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Review and rebuttal of the paper

Decay of bow thruster induced near-bed flow velocities at a vertical quay wall: A field measurement

Tukker et al.

Editor handling the paper: Miguel Esteban

The reviewers remain anonymous.

Dear editor,

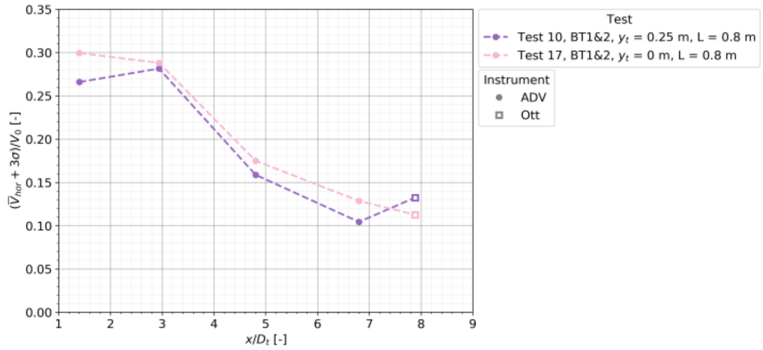
We would like to thank the reviewers for their insightful, fair and thorough reviews. This has helped us immensely to improve the document in term of clarity. We tried to handle all separate comments as well as possible. Below it is described what we did in response of the suggestions by the reviewers. While changes were made to the manuscript in reaction to nearly all of the comments, sometimes it is explained why nothing has been changed. Note that when we refer to line numbers to indicate where the changes were made, we use the line numbers in the updated manuscript,

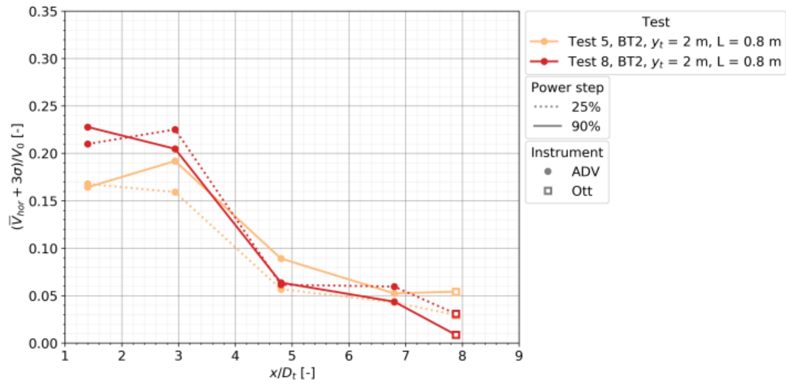
Regards,

The Author(s)

Reviewer 1 comments:

No.	Comment reviewer 1	Comment author
1	L85-L87: Provide the reference for the field measurements conducted in 2018	L114-115 Reference has been added (note that this is an internal research of Deltares which is not published). *“Deltares. (2018). Veldmetingen schroefstraalbelastingen (memo in Dutch), project number 11202175”.* Location of this reference has been changed from section 1 Introduction to section 2 Methodology.
2	L107: "with respect to the sensors" ----> "with respect to the sensors and quay wall"	L124: *“and the position of the vessel relative to the sensors and quay wall.“*
3	L134: "Acoustic Doppler Velocimeters (ADV)" ----> "ADV". Use only the abbreviation after the first mention (L105)	L150-151: *“ The near-bed flow velocities were measured with four Nortek Vector ADVs (Nortek, 2018) and two Ott C31 current meters (OTT-HydroMet, 2021) mounted on a measurement frame.”*.
4	L165: “for BT2 Δy = 3.5 m, 2 m, 0 m and -1.5 m.” Table 3 does not include a test for Bow Thruster 2 with Δy = -1.5 m, whereas a test with Δy = -2 m is observed (Test 15).	Indeed Δy = -2 m is the correct value. 1.5 m was a writing error. L197-198: *“while for BT2 Δy = 3.5 m, 2 m, 0 m and -2 m (Figure 15).”*
5	L167: “Δy = 1.75 m, 0 m, -1.75 m and -3.75 m”	Test 10 with Δy = 0.25 m was aborded after 50% power step. Therefore 90% was not measured. However, the 25% and 50% results of Test 10 were very similar to the results of Test 17 with Δy = 0 m. Test 17 included the largest power step of 90% (which

	According to Test 10 in Table 3, which involved both active bow thrusters (BT1 & BT2), there is also a Δy value of 0.25 m. This is despite the fact that the text states that for tests with Δx = 3 m and 5 m, the measurement frame was positioned with an offset of Δy = 0.25 m. However, Test 10 is listed among the tests with Δx = 0.8 m, not 3 m or 5 m. This discrepancy should be clarified or corrected in the text.	Test 10 did not). Therefore, no further analyses was done for Test 10 with Δy = 0.25 m. L244-249: *"Not every power step is measured for each test due to the instability at 50% power for BT2. Additionally, time constraints led to a focus on the 50% and 90% power steps, as these are assumed to produce the highest hydraulic loads on the bed. Several tests are excluded from further analysis: Test 1, a long measurement to determine the minimum duration for a stable flow velocity; Test 5, which is identical to Test 8 but with slightly lower measured velocities; Tests 6 and 7, which focused on load cell measurements not considered in this study; and Test 10, which was aborted after the 50% power step. "* Additional figure comparing Test 10 and Test 17 during the 50% power step: 
6	L191: Table 1 [auth: Table 3 is probably referred to] Are rows related to tests 6 and 7 missing from the table? What is the distinction between tests 1 and 2, as well as tests 5 and 8? Except for the "power" value, which is listed as variable values in the last column, all other parameters are identical. The title of the fifth column, likely "Δx", is not displayed.	- Test 1 was a long duration test of 10 min to determine the minimal duration before the flow velocity did not increase anymore (could be followed real time). Afterwards Test 2 was conducted as with the same parameters but for power steps 25%, 50% and 90% for 2 min each. Therefore, only test 2 is used for the analyses. - Test 6 and 7 are tests with load cells. During these tests the focus was not on measuring flow velocity but on bollard pull conditions. This is not included in this article. - During test 5 BT2 did not stay stable at 50%. Therefore, the test was repeated as Test 8. Test 5 and 8 were compared and the test with the highest flow velocities at

