidal stream or current. It must never be assumed that the direction of the stream will not vary from that indicated by the arrow.

Oceanography of the British Columbia Coast[2] states that Johnstone Strait is:

> . . . characterized by swift and rectilinear tidal currents. In the vicinity of shallow sills and constricted narrows, surface currents are accelerated even further, and take on a turbulent jetlike nature, generally associated with quasi-permanent tidelines that delineate rapid cross-stream changes in speed and direction of the set.

The same publication refers to Seymour Narrows:

> . . . as an illustration of the maximum strength attainable by tidal currents in the world ocean and to demonstrate their hazard to navigation . . .

It states that the waters in the vicinity of and south of the Narrows are especially affected by the tidal currents.

Canadian Hydrographic Service (CHS) charts used on board the "MANDARIN ARROW" —CHS 3539 and CHS 3540—show several arrows delineating the currents during flooding and ebbing phases of the tide (see Appendix A). One arrow is placed just north of the pulp wharf in Duncan Bay. It shows the ebbing current in

---

[2] R.E. Thomson, *Oceanography of the British Columbia Coast,* Canadian Special Publication of Fisheries and Aquatic Sciences. Bulletin 56, Fisheries and Oceans Canada, Ottawa (1981).

an easterly direction. There is no matching arrow referring to the flooding current in the vicinity of the wharf, although all other references to the tidal currents on the chart are paired.

According to the *Canadian Tide and Current Tables,* Volume 6, the tide at Duncan Bay was rising at the time of the occurrence, with low water predicted to be at 0435, and high water at 1032 (see Appendix B). This suggests the beginning of a flooding current; however, according to information obtained from the CHS, the current flow in Discovery Passage is driven by the difference in water level between the Strait of Georgia and Johnstone Strait. The relationship between the water level in Duncan Bay and the current in Discovery Passage is a complex and unpredictable one; the state of one cannot be inferred from the state of the other.

The CHS Geomatic Engineering Branch monitors and analyses the tides and currents in Canadian waters. In reference to Duncan Bay, it states that the transition period between ebb and flood may show large flow variations as the new pattern is established. The arrows shown on the charts only hold true once the ebb or flood is fully established. The absence of arrows does not imply the absence of significant currents.

The Pacific Pilotage Authority (PPA) has acknowledged that currents can create difficulties for large deep-sea vessels berthing in Duncan Bay. On 24 September 1993 the PPA issued a memo to shipping agents and coast pilots in which it recommended that, due to the extreme and unpredictable nature of the currents, the accessory horsepower for berthing in Duncan Bay be 50 percent greater than that normally required for docking and undocking. A "rule of thumb" is a minimum of five percent of the vessel's registered summer deadweight, converted to horsepower. Consequently, the PPA memo recommends that the numeral denoting accessory power for Duncan Bay be 7.5 percent of the numeral indicating a vessel's summer deadweight.

The summer deadweight of the "MANDARIN ARROW" is 51 733 t. The "REGENT" and "SEYMOUR CROWN" have 1050 and 730 brake horsepower, respectively; the vessel's bow thruster is rated as having 2040 brake horsepower. Thus, the combined horsepower of the tugs and the bow thruster was 3820, approximately 7.4 percent of the vessel's summer deadweight.

Previous Incidents

During berthing in Duncan Bay in August 1994, the "STAR EVANGER" was suddenly set eastward; it struck and heavily damaged the pulp wharf. The TSB investigation into that occurrence found that a subsurface current was acting on the vessel, causing her to move sideways.[3]

Since 1974, 22 instances of a deep sea vessel striking a wharf while berthing in Duncan Bay have been recorded. Each of these strikings, like the grounding of the "MANDARIN ARROW", originated with a sudden set or a swing of the manoeuvring vessel caused by currents. (On only two occasions was wind considered to have been a factor.) In these occurrences, the current was at various stages when the sudden surge hit the vessel; collectively, they show no consistent pattern of the set that could be linked with the tide in Duncan Bay, or with the known current stage in nearby waters.

