March 24, 2025 MIR-25-11

Contact of Tank Vessel *Hafnia Amessi* with Pier

On January 14, 2024, at 1019 local time, the 604-foot-long tanker *Hafnia Amessi* was transiting outbound d on the Cooper River near Naval Weapons Station, Joint Base Charleston, South Carolina, when the vessel struck the Naval Weapons Station Pier B (see figure 1 and figure 2).[1] Hull plating on the vessel's starboard side, a cement platform on the end of the pier, and a protective dolphin were damaged. There were no injuries, and no pollution was reported. Damage to the vessel and pier was estimated at $8.1 million.[2]

Figure 1. *Hafnia Amessi* underway following the contact with Pier B. (Source: US Coast Guard)

[1] In this report, all times are eastern standard time, and all miles are nautical miles (1.15 statute miles).

[2] Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. DCA24FM018). Use the CAROL Query to search investigations.

Casualty Summary

Casualty type	Contact
Location	Cooper River, north of Charleston, South Carolina 32°55.69 N, 79°56.24′ W
Date	January 14, 2024
Time	1019 eastern standard time (coordinated universal time –5 hrs)
Persons on board	25
Injuries	None
Property damage	$8.1 million est. (Pier B), $30,000 est. (*Hafnia Amessi*)
Environmental damage	None
Weather	Visibility 10 nm, scattered clouds, winds northwest 8 kts, air temperature 46°F, water temperature 53°F, sunrise 0723
Waterway information	Channel; project depth 40 ft, tidal flood current greater than 1 kt

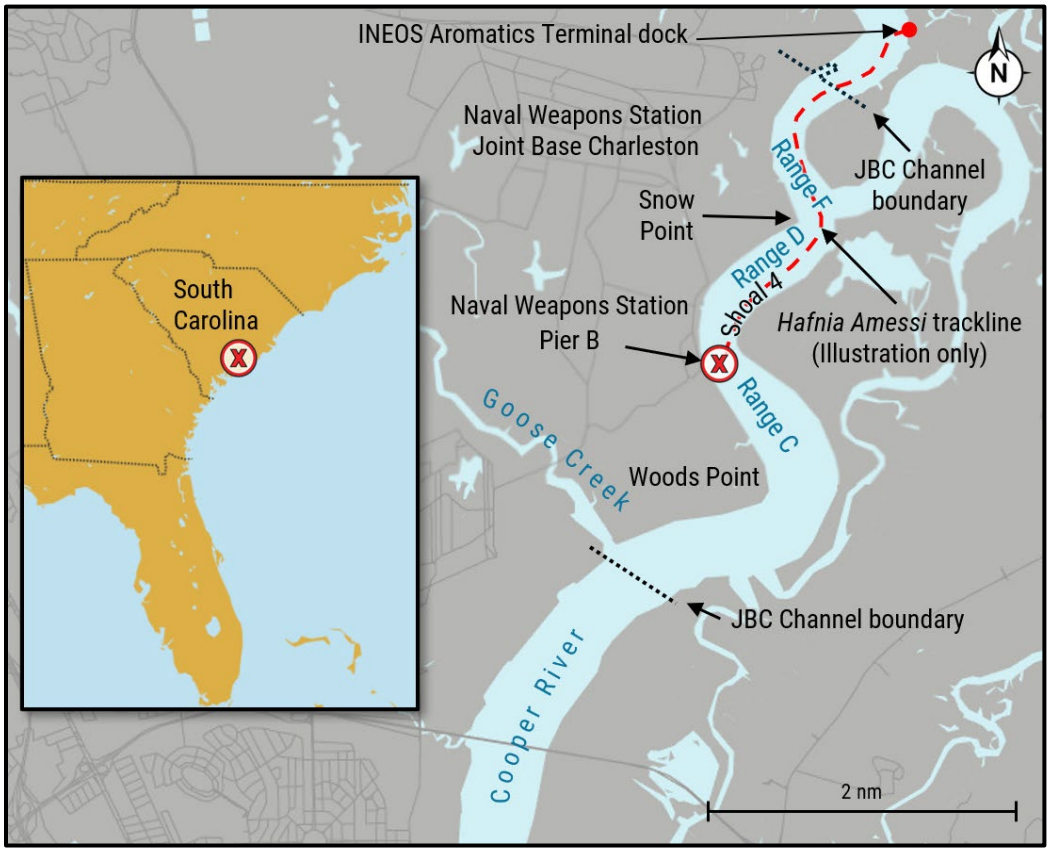

Figure 2. Area where the *Hafnia Amessi* contacted the Naval Weapons Station Pier B, as indicated by a circled *X*. (Background source: Google Maps)

1 Factual Information

1.1 Background

The Singapore-flagged *Hafnia Amessi* was a 604-foot-long, steel-hulled, liquid bulk cargo vessel (tanker) owned by Sea 342 Leasing Co. Ltd. and operated by Hafnia Middle East DMCC. Built in 2015, the vessel was double-hulled, meaning its cargo tanks were within an inner watertight hull separated by ballast tanks or other spaces from its outer hull. Double-hull construction is intended to minimize the chances of cargo loss to the environment by providing protection from side or bottom damage. The tanker was outfitted with a single rudder and a fixed-pitch, right-handed turning propeller directly driven by a 9,776-hp, slow-speed diesel main engine.

Constructed in 1954, Naval Weapons Station Pier B was originally 966 feet long and lay at a 30° angle to the west bank of the Cooper River. The platform at the end of Pier B consisted of a concrete deck supported by large piles. A large metal lattice-work tower sat atop the platform. The Pier B platform extended to the edge of the navigation channel, which measured 600 feet wide at the outer edge of Pier B and quickly narrowed to 550 feet downriver.

After the tanker *Bow Triumph* contacted the pier in 2022, a 300-foot section of the pier between the platform at the end of the pier and the shore side of the pier collapsed (see section 1.3.3). Pier B was no longer used after the *Bow Triumph* casualty.

1.2 Event Sequence

On January 14, 2024, after discharging all of its cargo at the INEOS Aromatics Terminal on the Cooper River in Wando, South Carolina, the *Hafnia Amessi* prepared to depart the terminal for a voyage to Texas City, Texas. About 0915, a Charleston Branch Pilots Association (CBPA) pilot boarded the tanker from the tugboat *Diane Moran*. Before disembarking the *Diane Moran*, the pilot instructed the tugboat's captain to have the *Diane Moran* escort the *Hafnia Amessi* downriver, with the tugboat off the tanker's starboard side. The pilot stated, "this order was a direct result of what I had learned from the *Bow Triumph* incident in 2022." (The CBPA pilot on the *Hafnia Amessi* was not involved in the *Bow Triumph* casualty.)

When the CBPA pilot entered the bridge of the *Hafnia Amessi*, he and the master conducted a master/pilot exchange.[3] According to the pilot, the master reported no deficiencies with the vessel's propulsion, machinery, steering, or navigation systems.

At 0948, the *Hafnia Amessi* got underway from the terminal on the Cooper River. The vessel was in ballast condition, with the CBPA pilot, a docking pilot, and a crew of 24 on board.[4] The docking pilot performed the undocking, with the *Diane Moran* and another tugboat, the *James Moran*, assisting the operation. Once the tanker was aligned in the channel, the docking pilot turned over the conn to the CBPA pilot and disembarked from the *Hafnia Amessi* to the *James Moran*. The *James Moran* then proceeded downriver, while the *Diane Moran* remained with the tanker, off its starboard side, as ordered by the CBPA pilot. When it got underway, the *Hafnia Amessi*'s drafts were 21.3 feet forward and 26.3 feet aft.

