KEEPING BRITAIN TRADING

IMMINGHAM EASTERN RO-RO TERMINAL

Additional Navigations Simulations Report

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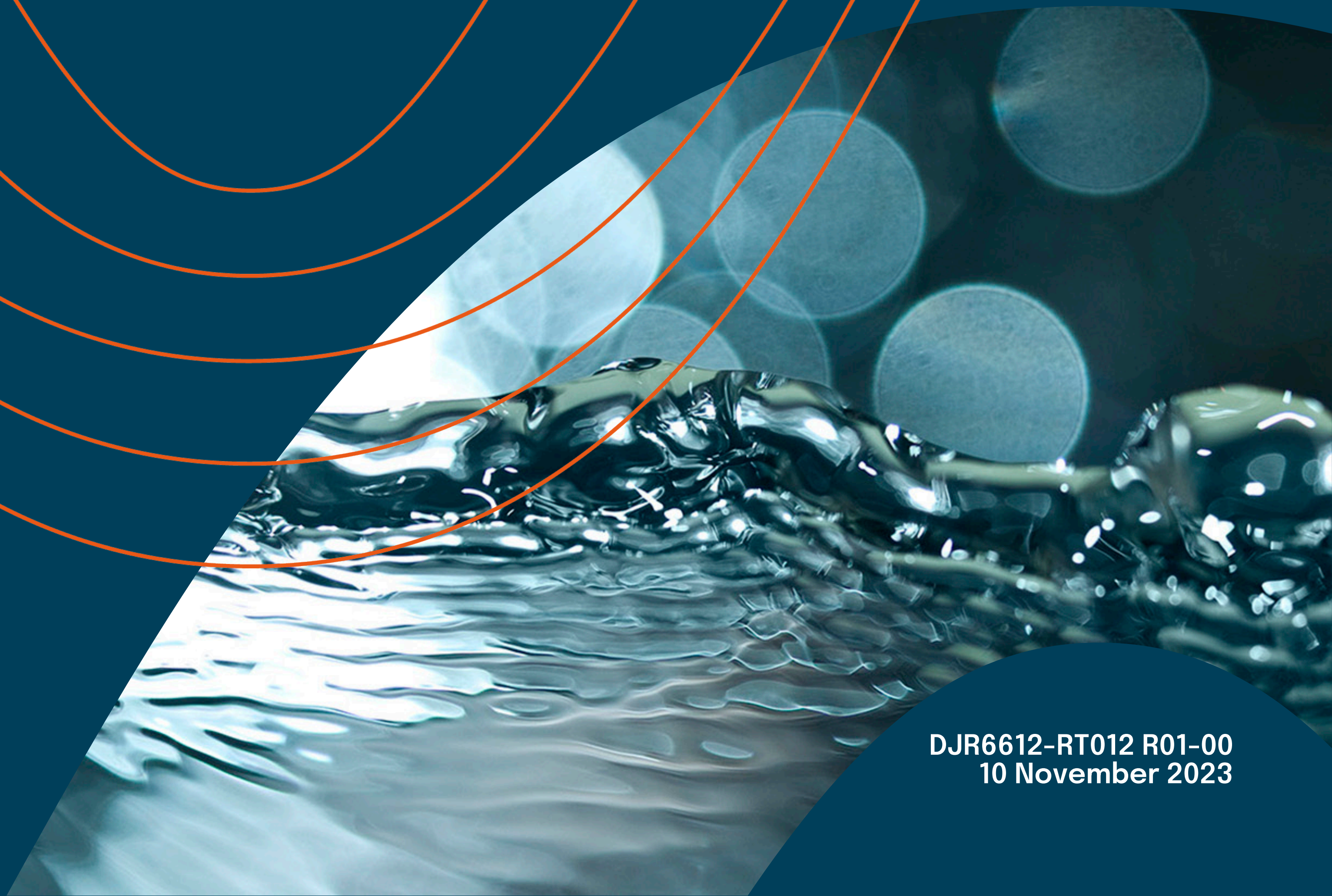

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Summary

Associated British Ports (ABP) Humber is considering the development of additional RoRo berth capacity to the east of the Immingham dock, which will be known as the Immingham East RoRo Terminal (IERRT).

ABP has commissioned HR Wallingford to undertake a series of desk studies and real-time navigation simulation studies to assess the feasibility of the design for the IERRT. This work is detailed in a series of reports numbered DJR6612-RT001 to RT009, produced between Dec 2021 and Sep 2023 (References 1 to 9).

Context for this study

The new facility is currently being subjected to a Development Consent Order Process. As part of that process, the Examining Authority encouraged ABP and Stakeholders to consider whether some further simulation work would enable them to come to a closer level of agreement on some of the navigational issues.

ABP proposed this short study to consider the following areas, which were somewhat contentious during the hearings:

- The proximity of the Eastern Jetty in relation to the IEERT terminal, in particular during manoeuvres at berth 3.
- The effects of the current direction at berths 2 and 3.
- The effect of the observed variation in the flow speed and direction in the main river area compared to HR Wallingford flow models for the same area.

Stakeholders raised several other areas for consideration in their responses to the invitation:

- Consideration should be given to specific parameters for machinery use and abort procedures.
- Specifically, the flows north of IOT should be set to 135 or 315 degrees true on the ebb and flood tide, respectively.
- Sensitivity of the outcomes to wind gusting and sheltering should be included.
- The simulations should be conducted in as near to normal operating conditions as possible.
- The simulations should consider the other IERRT berths.
- The layout should include the Eastern Jetty with Tug pontoon, moored tugs and a 185 m LOA MR2 tanker moored alongside.
- Manoeuvring policy and procedures should be included.

These issues were all addressed during the simulations and discussions. The stakeholders indicated that they were content with, or understood, the process and method in which they had been addressed.

Additionally, stakeholders raised 2 issues on which agreement was not reached during the simulations:

- The design vessel. Well-rehearsed discussions on this issue took place but were unresolved.
- Impact protection. This was an ongoing design issue at the time of the study and it was anticipated that further work will resolve disagreement in this area in due course.

Conclusions

16 runs were conducted at the proposed IERRT facility berth 3 and 1 run was conducted at berth 2.

The runs demonstrate that a Stena Transit class vessel is able to operate safely and efficiently in normal operating conditions to berths 1, 2 and 3. Successful runs were also completed in selected extreme conditions.

Commentary and key observations

Operations in normal conditions

It was explained and agreed during the initial briefing that a Force 5 wind (17-21 knots) (10 m AMSL) represented the maximum wind strength that could reasonably be expected at the facility once or twice a month on average. It was noted that there would be a seasonal variation with more occurrences in winter. This wind strength was represented in the simulator for both setting the vessel on and off the berth. For efficiency, only peak flood and ebb flow conditions that occur on the largest of spring tides were simulated. These flow conditions would only be expected for a few hours once every 28 days within a normal tidal cycle.

These were agreed as representative of the 'normal worst conditions' that might be expected once every month in the summer and maybe 3 to 4 times a month in the winter. However, the coincidence of strong winds and peak flows is expected be to occur with a reduced frequency.

9 runs were conducted with the Stena Transit model to, and from, berth 3 in these conditions.

The harbour master outlined his thoughts on the manoeuvre with advice prior to each run. Tug assistance was not anticipated to be required by the PEC conducting the run and was not used. 8 of the runs were assessed as successful.

One run was assessed as marginal due to the proximity to adjacent vessels. The marginal aspect was repeated and shown to be achievable. In considering this assessment, it should be noted that this was the first run in the simulator conducted by the PEC in this study. Furthermore. the PEC reasonably stated that in reality his view from the bridge wing would have enabled him to better judge the distance to other vessels.

Manoeuvres to and from berths 1 and 2 in these conditions using the Stena Transit model were discussed amongst the participants. It was agreed that, in general, the manoeuvres to, and from, berth 2 would be similarly challenging as those undertaken and manoeuvres to berth 1 would be less challenging.

It was agreed that the manoeuvres executed during this study in these conditions should be considered repeatable with appropriate training for PECs and pilots.

DFDS noted that ideally runs should be undertaken to all berths in all conditions. HR Wallingford noted that for efficiency it is normal when considering port design to assess the worst cases and, where possible, apply the understanding from those simulations to other cases. Pertinently. there is a substantial collection of simulations and derived understanding for manoeuvres at other berths to assist in this process.

Extreme Operating Conditions

In line with previous studies into the feasibility of operations at IERRT, runs have been included considering coincident extreme wind conditions and peak ebb and flood tides.

It was explained and agreed during the initial briefing that a low Force 7 wind (27 to 33 knots) (10 m AMSL) represented the maximum wind strength that could reasonably be expected for operations to continue at the facility. This wind strength was applied based on a variation of +/- 2.5 knots around a 27.5 knot mean, and additional sensitivity increased the variation to +/- 5 knots to consider the effect of gusts.

This wind strength was explained to be equivalent to the maximum wind strength that might occur at the location several times a year. APT noted that they cease operations when their anemometer, approximately 8 m AMSL, shows 35 knots, based on 30 to 60 second gusts, which is expected to occur around 6 times a year. Peak spring flood and ebb conditions were used throughout.

The extreme operating conditions used in this study broadly equate to the conditions used for the previous feasibility studies, noting that several runs have also been conducted with winds between 30 and 35 knots to ensure the assessment of the design using a 'proxy' design vessel was conservative.

As for the normal conditions, the harbour master outlined his thoughts on the manoeuvre with advice prior to each run. Two 50 t BP ASD tugs were requested by the PEC and used on each run. The level of tug power required was never considered excessive by the tug master or the simulation participants. 8 runs were completed in extreme conditions and all were assessed as successful.

Layout of the port and eastern jetty

HR Wallingford provided a layout for the port and proposed infrastructure based on drawings provided for previous studies.

The tug pontoon was reinstated at the end of the eastern jetty as it had been removed for previous studies. 4 tugs moored double banked on the jetty were included in the simulation on the tug pontoon and a 185 m MR2 tanker was moored on the eastern jetty to ensure the conditions for the approach to berth 3 were as confined as could reasonably be expected.

During the briefing for this study it was highlighted that the design for the rear caissons at IERRT had been altered from that originally provided for the navigation simulations.

HR Wallingford has reviewed the changes and note:

- The changes to the size of the caissons at the rear of the IERRT structure make no substantive change to the geometry of the berths at IERRT. Consequently, the previous work undertaken for all classes of ships considered remains pertinent.
- HR Wallingford's previous modelling shows that during the early part of the low-water flood the caissons create a blockage with an associated minor acceleration and diversion of the flow at the northern end of IERRT towards IOT 8 and 6. This has been investigated in previous studies and found to be navigationally insignificant. An initial review of the new situation indicates that the blockage effect is not likely to significantly increase any acceleration or deviation in the flow towards IOT 8 and 6 than has already been demonstrated in modelling.
- HR Wallingford has recommended to ABP that a revised flow model considering the changes in design is produced and a comparison with the previous flow model is made to ensure that the assessments outlined above are valid.

Flows north of IOT

A comparison of the flow modelling to Tidal Diamond B (BA 3497 and tidal diamond D on page 118 of the pilot handbook) has been undertaken This was presented to stakeholders during the briefing for this study and the details are provided in Appendix B.

At the request of stakeholders the modelled flows in the main part of the river were adjusted using a coarse vector during peak ebb and flood conditions. This was to represent the situation where flows set strongly either 135 degrees towards IOT on the ebb tide or 315 degrees away from IOT on the flood tide.

The flows north of IOT as a result of the applied vector are shown in Table 1.1. Point A is a location approximately 150 m north of IOT A1 dolphin and point B is used for comparison with tidal diamond B, see Figure 1.1.

Table 1.1: Adjusted flows at point A and point B

	Point A speed (knots)	Point A direction (degN)	Point B speed (knots)	Point B direction (degN)
Peak flood	4.6	315	5.1	317
Peak ebb	4.1	135	4.7	144

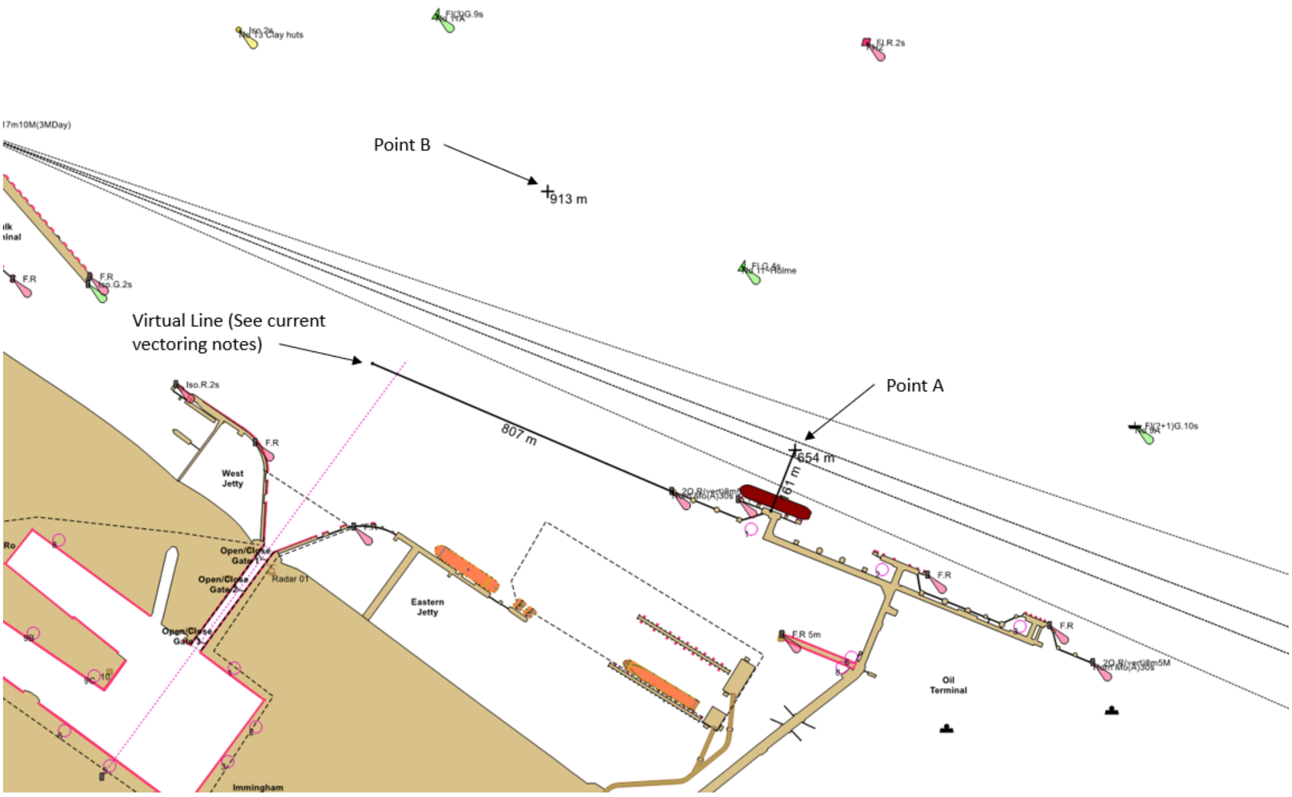

Figure 1.1: Diagram showing reference points used for tidal adjustments

HR Wallingford have high confidence in the flow model south and west of the IOT as described in the previous report, which is included as Appendix C.

In order to ensure that the flows in the vicinity of IERRT were based on the best available understanding, the vector adjustment was slowly reduced to zero once the vessel was clear to the south west of the IOT berthing line for arrivals. Similarly, the model flows were used for the initial stages of departure manoeuvres and the vector adjustment added once the vessel was clear of the dredged IERRT berthing area.

During the swing in to, and out of, the main river with the modified tidal streams no issues were encountered in normal or extreme conditions.

It should be noted that during the ebb tide special consideration needs to be given to planning the swing in to the main river to ensure the safe passing distance (150 m) on IOT is maintained.

The same techniques currently used for arrivals and departures from Immingham dock can be applied to this manoeuvre.

Sensitivity to wind sheltering and gusts

Sensitivity to wind sheltering was included in runs 10, 11 and 13. The PEC conducting the run was able to safely manoeuvre the vessel taking into account the predicted effect as the vessel approaches, or clears, the lee of adjacent moored vessels.

The modelled sheltering effect was reported to be appropriate and similar to that experienced in comparable real world operations at Immingham Sea Terminal.

HR Wallingford increased the gusting parameters on Runs 14 and 15 to include a variance +/- 5 knots based on discussions with stakeholders.

The effect of increased gusting was reported to be appropriate and similar to that experienced in comparable real world operations at Humber Sea Terminal.

Quantitative assessment

HR Wallingford conducted a qualitative simulation assessment based on their experience of running navigation simulations over 25 years. It is difficult to agree parameters which can consistently be applied and expert analysis of the situation provides a more efficient and nuanced assessment.

HR Wallingford briefed stakeholders of their proposed assessment criteria, which were the same as used in previous studies.

In addition to these criteria DFDS requested that some specific parameters should be included. These were briefed to all stakeholders. An additional stage was included in the debriefing process to enable a rapidly produced track plot to be presented to enable DFDS to apply their parameters within the process.

The manoeuvres were all conducted within the parameters detailed by DFDS. This was agreed subject to the opportunity to review the track plots in a measured manner. The track plots are included in Appendix A.

Tug use

HR Wallingford provided tug models representing 50t BP ASD tugs. The tugs used were agreed to be representative of those available on the Humber and their use was considered appropriate throughout.

Contents

Appendices

Tables

Figures

1 Introduction

Associated British Ports (ABP) Humber is considering the development of additional RoRo berth capacity to the east of the Immingham dock, which will be known as the Immingham East RoRo Terminal (IERRT).

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1.1 Context for this study

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- Impact protection. This was an ongoing design issue at the time of the study and it was anticipated that further work will resolve disagreement in this area in due course.

2 Simulation Configuration

2.1 General

The simulator setup was undertaken in accordance with HR Wallingford normal procedures, the layout, environmental models and ship manoeuvring models were tested before hand.

A copy of the pre simulation brief is included in Appendix E.

2.2 Environment

The environmental models and setup used in this study were the same as used in previous studies supporting IERRT development.

Details were briefed prior to commencing the simulations.

Additional information regarding analysis of the wind data used and the flow modelling is included in Appendices A, C and D.

2.3 Port Layout

HR Wallingford provided a layout for the port and proposed infrastructure based on drawings provided for previous studies (reference 1).

The tug pontoon was reinstated at the end of the eastern jetty, it had been removed from previous studies. 4 tugs moored double banked on the jetty were included in the simulation on the tug pontoon, and a 185m length MR2 tanker moored on the eastern jetty to ensure the conditions for the approach to berth 3 were as confined as can reasonably be expected.

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HR Wallingford has reviewed the changes and note:

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- HR Wallingford has recommended to ABP that a revised flow model considering the changes in design is produced and a comparison with the previous flow model is made to ensure that the assessments outlined above are valid.

The layout as simulated is shown in Figure 2.1. Apart from on run 1, a Transit class vessel was always included moored on the adjacent berth.

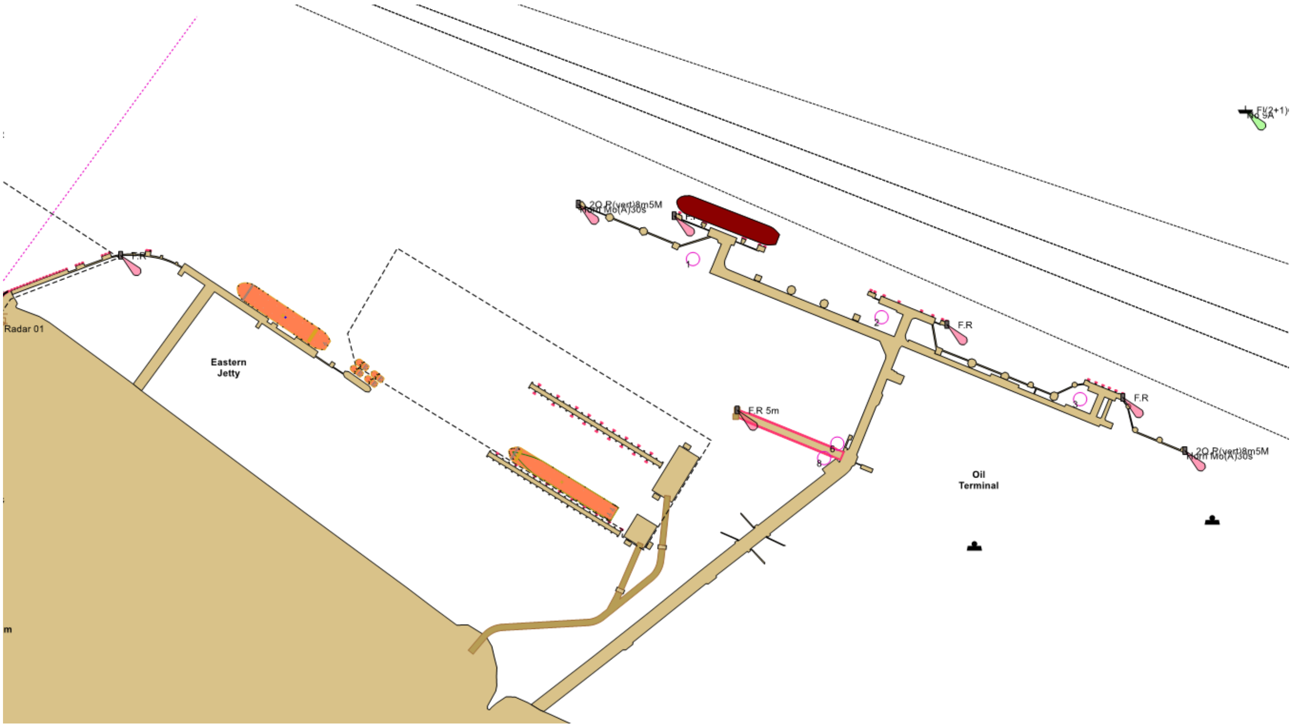


Figure 2.1: Port layout as simulated including tugs and vessels moored on eastern jetty

2.4 Design vessel

The design vessel for the study was the Stena T class, which was previously used for stakeholder simulations on the Humber. The manoeuvring characteristics are shown in Table 2.1.

Figure 2.2: Stena T Class

Table 2.1:Manoeuvring characteristics for Stena T class

Characteristic	Unit	Stena Transporter	
Ship type		RoRo Ferry	
Length overall	m	212	
Length between perpendiculars	m	194.8	
Beam overall	m	26.7	
Distance bridge to stern	m	190.2	
Draught	m	6.3	
Block coefficient		0.655	
Displacement	t	22,000	
Propulsion			
Main engine type		2 x STX MAN 9L48/60B	
Engine power (total)	kW	21,600	
No. of propellers, type		2 x CPP	
Bow thrusters	t	55	
Rudder type		Becker flap	
Max rudder angle	°	35	
Manoeuvring engine order		**Pitch (%)**	**Speed (knots)**
Full Ahead		100	20.9
STOP		0	0
Full Astern		100	-13.6
Windage			
Windage lateral	m²	4,050	
Windage frontal	m²	770	
Wind speed (knots)		**Beam wind force (t)**	
20		26	
25		41	
30		59	
35		80	

2.5 Tug models

HR Wallingford provided a 50t BP ASD tug model for use in this study.

This was agreed to be an appropriate model based on the current availability of tugs on the Humber, see Table 2.2.

Table 2.2: Number of tugs based on effective bollard pull in tonnes currently available on the Humber based on information provided by HES

BP (tonnes)	Number of tugs on Humber
50 to 59	8
59 to 69	3
69 +	6

HR Wallingford's navigation simulation system supports two types of tug models:

Centrally controlled tugs: The tug(s) assisting the vessel are controlled by the Simulator Operator following the Pilot's commands, and in a manner similar to that which would be expected in practice, with realistic delays applied. The response of each centrally-controlled tug is governed by a tug performance model that ensures the response times and maximum force deliverable by each tug varies with tug type, winch type, vessel water speed and assist mode (push, direct pull, powered indirect, indirect pull and transverse arrest) as well as the local wave conditions and any hull sheltering effects.

Independently controlled tugs: The independently controlled tugs are operated by a tug master from separate, but linked simulator bridge(s) configured as a tug. The behaviour and performance of each independent tug model, in terms of the response to any helm, engine and towline/fender forces, along with the effects of the local wind, wave and current conditions, is governed by a full mathematical tug manoeuvring model. The tug model represents motions in all six degrees of freedom (6DOF), i.e. surge, sway, heave, roll, pitch and yaw motions, and includes tug interactions with waves, the tow line, winches and fenders. Independent tugs can be used in conjunction with centrally controlled tugs to complete the full tug complement required for a manoeuvre.

With the independently controlled tug models, the operating delays and performance degradation are automatically taken into account. The centrally controlled tugs are subject to operating delays as shown in Table 2.3, and tug performance curves as shown in Figure 2.3 and Figure 2.4.

Table 2.3: Centrally controlled tug response settings

Tug response delay			Delay
Time to attach and secure			5 minutes (+ 3 minutes line pay-out)
Time to react to new thrust level command			1 minute
Time to react to change in thrust level			20 seconds
Time to change thrust direction	Direct	up to 90˚	Up to 1 minute
		90 to 180˚	Up to 2 minutes
	Indirect	roll into assist	Up to 30 seconds
		quarter to quarter	Up to 1 minute
Time to detach	Push/ pull mode		1 minute

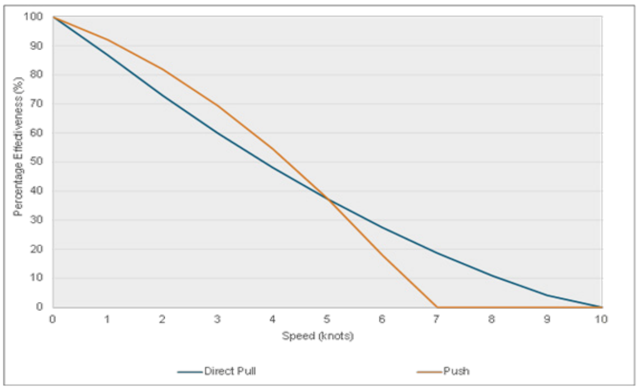


Figure 2.3: Effectiveness of centrally controlled tugs with water speed

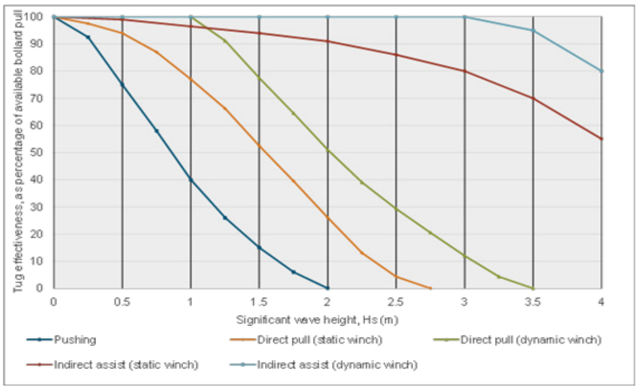


Figure 2.4: Effectiveness of centrally controlled tugs with wave height

3 Navigation simulation session

3.1 Simulation session

The real time navigation simulation session was conducted at HR Wallingford's UK Ship Simulation Centre on 07 and 08 November 2023 using 2 full mission ship bridge simulators. The demonstrations were facilitated by HR Wallingford staff with significant input from all stakeholders and suitably qualified pilots and masters controlled the ship manoeuvring models.

The attendees are detailed in Table 3.1.

Table 3.1: Attendance list

Attendees	Role	Organisation
[redacted]	Project Lead	HR Wallingford
[redacted]	Simulator Operator	HR Wallingford
[redacted]	Simulator Operator	HR Wallingford
[redacted]	Head of Marine Operations	ABP Humber(8 Nov only)
[redacted]	Harbour Master	ABP Humber
[redacted]	HES Dock Master	ABP Humber (Remote)
[redacted]	HES Project Team	(Remote)
[redacted]	Project Manager	ABP Project Team
[redacted]	Consents Lead	ABP Project Team
[redacted]	Pilot Operations	ABP Humber
[redacted]	VLS pilot	VLS pilot (ABP)
[redacted]	Senior Manager port development and deputy trade director	Stena
[redacted]	UK Operations	Stena
[redacted]	PEC holder/master	Stena
[redacted]	PEC holder/master	Stena
[redacted]	Marine Superintendent	IOT
[redacted]	Marine Consultant	Nash Maritime
[redacted]	Marine Operations	DFDS
[redacted]	Marine Consultant	DFDS
[redacted]	Tug master	SMS towage
[redacted]	Marine Operations	CLdN (Apologies)
[redacted]	Lawyer	ABP Legal Team (C&C)
[redacted]	Lawyer	DFDS Legal Team

3.2 Briefing and debriefing

The Pilots and Tug Masters were briefed on the simulation run conditions and objectives before each run. At the end of each run a debrief and discussion was used to capture their views, and those of any other participants.

The discussion considered the events of the run and key conclusions including any need for repeat runs or alterations to the run schedule. Expertise from the wide range of participants contributed to this important element of the study.

A daily summary discussion was held at the end of each simulation session day in which the key conclusions arising from the simulation runs were agreed.

3.3 Grading of results

Each simulation run was graded by the simulation participants as Successful, Marginal or Fail, according to the following evaluation criteria:

Successful

Standard manoeuvres:

- The ship remains under full control at all times without resorting to aggressive manoeuvring techniques;
- The ship stays within safe water areas with acceptable clearances to all port and other structures, and other berthed ships;
- Tugs are operating safely and within sustainable limits;
- For berthing manoeuvres, the ship ends the run alongside, or in such a position that lines would be ashore without appreciable difficulty, at zero speed, with an acceptable sway velocity and no appreciable yaw rate;
- For departure manoeuvres the ship exits smoothly, without risk of drifting onto port structures or other ships.

Emergency/failure situations:

- The ship is brought back under full control without encountering significant hazards, with the risk of only minor damage;
- The ship may leave the designated manoeuvring area boundaries, but still has acceptable under keel clearance and maintains acceptable clearances to other ships/structures throughout the recovery;
- Tugs are neither endangered nor asked to operate in an unsafe manner;
- The ship can be moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated/resolved.

Marginal

Standard manoeuvres:

- The Pilot considers the ship is at the limit of control during standard manoeuvres;
- The ship stays within the safe water area boundaries, but with unacceptable clearances;
- The ship clears all port structures, and other berthed ships, but with unacceptable clearances;
- Tugs are operating safely, but approaching their sustainable operating limits (e.g. being used at 100% power for more than 15 minutes);
- For approach manoeuvres, the ship ends up alongside, but may have a high approach velocity. The manoeuvre can be concluded, but minor damage may occur;
- On departure, the ship is manoeuvred off the berth but with some difficulty. The manoeuvre is completed with the potential for minor damage only.

Emergency/failure situations:

- The ship is at the limits of control during the recovery from the failure;
- The ship has marginal under keel clearance or marginal clearances to other ships/structures during the recovery;
- Tugs operate at the limits of safety;

	• The ship is at the limits of controllability as it is moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated/resolved.
Fail	Standard manoeuvres: • The Pilot loses control of the ship; • The ship strays outside the safe water area boundaries and/or grounds; • The ship either contacts, or has a near-miss with port structures and/or other berth ships; • Tugs are required to operate in an unsafe manner, or exceed sustainable operating limits (e.g. being used at 100% power for more than 30 minutes); • For approach manoeuvres, the ship cannot get alongside at all, or contacts the berth with sufficient force that severe damage may have occurred; • On departure, the ship either cannot be manoeuvred off the berth, or encounters significant difficulty in manoeuvring, such that severe damage may have occurred. Emergency/failure situations: • The Pilot cannot regain control of the ship before the ship is endangered; • The ship cannot be prevented from entering dangerously shallow water and/or grounds; • The ship either contacts or has a near-miss with a known hazard, port structures, and/or other berth ships; • Tugs are endangered or are asked to operate in an unsafe manner; • The ship cannot be moved into safe, deep water or to a position suitable to anchor safely.
Aborted	The run was aborted for efficiency reasons, to save wasting any time, due to either: • The initial manoeuvring strategy or approach/departure manoeuvre was deemed to be inappropriate right at the start, so the run would be bound to fail if continued; or • Because of the need to test aspects of the ship manoeuvring model.

3.3.1 Additional parameters proposed by DFDS

DFDS requested that ABP consider the following parameters when determining if each run is characterised as a 'success', 'marginal' or 'failure':

- 100% Bow thruster use in excess of 3 minutes (continuously or nearly continuously) should be deemed to be 'marginal' as it indicates a vessel on the very limit of what should be considered a 'safe' manoeuvre.
- Engine use in excess of 60% is deemed 'marginal' as from experience DFDS masters know this is the limit of what should be considered a 'safe' manoeuvre.
- If either of the first 2 criteria were met whilst working with the assistance of a tug they were deemed a failure due to the danger to the tug and her crew by the excessive wash this amount of machinery would cause.
- Tug power in excess of 100% for more than 3 minutes were considered marginal as again they do not represent 'safe' manoeuvres.

In relation to 'aborts'- the master or pilot needs to demonstrate the vessel is in a state where it could safely escape to the river before the simulation can be stopped.

These criteria were briefed to stakeholders prior to commencing the study. It was not possible to agree the specific quantitative aspects described in relation to the assessment. However there was consensus that the parameters should be used a basis to support assessment and if necessary further detailed discussion amongst the simulation participants.

To support the process HR Wallingford ensured that a draft version of the track plot was available as soon as practicable after each run completion.

3.4 Simulation run summary

The simulation run summary is shown in Table 3.2. The following abbreviations are used in the table:

- Pilot/PEC;
- LZ - Laas Van Der Zee;
- GVF - Gerrt Jan Feringa;
- Tug descriptions:
  - ICT – Independently Controlled Tug;
  - CCT – Centrally Controlled Tug;
  - Cl – Centre lead;
  - Qtr – Quarter.

Table 3.2: Run Summary Table

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide (Time state)	Wind (Dir. Speed)	Assessment
1	GVF	Approach to No 3 berth in normal conditions	Stena Transporter	N/A	Peak Ebb (HW +4hrs)	SW (225°) 17.5 kts ± 2.5 kts	Success
2	LZ	Departure from No 3 berth in normal conditions	Stena Transporter	N/A	Peak Ebb (HW +4hrs)	SW (225°) 17.5 kts ± 2.5 kts	Marginal
2.1	LZ	Departure from No 3 berth in normal conditions	Stena Transporter	N/A	Peak Ebb (HW +4hrs)	SW (225°) 17.5 kts ± 2.5 kts	Success
3	GVF	Approach to No 3 berth in normal conditions	Stena Transporter	N/A	Peak Ebb (HW +4hrs)	NE (045°) 17.5 kts ± 2.5 kts	Success
4	LZ	Departure from No 3 berth in normal conditions	Stena Transporter	N/A	Peak Ebb (HW +4hrs)	NE (045°) 17.5 kts ± 2.5 kts	Success
5	LZ	Approach to No 3 berth in normal conditions	Stena Transporter	N/A	Peak Flood (HW -2hrs)	NE (045°) 17.5 kts ± 2.5 kts	Success
6	GVF	Departure from No 3 berth in normal conditions	Stena Transporter	N/A	Peak Flood (HW -2hrs)	NE (045°) 17.5 kts ± 2.5 kts	Success
7	LZ	Approach to No 3 berth in normal conditions	Stena Transporter	N/A	Peak Flood (HW -2hrs)	SW (225°) 17.5 kts ± 2.5 kts	Success
8	GVF	Departure from No 3 berth in normal conditions	Stena Transporter	N/A	Peak Flood (HW -2hrs)	SW (225°) 17.5 kts ± 2.5 kts	Success
9	LZ	Approach to No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (ICT) Tug 2: Port quarter (CCT)	Peak Ebb (HW +4hrs)	NE (045°) 27.5 kts ± 2.5 kts	Success

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide (Time state)	Wind (Dir. Speed)	Assessment
10	GVF	Departure from No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Port quarter (ICT)	Peak Ebb (HW +4hrs)	NE (045°) 27.5 kts ± 2.5 kts Sheltering off	Success
11	GVF	Approach to No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Port quarter (ICT)	Peak Flood (HW -2hrs)	NE (045°) 27.5 kts ± 2.5 kts Sheltering on	Success
12	GVF	Departure from No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Port quarter (ICT)	Peak Flood (HW -2hrs)	NE (045°) 27.5 kts ± 2.5 kts Sheltering off	Success
13	LZ	Approach to No 2 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Starboard quarter (ICT)	Peak Ebb (HW +4hrs)	SW (225°) 27.5 kts ± 2.5 kts Sheltering on	Success
14	GVF	Departure from No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Port quarter (ICT)	Peak Ebb (HW +4hrs)	SW (225°) 27.5 kts ± 5 kts Sheltering off	Success
15	LZ	Approach to No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Centre-lead forward (CCT) Tug 2: Starboard quarter (ICT)	Peak Flood (HW -2hrs)	SW (225°) 27.5 kts ± 5 kts Sheltering off	Success
16	LZ	Departure from No 3 berth in extreme conditions	Stena Transporter	2 x 50 t ASD tugs Tug 1: Starboard shoulder (CCT) Tug 2: Starboard quarter (ICT)	Peak Flood (HW -2hrs)	SW (225°) 27.5 kts ± 2.5 kts	Success

4 Simulation track and data plots

The results of each navigation simulation run are available in the form of plots of the vessel tracks and graphs of key data parameters recorded during the run. These data are presented in Appendix A.

The vessel data and track plots show:

- The position of the ship and the tugs at one minute intervals is indicated by a succession of black and blue vessel outlines. Red vessel outlines indicate the vessel's position every 10 minutes from the start of the run;
- The positions of port structures and aids to navigation;
- A north arrow;
- A scale bar.

The data graphs plot the variation of various key parameters against elapsed simulation time and graphs have been included for all vessels in all of the runs. These graphs are presented by vessel, starting with the ship, and then the independent tug (where applicable). The vessel ID is identified in the text block on the bottom right of each page.

5 Commentary

Commentary and key observations

Operations in normal conditions

It was explained and agreed during the initial briefing that a Force 5 wind (17-21 knots) (10 m AMSL) represented the maximum wind strength that could reasonably be expected at the facility once or twice a month on average. It was noted that there would be a seasonal variation with more occurrences in winter. This wind strength was represented in the simulator for both setting the vessel on and off the berth. For efficiency, only peak flood and ebb flow conditions that occur on the largest of spring tides were simulated. These flow conditions would only be expected for a few hours once every 28 days within a normal tidal cycle.

These were agreed as representative of the 'normal worst conditions' that might be expected once every month in the summer and maybe 3 to 4 times a month in the winter. However, the coincidence of strong winds and peak flows is expected be to occur with a reduced frequency.

9 runs were conducted with the Stena Transit model to, and from, berth 3 in these conditions.

The harbour master outlined his thoughts on the manoeuvre with advice prior to each run. Tug assistance was not anticipated to be required by the PEC conducting the run and was not used. 8 of the runs were assessed as successful.

One run was assessed as marginal due to the proximity to adjacent vessels. The marginal aspect was repeated and shown to be achievable. In considering this assessment, it should be noted that this was the first run in the simulator conducted by the PEC in this study. Furthermore. the PEC reasonably stated that in reality his view from the bridge wing would have enabled him to better judge the distance to other vessels.

Manoeuvres to and from berths 1 and 2 in these conditions using the Stena Transit model were discussed amongst the participants. It was agreed that, in general, the manoeuvres to, and from, berth 2 would be similarly challenging as those undertaken and manoeuvres to berth 1 would be less challenging.

It was agreed that the manoeuvres executed during this study in these conditions should be considered repeatable with appropriate training for PECs and pilots.

DFDS noted that ideally runs should be undertaken to all berths in all conditions. HR Wallingford noted that for efficiency it is normal when considering port design to assess the worst cases and, where possible, apply the understanding from those simulations to other cases. Pertinently. there is a substantial collection of simulations and derived understanding for manoeuvres at other berths to assist in this process.

Extreme Operating Conditions

In line with previous studies into the feasibility of operations at IERRT, runs have been included considering coincident extreme wind conditions and peak ebb and flood tides.

It was explained and agreed during the initial briefing that a low Force 7 wind (27 to 33 knots) (10m AMSL) represented the maximum wind strength that could reasonably be expected for operations to continue at the facility. This wind strength was applied based on a variation of +/- 2.5 knots around a 27.5 knot mean, and additional sensitivity increased the variation to +/- 5 knots to consider the effect of gusts.

This wind strength was explained to be equivalent to the maximum wind strength that might occur at the location several times a year. APT noted that they cease operations when their anemometer, approximately 8 m AMSL, shows 35 knots, based on 30 to 60 second gusts, which is expected to occur around 6 times a year. Peak spring flood and ebb conditions were used throughout.

The extreme operating conditions used in this study broadly equate to the conditions used for the previous feasibility studies, noting that several runs have also been conducted with winds between 30 and 35 knots to ensure the assessment of the design using a ‘proxy' design vessel was conservative.

As for the normal conditions, the harbour master outlined his thoughts on the manoeuvre with advice prior to each run. Two 50 t BP ASD tugs were requested by the PEC and used on each run. The level of tug power required was never considered excessive by the tug master or the simulation participants. 8 runs were completed in extreme conditions and all were assessed as successful.

Layout of the port and eastern jetty

HR Wallingford provided a layout for the port and proposed infrastructure based on drawings provided for previous studies.

The tug pontoon was reinstated at the end of the eastern jetty as it had been removed for previous studies. 4 tugs moored double banked on the jetty were included in the simulation on the tug pontoon and a 185 m MR2 tanker was moored on the eastern jetty to ensure the conditions for the approach to berth 3 were as confined as could reasonably be expected.

During the briefing for this study it was highlighted that the design for the rear caissons at IERRT had been altered from that originally provided for the navigation simulations.

HR Wallingford has reviewed the changes and note:

- The changes to the size of the caissons at the rear of the IERRT structure make no substantive change to the geometry of the berths at IERRT. Consequently, the previous work undertaken for all classes of ships considered remains pertinent.
- HR Wallingford's previous modelling shows that during the early part of the low-water flood the caissons create a blockage with an associated minor acceleration and diversion of the flow at the northern end of IERRT towards IOT 8 and 6. This has been investigated in previous studies and found to be navigationally insignificant. An initial review of the new situation indicates that the blockage effect is not likely to significantly increase any acceleration or deviation in the flow towards IOT 8 and 6 than has already been demonstrated in modelling.
- HR Wallingford has recommended to ABP that a revised flow model considering the changes in design is produced and a comparison with the previous flow model is made to ensure that the assessments outlined above are valid.

Flows north of IOT

A comparison of the flow modelling to Tidal Diamond B (BA 3497 and tidal diamond D on page 118 of the pilot handbook) has been undertaken This was presented to stakeholders during the briefing for this study and the details are provided in Appendix B.

At the request of stakeholders the modelled flows in the main part of the river were adjusted using a coarse vector during peak ebb and flood conditions. This was to represent the situation where flows set strongly either 135 degrees towards IOT on the ebb tide or 315 degrees away from IOT on the flood tide.

The flows north of IOT as a result of the applied vector are shown in Table 1.1. Point A is a location approximately 150 m north of IOT A1 dolphin and point B is used for comparison with tidal diamond B, see Figure 1.1.

Table 5.1: Adjusted flows at point A and point B

	Point A speed (knots)	Point A direction (degN)	Point B speed (knots)	Point B direction (degN)
Peak flood	4.6	315	5.1	317
Peak ebb	4.1	135	4.7	144

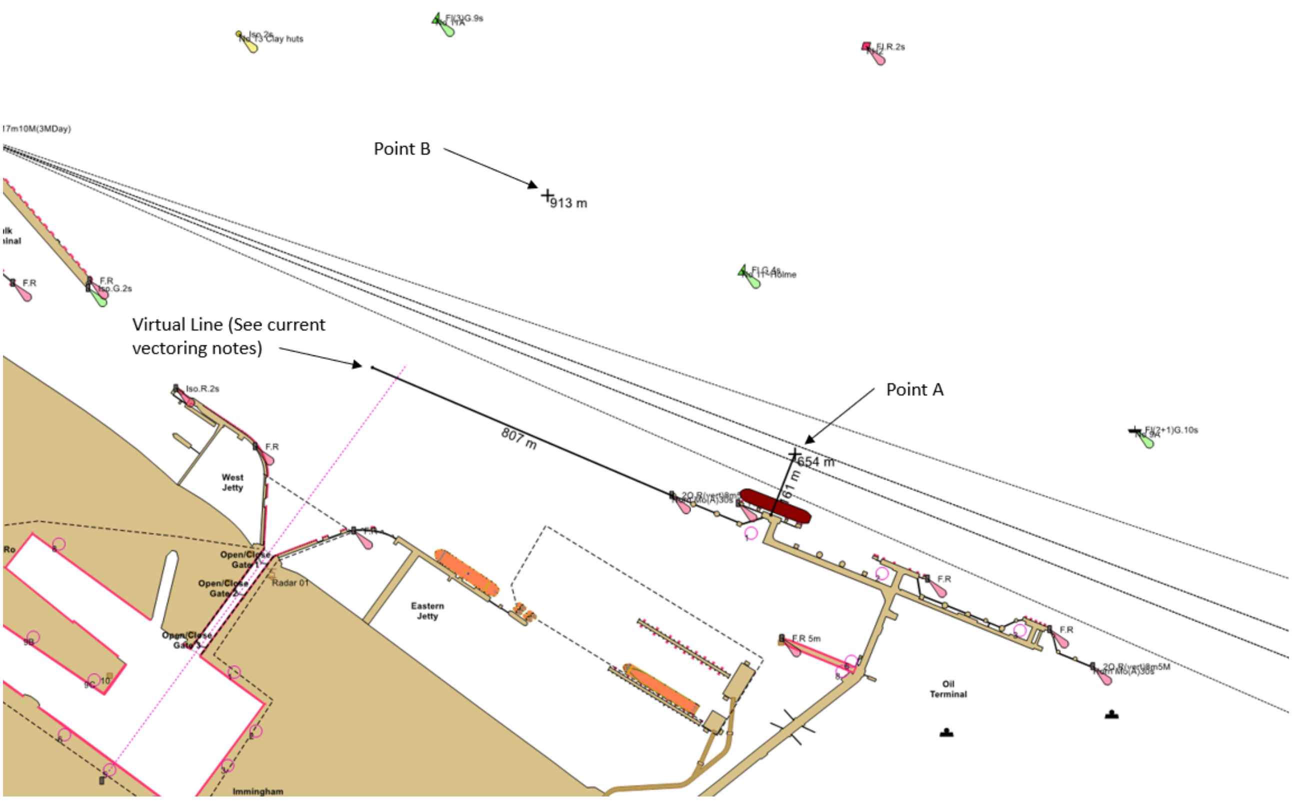


Figure 5.1: Diagram showing reference points used for tidal adjustments

HR Wallingford have high confidence in the flow model south and west of the IOT as described in the previous report, which is included as Appendix C.

In order to ensure that the flows in the vicinity of IERRT were based on the best available understanding, the vector adjustment was slowly reduced to zero once the vessel was clear to the south west of the IOT berthing line for arrivals. Similarly, the model flows were used for the initial stages of departure manoeuvres and the vector adjustment added once the vessel was clear of the dredged IERRT berthing area.

During the swing in to, and out of, the main river with the modified tidal streams no issues were encountered in normal or extreme conditions.

It should be noted that during the ebb tide special consideration needs to be given to planning the swing in to the main river to ensure the safe passing distance (150 m) on IOT is maintained.

The same techniques currently used for arrivals and departures from Immingham dock can be applied to this manoeuvre.

Sensitivity to wind sheltering and gusts

Sensitivity to wind sheltering was included in runs 10, 11 and 13. The PEC conducting the run was able to safely manoeuvre the vessel taking into account the predicted effect as the vessel approaches, or clears, the lee of adjacent moored vessels.

The modelled sheltering effect was reported to be appropriate and similar to that experienced in comparable real world operations at Immingham Sea Terminal.

HR Wallingford increased the gusting parameters on Runs 14 and 15 to include a variance +/- 5 knots based on discussions with stakeholders.

The effect of increased gusting was reported to be appropriate and similar to that experienced in comparable real world operations at Humber Sea Terminal.

Quantitative assessment

HR Wallingford conducted a qualitative simulation assessment based on their experience of running navigation simulations over 25 years. It is difficult to agree parameters which can consistently be applied and expert analysis of the situation provides a more efficient and nuanced assessment.

HR Wallingford briefed stakeholders of their proposed assessment criteria, which were the same as used in previous studies.

In addition to these criteria DFDS requested that some specific parameters should be included. These were briefed to all stakeholders. An additional stage was included in the debriefing process to enable a rapidly produced track plot to be presented to enable DFDS to apply their parameters within the process.

The manoeuvres were all conducted within the parameters detailed by DFDS. This was agreed subject to the opportunity to review the track plots in a measured manner. The track plots are included in Appendix A.

Tug use

HR Wallingford provided tug models representing 50t BP ASD tugs. The tugs used were agreed to be representative of those available on the Humber and their use was considered appropriate throughout.

6 References

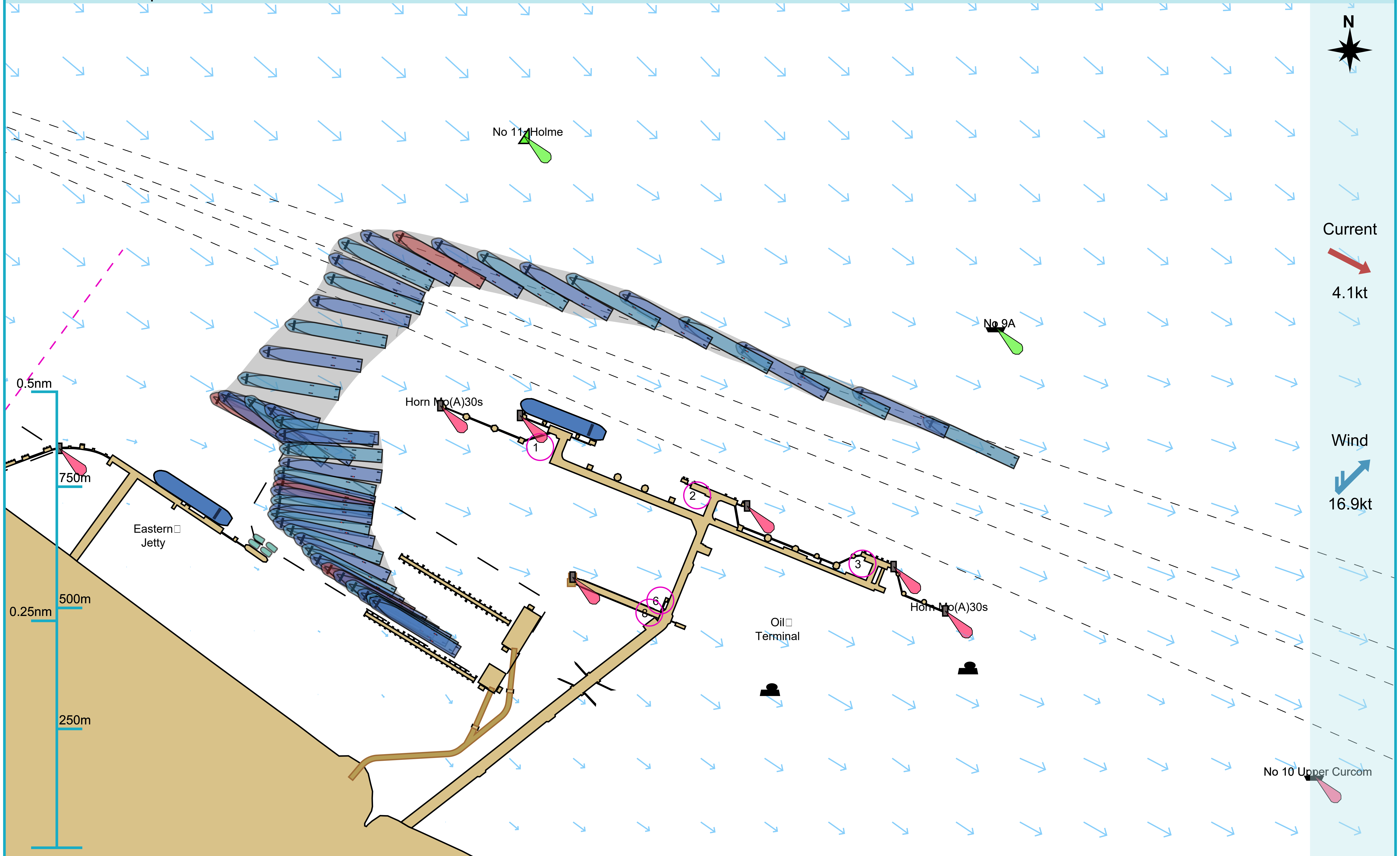
1. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Design review and navigation studies" , Report no. DJR6612-RT001-01-00, 26 Jul 2022.
2. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Navigation simulation study Dec 2021", Report no. DJR6612-RT002-04-00, 10 Oct 2023.
3. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Navigation simulation study with 1 degree rotation", Report no. DJR6612-RT003-02-00, 04 Aug 2022.
4. HR Wallingford, "Project Sugar – Immingham East Development – Quasi-static force assessment", Report no. DJR6612-RT004-01-00, 26 Jul 2022.
5. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Navigation simulation study - July 2022", Report no. DJR6612-RT005-05-00, 06 Sep 2023.

6. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Ship mooring analysis”, Report no. DJR6612-RT006-02-00, 19 Oct 2022.
7. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Flow model comparison with October 2022 ADCP survey”, Report no. DJR6612-RT007-01-00, 22 Dec 2022.
8. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Navigation Simulation – Stakeholder Demonstrations”, Report no. DJR6612-RT008-03-00, 11 Aug 2023.
9. HR Wallingford, “Immingham East RoRo Terminal – Summary of simulated flow conditions”, Report no. DJR6612-RT009-01-00, 09 Aug 2023.
10. Jacobs, ”Jetty Arrangements”, Drawing B2429400-JAC-00-ZZ-M2-ZZ-0003, received 26 May 2022.

Appendices

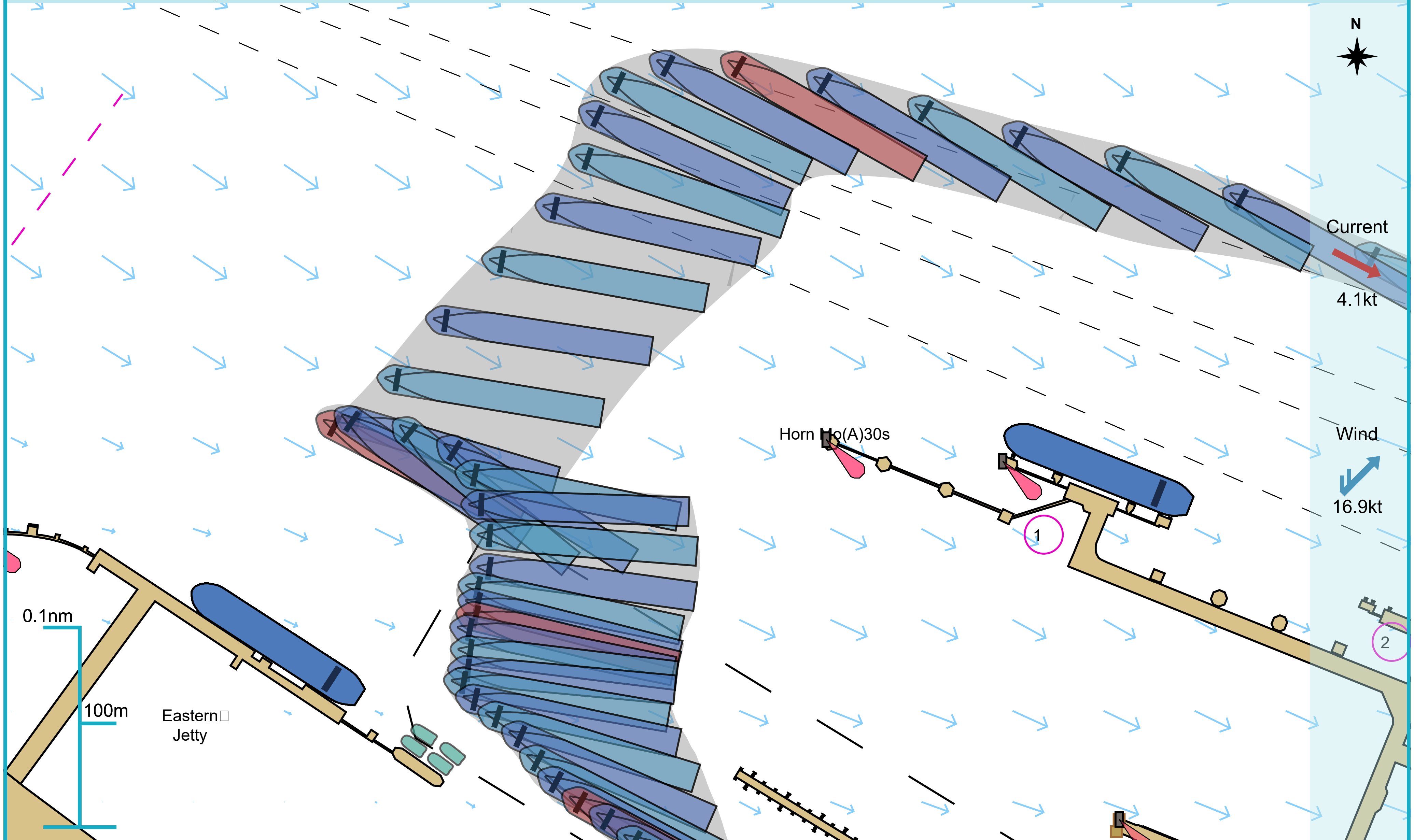
A Track plots

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



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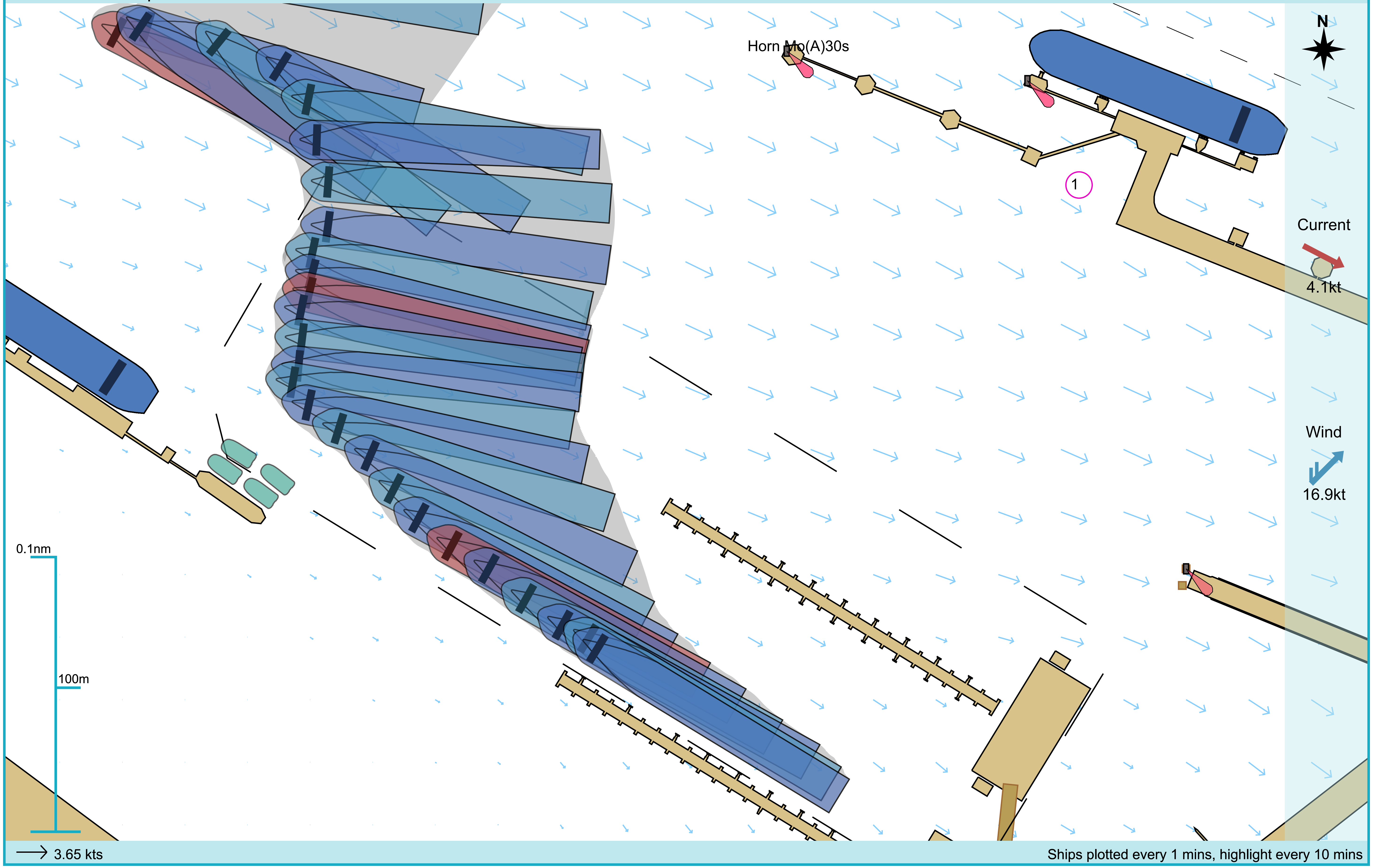
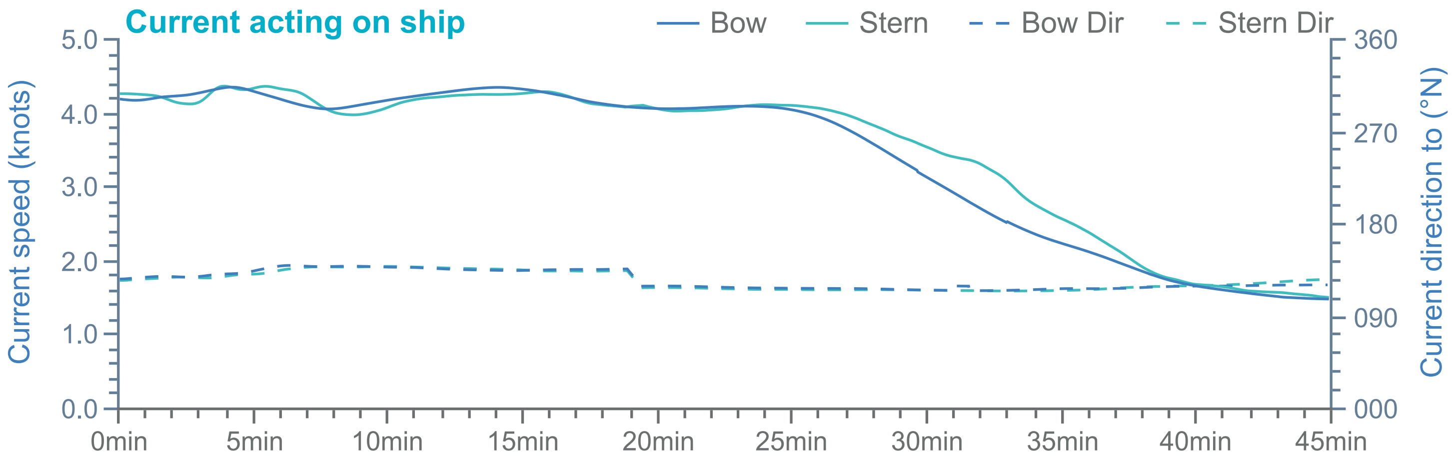
Manoeuvre track plot

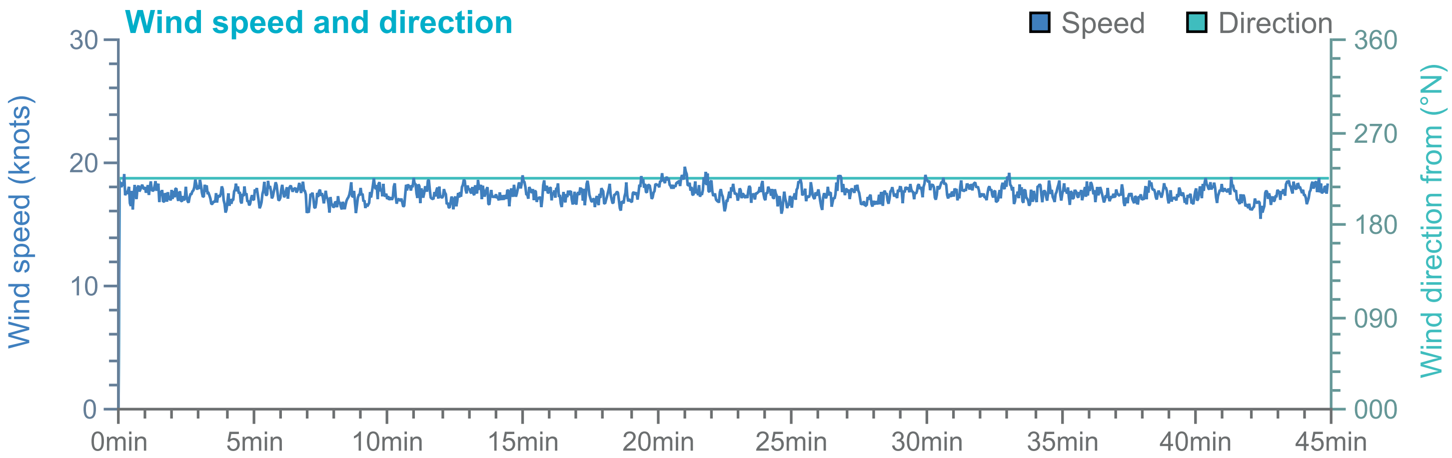


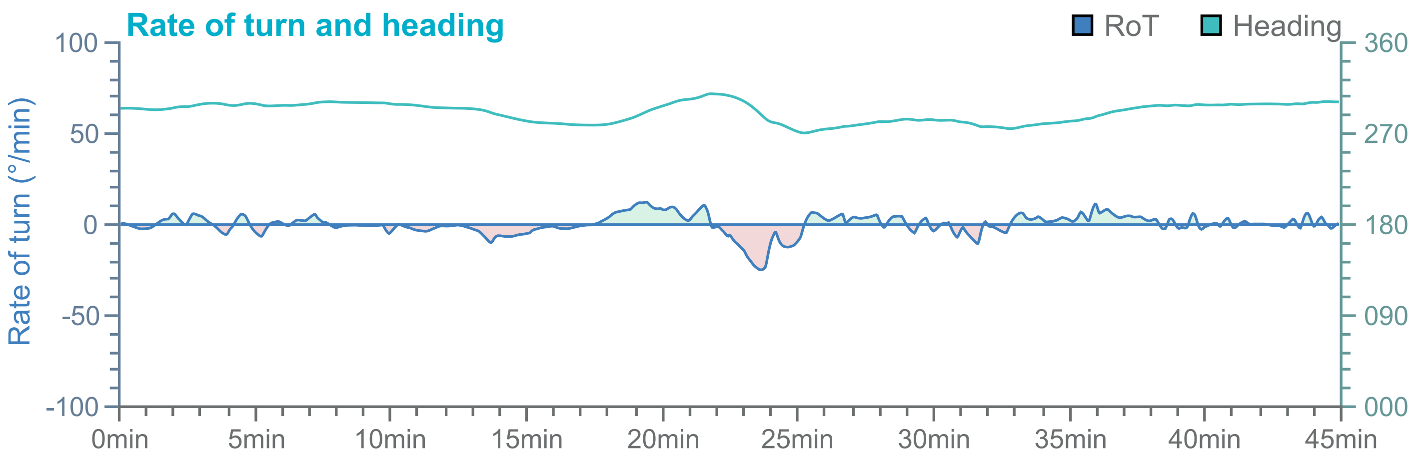
Ships plotted every 1 mins, highlight every 10 mins

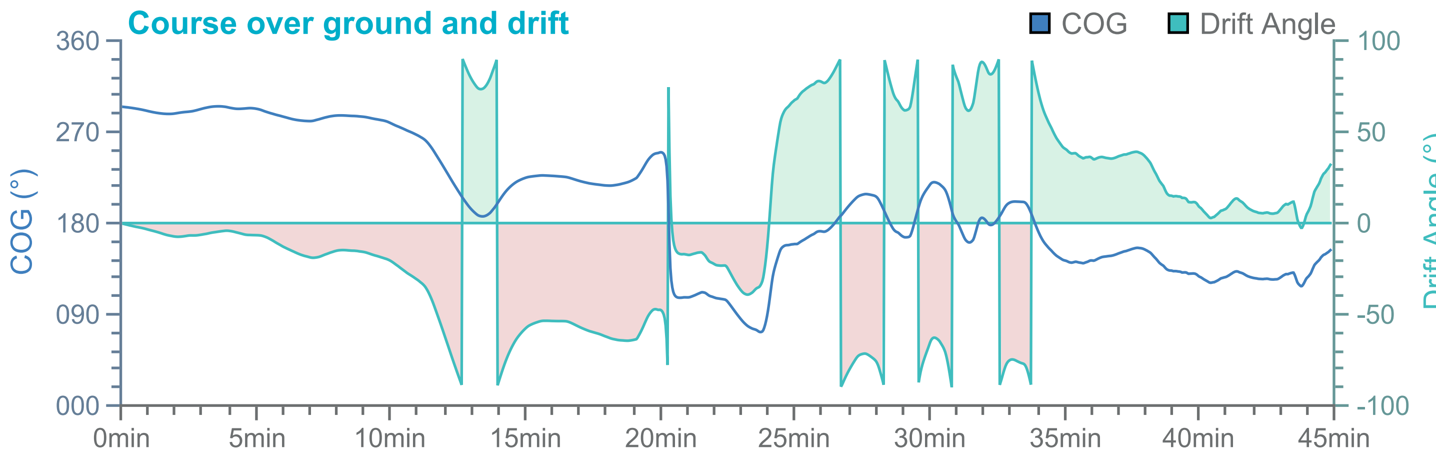
Current acting on ship



Wind speed and direction




Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
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-100
0min
5min
10min
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20min
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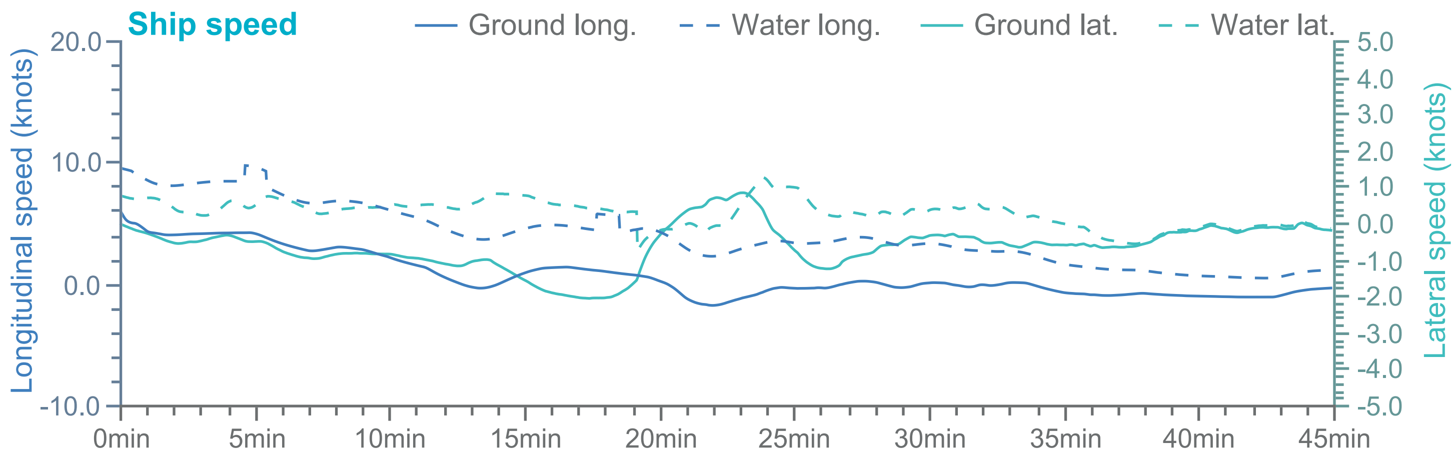
30min
35min
40min
45min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
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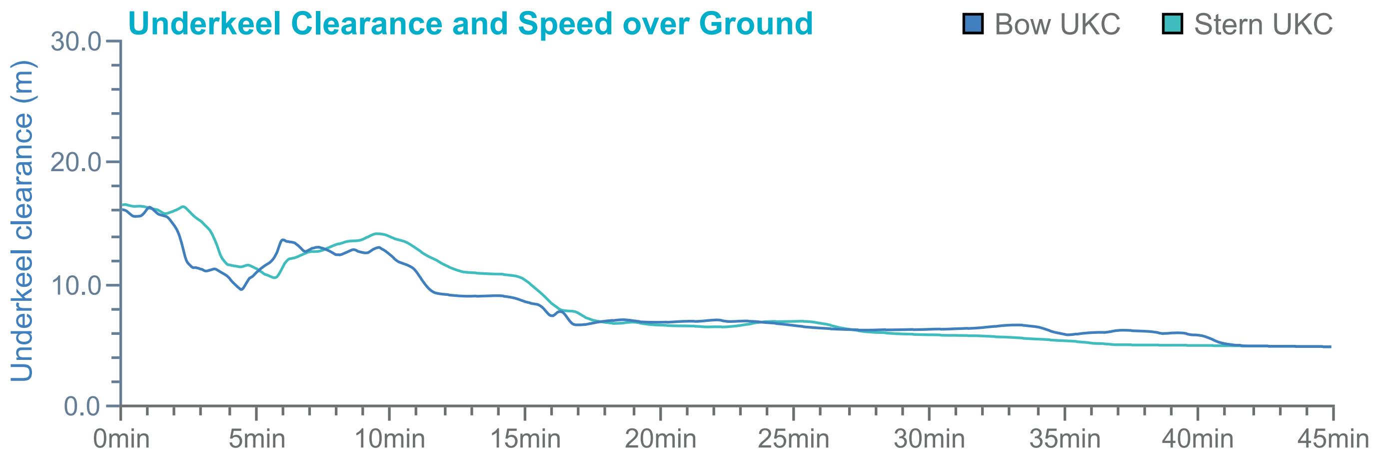
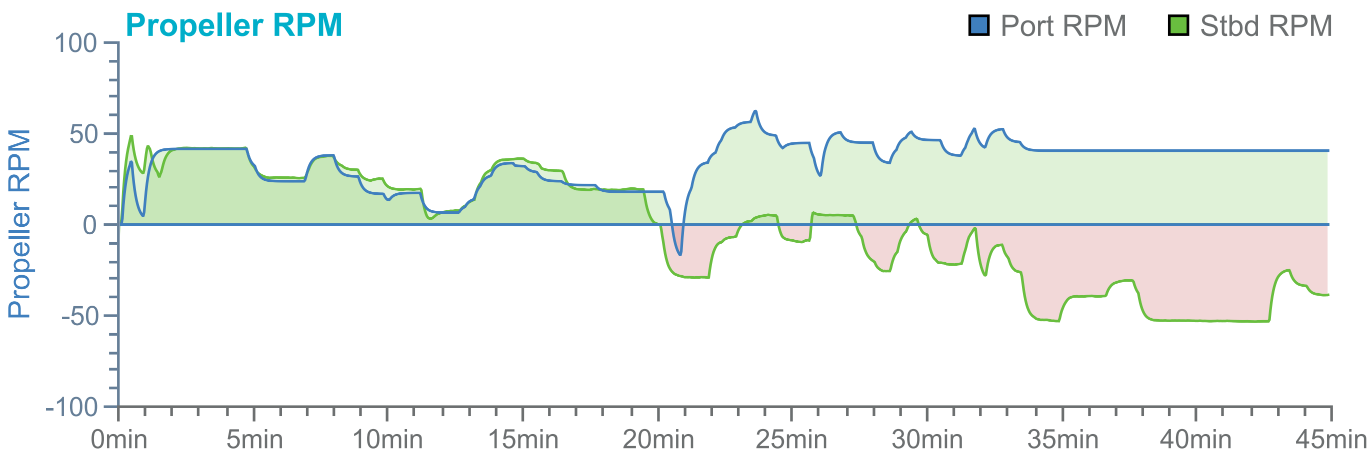
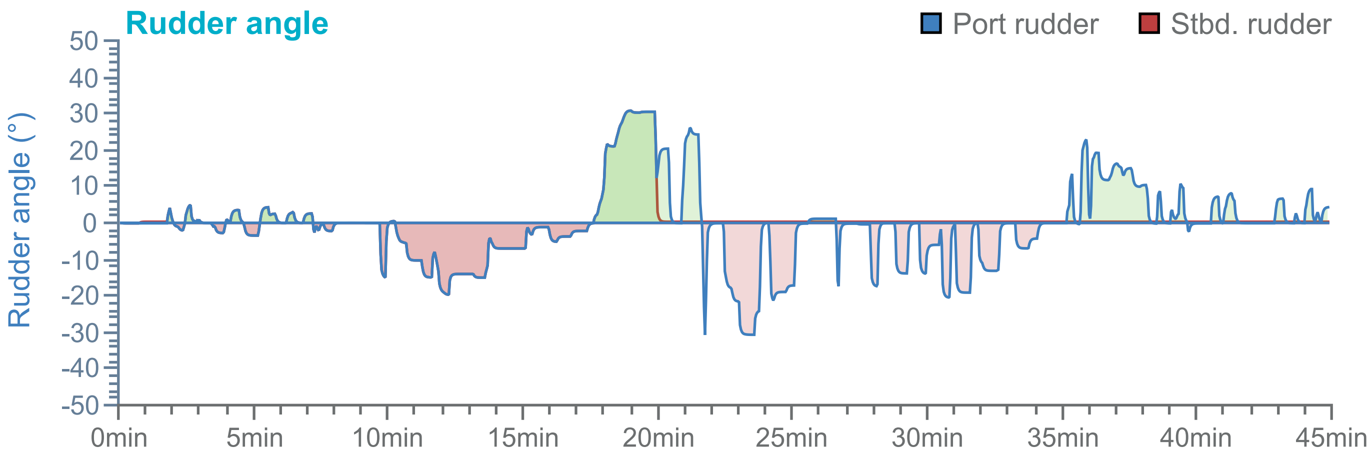
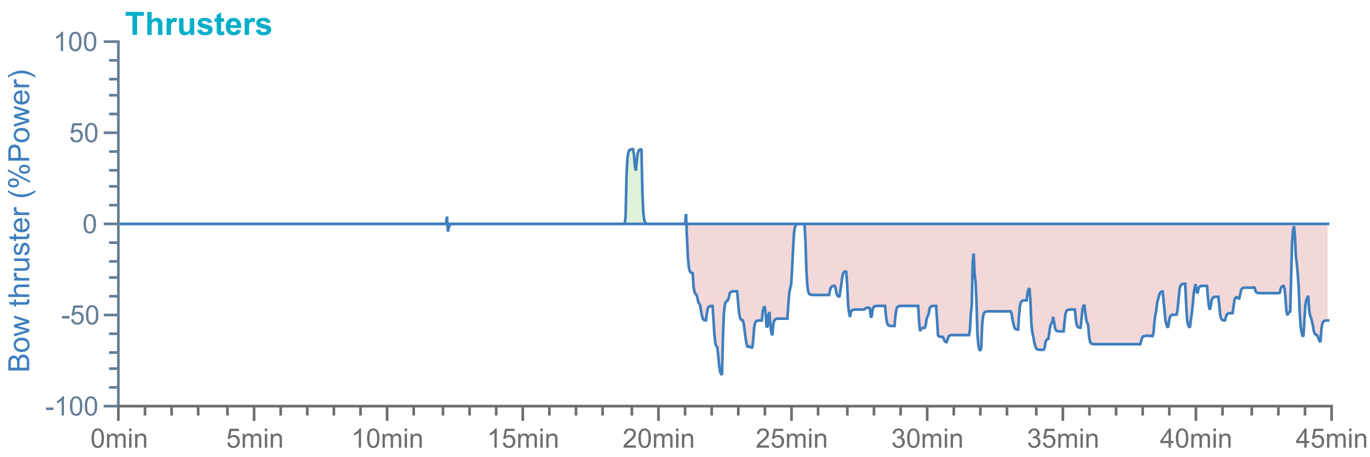

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

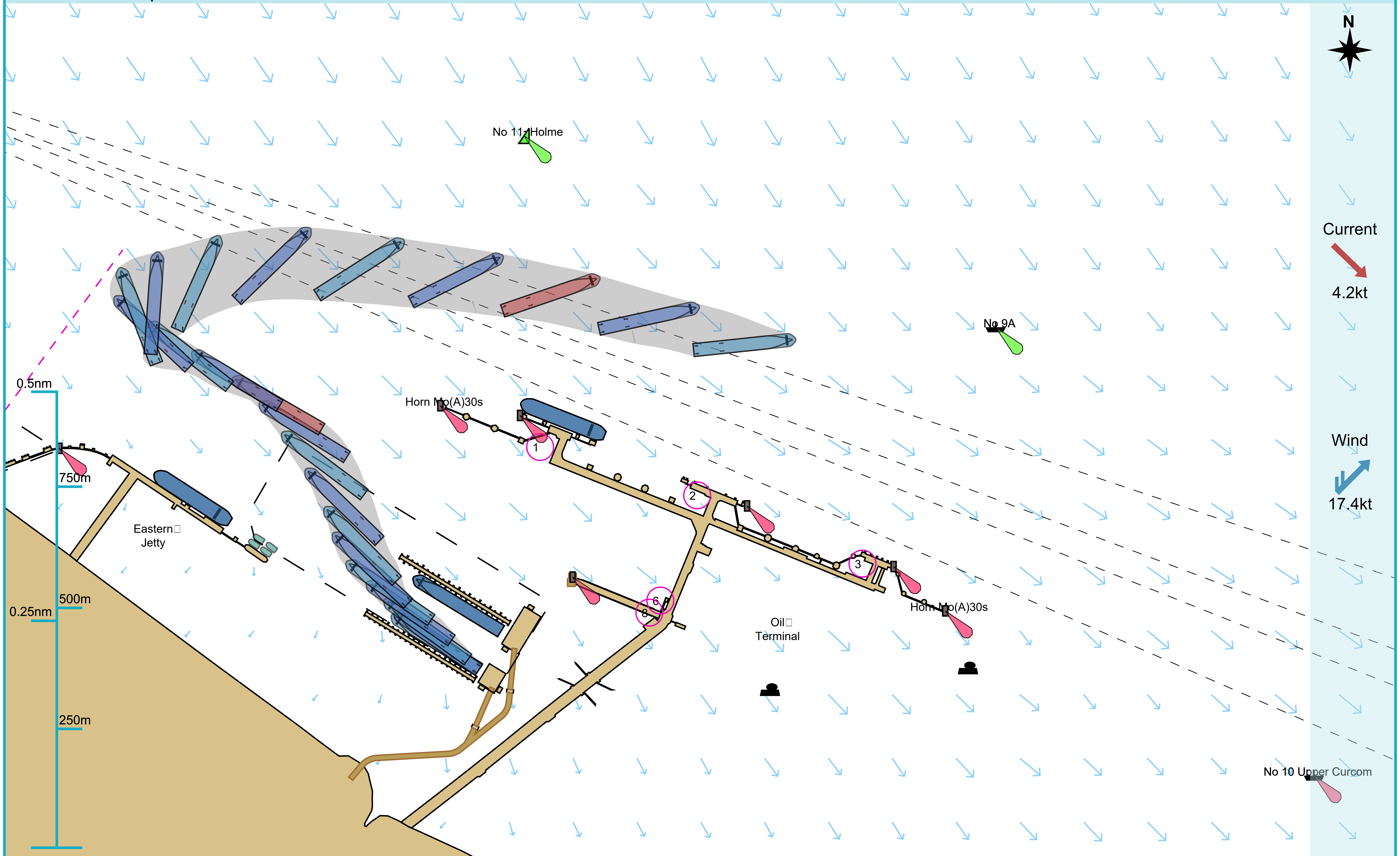
Overview | Environment | Stena Transporter