---

[3] TSB Report No. M94W0070

Analysis

The number of instances in which a large vessel has experienced serious difficulties during berthing operations in Duncan Bay supports the warnings published in the *Sailing Directions* that the currents in this body of water may be unpredictable and strong. When the "MANDARIN ARROW" was approaching the pulp wharf, the tide was at its early flooding stage. One of the tugs reported that no significant current set was near the wharf; yet, a few minutes later, the "MANDARIN ARROW" moved rapidly sideways.

With a total displacement of 43 510 t, a very large force would be required to move the "MANDARIN ARROW" sideways. As there was no wind and no apparent surface current a few minutes earlier, the origin of the force was likely either a sudden surge of surface current or a subsurface current that did not affect the shallower-draught tugboats, or both.

The TSB investigation into the striking of the pulp wharf by the "STAR EVANGER" cited a subsurface current as one of the probable causes leading to that occurrence. The unpredictable nature of the currents in Duncan Bay—and their effect on manoeuvring vessels—has been acknowledged by the PPA, which determined that the total accessory power available in Duncan Bay should be greater than that normally needed for berthing. The recommended accessory power level is a somewhat imprecise calculation, based on experience. As the "MANDARIN ARROW" was only partially loaded, the available accessory power (7.4 percent of the summer deadweight) was within the range considered sufficient to bring her safely alongside.

However, as the tugs were not using securing lines, the actual horsepower available at any given moment was limited to that of the bow thruster and one (pushing) tug. The combined horsepower of the bow thruster and the tug on the port side was only 2770, or 5.3 percent of the summer deadweight. Furthermore, the two tugs were not designated docking tugs—one of the reasons the pilot did not secure them to the "MANDARIN ARROW".

When the "MANDARIN ARROW" started moving bodily towards the shore, the pilot ordered the tug from the starboard side to shift to the port side. Without any attachment to the vessel, it was the only method by which he could use this tug's power to counteract the set. The tug executed the order; however, time was lost while it moved around the stern of the "MANDARIN ARROW". Had there been a line from the vessel secured to the tug's bow, the latter might have started pulling the "MANDARIN ARROW" almost immediately (if so desired) after the bridge team noticed the vessel's unwanted movement.

Other countermeasures applied by the bridge team, i.e. the use of bow thruster, starboard anchor, main propulsion, and rudder, were appropriate in the existing circumstances. The tugs and the bow thruster were supposed to push the vessel against the current and away from danger. The main propulsion in the ahead mode together with (very effective) Schilling rudder in the hard-to-port position undoubtedly produced a turning force opposing the set of the current.

Subsequently, the master and the pilot changed their original order and reversed the propulsion to abort the approach. At the time the propeller was reversed, the heading was approximately 240°T and the vessel was swinging to port from 268°T. While it is uncertain whether the ahead thrust with full port side rudder would have stopped the vessel from running aground, the attempt to abort the approach at this stage could not have

produced the desired results. When it was executed, the port side was probably only about 25 m from the shoal, and the distance was closing.

The "MANDARIN ARROW" grounded and the engine was stopped at 0540:57; it had been running astern for approximately two minutes, and at full power for only part of that time. Even if the vessel had had no forward motion, it would have taken more time for the astern thrust to overcome her mass, accelerate, and pull astern. The athwartships momentum continued during this time, and the vessel closed the distance to the rocky shoal faster than the reversed propulsion could move her *past* the shoal. Additionally, the right-handed propeller in the reverse mode produced, at the stern, a lateral thrust to port that augmented the existing sideways motion.

The immediate post-accident orders and undertakings by both the crew and the authorities were appropriate in the circumstances. In its evaluation of the berthing conditions in Duncan Bay, the PPA studied this occurrence and 22 similar occurrences. The PPA subsequently made a number of recommendations which, if implemented, are likely to improve berthing conditions in Duncan Bay.

Findings

1. The "MANDARIN ARROW" grounded while approaching a berth in Duncan Bay when a current suddenly set her to the east and off the planned path.

2. The currents in Duncan Bay have been known to cause berthing difficulties in the past.

3. Currents in the Duncan Bay area do not follow a pattern that allows for accurate prediction.

4. In 1993 the PPA recommended that vessels berthing in Duncan Bay have available accessory horsepower 50 percent greater than that normally required for docking and undocking in other berthing circumstances.