Beginning the transit down the Cooper River, the CBPA pilot ordered dead slow ahead, followed by slow ahead. According to the *Hafnia Amessi*'s pilot card, slow ahead corresponded to 9.0 knots of speed when the tanker was in ballast in open water with no current.

At 1000, the vessel entered the Joint Base Charleston Channel (referred to as the JBC Channel in US Army Corps of Engineers documents), 0.5 miles downriver from the INEOS terminal. Shortly after entering the channel, the *Hafnia Amessi* encountered a bend to port, onto the section of the river containing Range F (see figure 2). The pilot stated that, as the vessel rounded the bend, he noticed "an exceptional amount of tidal current on buoy number 80," which was a navigation aid on the inside of the bend. He said, "[the current] reduced my speed to less than 5 knots, and in all my years working down here, I've never seen a wake on a buoy at that location to be so strong."

After Range F, the river made a bend to starboard onto Range E and then Range D (see figure 3). After passing through the bend, the pilot continued to issue rudder commands to steer the ship toward the next bend, a port turn onto the stretch of the river containing Range C and Naval Weapons Station Pier B. On the eastern

[3] A *master/pilot exchange* is required at the start of pilot transits and includes discussion of the vessel's navigational equipment, any limitations of maneuverability, available engine speeds, berthing maneuvers, intended course and speed through the waterway, anticipated hazards along the route, weather conditions, composition of the bridge team and deck crew, etc.

[4] A vessel that is *in ballast* is a vessel with empty cargo tanks or holds that has taken on ballast water.

side of the river, near the bend toward Range C, was an area designated as "Shoal 4" that was known to silt up following periodic dredging operations.

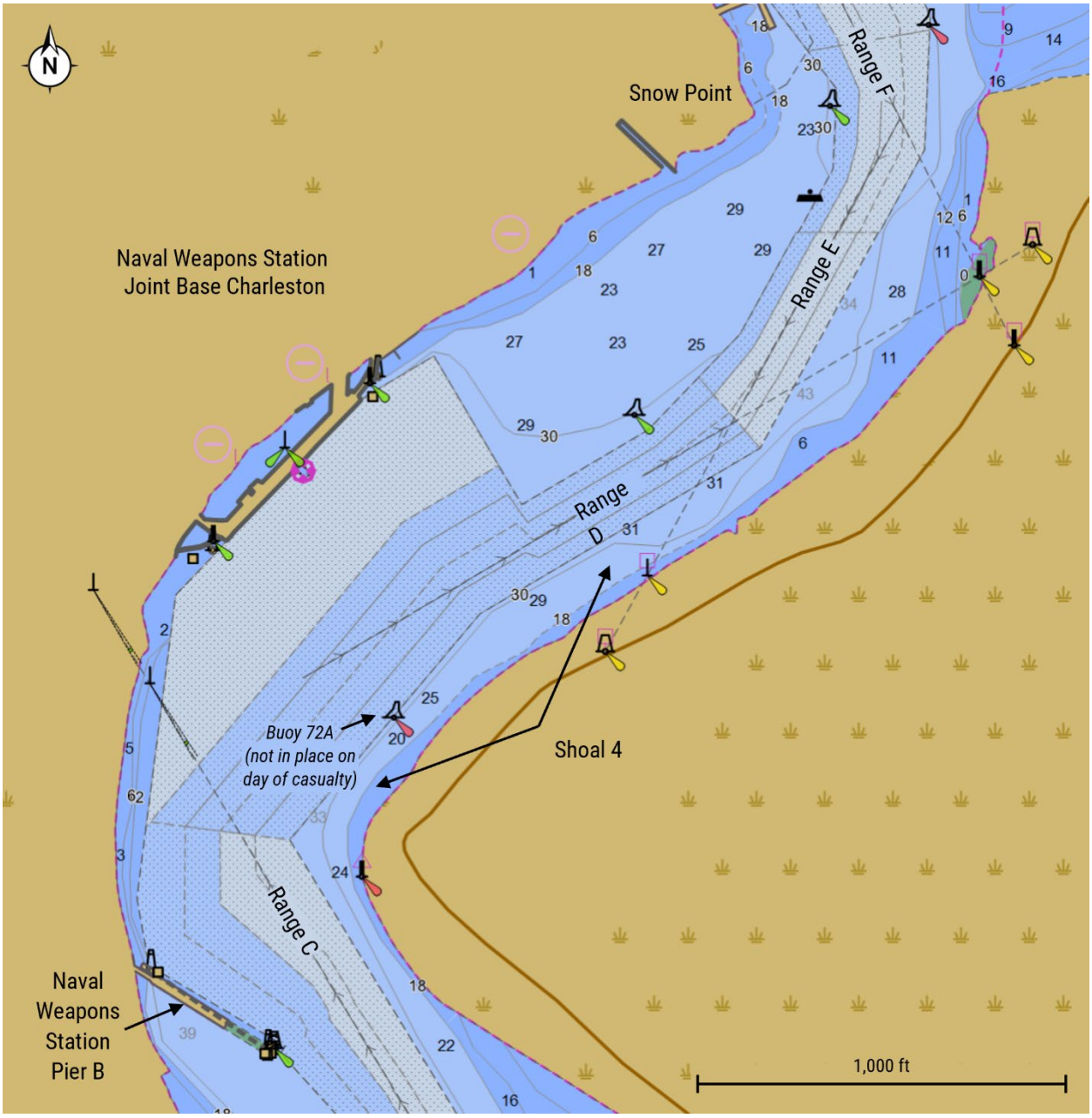

Figure 3. National Oceanic and Atmospheric Administration (NOAA) electronic navigation chart (ENC) US5SC1LO, accessed on January 30, 2025, showing the area of the Cooper River where the *Hafnia Amessi* would eventually strike Pier B.

At 1014, the *Hafnia Amessi* was positioned in the center of the Range D portion of the JBC Channel, with rudder midship, and transiting at 7.5 knots speed over ground. Winds were from the northwest at 8 knots. At 1014:11, the pilot ordered 10° port rudder (see figure 4). He said, "I just put [the rudder over] very quickly just to

see if I would get some kind of rate of turn, and I did." Twenty-one seconds later, he ordered the rudder back to midship.