Manoeuvre track plot



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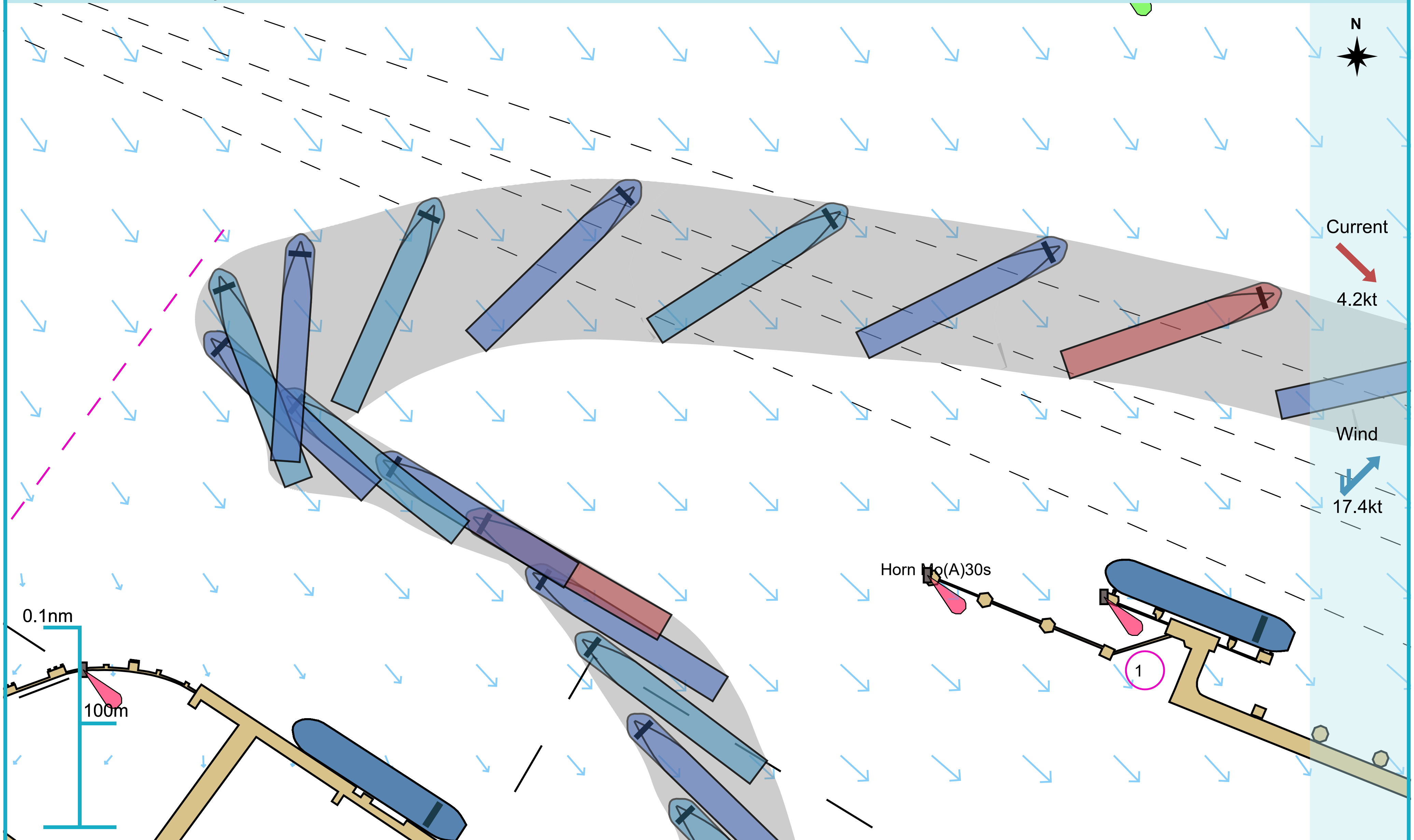
Manoeuvre track plot



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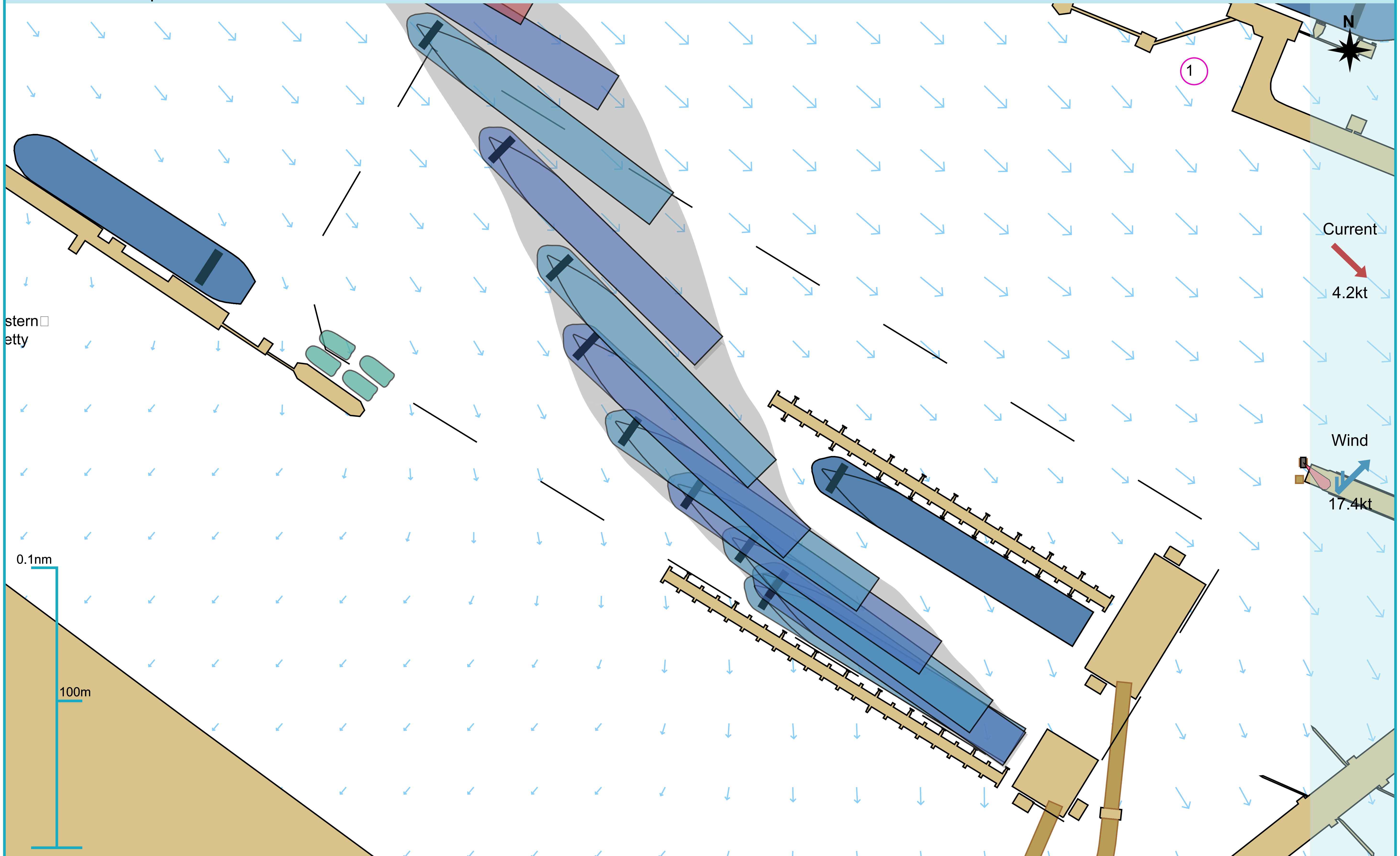
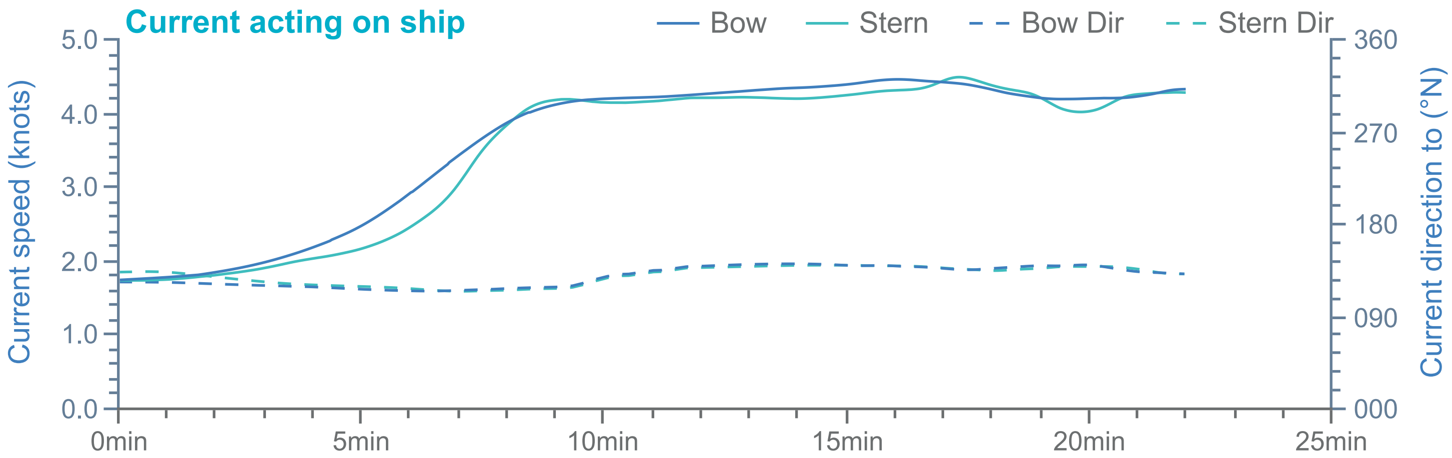
Manoeuvre track plot



3.54 kts

Ships plotted every 1 mins, highlight every 10 mins


Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
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5min
10min
15min
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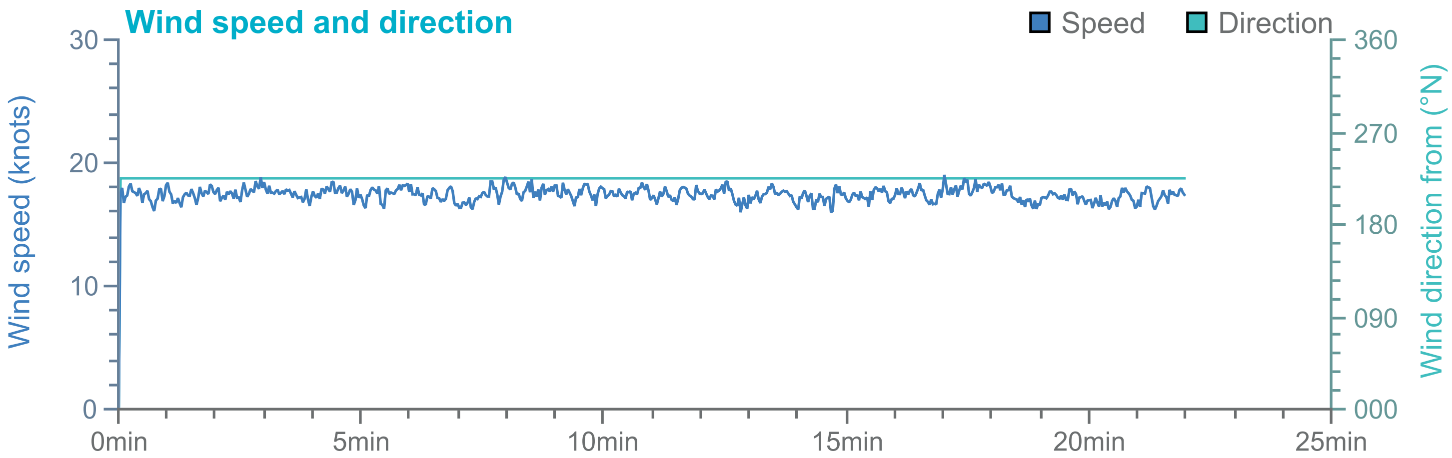
Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
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20
10
0
360
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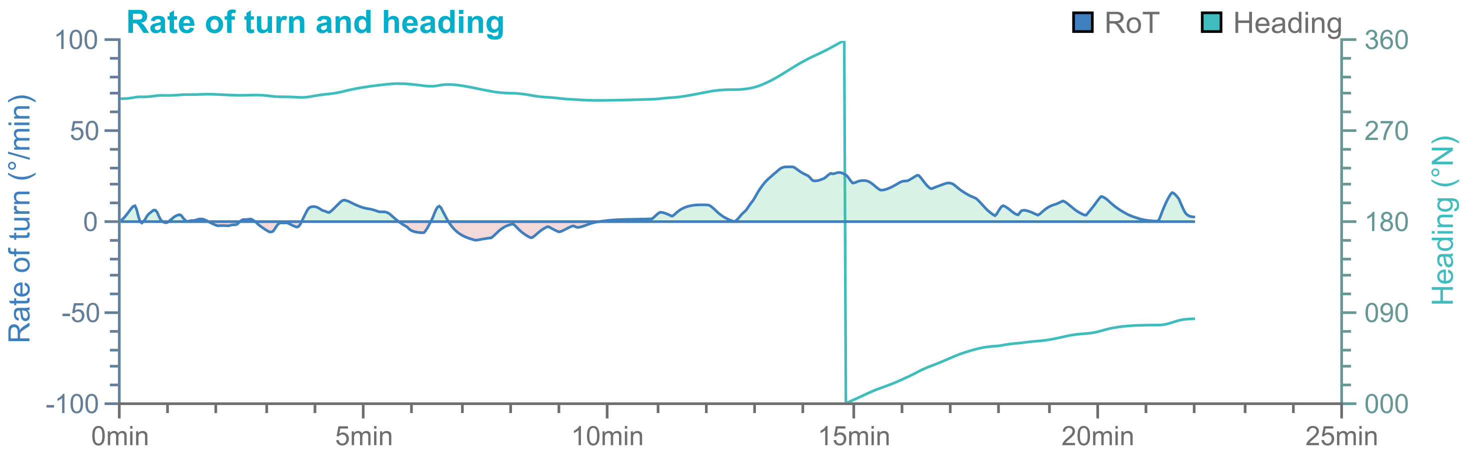
10min
15min
20min
25min


Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
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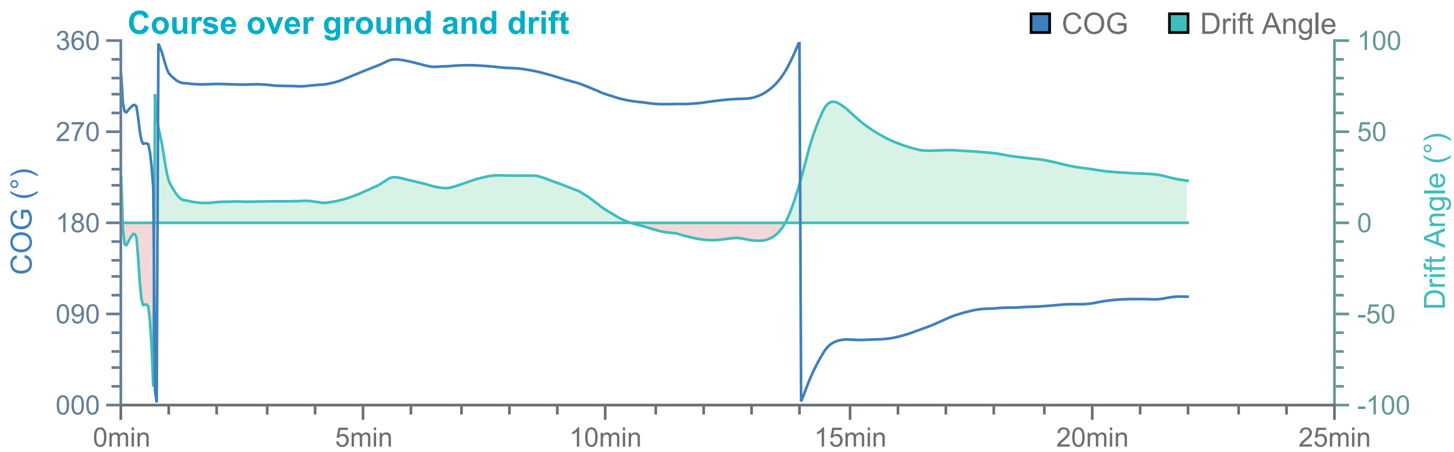
Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
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090
000
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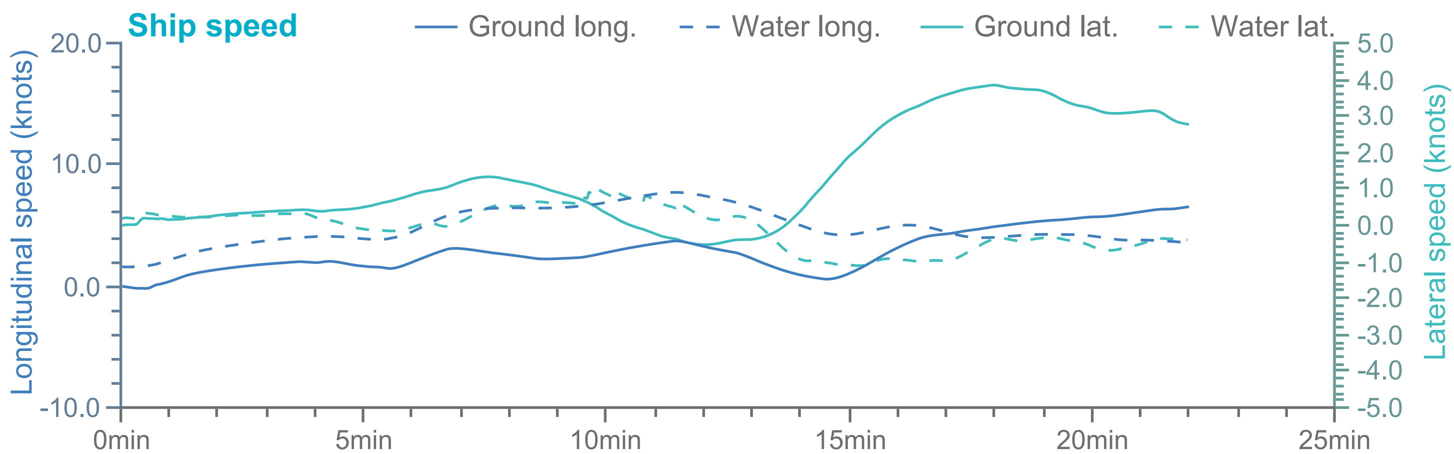
10min
15min
20min
25min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
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-4.0
-5.0
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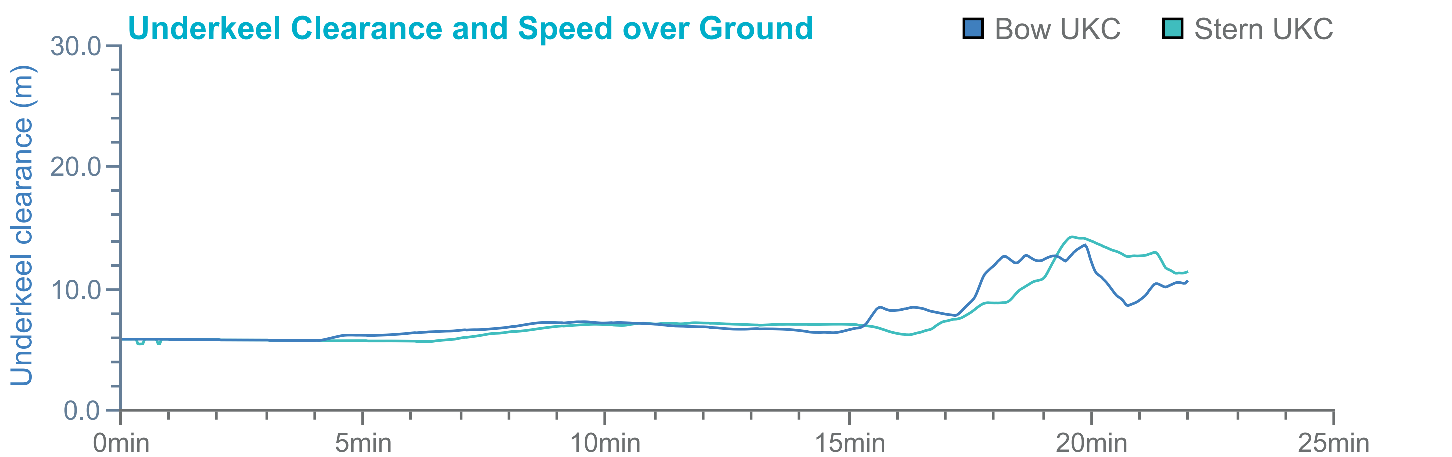
25min


Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
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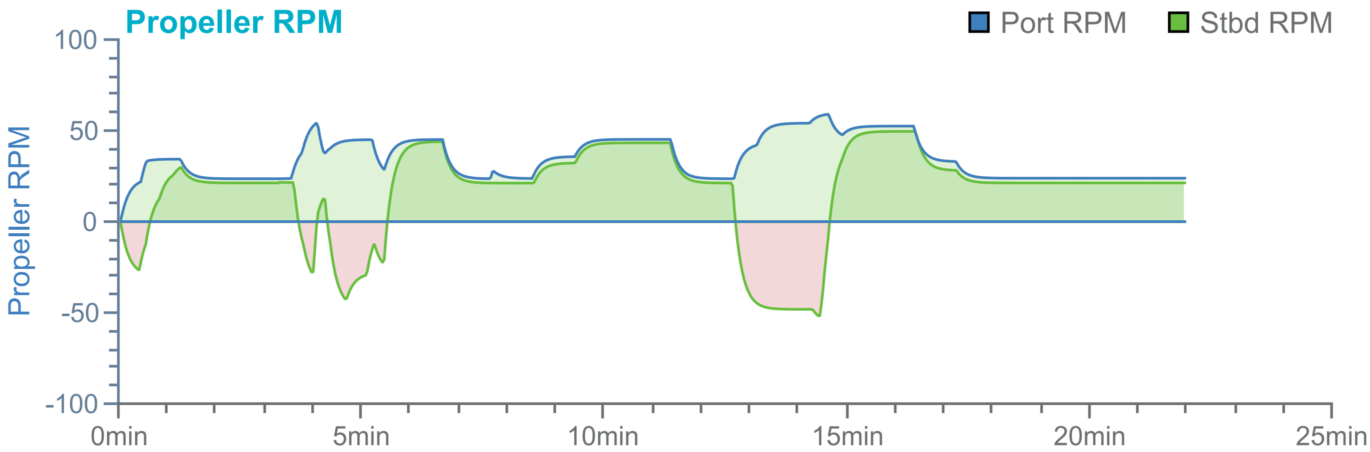
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
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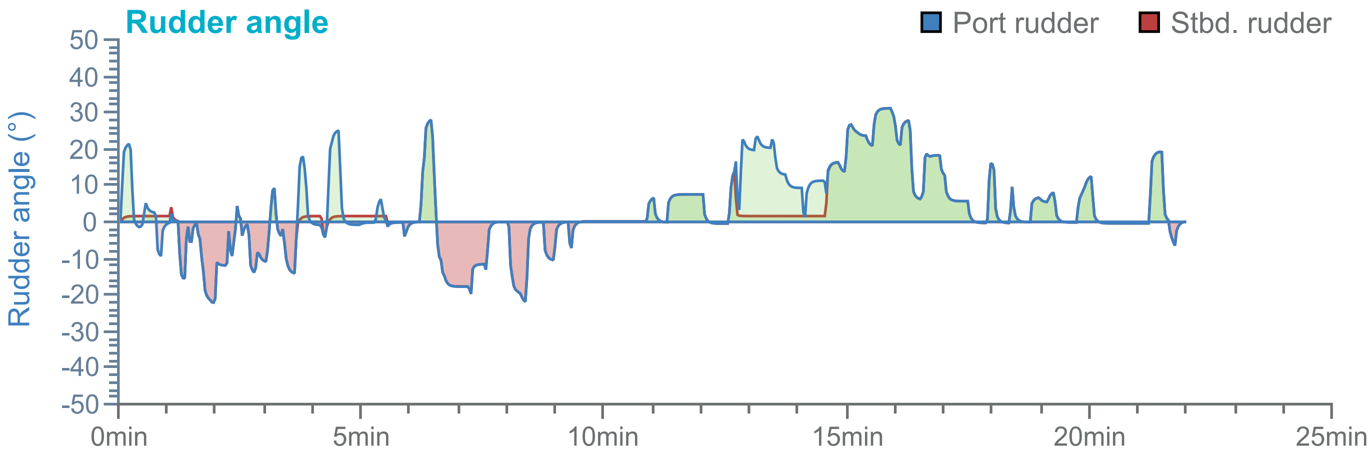
50
0
-50
-100
0min
5min
10min
15min
20min
25min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
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30
20
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0
-10
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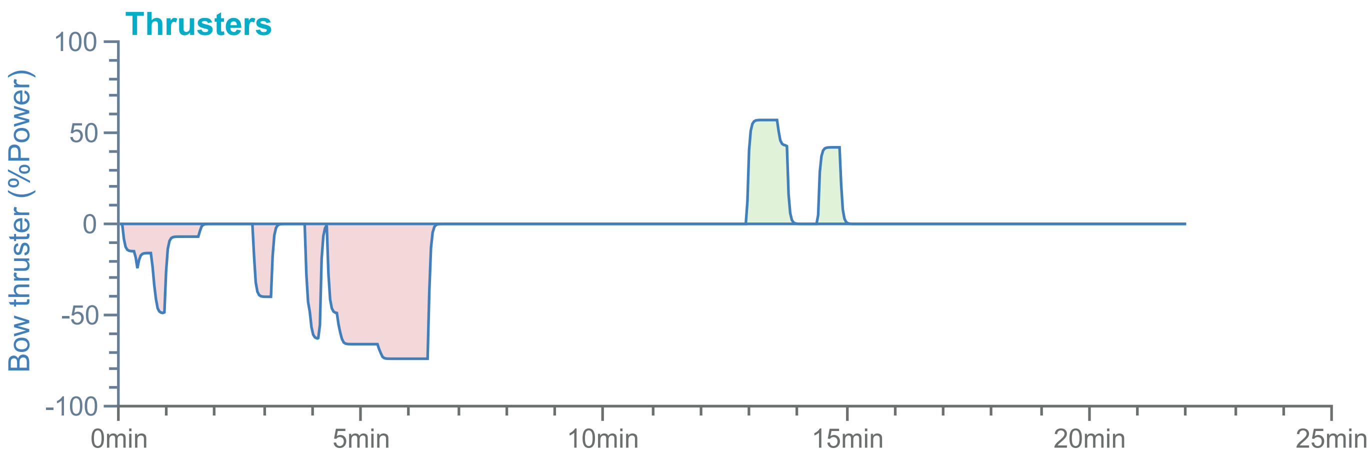
10min
15min
20min
25min


Thrusters
Bow thruster (%Power)
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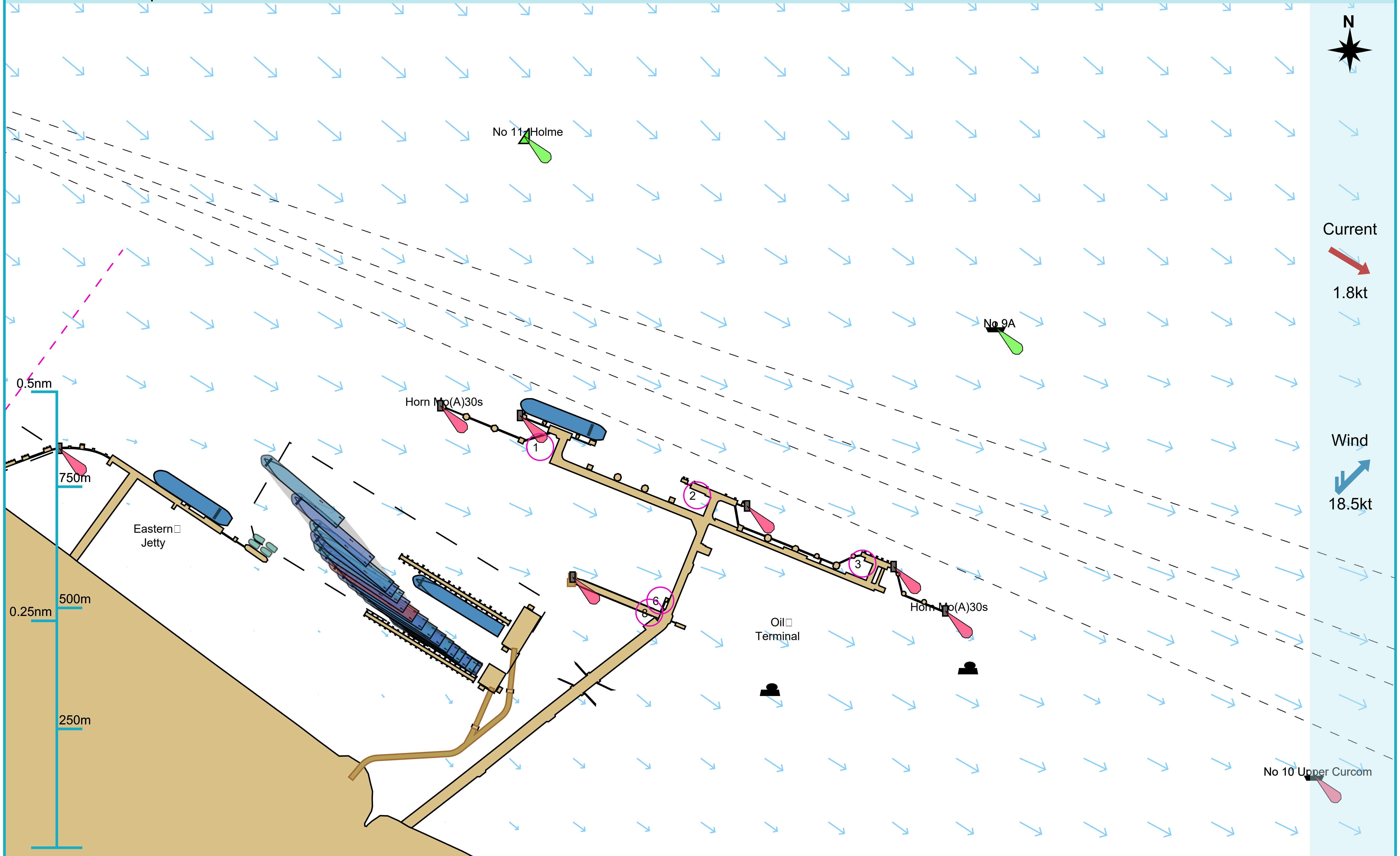
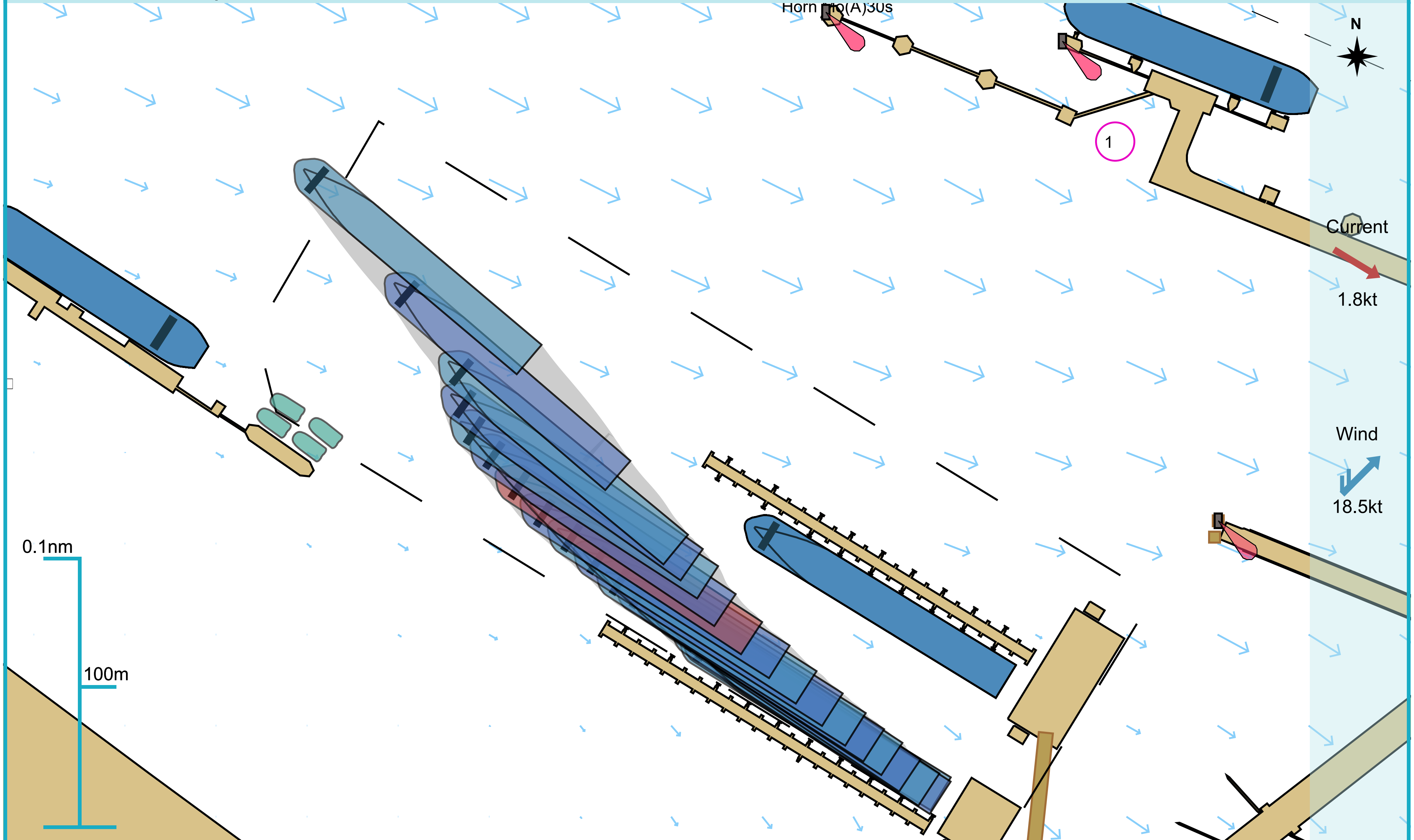
0
-50
-100
0min
5min
10min
15min
20min
25min

Manoeuvre track plot



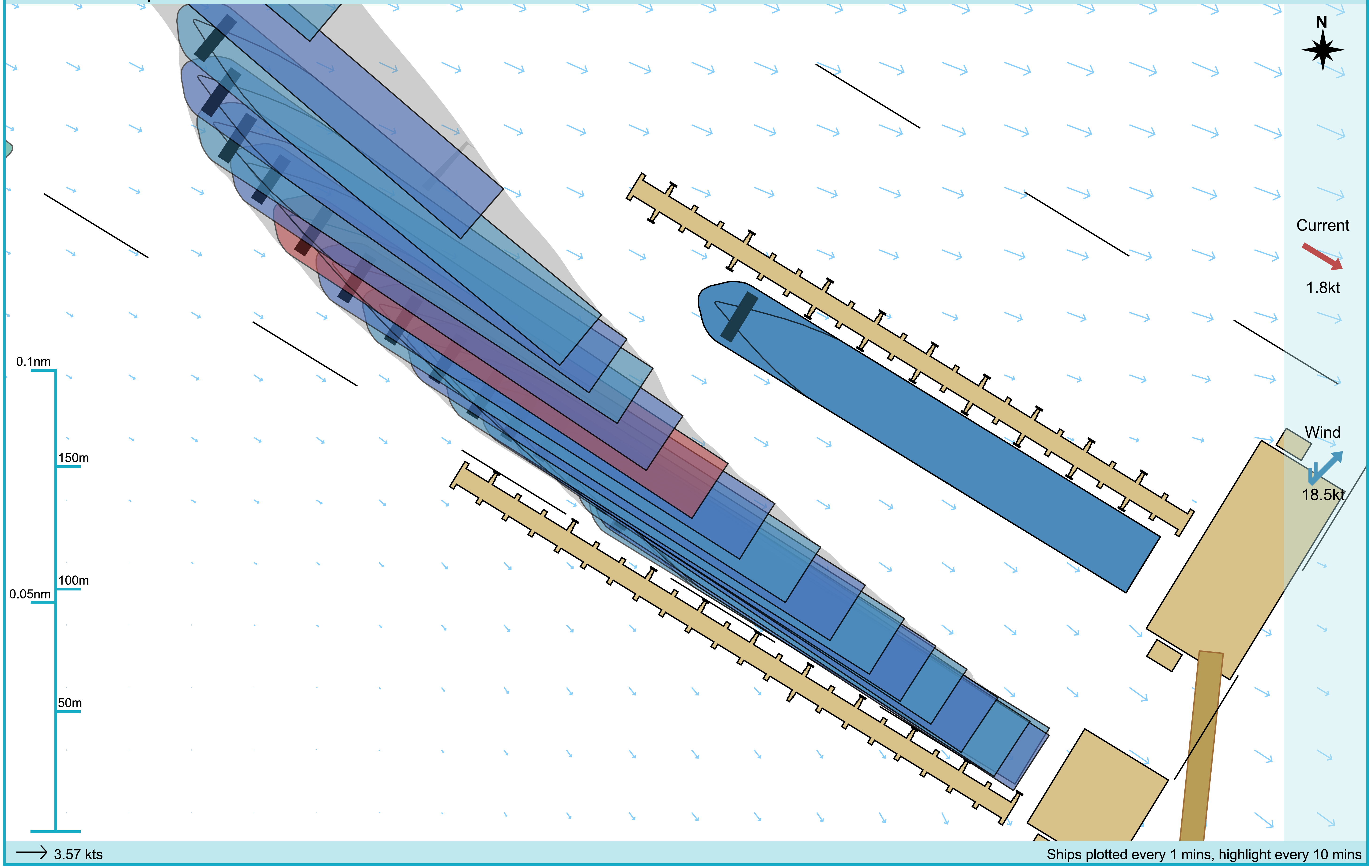
Ships plotted every 1 mins, highlight every 10 mins

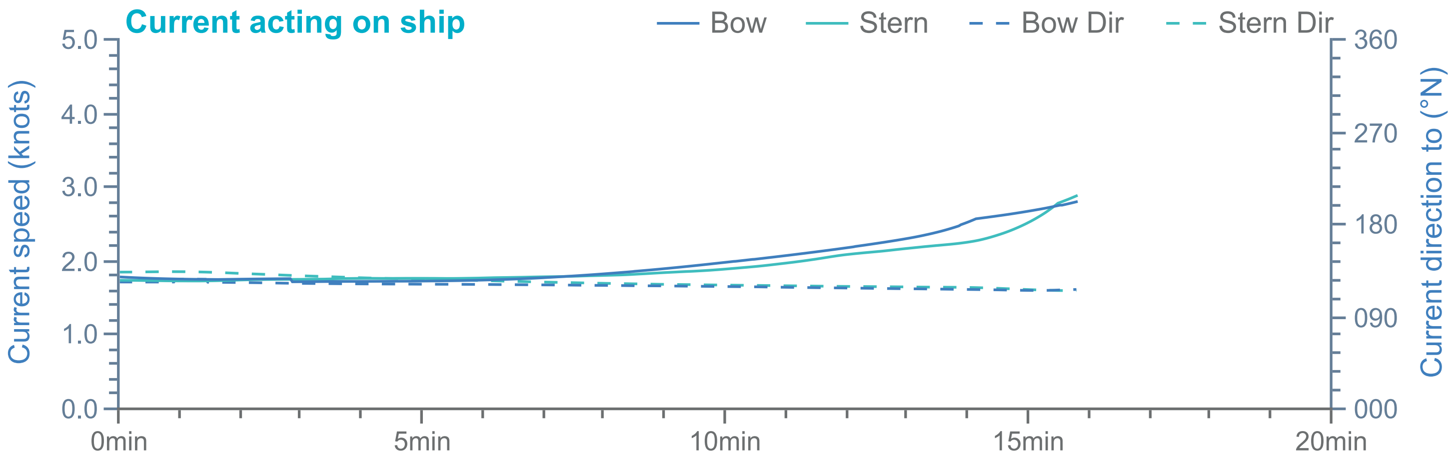
Manoeuvre track plot

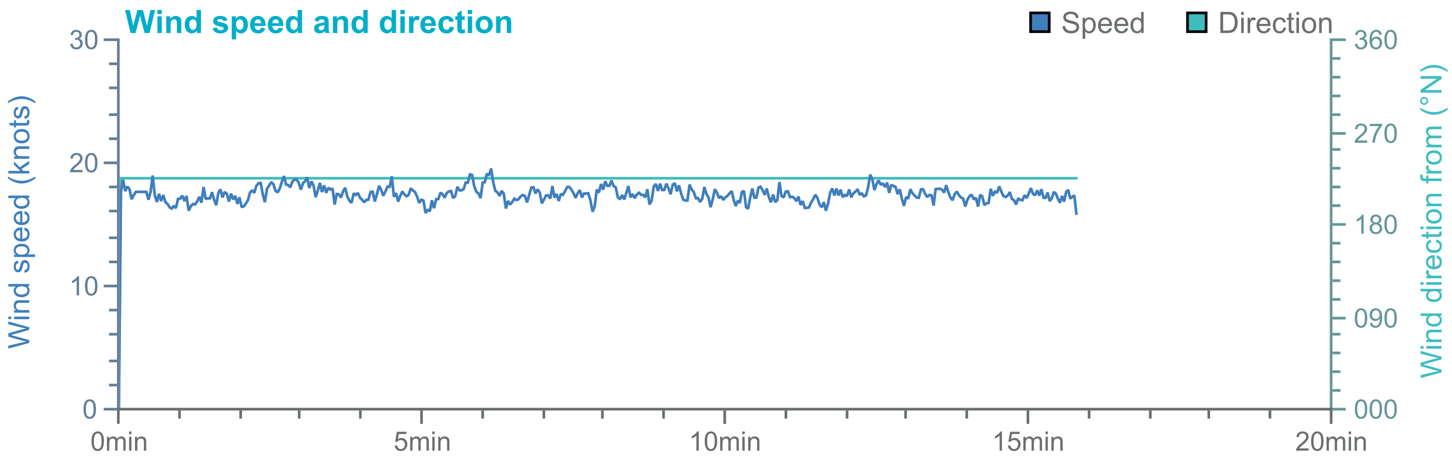


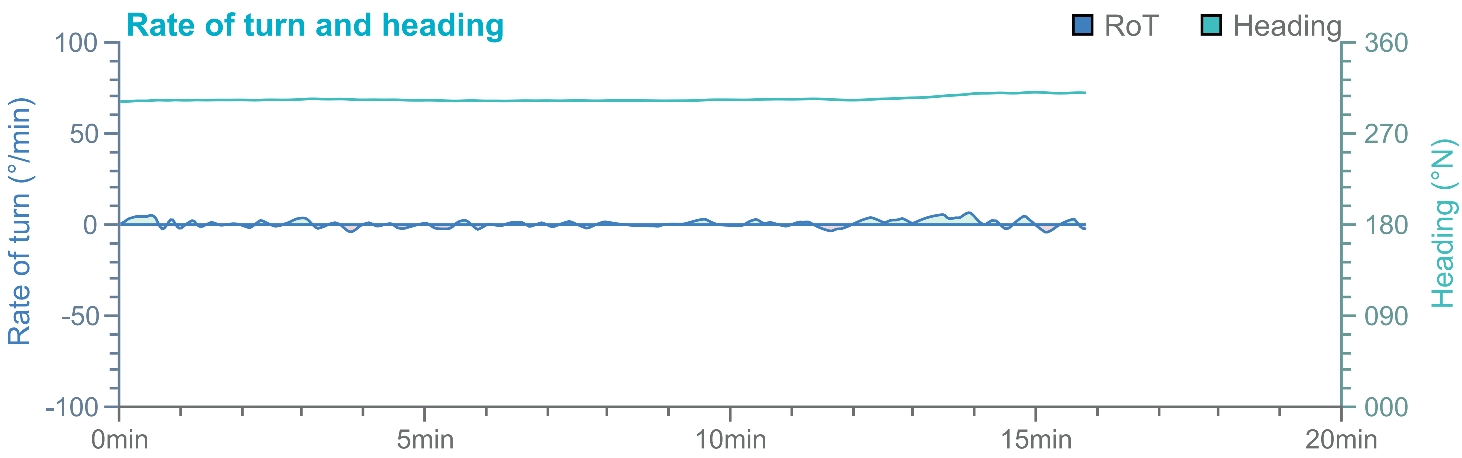
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

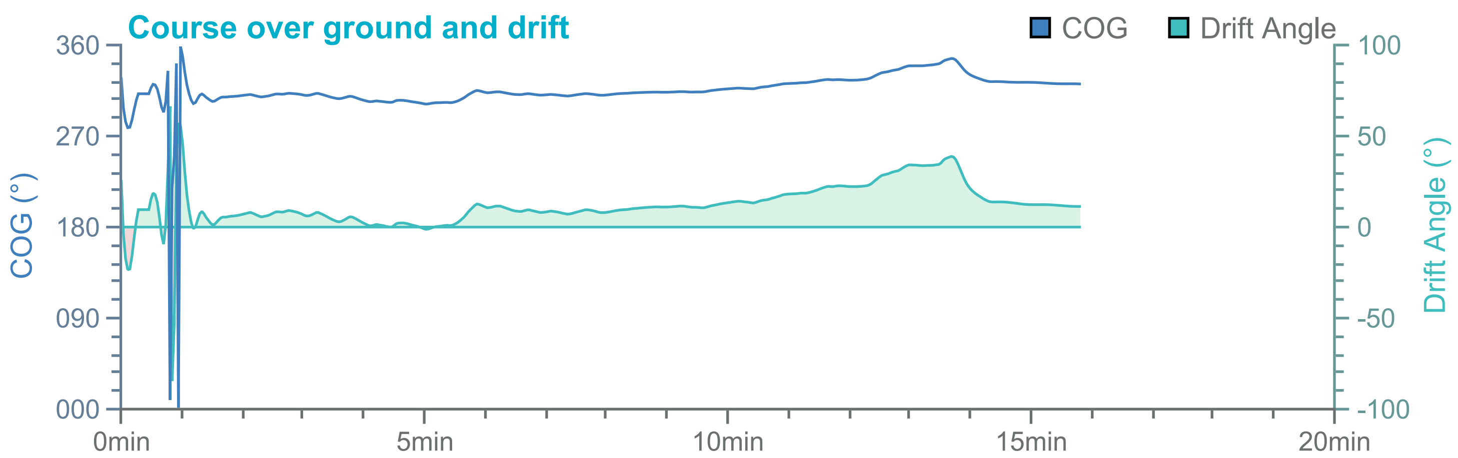



Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min

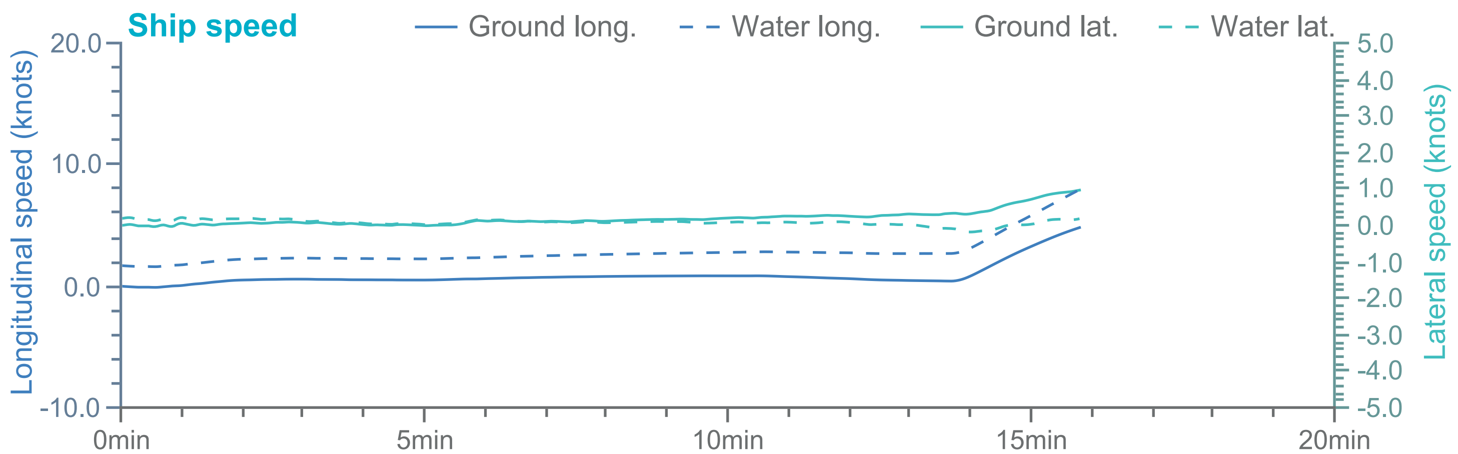

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min



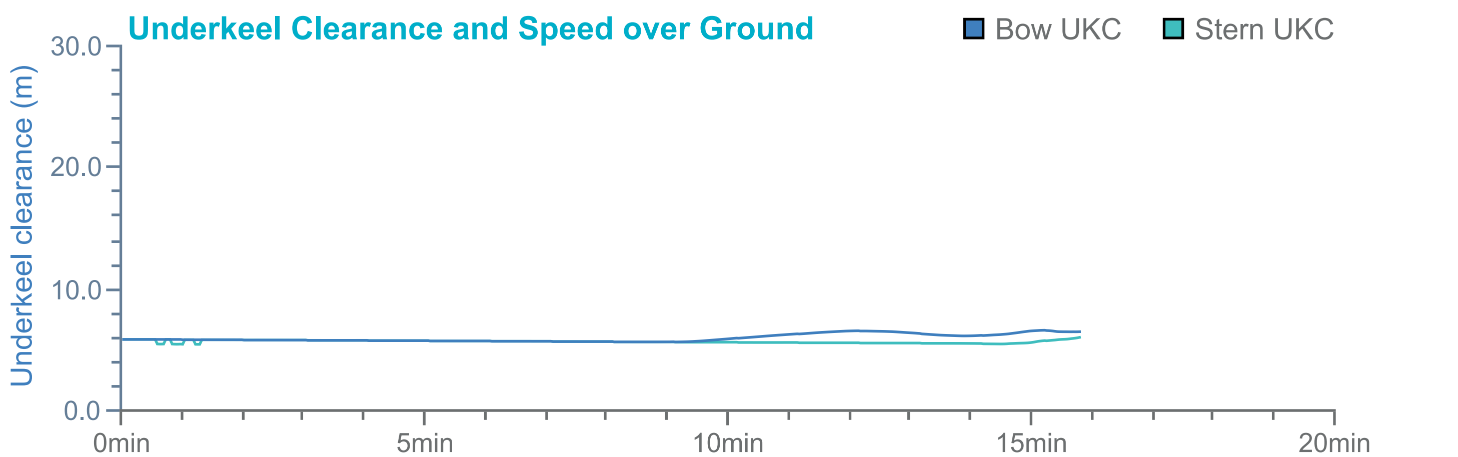
Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min



Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min

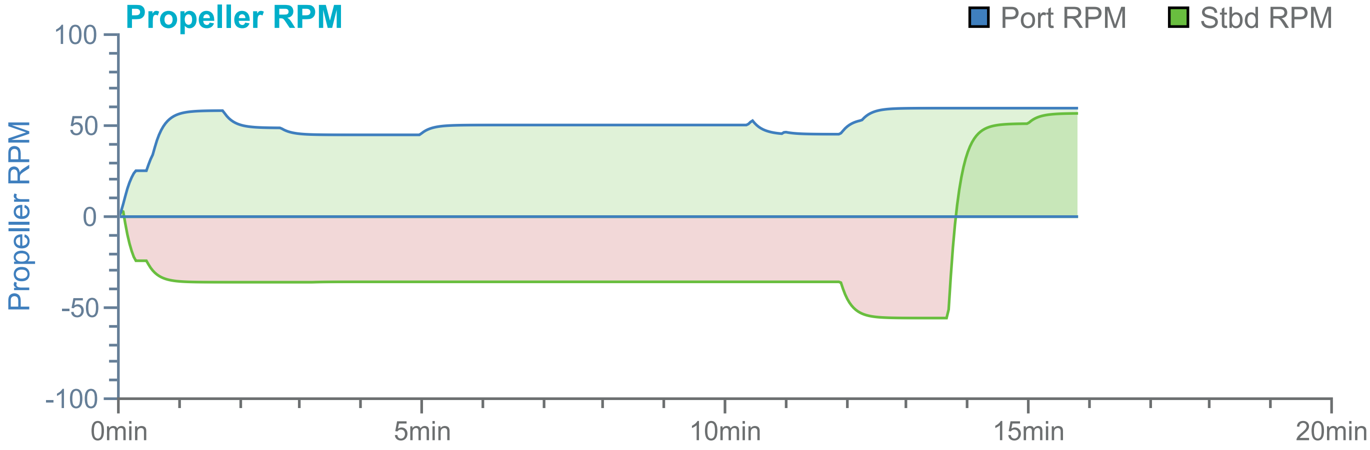


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min

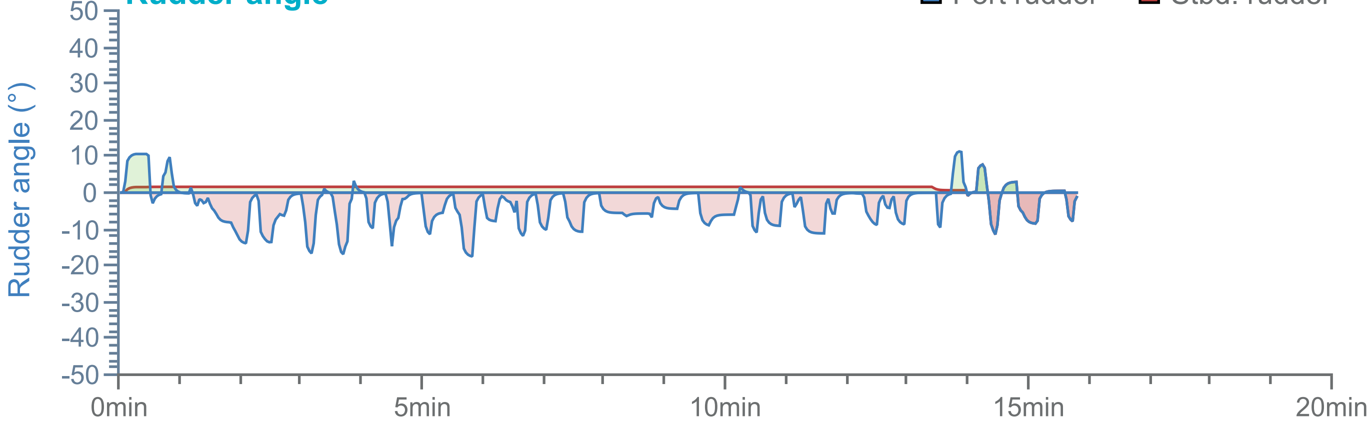


Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min

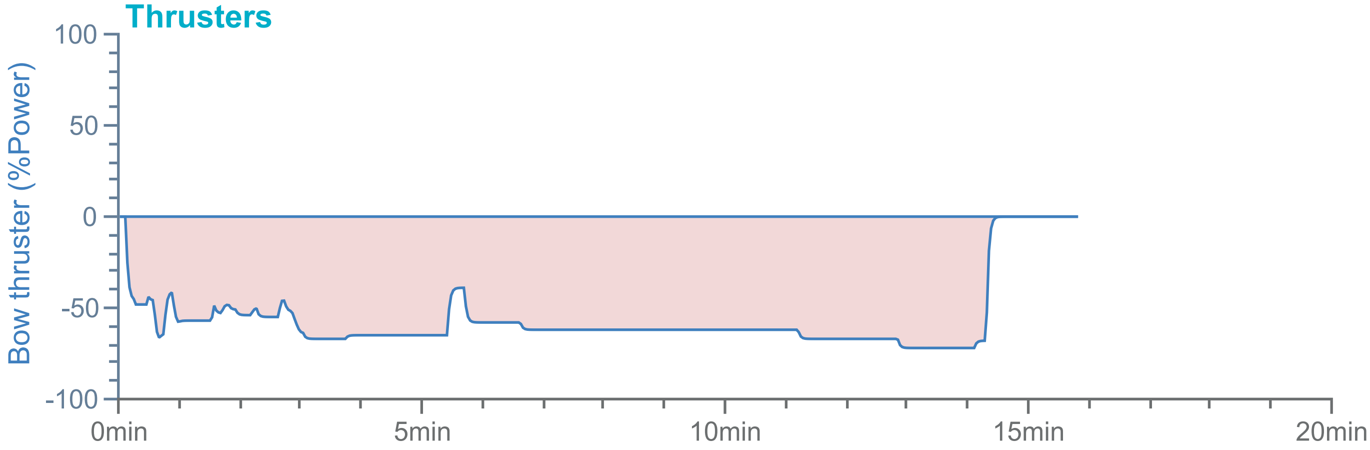
Propeller RPM



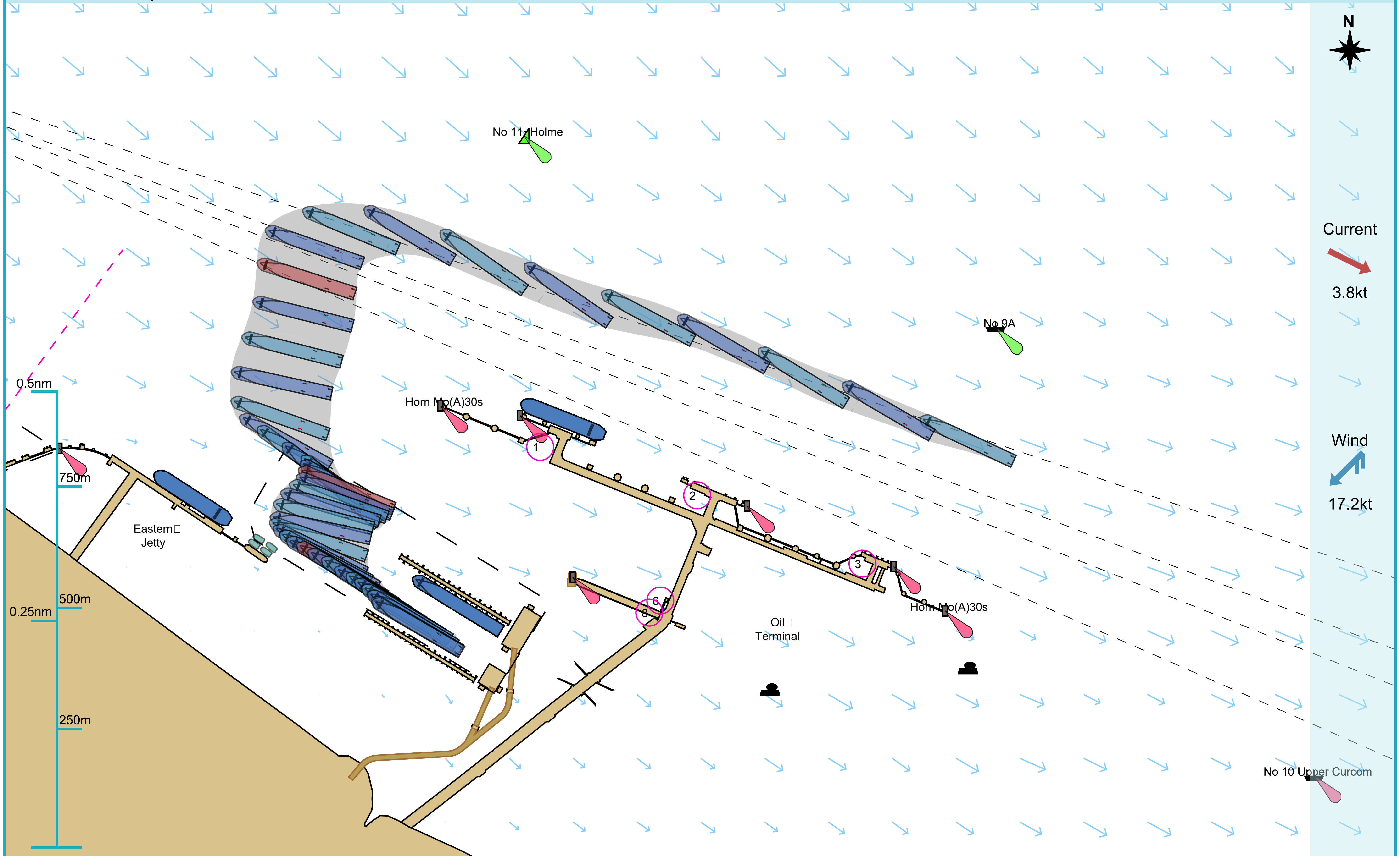
Rudder angle



Thrusters

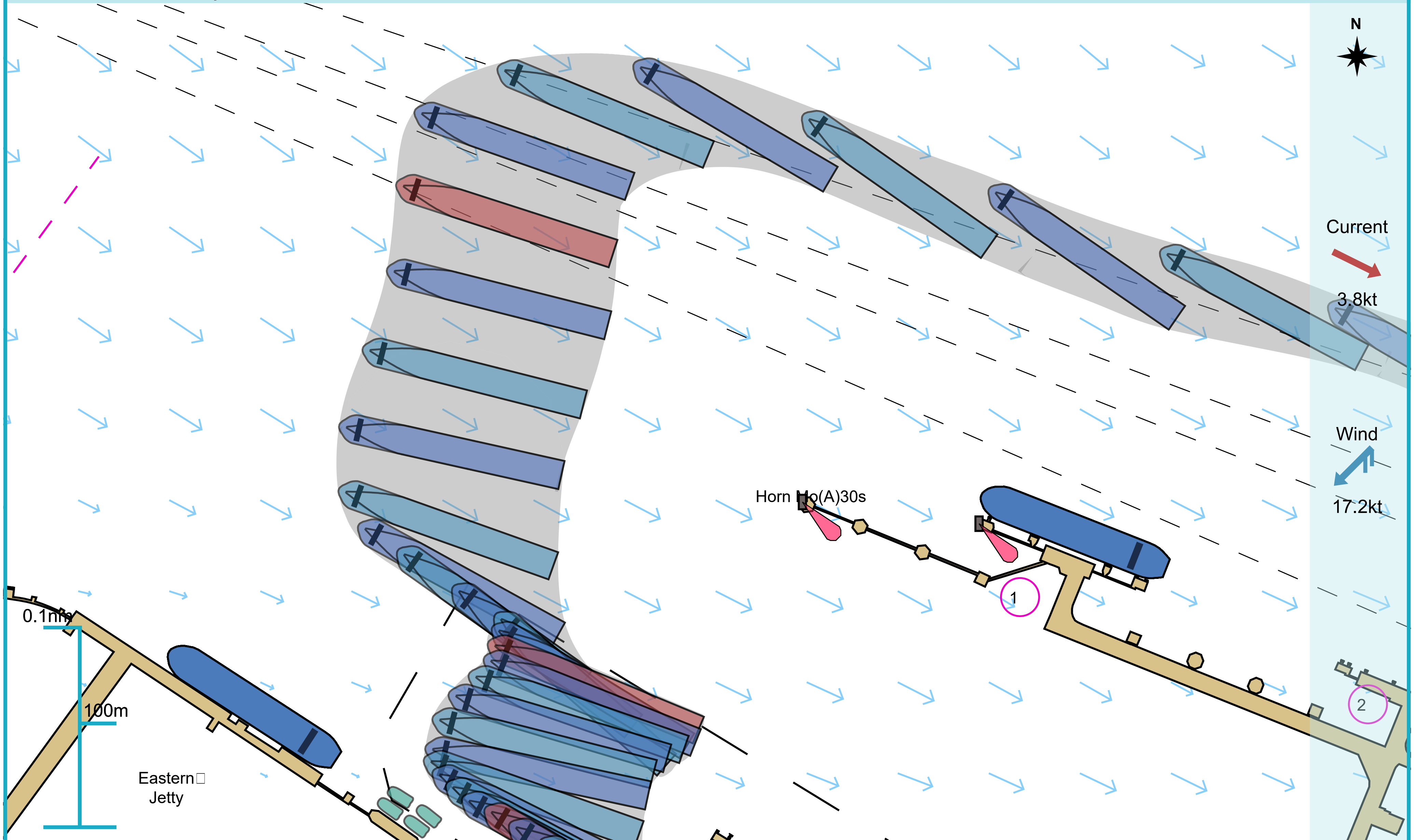


Manoeuvre track plot



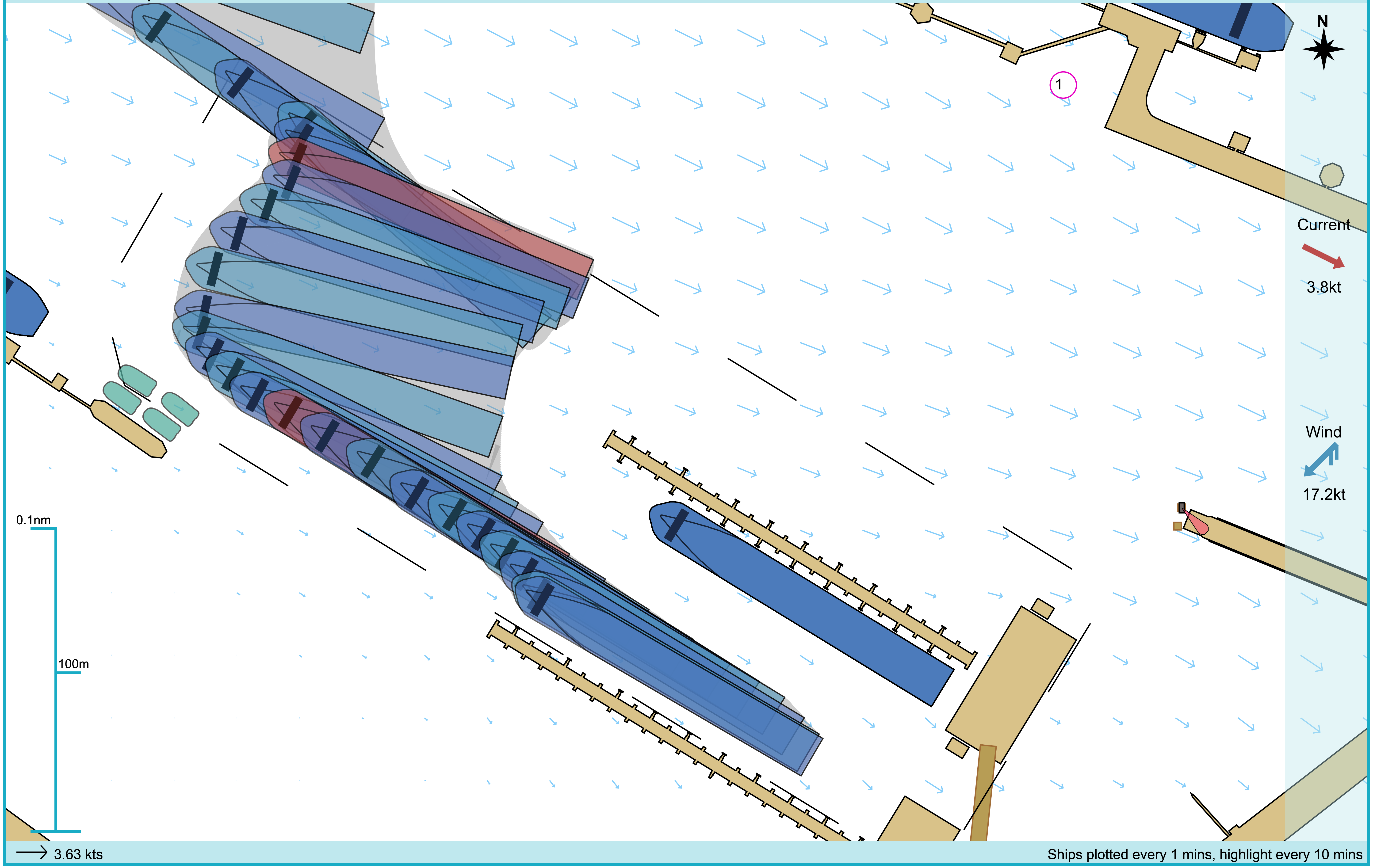
Ships plotted every 1 mins, highlight every 10 mins

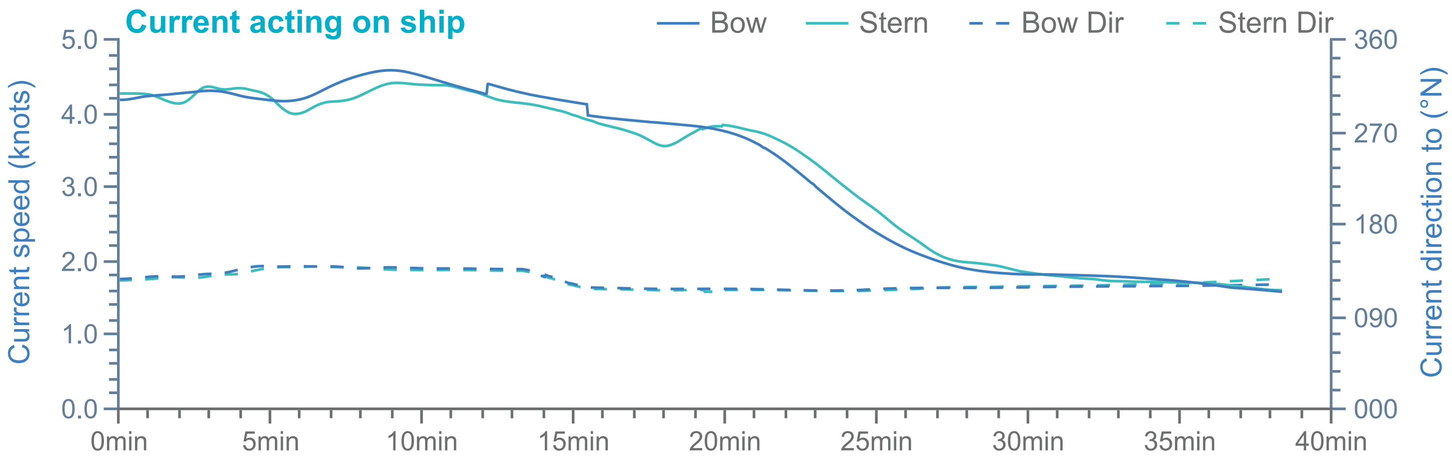
Manoeuvre track plot

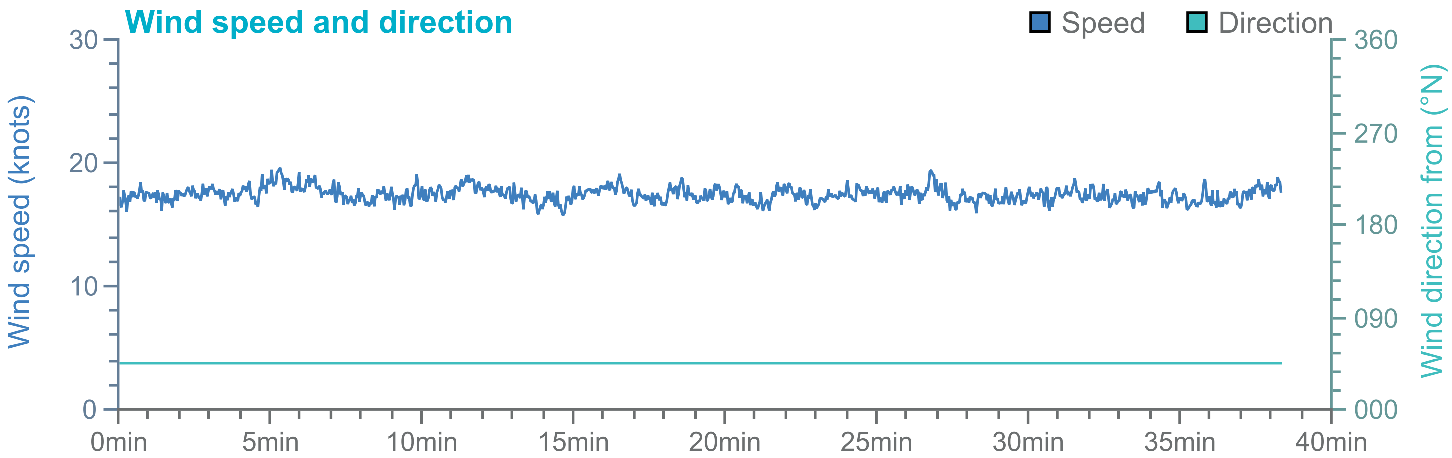


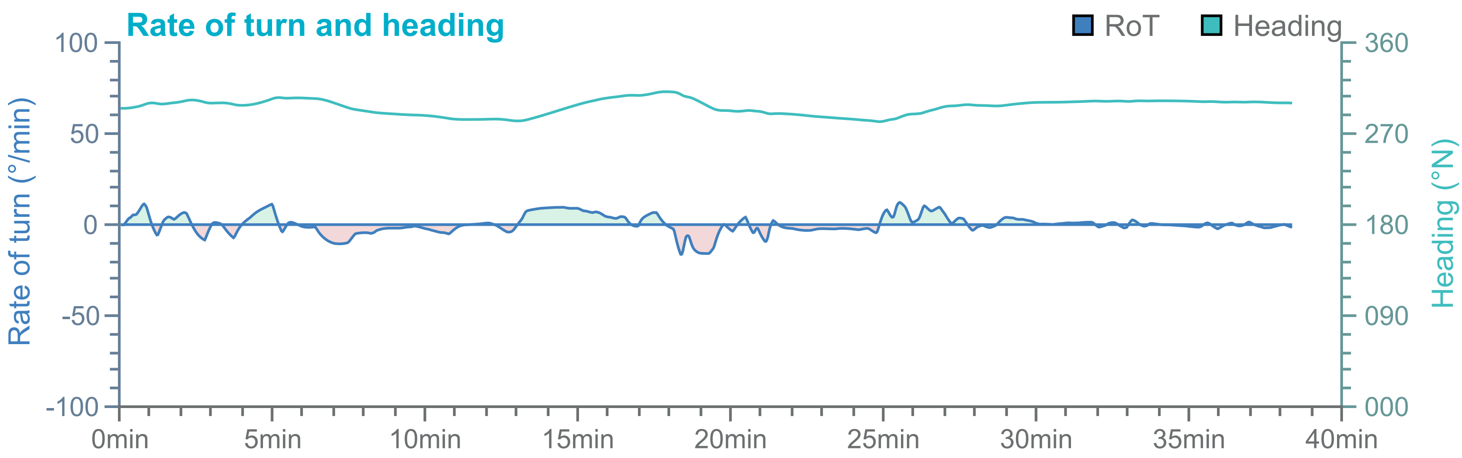
Ships plotted every 1 mins, highlight every 10 mins