		ADV1 and ADV2 was used for the analyses (Test 8). See figure below for the comparison between Test 5 and for 25% and 90% power.  - Title of fifth column in Table 3 is added. L244-249: *“Not every power step is measured for each test due to the instability at 50% power for BT2. Additionally, time constraints led to a focus on the 50% and 90% power steps, as these are assumed to produce the highest hydraulic loads on the bed. Several tests are excluded from further analysis: Test 1, a long measurement to determine the minimum duration for a stable flow velocity; Test 5, which is identical to Test 8 but with slightly lower measured velocities; Tests 6 and 7, which focused on load cell measurements not considered in this study; and Test 10, which was aborted after the 50% power step. “*
7	L249: “The effect of the applied bow thruster power is first shown for each of the statistical parameters power step for all the tests …” To avoid reader confusion, it is crucial to clarify that Figures 8 and 9 display the "average values" of test results, which evaluate the effects of bow thrusters' power. This is similar to the later	Figure captions edited. In the updated article the figure numbers are 11 and 12. L329-331: *“Figure 11: Average values of V ̅_hor(a) and σ_hor (b) for the moored tests (Test1-21) at 25%, 50% and 90% power. The markers depict the average over the tests and the error bars indicate the maximum and minimum measured value for V_max (a) and r_hor (b).The derived mean values (markers) including error bars for the maximum and minimum values of Test 1-21 at 25%, 50% and 90% power for the average absolute flow velocity V ̅_hor (a) and its standard deviation σ_hor (b). The water depth was h = 6.3 m and the distance between the bed and the axis of BT1 and BT2 was ht = 3.16 m. “*

	description of examining the effects of the number of bow thrusters (lines 280 to 282)	*L339-342:* *"Figure 12: Average values of V_max (a) and r_hor (b) for the moored tests (Test1-21) at 25%, 50% and 90% power. The markers depict the average over the tests and the error bars indicate the maximum and minimum measured value for V_max (a) and r_hor (b).The derived mean values (markers) including error bars for the maximum and minimum values of Test 1-21 at 25%, 50% and 90% power for the he maximum flow velocity V_max (a) and relative turbulence intensity r_hor (b).The water depth was h = 6.3 m and the distance between the bed and the axis of BT1 and BT2 was ht = 3.16 m."*
8	L254: "However, for V_{hor} during all power steps slightly higher values are measured by the second sensor in comparison to the first sensor." This trend is also observed for σ_{hor} at a power level of 50%."	Indeed, but for σ_{hor} this not at 50% but at 25% power. At 50% power for σ_{hor} the values are similar. L318-319: *"However, for V̅_hor during all power steps slightly higher values are measured by ADV2the second sensor in comparison to the ADV1first sensor. A similar trend is observed for σ_hor at 25% power."*
9	L281: "Note that these values represent respectively 7 (BT2 and BT1&2) and 5 (BT1) tests with somewhat different Δy." To study the impact of the number of bow thrusters, it is essential to ensure consistency in the number of experiments and parameters analysed for each case when using average values from various tests. I realize that it may not be feasible to conduct experiments uniformly across all cases due to limitations, but it is important to focus on conducting similar experiments to assess the	Fully agree on this, therefore the analysis of the difference in bow thruster is changed to limit the comparison on three tests per bow thruster with the same value Δx = 0.8 m and equal or very similar values for *Δy* . Some deviation of *Δy* between the tests of 0.25 – 0.5 m was chosen to use as otherwise there was only the option of *Δy* = 0 to compare BT1, BT2 and BT1&BT2 on, Updated Figure 13 added. L348-352: *"Three tests per BT with Δx = 0.8 m and equal or similar values for Δy are compared to each other. For BT1 these are Test 11 (Δy = 2 m), Test 12(Δy = 0 m) and Test 9 (Δy = -1.5 m). For BT2 these are Test 8 (Δy = 2 m), Test 2 (Δy = 0 m) and Test 15 (Δy = -2 m). For BT1&2 these are Test 14 (Δy = 1.75 m), Test 2 (Δy = 0 m) and Test 15 (Δy = -1.75 m). Note that these values represent respectively 7 (BT2 and BT1&2) and 5 (BT1) tests with somewhat different Δy. For the separate bow thrusters, similar decay profiles are*

	effects of variations in each parameter for different values of the desired parameter.	*observed with BT1 and BT2 overall BT1 measuring very similar the lowest values for V_max."*
10	Line 295: "four different values for Δy are studied …" See comment above (L167).	See answer comment 5.
11	Line 303: "while for the fifth sensor (Ott2) slightly higher values for $Vmax$ were measured at Δy = -3.5 m during Test 3." Can the authors provide an explanation for this change in the variation trend during Test 3 (the increase in the recorded velocity in the fifth sensor)? Could this also be a measurement error? Similar to what has been suggested for Figure 18a (line 434).	This higher value in Figure 14a (Previous Figure 11a) for Test 3 can have several explanations. 1. A measurement error such as in Figure 15b and Figure 21a. 2. Due to the higher flow velocities near the inflow zone of the BT. 3. Since the flow is vertically confined more towards the stern due to a larger draft. Therefore, looking at Figurer 14, 15 and 16 the highest flow velocities are measured in the direction of the stern. So it looks as if the jet reflects under an angle to the quay wall towards the stern. As the measured values of Ott2 of Test 3 are comparable in magnitude to Ott2 of Test 9 in Figure 14 I don't think it is a measurement error but due to explanation 3. While the values measured by Ott2 for Test 15 in Figure 15 are harder to explain. See comment 50 of reviewer 2. L504-505: *'This discrepancy could not be explained with the current data"*
12	L323: "Test 15 of BT1"---->"Test 15 of BT2"	L391-392: *"An exception is observed for Δy = -3.75 m (Test 16), for which a similar pattern is observed as for Test 15 of BT2,"*
13	L384-L388: Refer to Figure 16 for clarification on the defined locations.	L457: *"The described locations are illustrated in* ***Fout! Verwijzingsbron niet gevonden.****."*
14	L389: Specify in the text what "aL" refers to.	aL is a dimensionless coefficient that adjusts the efflux velocity V0 based on the specific geometric characteristics of the distance between the vessel and the quay. L460-462:

		"In Equation (6) and (7) a_L is a dimensionless coefficient based on the bow thruster diameter D_t and the distance L_BT between the bow thruster outlet and the quay wall."
15	L437: "The unusual high prediction of the German method of 0.66 V/V0 …" Refer to Figure 18a or its caption.	L508-510: *"The unusually high prediction of the German method of 0.66 V/V0 (see caption Figure 21) is most likely due to the quay wall clearance LBT2/Dt = 2.89 falling outside the range of LBT/Dt for which the German method is developed and validated (Table 4). "*
16	L546: "the bed. The results…" ---> "the bed, the results…"	L572-575: *"Current guidelines (Dutch and German method) indicate that the maximum flow velocity occurs near the intersection of this corner. However, the results from Gent, shown in Figure 11a and Figure 12a, indicate that the highest near-bed flow velocity was measured at the second sensor at x/Dt = 2.94."*
17	L566: "In Gent" ----> "in Gent"	See newly written sentence in comment 16 above.
18	L638: "As increasing LBT1"----> "As increasing LBT2"	L672-673: *"As increasing LBT2 from 3.09 m to 5.29 m results in higher flow velocities. "*