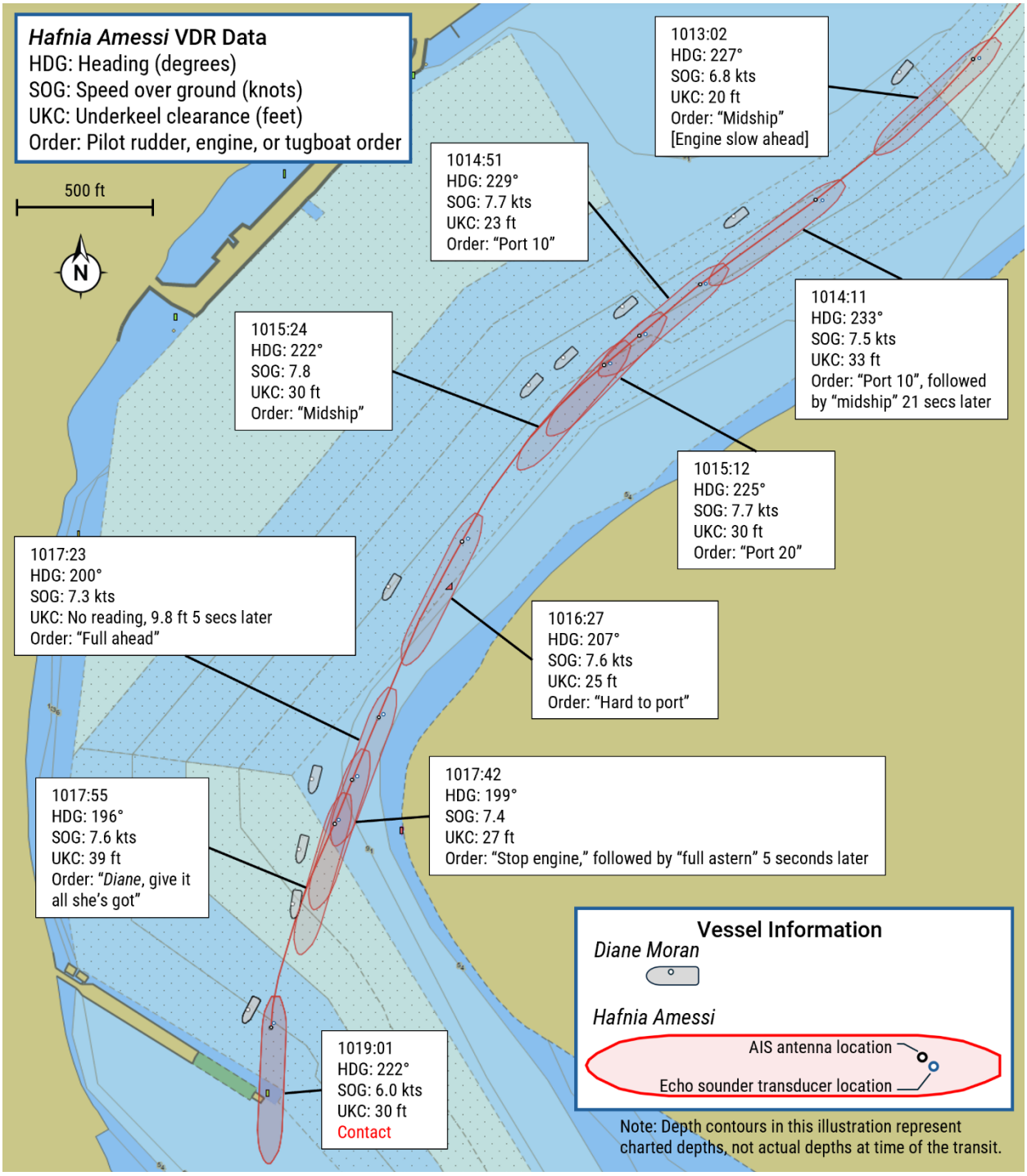

Figure 4. *Hafnia Amessi* automatic identification system (AIS) trackline. (Background source: NOAA ENC US5SC1LO as viewed on Made Smart)

At 1014:51, the pilot ordered port 10° rudder, increasing the rudder order to 20° after 21 seconds. The pilot stated that, as the *Hafnia Amessi* approached the bend onto Range C, he favored the eastern side of the 650-foot-wide channel because he expected the ship would be set toward the outside (west side) of the bend when the full flood current on Range C took effect. However, he said, "I found myself creeping toward that [east] bank more than I had planned or expected."

At 1015:24, he ordered the rudder to midship. At the time, the *Hafnia Amessi* was left (east) of the center of the channel, on a heading of 222° at a speed of 7.8 knots. The underkeel clearance (UKC), as recorded on the ship's echo sounder, was 30 feet.[5]

At 1016:27, as the *Hafnia Amessi* approached the apex of the turn, the pilot ordered the rudder hard to port. The vessel's heading was 207°, its UKC was 25 feet, and its speed was 7.6 knots. According to the pilot, he saw no rate of turn after the rudder swung over. He said, "with Pier B dead ahead, I ordered the engine to full ahead to increase flow over the rudder." When he issued the engine order, at 1017:23, the vessel's heading was 200°. At the time, the echo sounder displayed no depth reading; 5 seconds later, the echo sounder recorded a UKC of 9.8 feet.

The pilot stated that, after the order to increase speed, there was still no change in the *Hafnia Amessi*'s rate of turn to port. Therefore, at 1017:33, he ordered the *Diane Moran* to take station on the tanker's bow. As the tugboat moved into position, the pilot ordered stop on the *Hafnia Amessi*'s engine, followed by full astern.

The *Diane Moran* touched down on the *Hafnia Amessi*'s starboard bow at 1017:55, and the pilot ordered the tugboat captain to "give it all she's got." With the *Diane Moran* pushing on the *Hafnia Amessi*'s bow, the tanker's rate of turn to port increased. The *Diane Moran* continued pushing until 1018:27, when the tugboat captain had to back his vessel away to avoid contact with Pier B by the *Diane Moran*. The *Hafnia Amessi*'s heading when the tugboat stopped pushing was 187°.

The *Hafnia Amessi*'s momentum carried it forward, with its bow moving to port and its stern swinging to starboard. At 1019:01, the starboard side of the vessel's hull pushed over a protective dolphin and contacted the northeast corner of the Pier B platform. The *Hafnia Amessi*'s speed at the time it made contact was 6.0 knots.

[5] *Underkeel clearance* is the vertical distance between the bottom of a vessel and the seafloor or river bottom, as measured at the vessel's echo sounder transducer. The transducer on the *Hafnia Amessi* was located 504 feet aft of the bow, 1 foot starboard of centerline.

1.3 Additional Information

According to the pilot, there were no apparent issues with the *Hafnia Amessi*'s steering or propulsion, and the vessel's crew responded to his orders as expected. Investigators reviewed voyage data recorder (VDR) data (audio and parametric) and found that the rudder and engine matched orders given by the pilot throughout the transit.

1.3.1 Damage

On the *Hafnia Amessi*, hull plating was inset up to 3 inches, and paint was scraped away along a 67-foot-long-by-3-foot-wide area of the vessel's starboard side above the waterline (see figure 5). Three transverse bulkheads that intersected the hull plating in the damaged area sustained buckling of about 1–2 inches. The estimated cost to repair the damage was $30,000.

Figure 5. *Hafnia Amessi* starboard side after the contact, showing inset plating and scraped paint within circled area. (Background source: Coast Guard)

Cement on the northeast corner of the Pier B platform deck was cracked, with a small portion falling into the water. The protective dolphin, which was constructed of wood piles and positioned near the corner of the platform, was knocked over (see figure 6). The estimated cost to repair the damage to Pier B and the dolphin (not including previous damage from the *Bow Triumph* casualty) was $8.1 million.