5. The tugs assisting the "MANDARIN ARROW" were not designated docking tugs and were used in the pushing mode only.

6. The abort manoeuvre was initiated too late to have the intended result of withdrawing the vessel from danger.

7. The "MANDARIN ARROW" sustained extensive damage to her shell plating.

Causes and Contributing Factors

The vessel grounded as a result of being set suddenly onto a shoal. Contributing to the occurrence was the fact that, at this stage of the tide, currents in the area are unpredictable, the manoeuvres to withdraw the vessel from danger were undertaken too late to have the intended result, and the assisting tugs were not of a design well suited to assist in the docking of this large vessel.

Safety Action

In October 1999 the PPA's Safety and Operational Review Committee reevaluated the issue of berthing difficulties in Duncan Bay and made several recommendations:

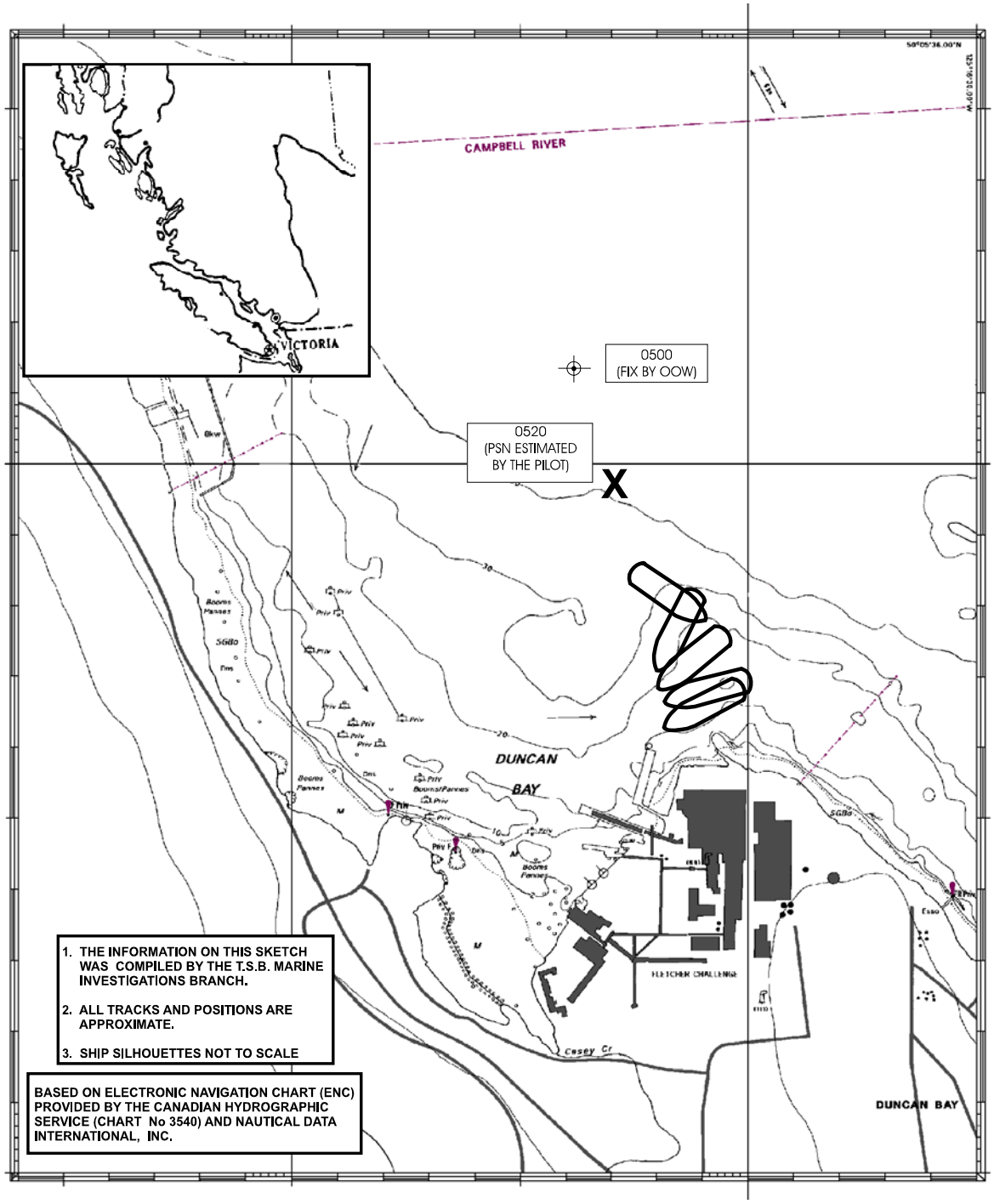
- simulator training specifically addressing the Duncan Bay area and conditions;
- an increased number of apprenticeship trips into Duncan Bay;
- review of the currency and familiarization trips into Duncan Bay;
- evaluation of the usefulness of current meter(s) in Duncan Bay;
- assurance that two suitable twin-screw docking tugs are available; and
- the placing of leading lights (ranges) along the wharf face as a guide to berthing vessels.