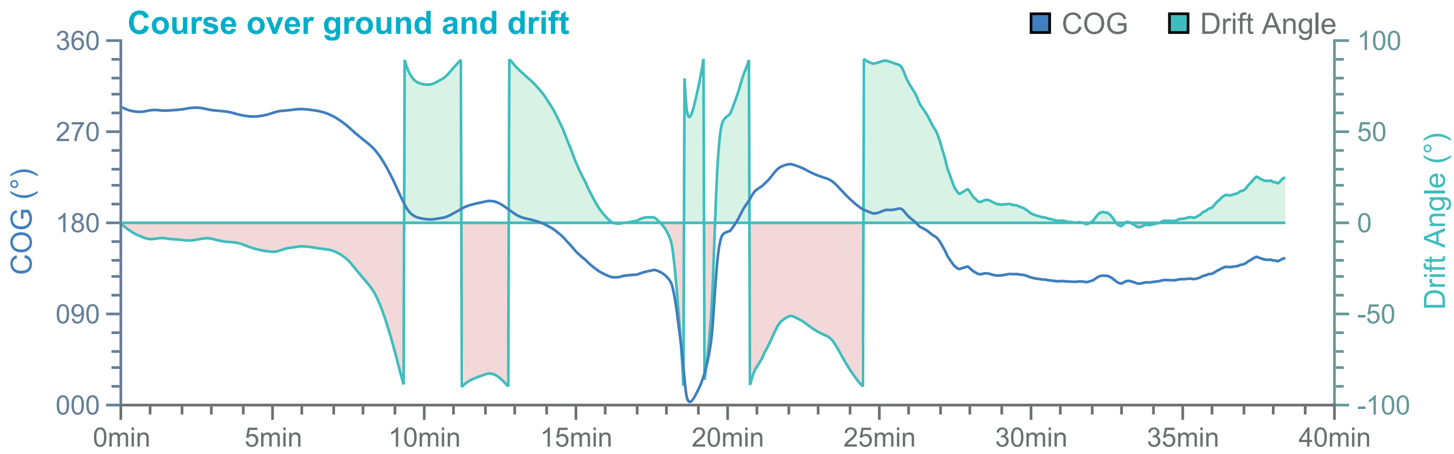
Manoeuvre track plot

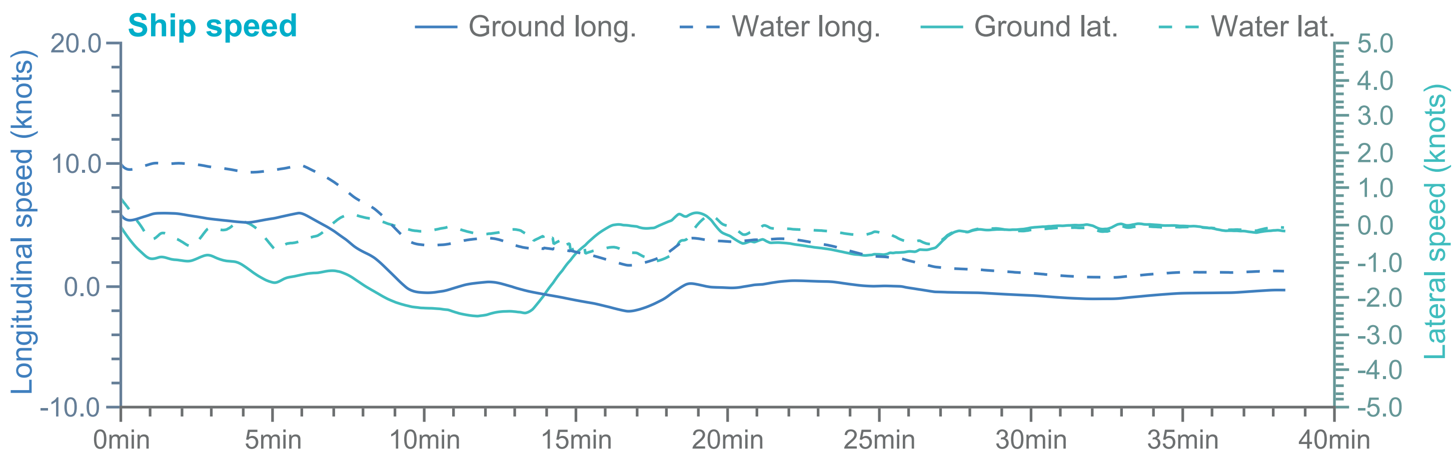


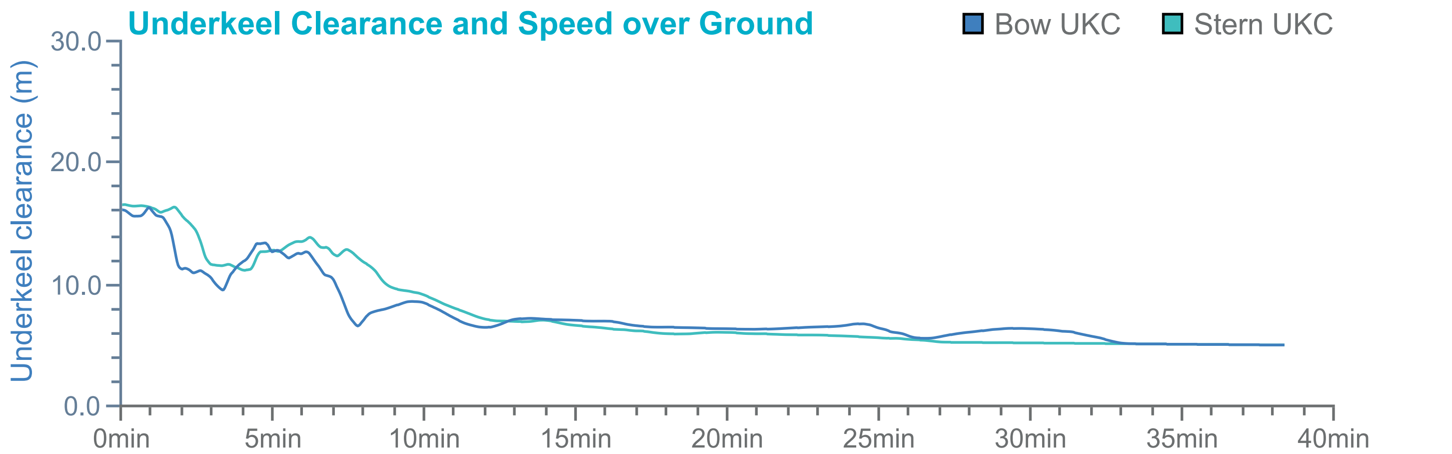

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

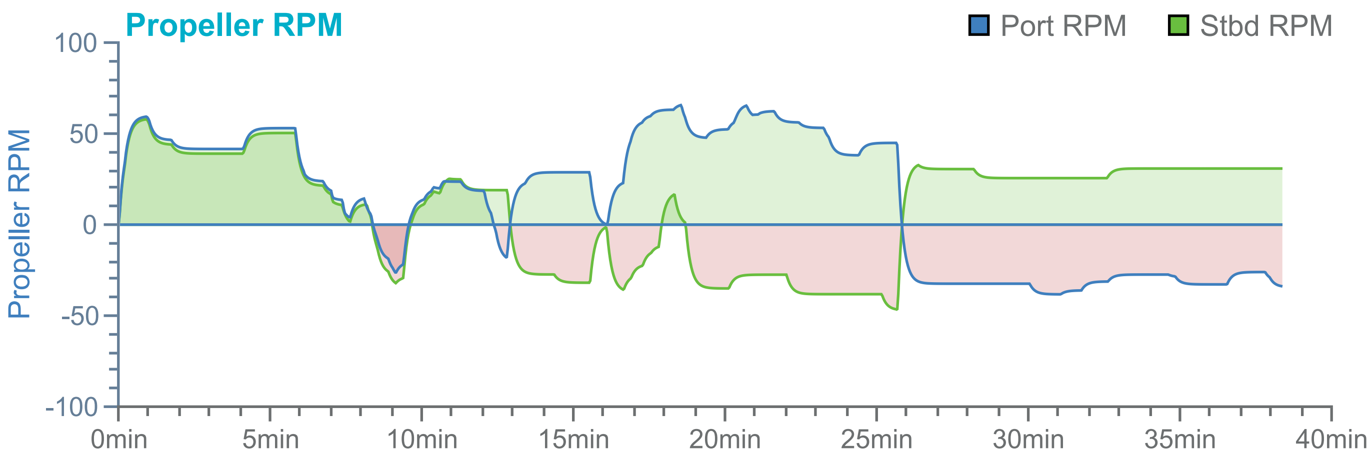

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

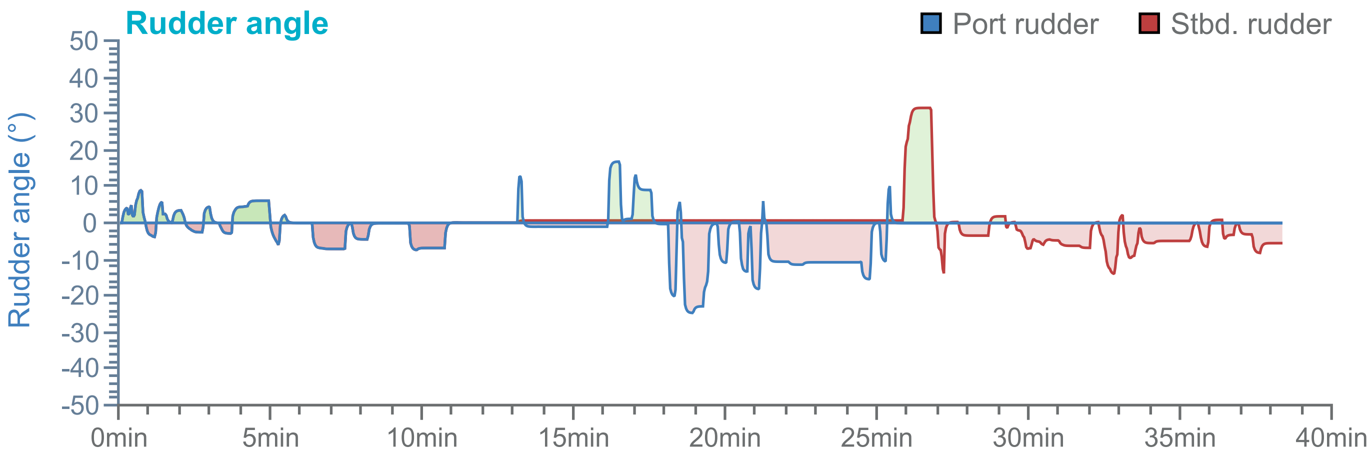

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

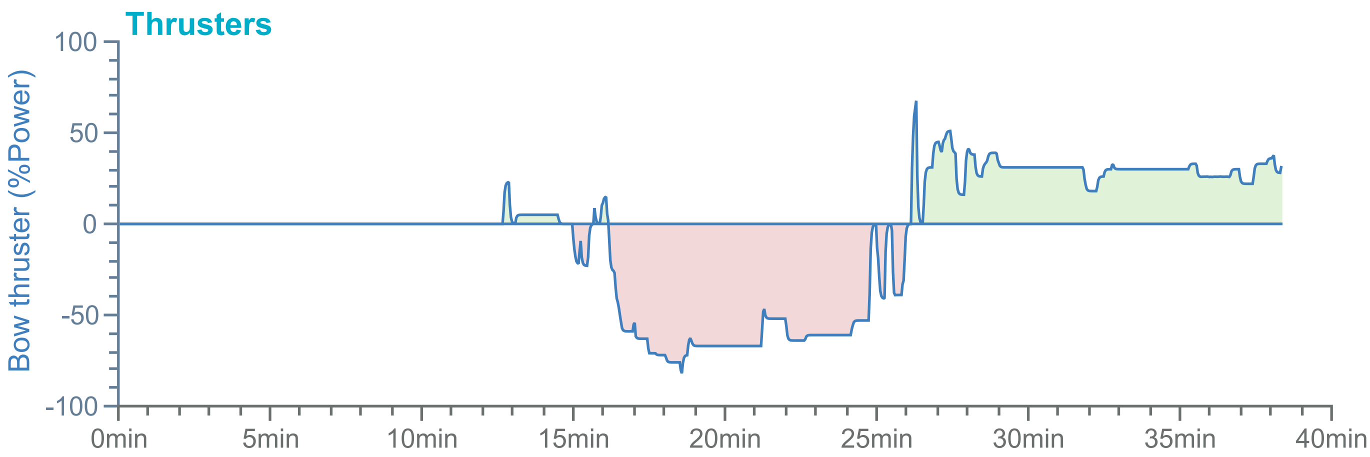

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

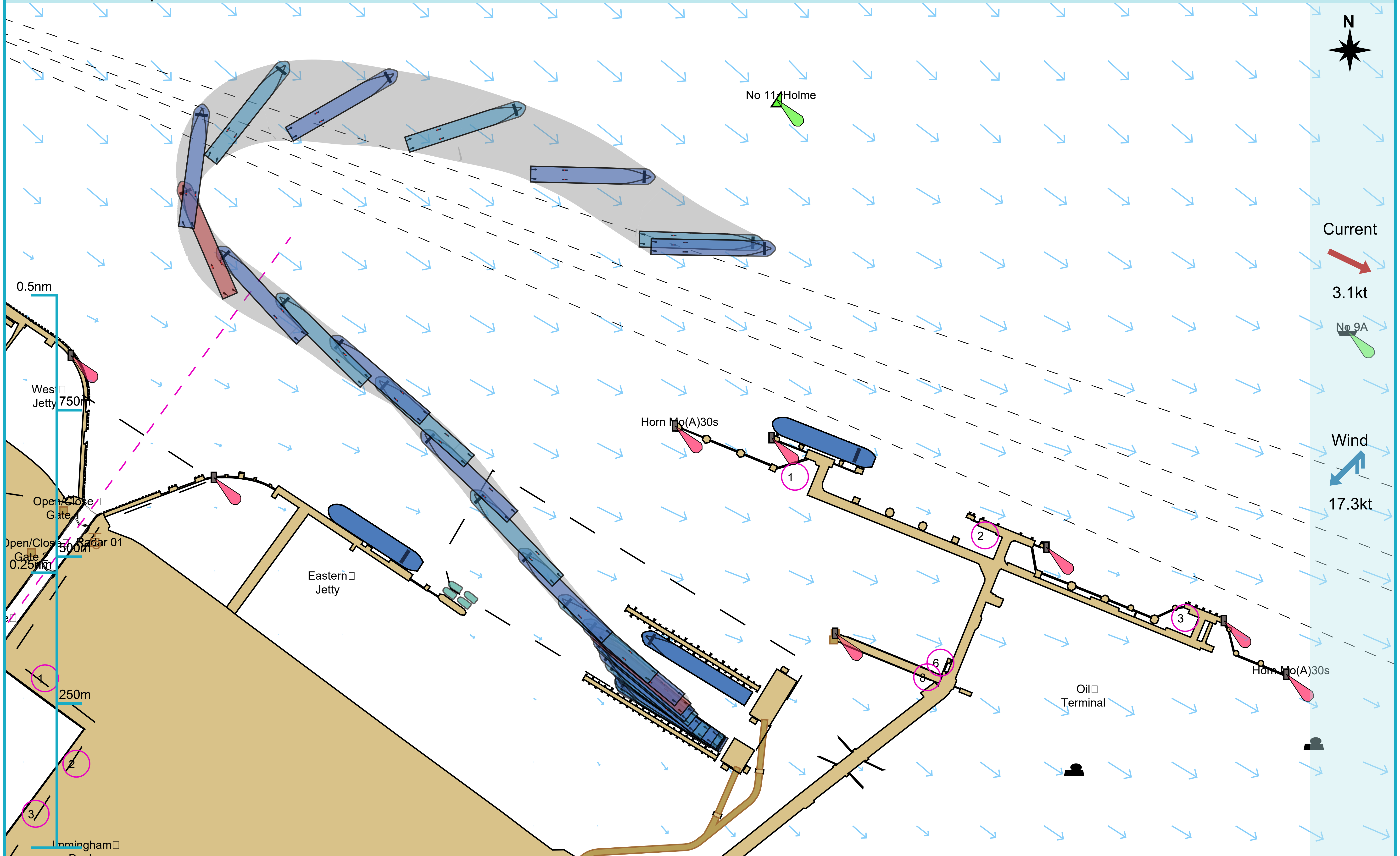

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min
40min

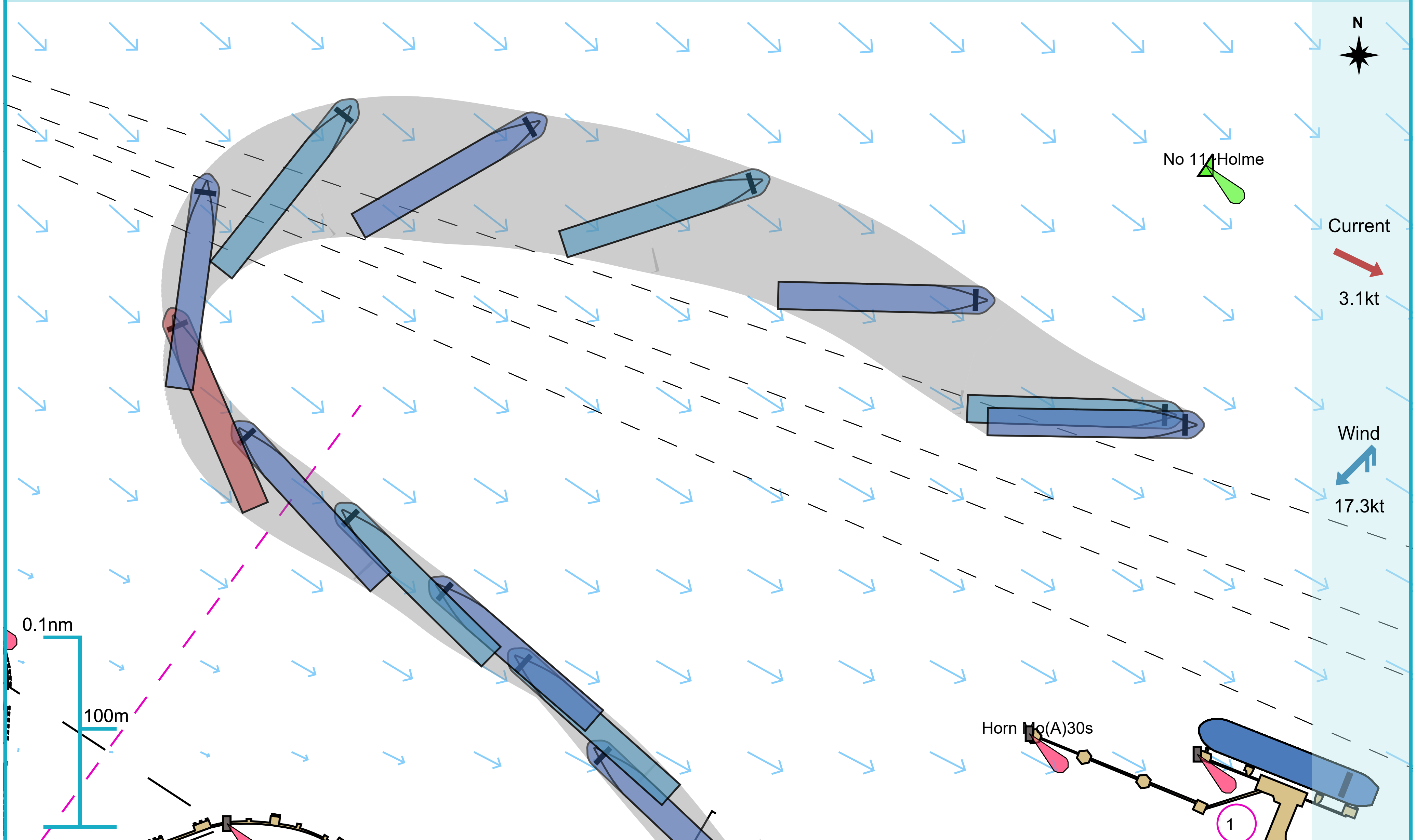

Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

Manoeuvre track plot



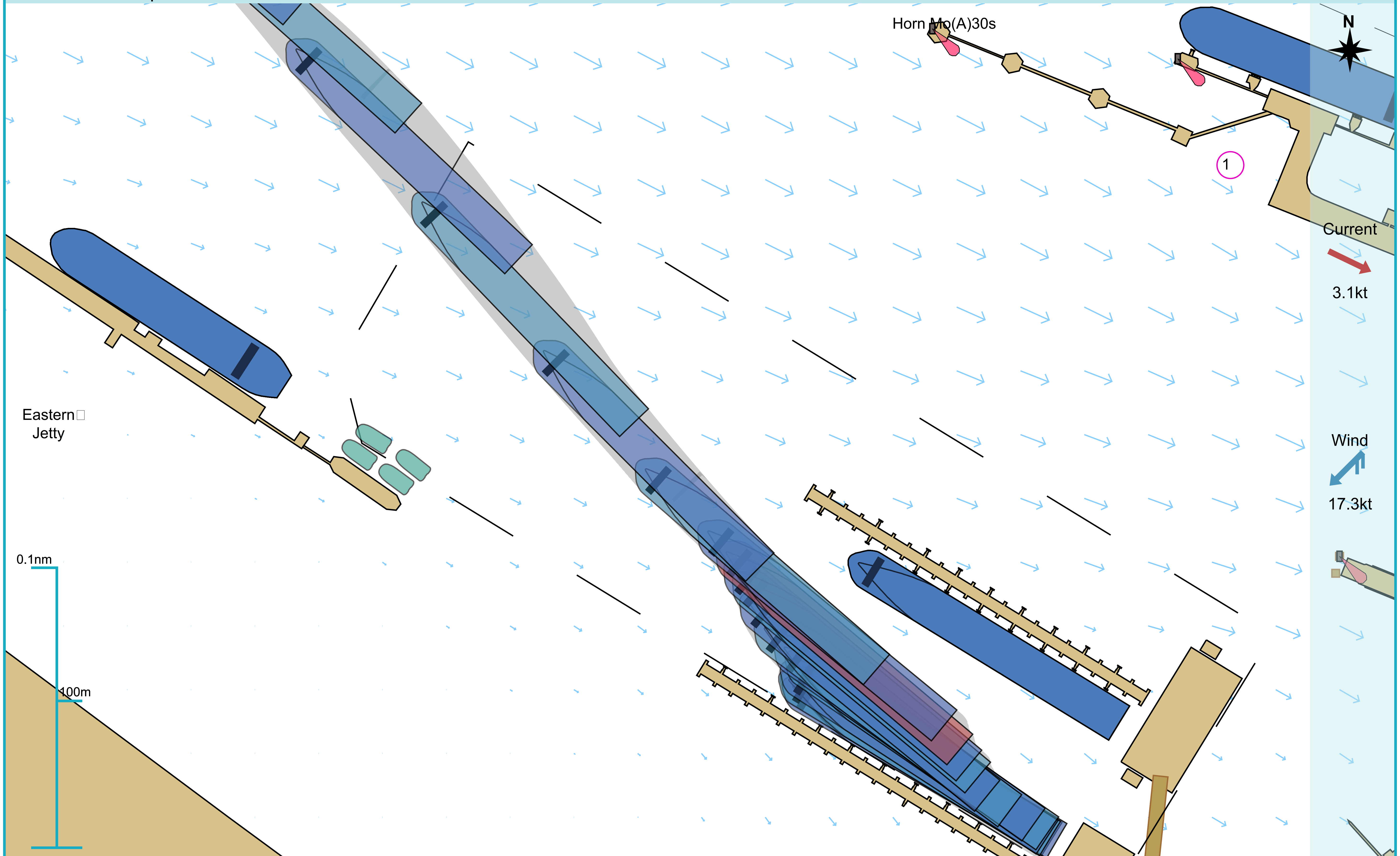
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



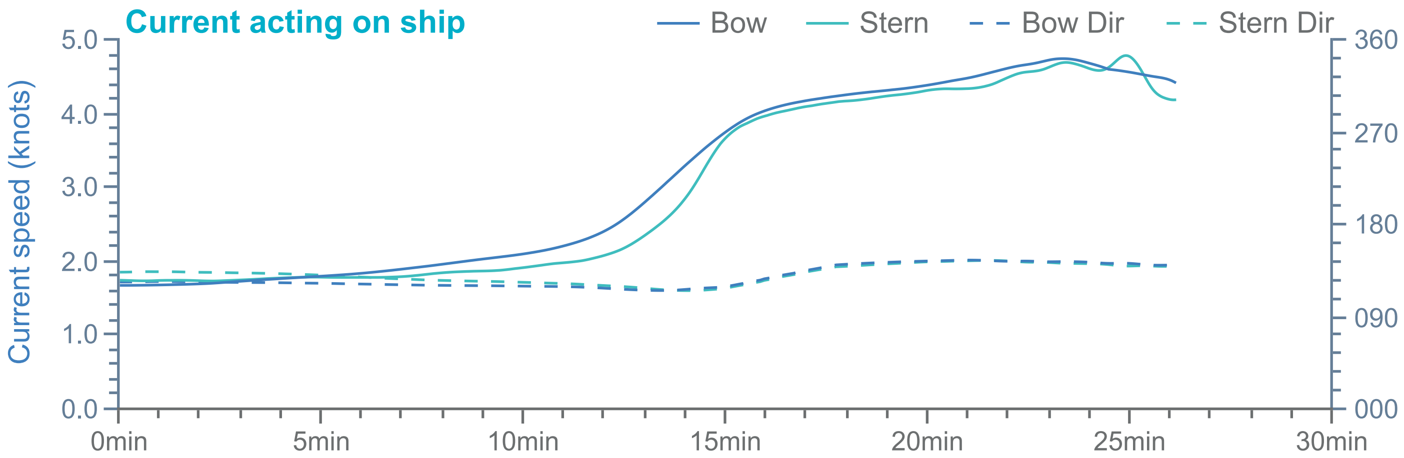
Ships plotted every 1 mins, highlight every 10 mins

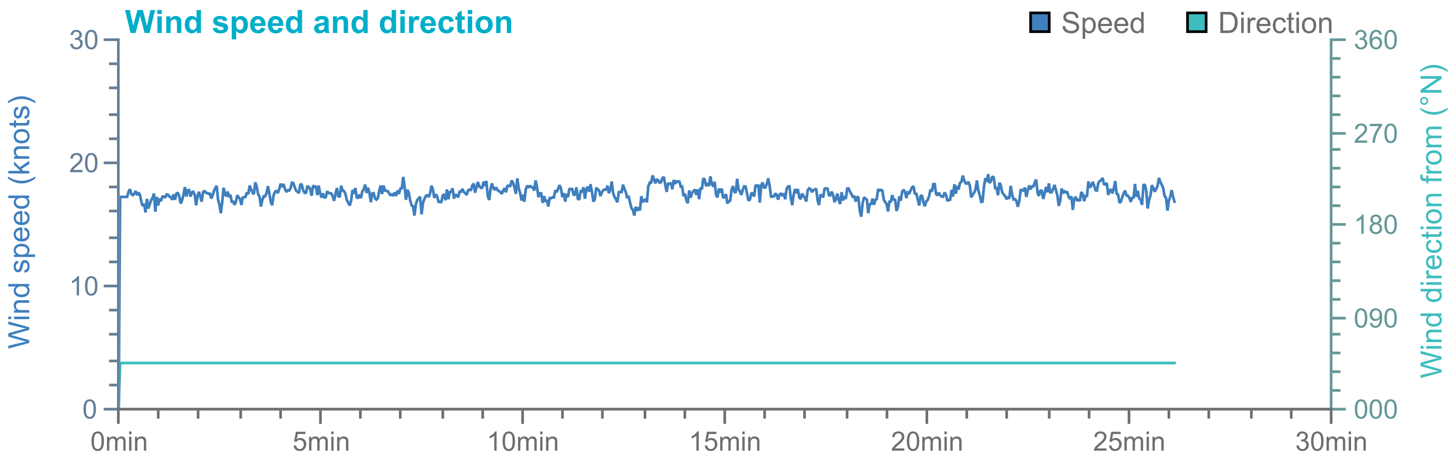
Manoeuvre track plot



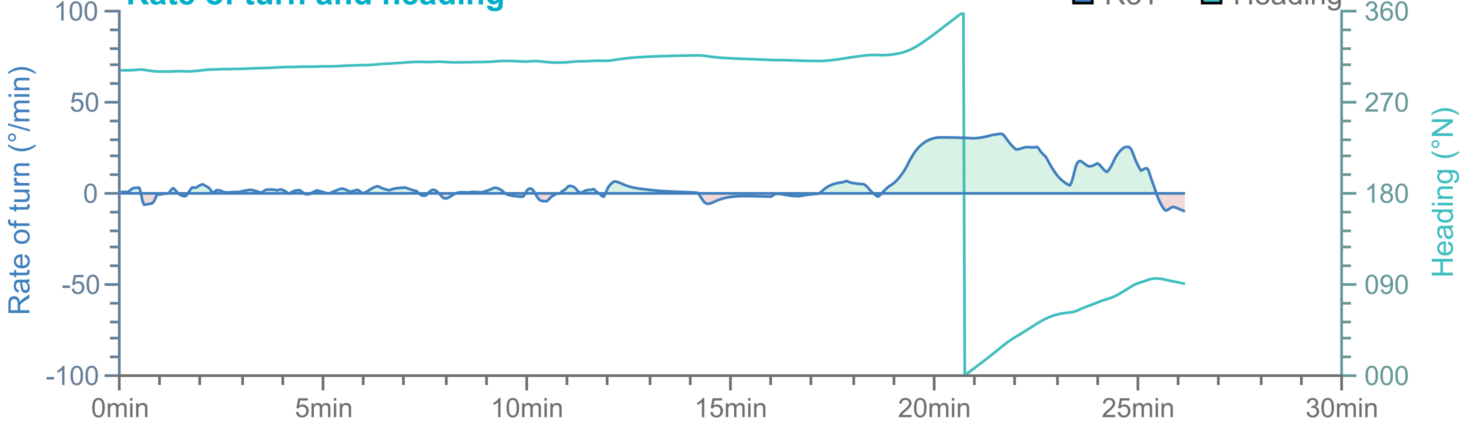
3.65 kts

Ships plotted every 1 mins, highlight every 10 mins

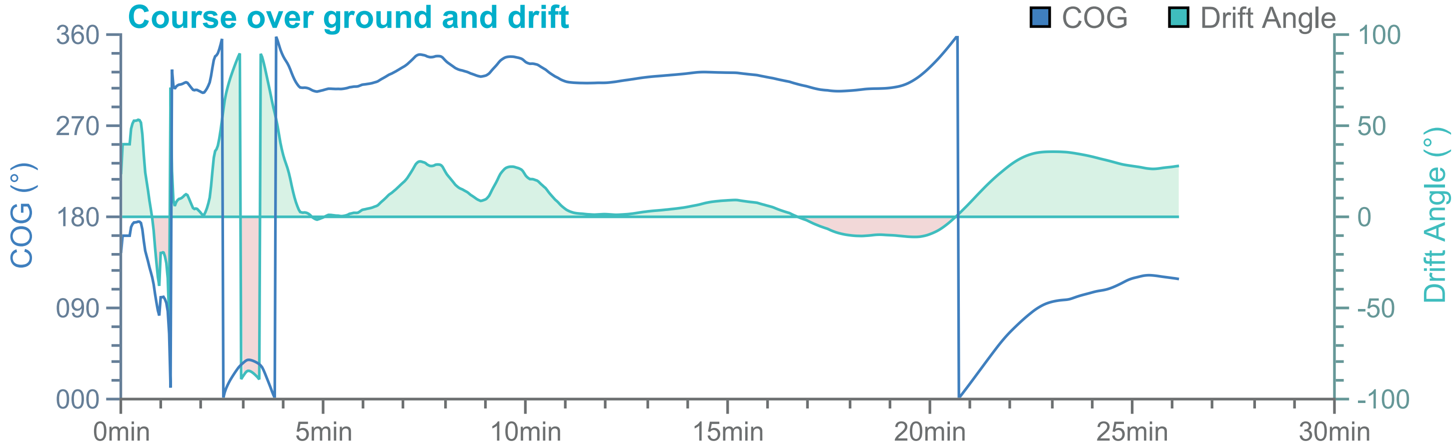

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

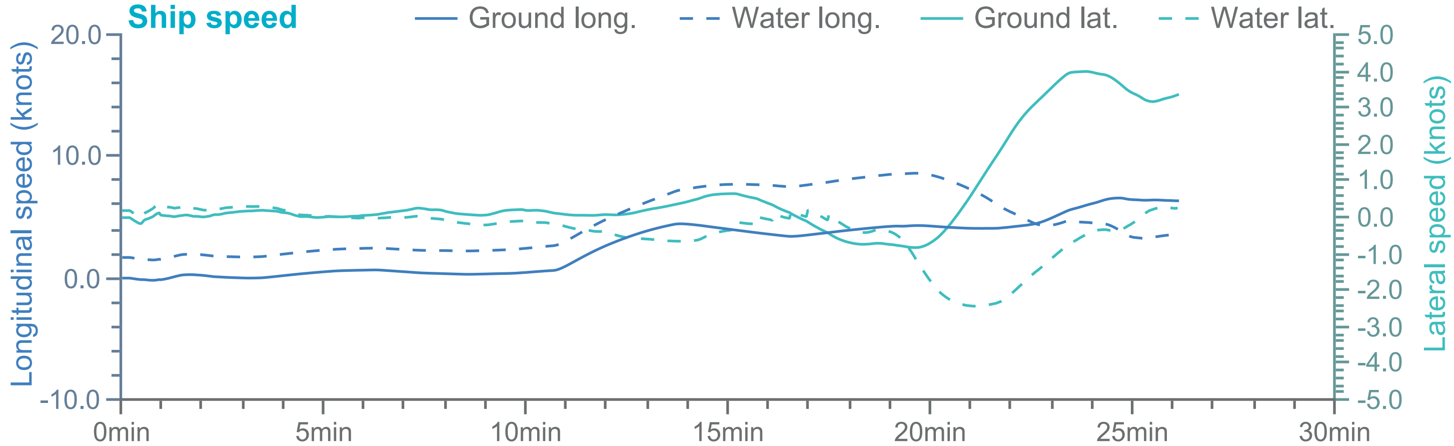
Rate of turn and heading



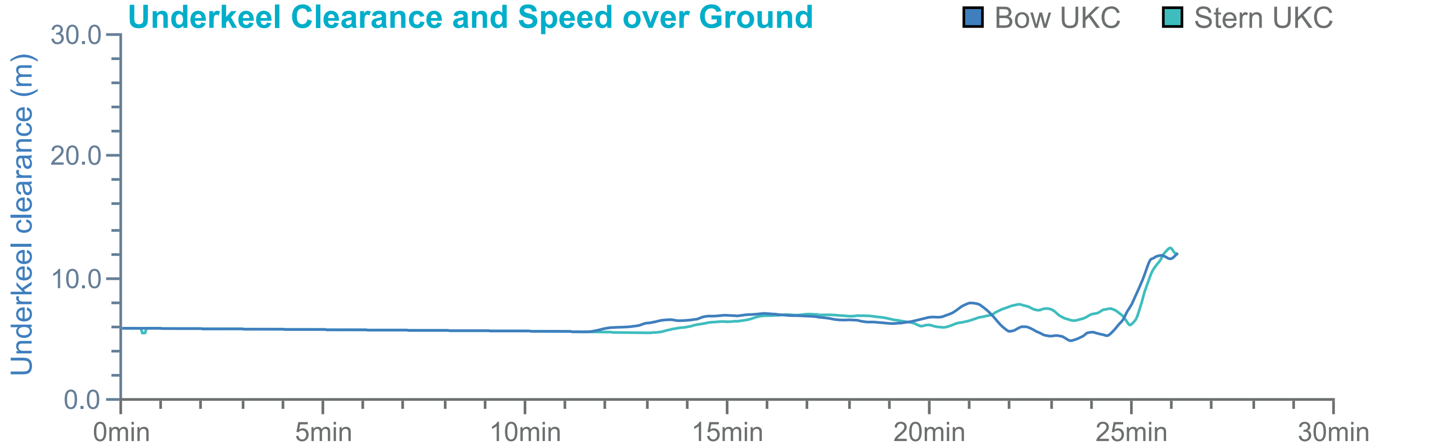
Course over ground and drift

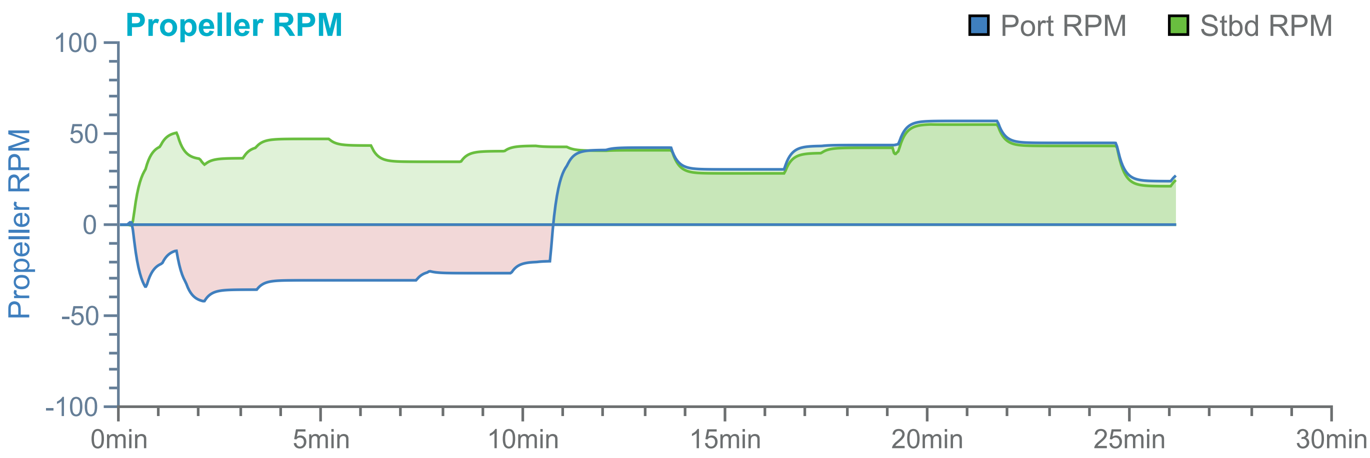


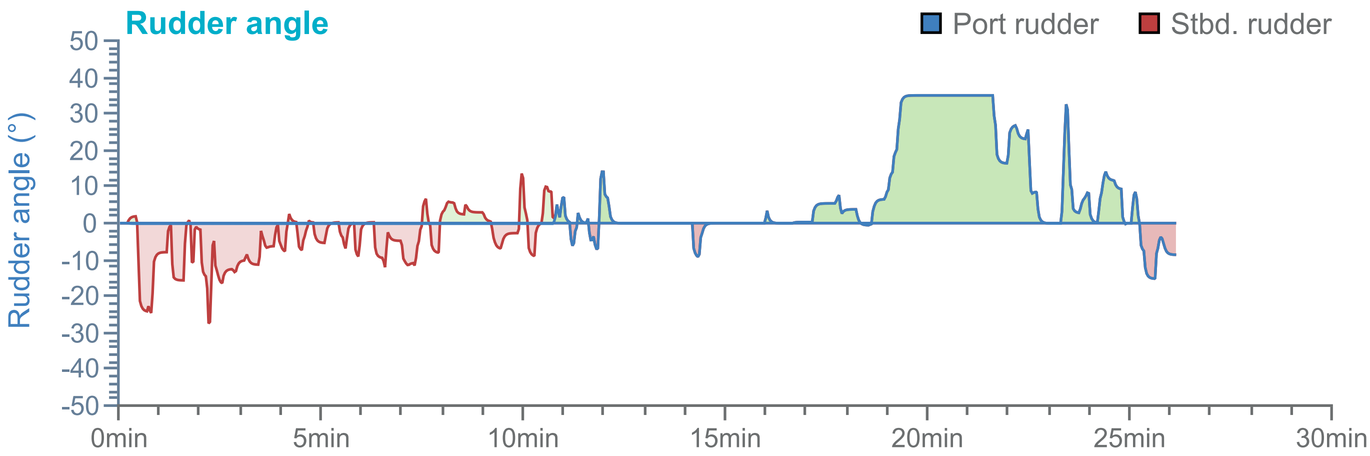
Ship speed

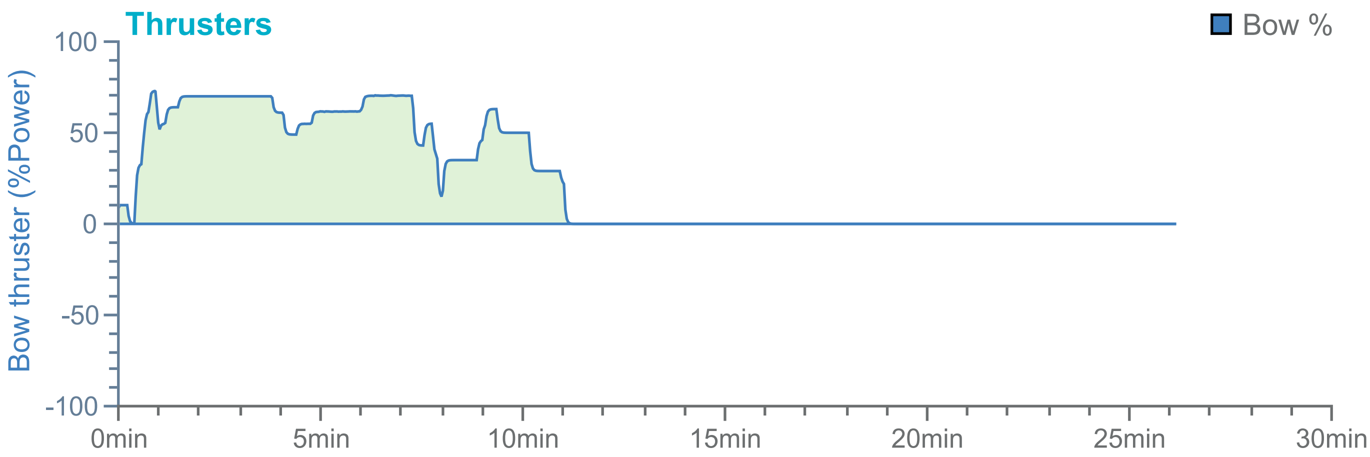


Underkeel Clearance and Speed over Ground

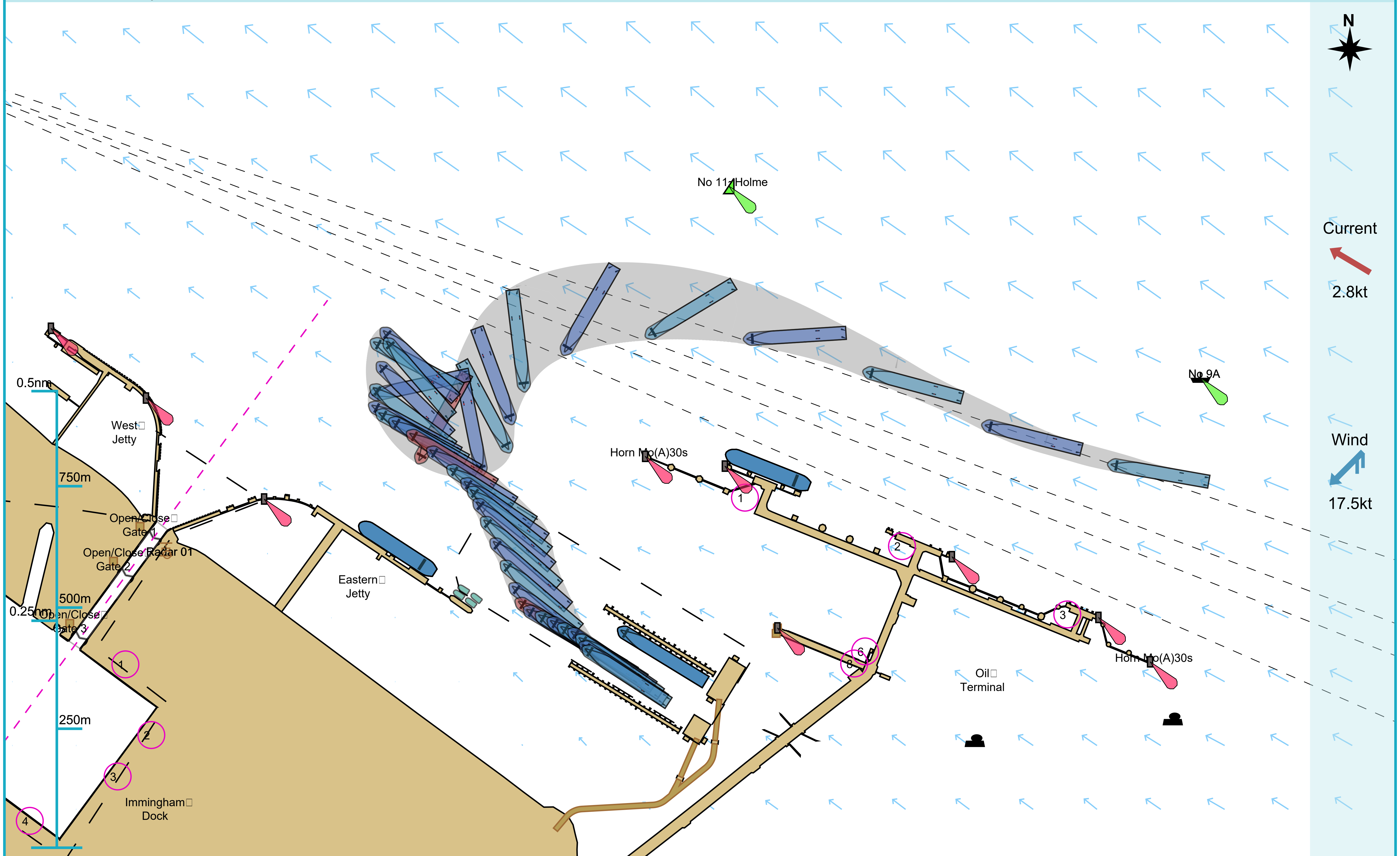



Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min

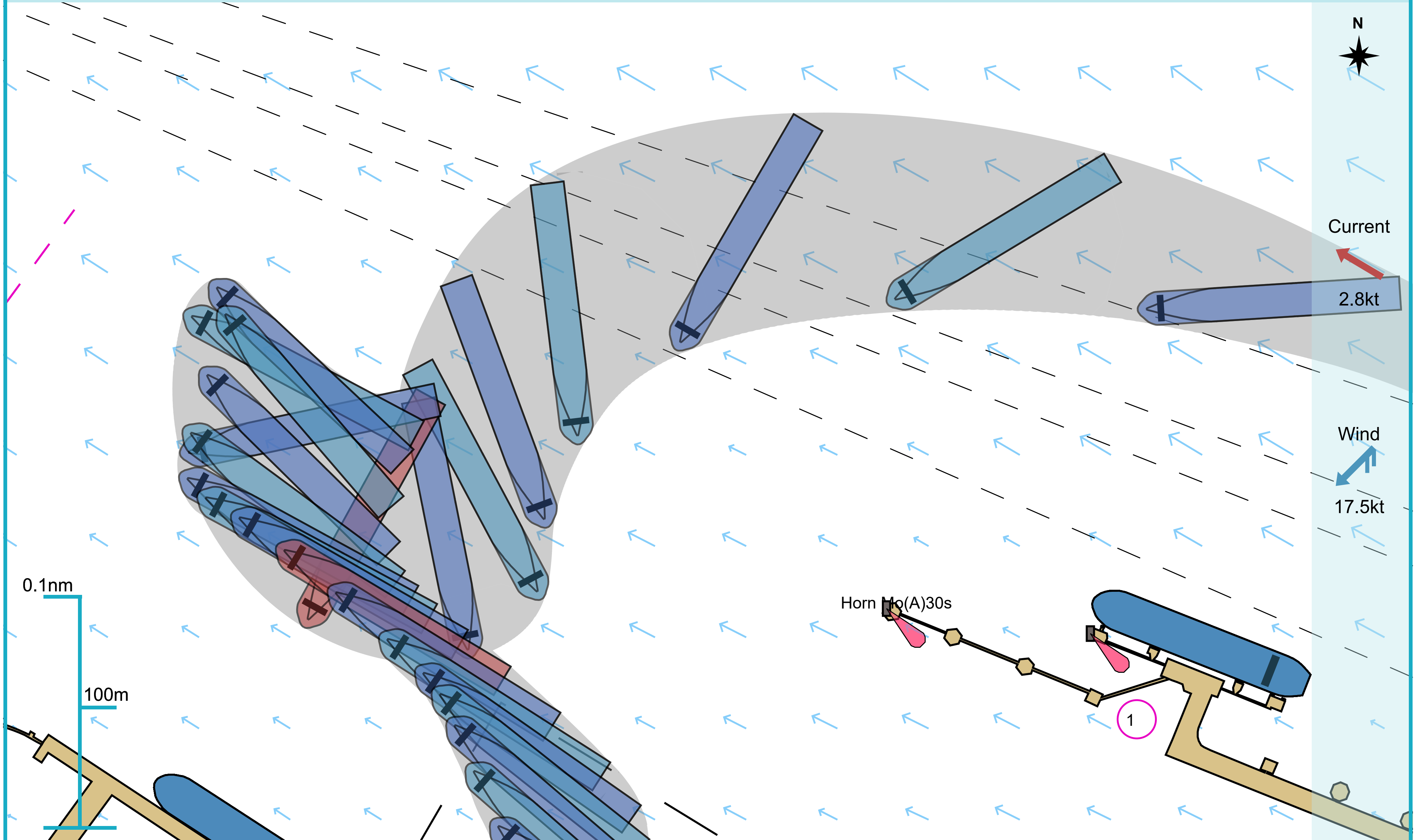

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

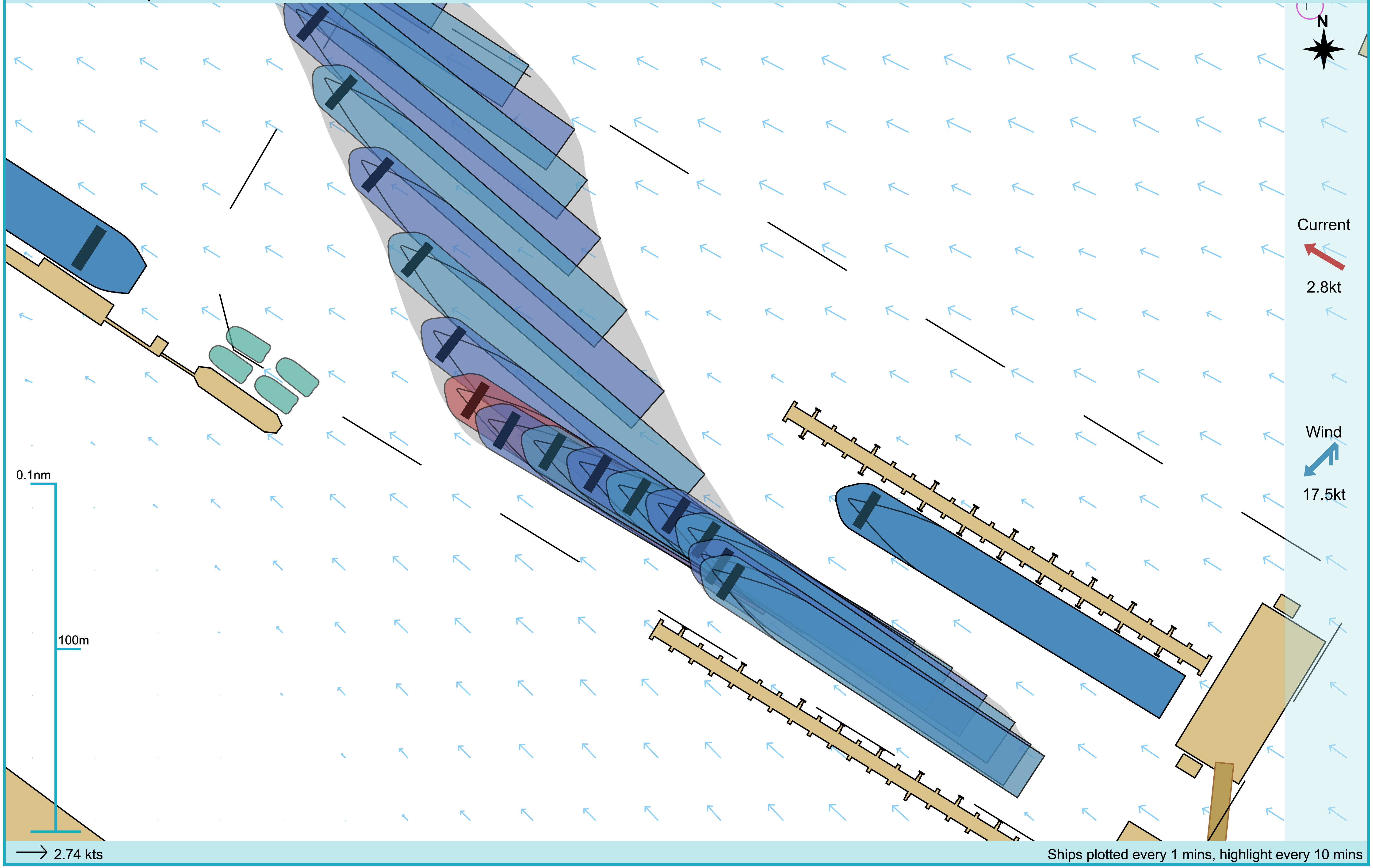
Manoeuvre track plot

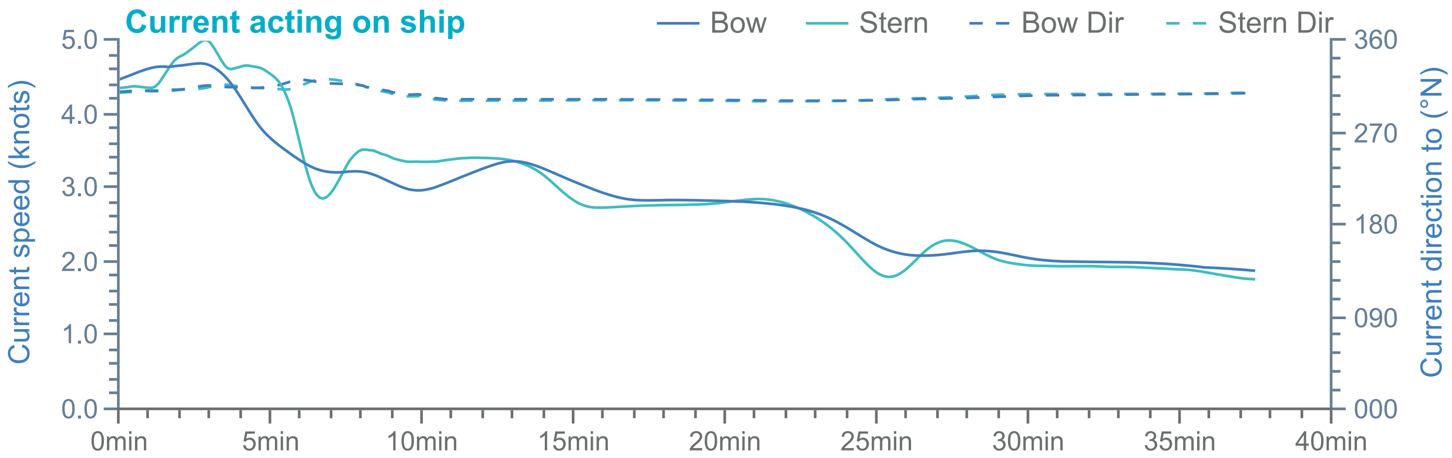


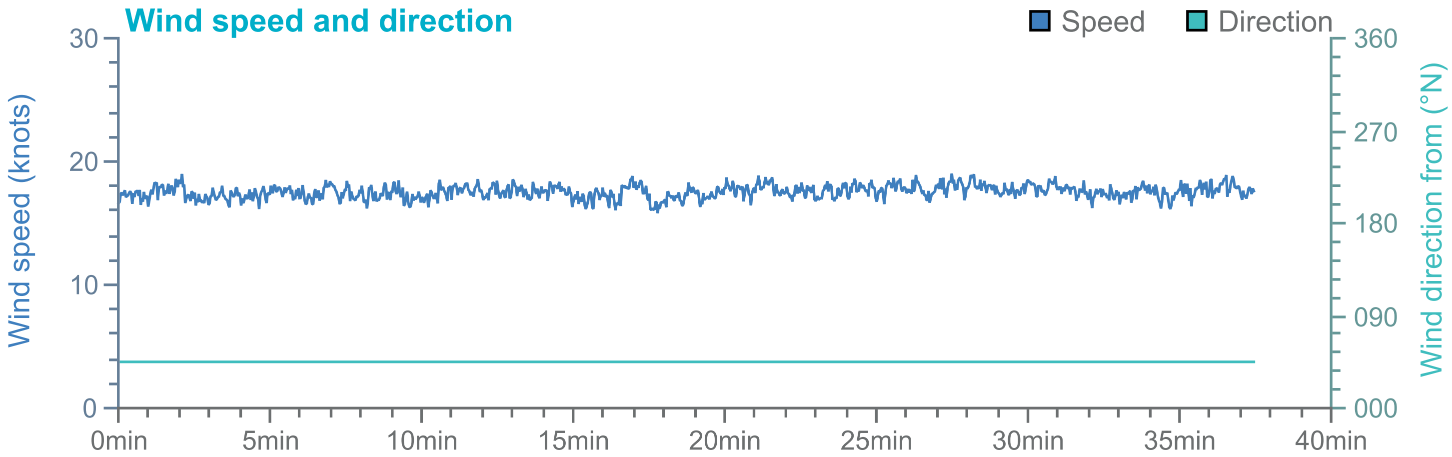
Ships plotted every 1 mins, highlight every 10 mins

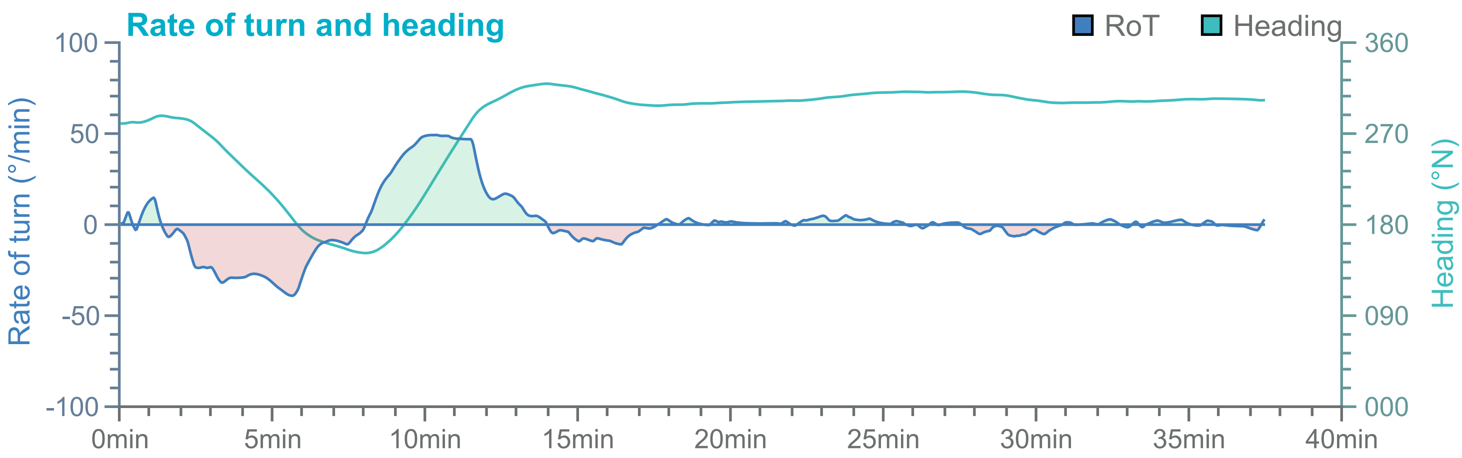
Overview | Environment | Stena Transporter

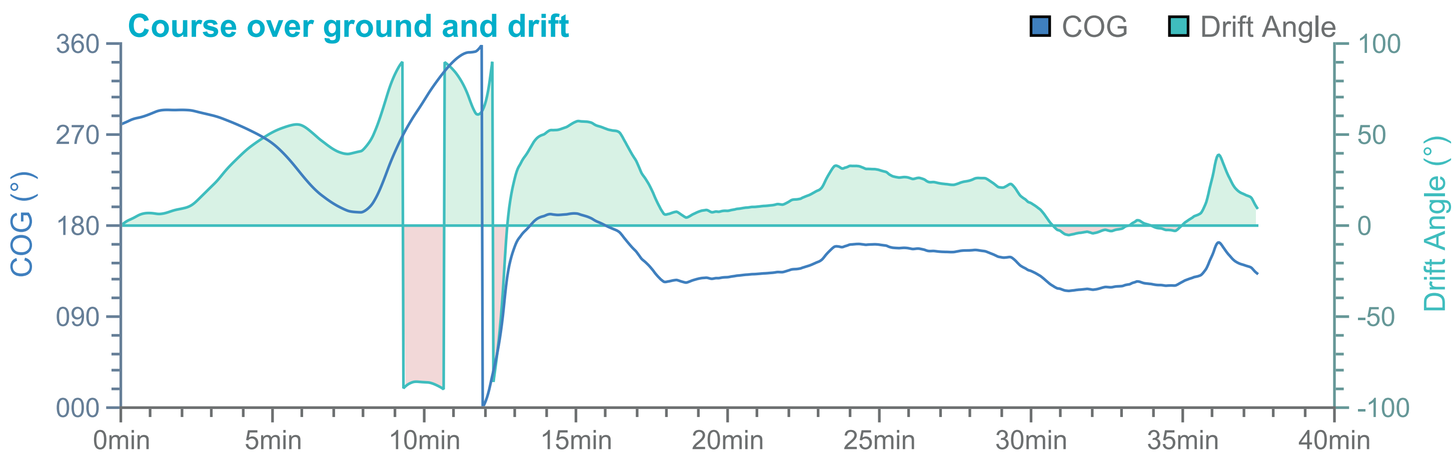
Manoeuvre track plot

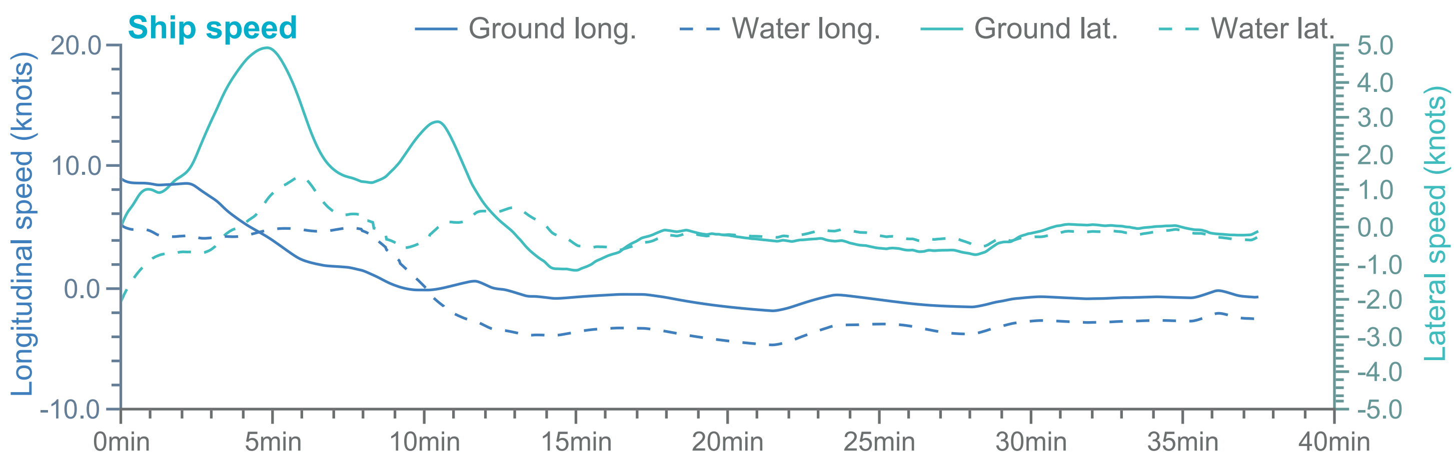


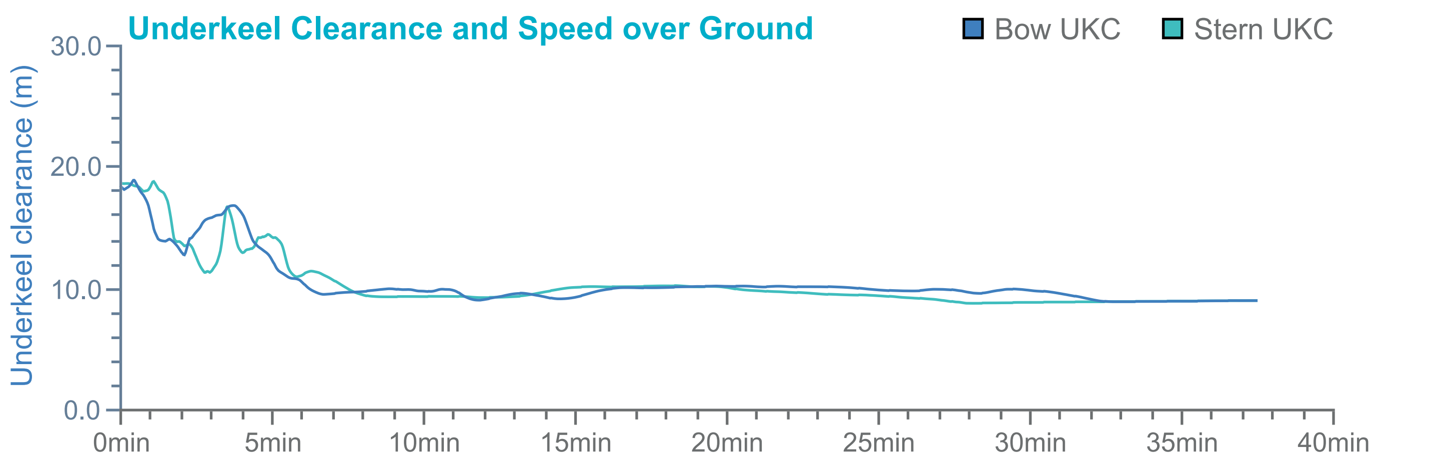

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

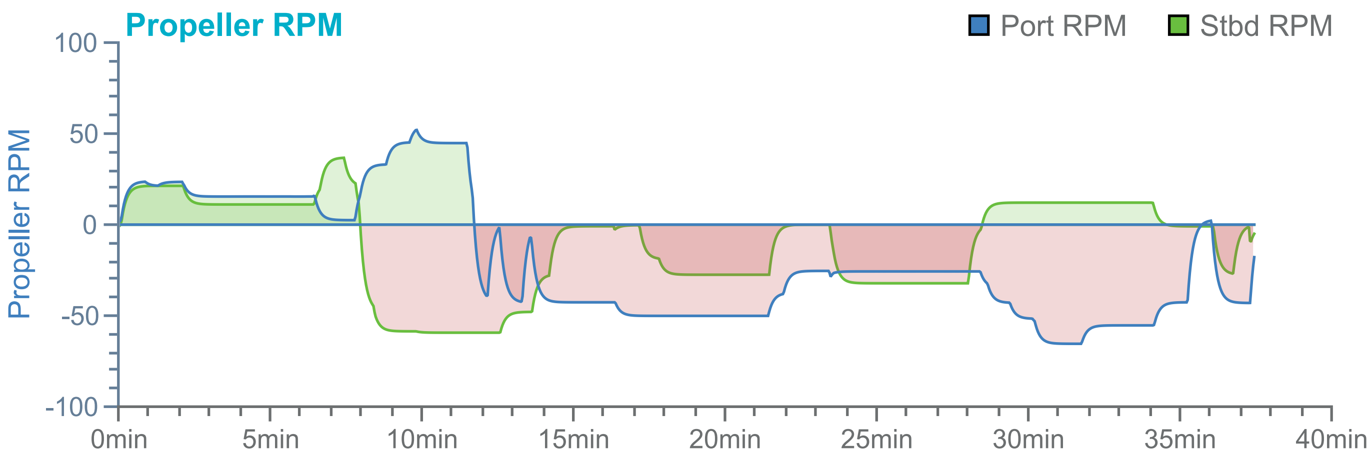

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

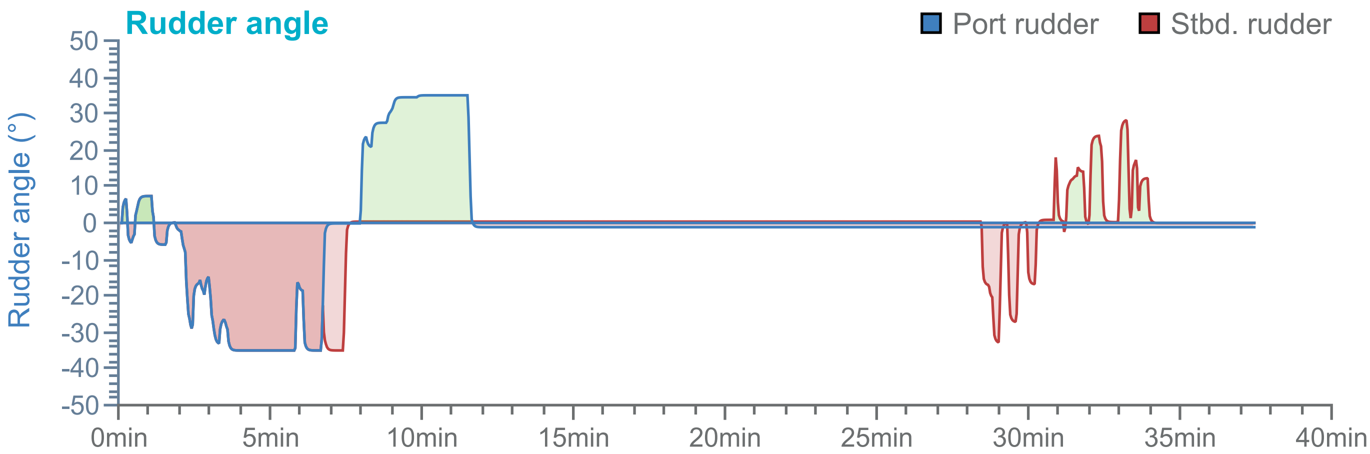

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

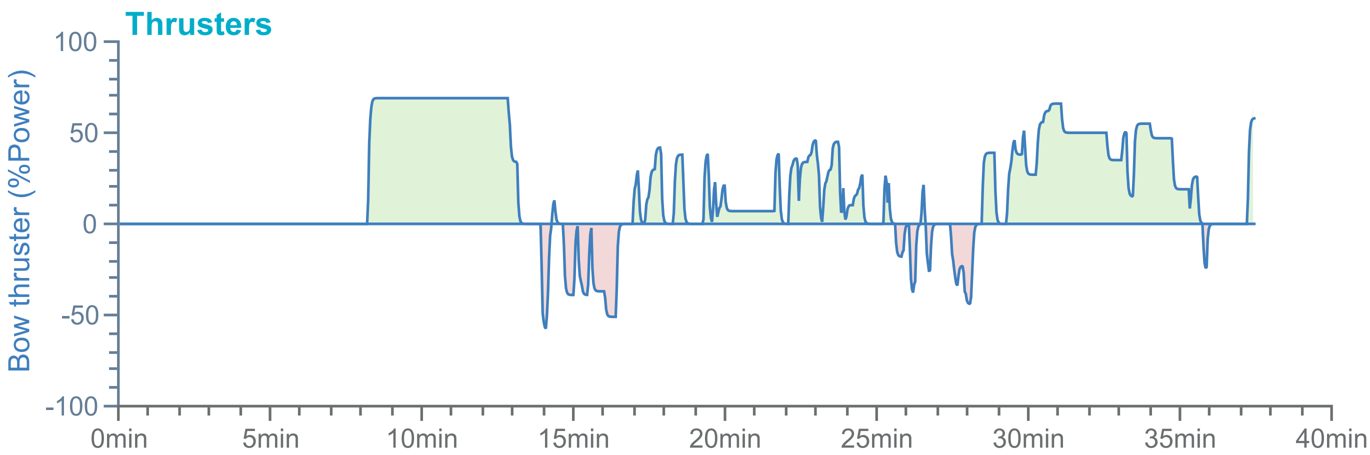

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

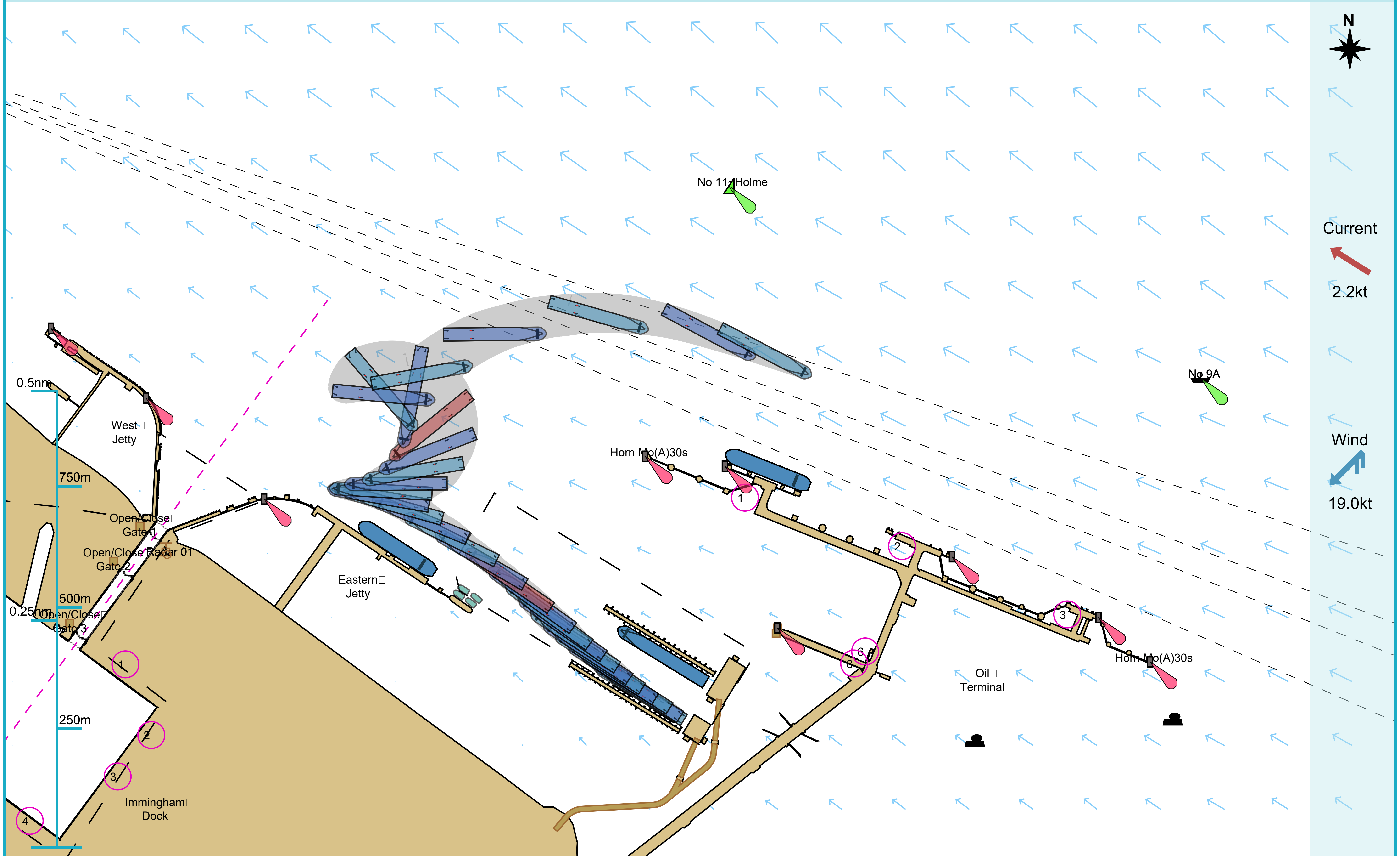

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min
40min

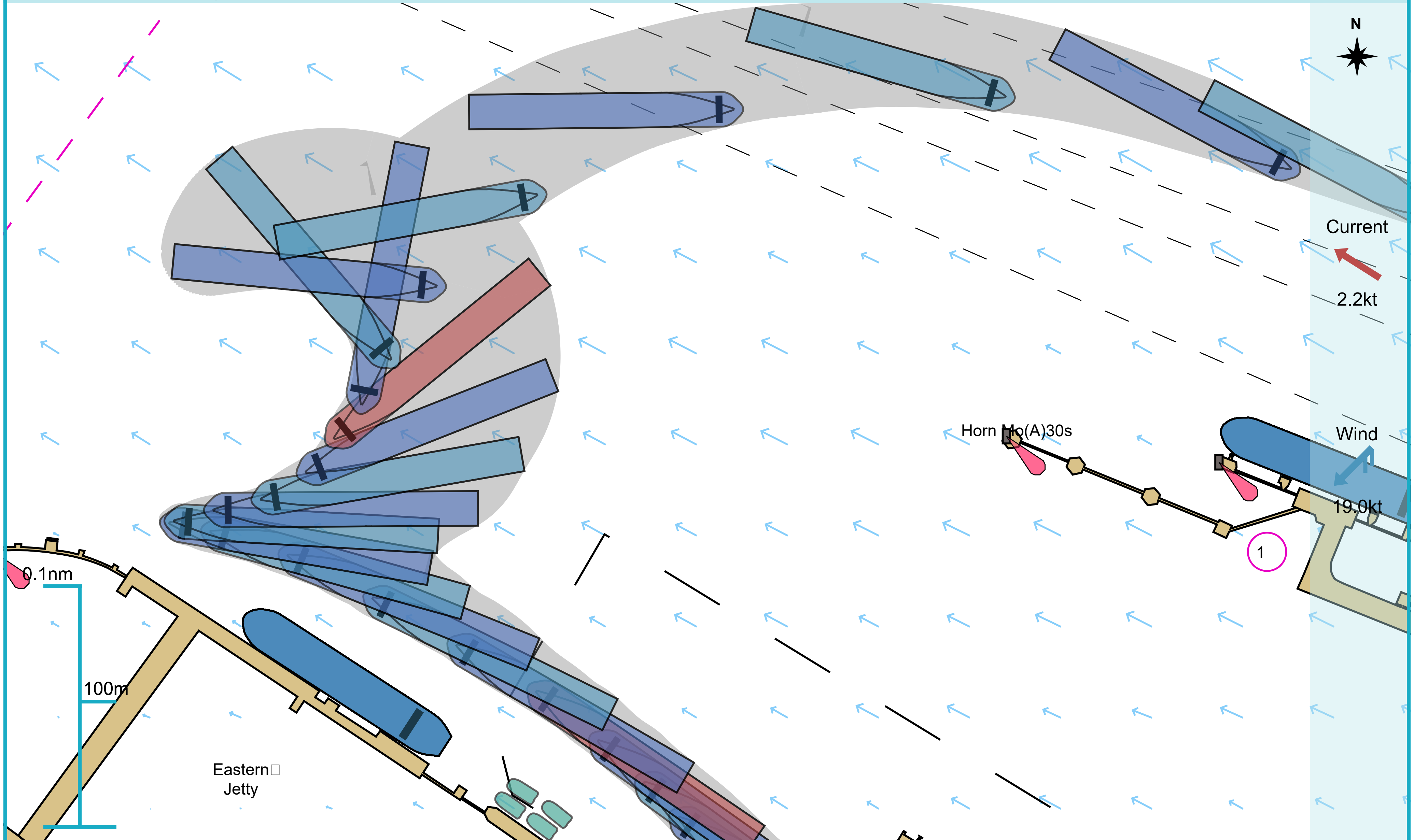

Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

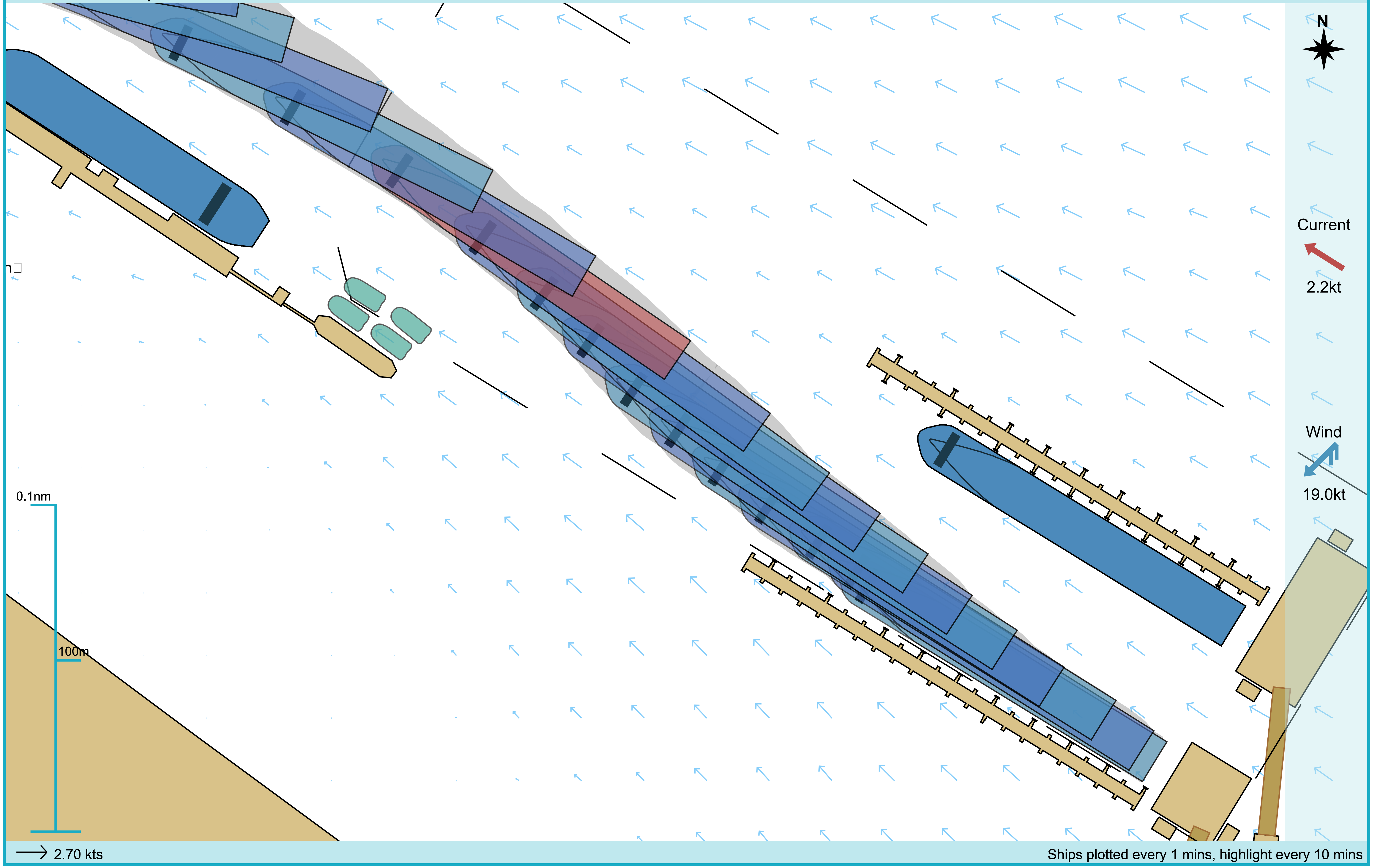
Manoeuvre track plot

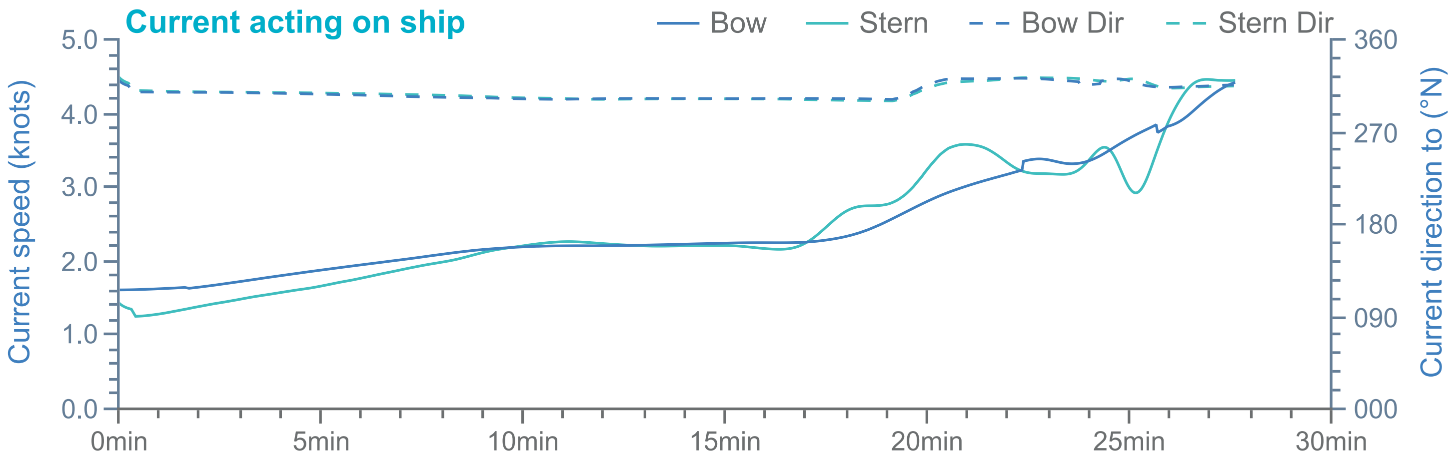


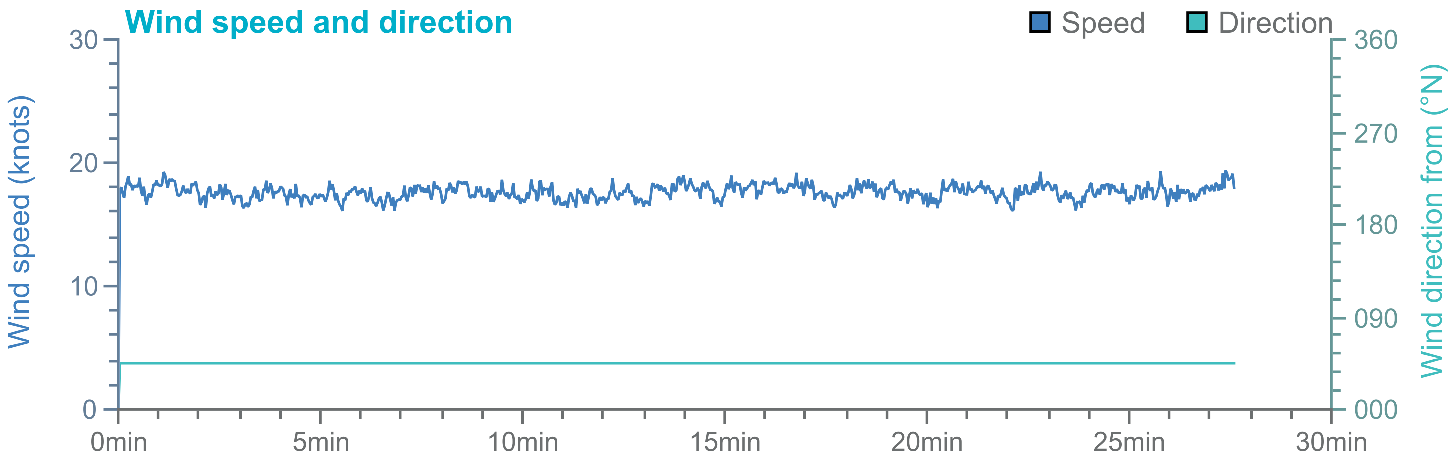
Ships plotted every 1 mins, highlight every 10 mins

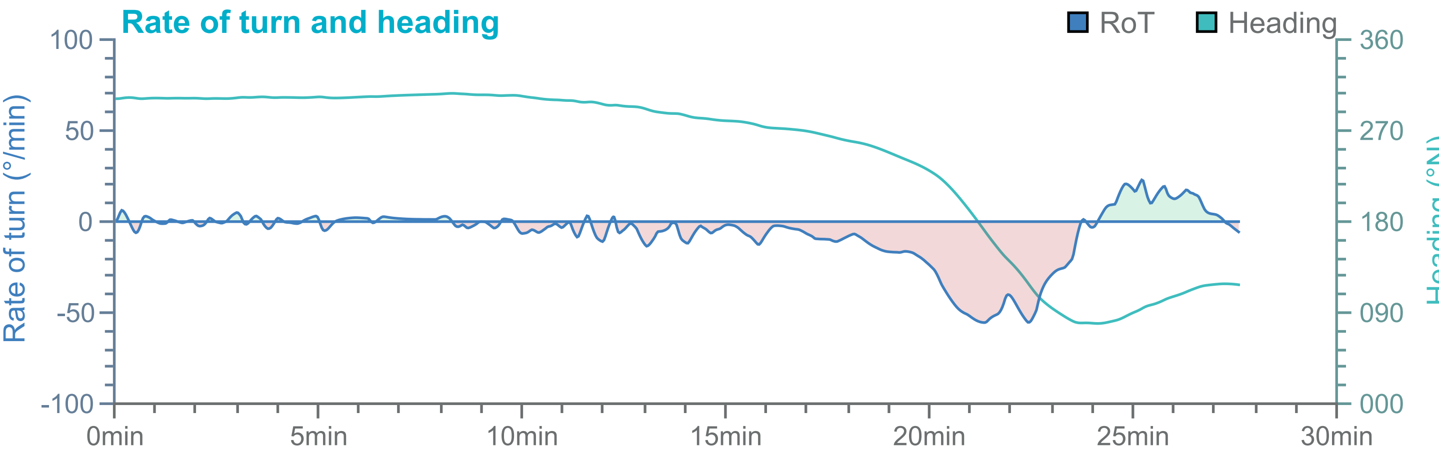
Overview | Environment | Stena Transporter