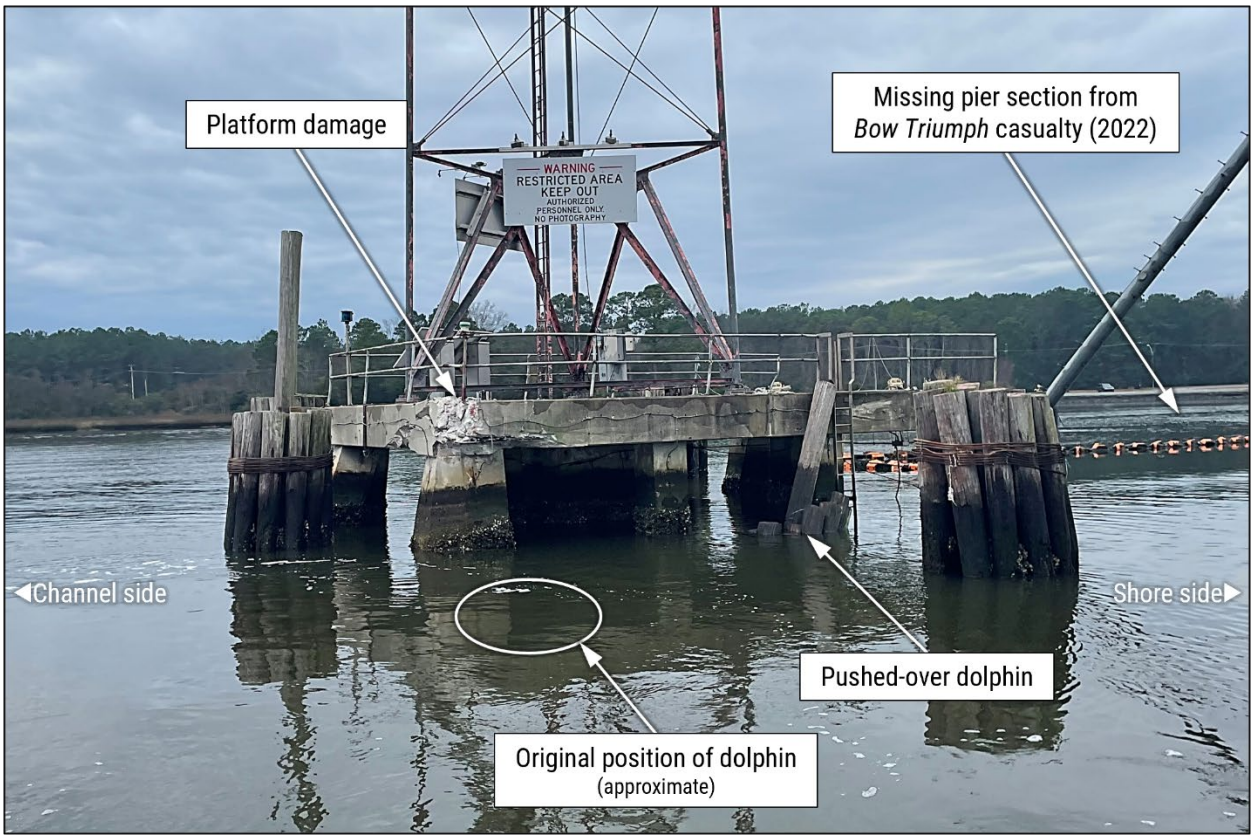

Figure 6. Naval Weapons Station Pier B, showing damage to the platform and protective dolphin.

1.3.2 Personnel

The CBPA pilot held valid Coast Guard credentials as a first-class pilot and a master of self-propelled vessels of unlimited tonnage upon oceans. He began his apprenticeship with the CBPA in 1997, becoming a pilot in 2000. He estimated that he had piloted more than 5,000 ships in Charleston-area waterways during his career. Since October 2017, he had piloted 21 ships downbound on the Cooper River from the INEOS terminal, including one within 12 months of the casualty (February 2023).[6]

[6] The CBPA pilot had conducted numerous transits on the JBC Channel before October 2017; however, records of his activities before this time were archived and were not readily available to investigators.

The pilot had made an upbound transit through the JBC Channel on December 26, 2023, about 3 weeks before the *Hafnia Amessi* transit. The *Hafnia Amessi* transit was his first trip on the tanker, but he had piloted a sister vessel and other vessels of similar size through the channel.

The *Hafnia Amessi* master held a valid certificate of competency as a deck officer class 1 (master mariner) issued by the Maritime and Port Authority of Singapore. The officer of the watch—the third officer—held a valid certificate of competency as a second mate of a foreign going ship issued by the Government of India. The helmsman held a valid certificate of proficiency as an able seafarer deck and a certificate of competency as a rating forming part of navigational watch, both issued by the Government of India.

Following the casualty, the CBPA pilot and the *Hafnia Amessi* master, third officer, and helmsman submitted to tests for alcohol and other drugs in accordance with Coast Guard regulations, and the results were negative.

1.3.3 *Bow Triumph*

On September 5, 2022, 16 months before the *Hafnia Amessi* contact with Pier B, the 600-foot-long tanker *Bow Triumph* was making a downbound transit of the Cooper River from the INEOS Aromatics Terminal. The tanker's drafts were 26.6 feet forward and 27.6 feet aft. A CBPA pilot was at the conn of the *Bow Triumph* (as previously noted, the pilots during the *Bow Triumph* and *Hafnia Amessi* casualties were not the same person). As the vessel made the turn from Range D to Range C in the JBC Channel at a speed of 7 knots, it was unable to maneuver through the turn and contacted Pier B, causing a 300-foot section of the pier to collapse. The National Transportation Safety Board (NTSB) determined that the probable cause of the contact of the *Bow Triumph* with Naval Weapons Station Pier B was the pilot's decision to maneuver the vessel close to the east bank while approaching the turn immediately before the pier, exposing the tanker to bank effect, which the pilot's subsequent rudder and engine orders could not overcome.[7]

1.3.4 Waterway Information

The Cooper River makes nine turns between the INEOS Aromatics Terminal and the lower Charleston Harbor. Because of the river's winding nature, large ships navigating the channel rarely steady on a course after exiting one turn and before

[7] NTSB, *Contact of Tank Vessel Bow Triumph with Pier*, MIR-24-09, April 15, 2024, https://www.ntsb.gov/investigations/AccidentReports/Reports/MIR2409.pdf.

entering the next turn. The *Hafnia Amessi* pilot stated that, while he used the array of navigational tools available to him, he principally relied on visual cues to navigate vessels through the many turns in the river.

The INEOS terminal was the only facility upriver of Pier B that could berth vessels the size of the *Hafnia Amessi*, and limited commercial traffic used the JBC Channel. In the 3 years before the *Hafnia Amessi* casualty, tank vessels over 500 feet in length made 70 transits downbound from the terminal—about two per month.

The *United States Coast Pilot* states that the waterways that include the JBC Channel "require constant dredging to maintain them at or near project depths, due to the silting of [the] Cooper River."[8] As stated in a 2019 dredging permit notification issued by the Corps of Engineers, Joint Base Charleston maintained the JBC Channel to provide sufficient depth for safe navigation and berthing of military vessels. The dredging permit authorized the area of Shoal 4 to be dredged up to a depth of 46 feet, allowing for 40 feet of required depth, plus 4 feet of "advance maintenance" and 2 feet of "allowable overdepth." Advance maintenance is dredging to a depth or width beyond the authorized channel dimensions in critical or fast-shoaling areas to avoid frequent re-dredging and ensure the least overall cost of maintaining a project area. Allowable overdepth is dredging that occurs outside the required dimensions to allow for inaccuracies in the dredging process.[9]

The Corps of Engineers managed Joint Base Charleston's maintenance dredging program by performing reimbursable work at Joint Base Charleston's request. Routine maintenance dredging for the channel was accomplished on a 15- to 20-month rotating cycle. The most recent dredging operations at Shoal 4 were completed on November 14, 2022, 14 months before the *Hafnia Amessi* casualty (the dredging occurred about 2 months after the *Bow Triumph* contact with Pier B under a maintenance dredging contract awarded before the 2022 casualty). The dredging depth of the channel, including areas of Shoal 4 within the channel, was contracted for 40 feet, with allowable overdepth; the permitted 4 feet of advance maintenance was not included. As explained by the Corps of Engineers Charleston District Navigation Branch Chief:

[8] NOAA, *United States Coast Pilot 4*, 56th Ed., Chapter 6, September 22, 2024, 251, CPB4_WEB.pdf (noaa.gov)

[9] US Army Corps of Engineers, *Navigation and Dredging Operations and Maintenance Policies*, ER 1130-2-520, November 29, 1996, 8-1.