Reviewer 2 comments:

No.	Comment reviewer 2	Comment author
1	L4: Title seems ok, not reflecting the scouring effects, but I advocate to remove this part anyways.	Title not adjusted. Scour section is taken out of the paper. See comment 56.
2	L25-40: While generally happy with the abstract structure, I recommend to be more specific with some of the results. The author(s) mention a couple different results, yet omitting clear numbers, ratios, or other specific things. Please reduce the amount of vague statements, by mentioning specific results.	L25-31: *"Near-bed flow velocities were measured at 26 cm from the smooth (asphalt) bed. At 1.5 and 3 m from the quay wall, the highest mean horizontal near bed flow velocities were measured in the order of 1 m/s, rapidly declining towards 0.4 m/s at 7 -8.5 m from the quay wall. Maximum flow velocities reach up to 3.6 times the mean flow velocity while the measured (local) relative turbulence intensities were in the range 0.3-0.6."*
3	L44: Why use brackets?	Not every vessel has more than one bow thruster. But within this sentence indeed the brackets can be left out. L45-46: *"During berthing operations vessels use bow thrusters to improve their manoeuvrability, reducing their reliance on tugboats."*
4	L47: More references would be appreciated; there is a large body of literature on the topic, so I suggest to give credit to those active in the field.	Extra references are added within the paragraphs about an unconfined propeller jet and the paragraph about a confined propeller jet. Due to the various comments on the introduction section, this section has been rewritten. References for the unconfined propeller jet: L60-63: *"Building on Albertson et al. (1950), various physical model studies, including those by Fuehrer and Römisch (1977), Blaauw & Van de Kaa (1978), Berger et al. (1981) and Verheij (1983), have developed semi-empirical relations to describe the velocity field within propeller jets. Additionally, a comprehensive review of the*

		equations used to predict velocity distributions in propeller jets is provided by Lam et al. (2011).” References on confined propeller jets: L66-70: *“Studies on the flow field and hydraulic loads of confined propeller jets include Blokland (1996), Schmidt (1998), Johnston et al. (2013), Wei et al. (2017), Abramowicz-Gerigk et al. (2018) and Cantoni et al. (2023). Current empirical methods for determining the flow velocities within a propeller jet reflected on a vertical quay wall are based on limited vessel configurations and (bow) thruster types (Blokland, 1996; Schmidt, 1998).”*

5	L54: This is vague and should be specified in more detail.	L49-53: “This results in significant hydraulic forces on the bed, and if left unprotected, scour may develop, potentially leading to instability of the quay wall (Roubos et al., 2014). Therefore, a thorough understanding of these complex and turbulent flow patterns of the jet within its confined environment is essential to accurately quantify potential scour damage and designing effective protective measures (Hamill & Kee, 2016).”
6	L62: Place references at the end of this sentence.	L68-70: *“Current empirical methods for determining the flow velocities within a propeller jet reflected on a vertical quay wall are based on limited vessel configurations and (bow) thruster types (Blokland, 1996; Schmidt, 1998).”*
7	L63: The use of singular implies that this is a very uniform velocity field, which it clearly is not, at least as soon as the jet leaves the duct.	Indeed, edited from singular (Velocity) to plural (Velocities). L68-70: *“Current empirical methods for determining the flow velocities within a propeller jet reflected on a vertical quay wall are based on limited vessel configurations and (bow) thruster types (Blokland, 1996; Schmidt, 1998).”*
8	L71: Can this be more detailed and specific? You are saying it is questionable, but omit to say	Entire paragraph rewritten: L78-91:

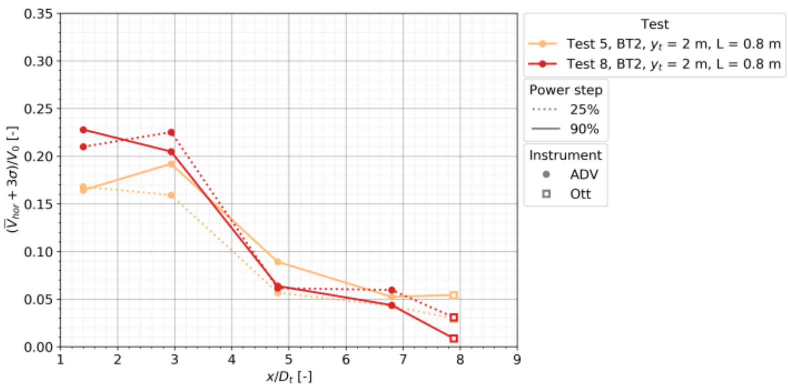
	what arguments are against the use of current methods. Please be more specific.	*"Discrepancies in near-bed flow velocities have been found between theoretical values from current design guidelines and those obtained from field measurements, scale models and numerical models of confined propeller jets. A CFD study, validated by field measurements, by DHI (2016) for the Port of Hamburg measuring near-bed flow velocities at an embankment resulted in flow velocities being approximately 30% lower than those predicted by the BAW (2010) design guidelines. Similarly, scale model tests by Deltares (2015), measuring the near-bed flow velocities of a reflected bow thruster jet at a vertical quay wall, found that the Dutch method (Blokland, 1996) was generally conservative, with measured near-bed flow velocity values averaging 40% lower than theoretical predictions for quay wall clearances up to 5.5 Dt. The study also found asymmetrical flow patterns and varying distances from the quay wall where the maximum flow velocity was measured. Additionally, the extend of the reflected bottom jet perpendicular to the quay wall varied during the measurement. The latter questions the current design guidelines for bed protection widths, which is based on vessel characteristics rather than the extent of the reflected bottom jet (PIANC, 2015). Consistent with these findings, field measurements by Cantoni et al.(2023) in the Port of Rotterdam, using an inland vessel with a 4-channel bow thruster, showed that both the Dutch and German methods overestimate near-bed flow velocities of a reflected jet at a vertical quay wall for small under keel clearances (~ 2 Dt) and small quay wall clearances (< 4 Dt)."*
9	L75: This needs to be improved or dropped: Master thesis cannot be used, unless they are peer-reviewed in other articles.	Removed, research by DHI (2016) (field measurements and CFD), Deltares (2015) (Scale model) and Cantoni et al.(2023) (field measurements) area added. See the paragraph L78-91 listed above in comment 8.
10	L78: This is a vague statement, please use more fact-based argument and state how large the differences between the standards and the scale models was.	*L79-85:* *"A CFD study, validated by field measurements, by DHI (2016) for the Port of Hamburg measuring near-bed flow velocities at an embankment resulted in flow velocities being approximately 30% lower than those predicted by the BAW (2010) design guidelines. Similarly, scale model tests by Deltares (2015), measuring the near-bed flow velocities of a reflected bow thruster jet at a vertical quay wall, found that the Dutch method (Blokland, 1996) was*