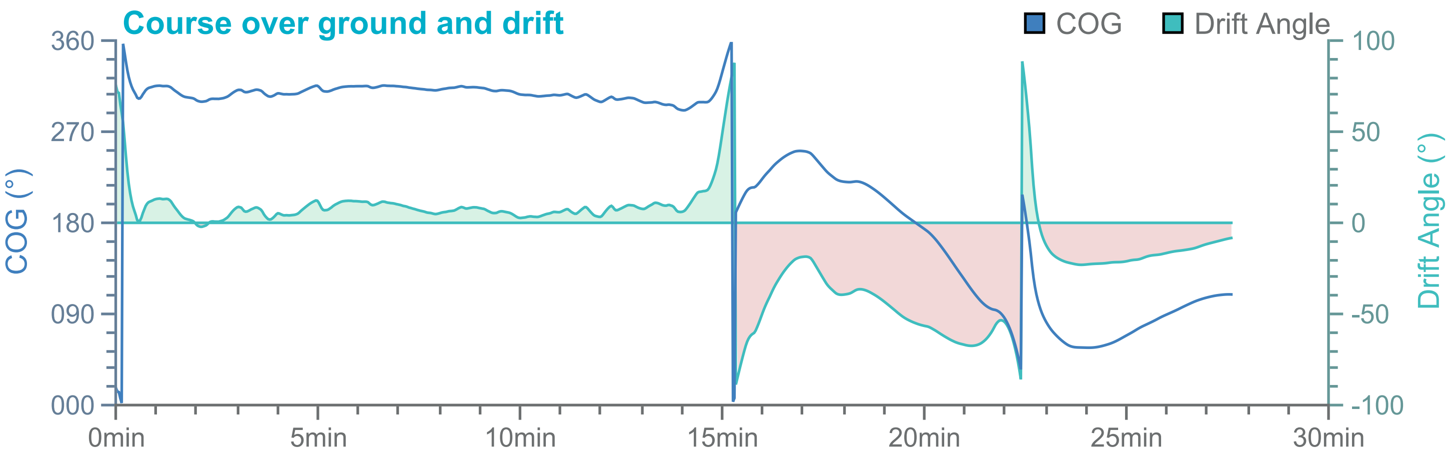
Manoeuvre track plot

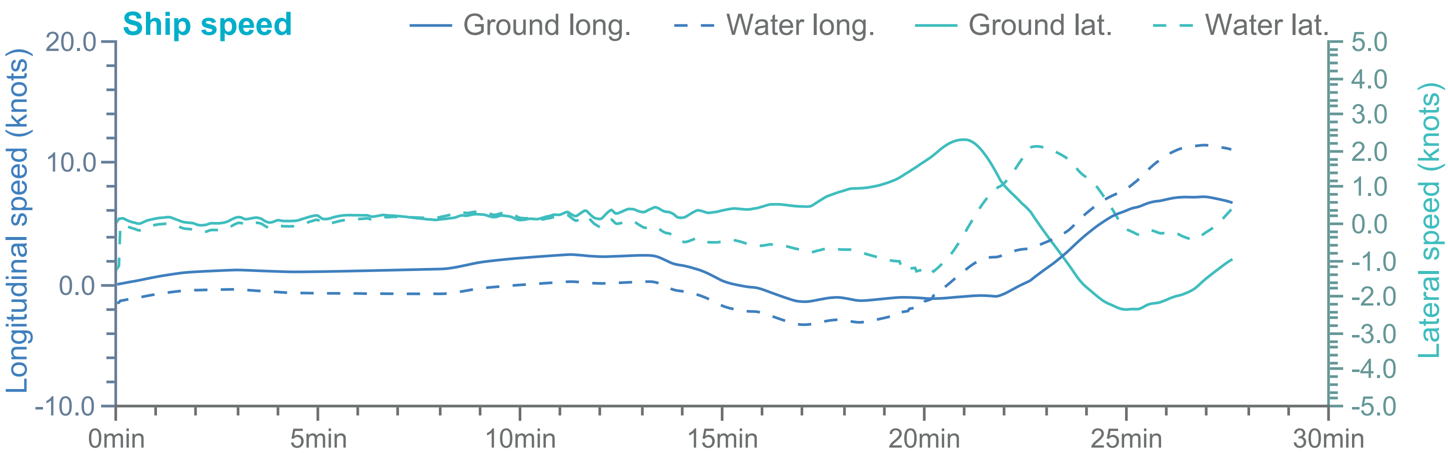


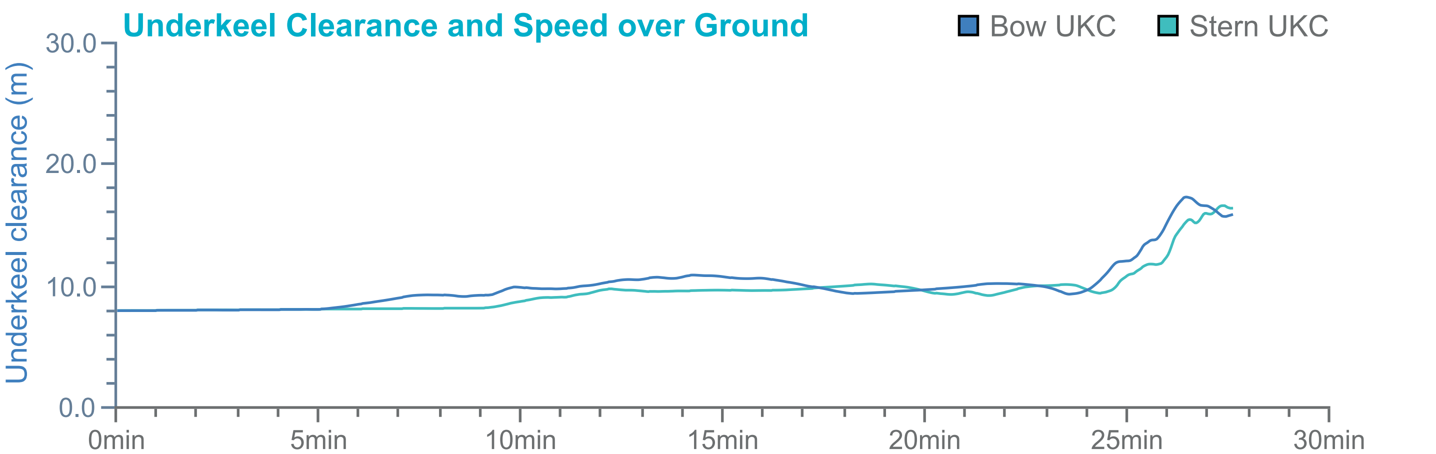

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

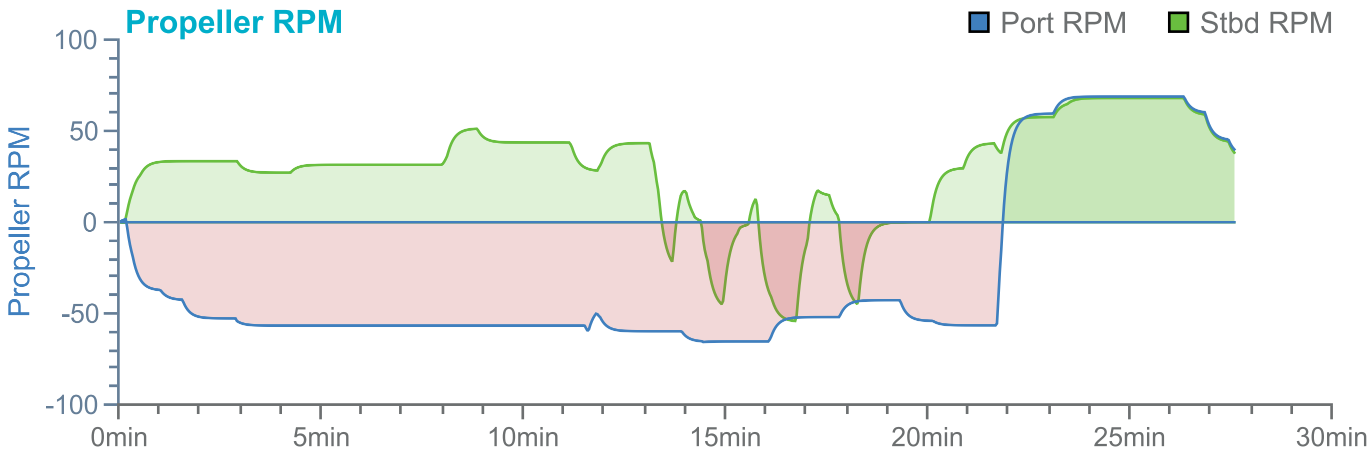

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

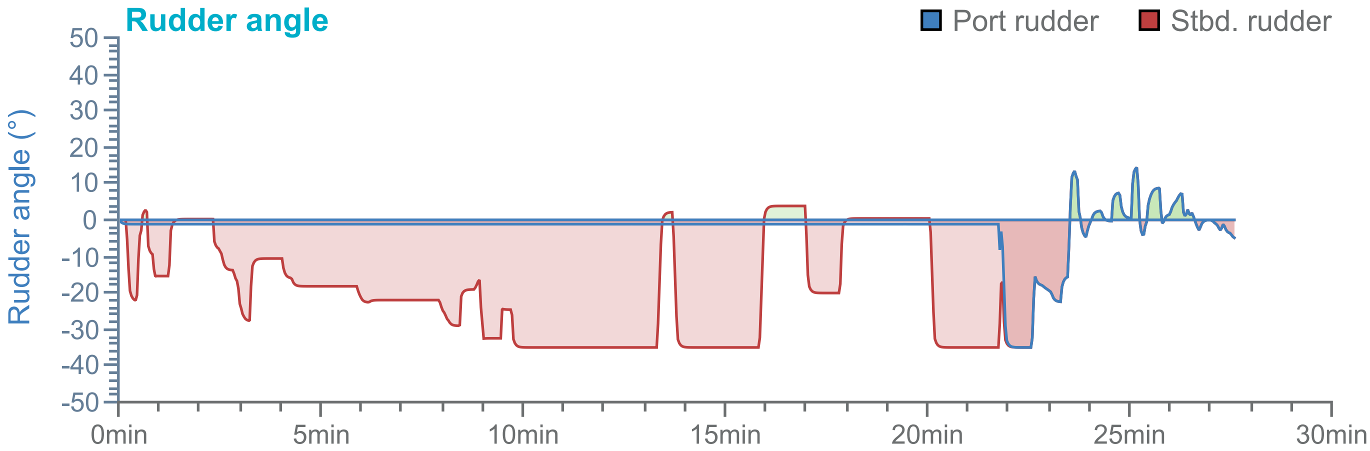

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min


Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min

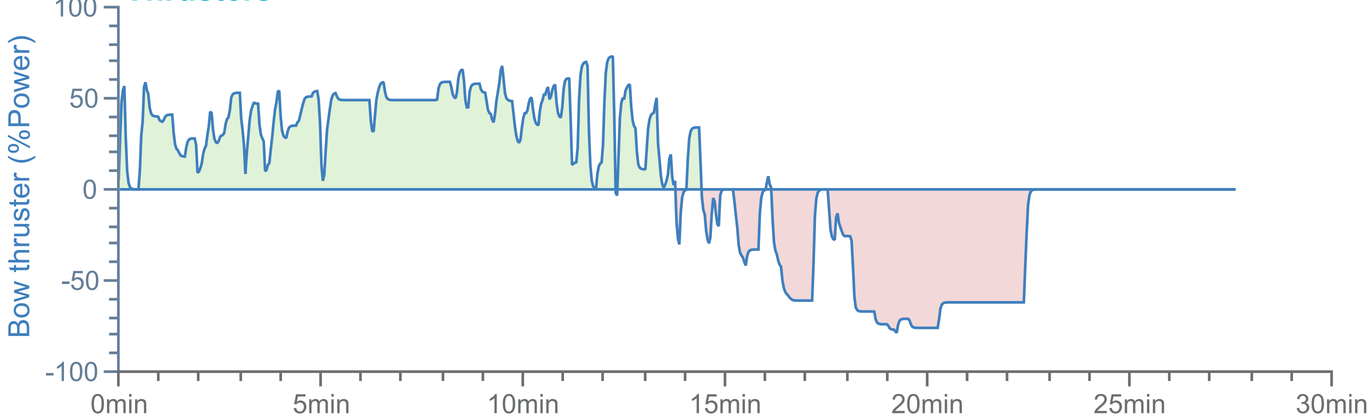
Propeller RPM



Rudder angle

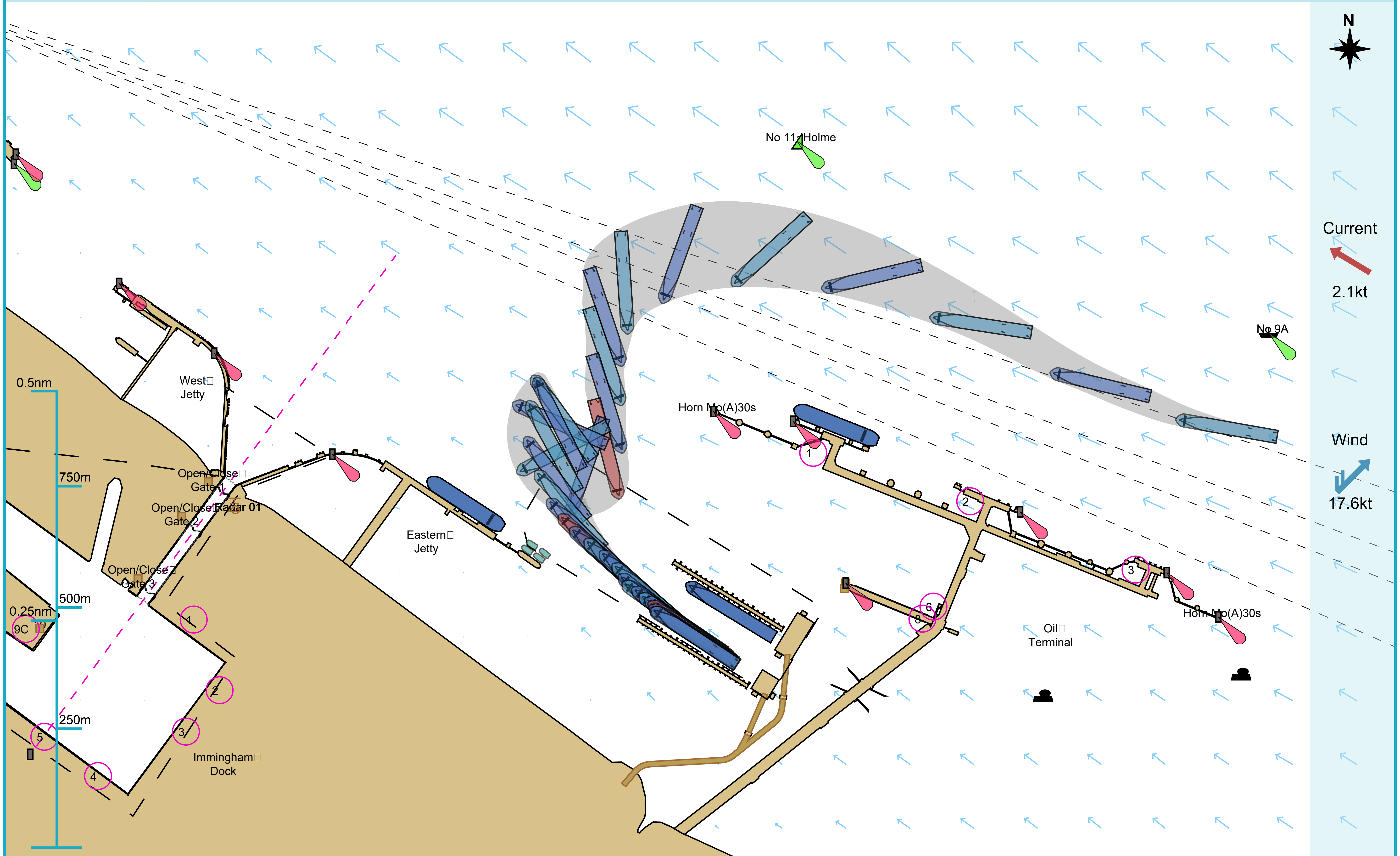


Thrusters



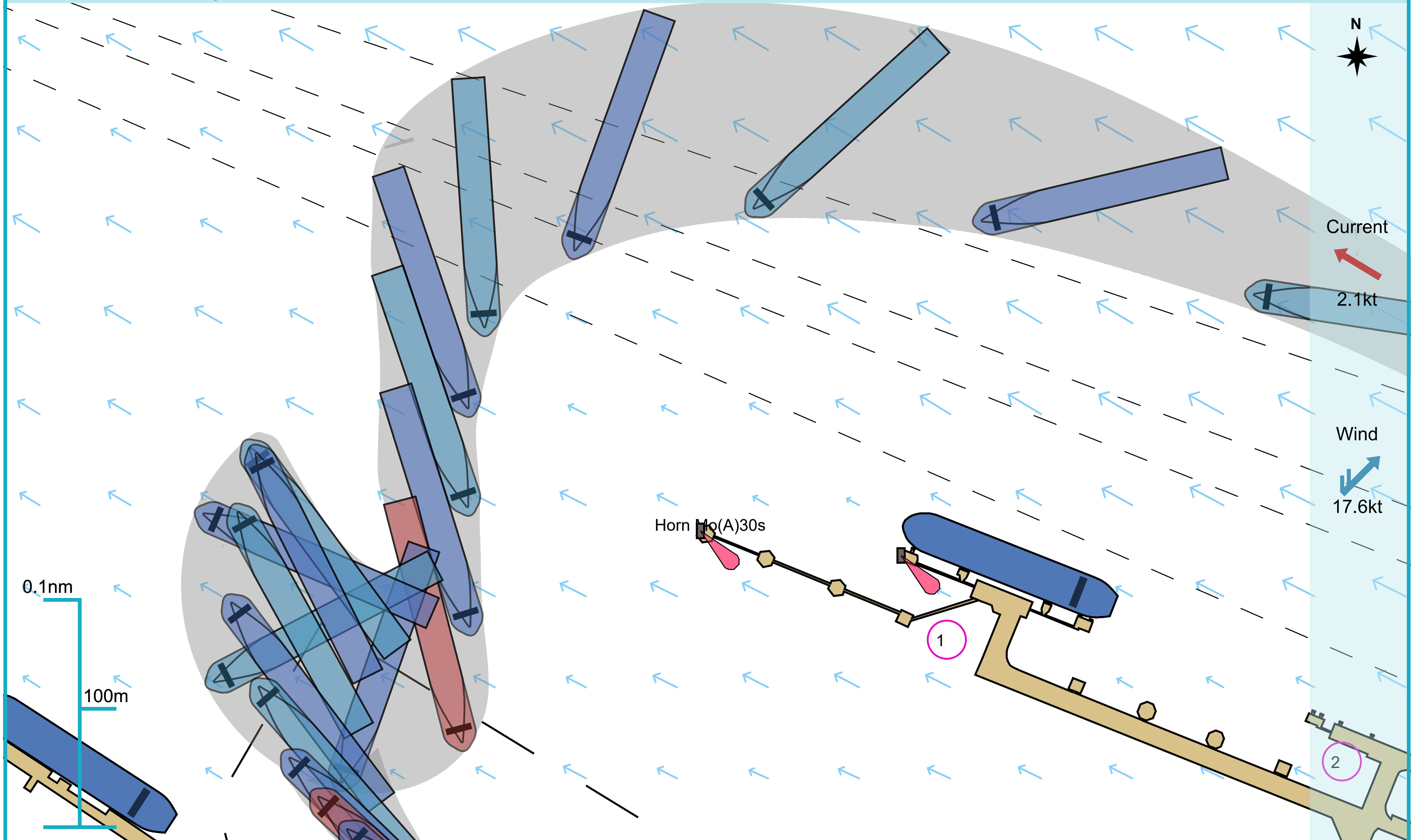
Overview | Environment | Stena Transporter

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

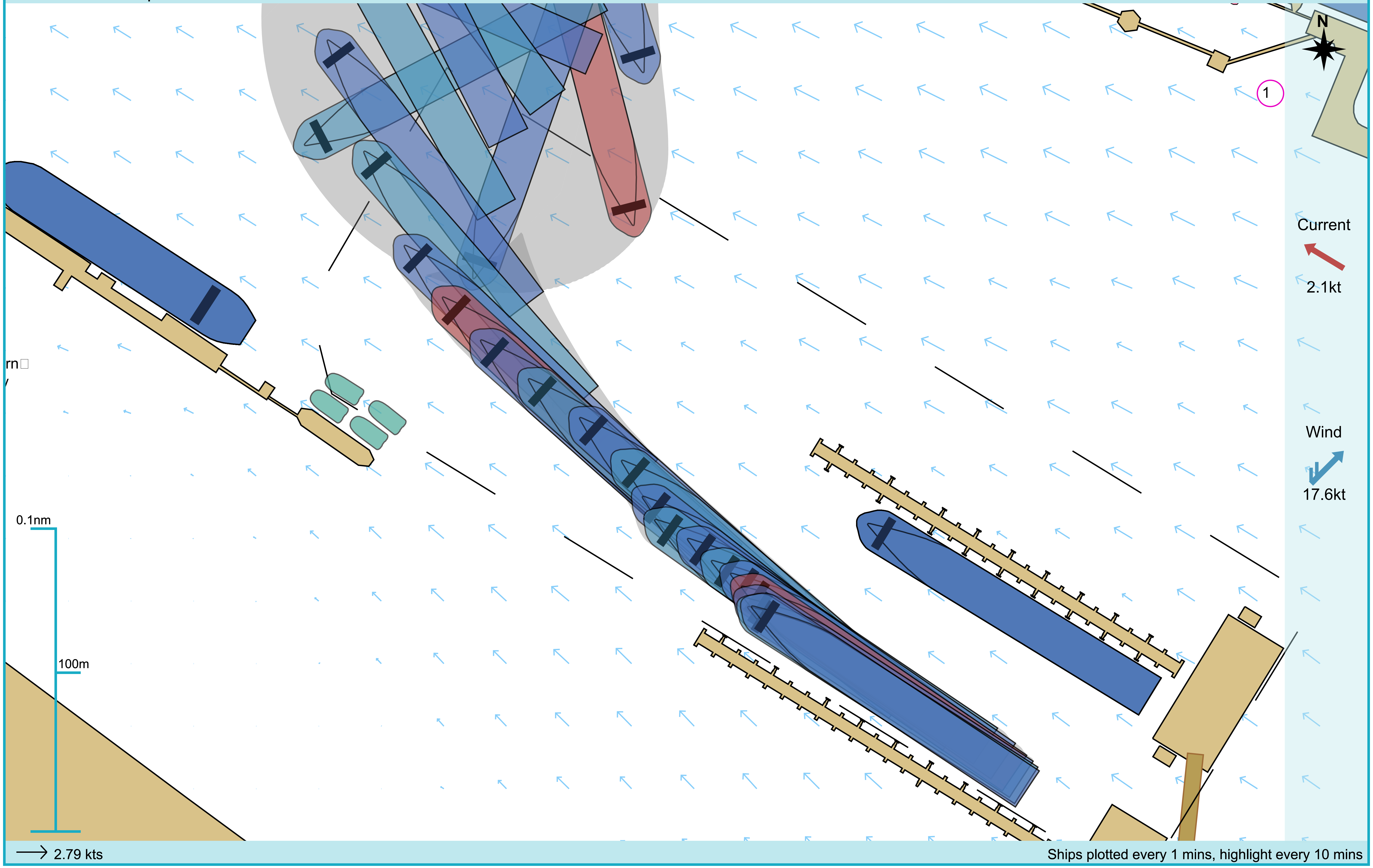
Manoeuvre track plot

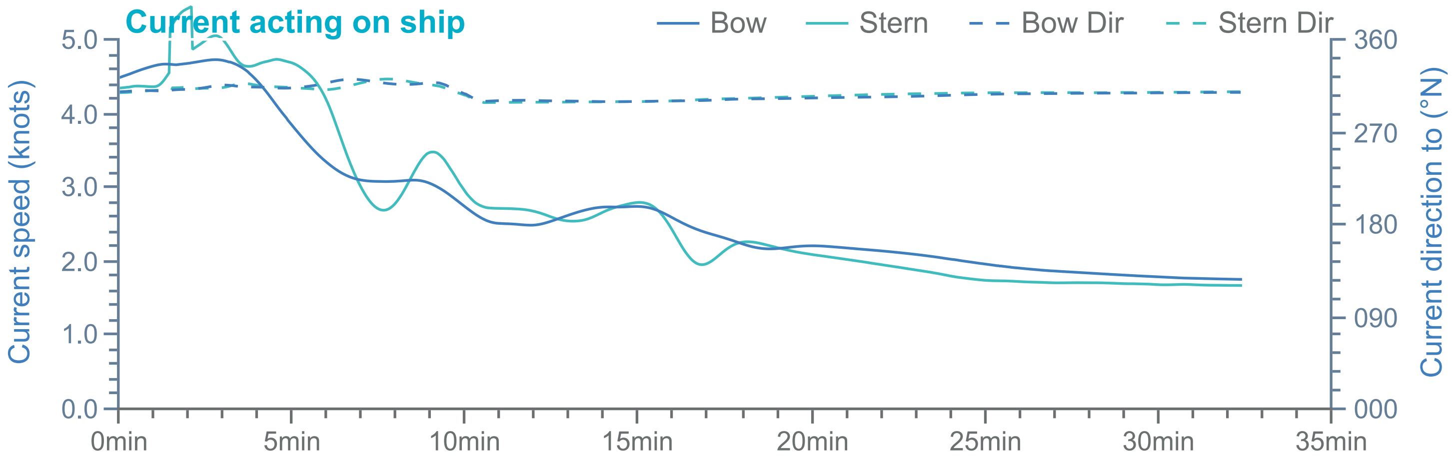


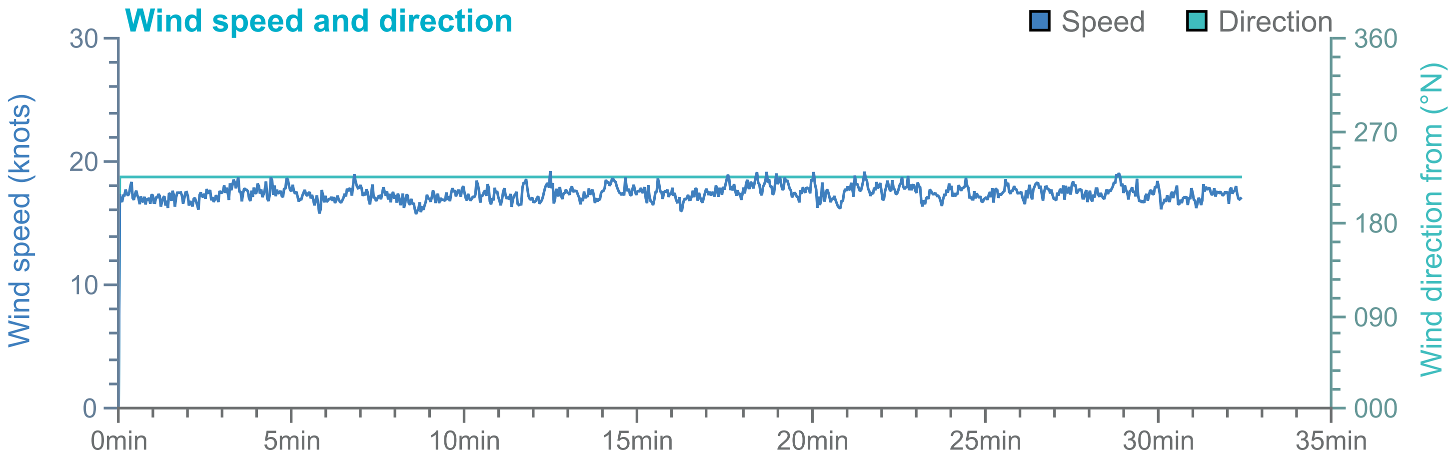
Ships plotted every 1 mins, highlight every 10 mins

Overview | Environment | Stena Transporter

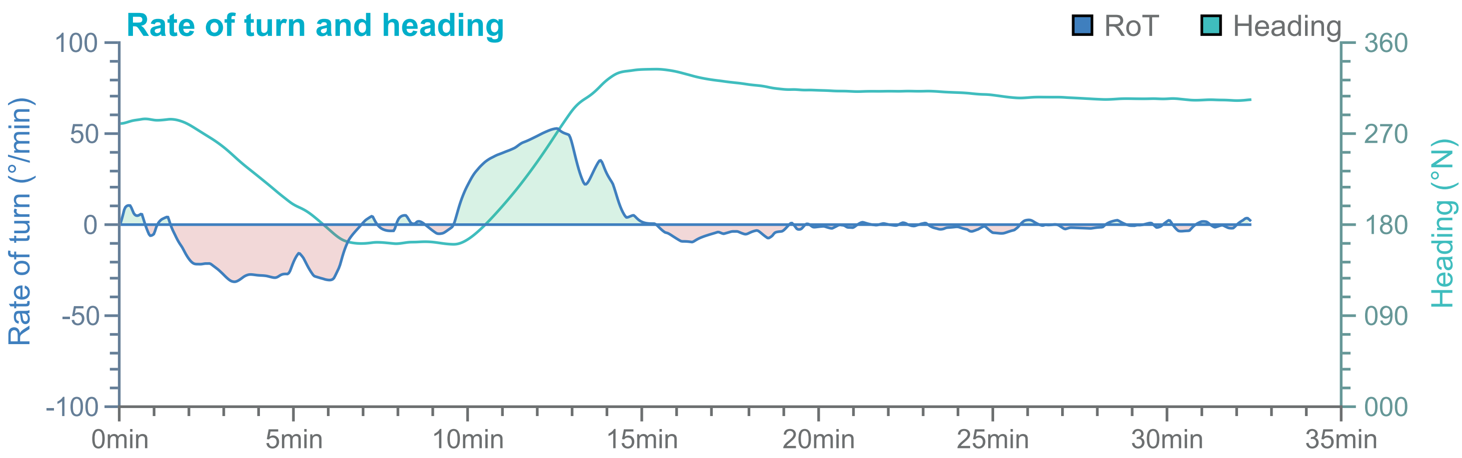
Manoeuvre track plot



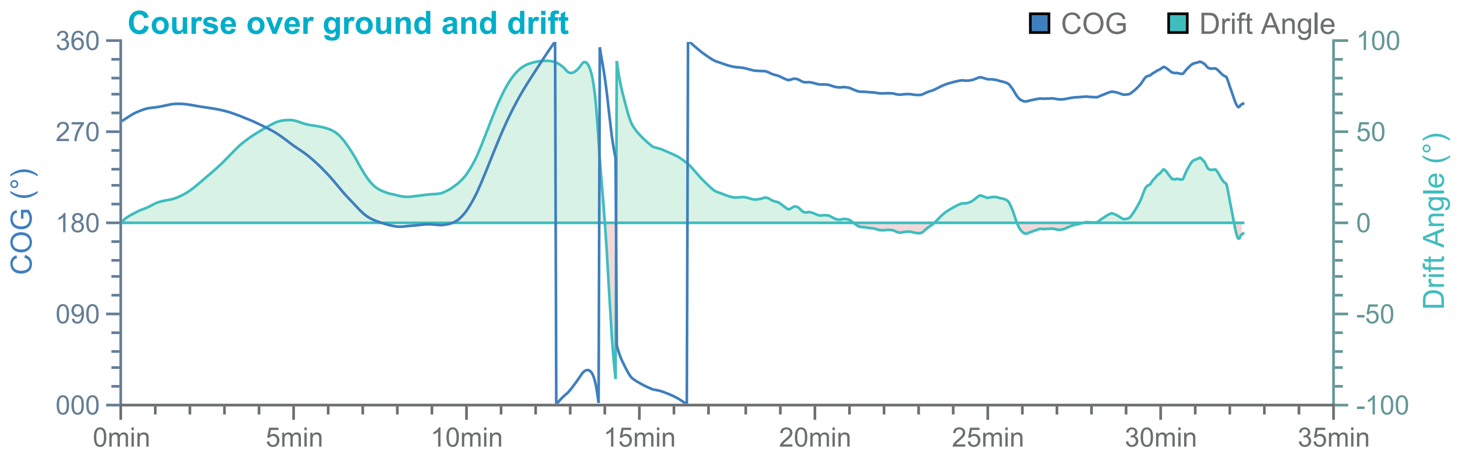

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

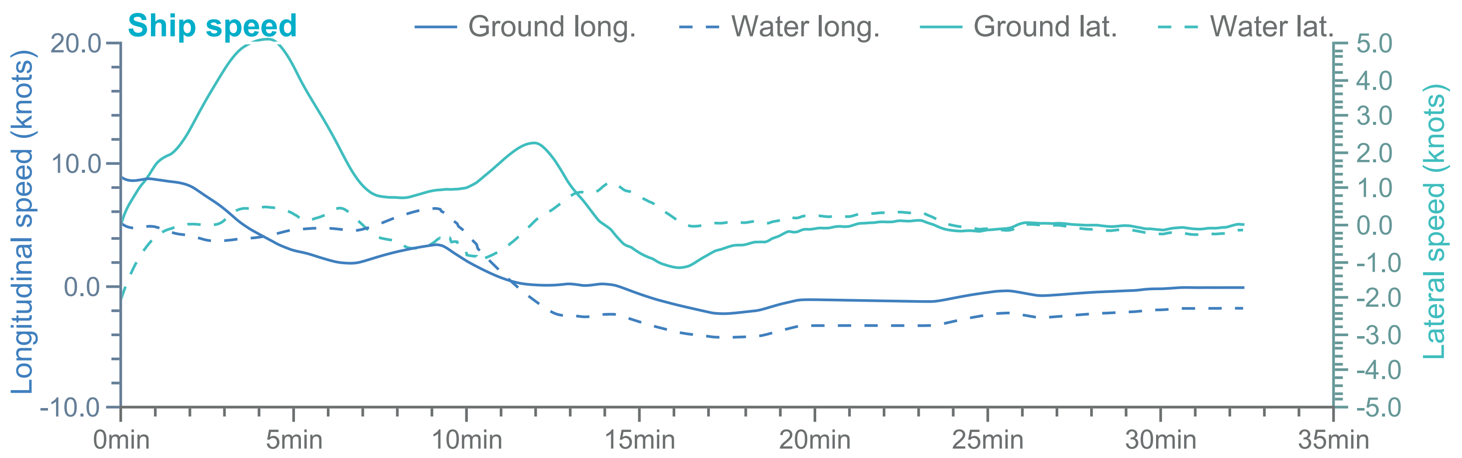
Rate of turn and heading



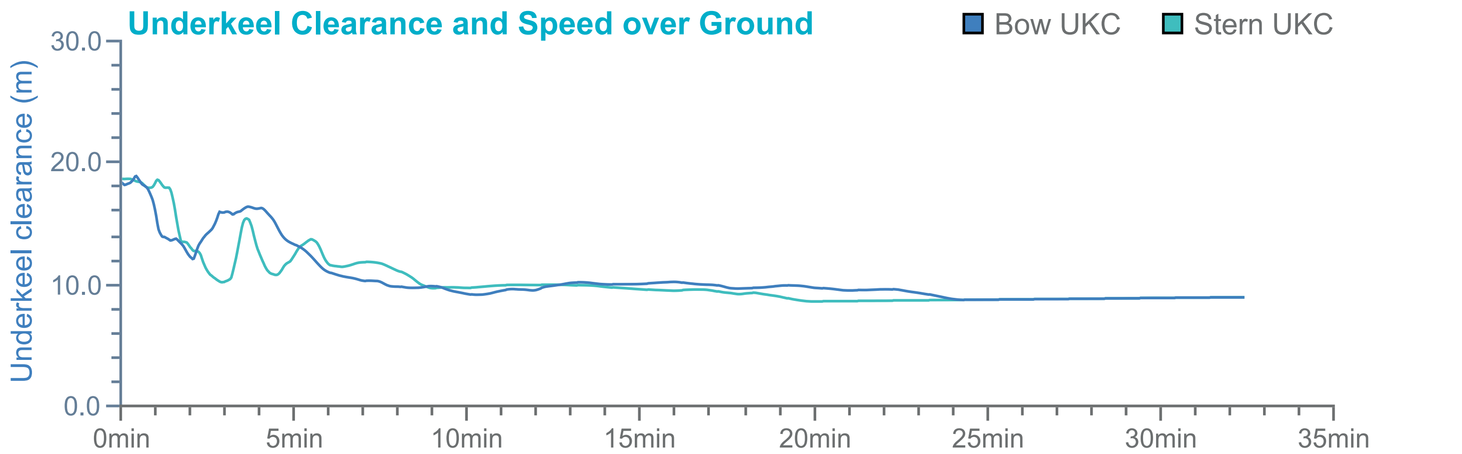
Course over ground and drift



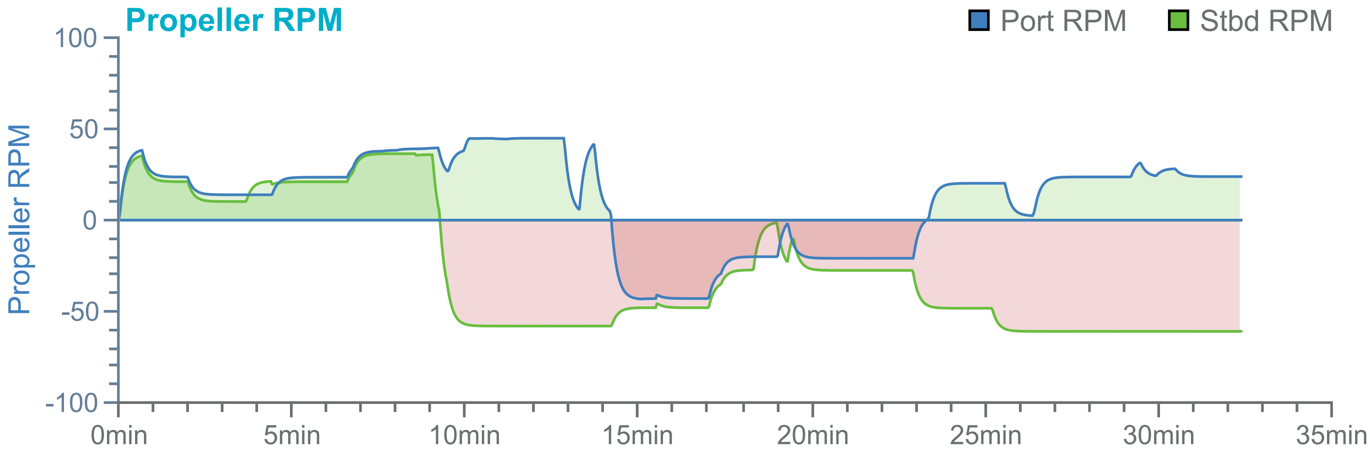
Ship speed

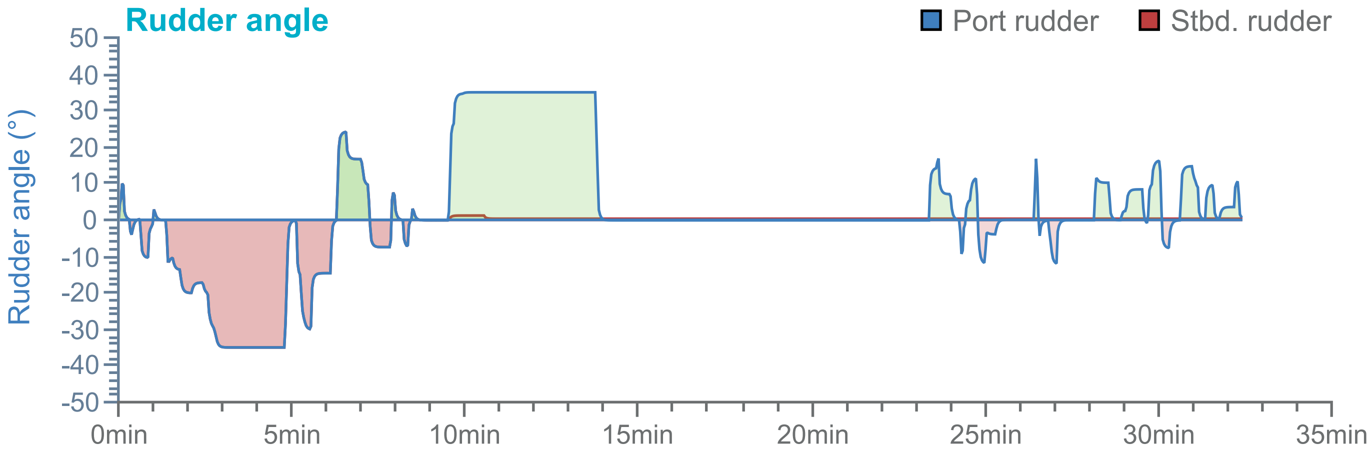


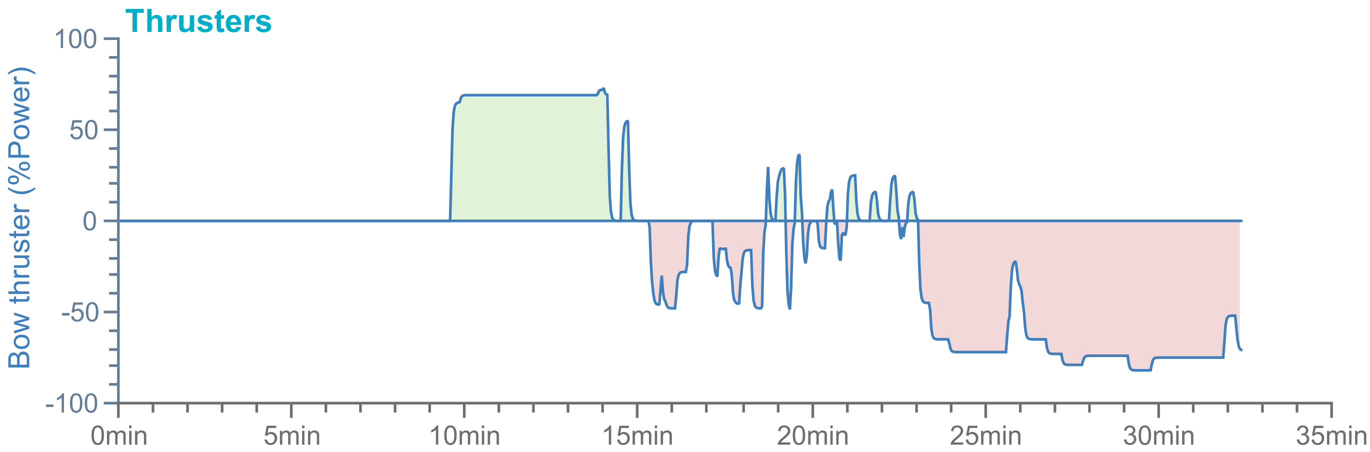
Underkeel Clearance and Speed over Ground



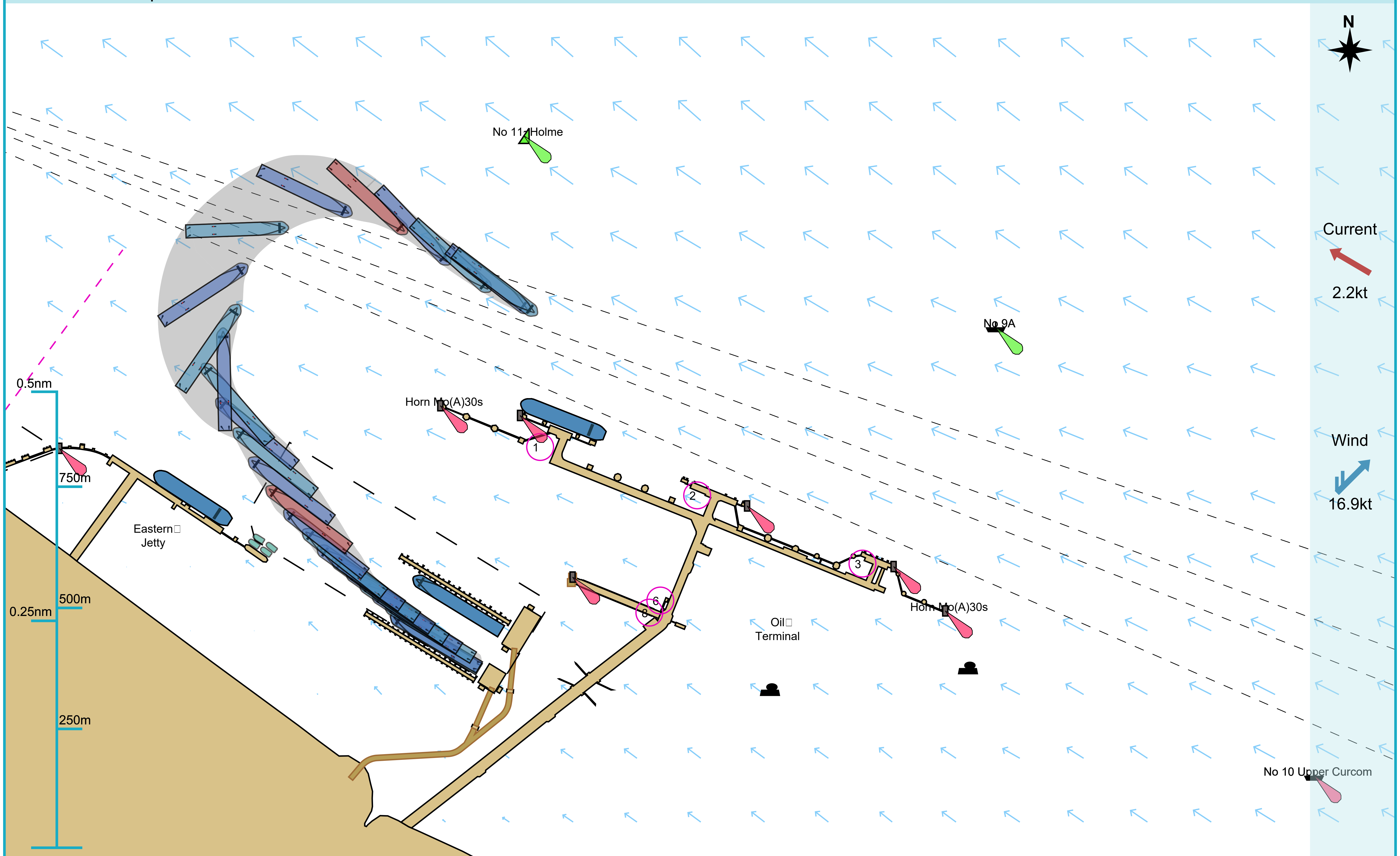
Overview | Environment | Stena Transporter





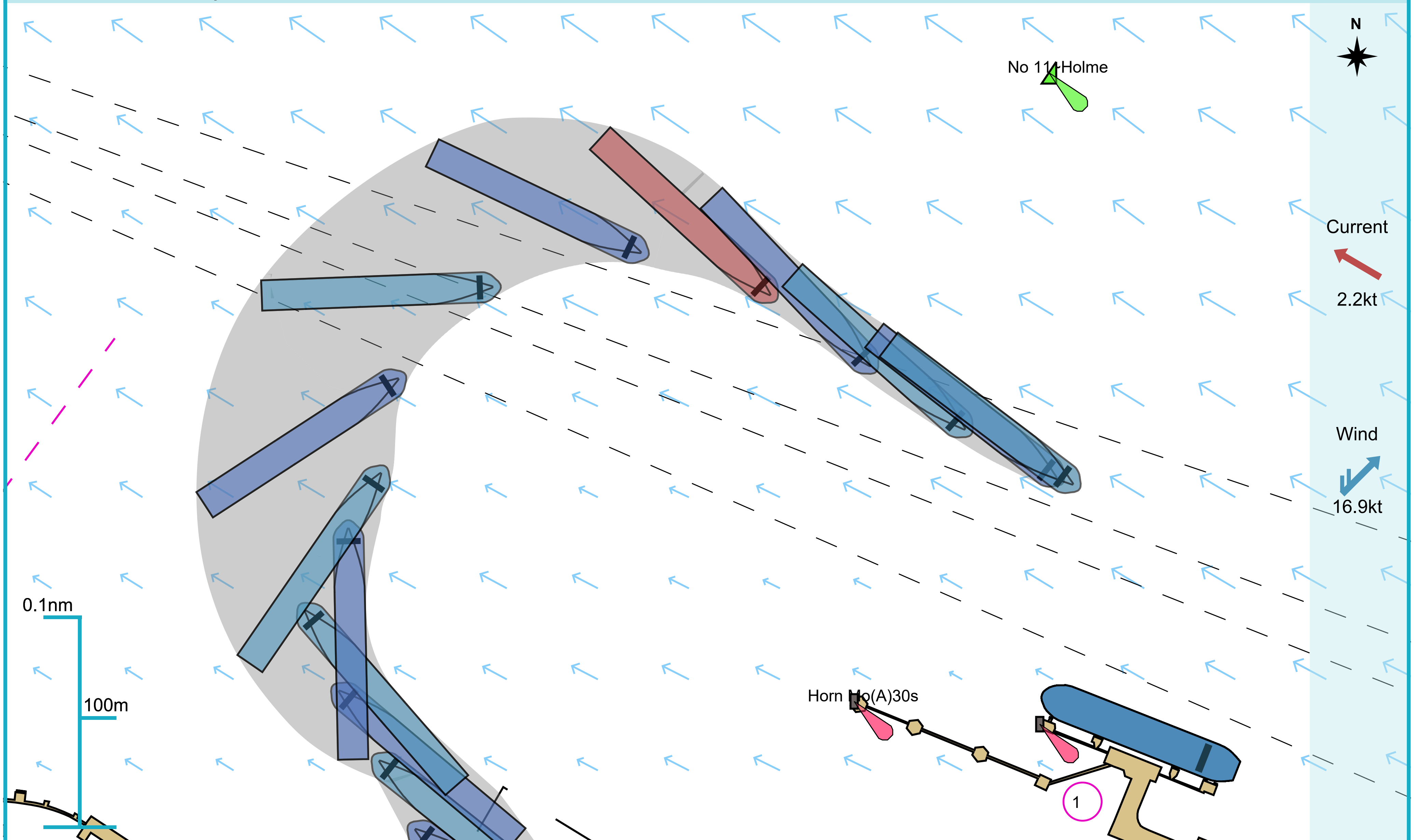


Manoeuvre track plot



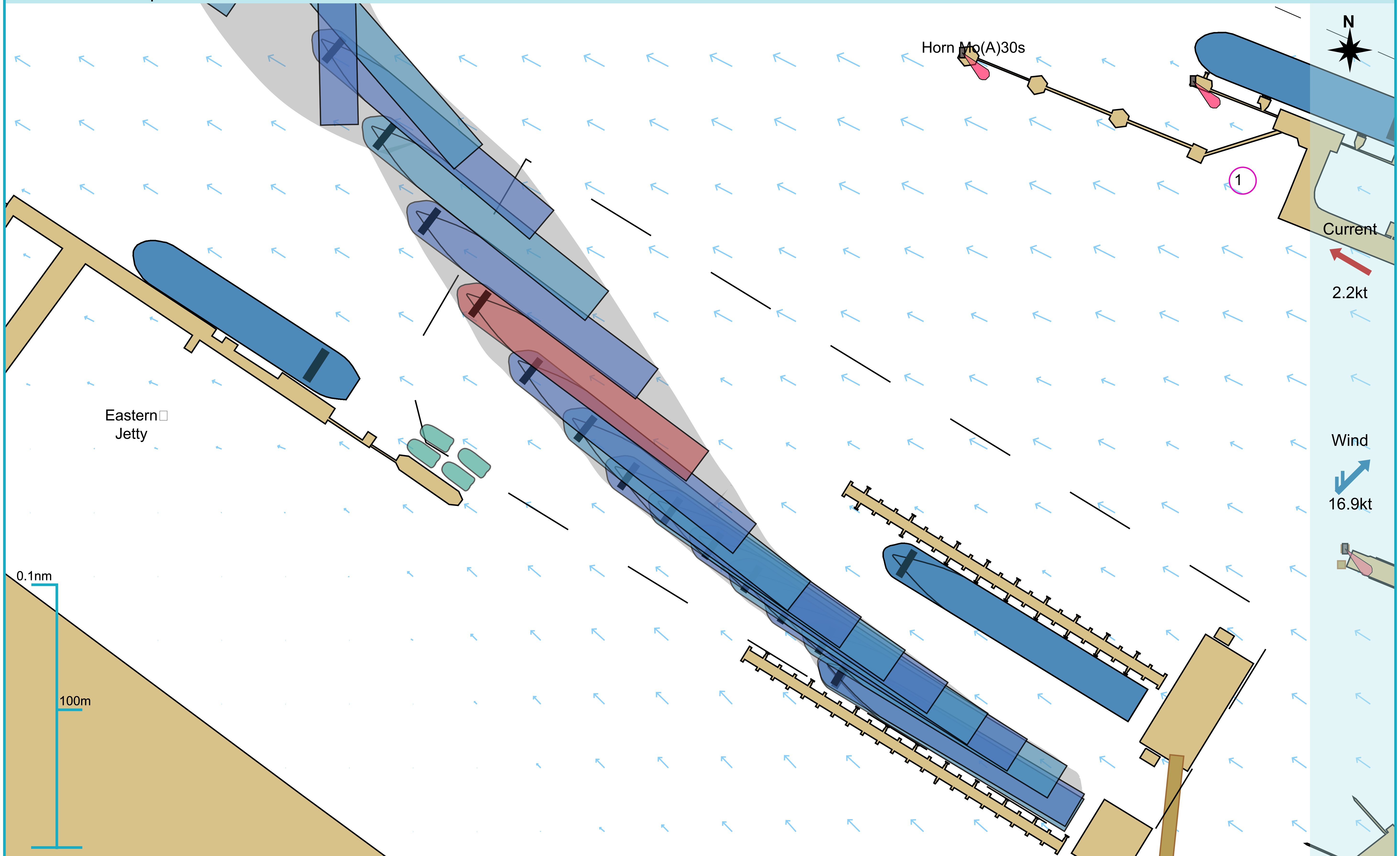
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



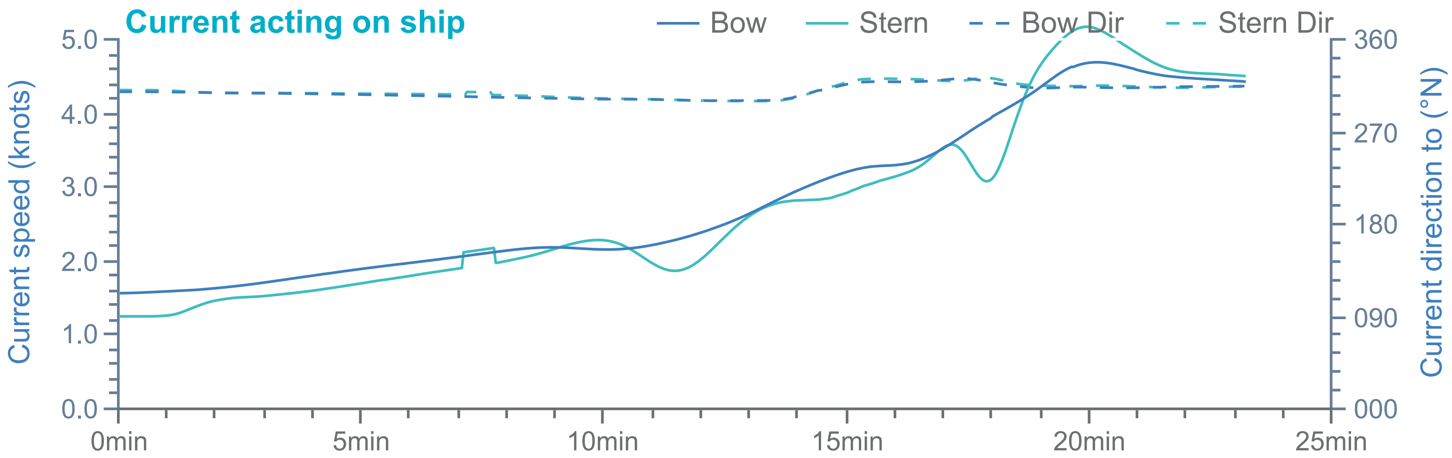
Ships plotted every 1 mins, highlight every 10 mins

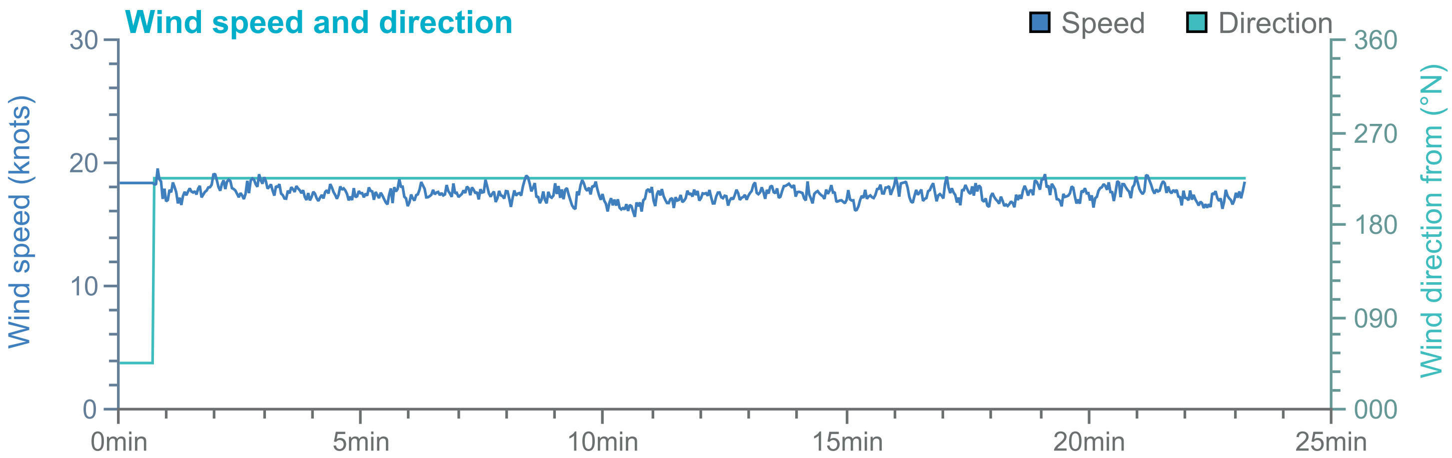
Manoeuvre track plot

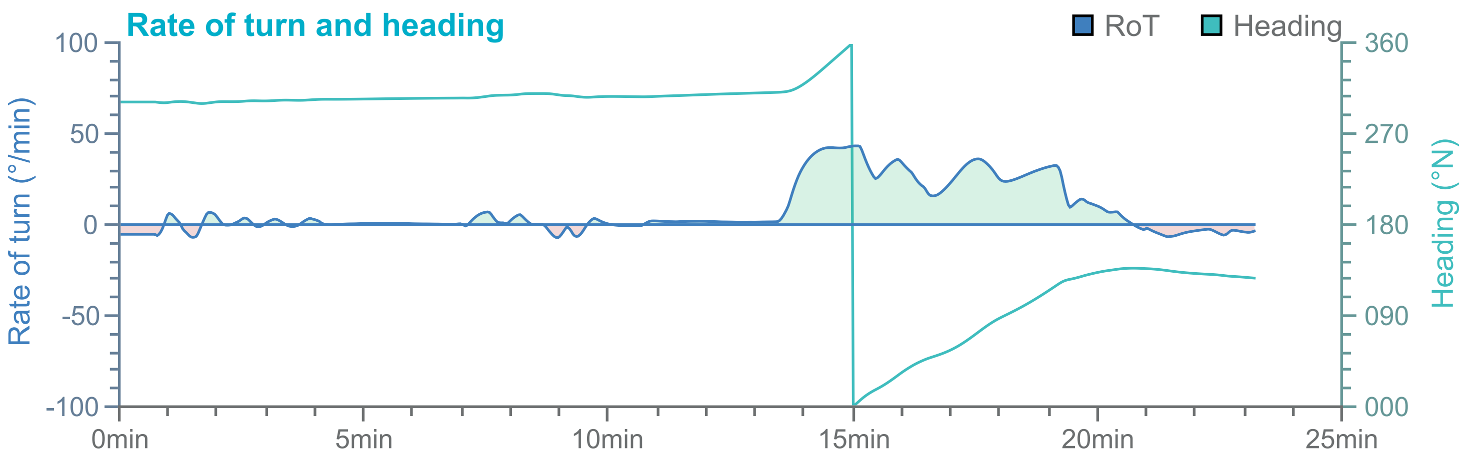


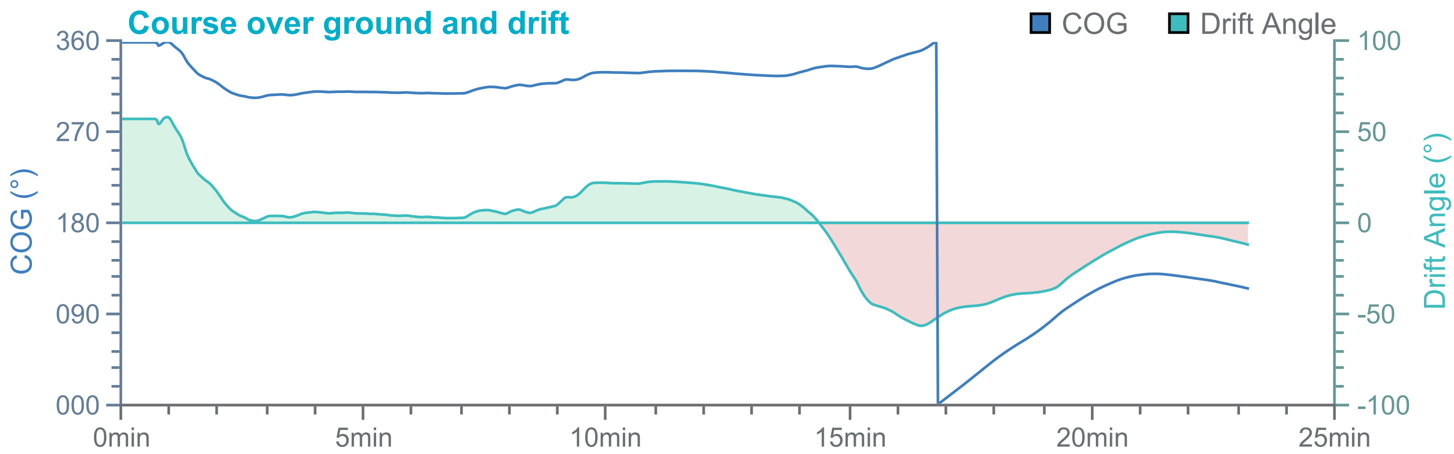
3.50 kts

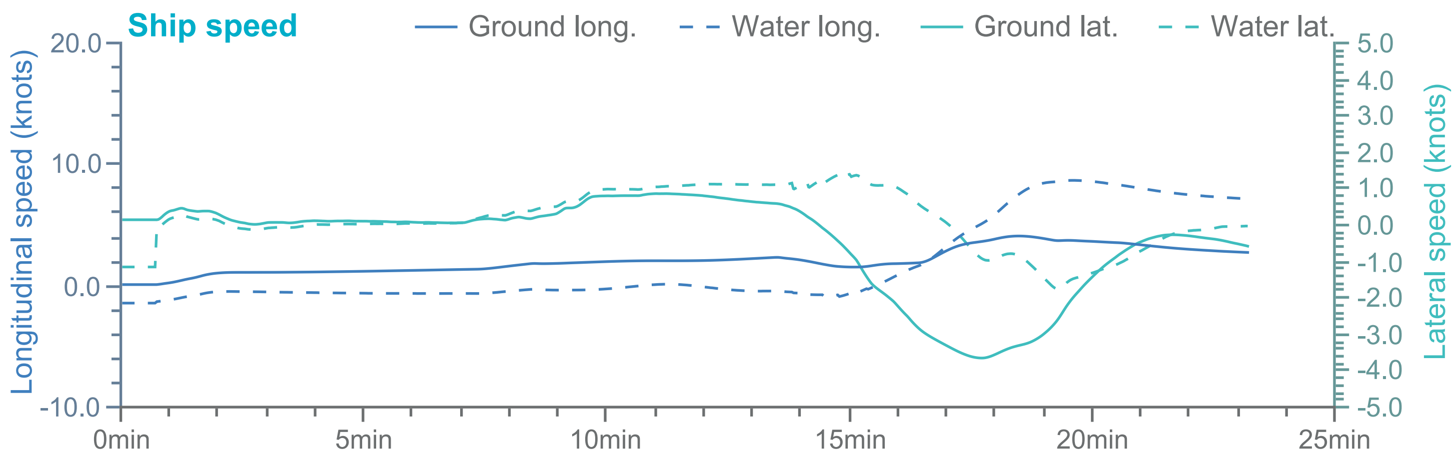
Ships plotted every 1 mins, highlight every 10 mins

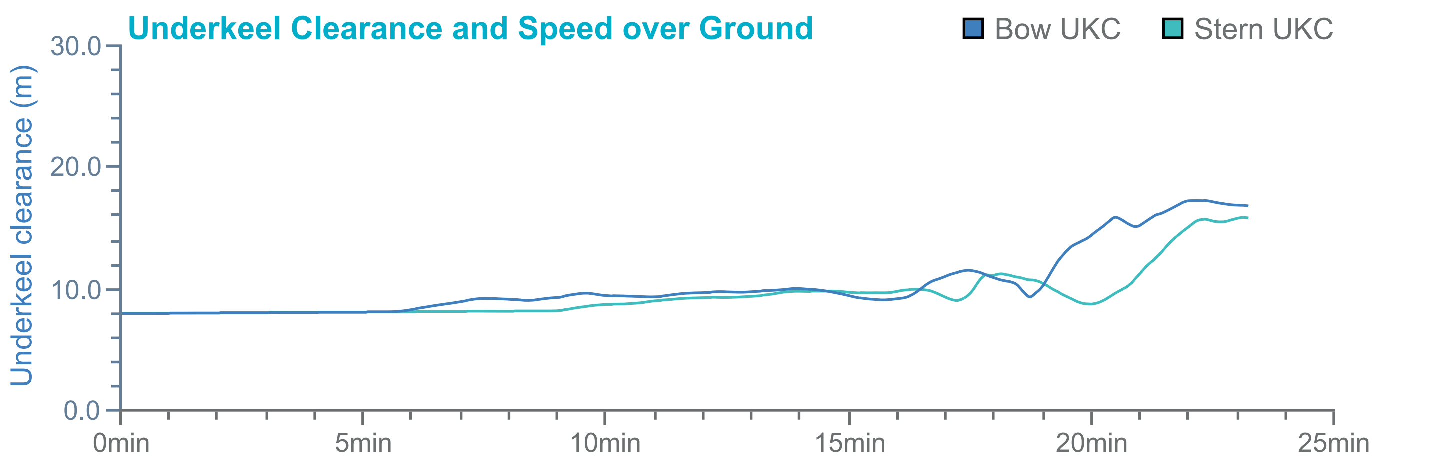

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

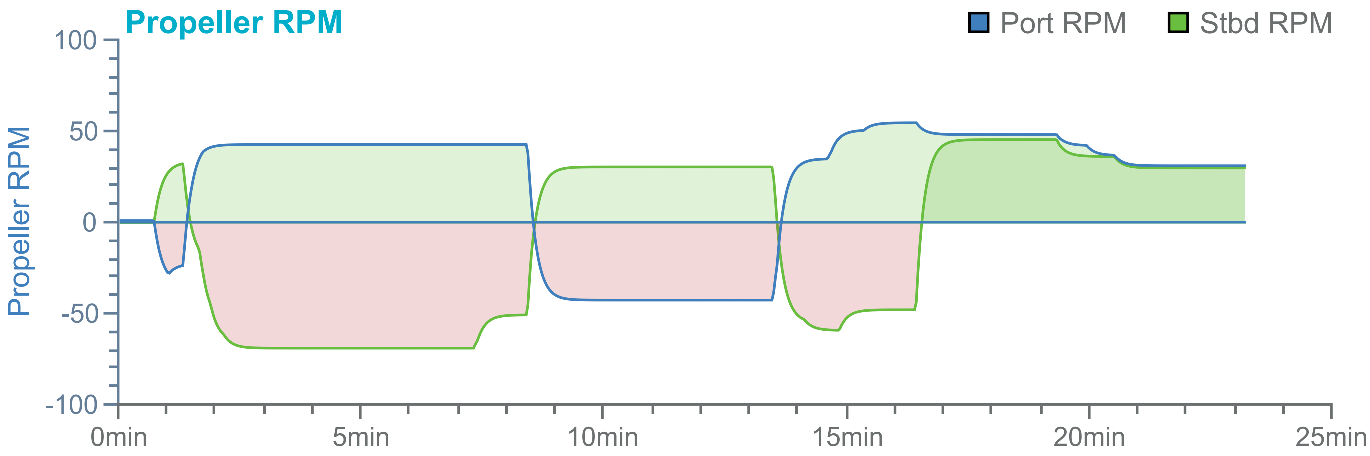

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

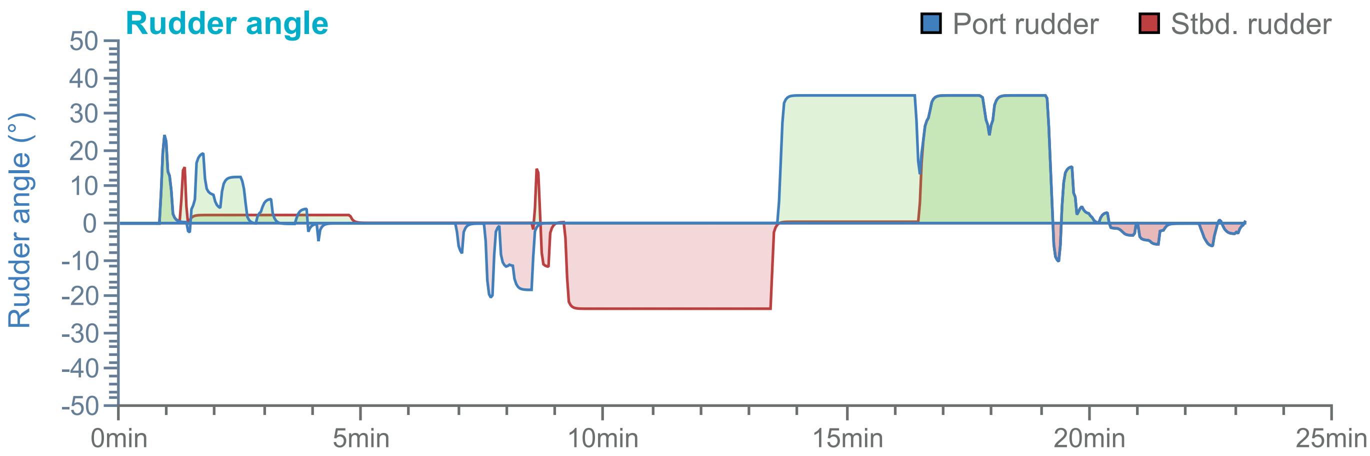

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min

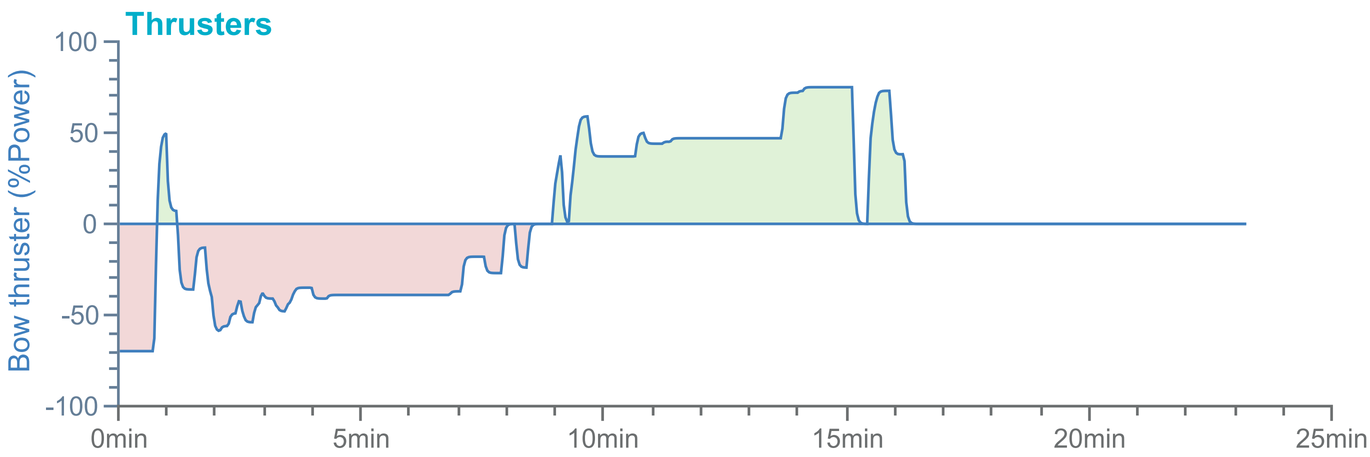

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min

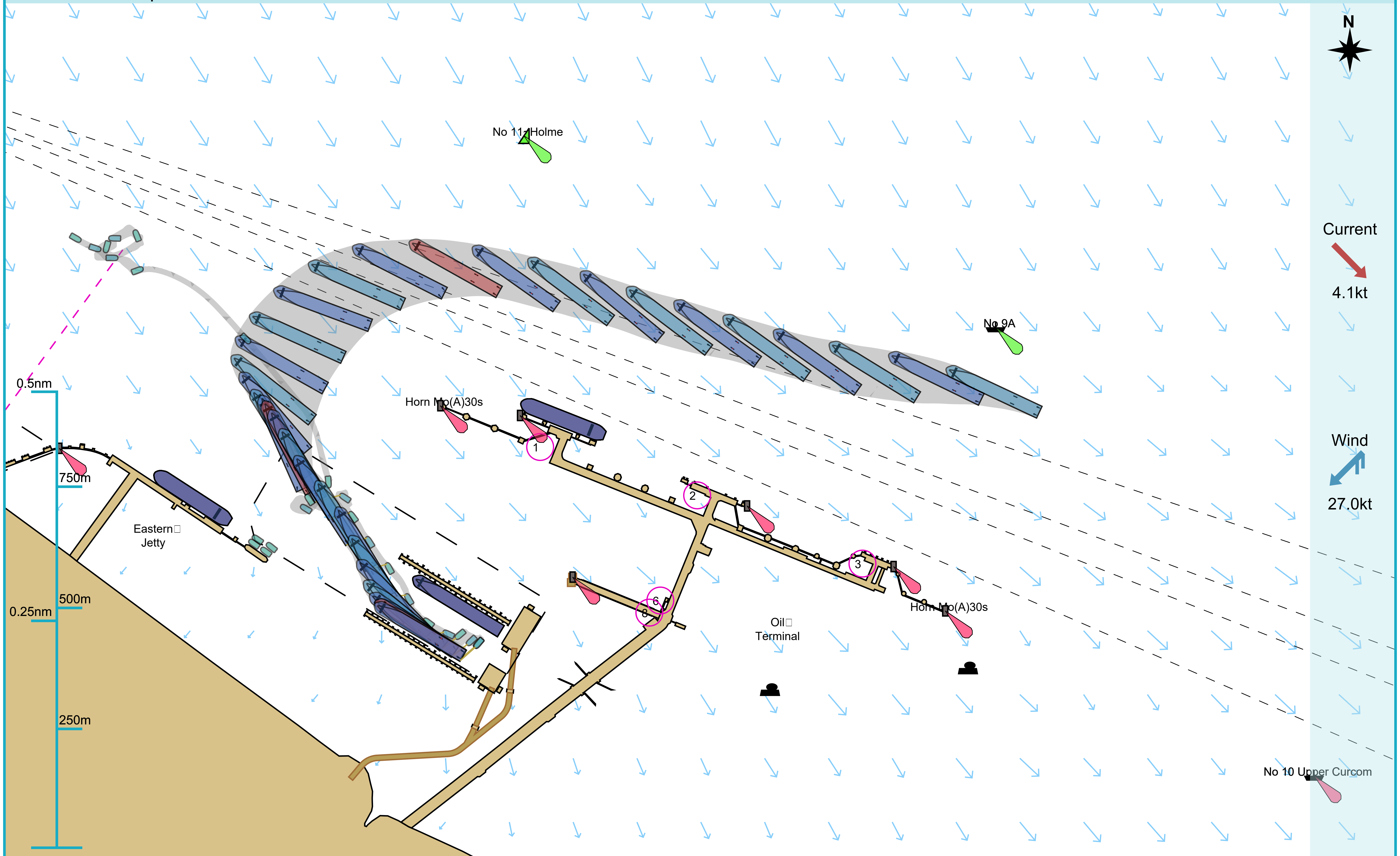

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min

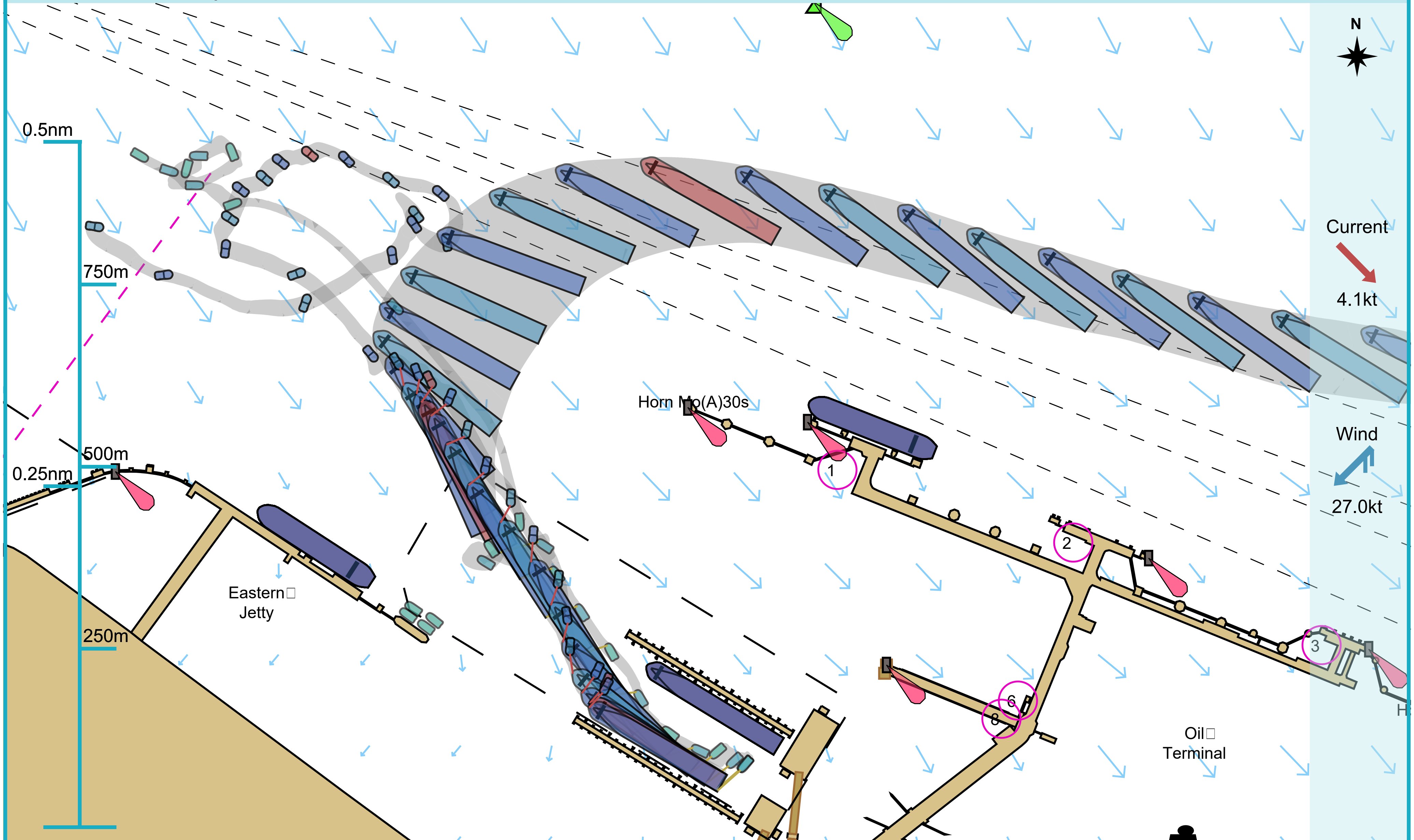

Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min

Manoeuvre track plot



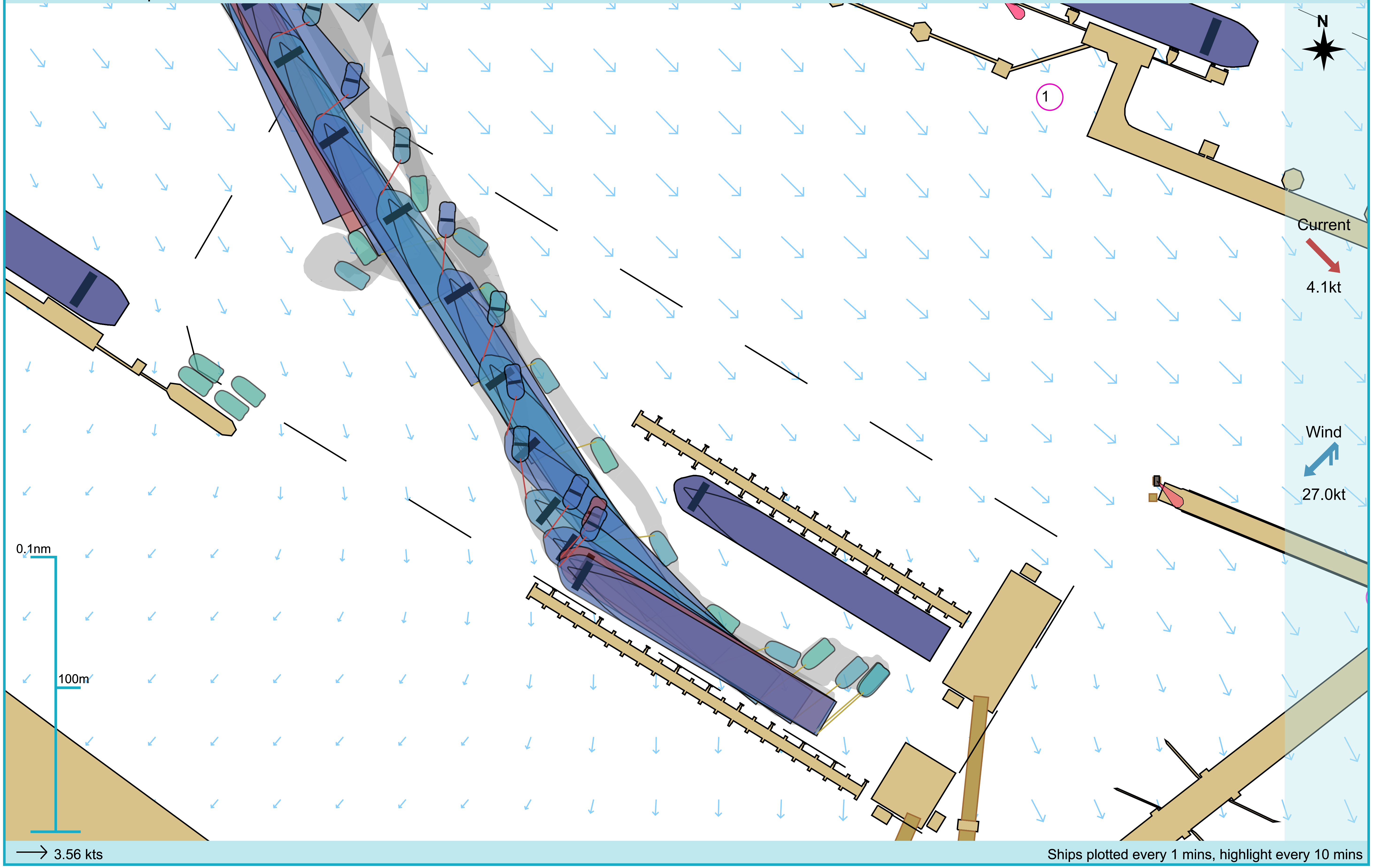
Ships plotted every 1 mins, highlight every 10 mins

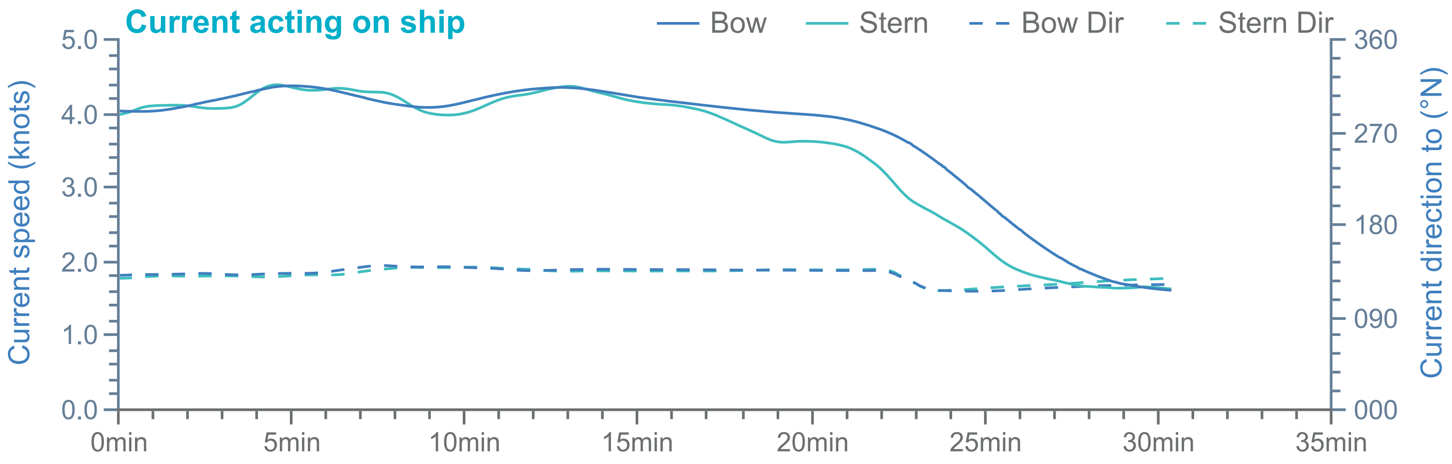
Manoeuvre track plot

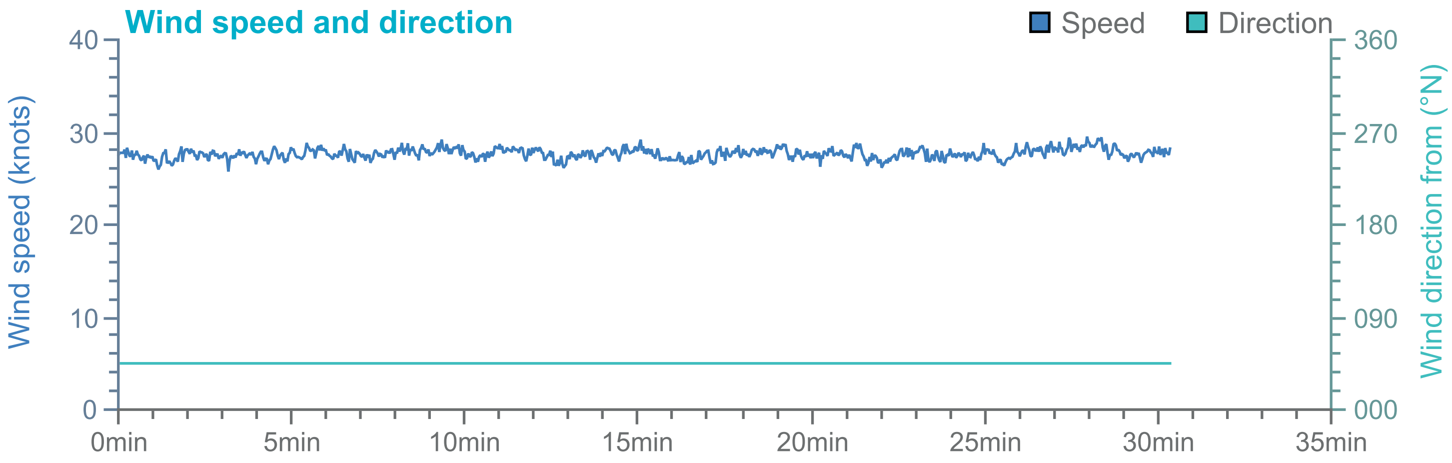


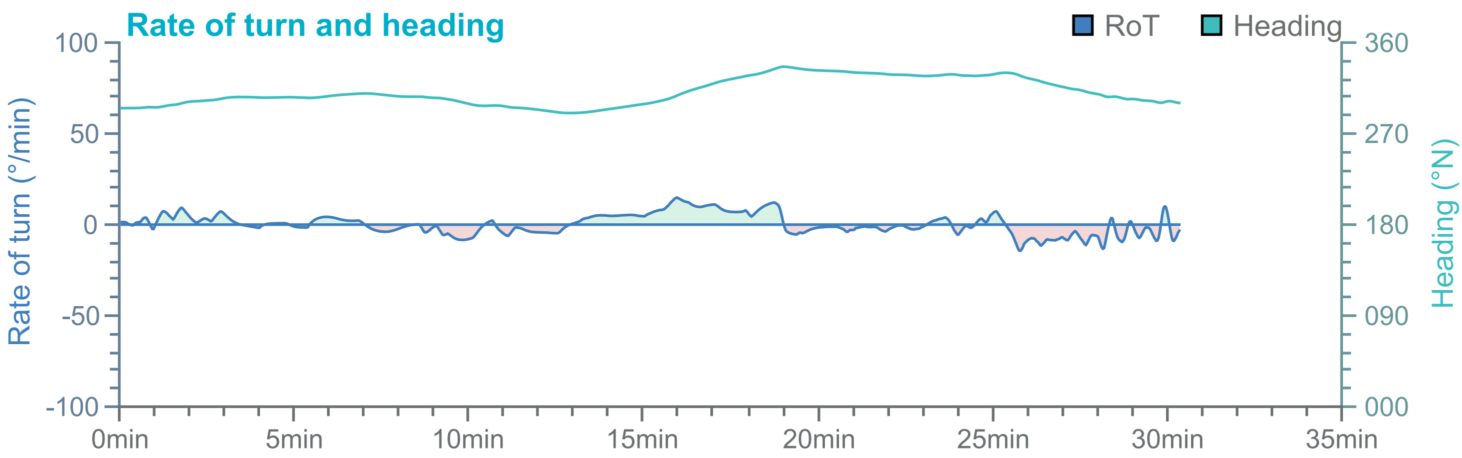
Ships plotted every 1 mins, highlight every 10 mins