> Joint Base Charleston knows that they can go a little bit deeper in these areas but it's going to cost them more money. But, from their standpoint, there's no benefit to … their mission in order to dredge these areas deeper.

According to the Acting Deputy Base Civil Engineer for Joint Base Charleston, maintenance dredging of the JBC Channel was performed to support US Department of Defense requirements at the base. "We don't dredge for commercial industry … there's no agreements between the Department of Defense and any other entity out there … to dredge for any other type of vessel," he said. "[Shoal 4] has not been a concern for our [Department of Defense] users."

Data from a Corps of Engineers hydrographic survey conducted 4 days after the *Hafnia Amessi* contact with Pier B (January 18, 2024) showed that silting in the area of Shoal 4 had reduced the depth to as shallow as 25 feet along the JBC Channel's eastern boundary since it was last dredged in late 2022. Depth increased along a slope toward the center of the channel. According to the Corps of Engineers Charleston District Navigation Branch Chief, "[Shoal 4] historically grows at a rapid pace in the first year post dredging and then begins to level out."

Following the *Bow Triumph* casualty, the Corps of Engineers conducted a trend analysis of the silting in Shoal 4. The Charleston District Navigation Branch Chief stated in August 2023 that, based on the results of the analysis, "The historical trend is pretty stable with how much material deposits in Shoal 4."

1.3.5 Downbound Transits of the JBC Channel

Automatic identification system (AIS) data from all tank vessels greater than 500 feet long that transited downbound through the JBC Channel in the 3 years before the *Hafnia Amessi* casualty showed that most vessels favored the center or western side of the channel (toward the outside of the bend) as they made the turn from Range D to Range C (see figure 7).[10] However, three vessels transited on the eastern side of the channel (toward the inside of the bend), near Shoal 4. Two of the three vessels, the *Bow Triumph* and *Hafnia Amessi*, contacted Pier B.

[10] Tank vessels as defined in this report include tankers and articulated tugs and barges (ATBs) with tank barges.

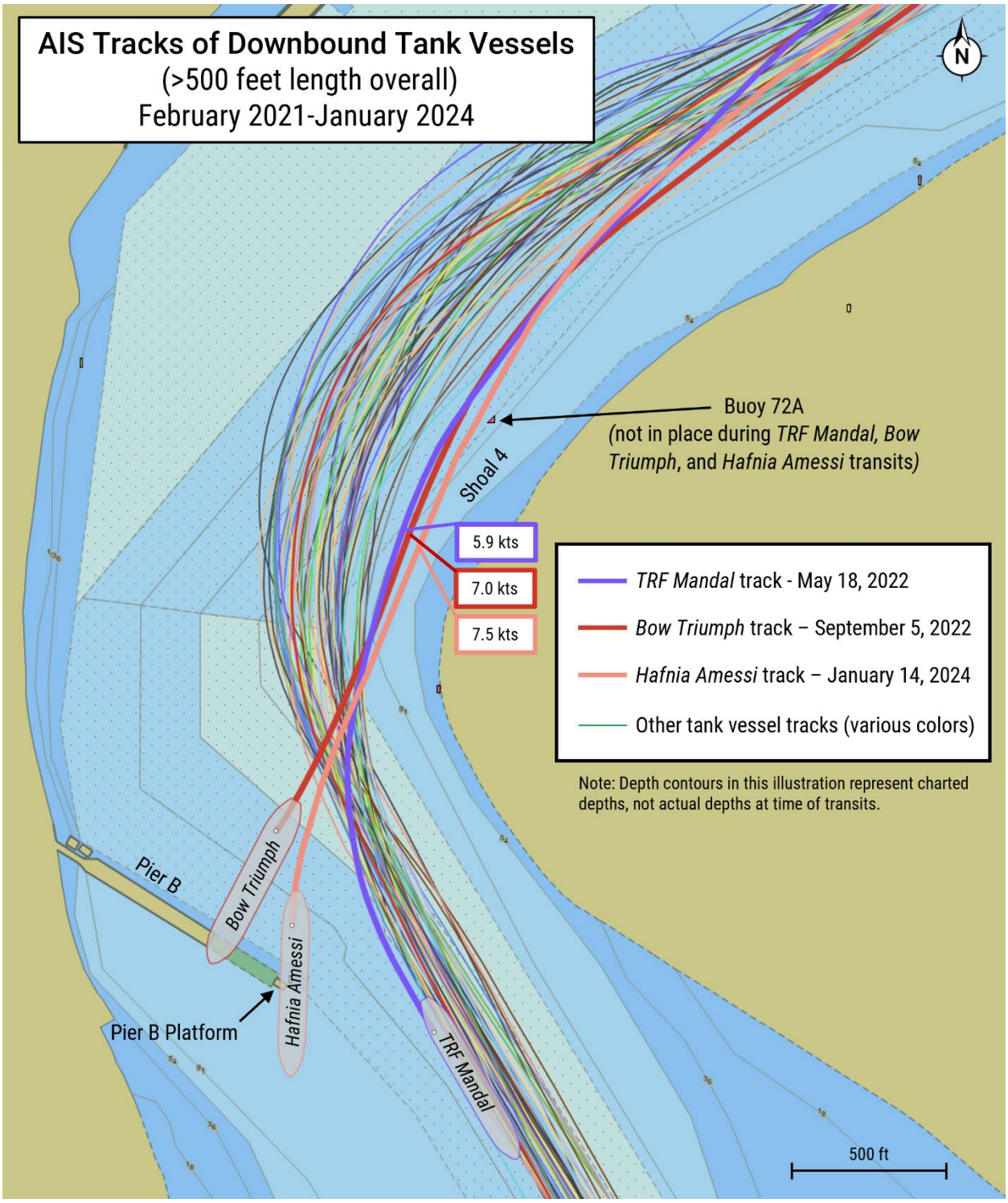

Figure 7. AIS tracks of tank vessels greater than 500 feet in length from February 2021 to January 2024. (Background source: NOAA ENC US5SC1LO as viewed on Made Smart)

The third vessel, the tanker *TRF Mandal*, rounded the bend near Shoal 4 just after 2100 on May 18, 2022. The tanker entered the turn at 6.4 knots and slowed to

5.9 knots as it passed Shoal 4 (the *Hafnia Amessi*'s speed when it passed the same location was 7.5 knots). The *TRF Mandal* remained clear of Pier B but finished the turn wider (more toward the outside/western side of the bend) than other vessels that had safely made the turn in the 3-year period. After exiting the turn, the *TRF Mandal* accelerated to 6.8 knots and completed the transit without incident.

The *TRF Mandal* was a sister vessel of the *Hafnia Amessi*: it was constructed at the same shipyard and had the same design, length and breadth, as well as nearly the same gross tonnage (ITC). During the May 2022 downbound transit, the same CBPA pilot that conned the *Hafnia Amessi* when it contacted Pier B in January 2024 was conning the *TRF Mandal*. A hydrographic survey conducted in May 2022—two weeks before the *TRF Mandal* transit—showed shallowing at Shoal 4 similar to the shallowing during the *Hafnia Amessi* transit.

Of the three vessels that transited on the eastern side of the channel, the *Hafnia Amessi*'s track came closest to the east bank of the river, based on AIS data (see figure 7).

1.3.6 Tides and Currents

The Cooper River experiences semi-diurnal tides and associated tidal currents, and, according to CBPA representatives, vessels transiting downbound from the INEOS Aromatics Terminal always sailed on a flood tide.