		generally conservative, with measured near-bed flow velocity values averaging 40% lower than theoretical predictions for quay wall clearances up to 5.5 Dt."
11	L81: So, again, how much overestimation to you conjure from the current state-of-the-art? Too vague writing.	See answer to comment 10 above.
12	L85: This part of the manuscript seems out of place. Please move everything that describes material and methods used into the next section/chapter. Also: I am greatly missing statements that make very clear where the specific lack of knowledge is. From these statements, the author(s) are asked to develop a set of specific objectives, clearly outlining the aim and scope of this research.	Moved to Section 2 Methodology the first paragraph. L113-118: *"Building on the uncertainties and limitations of current guidelines in determining the flow attack on the bed, initial field measurements were conducted as a pilot in November 2018 in the Port of Rotterdam to identify effective measurement techniques and setups (Deltares, 2018). Following these preliminary measurements, Cantoni et al. (2023) performed further field studies to gain a better understanding of the flow velocities near the bed. Utilizing these findings and lessons learned, new field measurements were executed from the 28th of September to the 1st of October 2020 in the North Sea Port of Gent at the Moervaart quay wall, located at 51°08'14.19" N, 3°47'23.95" E (WGS84) (Tukker, 2021)."* Furthermore, the last paragraph of Section 1 Introduction is rewritten to specify the knowledge gap. L92-103: *"The aforementioned discrepancies highlight the need for further research on confined propeller jets, particularly the reflected bow thruster jet on a vertical quay wall with small under keel and quay wall clearances. This situation is very common for inland vessels during manoeuvring in ports and waterways. Based on these discrepancies, especially found by Cantoni et al. (2023), the question arises whether the Dutch and German method can accurately predict the near-bed flow velocities after reflection on a vertical quay wall for an inland vessel using a 4-channel bow thruster. Therefore, new field measurements have been conducted, focussing on the near-bed flow velocities induced by a reflected bow thruster jet of a 4-channel bow thruster used by in*

		inland vessel at various distances from the quay. The aim is to determine the decay in near-bed flow velocities perpendicular to the quay wall, including the extent of the bottom jet, and to evaluate the measurement results against current design guidelines. The eventual goal where this research contributes to is to optimize bottom protections and their required width, which is of significant interest to the industry for ports and waterways. This study also seeks to gain additional insights into the locations where maximum flow velocities are measured and to observe asymmetrical flow patterns."
13	L103: Add lot/lon location.	L116-118: *"Utilizing these findings and lessons learned, new field measurements were executed from the 28th of September to the 1st of October 2020 in the North Sea Port of Gent at the Moervaart quay wall, located at 51°08'14.19" N, 3°47'23.95" E (WGS84) (Tukker, 2021)."*
14	L103: This is a bit of an unqualified statement. Why is this actually important to the research? Is this about the hull geometry (then give more information on this in specific terms), or the thruster power (state it explicitly), or something else?	L119-121: "The measurements involved the Somtrans XXV, which falls within the CEMT VIa Rijnmax class, one of the largest classes of inland vessels in the Netherlands. The dimensions of Dutch inland waterways and ports are based on this class, leading to small under keel clearances due to its large draught (up to 4,0 m)."
15	L105: Please be more specific and give manufacturer/make/type/measuremen t range, accuracy, etc.	Further elaborated within Table 1 (L177-178). L153-154: *"The near-bed flow velocities were measured with four Nortek Vector ADVs (Nortek, 2018) and two Ott C31 current meters (OTT-HydroMet, 2021) mounted on a measurement frame. The coordinates and setup of the sensors are detailed in Table 1."*
16	L112: Typographically, please use "protected space" between numbers and units throughout the manuscript; this will, in case of acceptance, be relevant	Adjusted.

	anyways for an accurate formatting of the article.	
17	L113: This is unclear: how was the rectangular cross-sectional area transformed. Introduce the equivalent diameter and say how it is derived (maybe it is just a geometrical consideration, but this still needs to be clarified.	L130-132 *"The bow thruster channels have a rectangular shape of 1.10 m wide by 0.82 m high, resulting in an equivalent circular bow thruster diameter (Dt) of 1.07 m, calculated as the diameter of a circle with the same cross-sectional area using the formula √((4·a·b"·")/π), where a is the width and b the height of the bow thruster outlet."*
18	L114: Left figure panel ok, right figure panel needs to be modified with adjusted font size (make it as large as the figure captions font size is. Could the author(s) add information on the mooring configuration? Was there any motion from the thruster effect working against the quay wall? How did you make sure the vessel was not moving at all?	Figure edited with larger font size. Mooring information added to the paragraph. Vessel was moored by means of mooring lines. At the bow multiple mooring lines from different angles where used to keep the vessel in place, as observed in figure 2a. The same was done at the stern of the vessel. L142-148: *"The vessel was securely moored at both the bow and stern using multiple lines angled strategically to maintain its position (Figure 2a). During the measurements, the thruster effect pushed the vessel away from the quay wall, increasing tension on the mooring lines keeping the vessel in position. Once the bow thruster reached the required power, the jet was developed and the flow velocities stabilized, the x- and y-position of the vessel was measured. Although continuous measurements of x and y were not conducted throughout the test duration, the accuracy in both directions is estimated to be within 10 cm due to the vessel being tightly moored during the tests. Detailed metadata of the vessel's position for each test is provided in Annex A."*
19 and 20	L121: Location unclear, please add to figure 2.	Location added in Figure 2 with a red dashed line and labels A-A.

21	L122: Accuracy of the values UKC and h_t? How did this change during the thrust motion? Can we assume that this vessel is not in motion at all? This will be very important when it comes to numerical modelling of this dataset, you present.	L139-141: *"During the measurement campaign the water depth was measured by pressure sensors recording a fluctuation in the water level in the range of ±0.04 m around the measured depth of 6.4 m (Tukker, 2021). "* Regarding the motion of the vessel. See comment 18.
22	L126: This information is repetitively provided, and still not clearly described what instruments these are. Please consolidate with the other instances where you mention those instruments.	See comment 15.
23	L139: Update table and give further specs of the instruments, resolution, sampling rate, software version, accuracy, etc. Do not place the table next to the figure, leave this typographic work for a later step, should the manuscript be accepted for publishing.	See comment 15.
24	L147: This remains unclear: you may want to place a full list of x/y/z positions in an annex that allows reconstruction of the full effort.	L147-148:' "*Detailed metadata of the vessel's position for each test is provided in Annex A.*"
25	L160: What do the authors mean by	Stationary processes are meant within the sentence. These are indeed further test runs. 'During' is removed to avoid confusion.