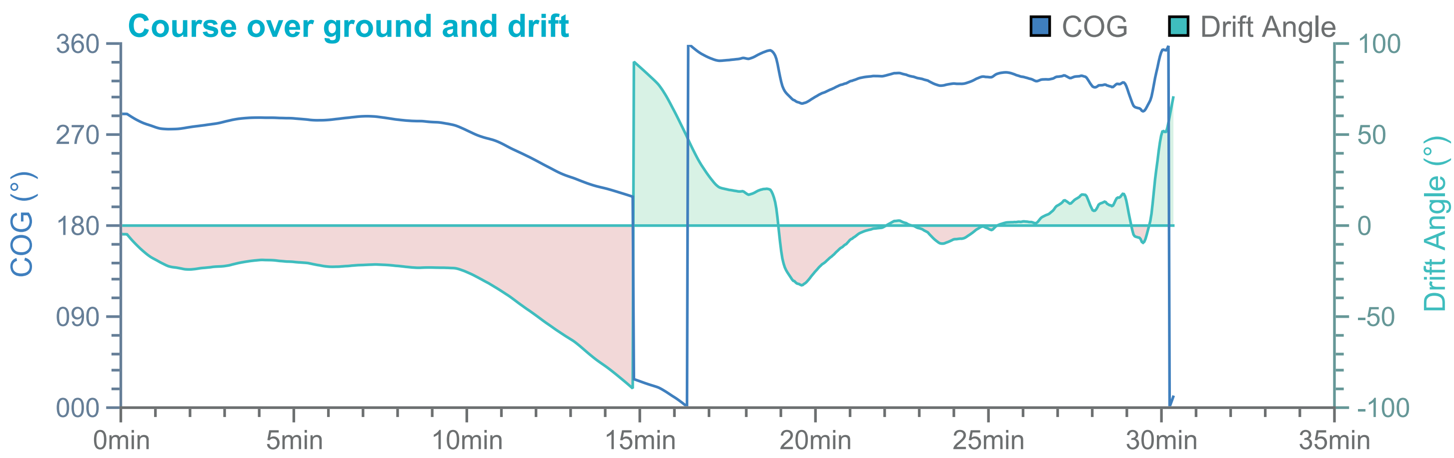
Manoeuvre track plot

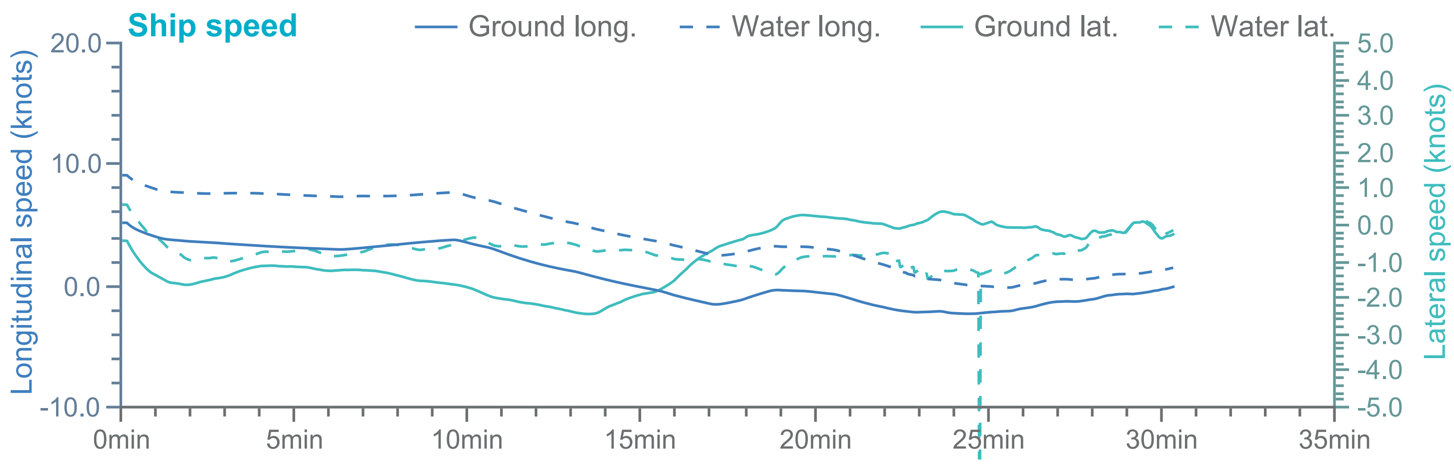


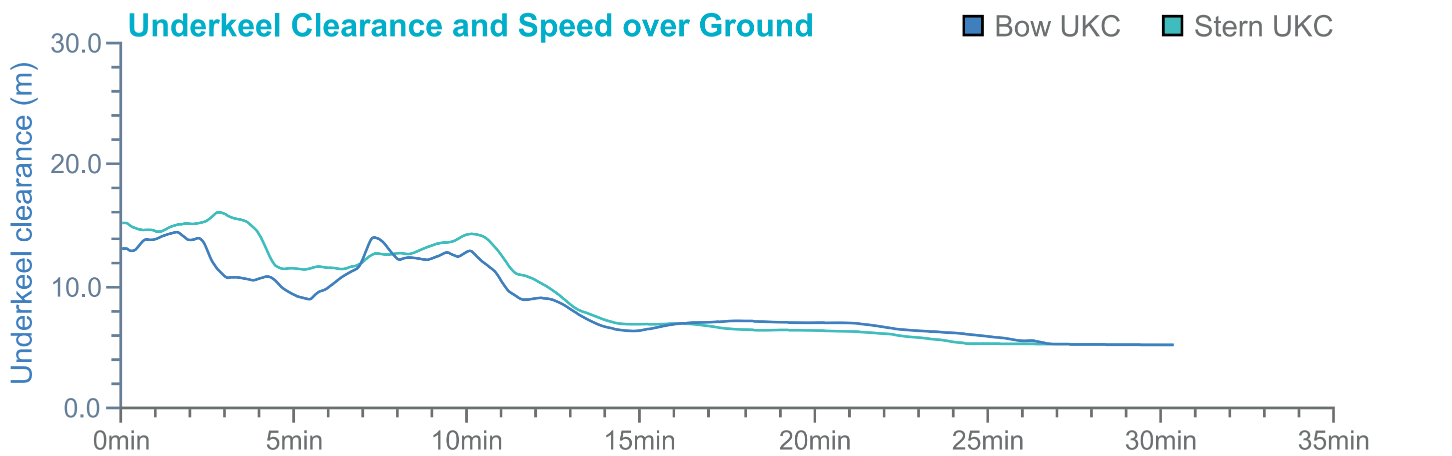

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

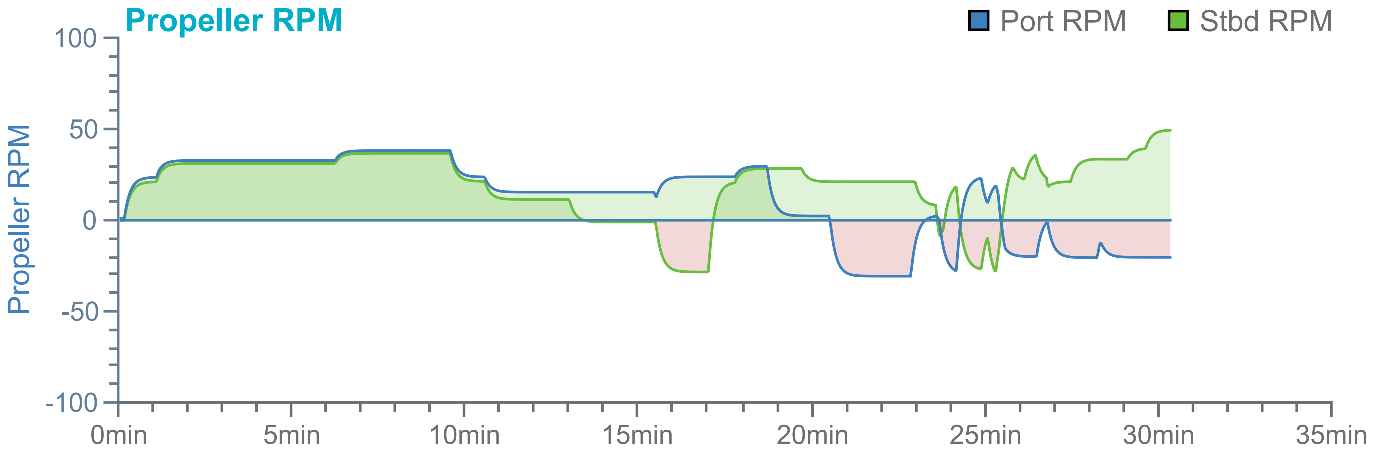

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

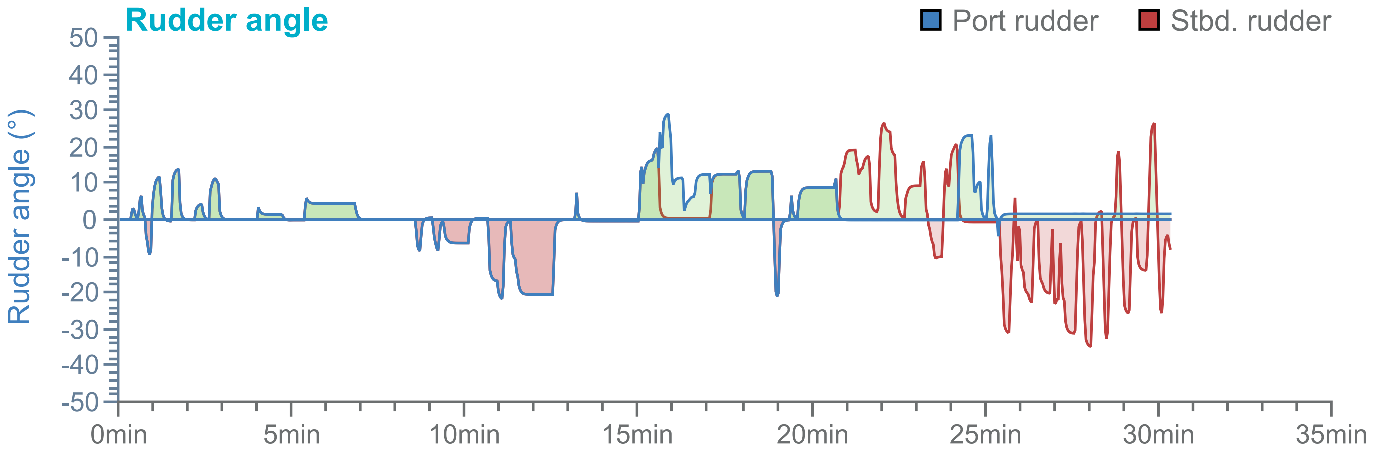

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

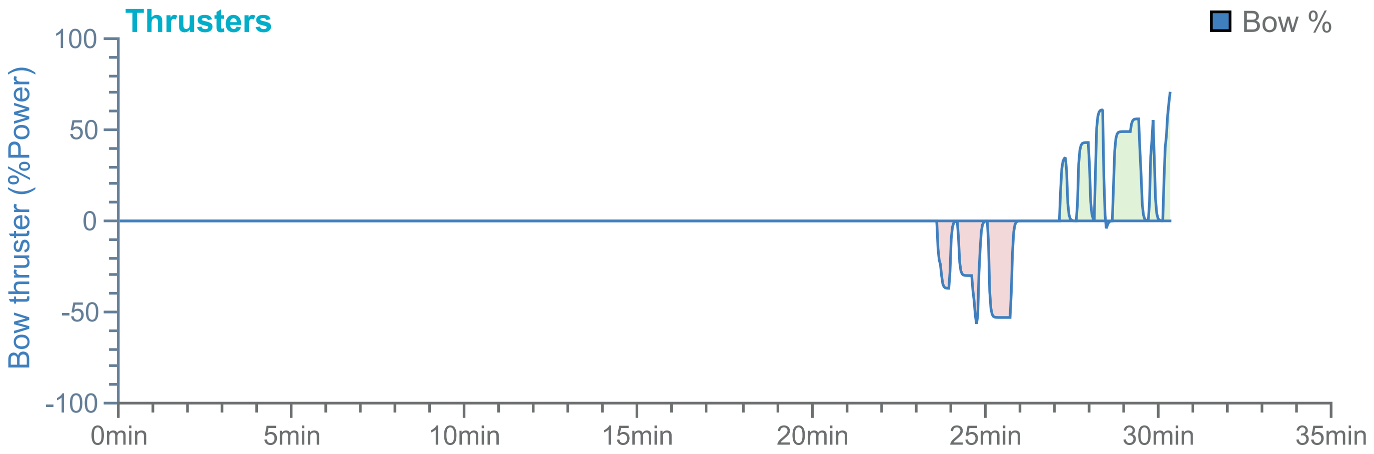

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min

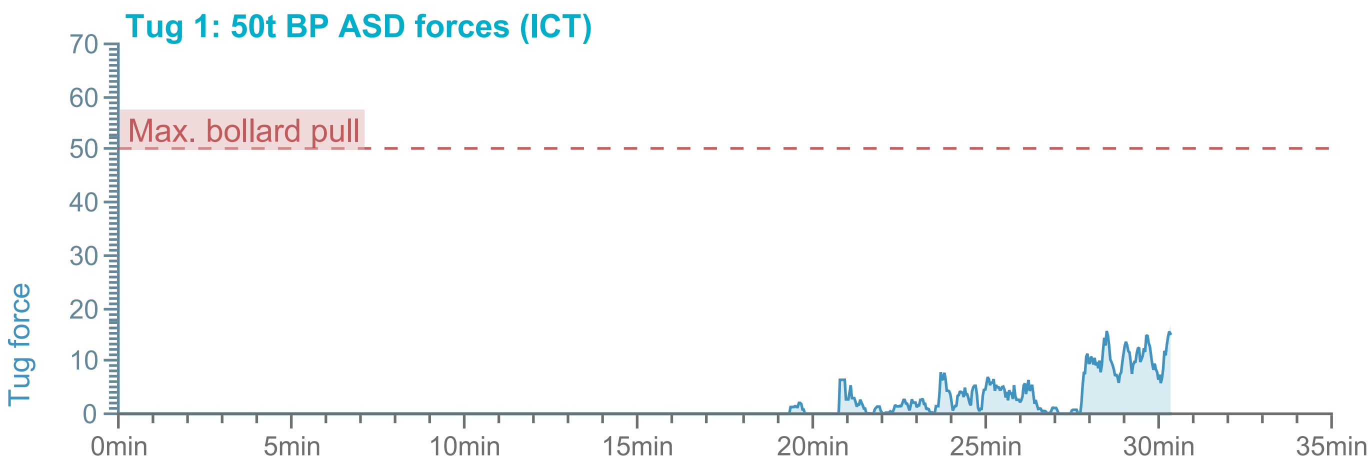

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min

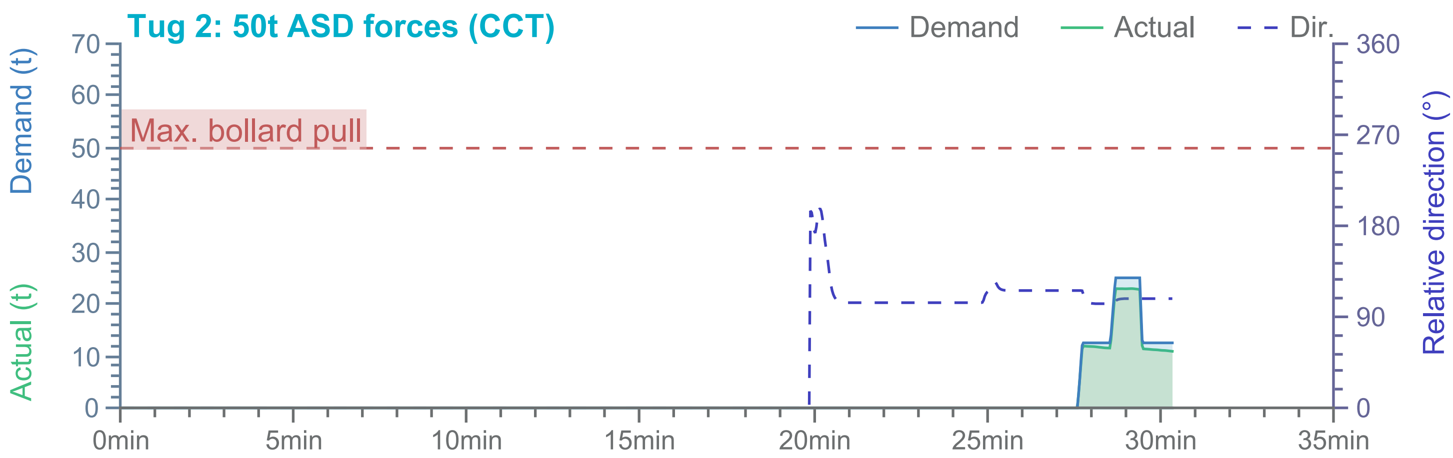
Overview | Environment | Stena Transporter | Tugs



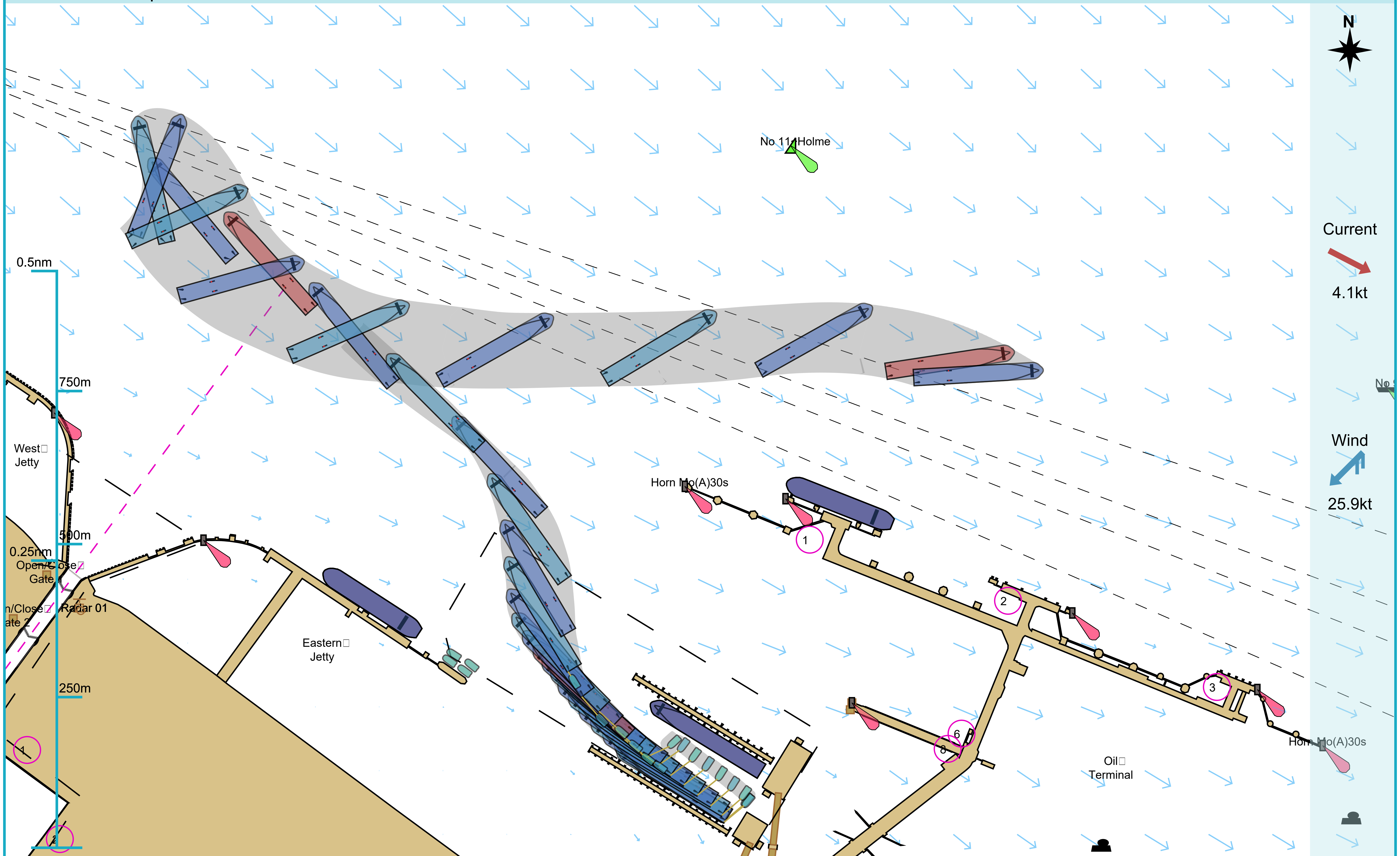





Tug 1: 50t BP ASD forces (ICT)
Tug force
Max. bollard pull
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min
25min
30min
35min

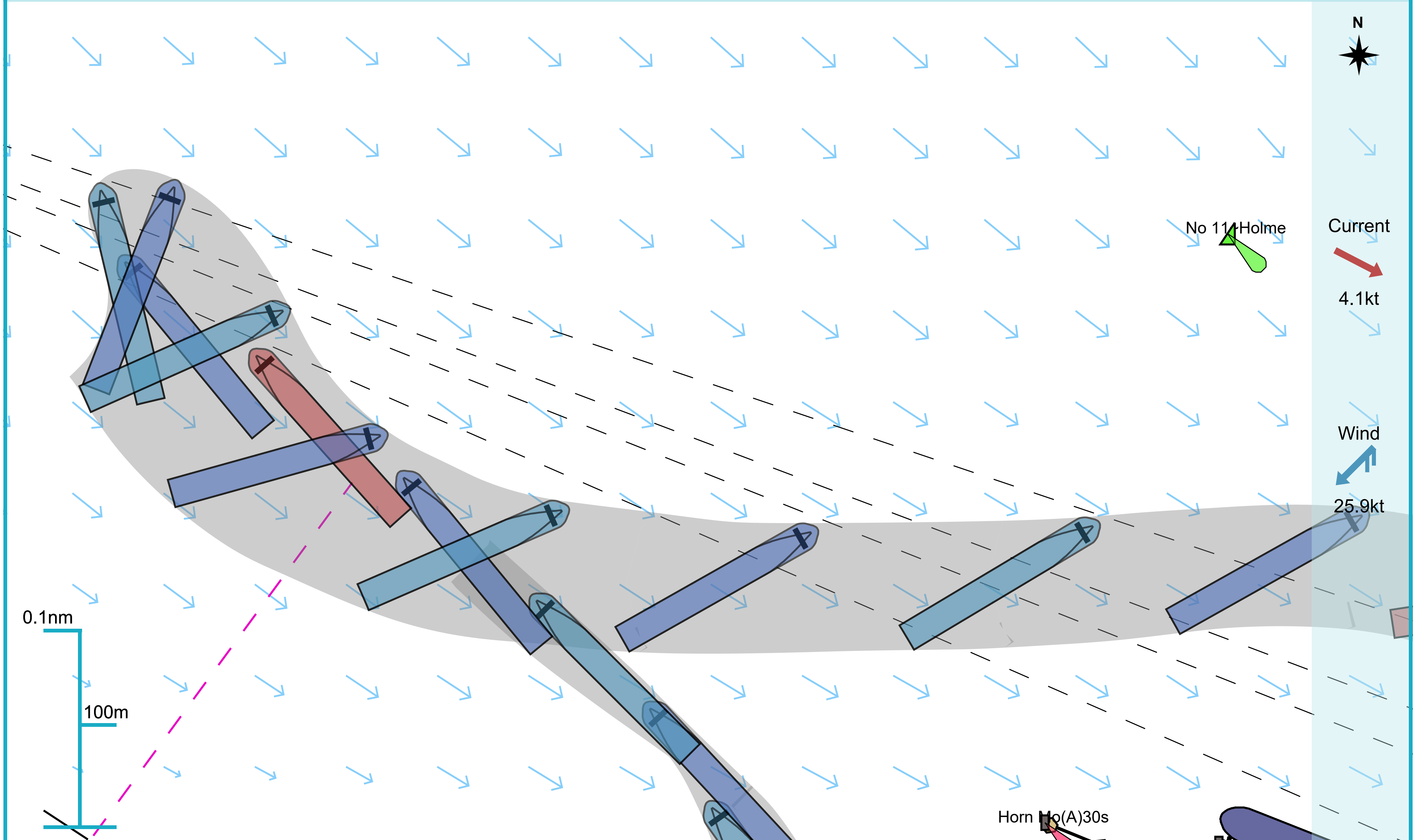

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Relative direction (°)
Max. bollard pull
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot



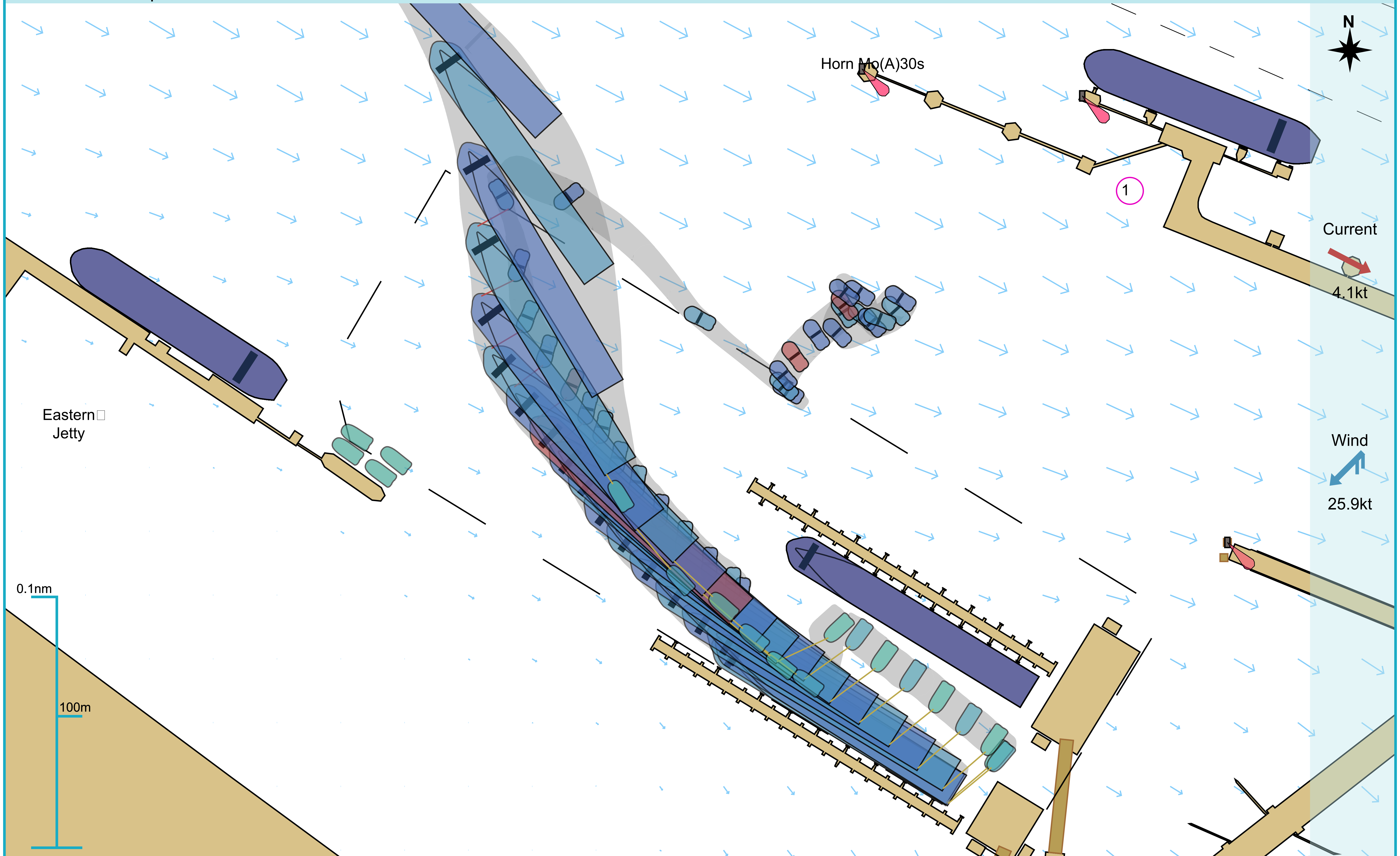
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



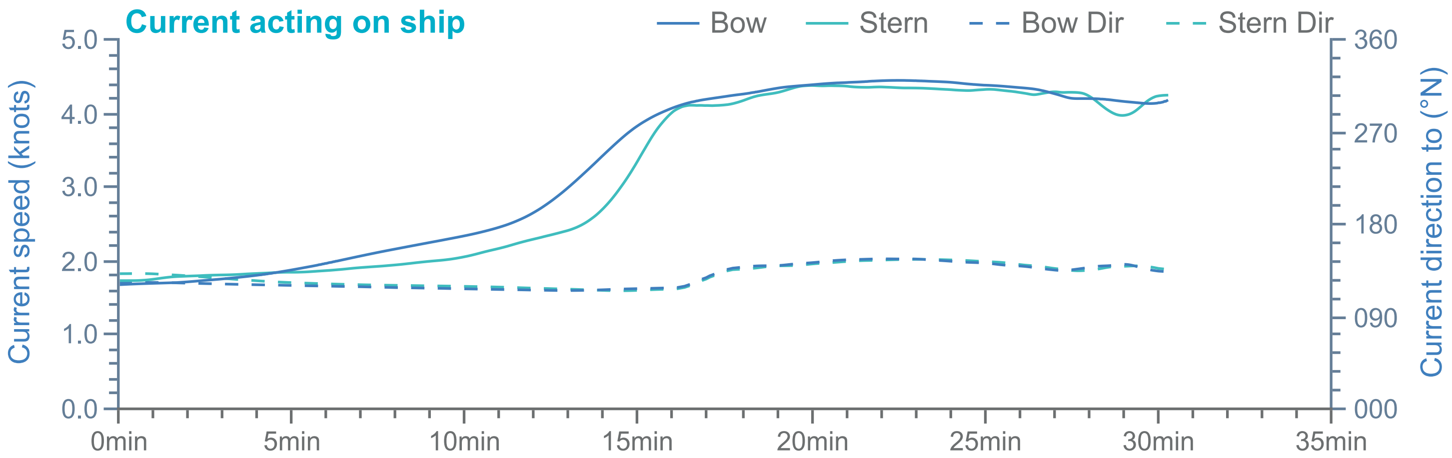
Ships plotted every 1 mins, highlight every 10 mins

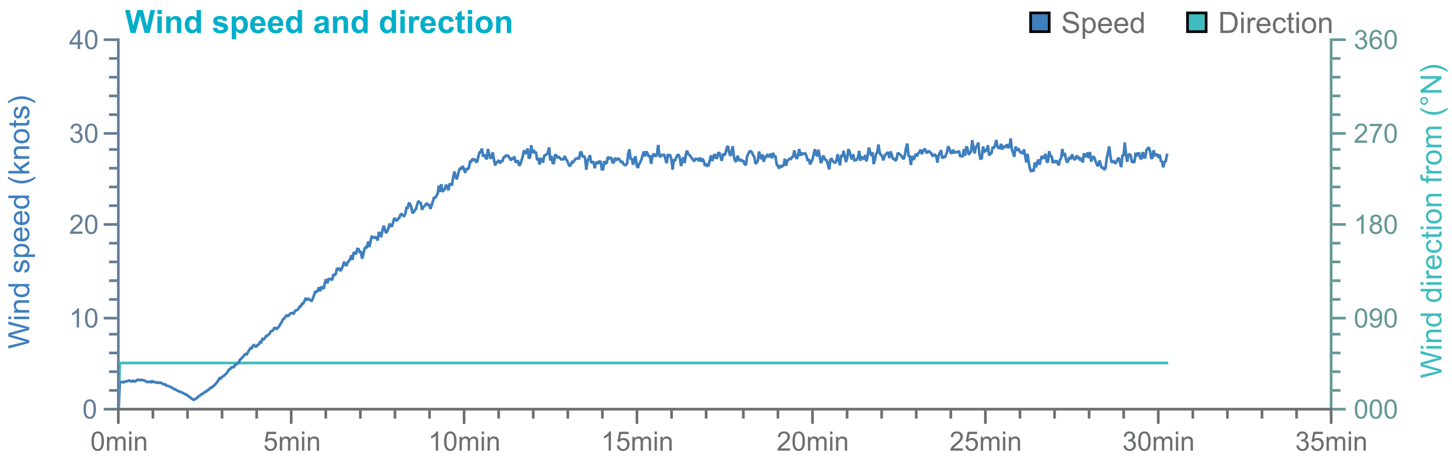
Manoeuvre track plot

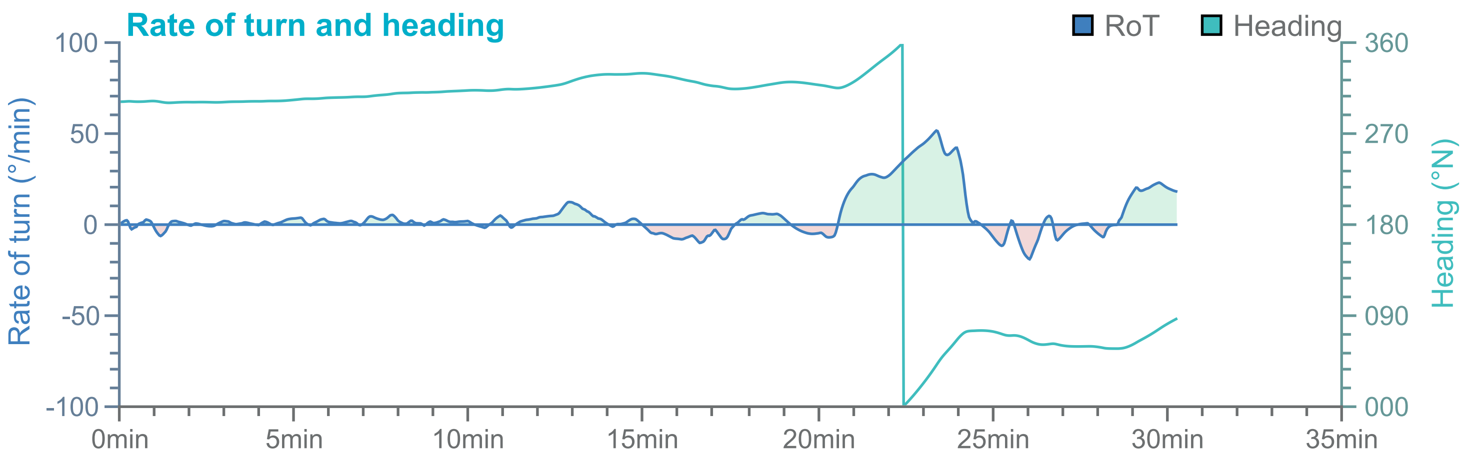


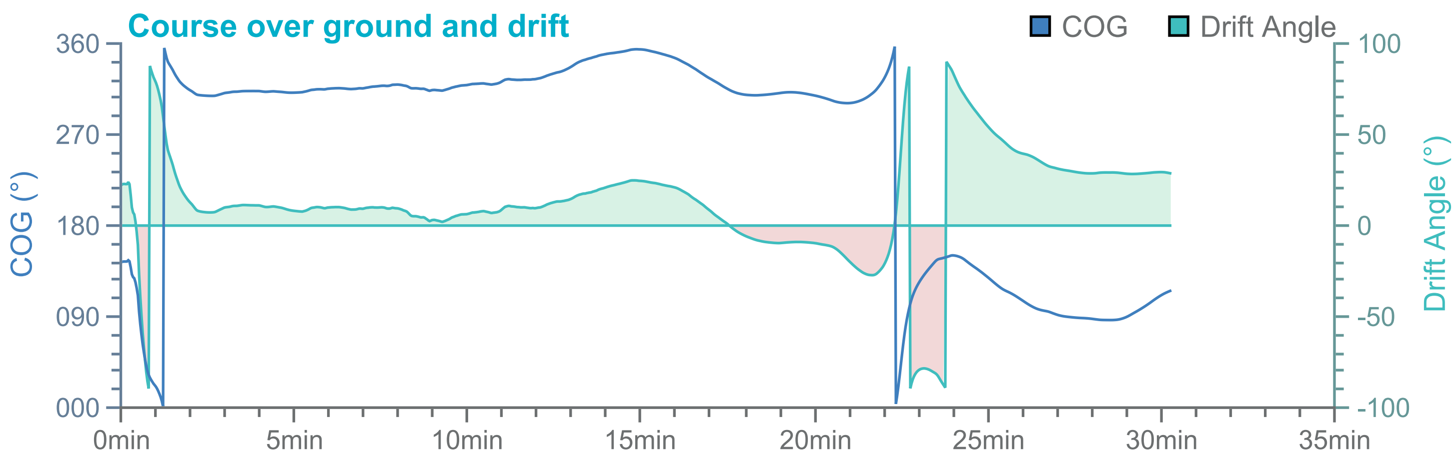
→ 3.65 kts

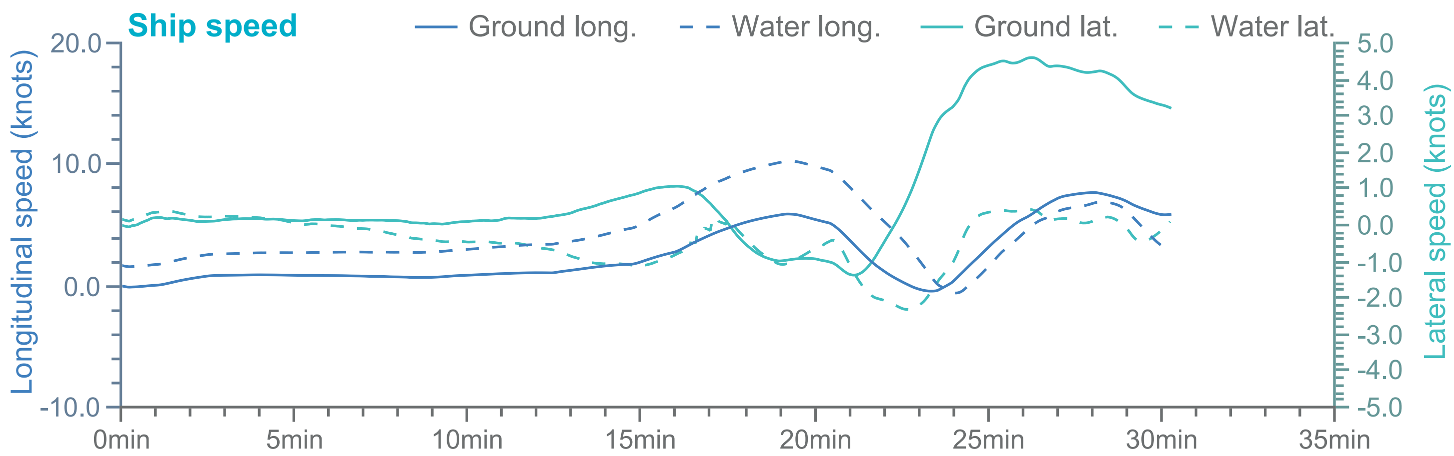
Ships plotted every 1 mins, highlight every 10 mins

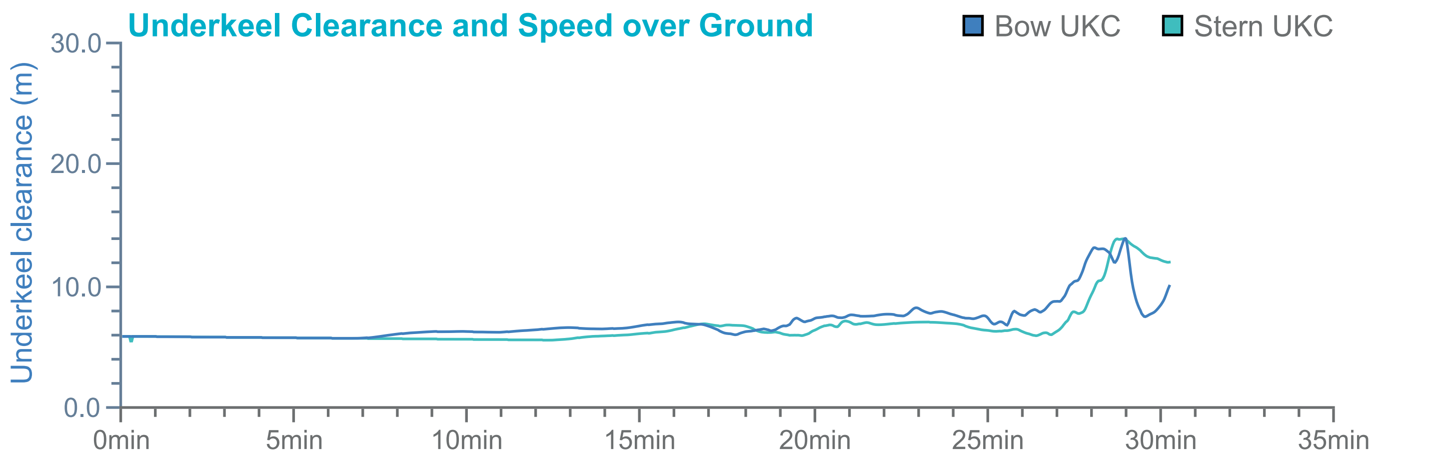

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

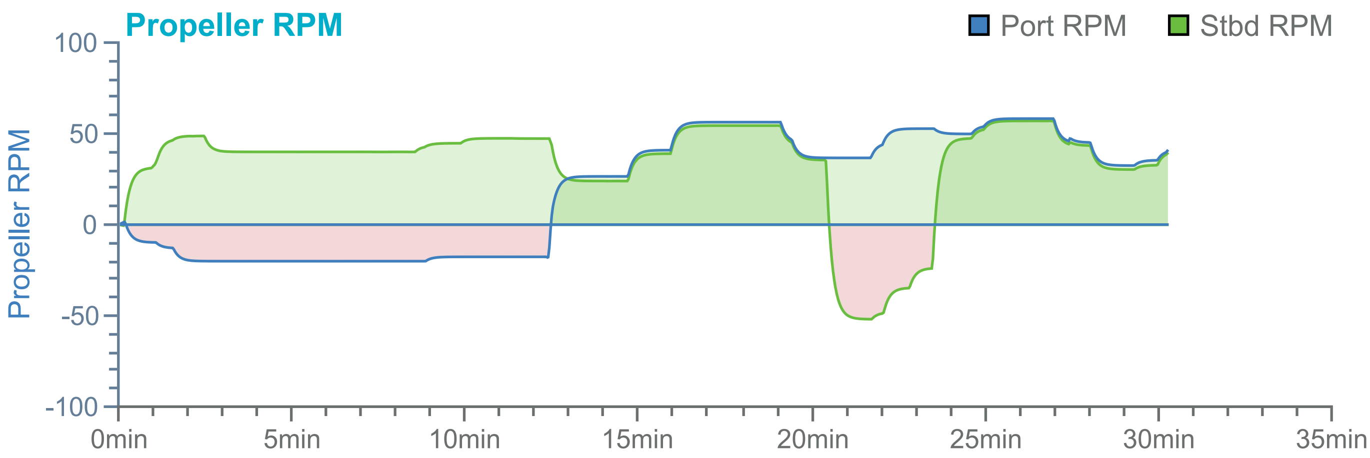

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

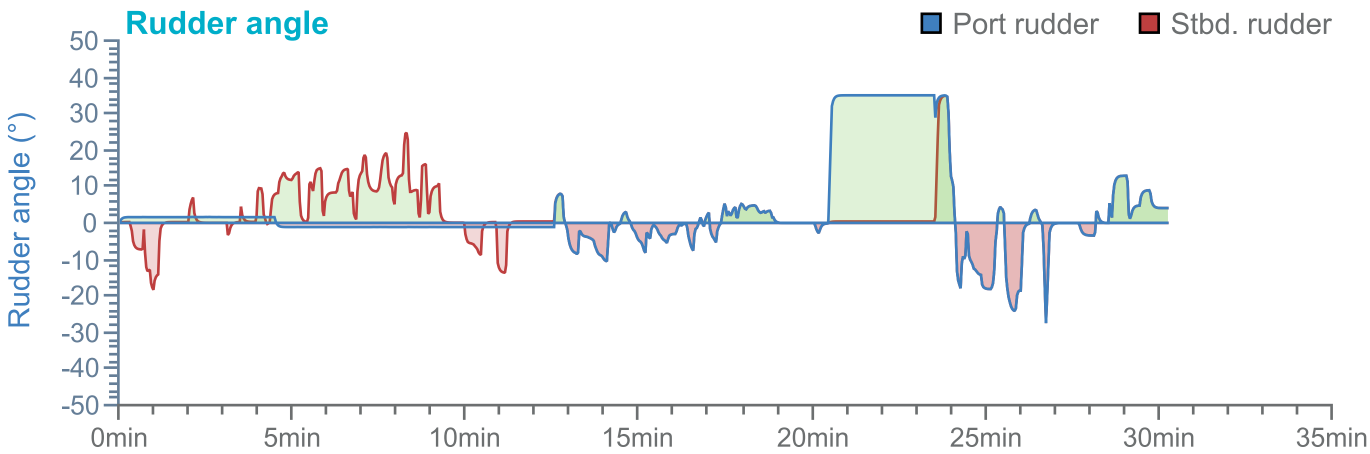

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

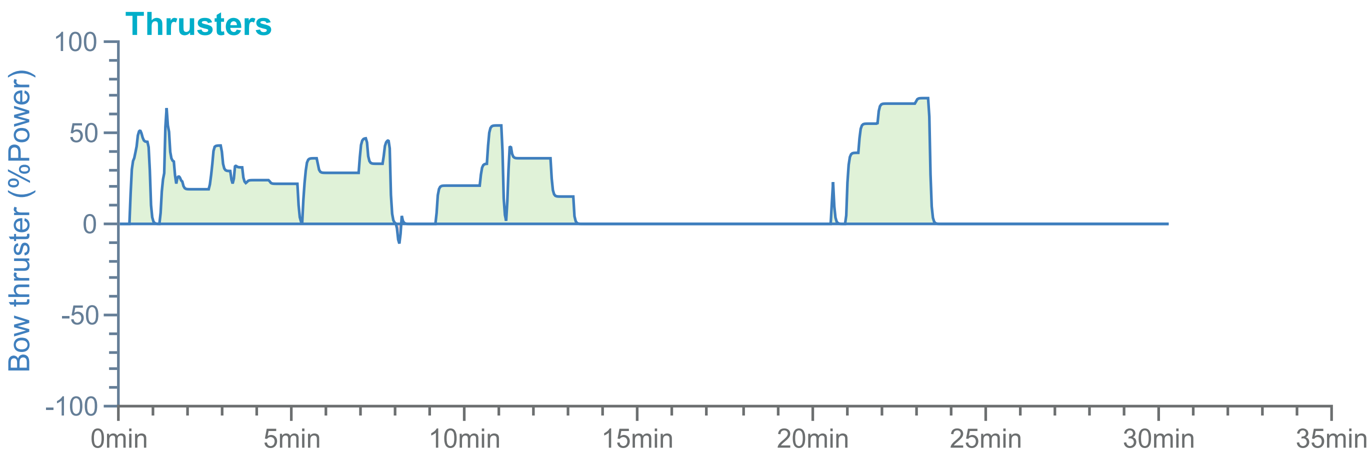

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

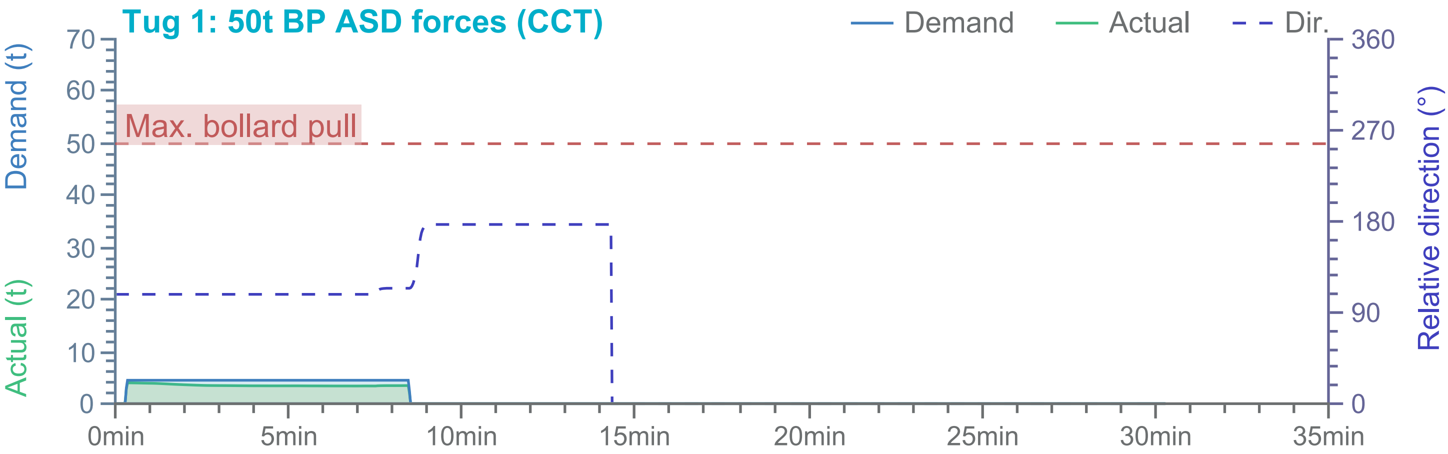

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min

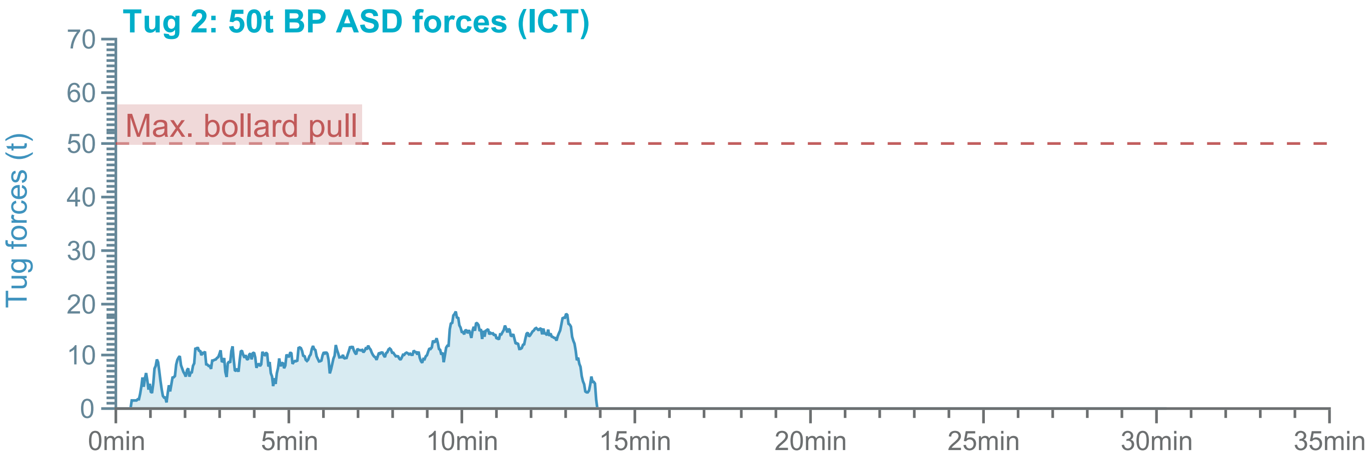

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

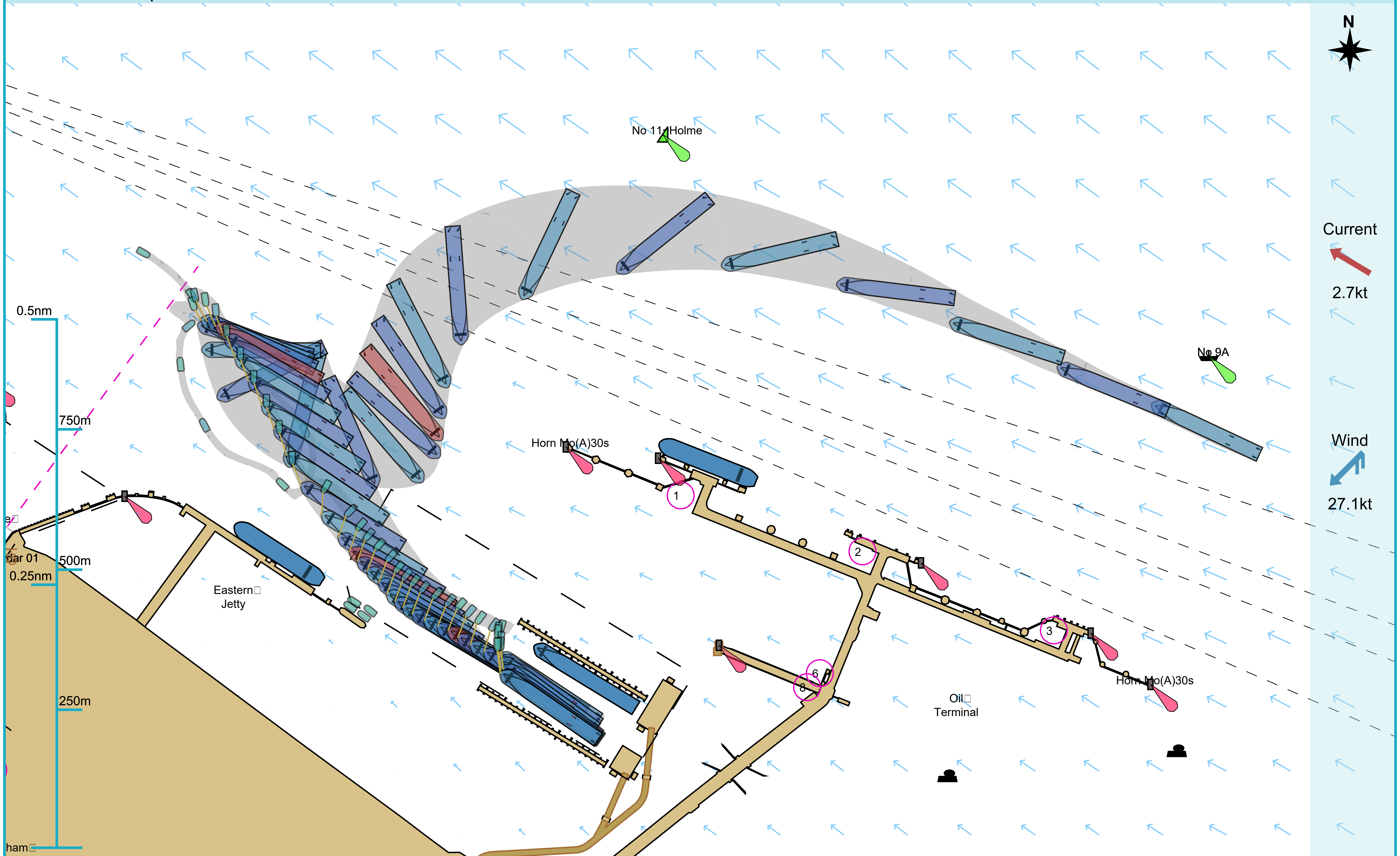

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Relative direction (°)
Max. bollard pull
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min

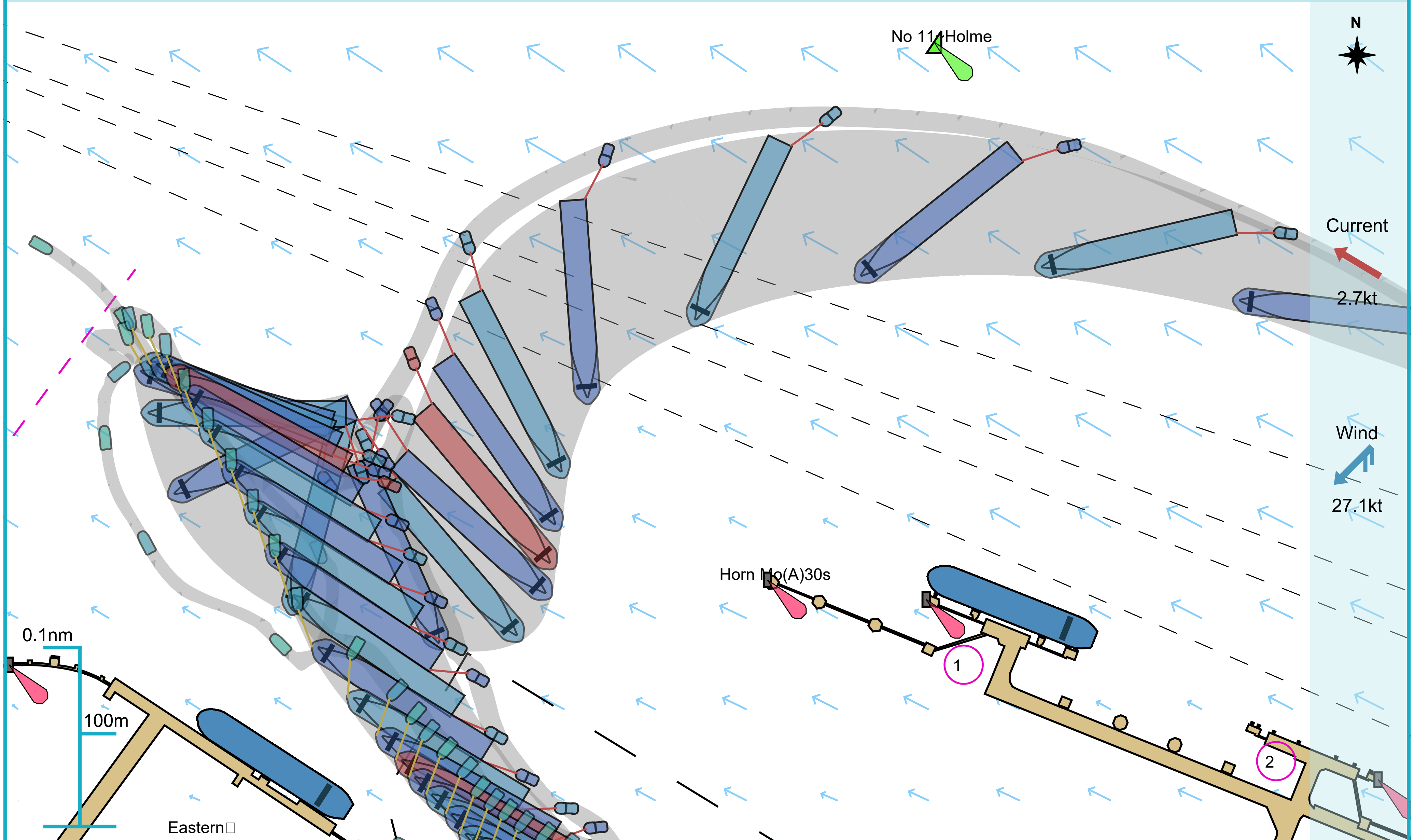

Tug 2: 50t BP ASD forces (ICT)
Tug forces (t)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot



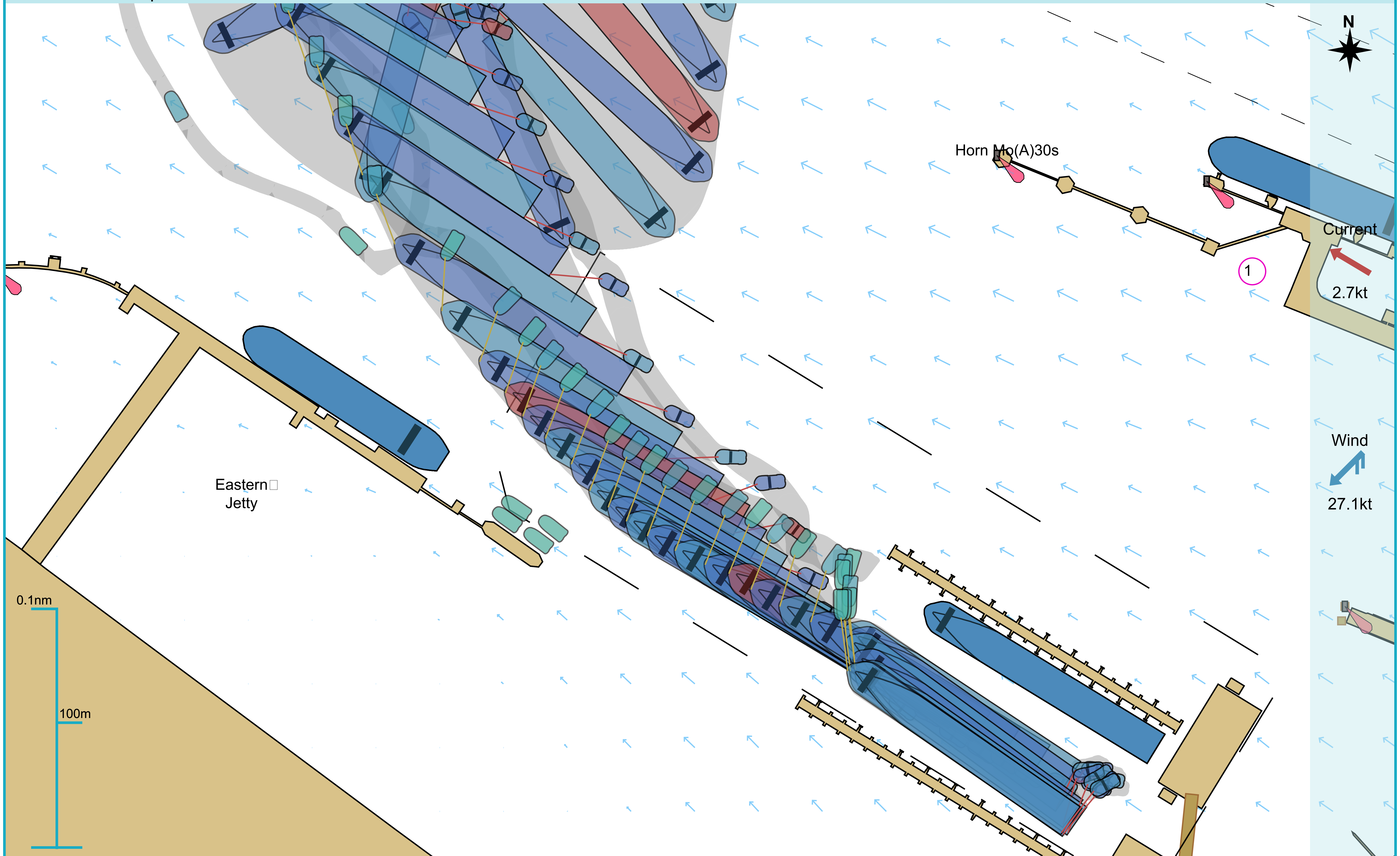
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



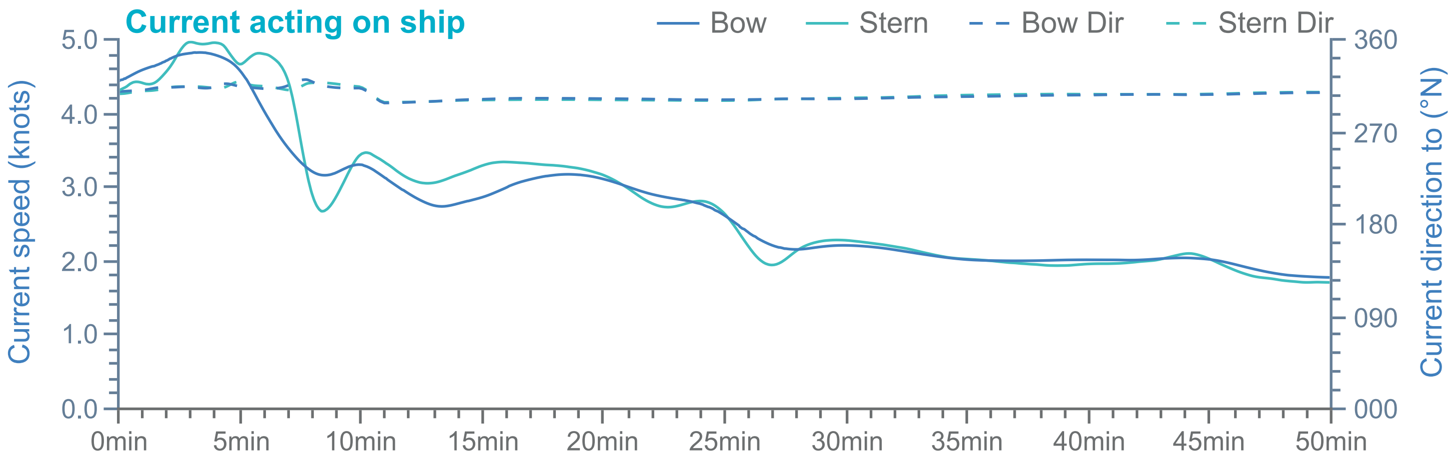
Ships plotted every 1 mins, highlight every 10 mins

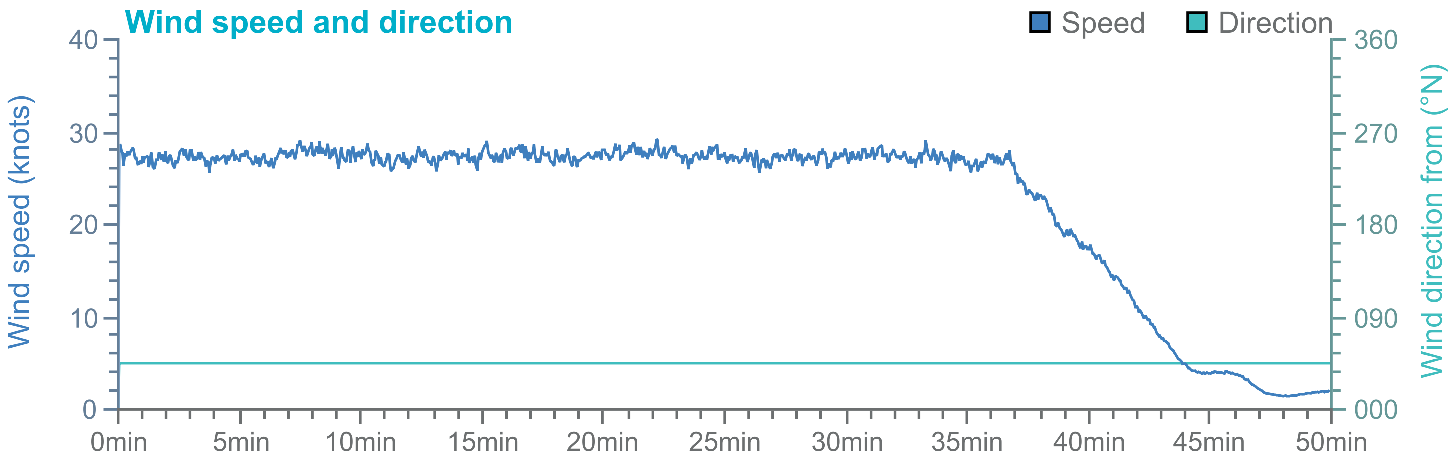
Manoeuvre track plot



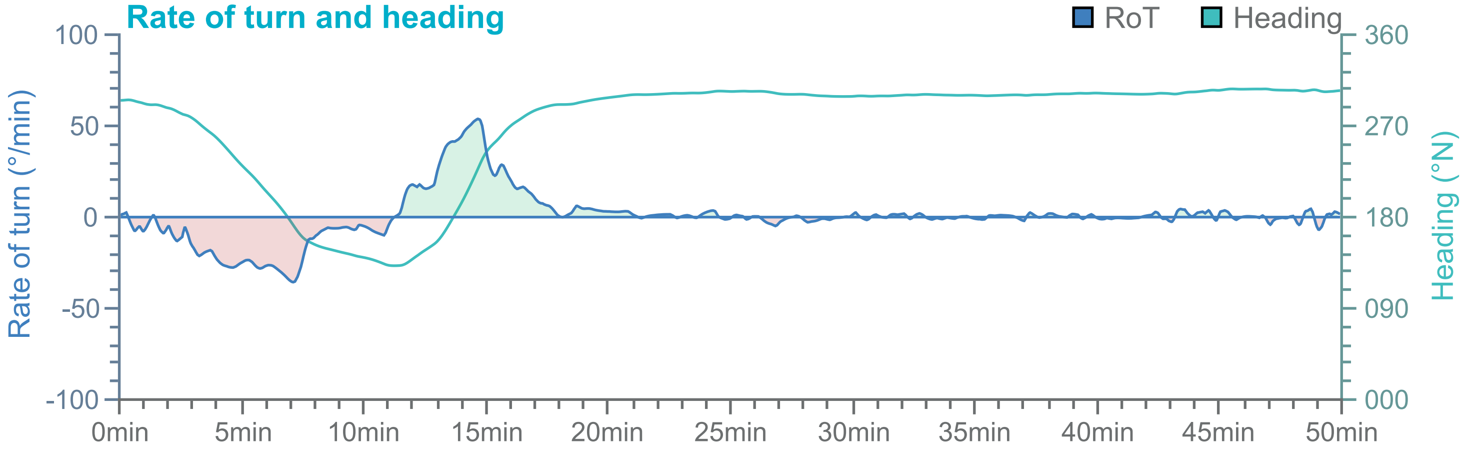
3.66 kts

Ships plotted every 1 mins, highlight every 10 mins

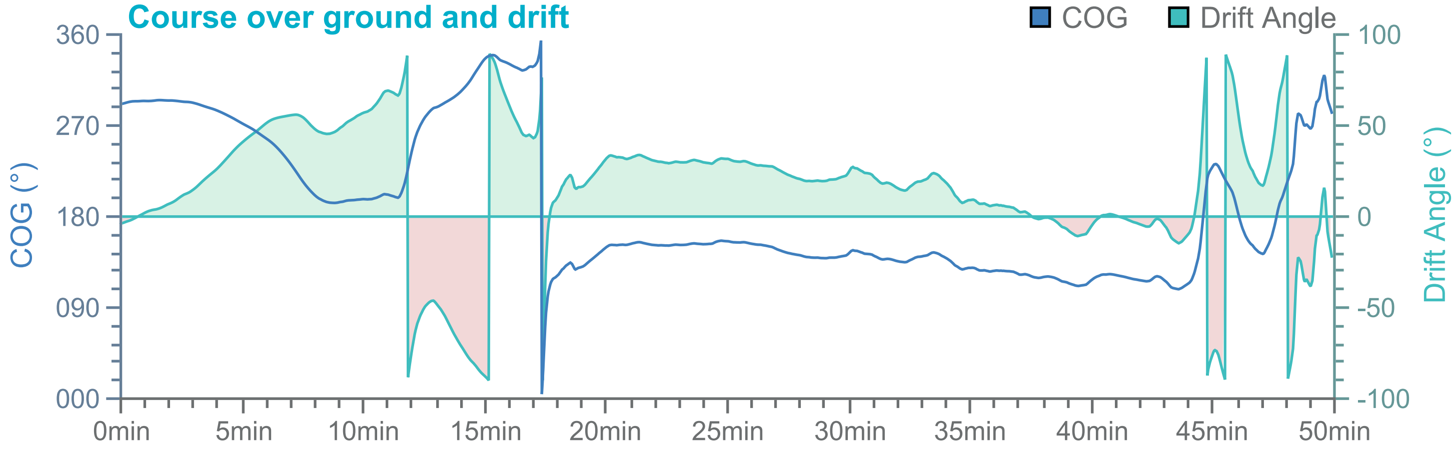

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

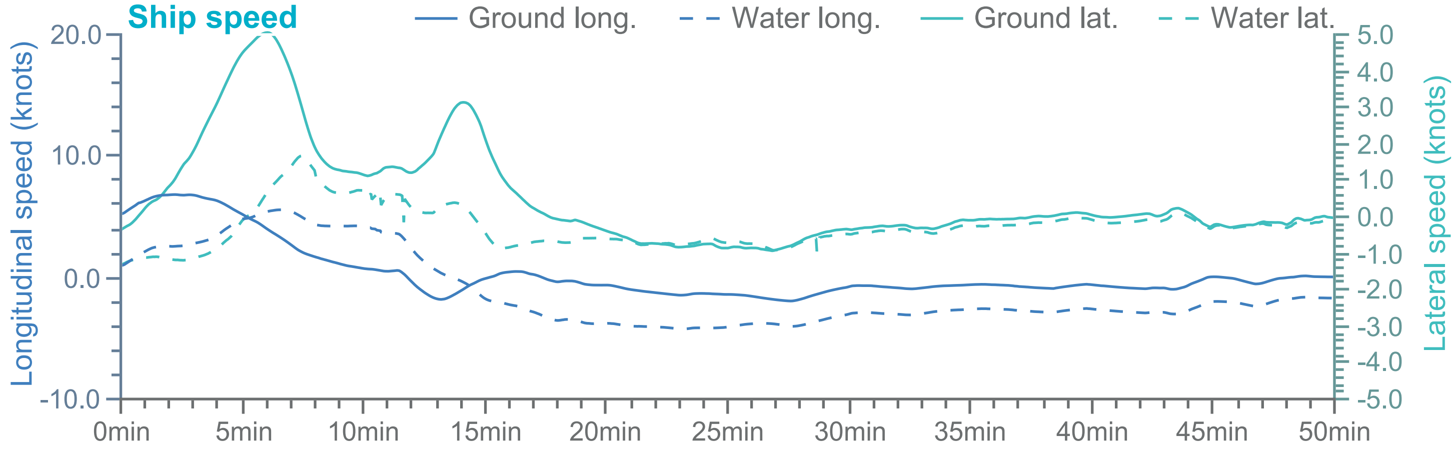
Rate of turn and heading



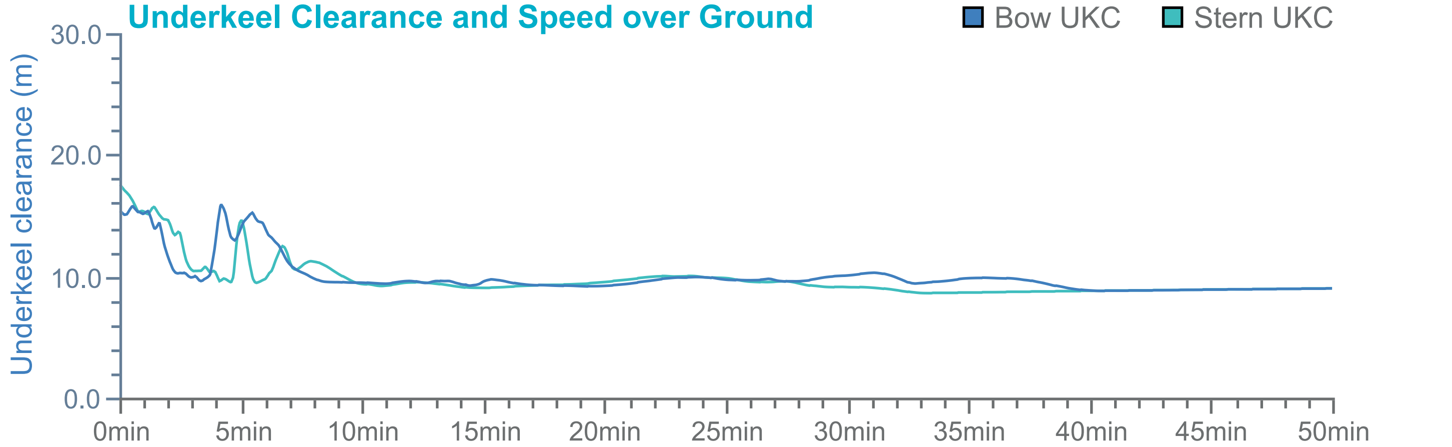
Course over ground and drift



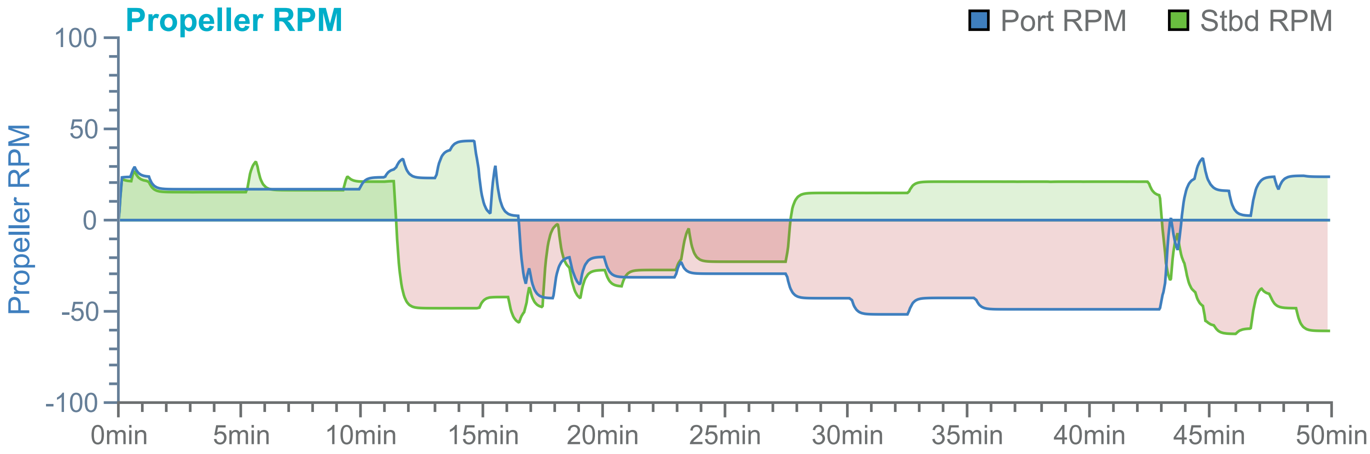
Ship speed

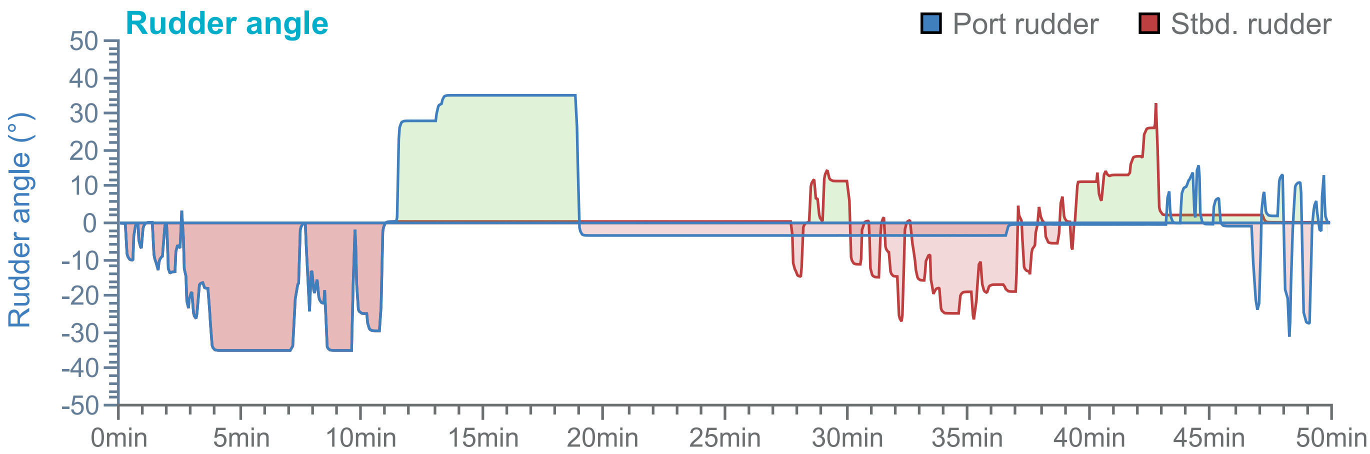


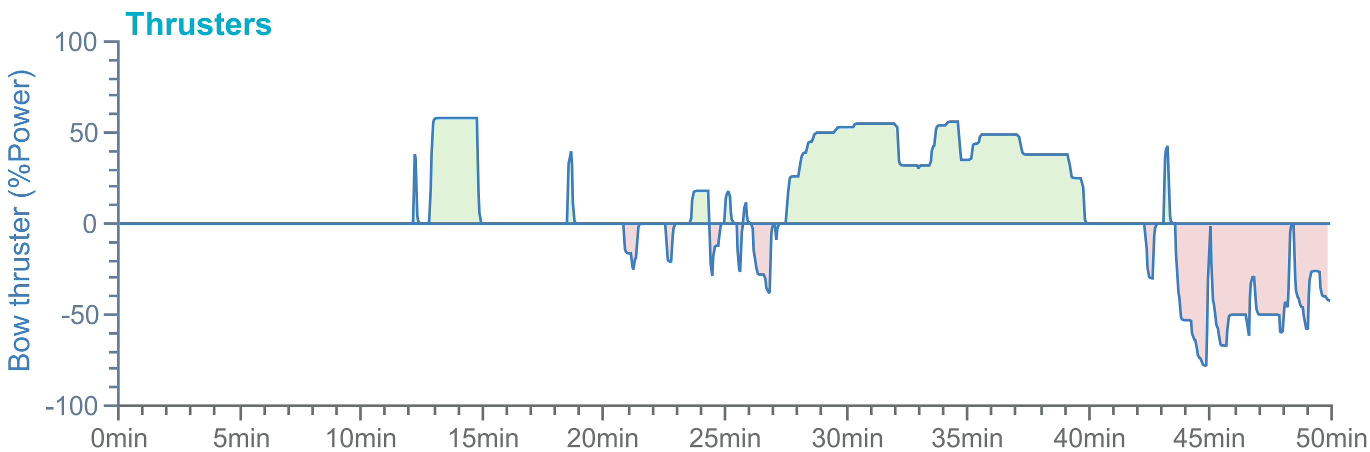
Underkeel Clearance and Speed over Ground