During the *TRF Mandal* transit on the evening of May 18, 2022, the predicted time of slack water at Snow Point (the point in the JBC Channel that forms the turn from Range F onto Ranges E and D; see figure 3) was 1915. The predicted maximum for the next flood current was 1.25 knots at 2224. The *TRF Mandal* passed Snow Point at 2100 that evening, 1 hour 24 minutes before the maximum tidal current. Based on the times of slack water and maximum flood tide, the predicted tidal current at the time the *TRF Mandal* passed Snow Point—about 10 minutes before it passed Pier B—was just under 1 knot (see figure 8).

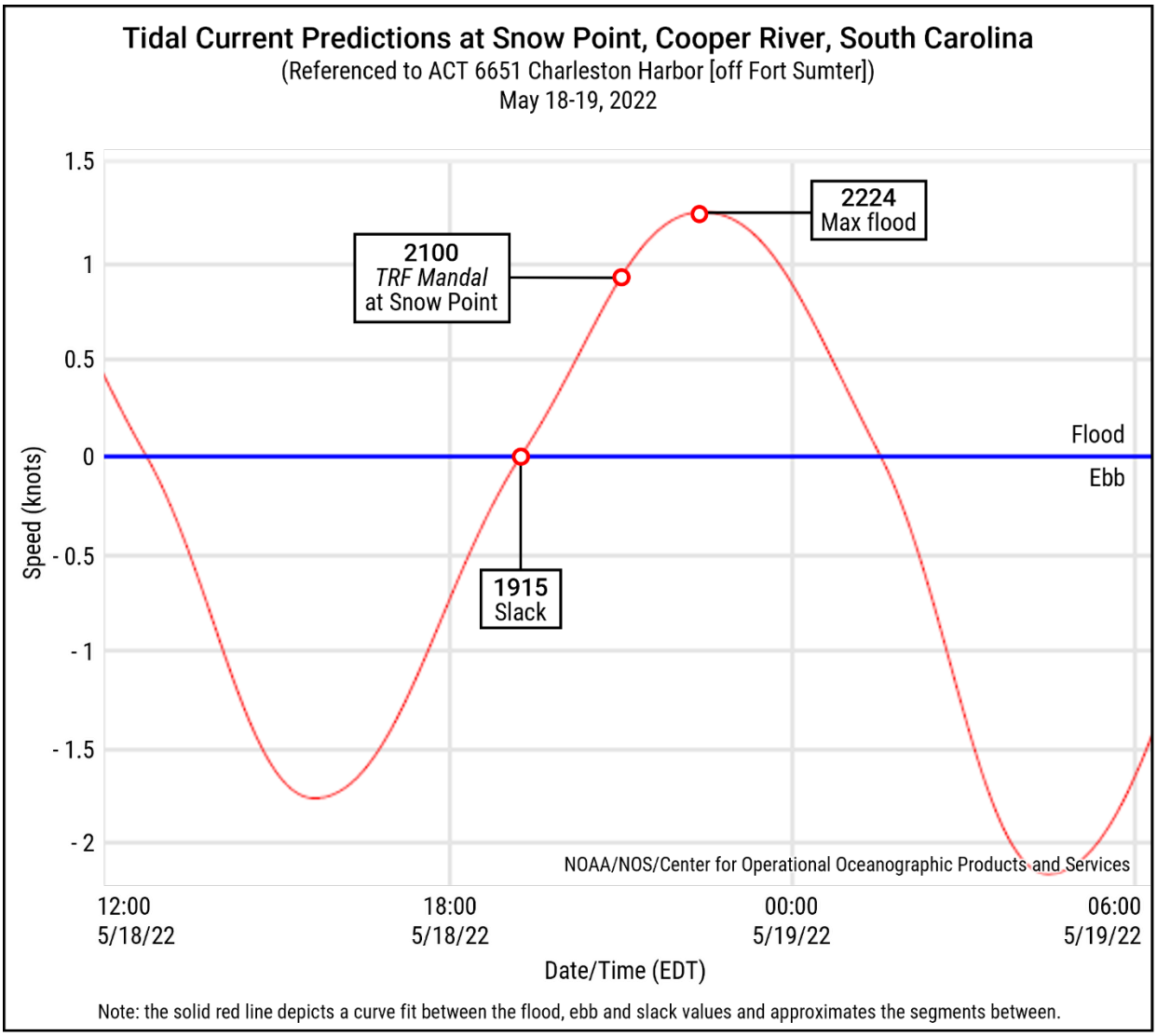

Figure 8. Tidal current predictions for Snow Point, Cooper River, South Carolina, on May 18, 2022. (Background source: NOAA)

During the *Hafnia Amessi* transit on the morning of January 14, 2024, the predicted maximum flood current at Snow Point was 1.29 knots at 0936. The next slack water was at 1234. The *Hafnia Amessi* passed Snow Point at 1010, 34 minutes after maximum tidal flood current. Based on the times of maximum flood tide and slack water, the predicted tidal current at the time the *Hafnia Amessi* passed Snow Point—about 9 minutes before it struck Pier B—was 1.2 knots (see figure 9).