	"during"? Is it to imply measuring transient processes or stationary processes? If the latter, these are simply further test runs, right?	L193: *"The second parameter that was altered is the used bow thruster."*
26	L164: Make sure to use italics for symbols, variables, and other math stuff.	Adjusted throughout the paper.
27	L175: All math symbols should be formatted italic	Adjusted throughout the paper.
28	L176: Please comment on the repeatability of all tests, in particular on the manoeuvring testing? How did the authors make sure that these tests were consistent in time and space?	A few tests with the same or similar parameters were repeated showing similar flow velocities. This was for BT2 Test 5 and Test 8 (same parameters) during the 25&% and 90% power step and for BT1&2 Test 10 and Test 17 (having a difference in Δy of 0.25 m) during the 50% power step. The results are shown below which are from (Tukker, 2021) the master thesis were the measurements used for this paper are discussed more elaborately.  Figure 7.1: Comparison Test 5 and Test 8 at 25% and 90% power.

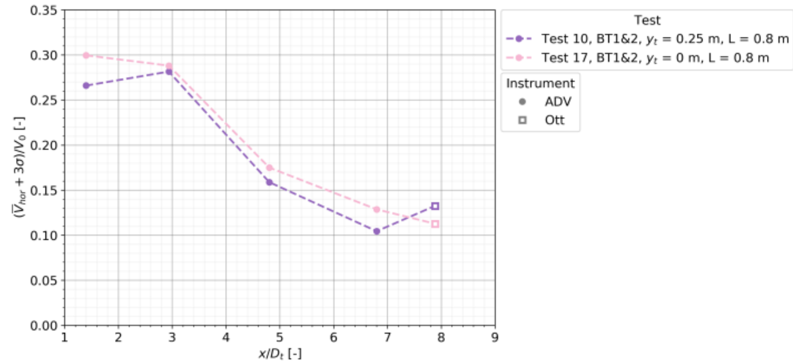


Figure 7.2: Comparison Test 10 and Test 17 at 50% power.

Leading to a very similar velocity decay profile and a relative difference in maximum flow velocity ($\bar{V}_{hor} + 3\sigma$) of:

25%	23.03%
50%	11.68%
90%	29.48%

Leading to an average of 21.4%.

The following is added within the discussion on the static tests:

L605-608:

"To ensure repeatability and consistency, the tests were conducted at a location with negligible flow and no other vessels present, within a short two-day period under constant environmental conditions. Two pairs of tests (Test 5 and 8, and Test 10 and 17) were repeated under nearly identical conditions. The average relative difference in maximum velocity ($\bar{V}_{hor} + 3\sigma$) was found to be 21.4%."

Regarding the maneuvering measurements, achieving repeatability is more challenging but feasible. For the berthing maneuvering tests, if the vessel starts the maneuver from the same xy location as in the original tests, repetition with a certain accuracy is possible. For the sailing tests, controlling the distance in the x-direction between the quay and the vessel is more difficult, and an accuracy within the range of meters would be reasonable.

		It is important to note that these measurements are field measurements. Therefore, exact replication of the tests is inherently challenging and maybe even impossible due to the local, non-laboratory conditions. However, a reasonably close enough approach with comparable conditions should be feasible.
29	L192: Please explain and justify the choice of measurement duration? Is this related to expected frequencies, or turbulence decay? Unclear	The paragraph on the characteristic time scale to determine the measurement duration choice is moved from the discussion section to section 2.2.2 Test overview including equation 1. L239-246: *"The duration of 2 min per subtest is based on the characteristic time scale of the turbulent motion. As this is difficult to determine, engineering choices were made based on the maximum length scale of turbulent fluctuations at the bottom and the advective velocity of the turbulent motion. The maximum length scale is the distance between the thruster and the bed, while the advective velocity is the maximum flow velocity at the bed (V¯_hor) (Deltares, 2015). Using the Dutch method (equation (8) and (9)), a maximum near-bed flow velocity of 2.65 m/s was calculated. With the bow thruster height above the bed of h_t = 3.24 m, the characteristic time scale T_c was 1.22 seconds. Consequently, a subtest duration of 100 times T_c, or 122 seconds (approximately 2 minutes), was chosen due to time restrictions for the measurement program, similar to the 2 minutes used per power step in the measurements by Cantoni et al. (2023)."* $$T_c = \frac{h_t}{\bar{V}_{hor}}$$
30	L194: One would assume that the highest loading on the bed exists for the full throttle of 100% power? Please explain.	Yes indeed, however, during the measurements the captain of the vessel showed us that 90% throttle of the bow thruster equalled the maximum power than could be used with the bow thruster. Therefore, more power than 90% was not possible and 90% power was used as equivalent for the full amount of power. See the table and figure below from (Tukker, 2021).

<table>
<tr>
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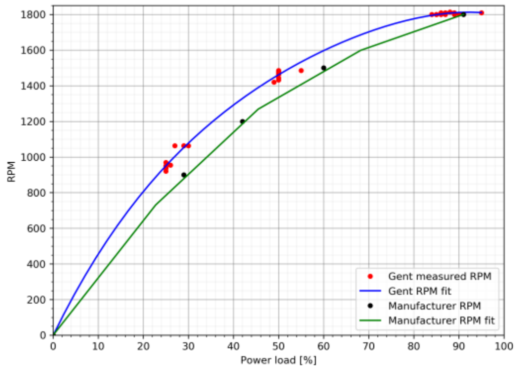
<td></td>
<td>
Table 3.7: RPM of the bow thruster with corresponding power load in % and the used power for determining V
<table>
<tr><th>RPM</th><th>Power load [%]</th><th>Used power for determining V_0 [kW]</th></tr>
<tr><td>940</td><td>25</td><td>98.5</td></tr>
<tr><td>1440</td><td>50</td><td>197</td></tr>
<tr><td>1800</td><td>90</td><td>394</td></tr>
</table>


Figure 3.31: Comparison between the measured RPM and corresponding power load (%) from the bridge of the S during the Gent measurements (red dots) and the values for the RPM with corresponding power load (%) provi manufacturer of the bow thruster (black dots).
</td>
</tr>
<tr>
<td>31</td>
<td>L202: This is vague, make specific what corrections were done, by which method (ref) and how

exactly.</td>
<td>Introduction of paragraph 2.3 Post-Processing is rewritten after which the 5 post-processing steps are elaborated more extensively. Each steps gives an explanation on what corrections were done and by which method including reference to those methods.

The general conditions are split up in a correction for the speed of sound (Step 1) and the orientation correction for xyz as described in reviewer comment 34.