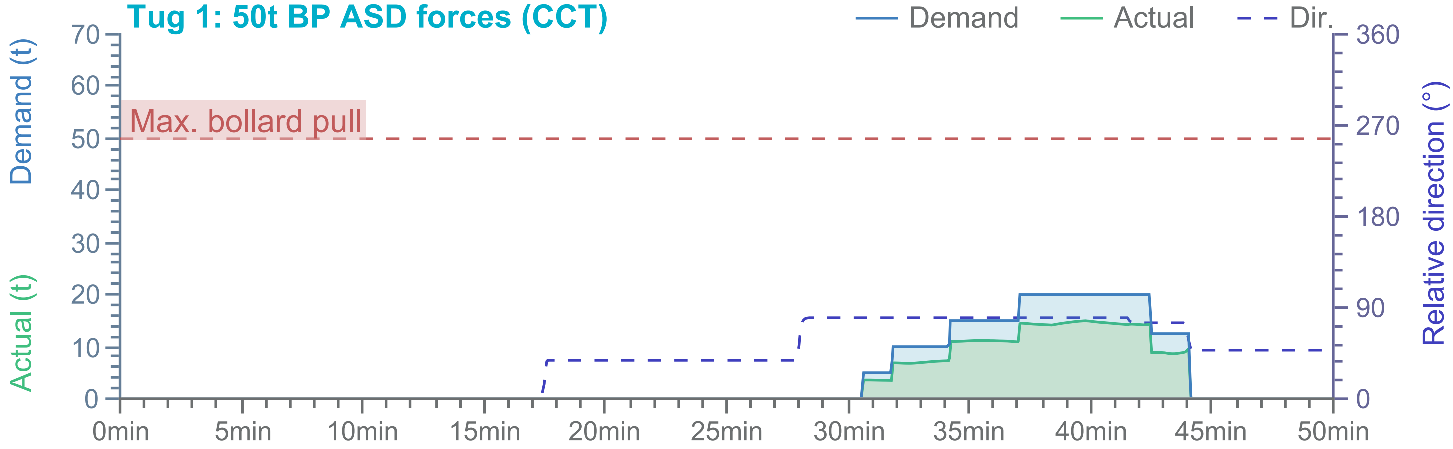
Overview | Environment | Stena Transporter | Tugs



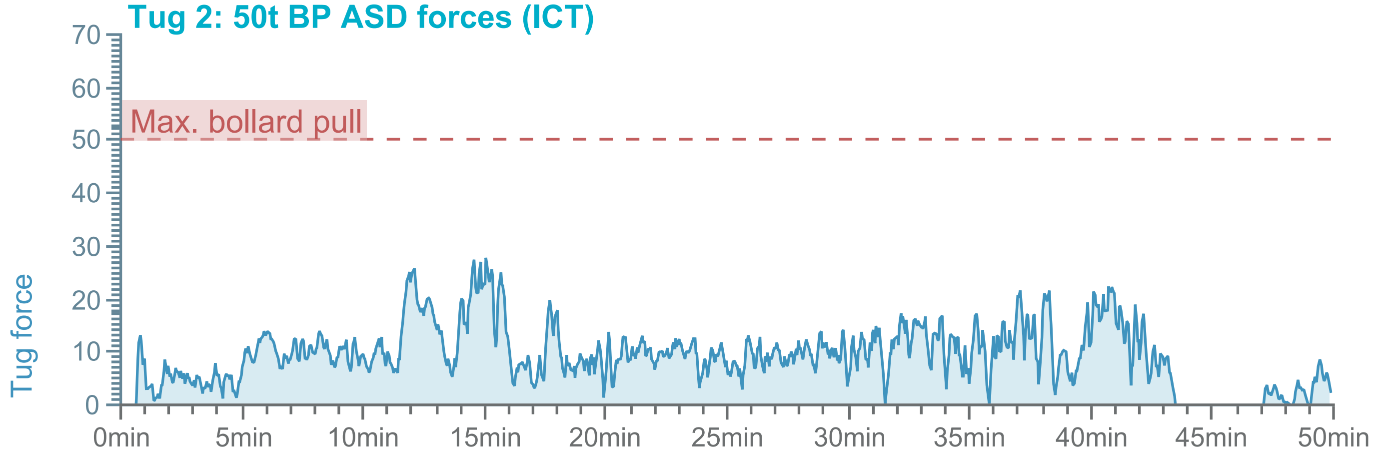




Tug 1: 50t BP ASD forces (CCT)



Tug 2: 50t BP ASD forces (ICT)

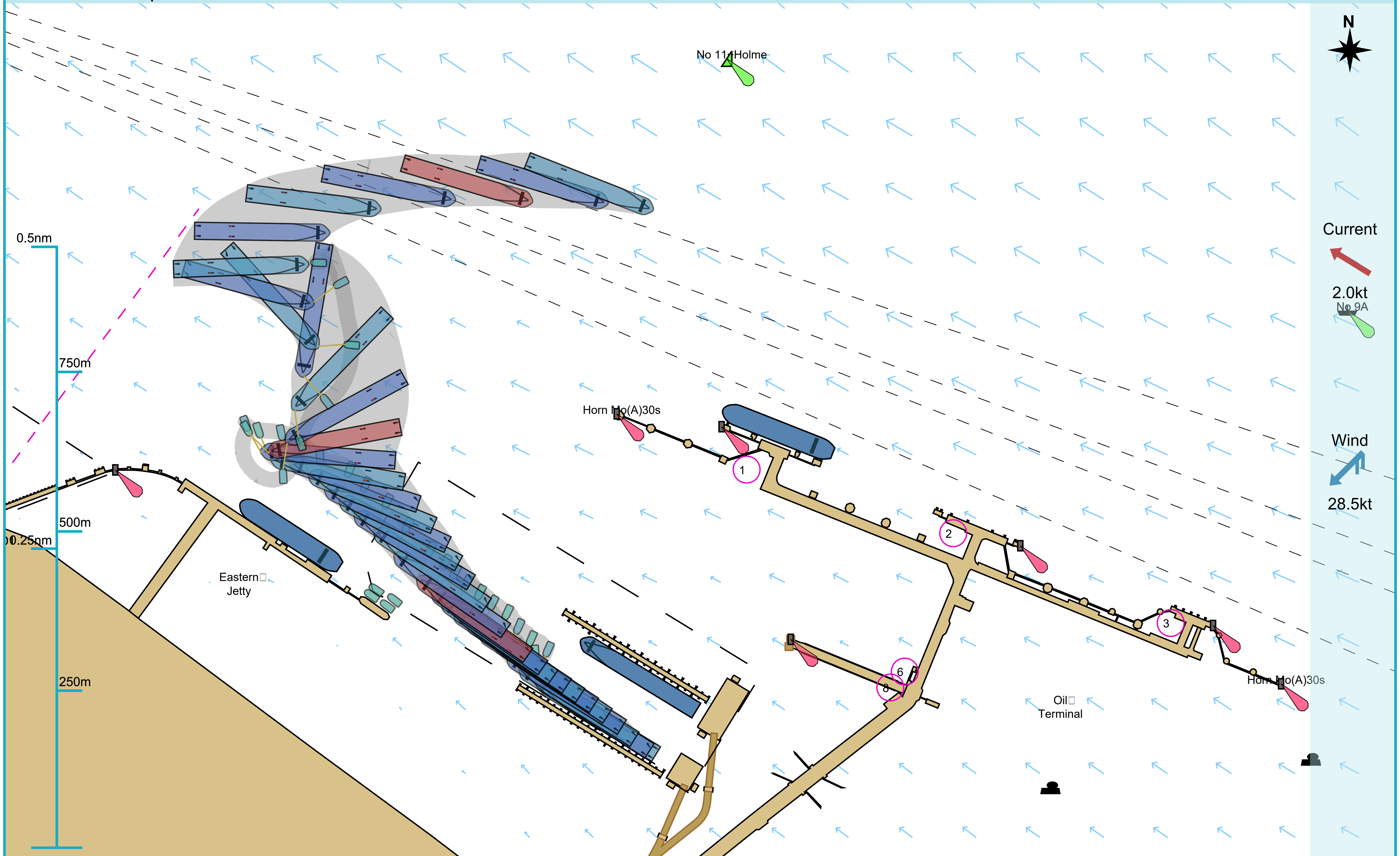


hr wallingford

Project: Humber
Session: DJR6612_IERRT_7_8_Nov_2023
Configuration: Peak Spring - 7m
Run: 12

Overview | Environment | Stena Transporter | Tugs

Manoeuvre track plot

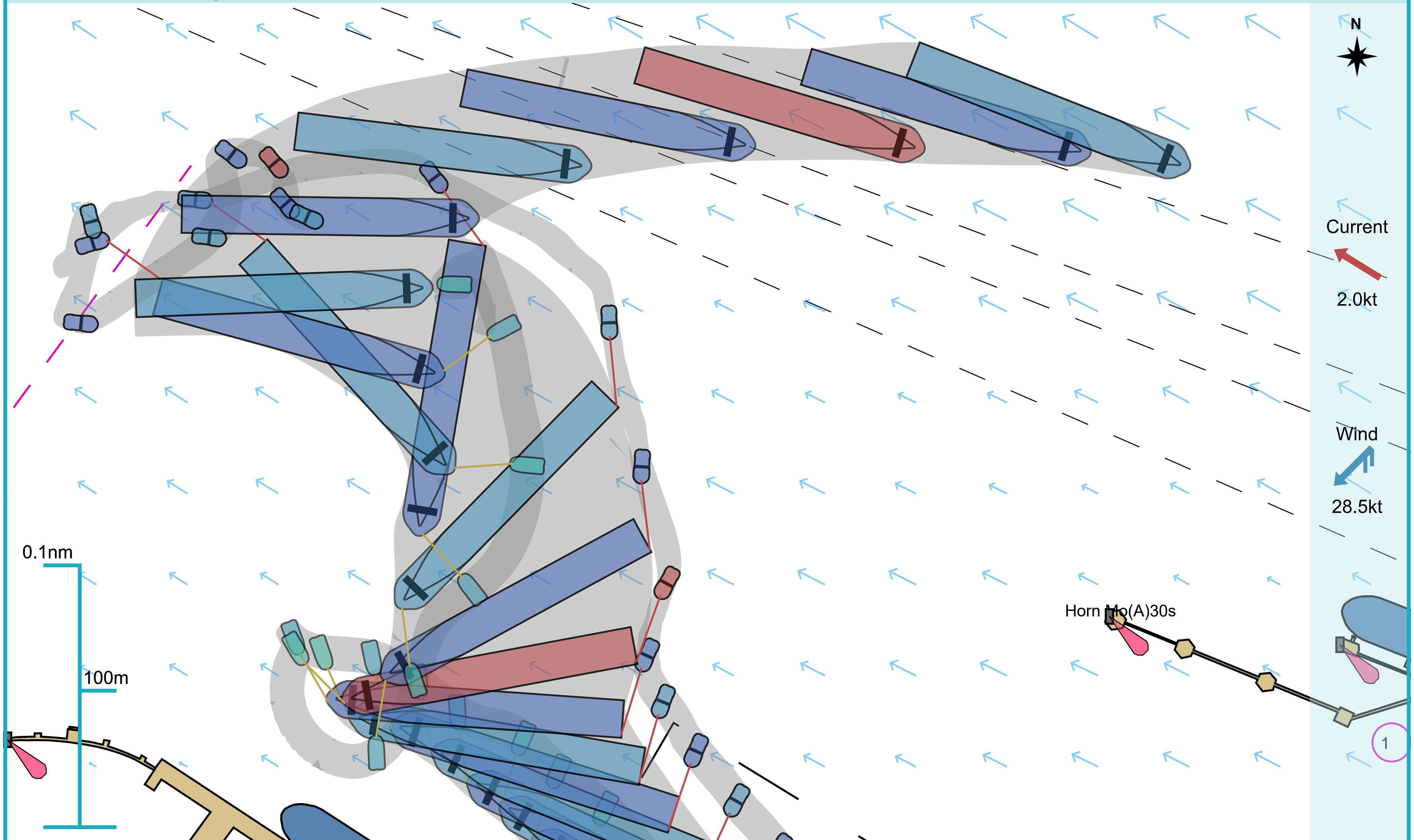


Ships plotted every 1 mins, highlight every 10 mins

Pilot: GVF
Manoeuvre: Departure

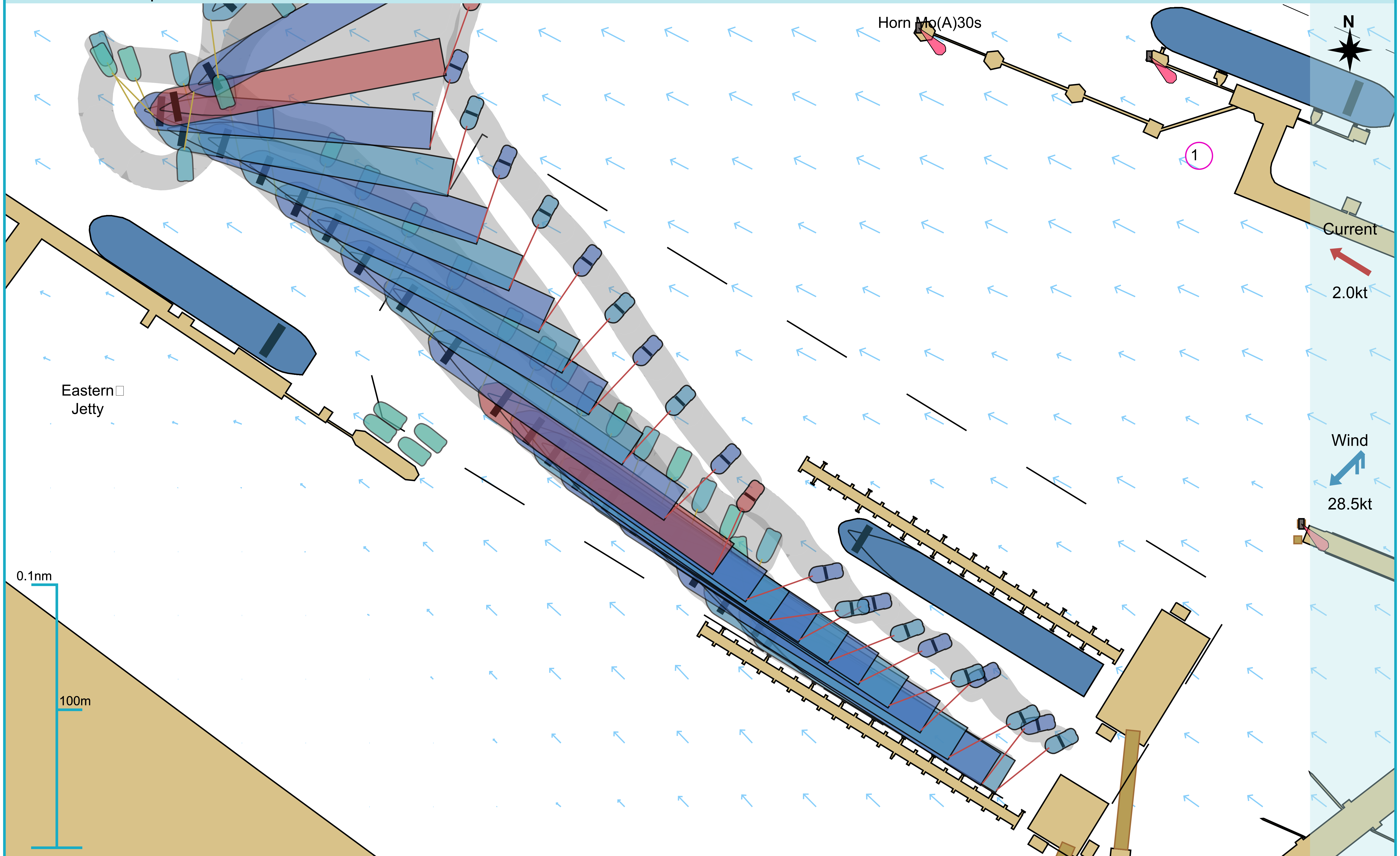
Ship: Stena Transporter

Manoeuvre track plot



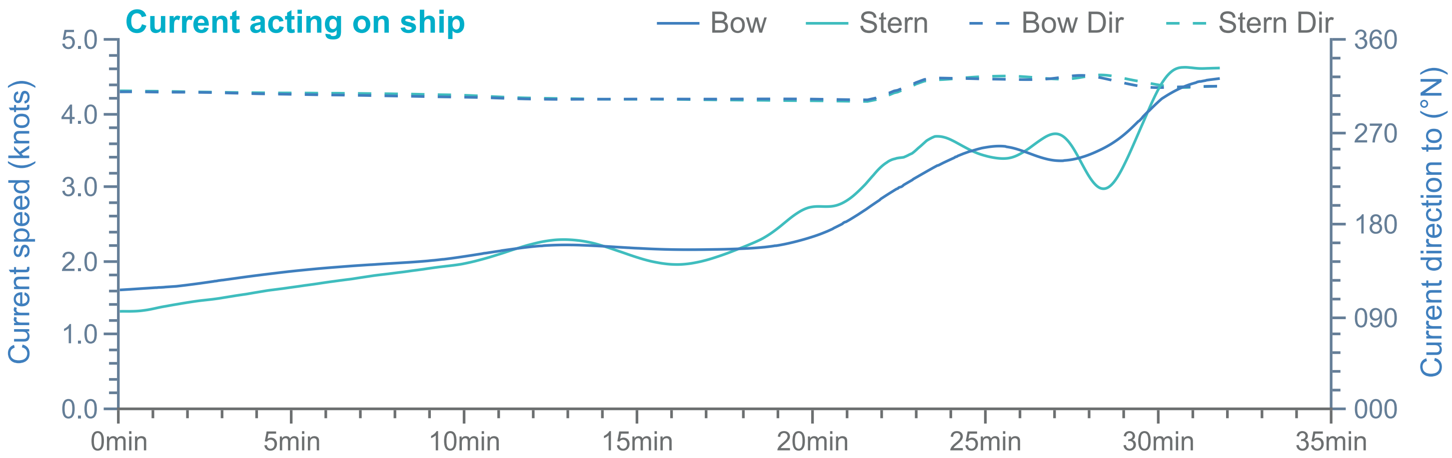
Ships plotted every 1 mins, highlight every 10 mins

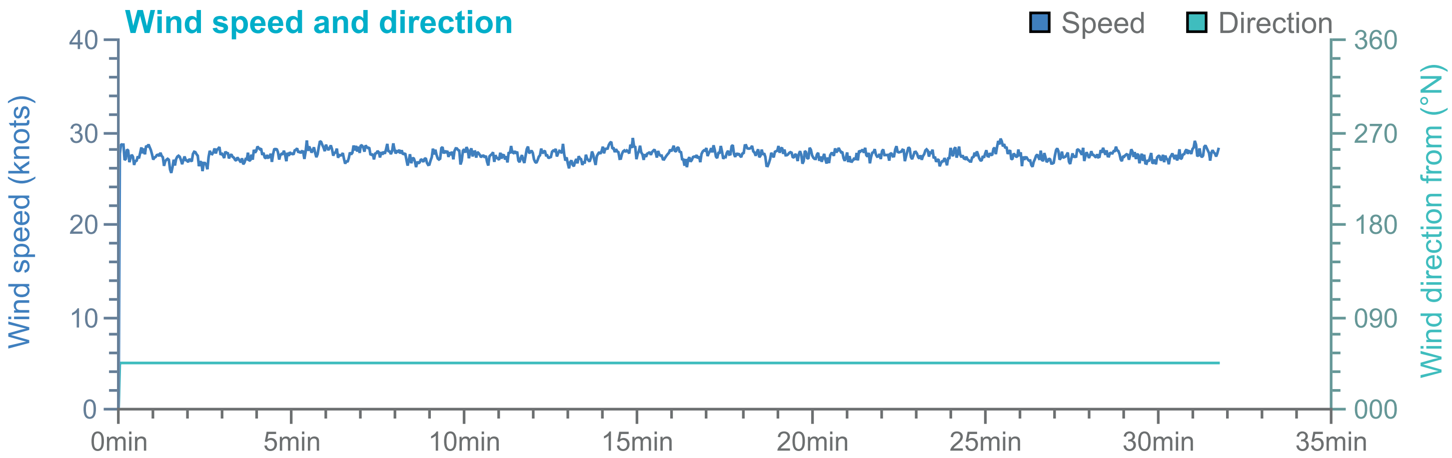
Manoeuvre track plot

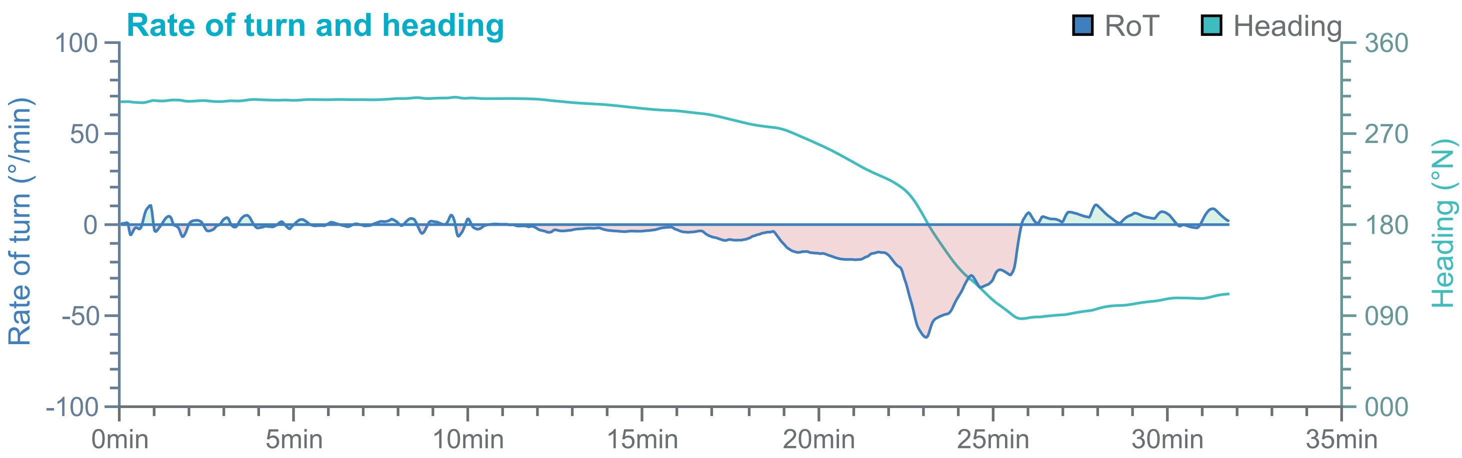


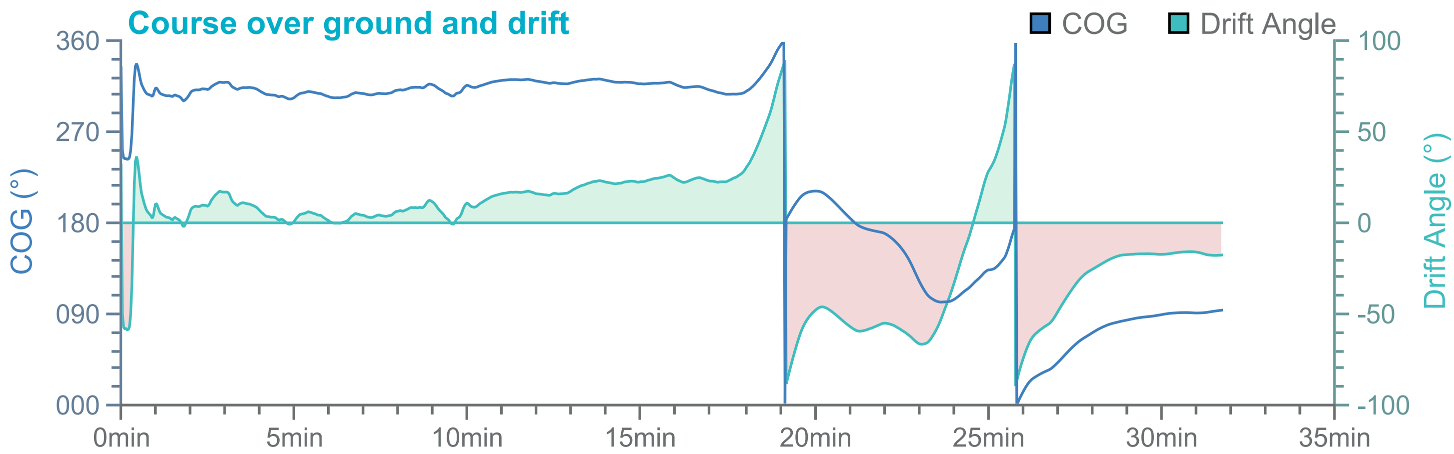
3.25 kts

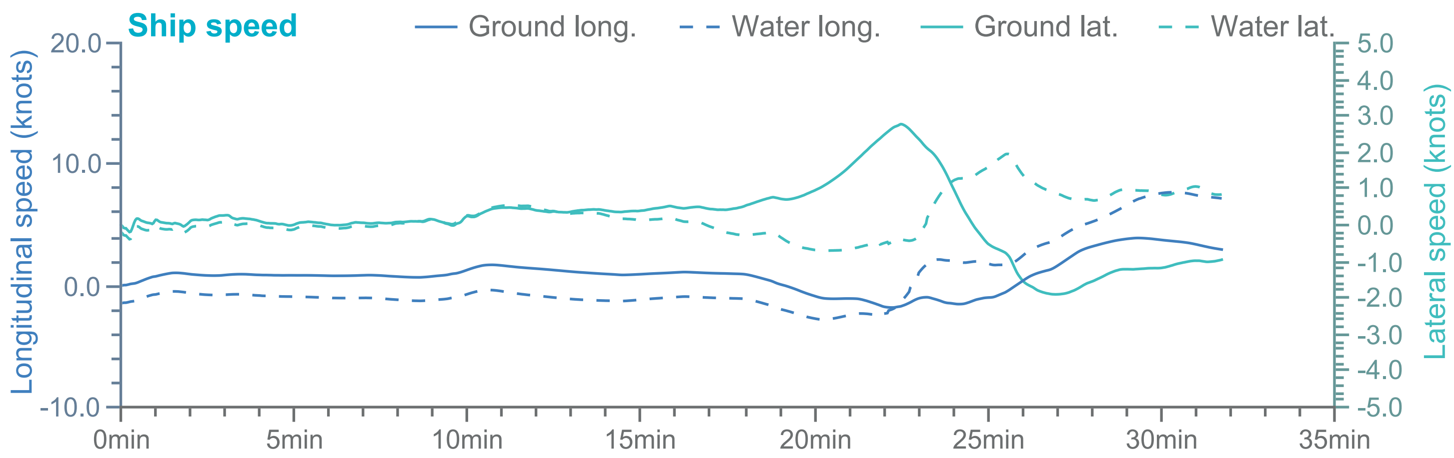
Ships plotted every 1 mins, highlight every 10 mins

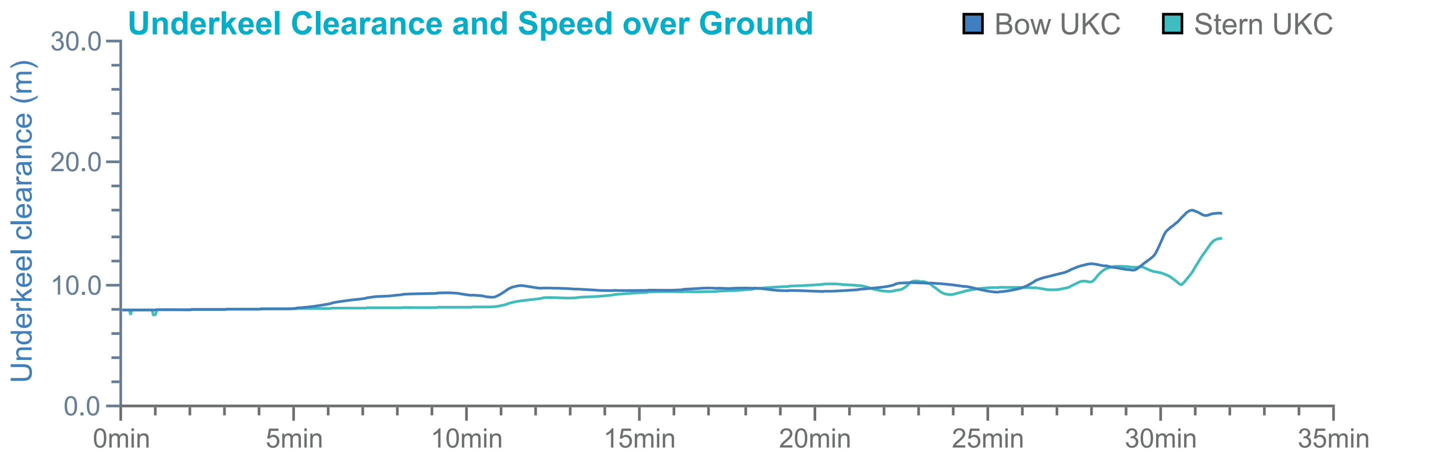

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

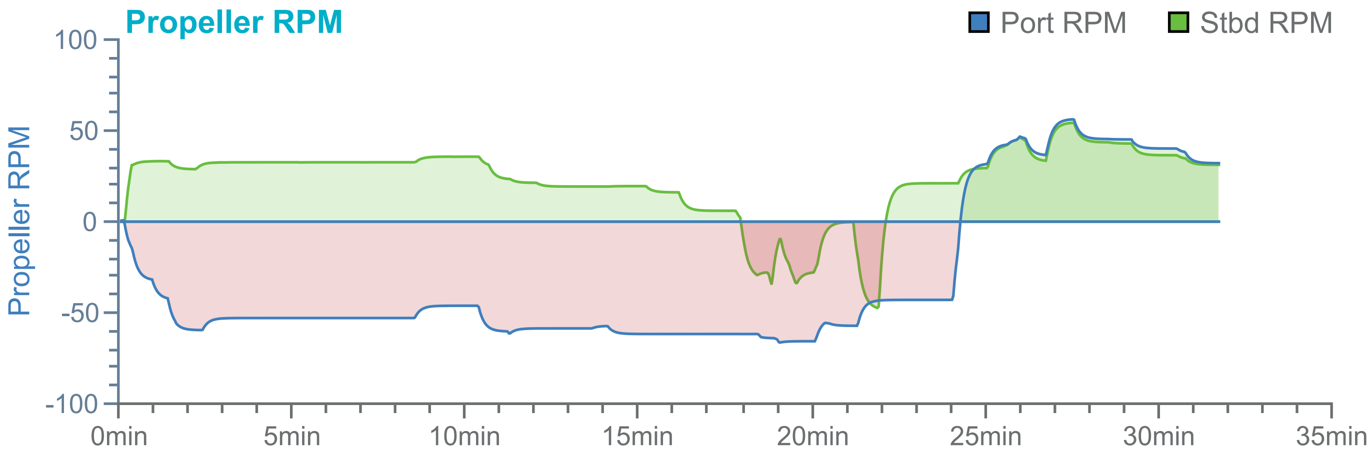

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

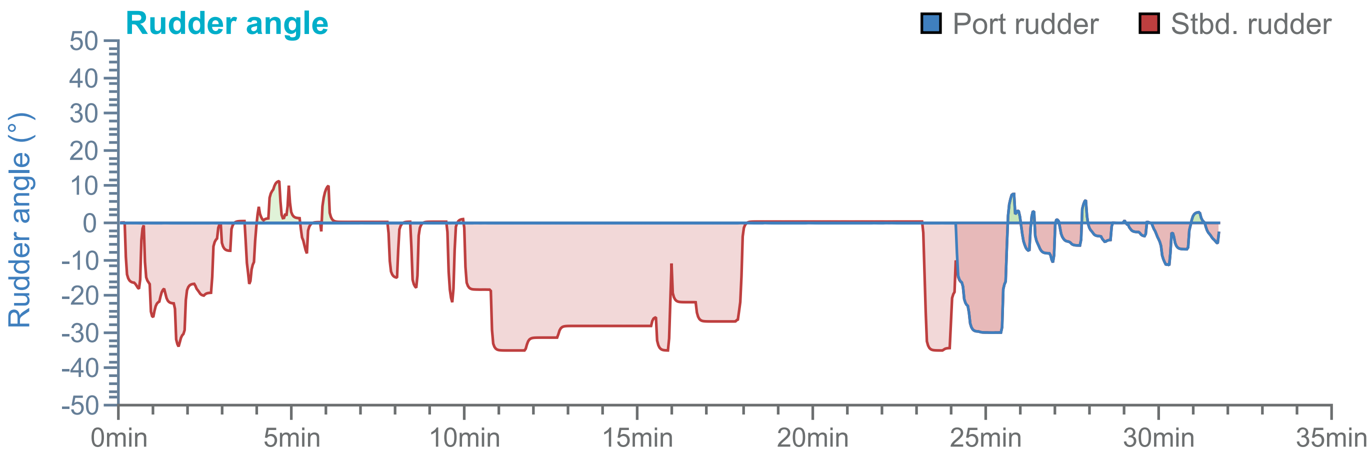

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

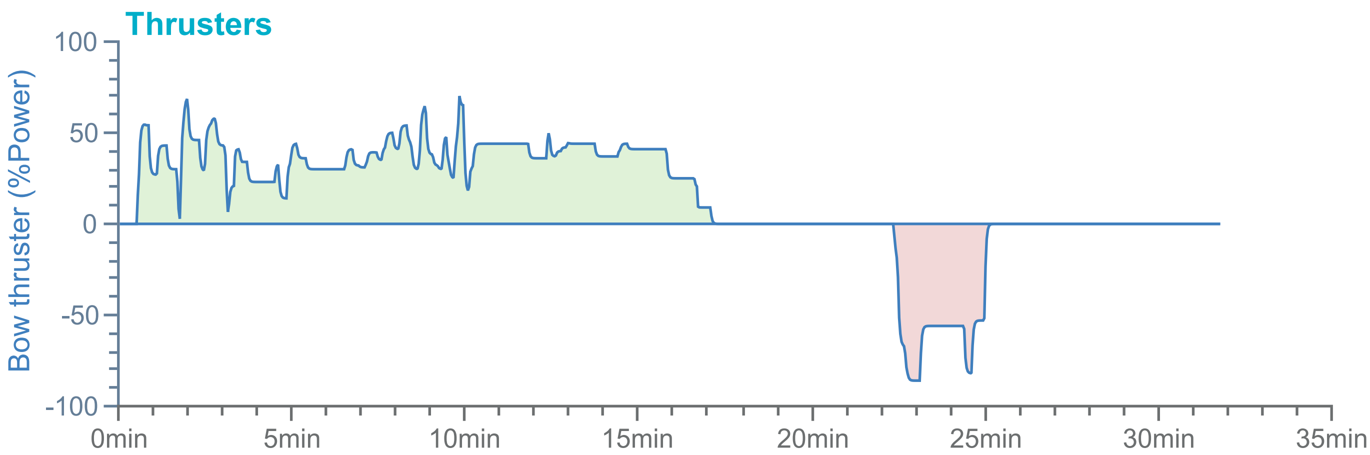

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

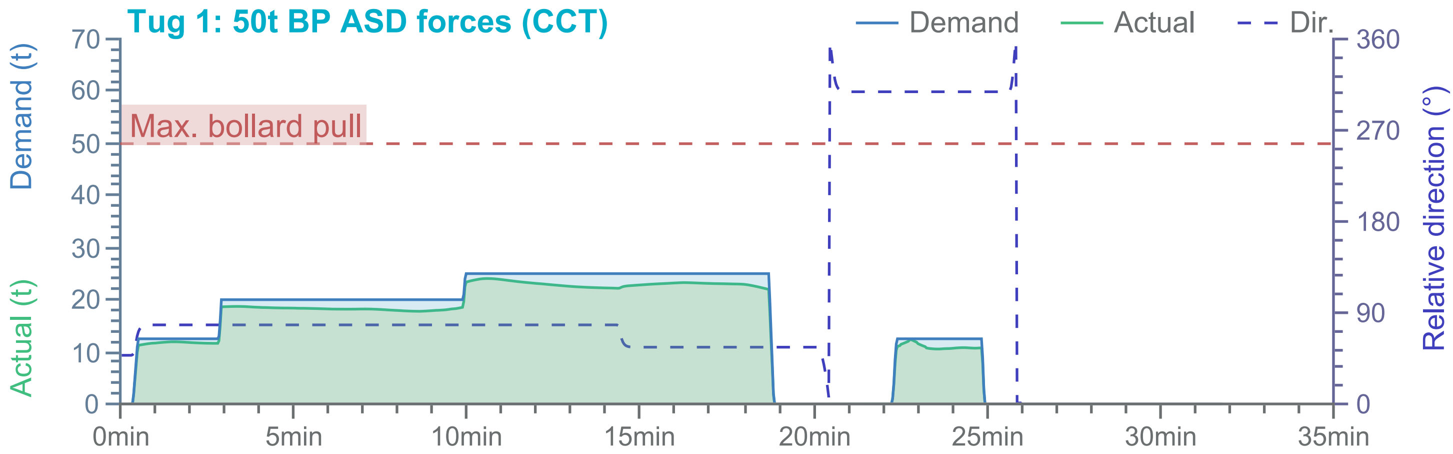

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min

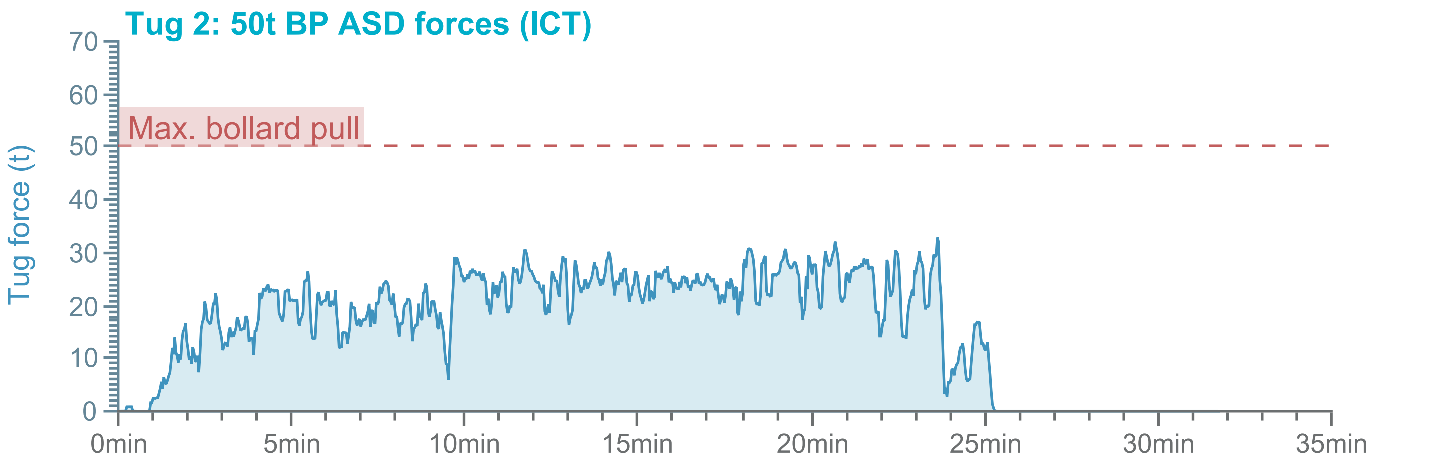

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

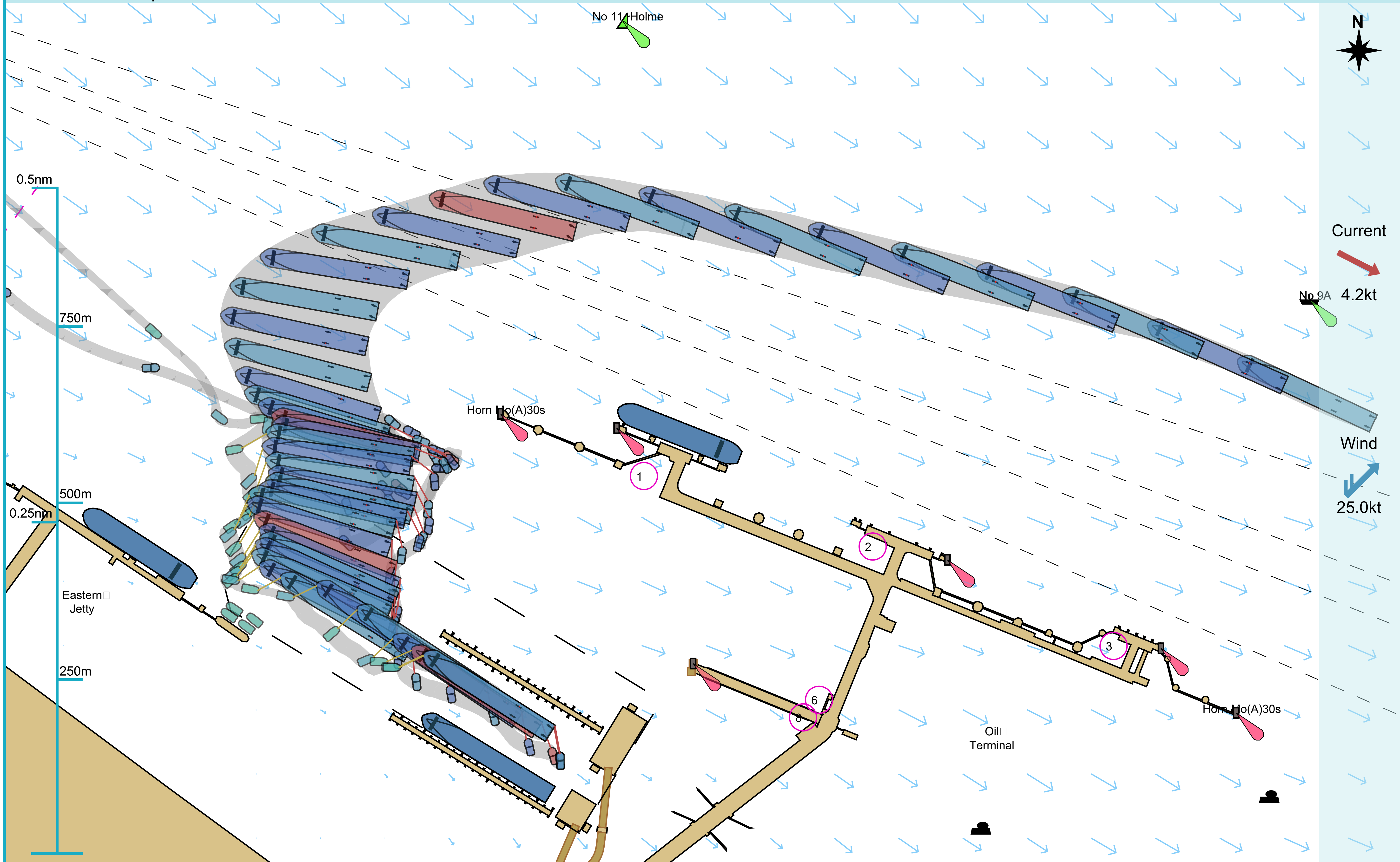

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Max. bollard pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min

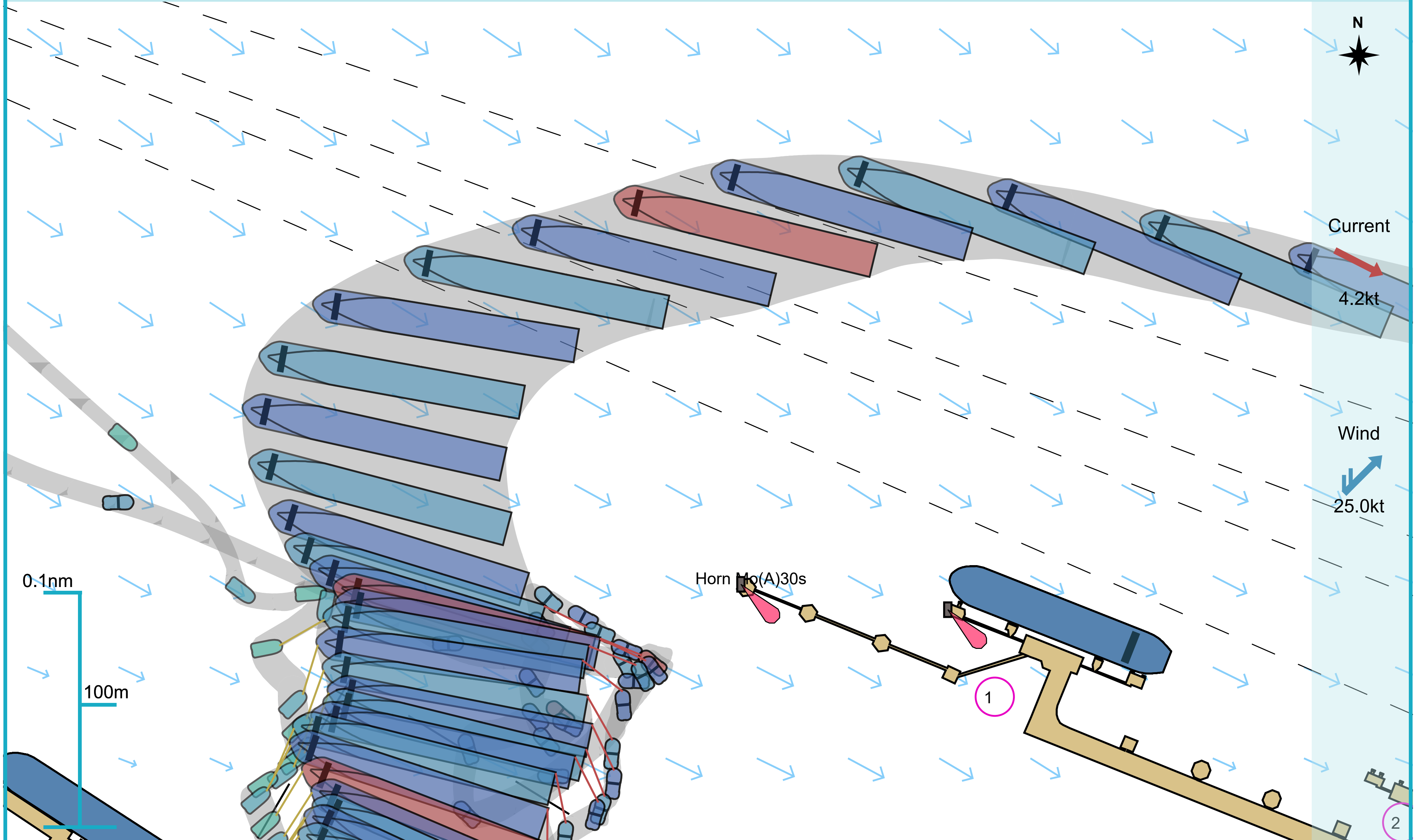

Tug 2: 50t BP ASD forces (ICT)
Max. bollard pull
Tug force (t)
0
10
20
30
40
50
60
70
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot



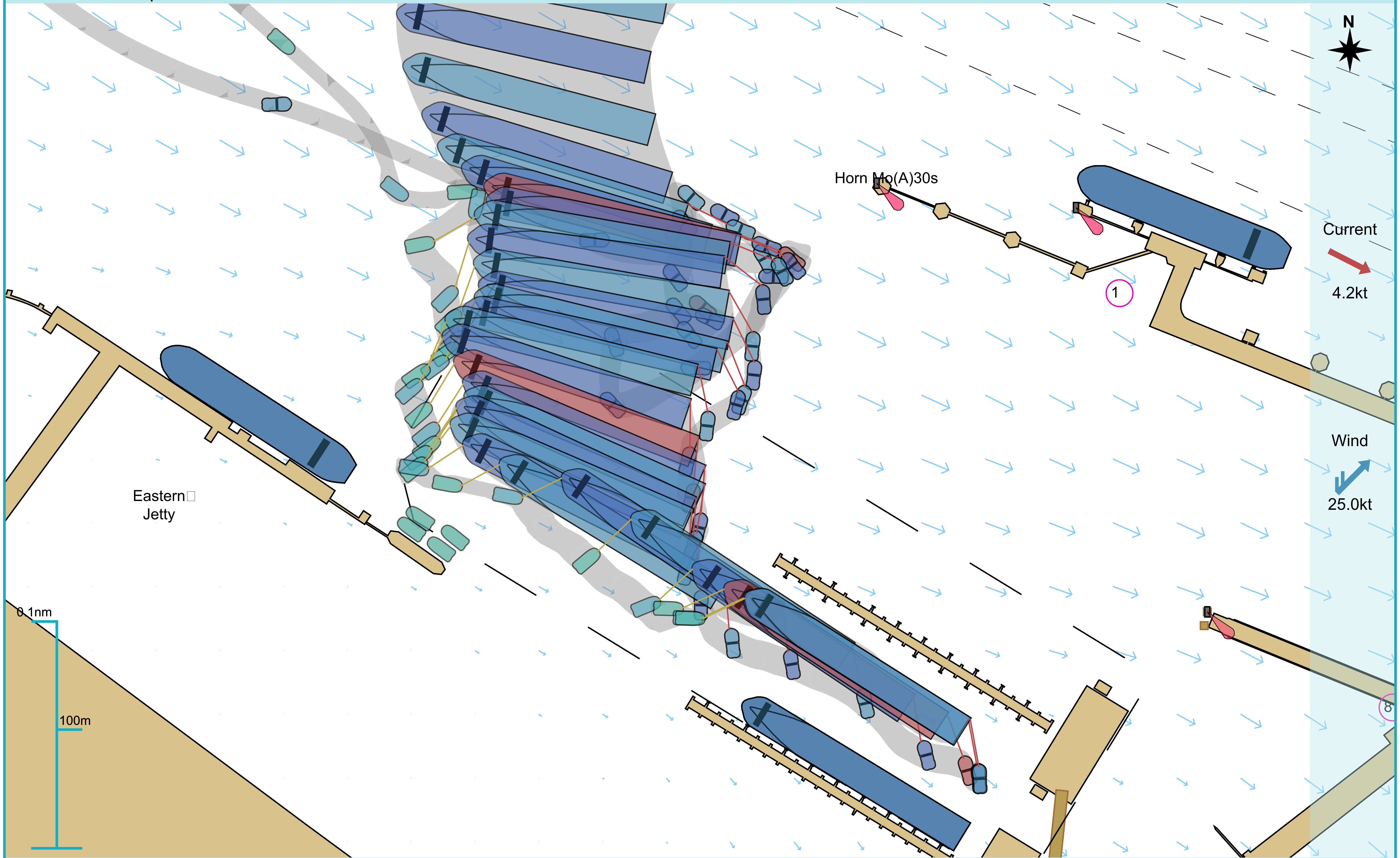
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

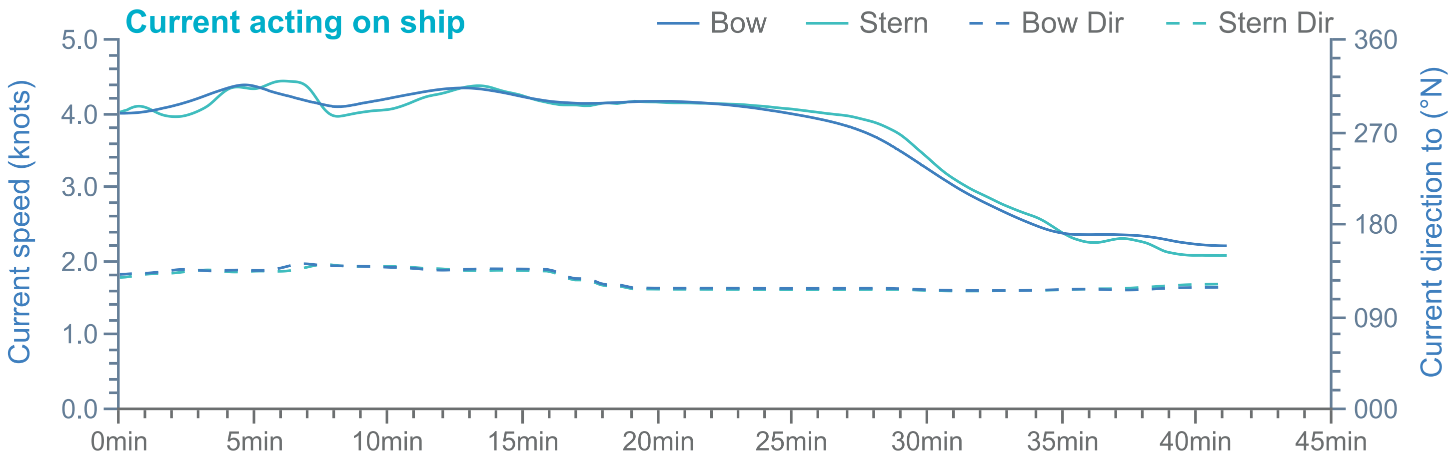


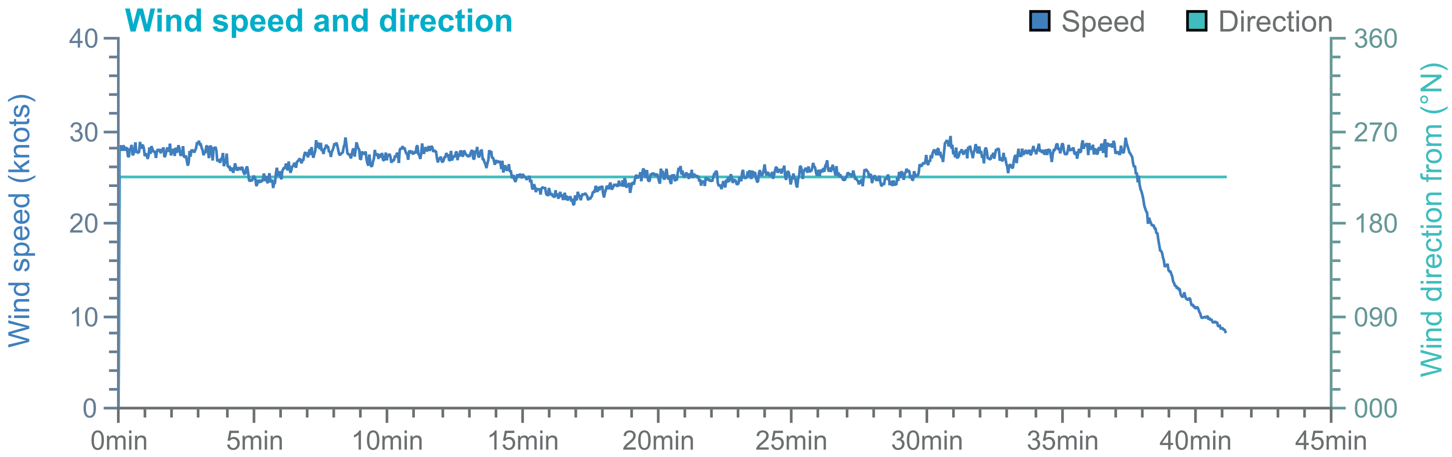
Ships plotted every 1 mins, highlight every 10 mins

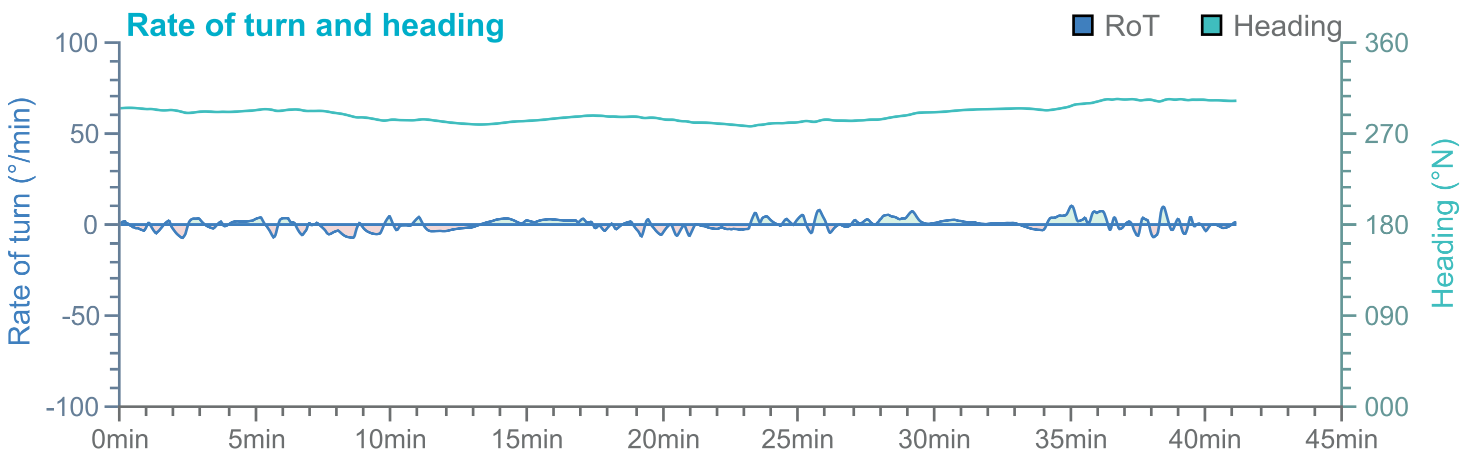
Manoeuvre track plot

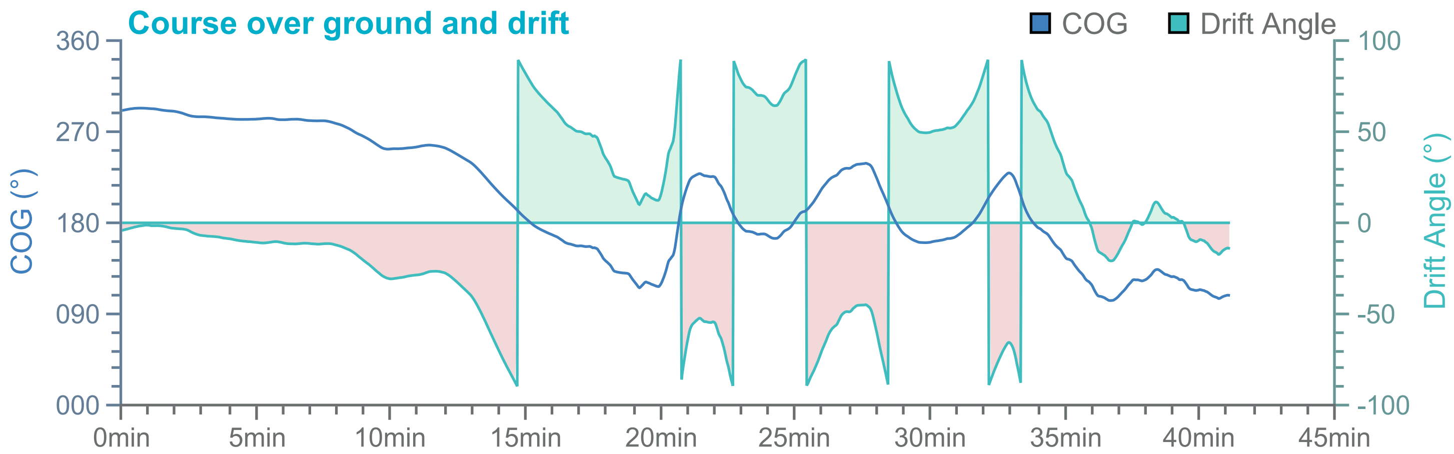


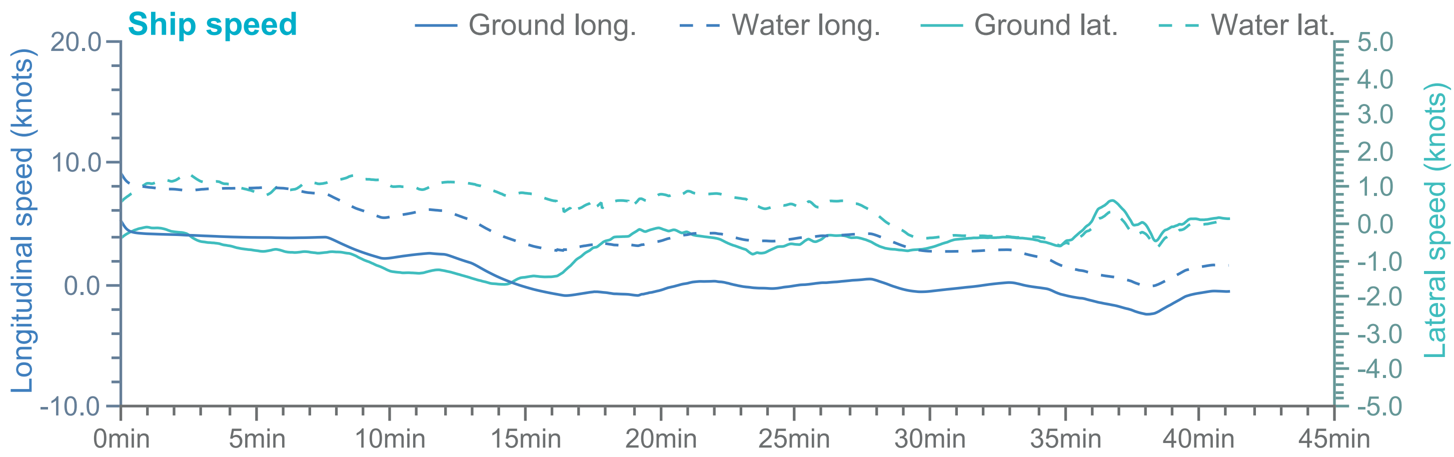
Ships plotted every 1 mins, highlight every 10 mins

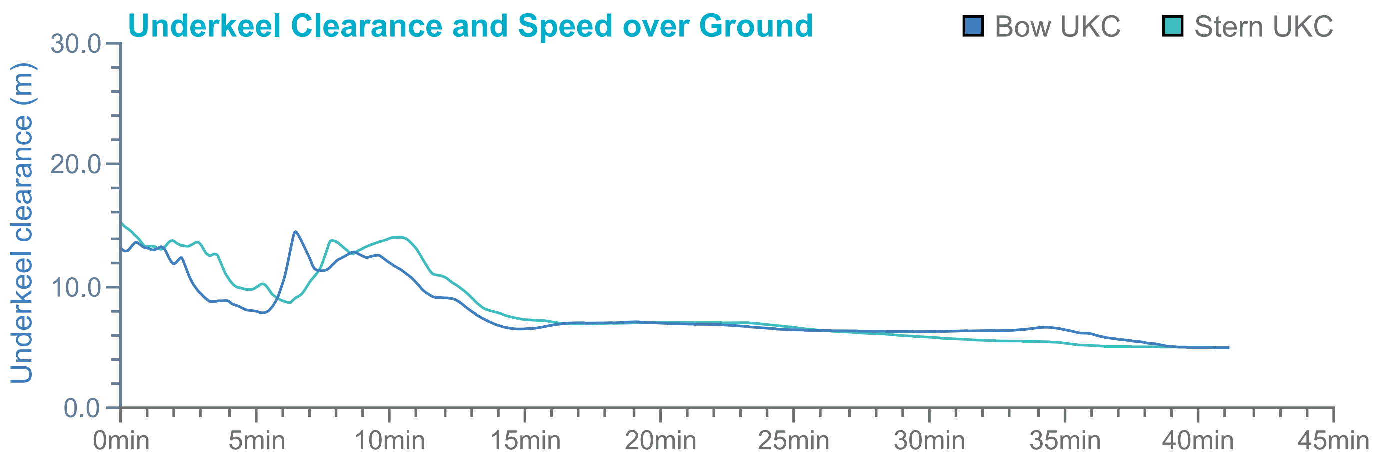

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

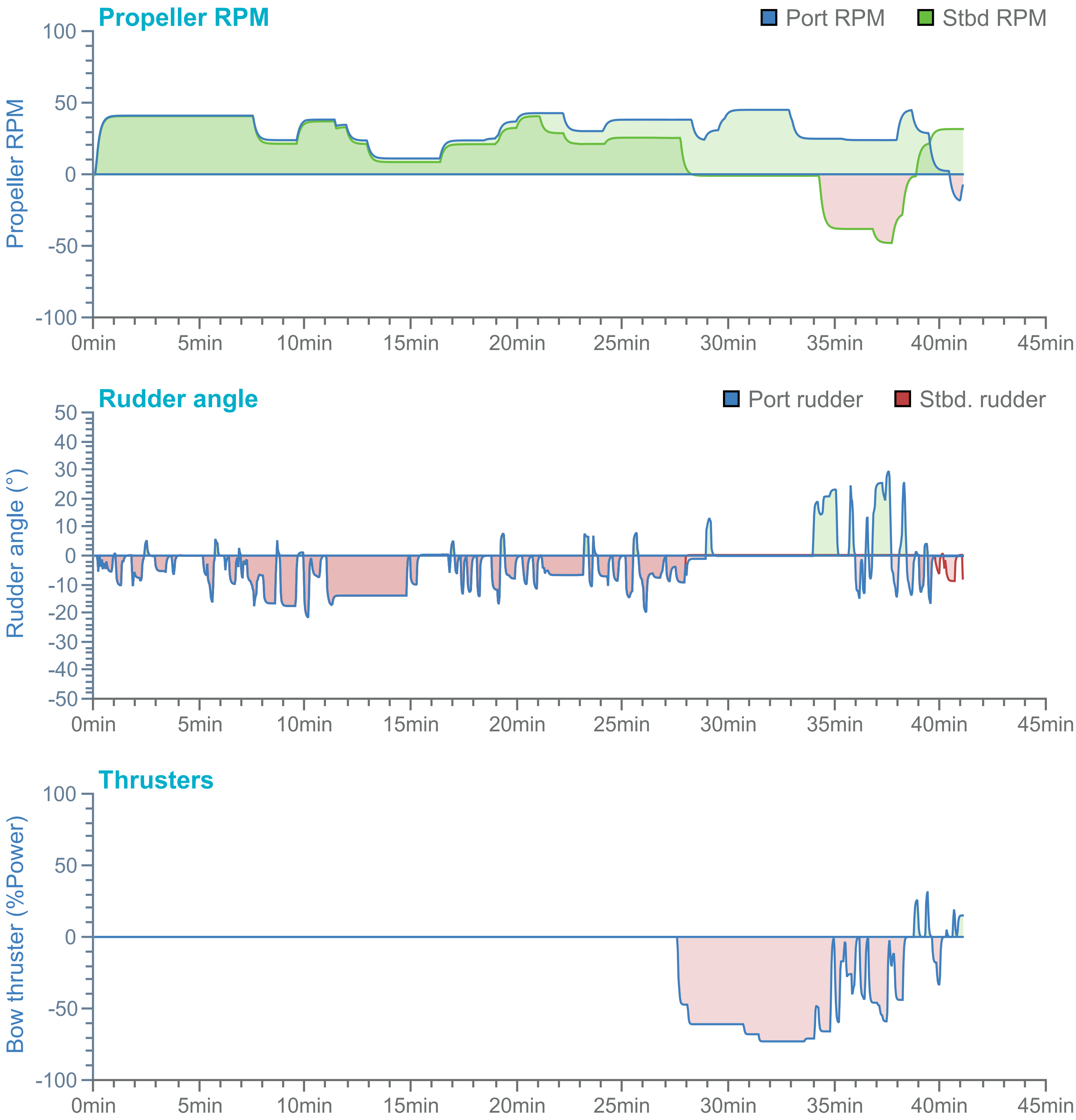

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

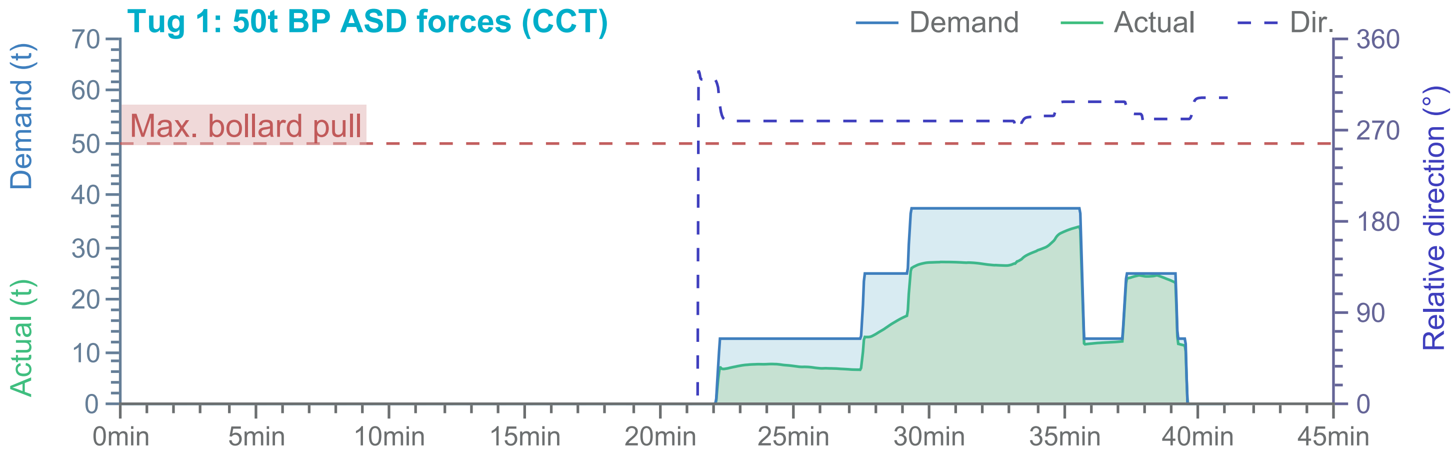

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

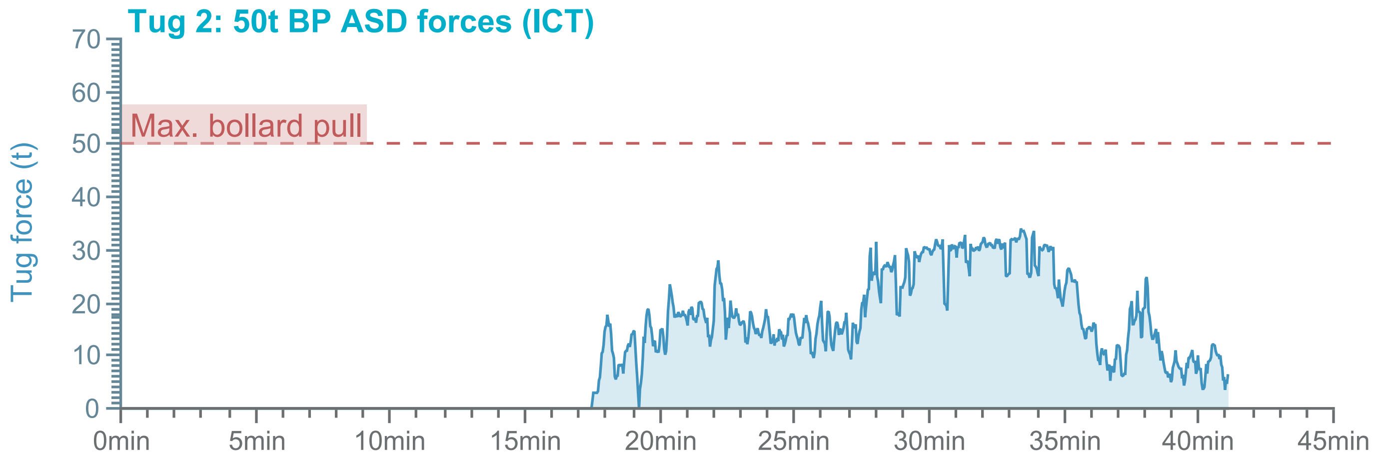

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

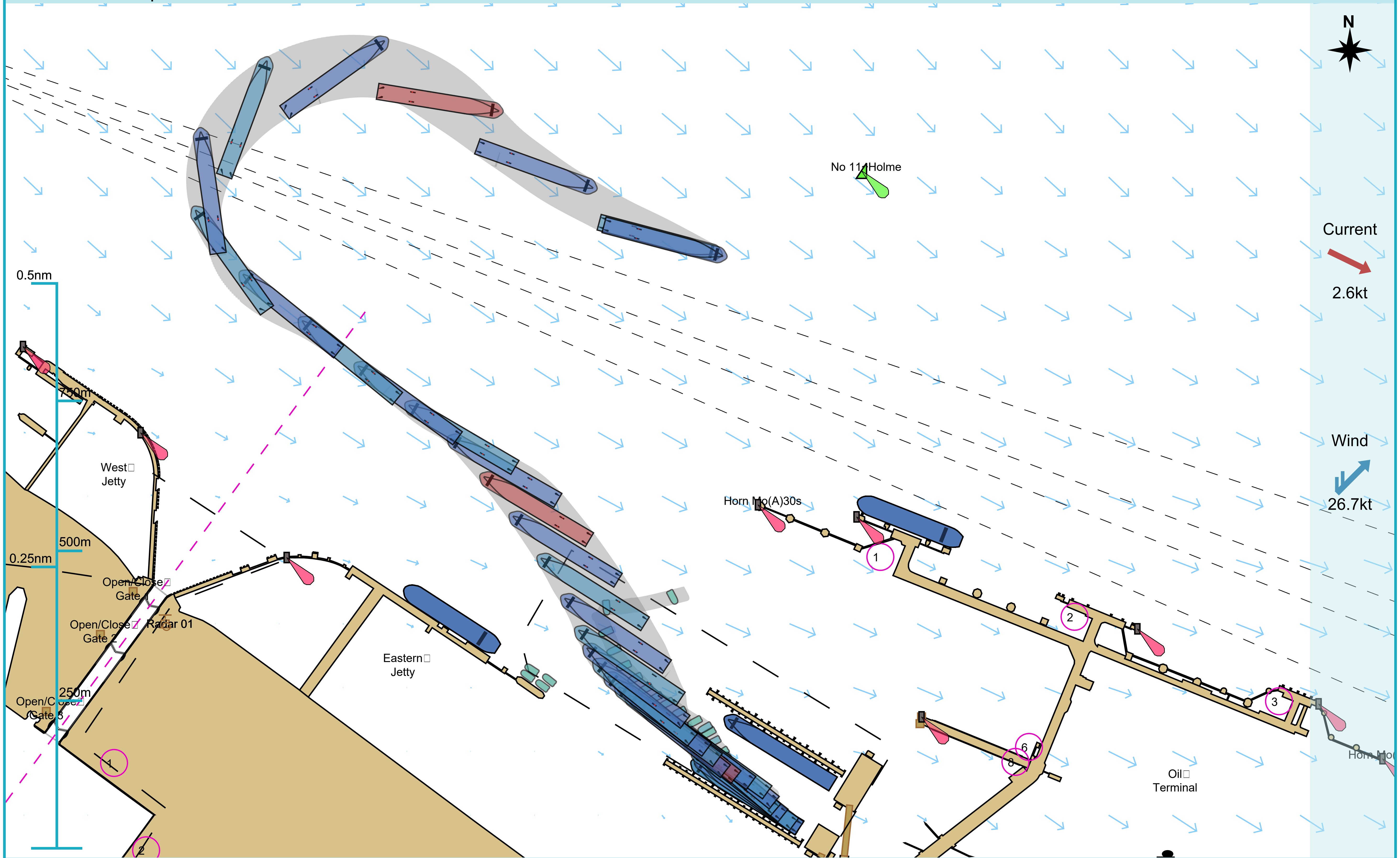

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
Thrusters
Bow thruster (%Power)


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Max. bollard pull
Demand (t)
Actual (t)
Relative direction (°)
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

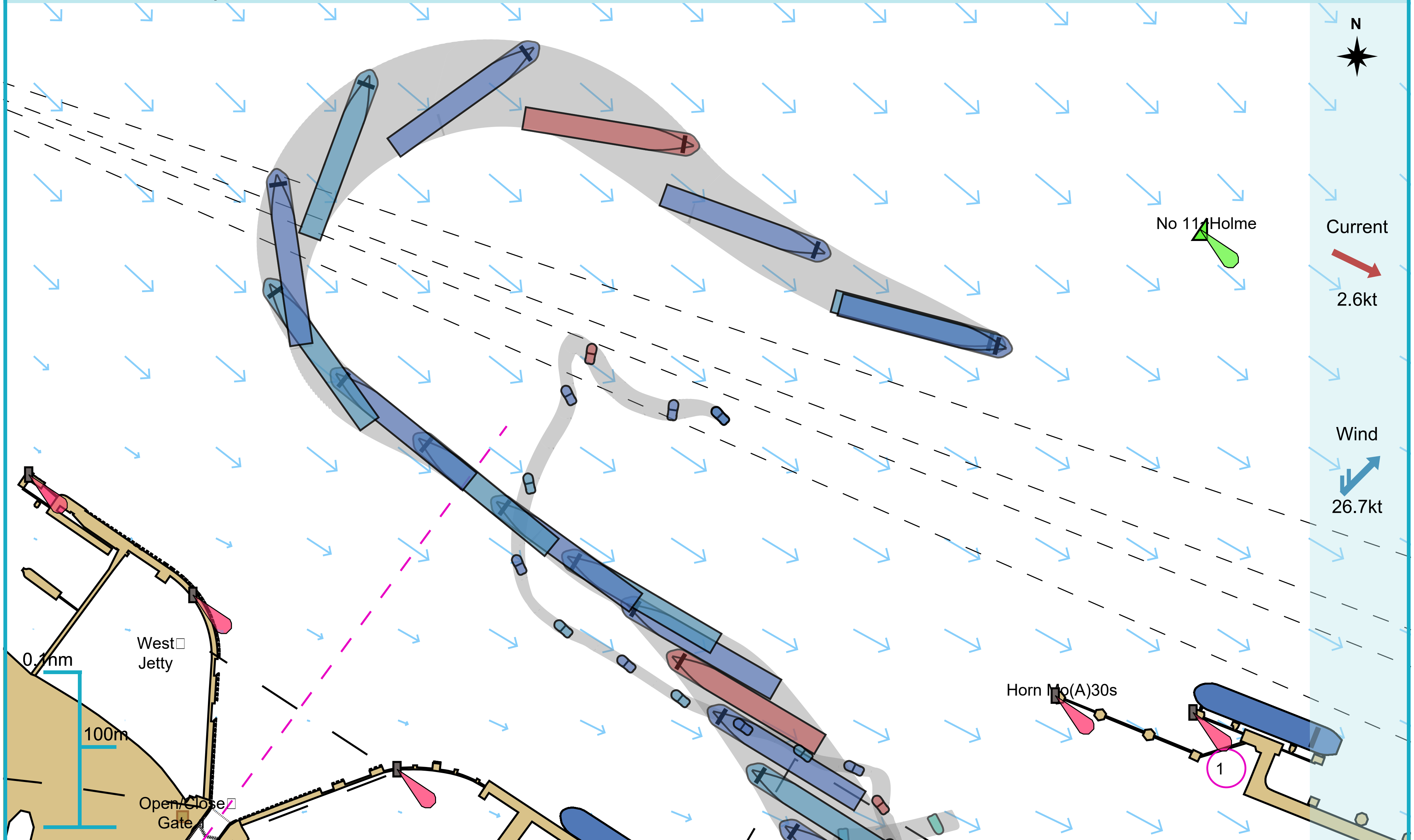

Tug 2: 50t BP ASD forces (ICT)
Max. bollard pull
Tug force (t)
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

Manoeuvre track plot



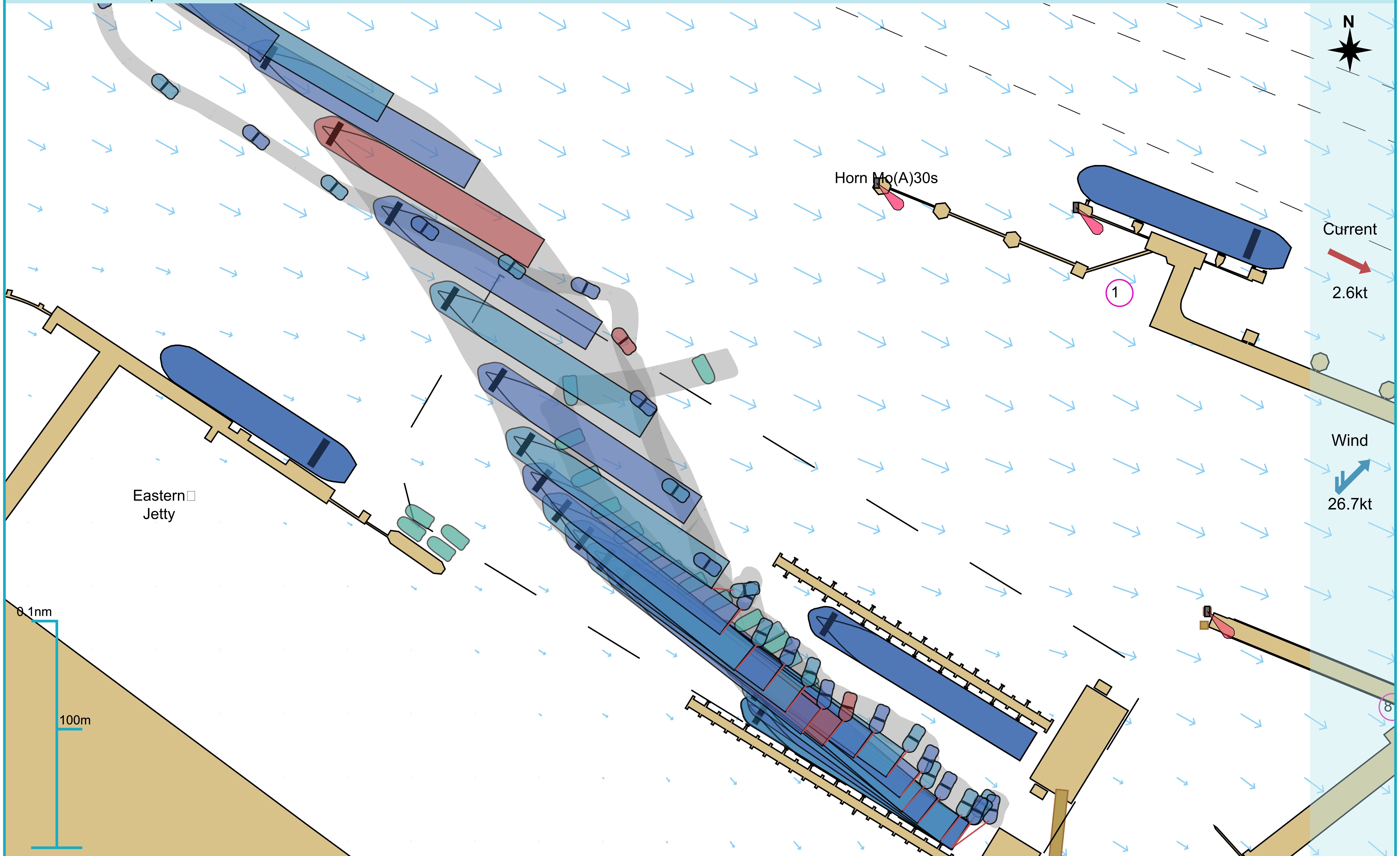
Ships plotted every 1 mins, highlight every 10 mins