Additionally, the PPA emphasizes BRM principles and reminds its pilots to ensure that masters are made aware of both the planned approach and an alternative abort plan. Furthermore, the PPA advises that information available to pilots should be shared with shipping companies in order that vessel navigation personnel can be fully informed in advance of a trip of any special circumstances pertaining to their intended passage.

In March 2000 the Duncan Bay simulation was completed and training commenced for both senior and apprentice pilots on the full-mission bridge simulator at Star Centre in Dania, Florida, USA.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 13 February 2001.

Appendix A — Sketch of the Occurrence Area

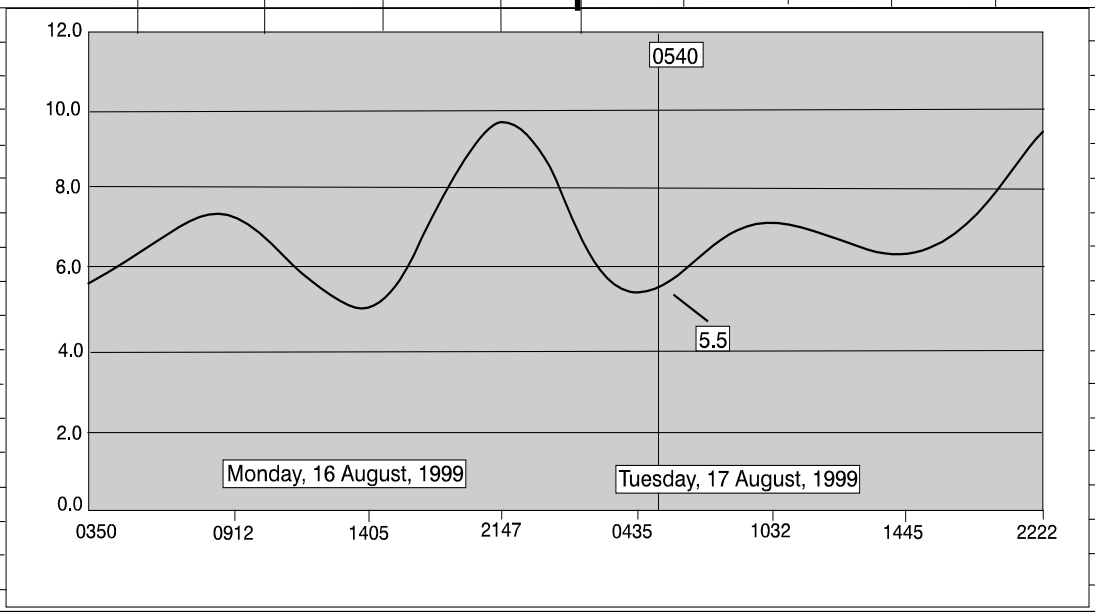


Appendix B — Tidal Calculations

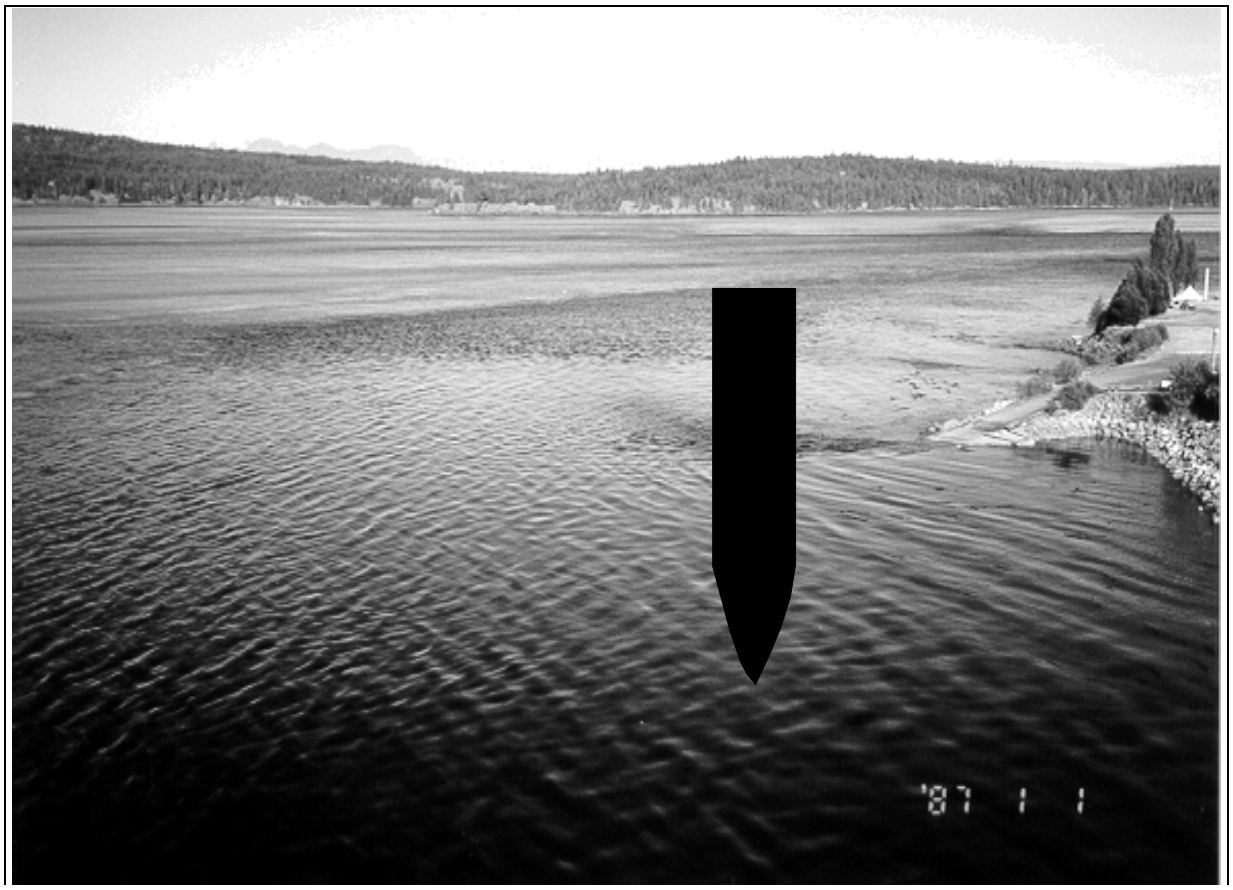
Location	**DUNCAN BAY, B.B.**		
		50°05'N	125°18'W
LOCAL TIME		**PDST**	
HIGHS AND LOWS		**In FEET**	
YY/MO/DD		**TIME**	**HT.**
		HHMM	**FEET**
		0350	5.7
		0912	7.3
		1405	5.1
		2147	9.6
1999/08/16 TUE		0435	5.4
		1032	7.0
		1445	6.4
		2222	9.3

There is no definite tidal current pattern in the Duncan Bay area and no current predictions are found in the Tide tables, vol. 6.

Tide at the time of grounding
0540 5.5 feet



Appendix C — Photographs


'87 1 1