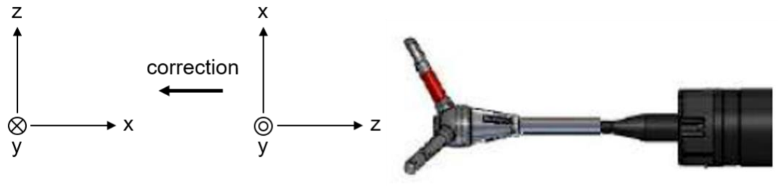
L265-266:

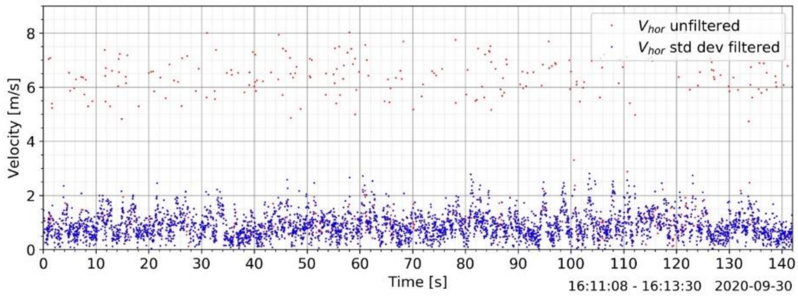
“(1) A correction for the speed of sound in water was applied to the flow velocity components of ADV1 and ADV4, as these ADVs measured with a salinity of 35 ppt instead of the assumed 0 ppt for freshwater.”</td>
</tr>
<tr>
<td>32</td>
<td>L203: How so? What method by which

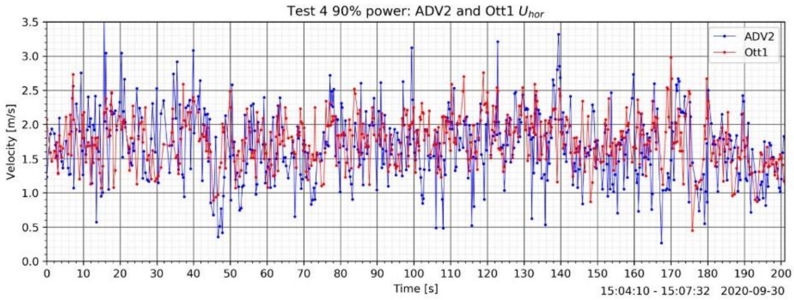
reference was used, or own procedure?</td>
<td>L267-270:

“(2) In this step, the data is filtered on signal strength and correlation based on the methods proposed by Nortek (2018). To quantify the data quality, a signal to (background) noise ratio of 15 dB is applied as threshold. Further, the correlation between two</td>
</tr>
</table>

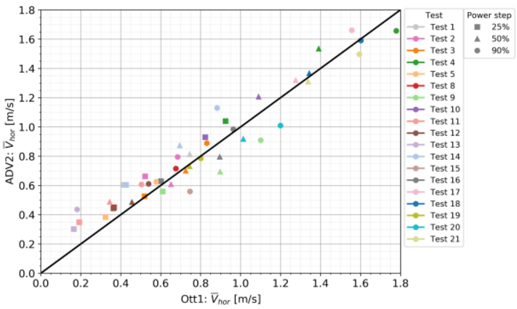
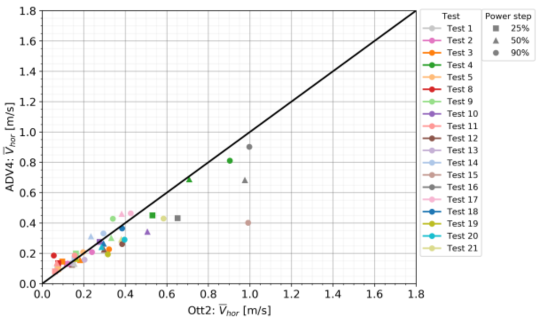
		pulse echoes being measured by the ADV should be larger than a threshold, for which the recommended 70% was used. " L271-275: *"(3) For ADV1 and ADV2, a bimodal distribution with outliers was observed in the measurement data, attributed to aliasing of the Doppler signal (Goring & Nikora, 2002; Durgesh et al., 2014). These outliers were removed by applying a standard deviation filter omitting all measurements outside the range of* $\overline{V} \pm 2\sigma$ *(per velocity component). This filtering approach effectively eliminated the spurious outliers caused by the aliasing of the Doppler signal (Tukker, 2021)."*
33	L205: Unclear: what spectral analysis?	See step 5 of the post processing: L287-300: *"(5) Measuring the flow velocity with an ADV set on a high sampling frequency and large velocity range can induce Doppler noise (Huang et al.,2020). Doppler noise is similar to white noise and caused by the intrinsic limit to the accuracy of the Doppler processing (Durgesh et al., 2014). In Figure 10Figure 7, the Doppler noise is observed as a constant resulting energy level in the higher frequencies of the spectrum. To determine the correct statistical parameters for the flow velocity near the bed, a noise correction method is applied. First, the flow velocity is transformed to a power spectrum of the measured horizontal flow velocity by means of the Welch (1967) (1967) method. Secondly, the variance of the noise (σ_noise^2) is obtained by assuming the noise level is equal to the spectral density at the higher frequencies ((f = 32 Hz). Subsequently, this variance due to this noise level is subtracted from the measured variance (σ^2) to determine the correct standard deviation (σ_corrected) by means of Equation (3(2). A visual representation of this method is illustrated in Figure 10Figure 7, where in blue the resulting variance is indicated. In Figure 10a the noise level is clearly visible, however, in Figure 10b it is less noticeable. This is due to the increased variance at the 90% power step induced by the higher flow velocities. As a result, the variance induced by the noise constitutes a smaller proportion of the total variance during the 90% power step than during the 25% power step."*