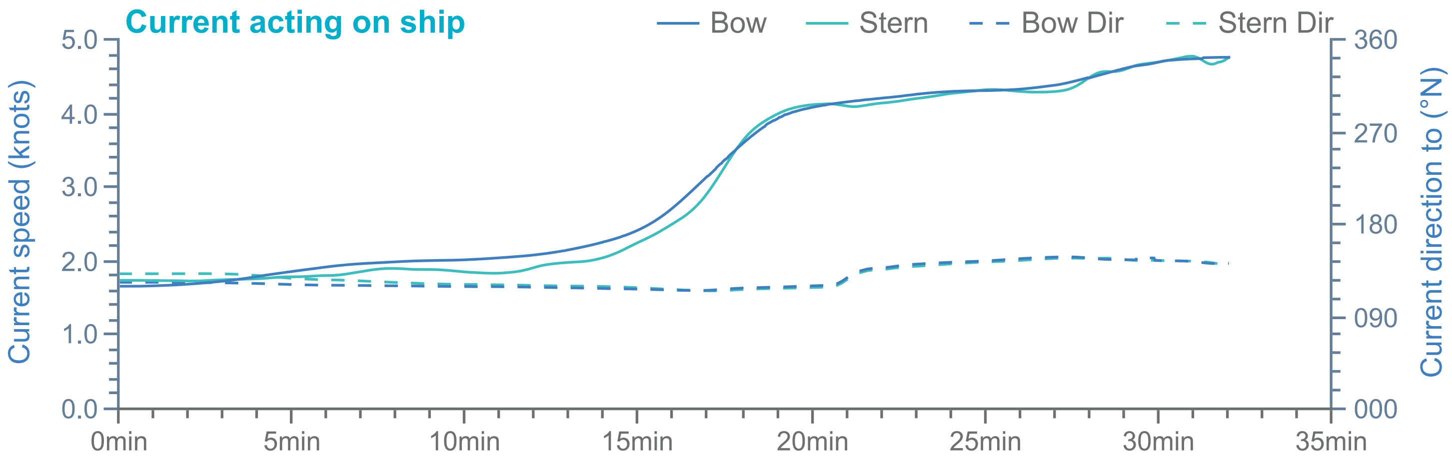
Manoeuvre track plot

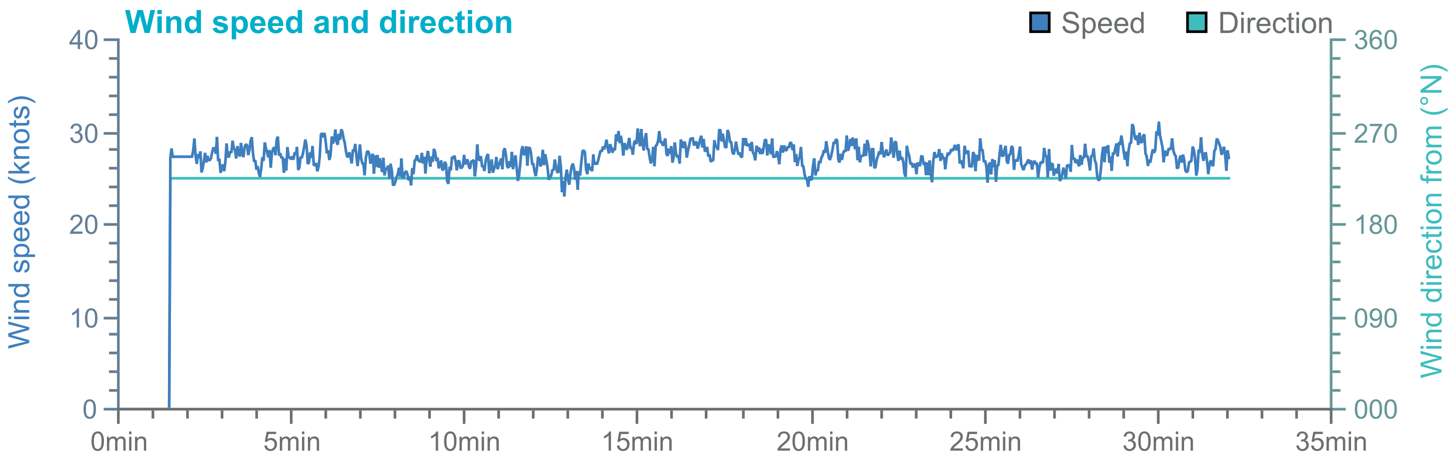


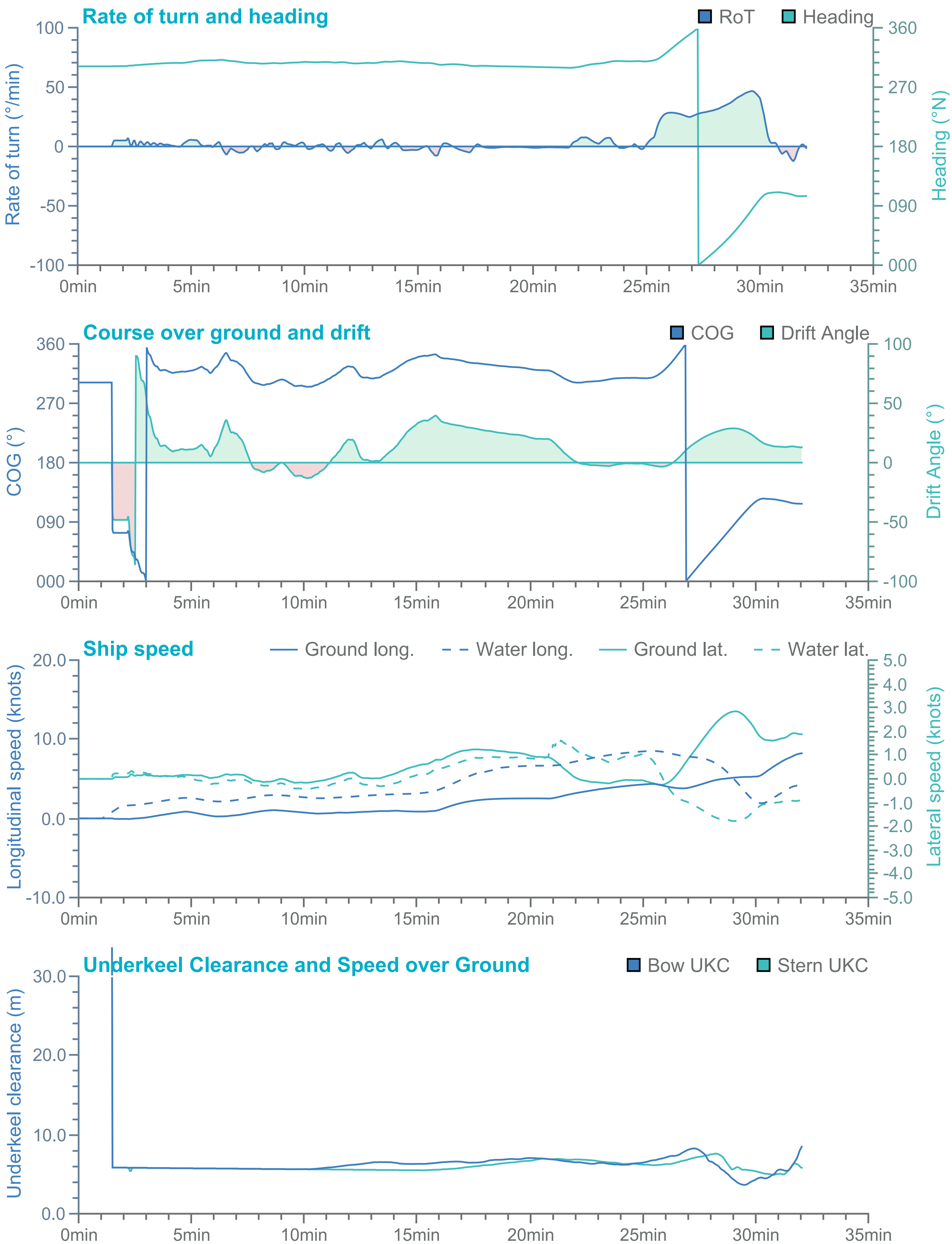
Ships plotted every 1 mins, highlight every 10 mins

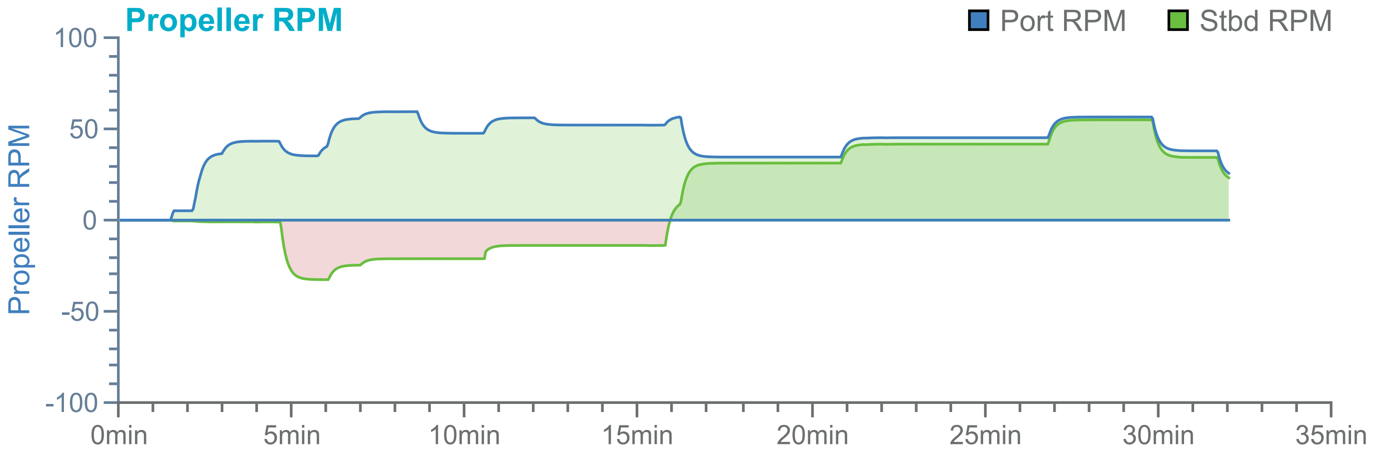
Manoeuvre track plot

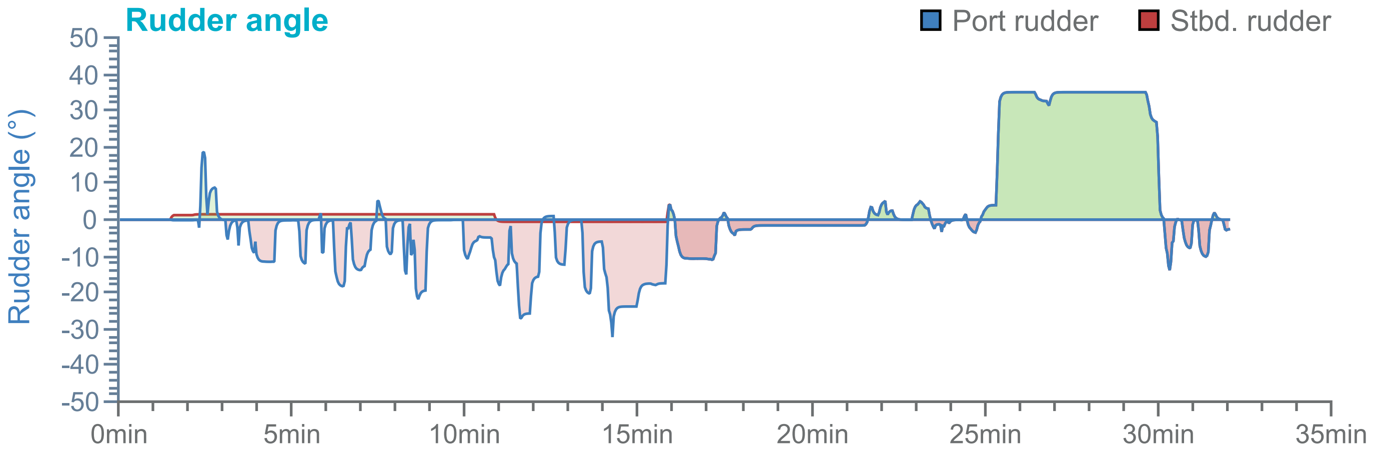


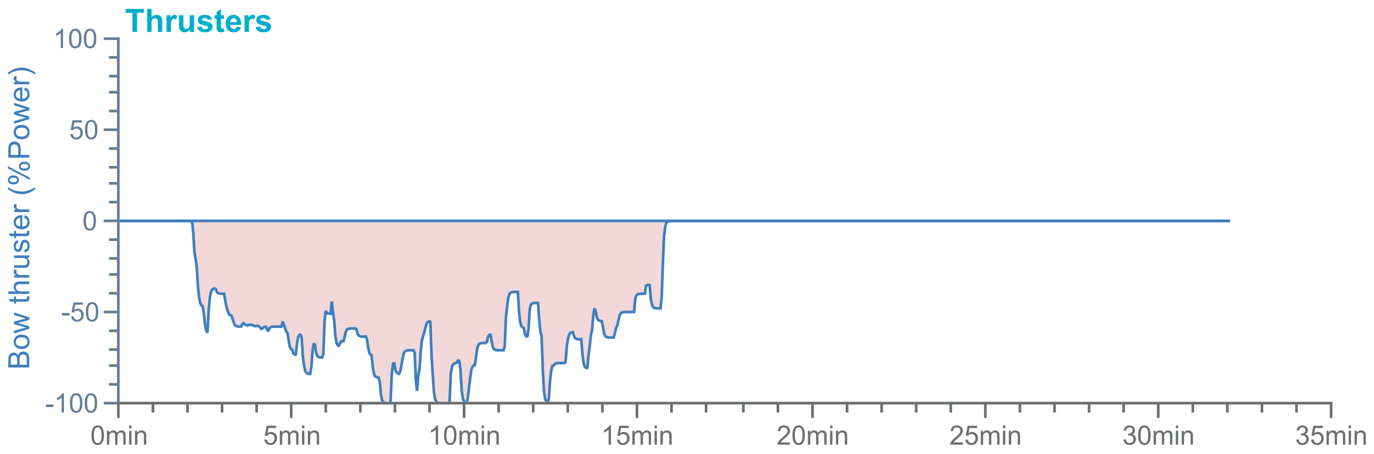

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

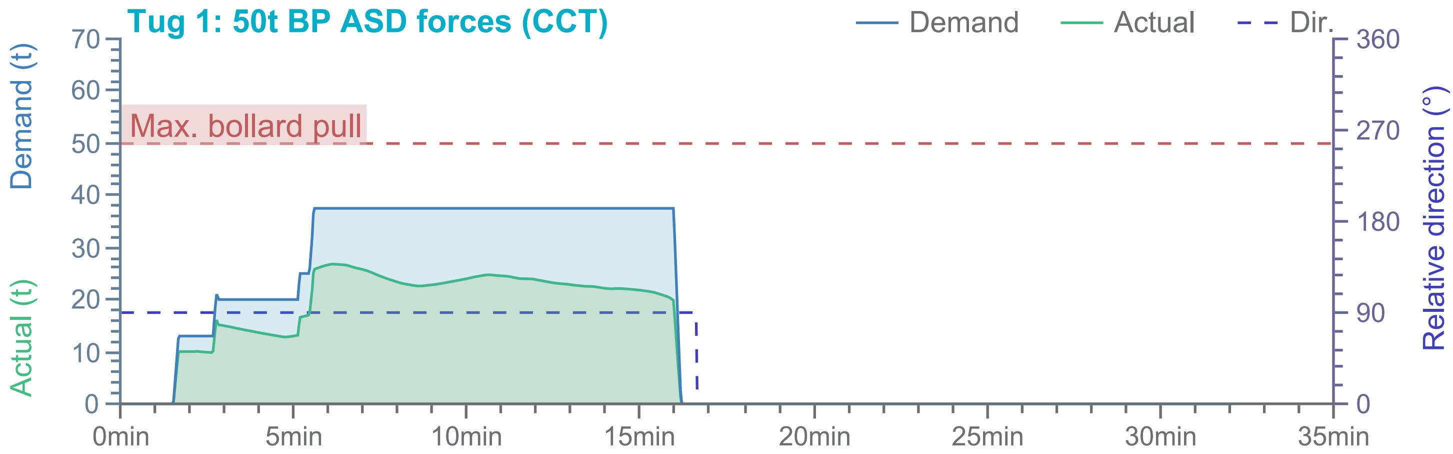

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

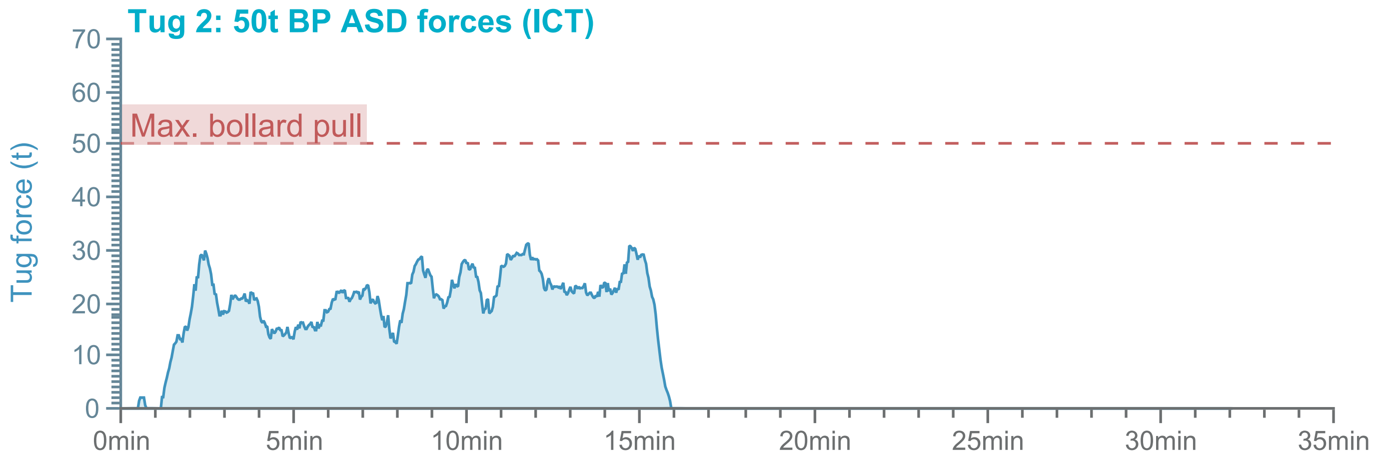

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

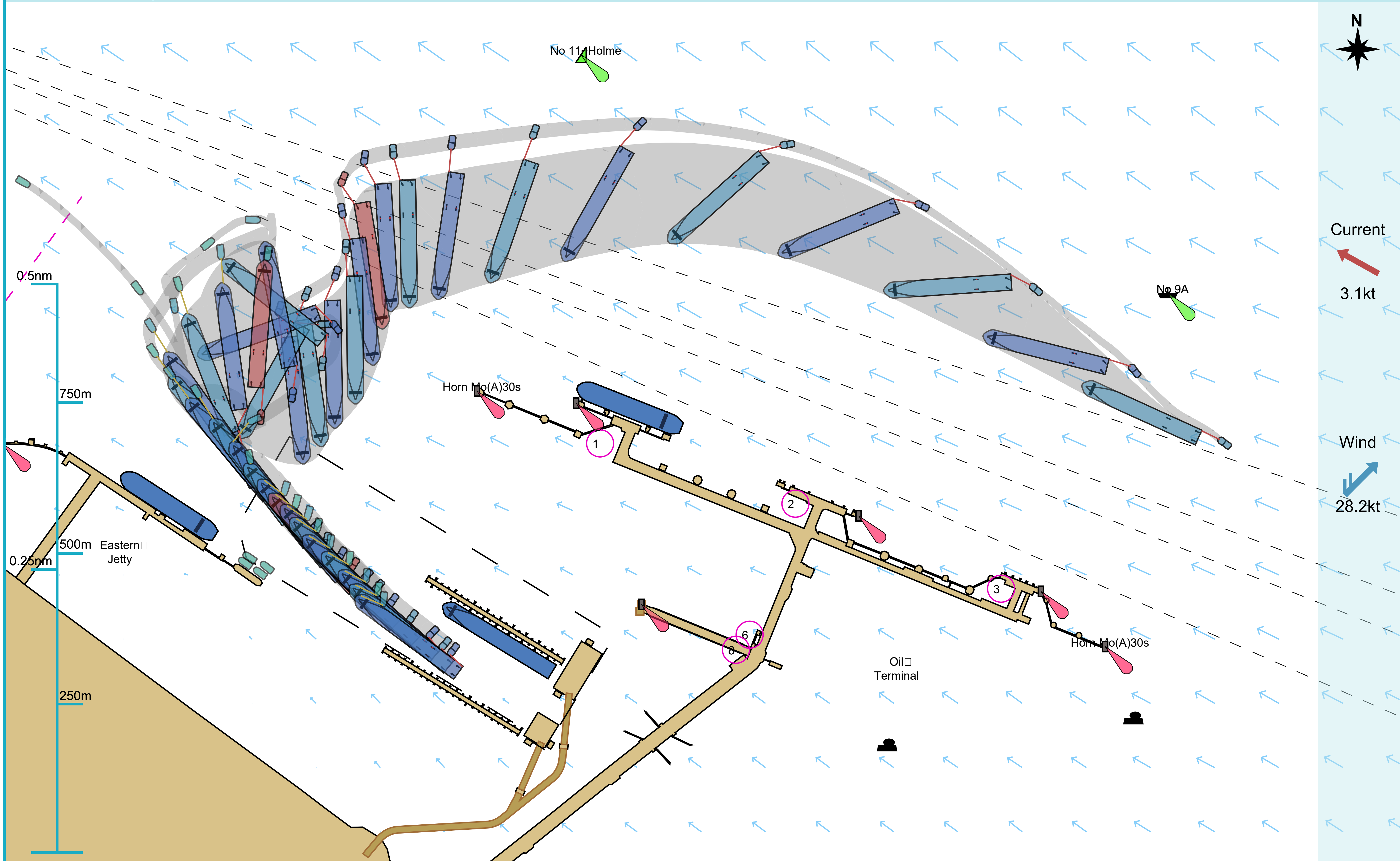

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Relative direction (°)
Max. bollard pull
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min

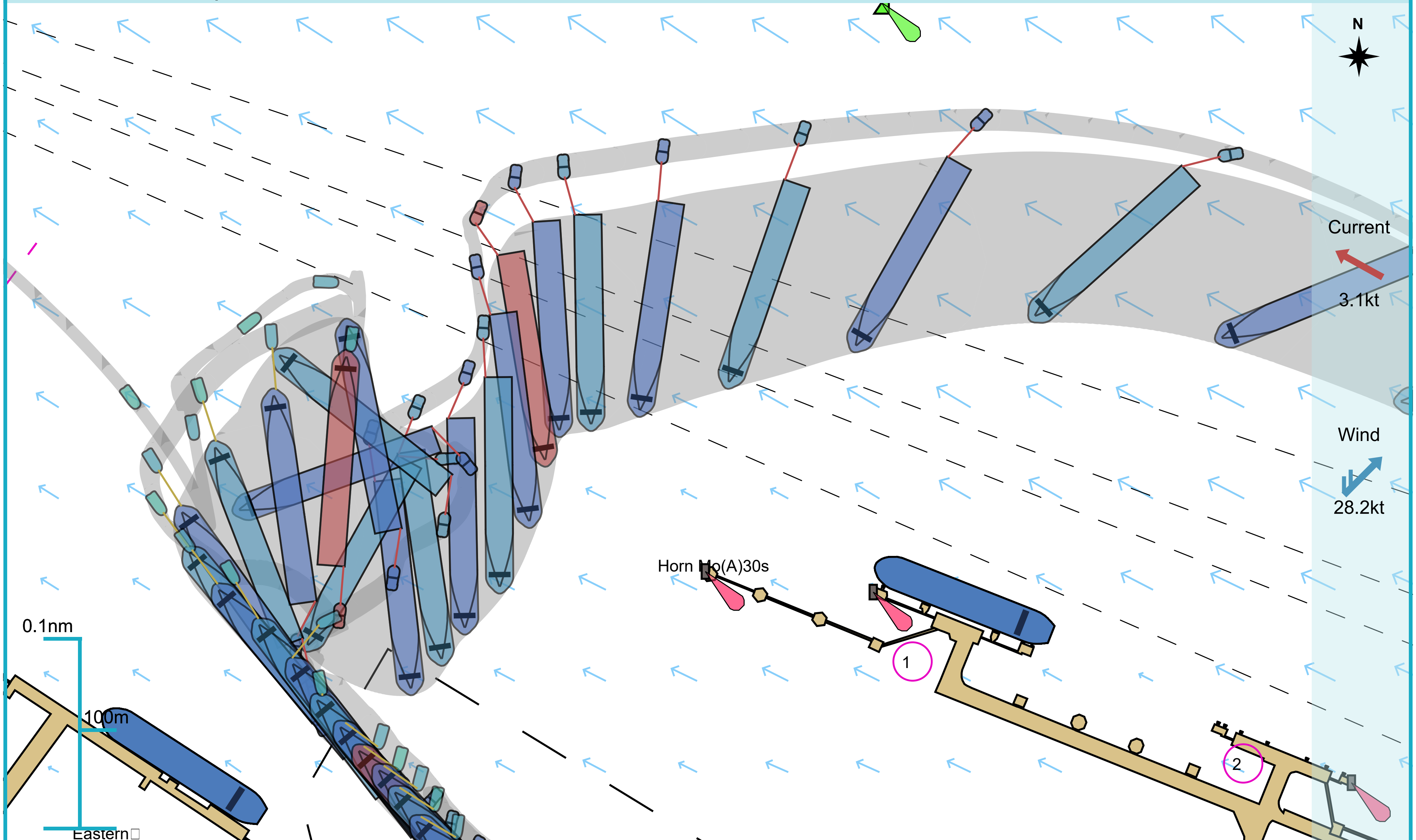

Tug 2: 50t BP ASD forces (ICT)
Tug force (t)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot



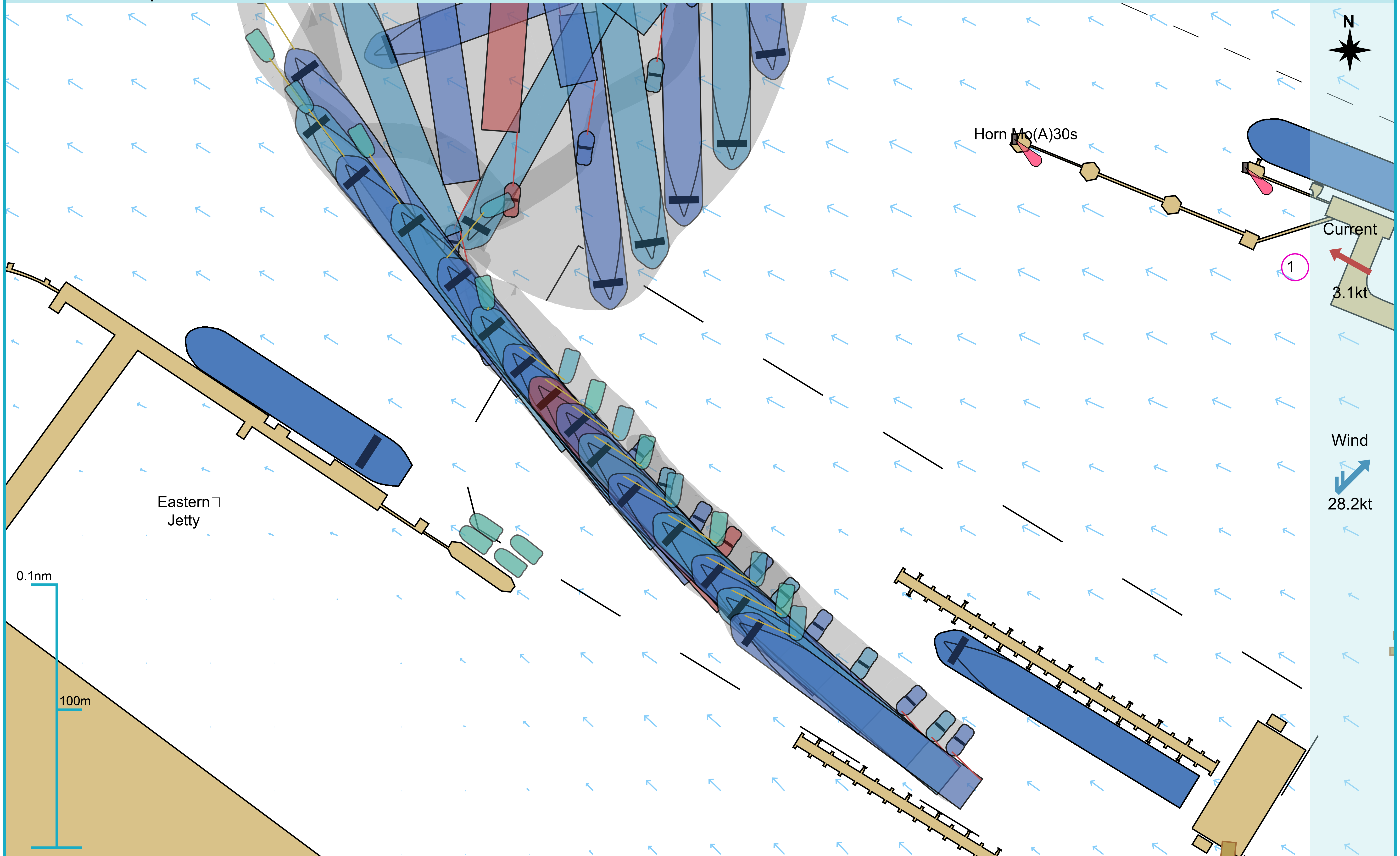
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



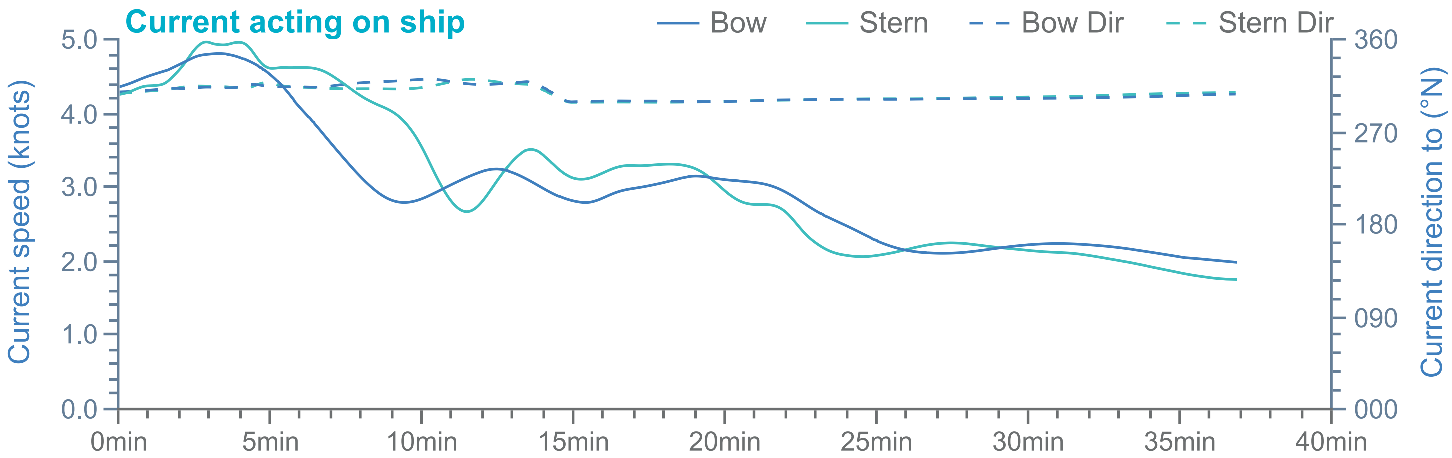
Ships plotted every 1 mins, highlight every 10 mins

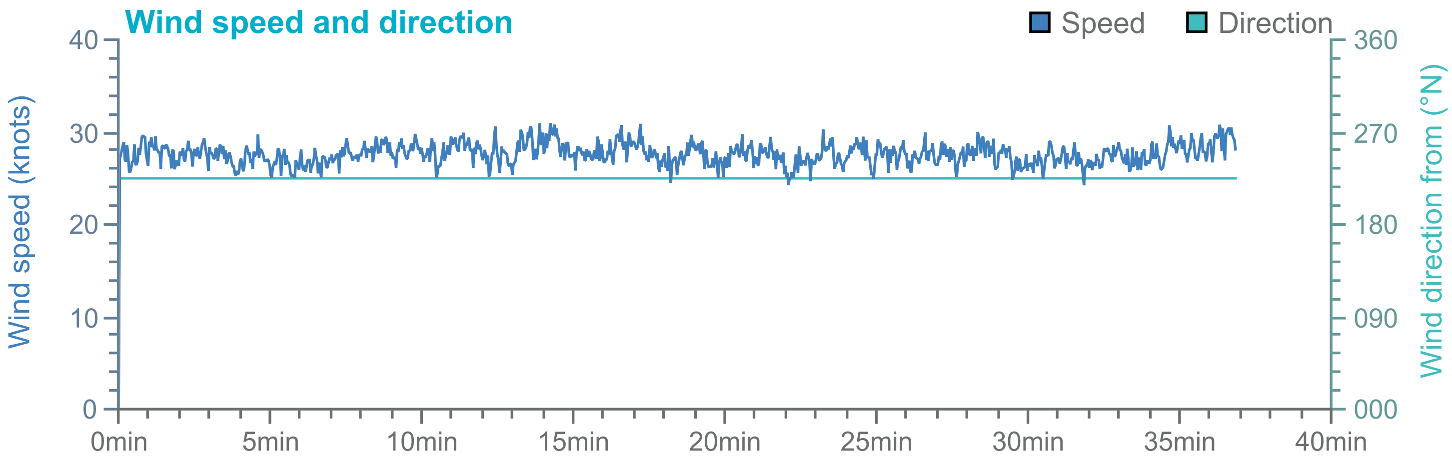
Manoeuvre track plot



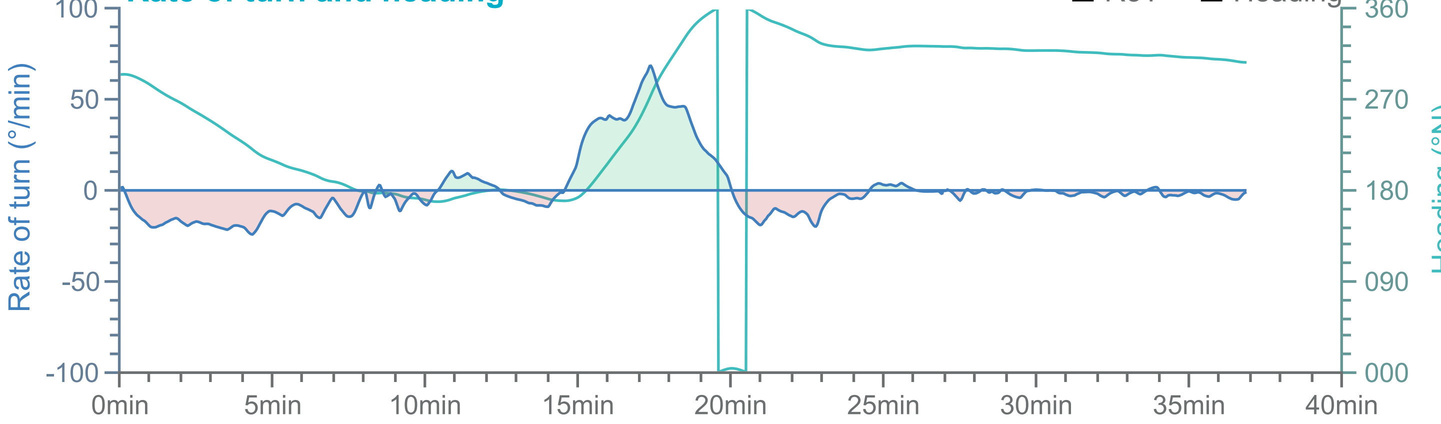
3.54 kts

Ships plotted every 1 mins, highlight every 10 mins

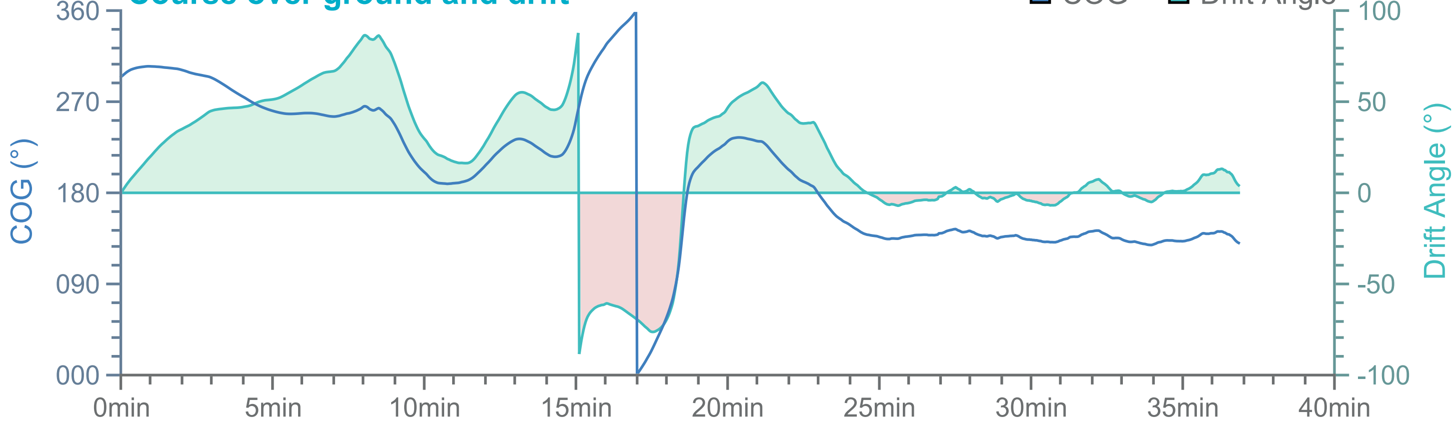

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
0.0
1.0
2.0
3.0
4.0
5.0
000
090
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min
40min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
0
10
20
30
40
000
090
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min
40min

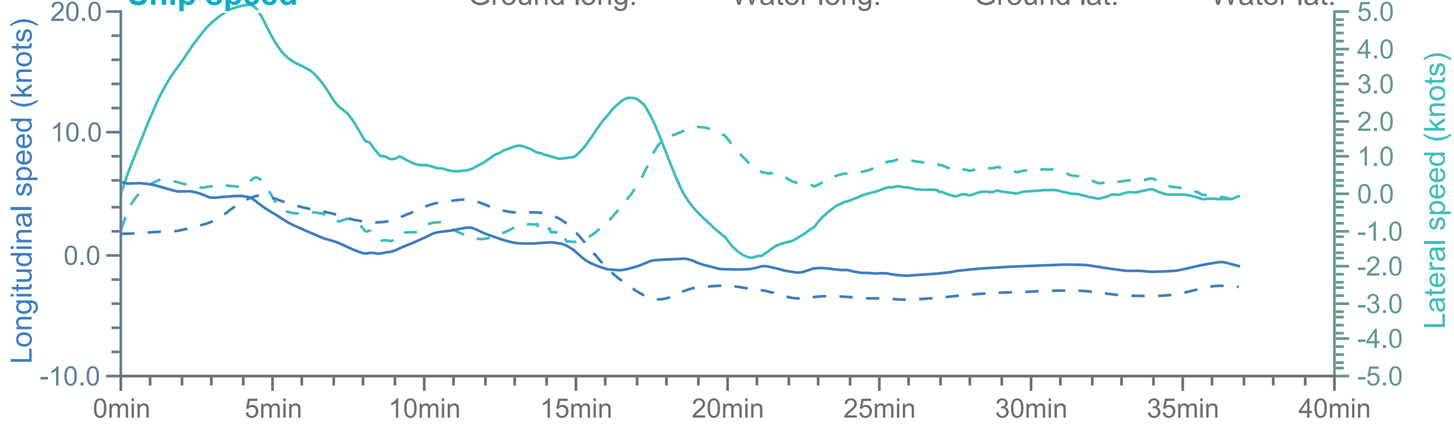
Rate of turn and heading



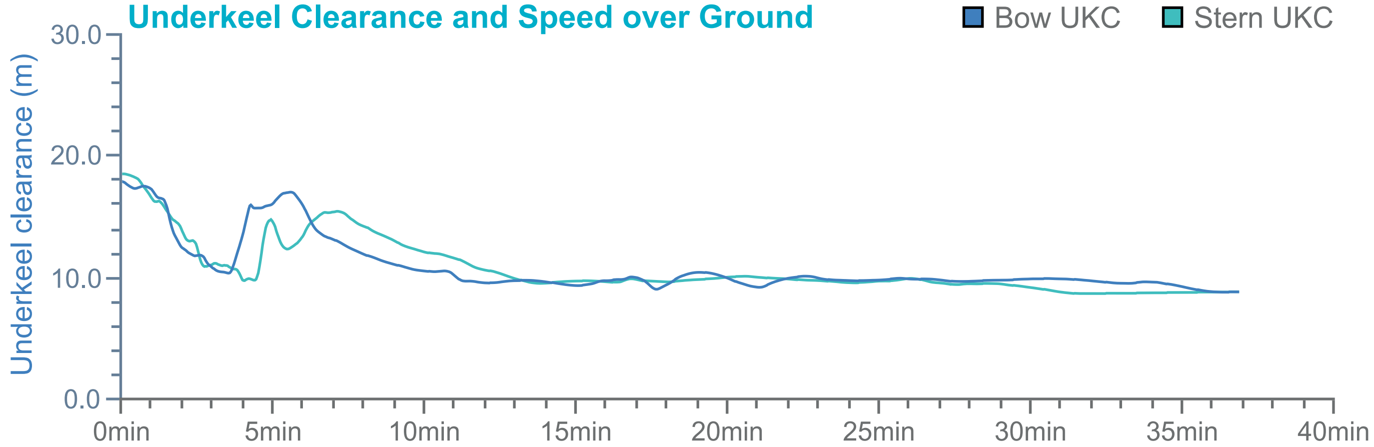
Course over ground and drift

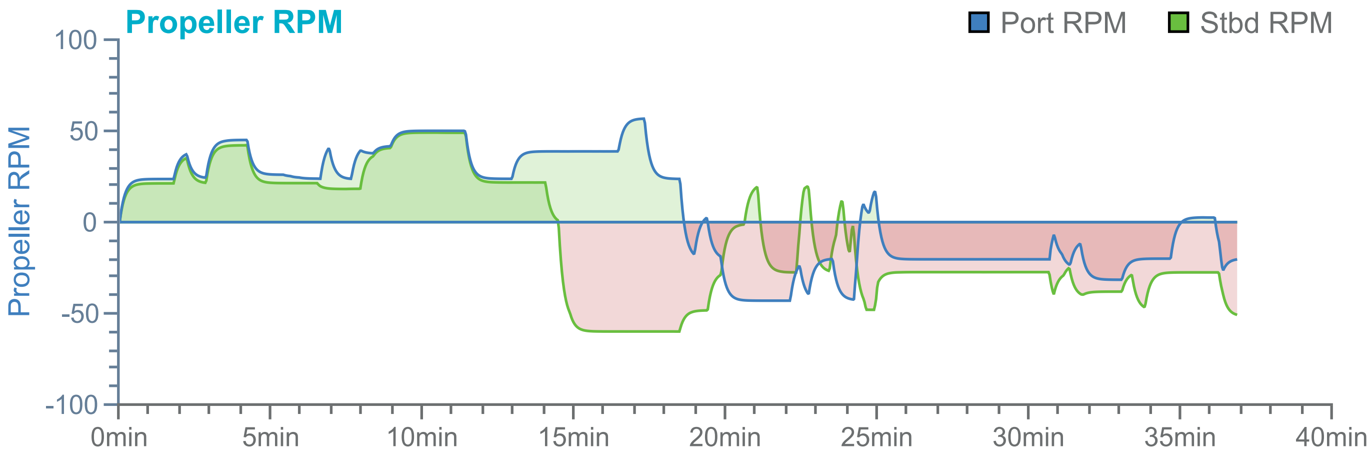


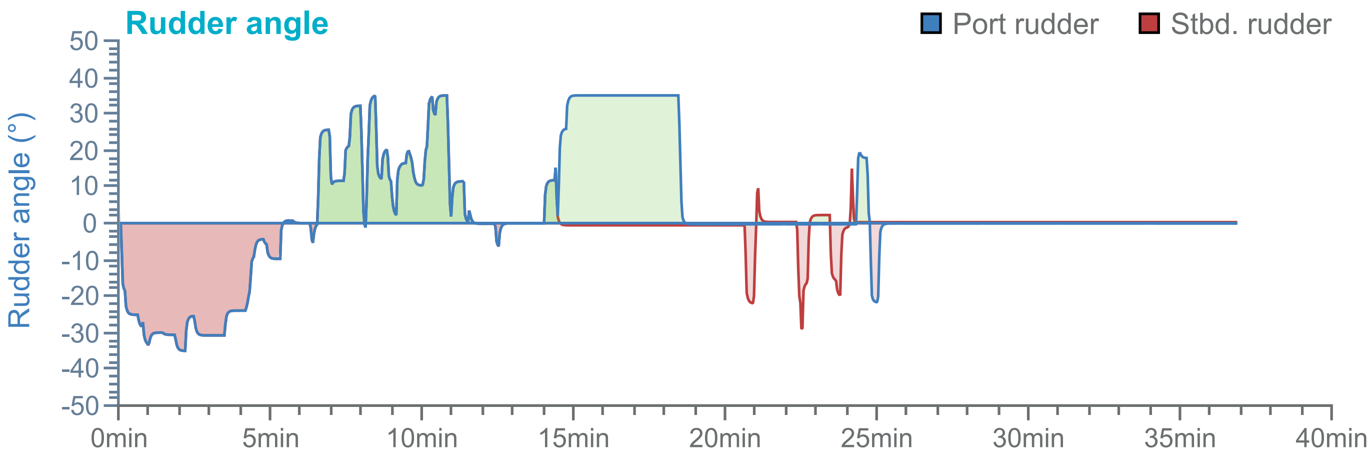
Ship speed

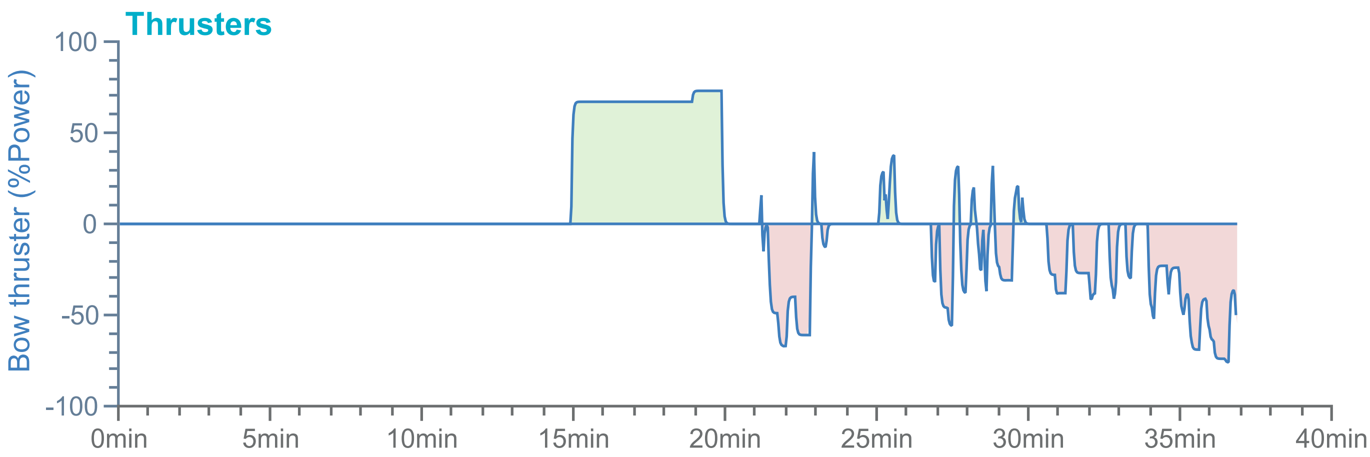


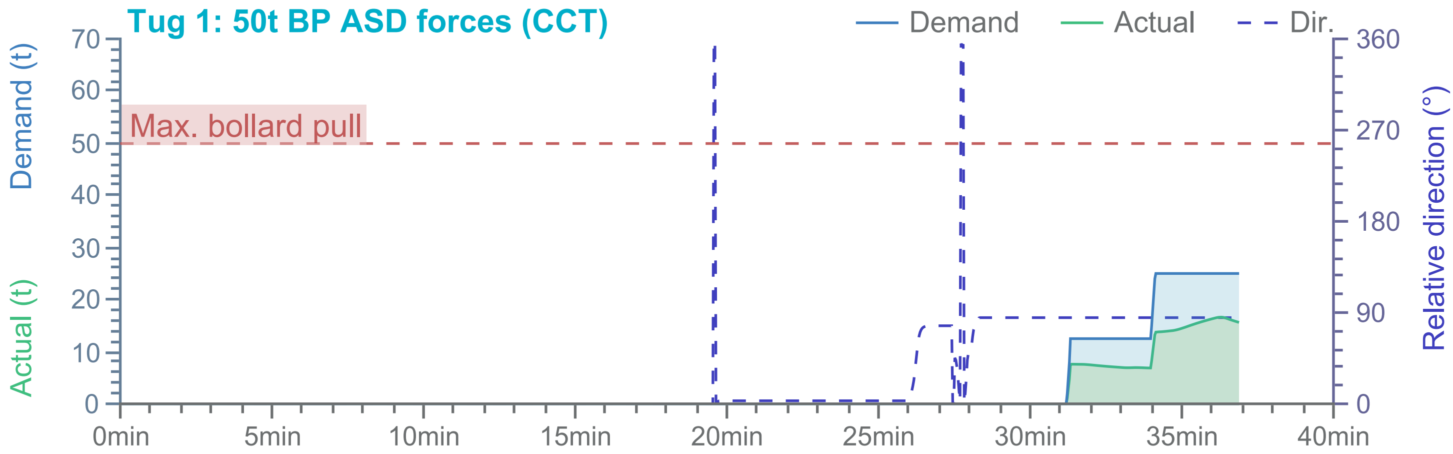
Underkeel Clearance and Speed over Ground

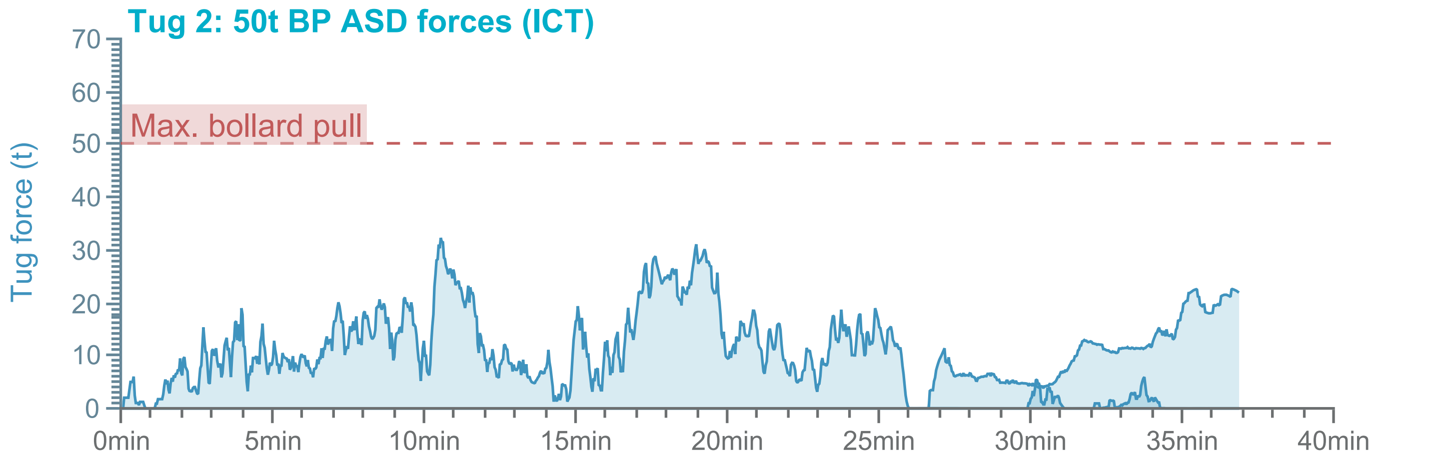



Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

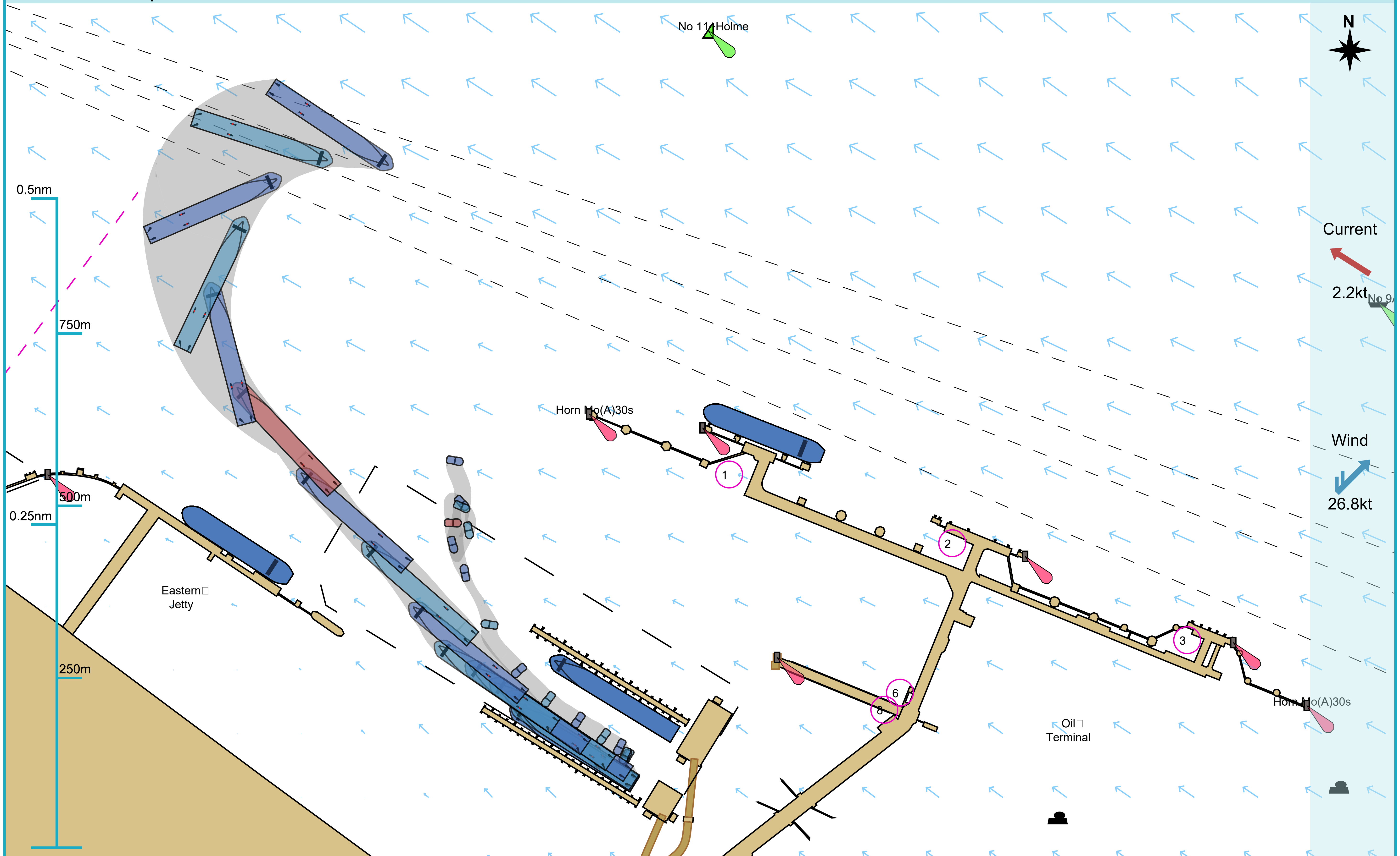

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min
20min
25min
30min
35min
40min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Relative direction (°)
Max. bollard pull
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min

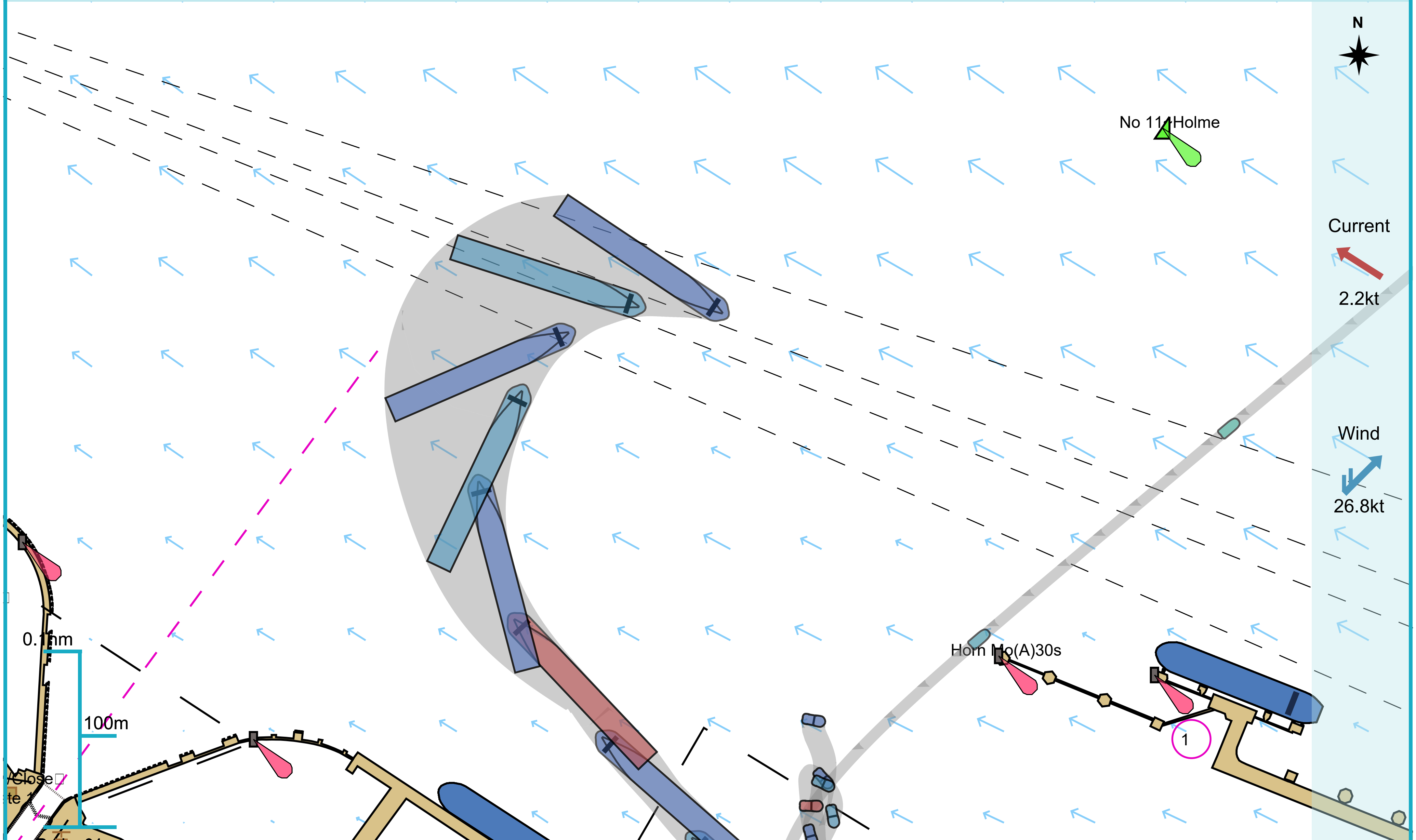

Tug 2: 50t BP ASD forces (ICT)
Tug force (t)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min
25min
30min
35min
40min

Manoeuvre track plot



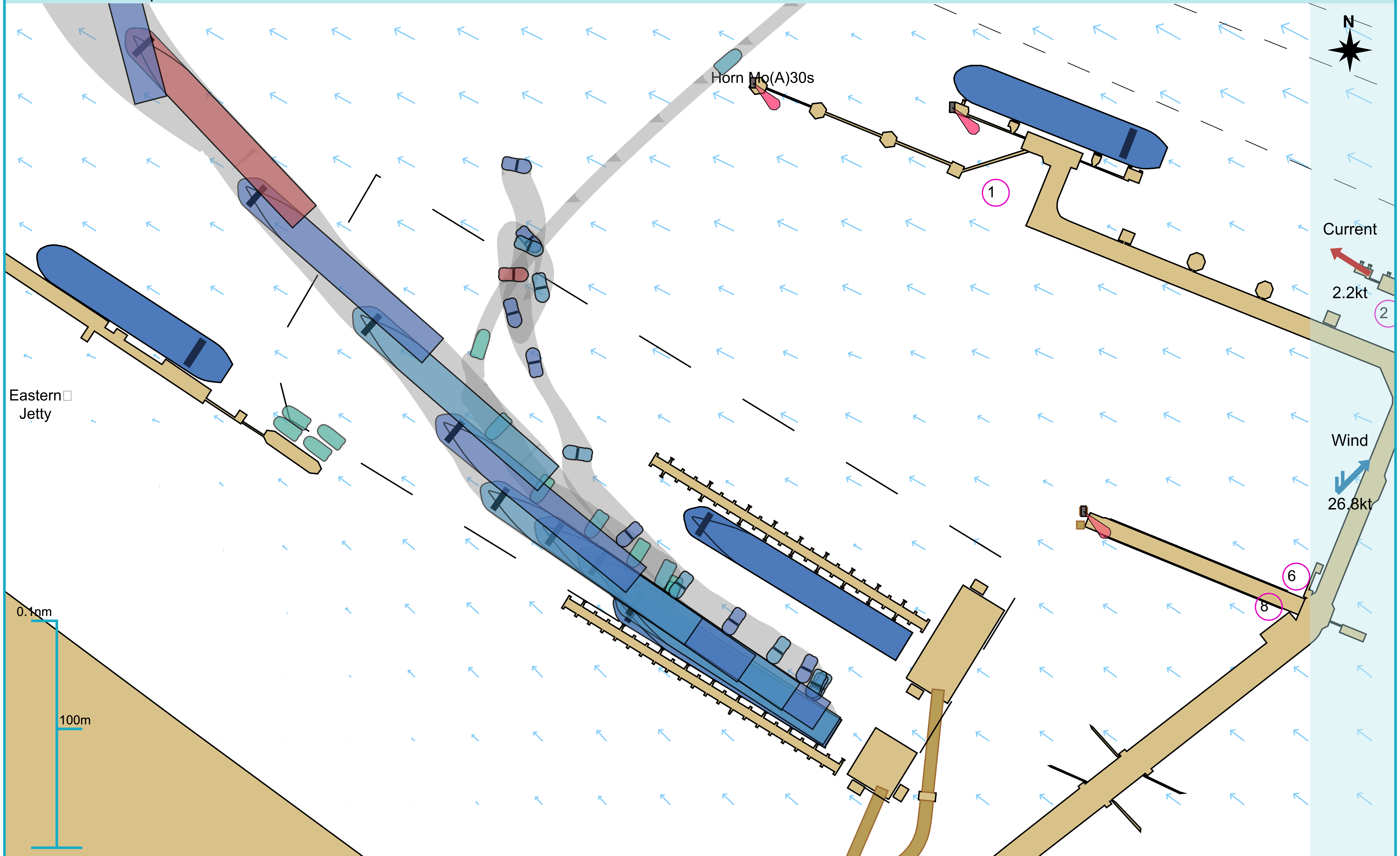
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



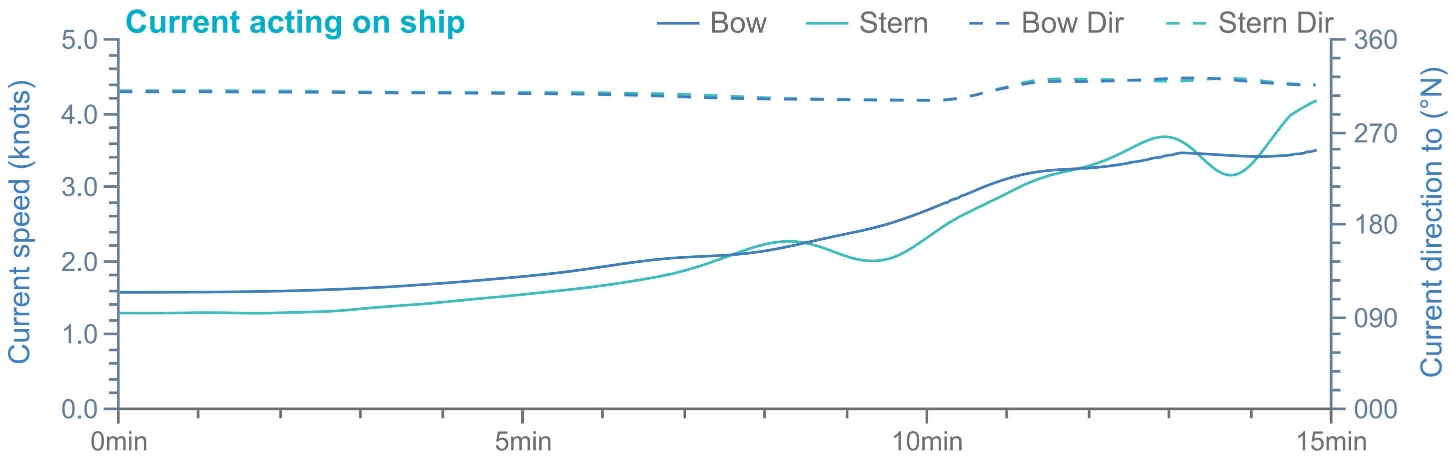
Ships plotted every 1 mins, highlight every 10 mins

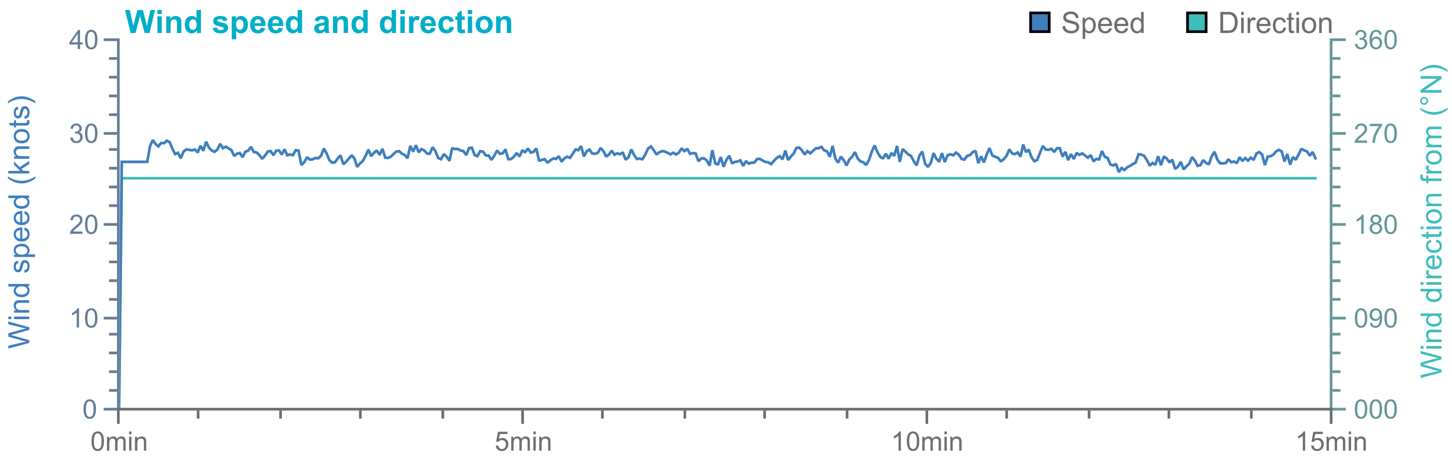
Manoeuvre track plot



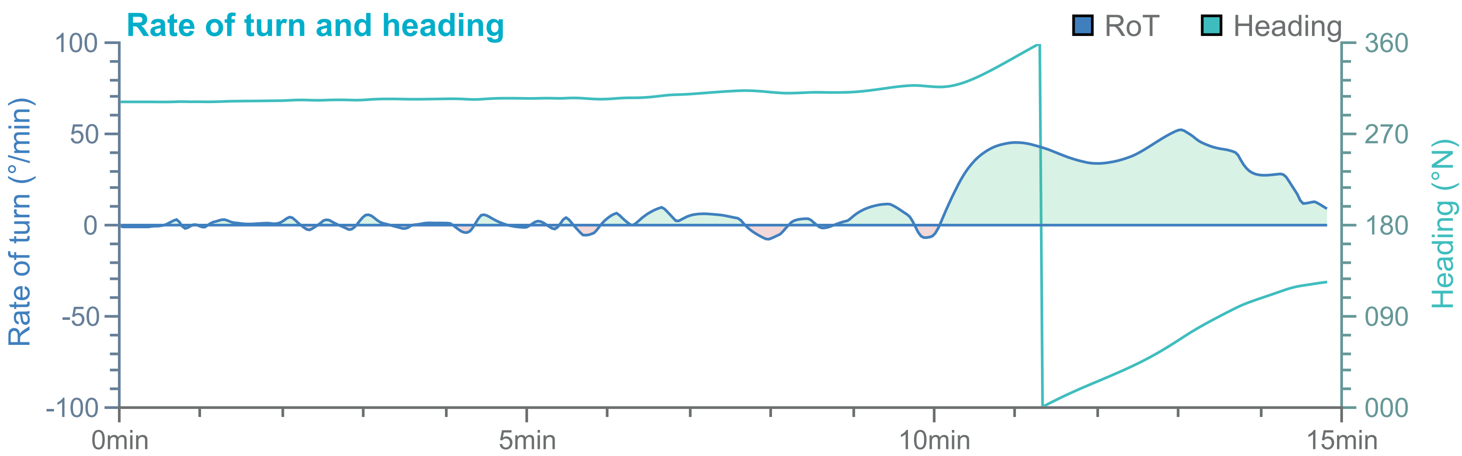
3.74 kts

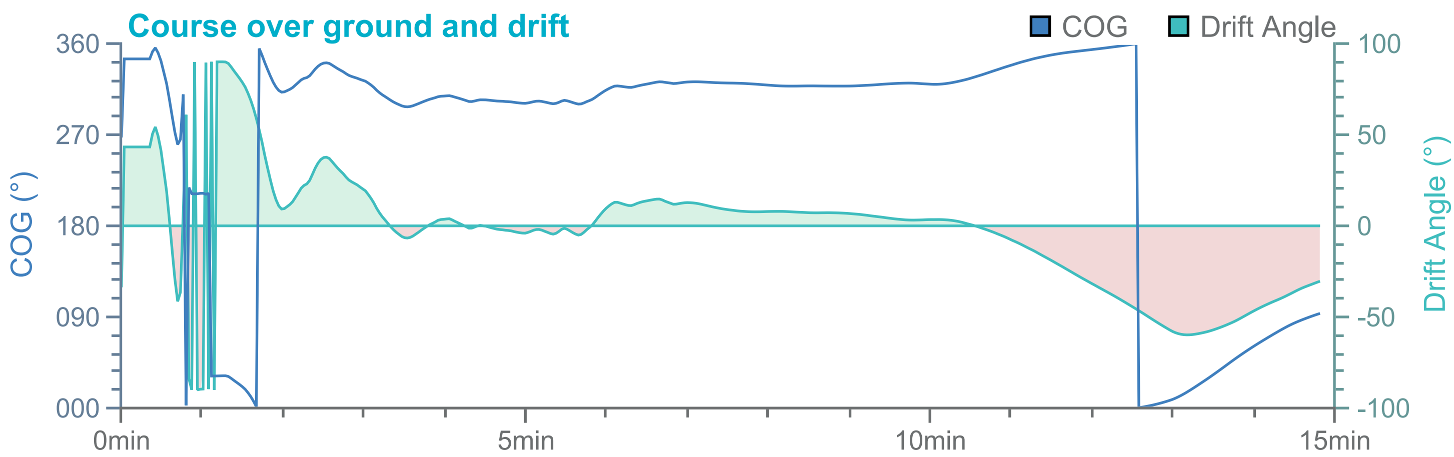
Ships plotted every 1 mins, highlight every 10 mins

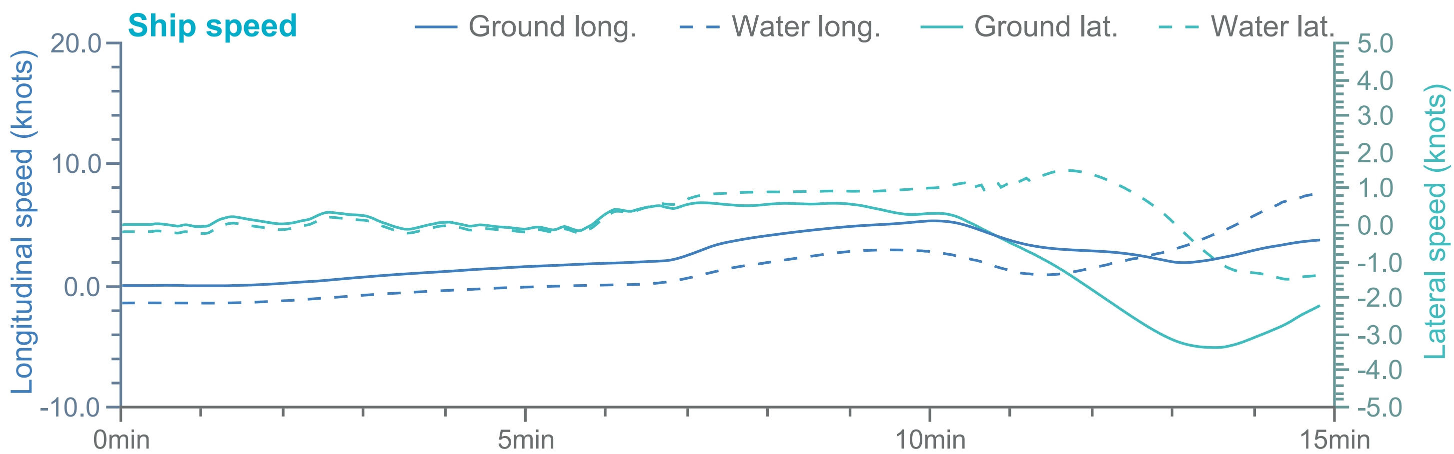

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction to (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min

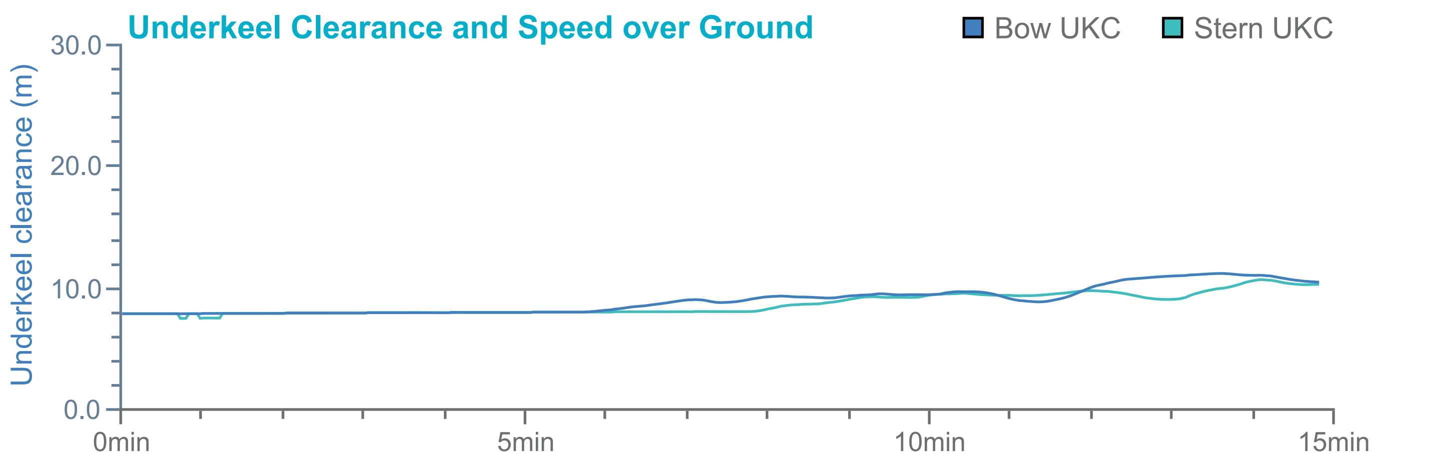

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction from (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min

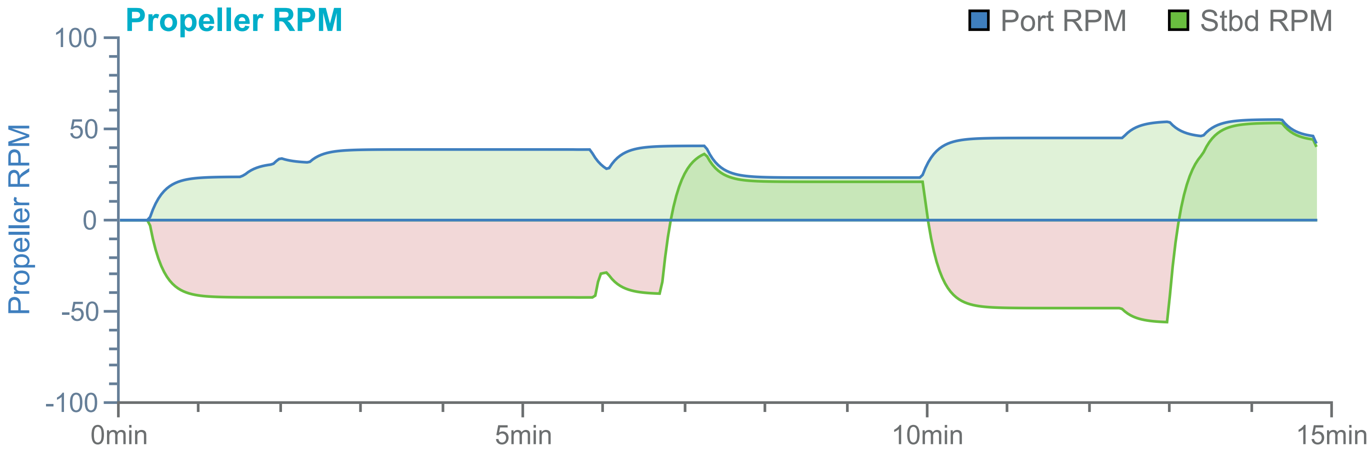
Overview | Environment | Stena Transporter | Tugs

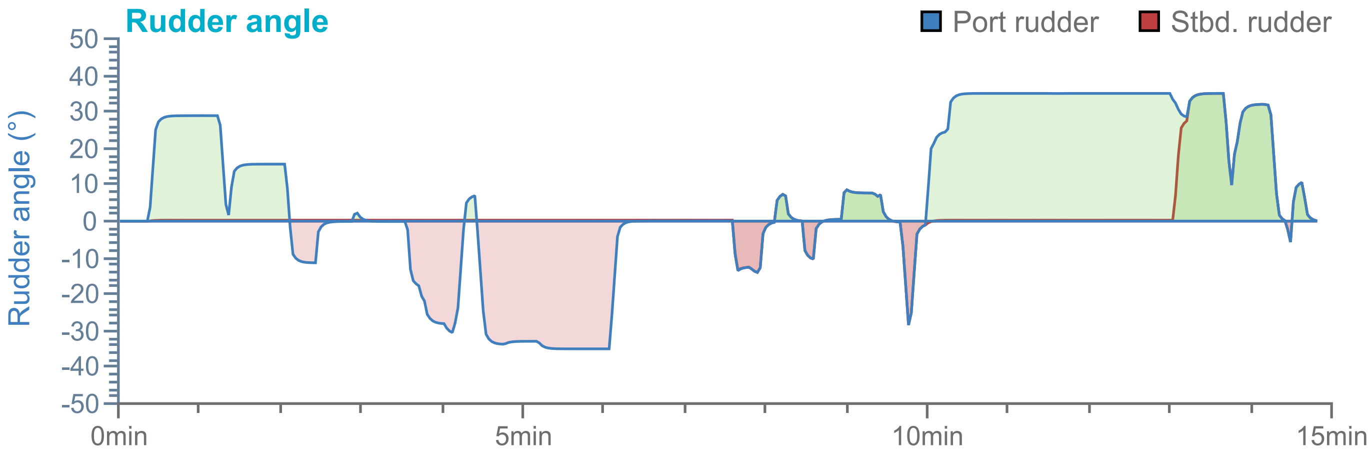


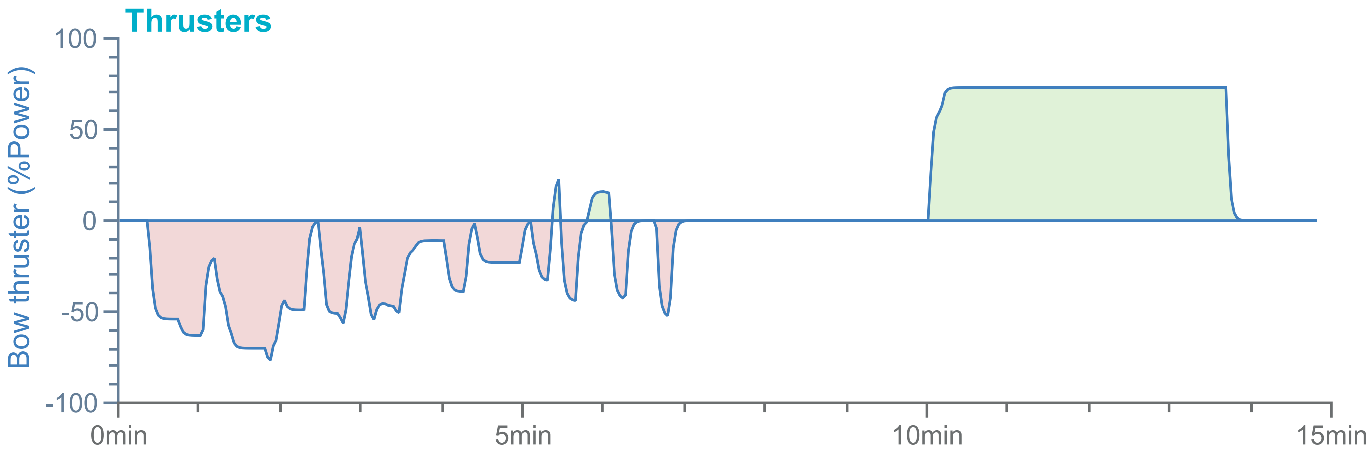


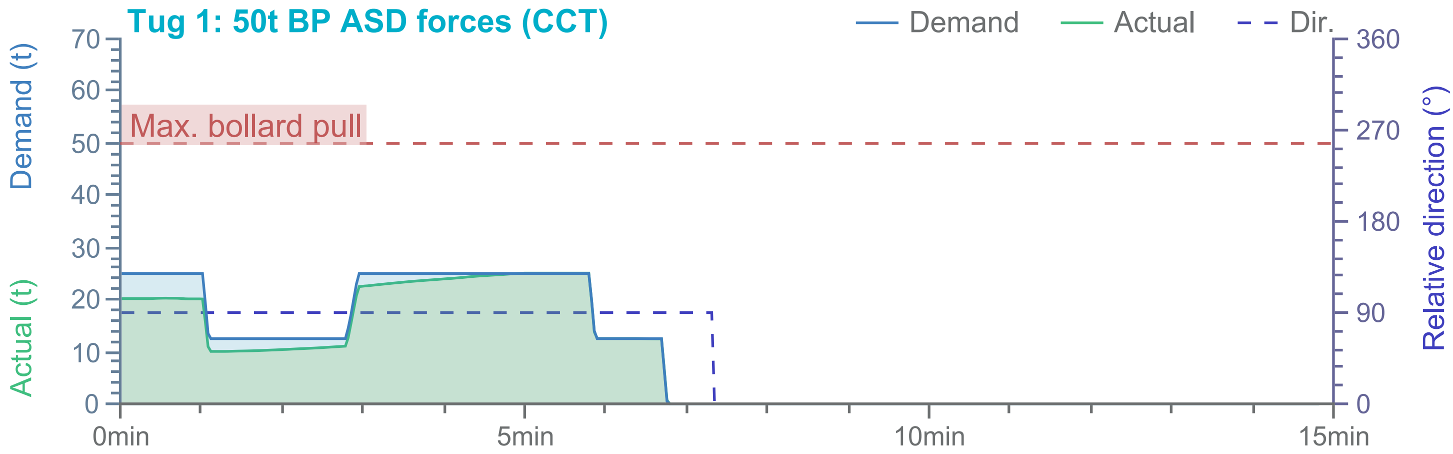


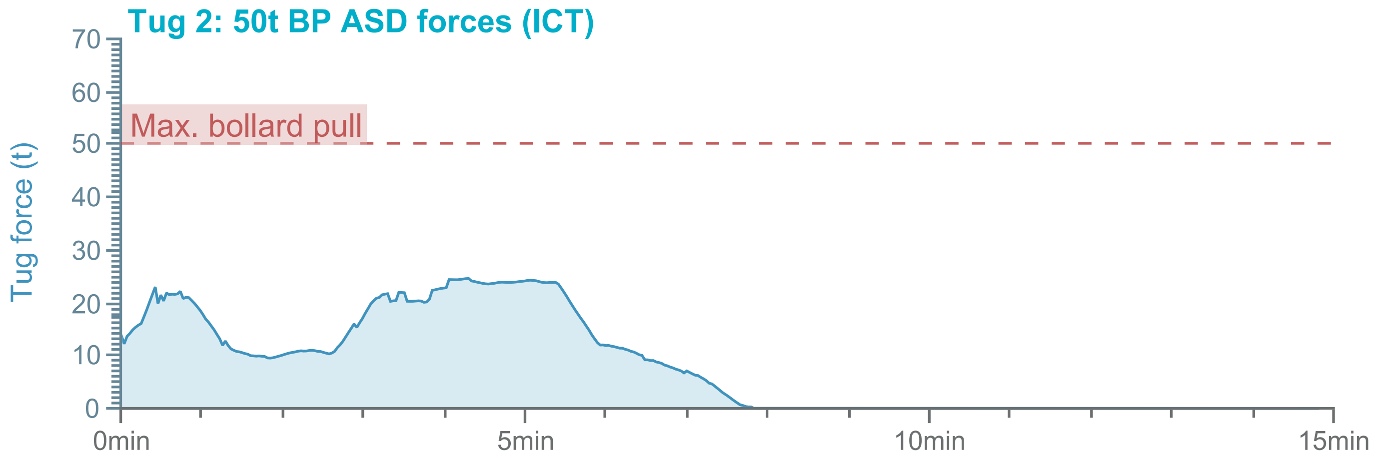



Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min


Tug 1: 50t BP ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Max. bollard pull
Relative direction (°)
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min


Tug 2: 50t BP ASD forces (ICT)
Tug force (t)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
5min
10min
15min

B Comparison of modelled flows against tidal diamond data

HR Wallingford have compared the flow data in their model with the tidal diamond on BA Chart 3497 and on page 118 of the Pilot handbook. This comparison is shown in the table below. For transparency HR Wallingford has provided 2 separate speed columns for each model. Note that the modelled ebb flows were scaled by a factor of 1.2 to account for the peak ebb flows observed using current sensing equipment.