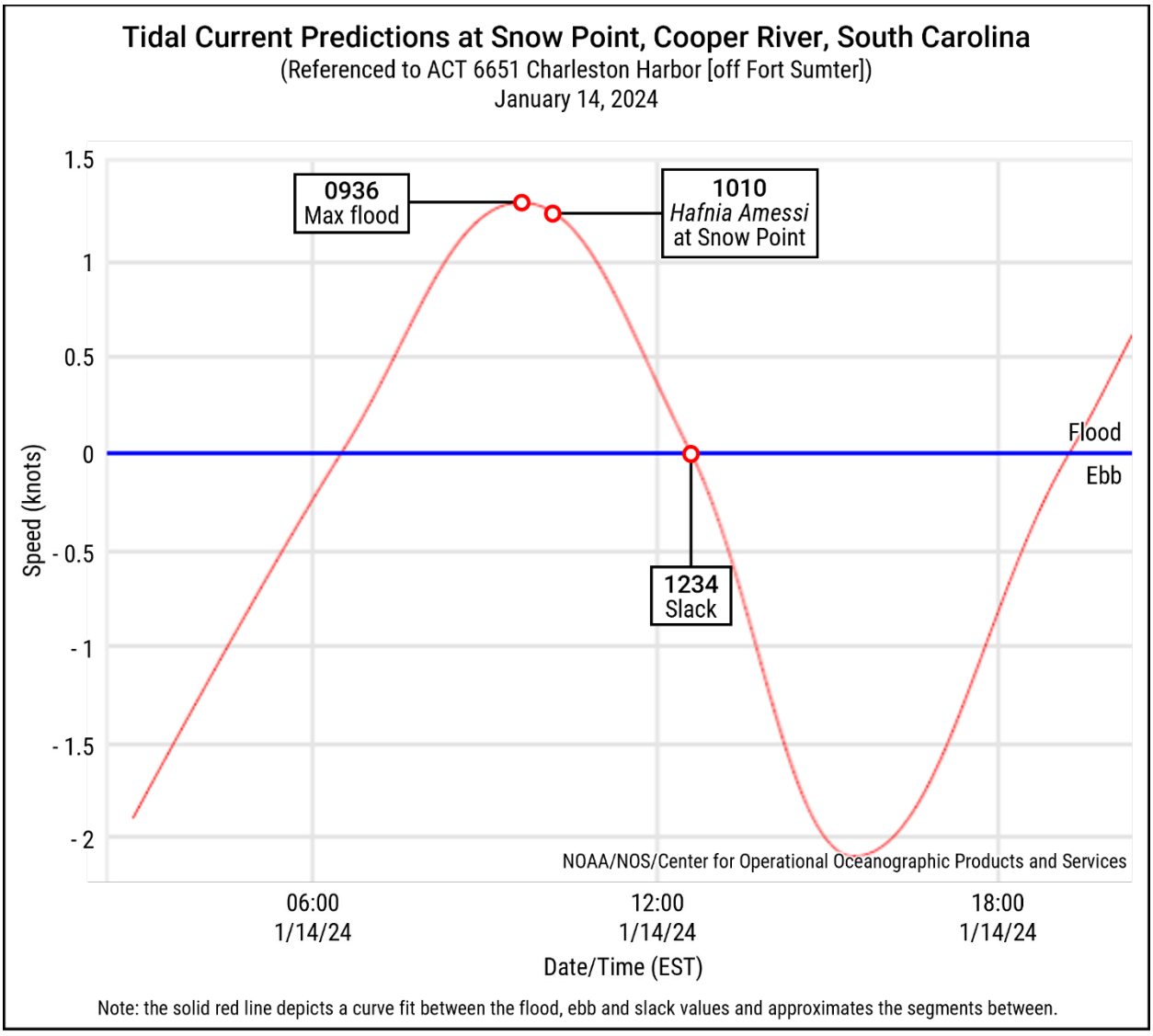

Figure 9. Tidal current predictions for Snow Point, Cooper River, South Carolina, on January 14, 2024. (Background source: NOAA)

1.3.7 Aids to Navigation

The Cooper River navigation channel, including the JBC Channel, is marked with a series of buoys and daymarkers in accordance with International Association of Marine Aids to Navigation and Lighthouse Authorities Region B (IALA B) standards.

On September 16, 2022, following the *Bow Triumph* contact with Pier B, the CBPA requested that the Coast Guard install a temporary navigation buoy to mark Shoal 4 until scheduled dredging was completed. According to the CBPA request, the purpose of the buoy was to "aid mariners in avoiding the advancing shoal while

setting up for the turn from Range D to Range C. … Once the channel is restored to project conditions, this aid will no longer be necessary."

The temporary buoy, designated "72A," was approved by the Coast Guard and installed on September 20, 2022. The Coast Guard removed the buoy on October 5, 2022, to allow for the scheduled dredging of the shoal. Dredging was completed in November; buoy 72A was not replaced after the dredging.

In March 2023, the CBPA requested that the Coast Guard reinstall Buoy 72A as a permanent aid to navigation, noting that "this aid has proven to be extremely effective aiding pilots to set up for the turn to Range C." The request was approved on January 3, 2024, and the permanent buoy was scheduled to be installed on January 17. Buoy 72A was placed in the river as scheduled, 3 days after the *Hafnia Amessi* contacted Pier B (see figure 3 and figure 7).

The *Hafnia Amessi* pilot told investigators after the casualty, "If this Buoy 72A had been there [during the tanker's transit of the JBC Channel], … that would have given me the tools to come more to the right and the information that I needed to avoid that spot and avoid getting sucked into that bank."

1.3.8 Postcasualty Actions

As a result of the *Bow Triumph* and *Hafnia Amessi* casualties, beginning on March 18, 2024, the Coast Guard Captain of the Port (COTP) for Charleston issued COTP orders requiring all vessels of 10,000 gross tons or more or with drafts exceeding 25 feet to "employ a tethered two-tug escort while transiting between Pier [B] and Snow Point." These orders were expected to remain in place unless and until port stakeholders adopted alternative measures to reduce the risk of casualties.

Further, the *US Coast Pilot 4* was amended, adding the section of the Cooper River between Pier B and Snow Point to designated "areas of particular concern" for Charleston Harbor. The *Coast Pilot* noted that this section of the river had "increased navigational risk due to a combination of variable hydrographic data, fixed structures, and critical military assets." The *Coast Pilot* also reiterated the COTP orders requiring tethered, two-tug escorts.[11]

[11] NOAA, *United States Coast Pilot 4*, 249–250.

2 Analysis

On January 14, 2024, about 1019 local time, while the tanker *Hafnia Amessi* was transiting downbound in the JBC Channel on the Cooper River, the vessel attempted to turn to port when navigating a bend in the river and struck the Joint Base Charleston Naval Weapons Station Pier B.

The *Hafnia Amessi* pilot told investigators that throughout the transit the rudder had responded as ordered, and there were no issues with the vessel's steering or propulsion. The VDR showed that rudder and engine responses matched the pilot's orders.

After making a starboard turn at 1010 onto Range D, the *Hafnia Amessi* pilot began to favor the eastern side of the channel as the vessel approached the port turn (bend) on Range C. According to the pilot, he did this because he expected the ship would be set toward the outside (western side) of the bend by the flood current on Range C. However, the pilot stated that during the approach to the turn, the tanker moved toward the east bank more than he had planned for or anticipated.

Winds were off the *Hafnia Amessi*'s starboard side at 8 knots while the vessel was on Range D. Transiting in ballast, the vessel had a greater freeboard and therefore a large surface area for the wind to act on. Although not strong, the winds may have contributed to the *Hafnia Amessi*'s movement toward the east bank.

When the *Hafnia Amessi* moved toward the east bank, the vessel approached Shoal 4 and was susceptible to bank effect. Bank effect is experienced by ships maneuvering in confined waters (e.g., close to a canal bank, riverbank, or shoal). While a vessel is making headway, water pushed ahead of and flowing down the side of the ship creates positive pressure forward of the pivot point and negative pressure aft. In a channel, the resultant forces can yaw a ship's bow away from the bank (bank cushion) while attracting its stern toward the bank (bank suction). Though bank effect is often experienced in waterways with steeply sided banks, *The Shiphandler's Guide* explains: "To a ship running in shallow water, with adjacent but gently shelving mud or sand banks, such as low-lying estuarial areas … the effect can be far more insidious and violent."[12] Generally, the faster the ship sails, the greater the suction at the stern.

[12] R. W. Rowe, *The Shiphandler's Guide*, 2nd edition (The Nautical Institute, 2007), 59.

As the *Hafnia Amessi* transited along the east side of the channel, the vessel traversed a section where shoaling had reduced the depth significantly. Between 1015:24 and 1017:28, the tanker's recorded UKC reduced from 30 feet to 9.8 feet. Given the slope of the channel bank, the clearance under the hull at the turn of the bilge on the vessel's port side was likely shallower than the recorded UKC (see figure 10).[13] At the same time the pilot was attempting to turn the *Hafnia Amessi* to port, the bank effect forces worked against the turn by pushing the bow away from the bank (to starboard) and pulling the stern toward the bank (to port).

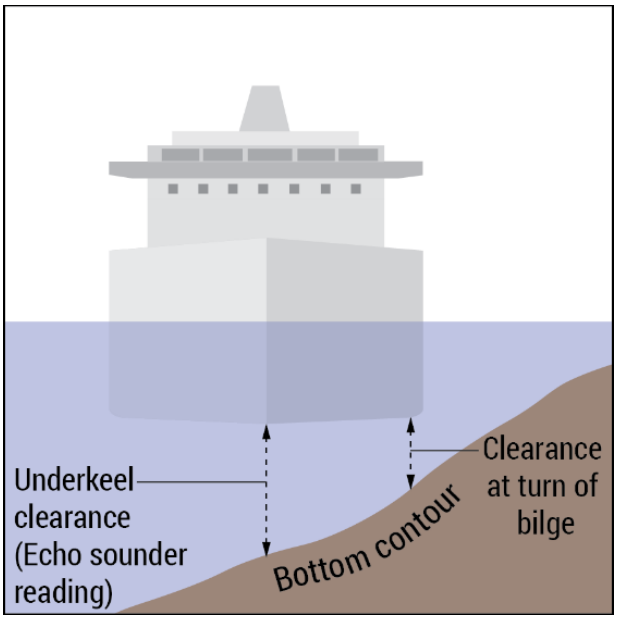

Figure 10. Exemplar of relative difference in hull clearances along a sloped bank/shoal. (Illustration does not reflect actual contour or vessel in this casualty.)