34	L210: Is this to transform from the instrument coordinate system to the local (result) coordinate system? Modify test and make more clear.	A correction for the ADV orientation of the x-, y- and z-direction is done for ADV3 and ADV4 which do not correspond to the defined x-, y- and z-reference system used within this article as shown in Figure 3 =, 4 and 5. • The positive x-direction of ADV3 was oriented towards the quay wall, opposite to ADV1 and ADV2. To align with the reference system, the x- and y-velocity measurements of ADV3 were multiplied by -1. • ADV4 had a fixed stem, and its tilt sensor did not record orientation. Corrections were applied to match the reference system. The original x-direction (pointing upwards) became the z-velocity, the original z-direction (towards the transmitter) became the x-velocity, and the y-velocity was multiplied by -  Figure X: Illustration of the orientation correction for ADV4. The originally measured *x* velocities are converted to *z*- velocities, the original *z*-velocities become the *x*-velocities and the original *y*-velocities are multiplied with a factor of -1 to comply with the defined reference system. Authors made the decision not to include this transformation in the article itself but only within this rebuttal to avoid confusion on the used reference system coordinates. Therefore, the pre-processing step 1 from Paragraph 2.3 Port processing is removed.
35	L214: Is this related to any of above listed steps for processing? The writing is a bit confusing, mentioning things in various places. Please harmonize and mention things each in one single place.	Yes, this is now written as separate step in step 3. The references are to literature about aliasing of the doppler signal which can cause outliers or spikes. From the figure below can be observed that some faulty measurements (outlyers) were present in the measurement. These outlyers were removed by omitting all measurements larger than $\bar{V}_{hor} + 2\sigma$ (per component). The 2σ threshold was similar to the 3σ threshold in filtering out the outliers with a difference of 0.3% for the filtered mean flow velocity ($\bar{V}_{hor}$) and a difference of 0.73% in standard deviation of the filtered flow velocity (σ). The

		standard deviation filtering technique performed better in filtering out the outliers than a median filtering technique (*Tukker, 2021).*  L271-275: *"(3) For ADV1 and ADV2, a bimodal distribution with outliers was observed in the measurement data, attributed to aliasing of the Doppler signal (Goring & Nikora, 2002; Durgesh et al., 2014). These outliers were removed by applying a standard deviation filter omitting all measurements outside the range of $\overline{V} \pm 2\sigma$ (per velocity component). This filtering approach effectively eliminated the spurious outliers caused by the aliasing of the Doppler signal (Tukker, 2021)."*
36	L217: Why these arbitrary thresholds? Please justify.	See the above answer to comment number 35. The arbitrary numbers were due to writing the average factor of how much the standard deviation was reduced after the above-mentioned filtering on 2 sigma. However, as pointed out, this is confusing. Therefore, only the filtering threshold above which the data points are omitted of 2 sigma is mentioned.
37	L220: This is vague writing: please improve.	Step 4 of post processing paragraph: L278-279: *"Damage to bed protections are primarily caused by the extremes in flow velocities, which are especially evident in the highly turbulent jets produced by bow thrusters."*
38	L240: As an addition, the authors could choose to present data for the 90% power level as well, this will give an extra-indication of how the data looks. There is space left, for a second figure panel to provide this data	Added as Figure 10b L296. L295-300: *"A visual representation of this method is illustrated in Figure 10, where in blue the resulting variance is indicated. In Figure 10a the noise level is clearly visible, however, in Figure 10b it is less noticeable. This is due to the increased variance at the 90% power step induced by the higher flow velocities. As a result, the variance induced by the noise constitutes a smaller proportion of the total*

		variance during the 90% power step than during the 25% power step."
39	L240: Also, what does the Ott data in these flows look like in a time-history?	Below the time history plot of Ott1 for Test 4 at 90% power (corresponding to the test of Figure 10) is given. ADV2 has been resampled to the Ott1 sampling frequency to compare the measured flow velocities. 
40	L250: Typically, numbers, abbreviations, etc. should not start a sentence.	L311-312: *"Both ADV2 and Ott1 measured similar values for $\bar{V}_{hor}$, while Ott1 measured significantly lower values for σ_{hor}, probably due to the lower dynamic response of the mechanical Ott meters."*
41	L261: Always use specific names of sensors, to not confuse audience.	All sensors are named after their specific name: ADV1, ADV2, Ott1, ADV3, ADV4 and Ott2. After Ott2 in brackets (fifth sensor) is written to make clear this is the last sensor. As the notation '2' could confuse readers to think it is the second sensor.
42	L263: See above comment.	See comment 41.
43	L270: Which ones? use abbreviations you introduced.,	See comment 41.
44	L273: : This is a result of the averaging over the different y-positions of the vessel? Also what again is the water depth/distance to the bottom of these measurements? Please add to the figure caption to make	Yes, averaging over the different y-positions of the vessels of Test 1-17 and over the tests with increased quall wall clearance *Δx* of Test 18-21. *L334-337:* *"Figure 11: Average values of V̄_hor(a) and σ_hor (b) for the moored tests (Test1-21) at 25%, 50% and 90% power. The markers depict the average over the tests and the error bars indicate the maximum and minimum measured value for V_max (a) and r_hor*

	more clear.	*(b). The water depth was h = 6.3 m and the distance between the bed and the axis of BT1 and BT2 was ht = 3.16 m. "*
45	L290: I appreciate that the authors presented a cross-sectional view of a single bow thruster's flow field sidewards and beneath the vessel, I however miss a discussion on the combined use of the BT. How do these velocity fields combine and interact? Is the arrangement of BT1 and BT2 a vessel specific feature, or a general construction specs of all vessels? This would be a good discussion towards the generality of this manuscript, in order to allow the audience to understand the applicability of the results in future settings.	*L660-664:* *"The PIANC (2015) guidelines consider two methods for combining multiple bow thrusters: linear and quadratic superposition. Quadratic superposition applies only for large distances behind the thruster and is not suitable for berthing operations. Therefore, in Gent, only linear superposition (BT1+BT2) is relevant and closely matched the measured V¯_hor, but overestimated for V_max at ADV1 and ADV2. Furthermore, this method does not account for factors like bow thruster type, channel length, bow thruster outlet shape, bow thruster propeller location and shape of the vessel."*
46	L295: Odd sentence start	L362-363: *"Further research is needed to determine which of these characteristics has the most influence on V_{max}."*
47	L311: Have the ADV and Ott been analysed comparatively to allow the combined use in this manuscript? How confident are the authors that these can be used this way?	Yes, Ott1 has been compared to ADV2 (same location in x-direction) while Ott2 has been compared to ADV4, with Ott2 being 1.16 m further away from the quay in x-direction. A thorough analyses is made and elaborated in Tukker (2021). However, as this did not fit in the proposed paper. Within the paper in the first paragraph of Section 3 Results the following is written down: *L311-314:* *"Both ADV2 and Ott1 measured similar values for $\bar{V}_{hor}$, while Ott1 measured significantly lower values for σ_{hor}, probably due to the*