In addition to bank effect, the *Hafnia Amessi* would have also been affected by the flood current when the vessel rounded the turn onto Range C. As the tanker's bow emerged from the shadow of the east bank, the current would have acted on the submerged portion of the vessel's port bow—pushing it away from the bank and further working against the attempted port turn.

The predicted current at Snow Point, just upriver of the turn, was 1.2 knots. Actual currents can vary from predicted currents based on factors such as downstream storm surges and upstream waterflow. As the *Hafnia Amessi* passed buoy 80 upstream of Pier B, it experienced "an exceptional amount of tidal current," according to the pilot, which reduced the vessel's speed to less than 5 knots—4 knots slower than its rated speed at slow-ahead. The pilot said, "In all my years working down here, I've never seen a wake on a buoy at that location to be so strong." Based on his observations, it is likely that the current in the JBC Channel exceeded the predicted tidal current, further impacting the *Hafnia Amessi*'s ability to maneuver through the turn.

In 2022, the *Bow Triumph* experienced bank effect and current forces, which the pilot's rudder and engine orders could not overcome, resulting in contact with

[13] The *turn of the bilge* is the area of transition from the bottom plate to the side plate on a vessel's hull.

Pier B. Similar to the *Bow Triumph* casualty, the *Hafnia Amessi* pilot's rudder and engine orders could not overcome the bank effect and current forces acting on the tanker, resulting in the vessel's contact with the same pier.

The silting of the Cooper River on the eastern bank at Shoal 4 was a known hazard, and almost all the tank vessels of similar size that transited downbound through the bend in the 3 years before the *Hafnia Amessi* casualty approached via the center or western side of the channel (see figure 7). Vessels that approached the bend in this manner navigated through the turn without incident. The *TRF Mandal*, the *Bow Triumph*, and the *Hafnia Amessi* were the three exceptions, transiting on the eastern side of the channel as they approached the bend. Only the *TRF Mandal* negotiated the turn without incident, although it finished the turn wider (more to the outside/western side of the channel) than any other tank vessel that successfully navigated through the bend.

The *TRF Mandal*—a sister vessel of the *Hafnia Amessi* (same design, length, and breadth; nearly the same tonnage)—had the same pilot aboard (as the *Hafnia Amessi),* and, when he piloted the *TRF Mandal*, he followed a similar route near the east bank. Various factors may account for the different outcomes between the *TRF Mandal* and *Hafnia Amessi* transits. The *TRF Mandal* entered the turn at a speed over ground 1.6 knots less than the *Hafnia Amessi*. Additionally, the predicted current at the time of the *TRF Mandal* transit was about 0.2 knots slower than the current during the *Hafnia Amessi* transit. Consequently, the difference between the *TRF Mandal*'s and *Hafnia Amessi*'s speeds through the water was even greater than the difference in speeds over ground. Also, according to AIS data, the *TRF Mandal* transited farther from the riverbank than the *Hafnia Amessi*. According to research on hydrodynamic forces in narrow channels, at low speeds, the yawing moment on a vessel caused by bank effect varies at roughly the square of a vessel's speed (S^2) in a deep channel. In waters where the ratio of depth to draft is less (shallower), the yawing moment increases as a function of speed to a power that may exceed 5 (S^{5+}).[14] Additionally, the magnitude of the forces and moments acting on a ship increase with decreasing distance off the bank.[15] Therefore, the differences in speed, current flow, and distance from the bank between the *TRF Mandal* and *Hafnia Amessi* transits, while small, would have had a significant effect on each vessel's maneuverability. Although the *TRF Mandal* successfully navigated the turn, the *Bow Triumph* and *Hafnia Amessi* casualties demonstrate that transiting in the center of the channel is prudent to avoid

[14] I. W. Dand, *On Ship-Bank Interaction*, The Royal Institution of Naval Architects, 1981, 27-28, 35.

[15] I.W. Dand, "The Physical Causes of Interaction and its Effects," *The Nautical Institute Conference on Shiphandling*, Nautical Institute, 1977, 47.

the risks associated with bank effect and current. If the *Hafnia Amessi* had approached the turn on to Range C in the relatively open water to starboard, the bank effect on the vessel's port side would have been minimized, and the vessel would have been better positioned to handle the oncoming flood current.

To prepare for the *Hafnia Amessi*'s transit, the pilot ordered the tugboat *Diane Moran* to escort the tanker down the Cooper River. The pilot stated that this order was a direct consequence of what he had learned from studying the *Bow Triumph* casualty. When it became apparent that the *Hafnia Amessi* was not responding to rudder and engine orders as the pilot anticipated and was in danger of striking Pier B, the pilot directed the *Diane Moran* to push on the tanker's bow. According to the pilot, the ship's rate of turn did not increase until the tugboat began pushing. The *Diane Moran* pushed on the bow until it became too dangerous for the tugboat to remain in position without hitting the pier itself. The *Hafnia Amessi* contacted the end of the pier on its starboard side, but due to the turn induced by the tugboat, damage to both the pier and ship was considerably less than the damage caused by the *Bow Triumph* casualty. The *Diane Moran* captain's quick response to the pilot's orders and his skilled maneuvering of the tugboat prevented a more serious casualty.

3 Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the contact of the tanker *Hafnia Amessi* with Naval Weapons Station Pier B was the pilot navigating the vessel too close to the east bank while approaching the turn immediately before the pier, exposing the tanker to bank effect, which the pilot's subsequent rudder and engine orders could not overcome.

3.2 Lessons Learned

Planning for Hydrodynamic Forces in Areas Subject to Shoaling

Hydrodynamic forces reduce rudder effectiveness (squat and shallow water effect) and yaw the bow away from the closest bank and pull the stern in (bank effect). Shoaling can reduce the water depth in shallow waters, such as channels, below charted or expected, and therefore exacerbate the forces on a vessel. Bank effect can have an undesired effect on vessels, even for the most experienced shiphandlers. Pilots, masters, and other vessel operators should consider the risks in areas known for shoaling when planning transits. Where appropriate, employ additional measures to mitigate the risk, including use of tugboats, reducing or increasing speed, and/or delaying the transit until more favorable conditions exist.

Vessel Particulars

Vessel	*Hafnia Amessi*
Type	Cargo, Liquid Bulk (Tanker)
Owner/Operator	Sea 342 Leasing Co. Ltd./Hafnia Middle East DMCC (Commercial)
Flag	Singapore
Port of registry	Singapore
Year built	2015
Official number	402988 (Singapore)
IMO number	9719745
Classification society	American Bureau of Shipping
Length (overall)	603.9 ft (184.1 m)
Breadth (max.)	89.9 ft (27.4 m)
Draft (casualty)	23.8 ft (7.3 m)
Tonnage	23,676 GT ITC
Engine power; manufacturer	9,776 hp (7,290 kW); Hyundai-B&W 6S50ME-B9.3 diesel engine

NTSB investigators worked closely with our counterparts from **Coast Guard Sector Charleston** throughout this investigation.