		lower dynamic response of the mechanical Ott meters. However, Ott2, located 1 m from ADV4 in positive x-direction, measured similar values for both $\bar{V}_{hor}$ and σ_{hor} which could be due to the lower-frequency turbulence of the flow." This is further elaborated within the below figurers:  Figure 5.5: Mean horizontal flow velocity ($\bar{V}_{hor}$) of ADV2 compared to Ott1 for 25%, 50% and 90% power. Both ADV2 and Ott1 are located at 3.15 m from the quay wall. In black, the line x=y is plotted.  Figure 5.6: Mean horizontal flow velocity ($\bar{V}_{hor}$) of ADV4 compared to Ott2 for 25%, 50% and 90% power. ADV4 is located at x = 7.29 m while Ott2 is positioned at x = 8.45 from the quay wall. In black, the line x=y is plotted.
48	L357: See earlier comment on repeatability, plus, how close is the measured berthing manoeuvre to what usually happens when no science observation is taking place?	See answer at comment number 28. The measured berthing manoeuvre is based on the routine berthing procedure performed by the vessel's captain. The only aspect that was orchestrated was the starting location of the berthing manoeuvre, ensuring that BT1 and BT2 were positioned above the measurement frame sensors.".
49	L373: Give numbers instead of vague description.	L437-438: *"Even though the number of manoeuvring tests was limited to three tests (Test 22, 23 and 24), the manoeuvring tests did not result in higher flow velocities near the bed than the moored tests."*
50	L442: I dare say that this is not very	There is no scientific explanation for why the Ott2 in Figure 21a is showing a much higher value for $\bar{V}_{hor}$ than derived from

	scientific argument: please justify.	$\bar{V}_{hor,Dutch-BAW}$. Therefore, it might be a measurement error. However, this is an assumption. It could also be due to the inflow zone of the bow thruster as was also observed within other figurers explaining higher measured velocities for Ott2 than for ADV4. However, in Figure 21a Ott2 is showing extremely high flow velocities. This is observed during Test 15 in Figure 15b. Therefore, the extreme high values is also not inline with other measured values for Ott2 with BT1 or BT2 which were also influenced by the inflow zone. Therefore, the following is added: L508-509: *'This discrepancy could not be explained with the current data."*
51	L445: Please complete this sentence.	L510-512: *"**Fout! Verwijzingsbron niet gevonden.** and **Fout! Verwijzingsbron niet gevonden.** demonstrate the high sensitivity of the German method to variations in quay wall clearances, overestimating $\bar{V}_x$ for small quay wall clearances while slightly underestimating $\bar{V}_x$ for larger quay wall clearances."*
52	L446: Also, this conclusion seems a bit drastic, given a single clearance value that overestimated. Please harmonize argument and be more considerate.,	Agreed. What was meant was that by looking at all the four figurers in Figure 20 and 21 it can be concluded that the German method is very sensitive to variations in quay wall clearance. More than the Dutch method. L510-512: *"**Fout! Verwijzingsbron niet gevonden.** and **Fout! Verwijzingsbron niet gevonden.** demonstrate the high sensitivity of the German method to variations in quay wall clearances, overestimating $\bar{V}_x$ for small quay wall clearances while slightly underestimating $\bar{V}_x$ for larger quay wall clearances."*
53	L448: hat sentence generally applies to comparisons between new measurements and existing	Indeed, the ranges of dimensions/parameters where the Dutch method, German method and this research are based on are given in an overview in Table 4 L485-486.

	guidelines. Please make sure these limits are well established in this work.	
54	L473: Use abbreviations.	See comment 41.
55	L473: That statement is unclear to me, and difficult to join with the measurements.	Rephrased to better explain what is meant with this sentence to the following: L538-541: *'Consequently, for the low mean flow velocities measured by ADV3 and ADV4, the relative turbulence intensity may not be a reliable indicator of actual turbulence levels. This is because small fluctuations in velocity can result in disproportionately high relative turbulence intensity values, which may not accurately reflect the true turbulence characteristics of the flow."*
56	L499: Not sure about the structure of chapter 4, and more importantly, I am unhappy about the change in topic. I would actually argue that this is off-topic and should be removed from the writing. It does only loosely contribute to the understanding of the velocities, and the exercise of bed protection design is a rather practical one. If possible, I recommend to the authors to remove this part of the manuscript. As an indication, the authors are not writing in their introduction about bed protection schemes, and much would have to be said about it, giving full merit of the	Section removed and paragraph added to discussion: *"The evaluation of bed protection design at the Moervaart quay wall in the North Sea Port Gent reveals that, when the measured near-bed flow velocities are used as the sole input to calculate the required bed protection, significantly smaller rock sizes and asphalt mattress thickness would be necessary to withstand the hydraulic load of the jet in comparison to current guidelines (PIANC, 2015). Further research is needed to determine whether this finding is generally applicable."*

	existing literature on scour protection.	
57	L551: I am surprised that the choice of vessel is not discussed, other than saying that this apparently is one of the largest ships… Please make the vessel type, hull shape, arrangement of BTs a topic in your discussion.	L596-601: *"The CEMT Via Rijnmax class inland vessel was chosen for the measurements in Gent due to its large draught and minimal under keel clearances, simulating the highest hydraulic loads on the bed. The study focused on inland vessels, which typically feature a box-shaped hull with a flat bottom and vertical sides, unlike the V-shaped hulls of sea-going vessels. The limited space between the quay wall, hull, and bed can lead to higher flow velocities and greater impact on the bed, increasing frictional forces and resulting in more turbulent eddies and vortices. However, the rectangular channel shape and the propeller's position at the bow thruster entrance minimize the jet's swirling motion."*
58	L557: Odd sentence, please revise	L575-576: *"Physically, the blunt corner between the quay wall and the bed is expected to be a stagnation point with negligible quay-perpendicular velocities."*
59	L564: Expand on this argument and better explain what effects could happen in different sheet pile constructions.	L581-586: *"A second limitation is that during the field measurements, the influence of the sheet pile wall configuration on the reflected jet was not studied, leaving this influence unknown. Different configurations of sheet pile walls can affect the behavior of the reflected jet by altering flow patterns and turbulence characteristics. Variations in alignment, surface roughness, and structural features can cause the jet to deflect in various directions, affecting the distribution of flow velocities. For example, an angled wall may concentrate velocities in certain areas, while irregularities such as interlocking sections can create localized turbulence and swirling currents. "*
60	L570: Ahh, this information should have come quite a bit earlier, I had made a comment. Please move justification to the earlier position and expand on the	See comment 29, moved to section 2.2.2 Test overview.

	estimation of the eddy count.	
61	L570: BTW, the equation is not really well introduced and should equally be moved to an earlier location.	See comment 29, moved to section 2.2.2 Test overview.
62	L658: Word choice.	L696-697: *“However, at greater distances (x) from the quay wall, the highest flow velocities are measured towards the stern of the vessel.”*

Additional notes:

L484-487:

“Please note that due to the measured deviation of Δx (recorded at BT2) from the predefined target value of Δx, an average deviation of 0.36 meters, calculated over Tests 1-21, has been accounted for. This adjustment is added to LBT1 and LBT2 for the considered tests in Figure 20 and Figure 21, ensuring a fair comparison with the guidelines.”