HR Wallingford considers that the general correlation of the mean spring model with the mean spring tides from the tidal diamonds, in terms of both speed and direction, demonstrates that the representation of flows in the models used in this study are appropriate and particularly when considering the general complexity in the flows at Immingham.

Furthermore, the period in the tidal cycle where the peak rates occur shows a very good comparison and was the period normally cited as of concern.

HR Wallingford note that the apparent large variance in flow direction around slack water is to be expected and the models show a large variation in direction over the 30 to 60 minutes either side of that point.

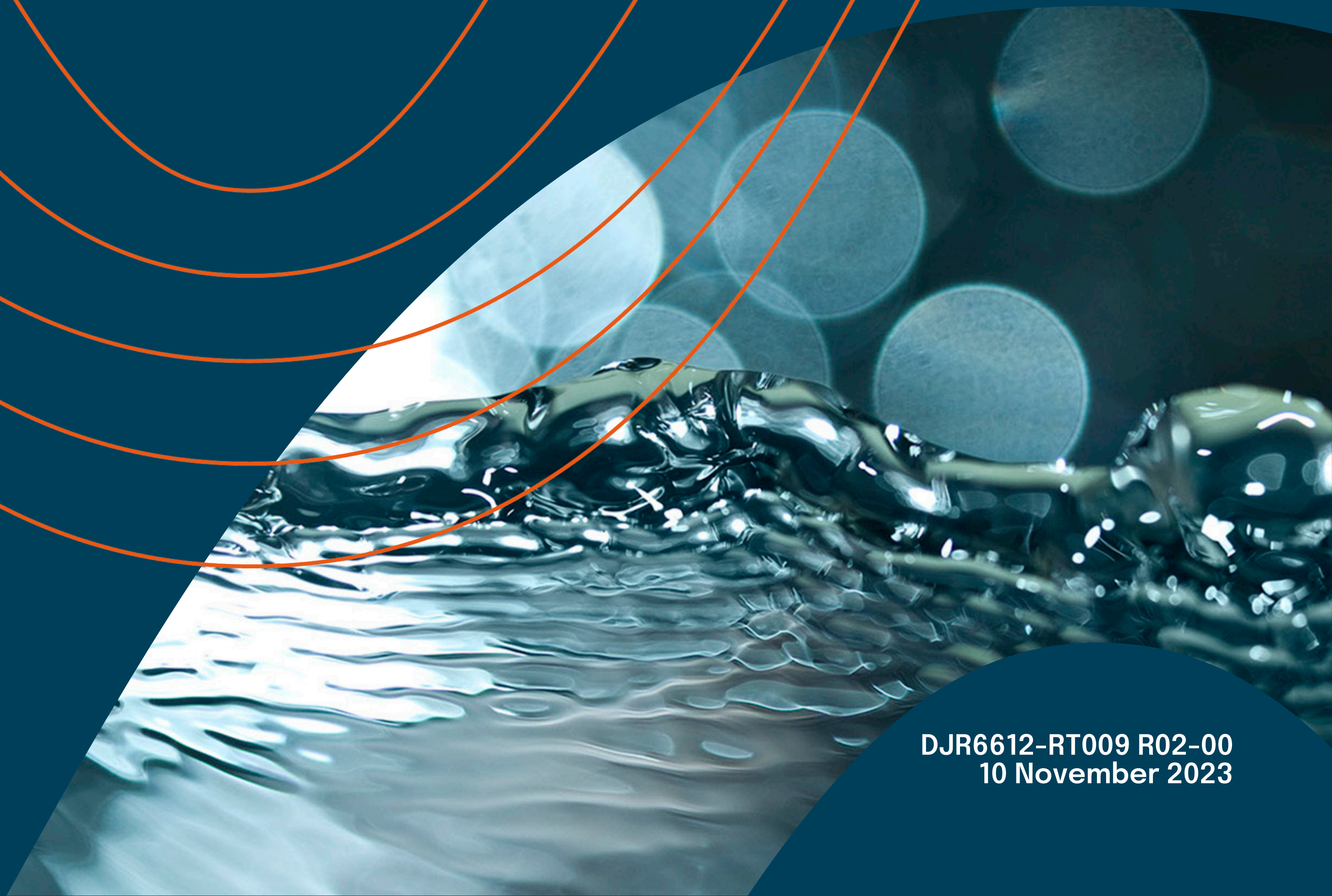
Time (hours)	Current Direction (degN)	Current Velocity (kts)	Current Velocity (kts) x1.2	Current Direction (degN)	Current Velocity (kts)	Current Velocity (kts) x1.2	Directions of spring streams (deg N)	Spring rates (kts)	Directions of spring streams (deg N)	Rates of neap tides (kts)
HW-6	129	2.9	3.5	132	2.7	3.3	132	2.6	106	0.8
HW-5	135	0.6	0.7	148	0.2	0.3	239	0.2	004	0.2
HW-4	305	2.5	3.0	308	2.5	2.9	303	2.2	310	1.1
HW-3	304	3.7	4.4	307	3.5	4.1	305	3.3	313	1.7
HW-2	305	3.9	4.7	308	3.7	4.5	314	3.2	308	1.7
HW-1	305	2.9	3.4	308	2.9	3.5	315	3.0	319	1.1
HW	302	1.7	2.0	306	1.6	1.9	319	1.3	341	0.3
HW+1	265	0.2	0.2	210	0.1	0.1	122	1.3	135	0.7
HW+2	134	2.0	2.4	137	1.9	2.2	133	3.3	134	1.4
HW+3	131	3.4	4.1	133	3.1	3.7	129	4.0	128	2.4
HW+4	129	3.8	4.6	131	3.6	4.3	132	4.4	132	2.8
HW+5	129	3.7	4.4	132	3.5	4.2	126	3.5	135	2.6
HW+6	129	3.4	4.0	132	3.1	3.7	132	2.9	136	1.6

It should be noted that it is not normal practice to try and verify a flow model against a tidal diamond in an area as complex as the Humber . This is because the tidal diamond is an artefact of data combined with cartography and is intended to indicate a general pattern, whereas a flow model is more precise.

C RT009 – Description of flow modelling previously undertaken

Immingham East RoRo Terminal

Summary of simulated flow conditions



DJR6612-RT009 R02-00
10 November 2023

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Prepared	Approved	Authorised
Mike Parr	pp Ian Cruickshank	pp Ian Cruickshank

Contents

Figures

1 Introduction

Associated British Ports (ABP) Humber are considering the development of additional RoRo berth capacity to the east of the Immingham dock, which will be known as the Immingham East RoRo Terminal (IERRT).

HR Wallingford have undertaken a series of studies for the project, including real time ship navigation simulation assessments of the feasibility of the design for the IERRT.

The purpose of this document is to summarise the various modelling tasks which have been undertaken by HR Wallingford to consider the flow conditions on the tidal River Humber in support of the navigation assessments. Specifically, HR Wallingford have been asked to comment on the area for which they have high confidence in the flow modelling work.

Observers may often have a simplified view of the flows at Immingham, however, historical evidence, recent data collection and computational flow modelling show that there is significant variation in flow speed and, notably, direction, associated with the tidal cycle. Fully understanding this variation is further complicated by the effects of the infrastructure in the river, fresh water flows and ongoing dredging works.

There has been considerable effort made to understand and model the flows at IERRT to ensure the design is safe and appropriate from a navigation perspective. This document summarises that effort and describes the level of confidence in the computational flow modelling.

2 Flow conditions

2.1 Flow data collection, modelling and analysis

HR Wallingford have undertaken 2 significant pieces of work to understand and verify the flows in the vicinity of IERRT:

- In Spring 2022 HR Wallingford undertook a detailed statistical analysis considering the nature and directions of flows in the vicinity of IERRT (Reference 1). This work was based on 6 months of fixed AWAC flow observations between Nov 2019 and Jun 2020, provided by ABPmer (Reference 4).
- In the autumn of 2022 HR Wallingford undertook an independent comparison of additional flow data collected by ABPmer, using a vessel mounted ADCP sensor in the vicinity of Immingham Harbour in Autumn 2022 (Reference 3), and the original data from the fixed AWAC buoy. The data was also used to verify HR Wallingford's TELEMAC-3D flow model (Reference 2).

References 1 to 4 should be consulted to obtain a full understanding of the detailed work which supports this summary document.

2.2 Flows in the vicinity of IOT and IERRT

Observers have suggested that the currents in the vicinity of the IOT flow in a single, particularly consistent direction. However, the flows at Immingham East Outer Harbour are highly complex, as shown in the AWAC data collected over 6 months between Nov 2019 to Jun 2020.

This complexity is similarly reflected in the TELEMAC-3D flow model produced by HR Wallingford and the guidance provided to Pilots and PECs in the Port of Humber Passage Plan (see Reference 5).

The flows have a significant variation in direction across the tidal cycle and they are not rectilinear on the ebb and the flood tides. As such, they cannot readily be analysed by casual observation and anecdotal evidence of the flows needs to be carefully considered.

The complexity of the flows can be seen in Figure 2.1, which shows the variation in flow direction and speed based on the 6 month AWAC flow observations (Reference 3). The data was collected at a single point between IOT and Immingham Eastern Jetty, a shown in Figure 2.2.

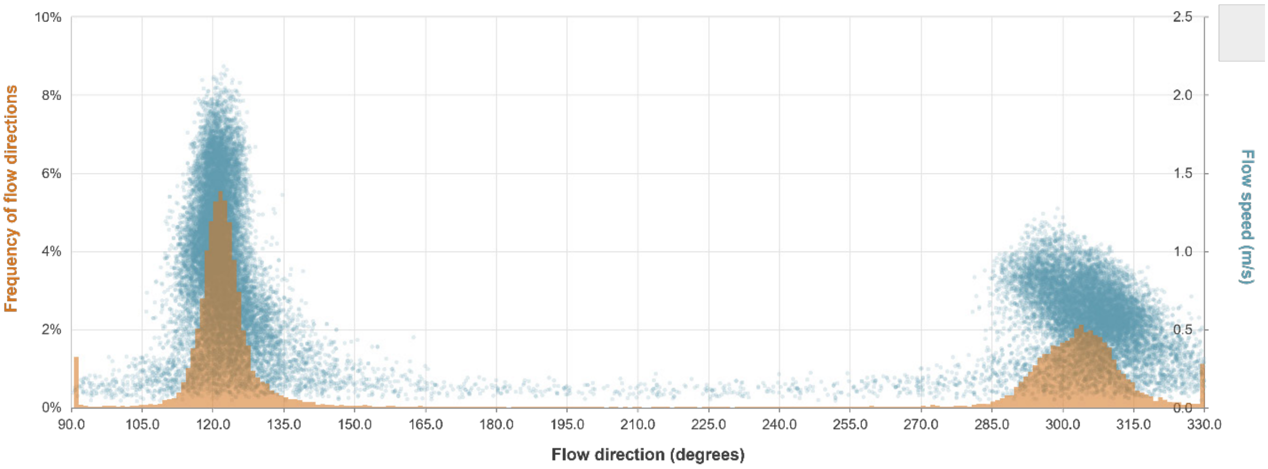


Figure 2.1: Comparison of frequency of depth averaged flow direction with flow speed

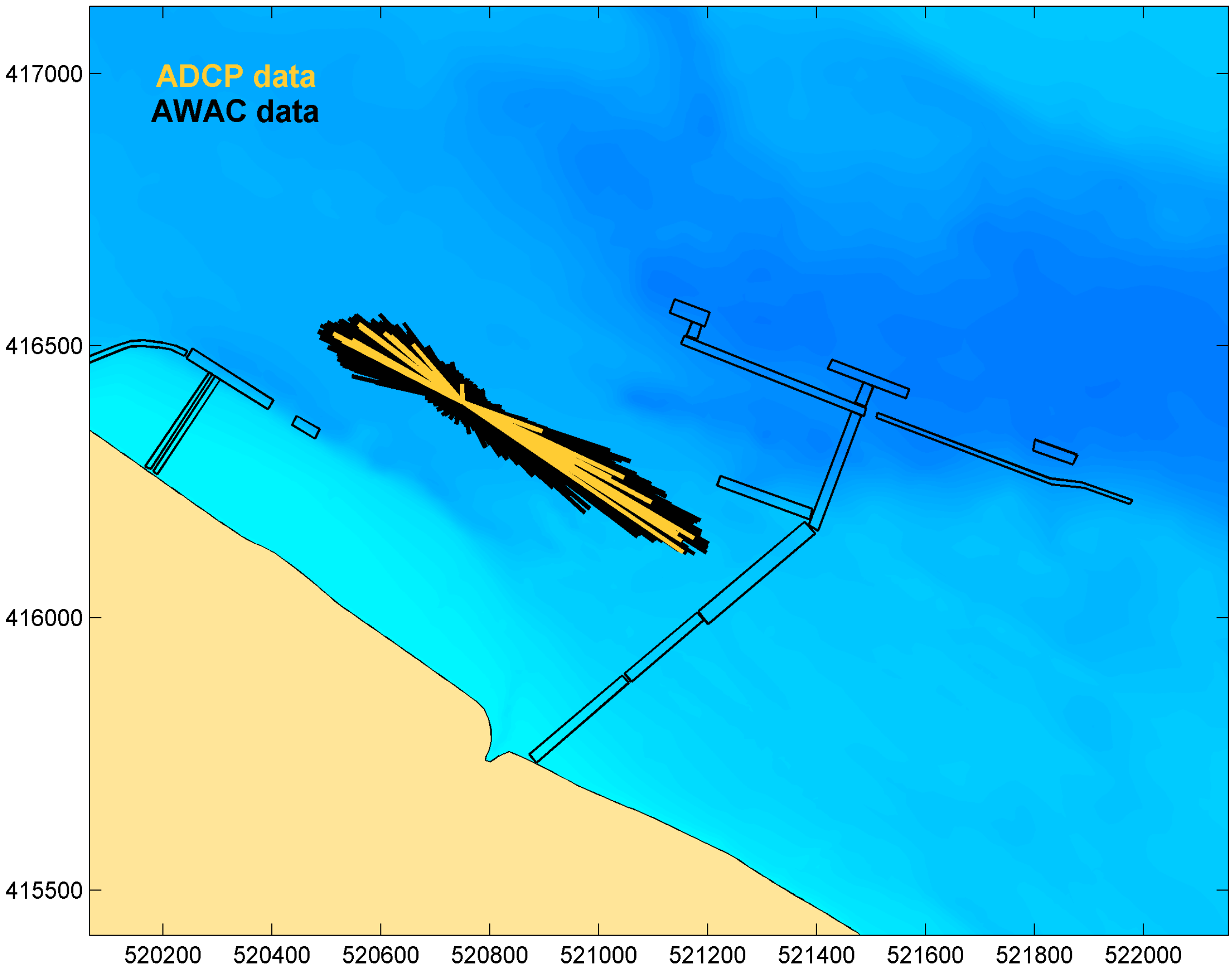


Figure 2.2: Comparison of envelope of observed currents for AWAC dataset and ADCP point

The nature of the flows is described in detail in Reference 1 and the key observations are:

- The mean flow direction varies depending on the tidal range;
- The nature of the flows is significantly different during neap tides compared to flood tides;
- Larger flow speeds occur during the ebb tide;
- Neap flows are less strong, but also less well aligned to the natural direction of the river;
- Stronger spring flows are better aligned with the river;
- The flow directions are not rectilinear, comparing the ebb and the flood, so the mean directions do not differ by exactly 180˚;
- The strongest flood tide flow speeds are not aligned with the mean direction.

For these reasons HR Wallingford developed and recommended a quasi-stationary analysis of the current forces likely to be experienced by vessels at the IERRT berths, based on different proposed berth orientations.

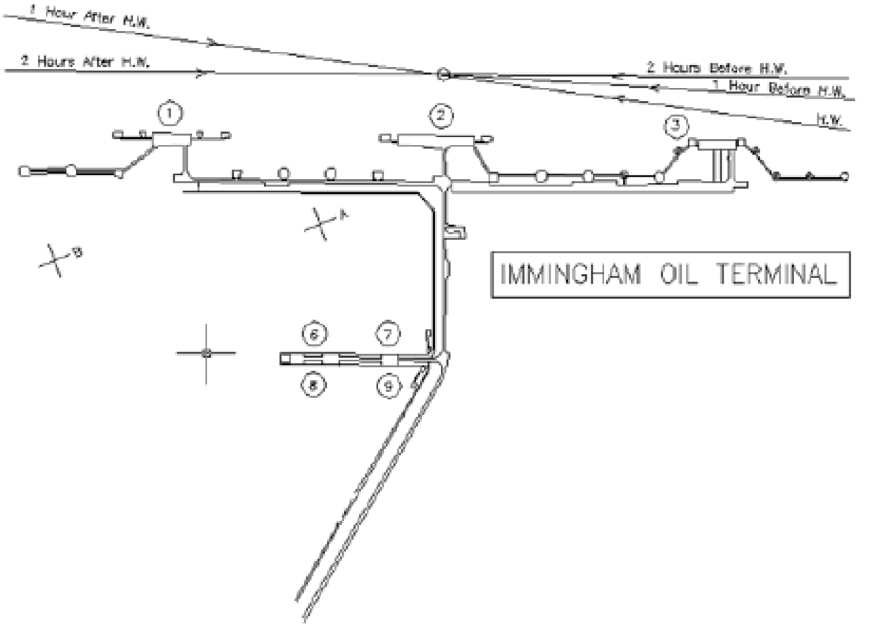
This analysis concluded that orientating the IERRT berths at 300˚T/120˚T (the directions of the greatest flow speeds) would create the optimum situation where, on average, the vessels approaching the berths would experience the minimum effect based on flows.

This does not mean that cross flows will not be experienced at IERRT, but, on average, the effect will be minimised. In particular it means that the berths are aligned to the strongest and most challenging flows, not necessarily the most frequent, where the effect may be less strong.

The complexity of the flows in the vicinity of IERRT are also described in detail in the Humber Port Passage Plan. The extract in Figure 2.3 shows page 33 and the predicted flow directions around high water inside of the main IOT terminal and towards the river. Although the data is from 1964, and anecdotally the flows have changed direction since then due to dredging, the data indicates that there has always been significant complexity in the directionality of flows in the vicinity of IOT.

Another way of considering the complexity of flows in the vicinity of the IERRT berths is to examine the vector plot in Figure 2.2. The centre of the yellow and black lines on the plot indicates the location of the AWAC buoy deployed between Nov 2019 and Jun 2020. The black vectors show the direction of all flow records, with their length relative to strength. The yellow vectors show flow data collected at the same position using vessel mounted ADCP in the autumn of 2022.

The figure clearly shows a significant variation in flow directions and strengths. In a single image it can also be seen that the verification flow data, shown in yellow, that was collected in autumn 2022, is contained within the envelope of the ADCP data set, and shows a similar variation, albeit for a much smaller sample.



TIDAL STREAM OBSERVATIONS TAKEN
5th NOV., 1964. POSITION 'A' BEARING 091°
DISTANT 1375M TOWER 'A' IMMINGHAM DOCK

	Hours (GMT)	Direction	Rate knots	Spring Rate knots	Neap Rate knots
Before HW Immingham	6	104°	2.32	2.36	1.20
	5	106°	0.61	0.63	0.32
	4	283°	1.66	1.71	0.86
	3	294°	1.56	1.60	0.81
	2	299°	1.63	1.66	0.85
	1	304°	1.42	1.45	0.74
	HW	**312°**	**0.94**	**0.96**	**0.49**
After HW Immingham	1	130°	0.95	0.97	0.49
	2	114°	2.58	2.63	1.39
	3	114°	3.69	3.76	1.92
	4	112°	3.76	3.84	1.96
	5	110°	3.53	3.60	1.84
	6	105°	2.63	2.69	1.36

TIDAL STREAM OBSERVATIONS TAKEN
5th NOV., 1964. POSITION 'B' BEARING 089°
DISTANT 1057M TOWER 'A' IMMINGHAM DOCK

	Hours (GMT)	Direction	Rate knots	Spring Rate knots	Neap Rate knots
Before HW Immingham	6	118°	1.95	2.00	1.02
	5	115°	0.30	0.37	0.16
	4	278°	1.89	1.94	0.98
	3	290°	1.72	1.77	0.89
	2	292°	1.84	1.89	0.96
	1	296°	1.46	1.50	0.76
	HW	**309°**	**0.72**	**0.74**	**0.37**
After HW Immingham	1	126°	1.81	1.21	0.61
	2	115°	2.69	2.76	1.40
	3	114°	3.84	3.95	2.00
	4	113°	3.54	3.64	1.84
	5	114°	3.25	3.34	1.69
	6	112°	2.42	2.49	1.26

Figure 2.3: Extract from Humber Passage Plan 2021 showing flow information at IOT

Source: Humber Estuary Services

2.3 Flow data comparison

HR Wallingford directly compared the flows recorded using the ADCP in autumn 2022 with flows for a comparable tidal range collected over a year earlier by the AWAC buoy. The details for the data collection are in References 3 and 4, and the comparison is fully described in Reference 2.

Figure 2.4 shows a comparison of the observed current speed between the AWAC and ADCP surveys and Figure 2.5 shows a comparison of observed flow directions.

These two figures show that the current speeds are close for the two surveyed periods. The current directions are also almost identical during the ebb tide when currents are highest. During the flood tide the two datasets compare well at the time of peak flood currents. Later in the flood tide, from about 5 hours after low water, the observed directions, as the tide strength reduces, vary slightly, with the ADCP data turning towards 310-320˚N whereas the AWAC remains at approximately 305˚N. This variation is during the period of slack water, when the flow strength is least and has the greatest variation due to other factors, such as changes to the longitudinal density gradient associated with seasonal changes to fresh water flow, which would be expected to be at their greatest.

The figures also show a high level of correlation between collected data for similar tidal ranges on separate occasions using independent means of survey.

From this comparison HR Wallingford concluded that the flow phenomena shown in the long term current measurements are representative of the conditions in the area.

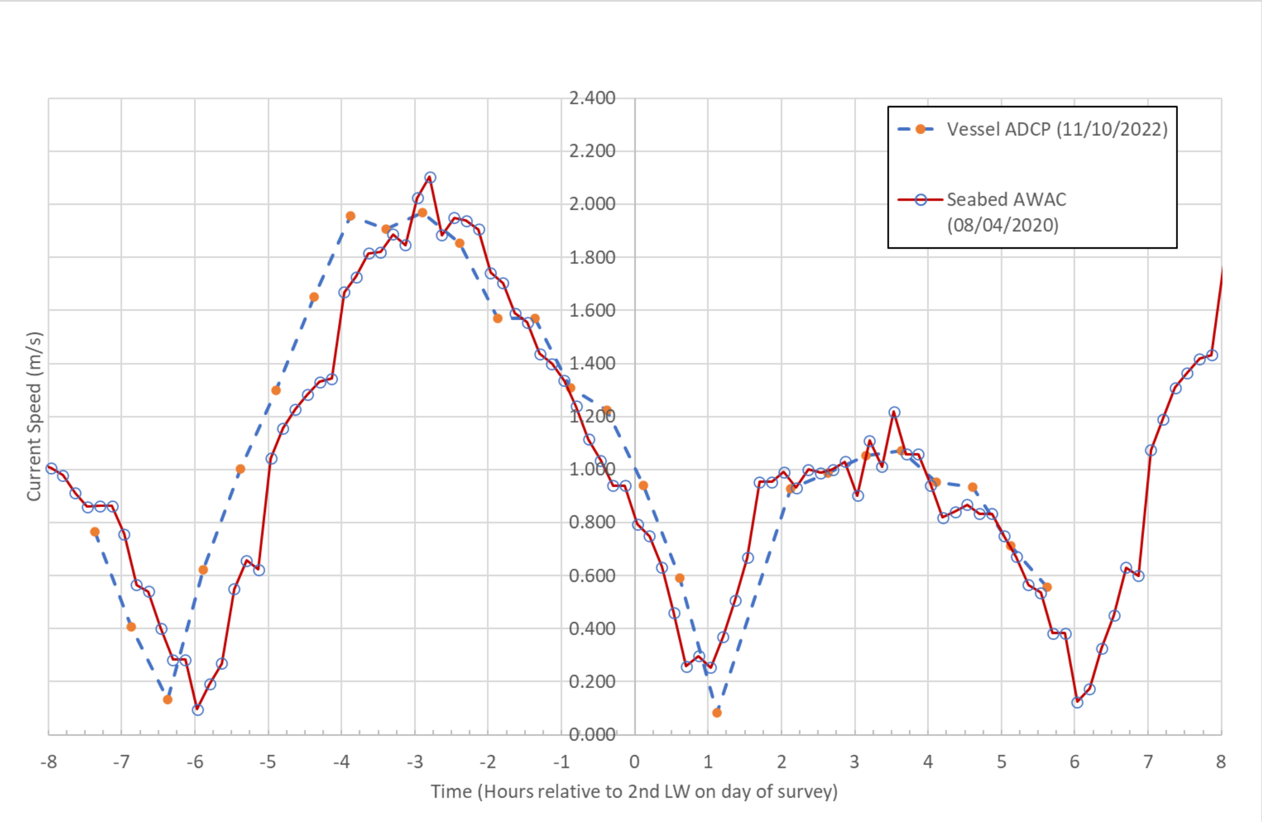


Figure 2.4: Comparison of observed current speed from AWAC 08/04/22 and ADCP 11/10/22

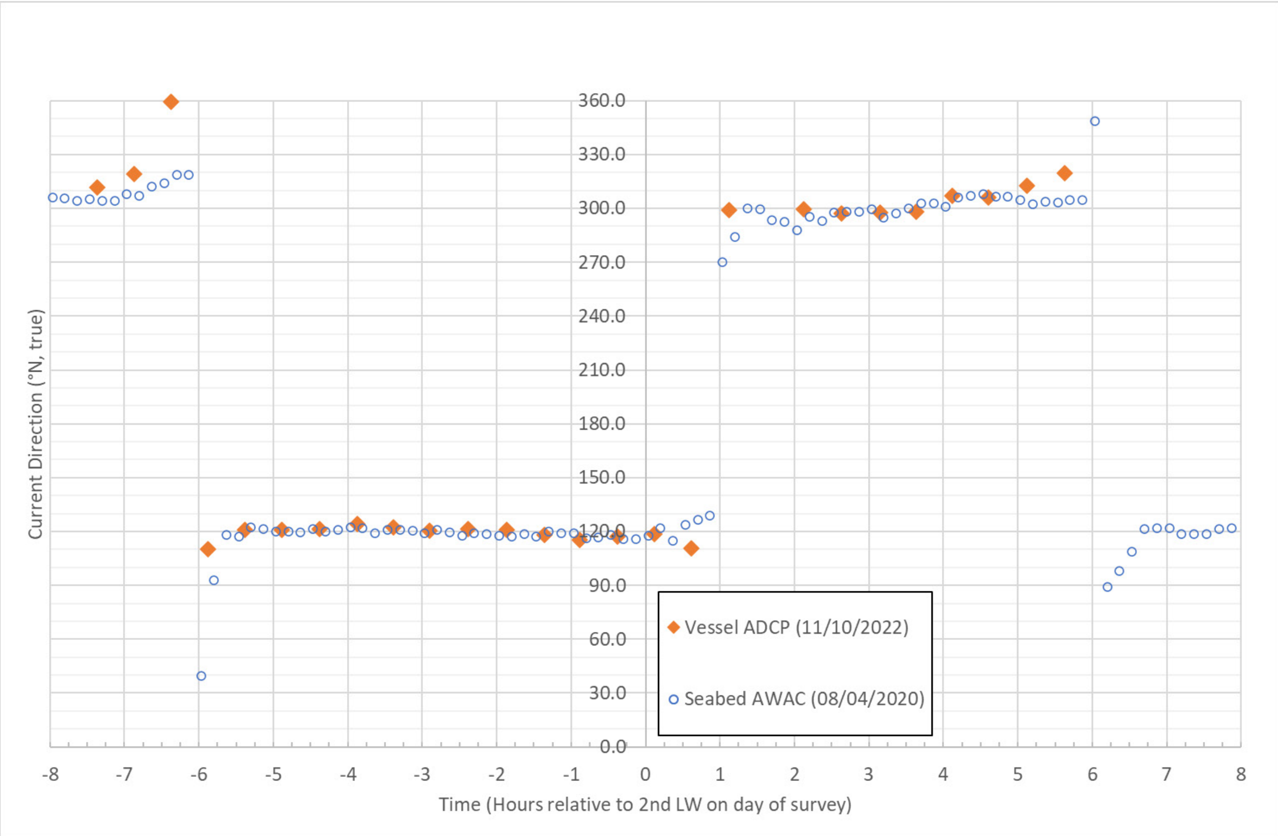


Figure 2.5: Comparison of observed current direction from AWAC 25/11/20 and ADCP 11/10/22

3 Flow model confidence

3.1 Validation against AWAC data

To understand the flows and provide data for the navigation simulation work, HR Wallingford produced a TELEMAC-3D flow model to represent the variation in current speed and direction throughout the water column. The measured data was used to validate this model.

In the case of the AWAC data, the current directions in the upper water column varied when compared to the through-depth average. This effect was considered to be associated with a longitudinal salinity gradient, which was also included in the 3D flow model.

The model was validated by comparison with the data from the AWAC buoy, which represented tides close to mean spring range. The key to aligning the model currents with the data was the addition of the longitudinal salinity gradient, which, in simple terms, represented the effect of fresh water in the river.

The key factor identified during the navigation simulation work, was the ability of the model to accurately represent the temporal variation in the directionality of the flows and where the model was adjusted was the focus of that effort.

A comparison of the modelled current speed and direction with those observed from the AWAC data is shown in Figure 3.1. It can be seen that the modelled flow directions correlate closely with the observed flow directions.

It was recognised that the model underpredicted the largest flow rates observed on the ebb tide, so, taking that into account, the flow speeds were manually scaled by between 15 and 20% during the simulation work. In each case the relevant Simulation Team were informed of this modification and this was also included in the study reports.

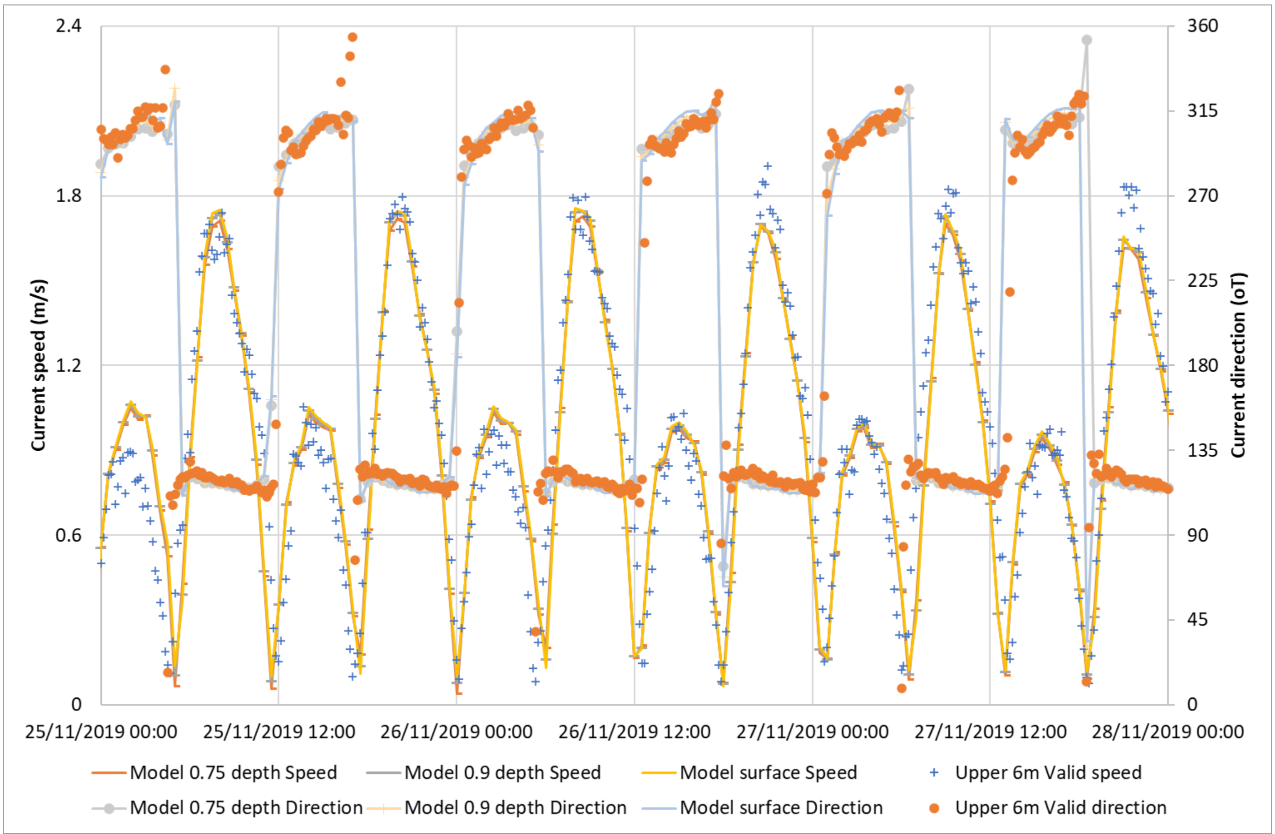


Figure 3.1: Comparison of model with data from AWAC 25-27 November 2019

Overall it was considered that the key phenomena shown by the AWAC data were well represented by the model, particularly with regard to the dominance of ebb tide currents and the variation in flood tide currents between 295˚N in on early flood to 315˚N, as the tide level approaches high water. During the ebb tide the current directions in both the model and the observations were more consistent, being towards around 120˚N.

3.2 Verification against ADCP data

As previously mentioned, additional flow measurements were made in the autumn of 2022 (Reference 4).

As well as collecting flow data at the location of the original AWAC buoy deployment, ABPmer also collected flow information across the approaches to Immingham lock and in the vicinity of IERRT. Data at 20 locations from the ADCP transects were extracted to provide timeseries data for comparison with the model. The transects and data extraction locations used for data analysis are shown in Figure 3.2.

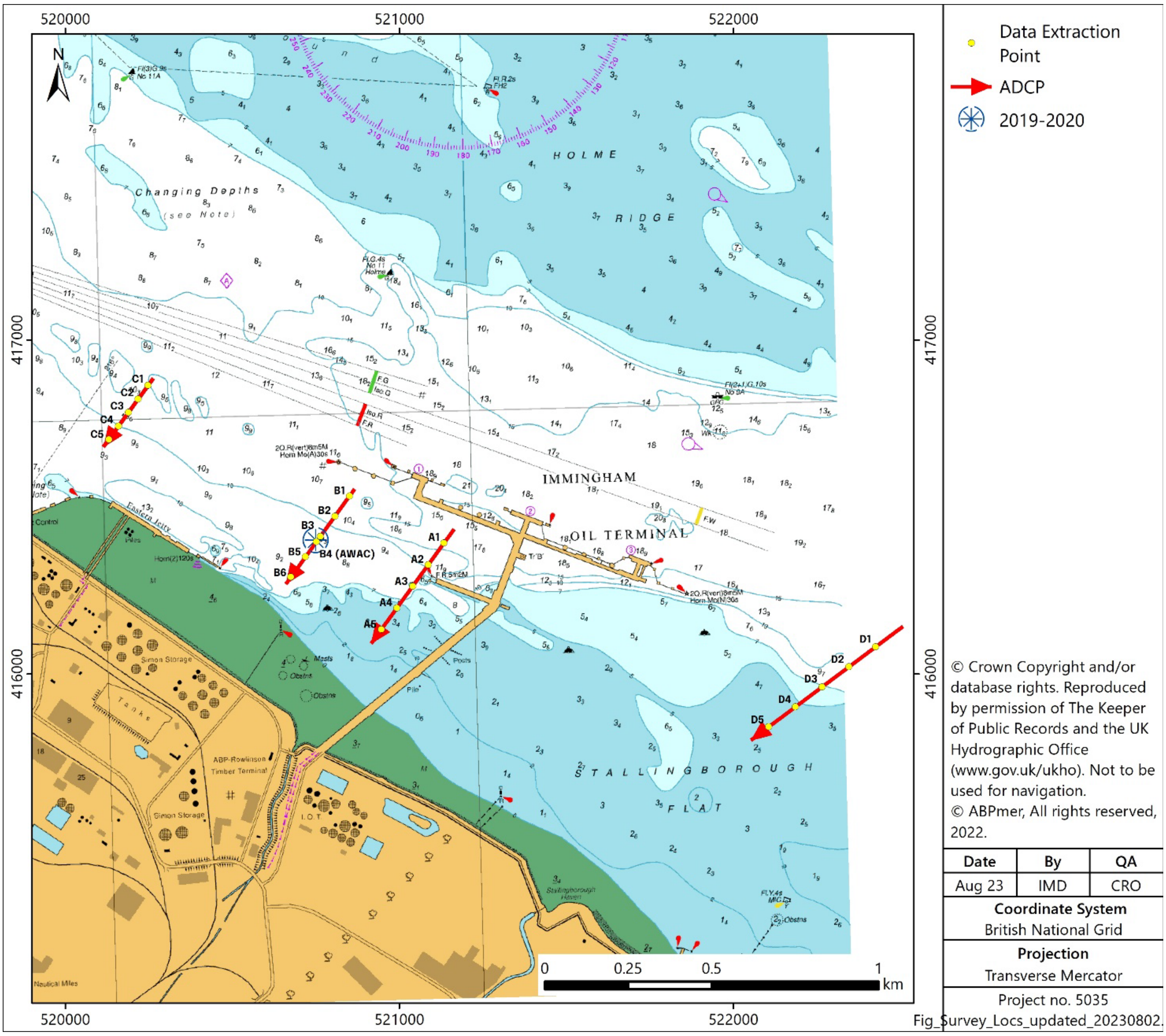


Figure 3.2: ADCP survey transects and extraction points

Source: ABPmer

The flow model data was compared directly with the survey data extracted at each of these locations. Full details of the process is described in Reference 2. The model setup and parameters were unchanged from the AWAC validation exercise.

The measured flow directions for 20 locations correlated well with the modelled data.

The flow rates, particularly during the peak ebb, correlated less well with modelled data. This reinforced the previous conclusion, from the validation against the AWAC data, which was taken into account in the navigation simulation by manual scaling of ebb flow speeds by 15 to 20%.

The results of the comparison underlined how well the HR Wallingford TELMAC flow model represented the direction of flow across the area of interest, not just at the single AWAC location.

A representative sample of comparative data for key locations are provided in Figure 3.3 to Figure 3.5.

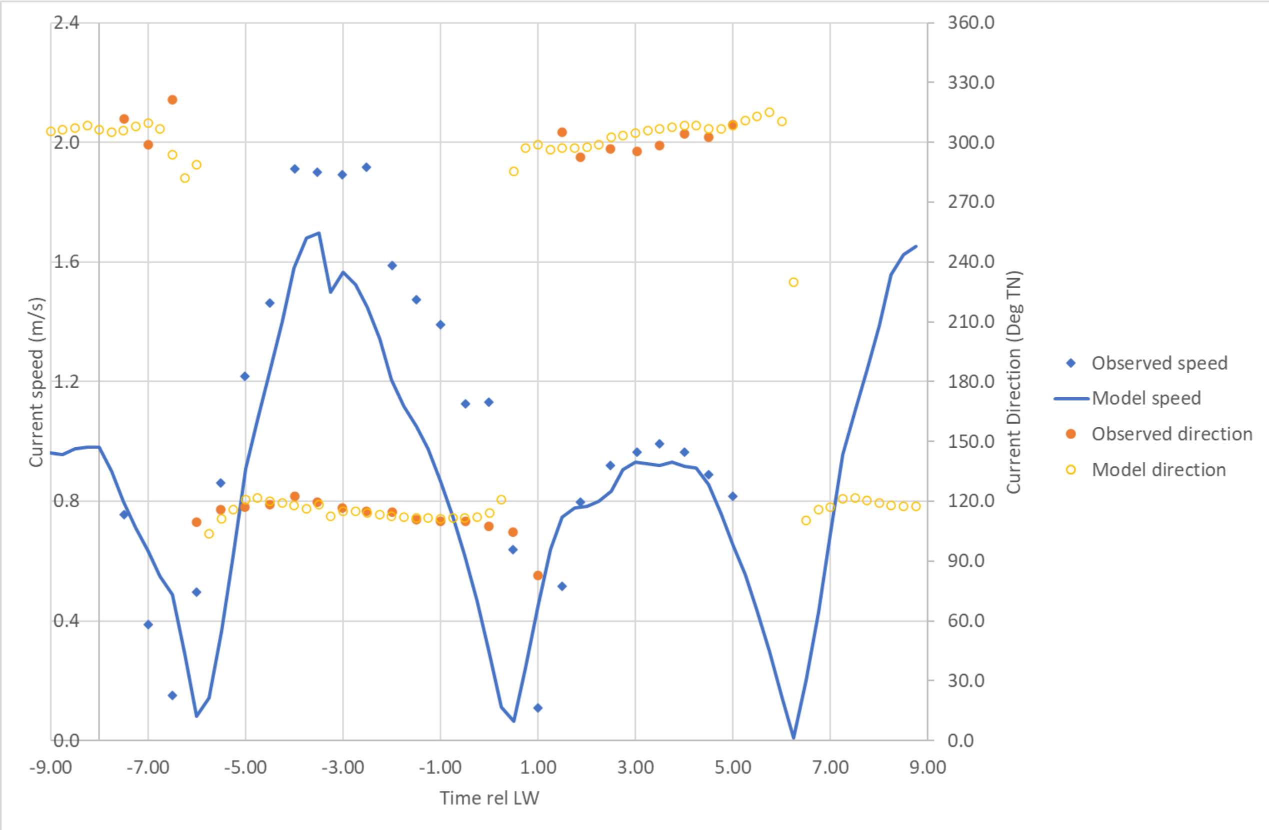


Figure 3.3: Comparison of model with data from ADCP point A3 11/10/22

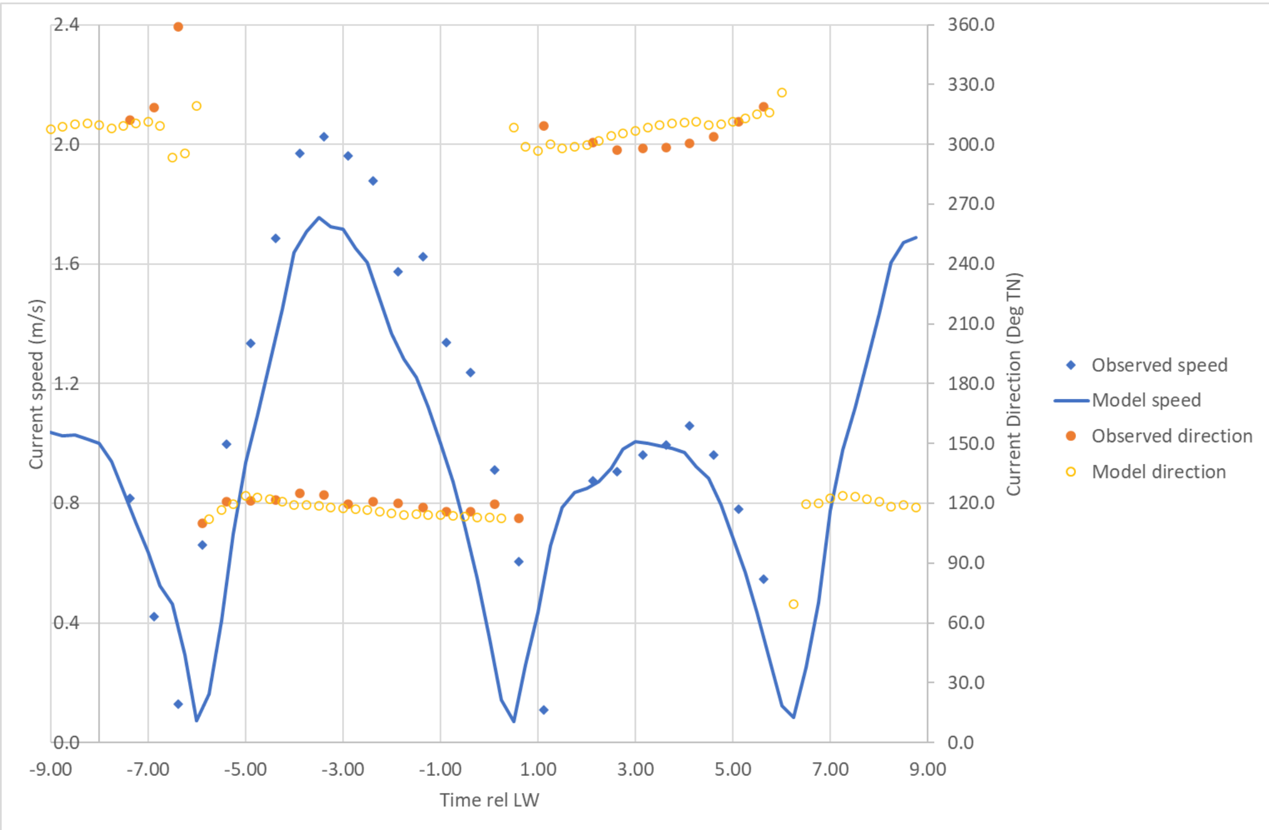


Figure 3.4: Comparison of model with data from ADCP point B3 11/10/22

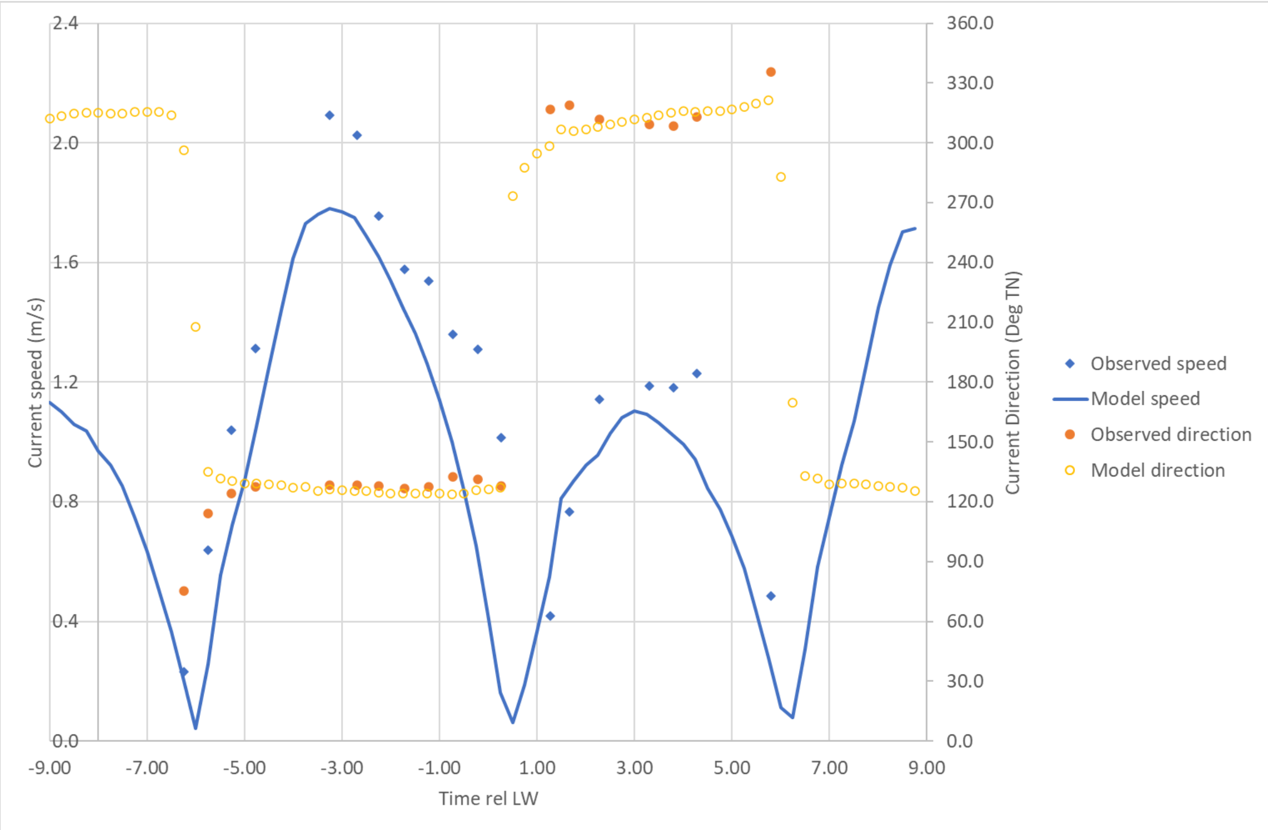


Figure 3.5: Comparison of model with data from ADCP point C3 11/10/22

At point A3 (Figure 3.3) which is in the vicinity of IERRT, and so was the focus for the study, the modelled directions correlated closely with the observed flows. Where there was a difference, the model was representing the anecdotal northerly flow tendency on the flood, so closer to 310˚T than 300˚T.

There was a similar pattern for locations further west at B3 (Figure 3.4) and C3 (Figure 3.5). Again these examples show there is more variation in the direction of on flood flow, however, the model tends to show a flow which is more closely aligned with the anecdotal 310˚T to 315˚T.

As previously mentioned, the modelled ebb flows under predicted the peak observed speeds, so were scaled by 15 to 20%.

Based on this analysis it was concluded that:

- The flow phenomena shown in the long term current measurements are representative of the conditions in the area and the model represented the spatial variation accordingly.
- It was confirmed that the long term AWAC data and flow model (verified using it), as applied to the project, were appropriate for the purposes of input to the navigation simulation and mooring analysis work.

3.3 Standards for modelling accuracy

Subsequently, the flow model was assessed according to the requirements of the Environmental Agency's 1998 guidance for estuarine modelling (technical report W113). In summary the standards require that:

- Modelled speeds should be within ±0.1 m/s or ±10-20% of observed speeds;
- Modelled directions should be within ± 20˚ of observed directions;
- These criteria should be satisfied for 90% of position/time combinations evaluated.

The statistical analysis of HR Wallingford's flow model, based on comparison with the AWAC data in the top 6m water depth, for a set of 5 spring tides shown in the model calibration report (Reference 2), gives the following results:

- The mean absolute error in modelled speed is 0.13 m/s or within 14% of the observed speeds, on average. This is 7.1% of the maximum observed current.
- Most of the errors are in the underprediction of peak ebb current speeds. Consequently, in the navigation simulation work, a 15% increase was applied to ensure they suitably conservative. Using this scaling in the model performance assessment reduced the mean absolute error to 0.12 m/s which is 6.2% of the maximum observed current.
- For directions, the mean absolute error was 15.5˚, so the model is within 20˚ of the observations for 90% of the time.
- Current directions would be expected to be more variable for low current speeds, especially at the turn of the tide. So if the differences in direction are only considered when the currents are navigationally significant (when greater than 0.25 knots), the mean absolute error in the modelled direction reduces to 12.5˚ and 92% of the modelled directions are within 20˚ of that observed.
- Further consideration showed that excluding the directional variability for current speeds of less than 0.5 knots reduces the mean absolute error in modelled direction to 6.5˚ and the simulated current directions were within 20˚ of those observed for 96% of the time.
- When considering the average ebb and flood tide directions, when currents are greater than 0.5 knots, the model directions were within 2° of those observed during the ebb tide and within 0.5˚ during the flood tide.

Therefore, these all fall within or are close to the standards for modelling accuracy in the areas of importance and in the stronger flow conditions, which are of more relevance here.

4 Conclusions

The measurements made by ABPmer have shown that the flows on the River Humber are complex. There is significant temporal variation in flow direction in the vicinity of Immingham and the proposed IERRT infrastructure. Consequently, ABP expended significant resources in collecting flow data to support the modelling of the flow to support the project.

The model created provided vital input to the navigation simulation work, which met the EA guidance for estuarine modelling accuracy. Consequently, HR Wallingford are confident in the modelled flow outputs based on extensive analysis and verification of the flow model using observed data.

The model and the basis for the original measured data were further verified using additional data provided by a second independent flow survey.

Consequently, there is a high level of confidence in the spatial and temporal flow conditions represented in the model for the area verified using the ADCP data collected in autumn 2022, as shown by the red area in Figure 4.1.

There are anecdotal reports of flows which vary from the modelled direction north of the IOT in the main channel, but the following observations should be taken into account:

- The reports are based on evidence from mariners navigating within the main channel and approaching berthing areas elsewhere, but with a similar complexity to IERRT. However, determining the nature of flows in those areas was not part of HR Wallingford's study work.
- The nature of the flows in the Humber means that they should not be considered from a single orientation, but a range of directions that varies during the tidal cycle on a micro and macro basis. The most important aspect to consider was that the IERRT berths were suitably aligned to the flows, based on the potential for flow variation and the effect this may have on

navigation (and mooring). It was considered that the work undertaken in the quasi-stationary analysis (Reference 1) provided an appropriate assessment of this aspect.

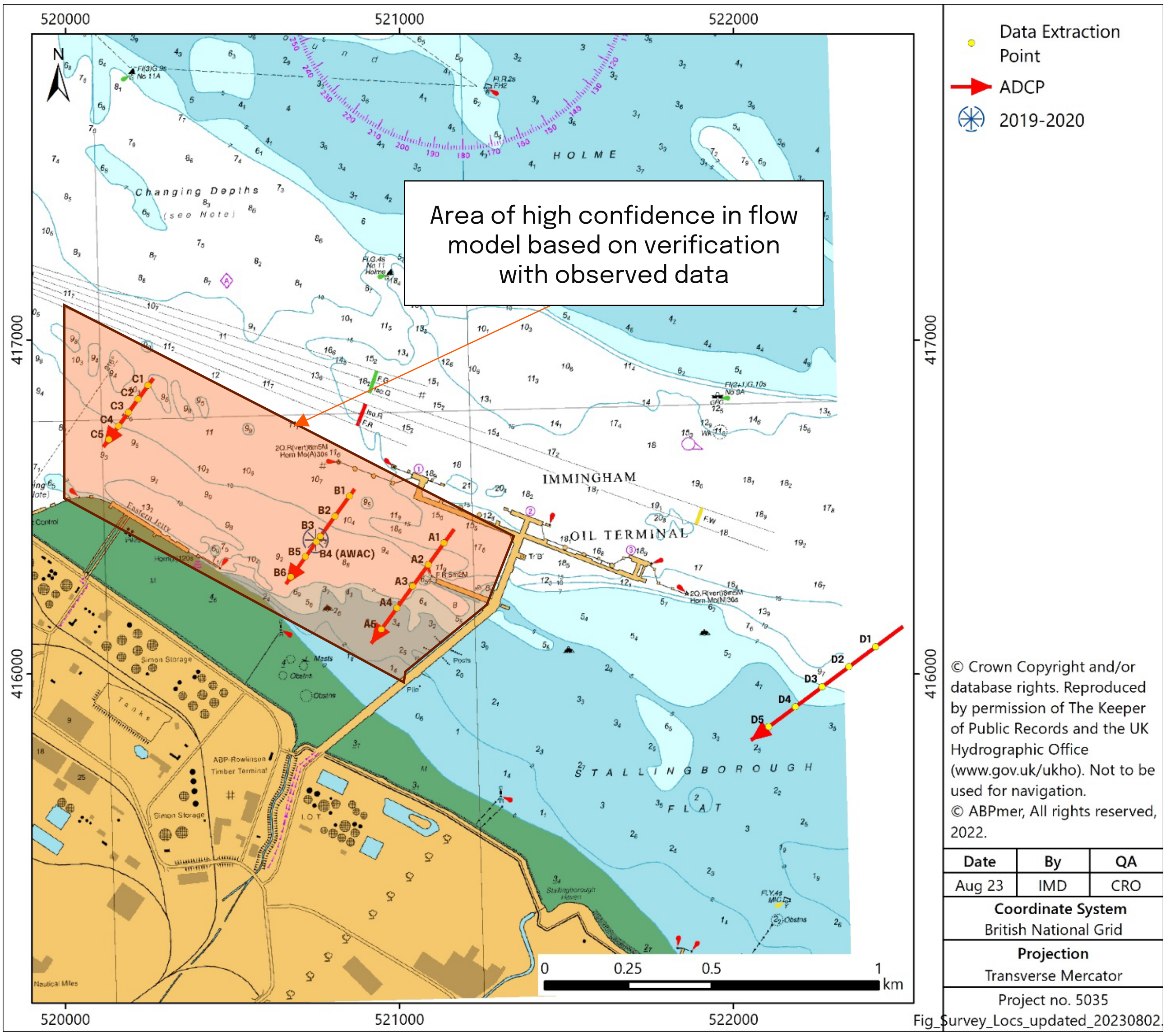


Figure 4.1: Area of flow model verification with observed data

5 References

1. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Quasi-static force assessment", Report no. DJR6612-RT0004-01-00, 08 Jul 22.
2. HR Wallingford, "Project Sugar – ABP Humber – Immingham East Development – Flow model comparison with October 2022 ADCP survey – November 2022", Report no. DJR6612-RT0007-01-00, 22 Nov 22.
3. ABPmer, "Nordic AWAC Deployment version 2, report ref. R3354," 2022.
4. ABPmer, "Immingham Eastern RoRo Terminal – ADCP survey", Report R.4059, 2022.
5. ABP HES, "Humber Port Passage Plan", 2021.

hr wallingford

We design smarter, more resilient solutions across both the natural and built environment to help everyone live and work more sustainably with water.

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D Letter describing HR Wallingford analysis of wind at IERRT and how sheltering is represented in the simulator

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2 November 2023

Our ref: DJR6612

Dear Josh

Re IOT response to ISH 3 Action 17 - Points 4 and 5

HR Wallingford provide the following additional information to support ABP response to IOT letter dated 31 October 2023.

HR Wallingford would wish to highlight that the simulator is a tool which is based on decades of experience accrued at HR Wallingford. The internal operation of the simulator is our intellectual property, and we would be reluctant to share that in detail.

We are able to provide details of the research and work on which the wind calculations are derived. However, we want to emphasise that the input from experienced mariners also significantly influences the response of models used in simulation. HR Wallingford has therefore taken account of a wide range of research and first-hand experience in the simulation system.

HR Wallingford can undertake further analysis, and provide more specific modelling for particular scenarios. However, it is HR Wallingford's position that the models provided and the assumptions included in those models are appropriate for the use case and are conservative, as required by ABP for this feasibility assessment. HR Wallingford would not advise further detailed simulation or modelling at this stage.

Point 4

Since undertaking the simulation studies, HR Wallingford has completed a further analysis of the wind parameters at the site. This shows that the original assumptions are conservative and appropriate. This work was undertaken to support the mooring analysis for the Immingham East Project and is summarised below:

Wind conditions at the site were derived from measured wind data provided by ABP Humber, collected from the Immingham Maritime Control Centre (at an elevation of 24m) between August 2020 and August 2021. The data included wind speeds for a gust duration of 3 seconds and 10-minute mean speeds.

HR Wallingford has post processed the wind data to provide wind speeds at an elevation of 10m and for a 1-minute mean duration. Noting that 10m above mean sea level is the Metrological standard and therefore used within the simulations.

HR Wallingford routinely applies a 1 minute gust value within their simulation as it is the gust length required for a large ship to show a measurable response.

The data was also analysed to determine the return period conditions in 30° sectors and is presented as follows:

- 1-minute mean wind speeds at 10m in Table 1.1,
- 10-minute means at 10m in Table 1.2, and
- 30-second mean speeds at 10m in Table 1.3.

Table 1.1: Return period wind conditions at site, 1 minute mean in knots

Return period (years)	Wind speed (1 minute mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	23	20	12	14	12	9	19	20	16	15	15	16
1	38	29	27	22	20	16	25	30	24	22	24	30
2	43	32	32	25	22	17	27	33	26	24	27	34
5	48	35	39	28	25	19	28	37	29	28	31	40

Table 1.2: Return period wind conditions at site, 10 minute mean in knots

Return period (years)	Wind speed (10 minute mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	20	17	10	10	8	5	14	17	14	12	13	14
1	33	26	23	14	12	9	19	26	20	17	21	26
2	37	28	28	16	14	10	20	29	22	18	23	30
5	42	31	34	18	16	11	22	32	24	20	26	35

Table 1.3: Return period wind conditions at site, 30 second mean in knots

Return period (years)	Wind speed (1 minute mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	24	21	13	15	13	10	20	21	17	16	16	17
1	40	31	29	23	21	17	27	32	25	23	25	32
2	46	34	34	27	23	18	29	35	28	25	29	36
5	51	37	41	30	27	20	30	39	31	30	33	42

This analysis indicates that, for a 0.1 year return period (10 times per year), a mean wind of 20 knots with a 1-minute gust of 23 knots would be representative of the routine operating conditions at the site. This therefore supports HR Wallingford's advice that for the north-easterly wind conditions (which are the most challenging for navigation) a mean wind speed of 27.5±5 knots at 10 meters as used in the simulations is commensurate with a 1 in 1 year return period 1 minute mean wind speed and therefore appropriate for the feasibility study.

Point 5

It is not agreed that full wind effects cannot be considered to be conservative. Particularly at the limiting wind speeds used in the simulation feasibility study where the vessel is at the limit of control. The most critical phase of the manoeuvre is when the vessel is in close proximity to structures and other vessels. In this scenario wind sheltering can be considered to provide the manoeuvring ship an advantage as the overall power required to control the vessel will be significantly reduced.

It is agreed that the transition from an unsheltered to a sheltered location can generate a turning moment and reduction in wind force that influences the manoeuvre and, in some circumstances, this may present a different challenge to manoeuvres as compared to the unsheltered wind speed. For this reason the sheltering effects were included in some simulations but were not shown to present an increased challenge compared to the unsheltered simulations and did not change the conclusions of the simulation study.

In the scenarios where sheltering effects were applied the pilots and masters were able to berth safely at IOT, despite the variation in wind strengths simulated. It was noted that the sheltering simulation was considered to adequately represent conditions that were apparent at other berths on the River Humber, and at the entrance to Immingham Lock

To further address APT points raised in their recent letter HR Wallingford are able to provide the following details of the modelling of the wind sheltering.

In the simulator, the wind conditions are characterised using speed and direction, which can be time-varying using a gusting model. The effect on a vessel, in terms of the induced forces and moments, is calculated using the instantaneous relative wind speed and direction and a set of vessel-specific coefficients. Normally these coefficients assume that the wind conditions are spatially invariant.

However, when sheltering is enabled in the simulator, the spatial variation in the wind conditions is accounted for in the following way. The relative wind speed and direction in the sheltered area are estimated using empirical equations based on published research. These equations modify the wind conditions based upon the proximity to, and relative orientation of, the vessel providing the shelter and the relative size of the vessels. A simple weighting method is applied to determine the contributions from different parts of a partially sheltered vessel to give an average description of the wind conditions over the vessel. The effect on the vessel is then calculated using the modified wind conditions in the normal way.

HR Wallingford considers that this method is appropriate to provide a reasonable and conservative approximation of the sheltering effect, and in this study, the method is useful to understand the additional level of control that a pilot needs to manage the vessel.

Yours sincerely

[redacted]

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Technical Director, Ships and Dredging

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E Simulation setup brief

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Humber Immingham Terminal

DJR 6612

07-08 November 2023

MPA

Domestic arrangements and Health and Safety

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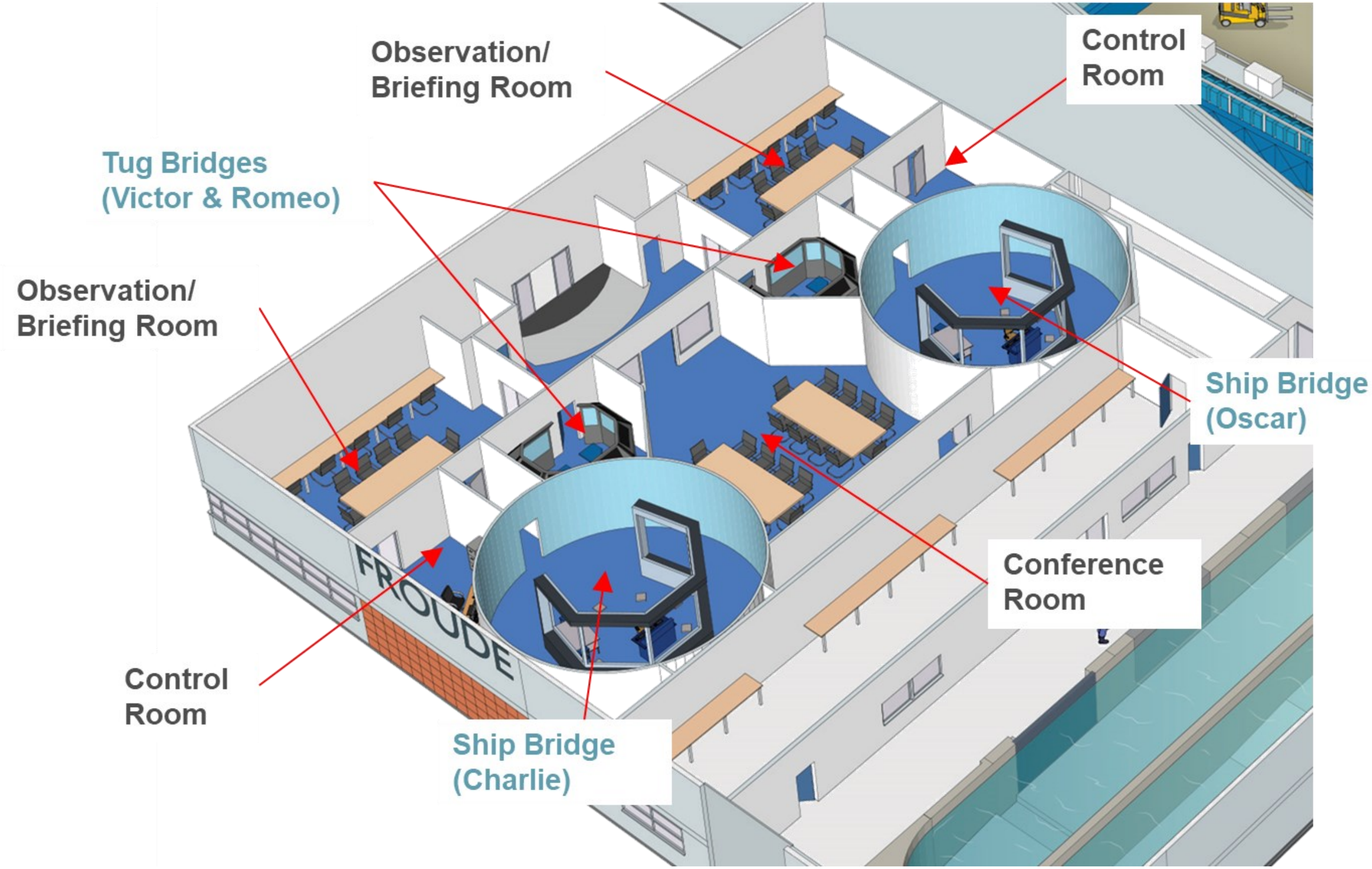
UK Ship Simulator



Orientation

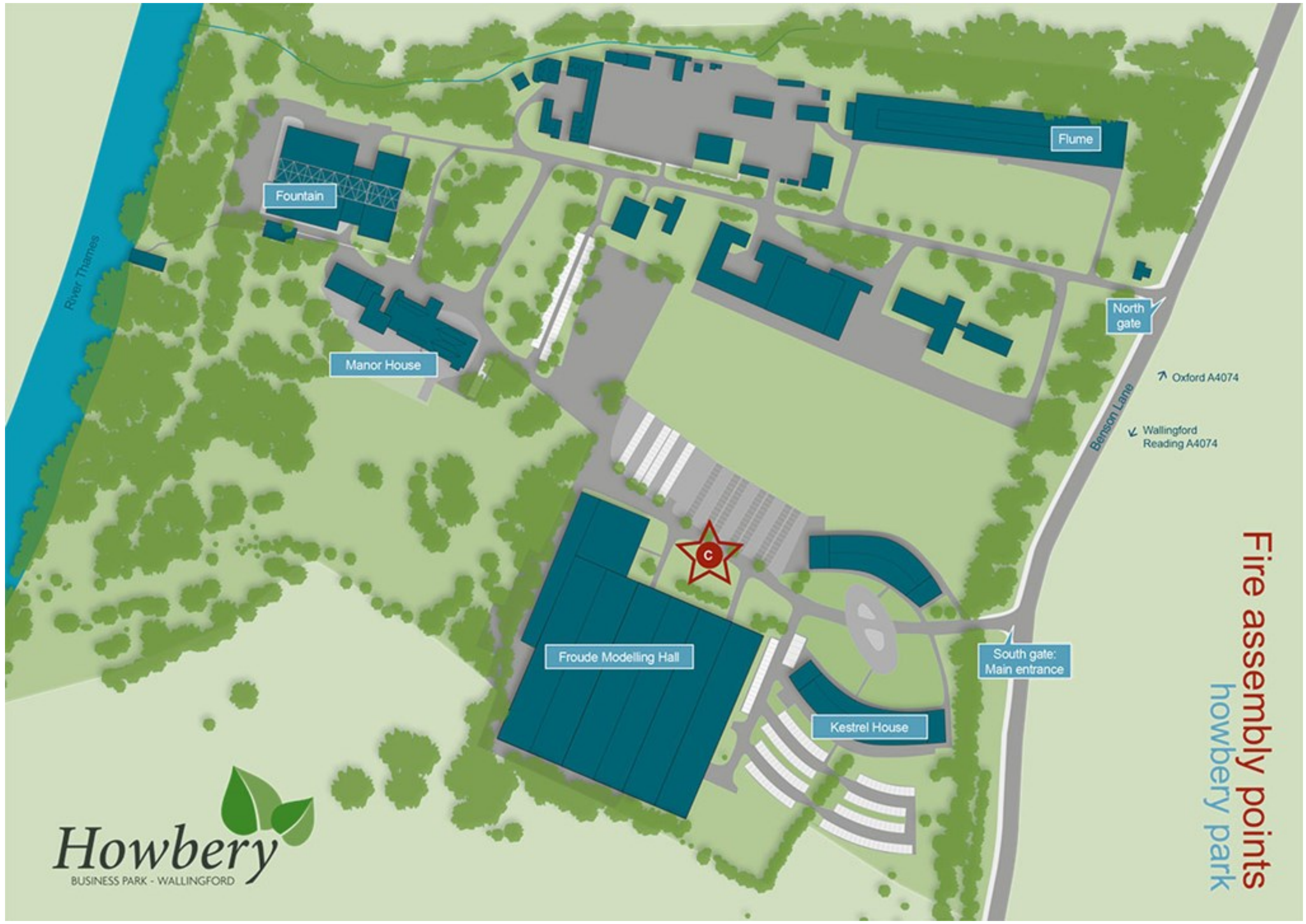
Facilities

Other visitors

Desks

Wires

In the event of a fire



Muster Point

Fire exit and muster area

Simulator Hazards

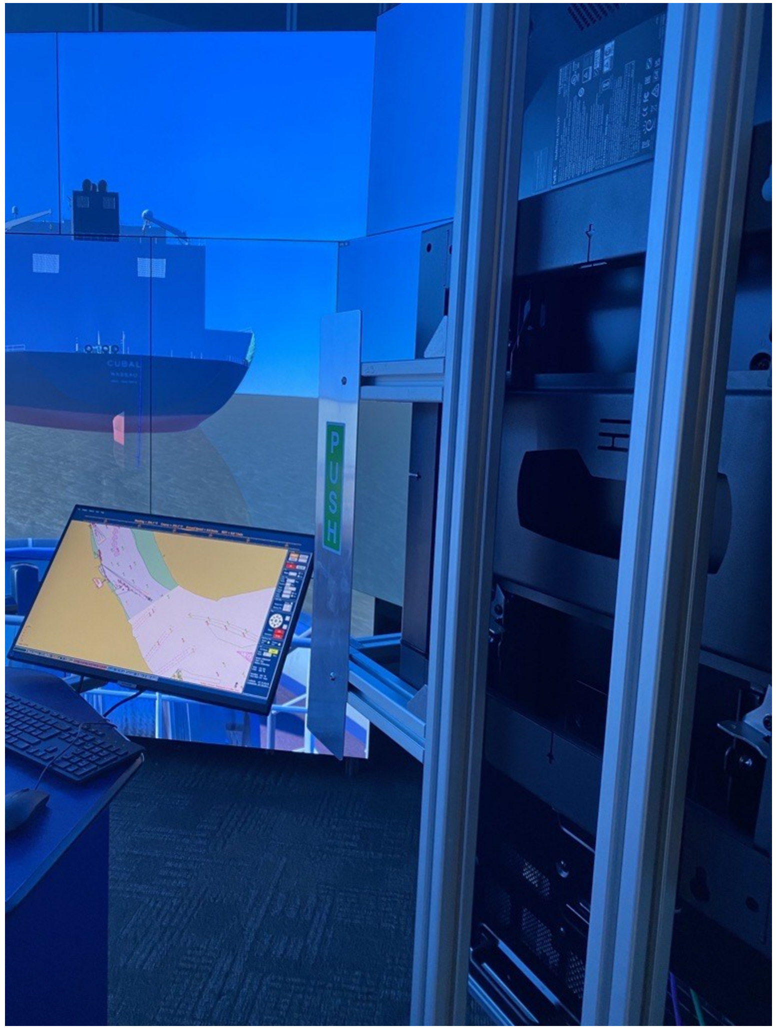
Projectors

Falls

Tug Sim Doors

Fragile

Should be closed during session



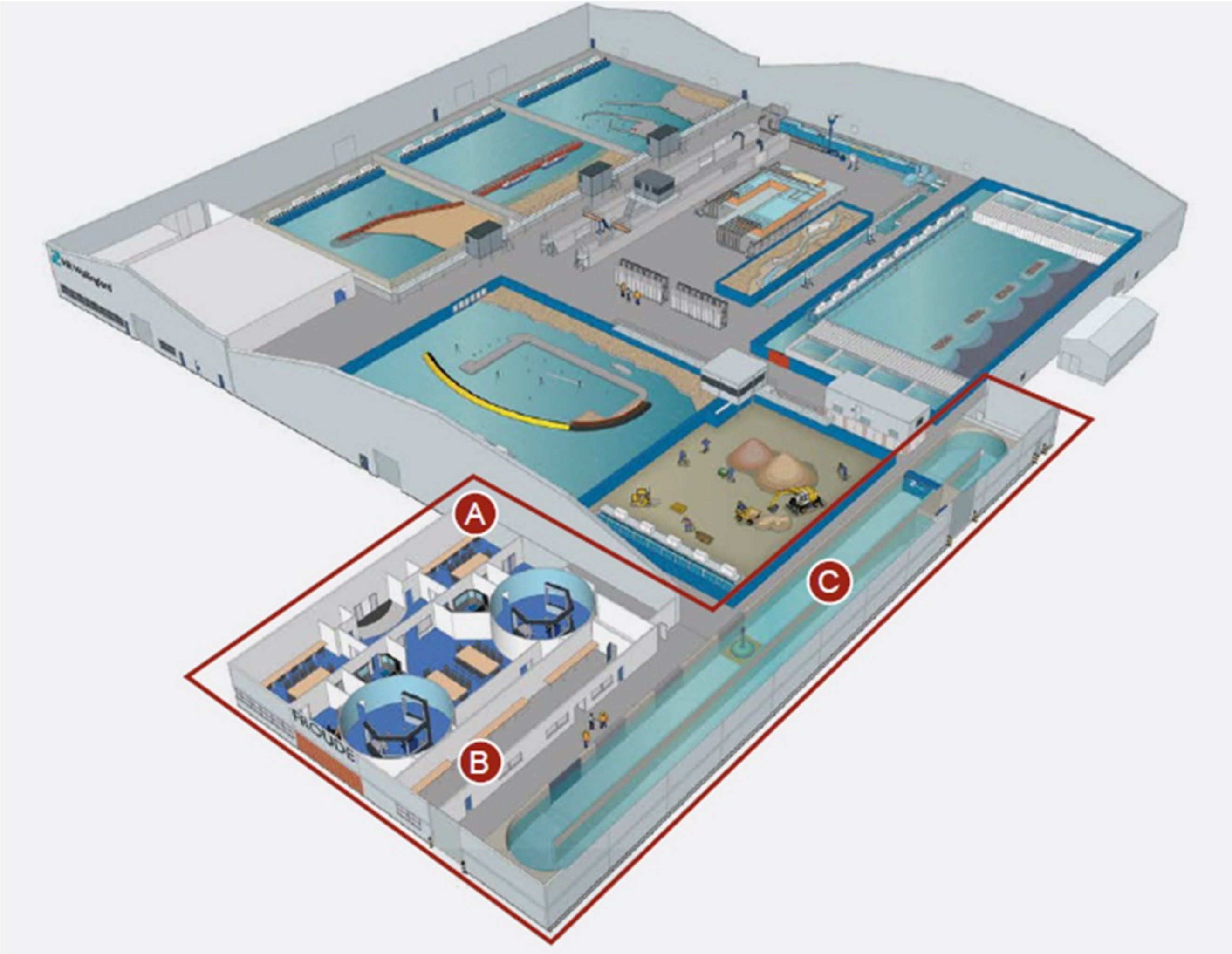
Froude Modelling Hall

Access restricted

Vehicle movements

Hi-Vis surcoats

No photography



Refreshments

Tea and Coffee

NOT ON THE BRIDGE!

https://manorcafeathowbery.touchtakeaway.net/menu

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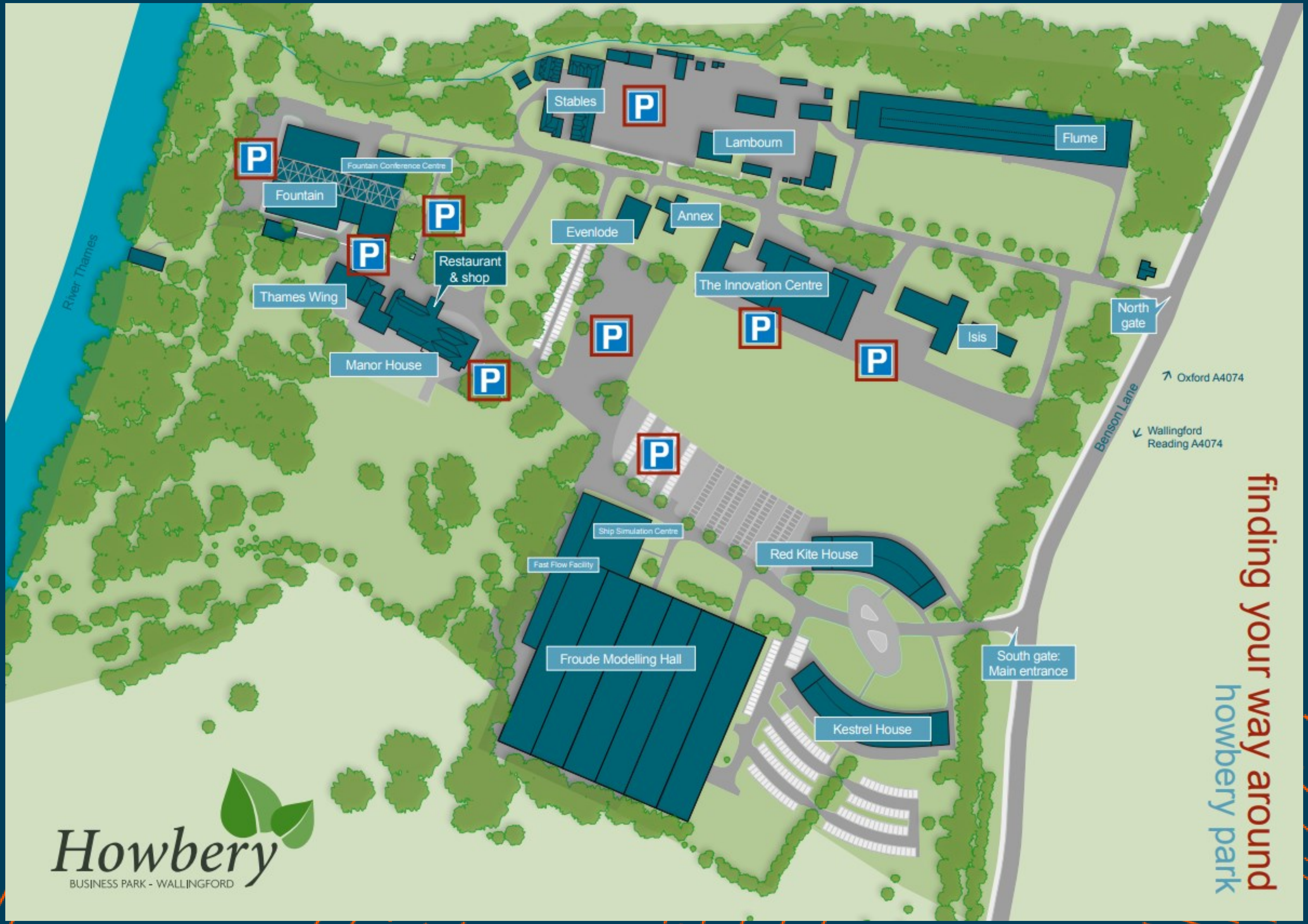
Leg stretch


Stables
Lambourn
Flume
Fountain
Fountain Conference Centre
Evenlode
Annex
Restaurant & shop
Thames Wing
The Innovation Centre
Isis
North gate
Manor House
River Thames
Oxford A4074
Benson Lane
Wallingford Reading A4074
Ship Simulation Centre
Fast Flow Facility
Red Kite House
Froude Modelling Hall
South gate: Main entrance
Kestrel House
finding your way around howbery park
Howbery
BUSINESS PARK - WALLINGFORD

Introductions and general plan

Key Principles

- Recognise that the process is frustrating – but not personal.

- Professional
- Respectful
- Collaborative emphasise areas of agreement
- Note areas of difference

- Efficient – let's not rehearse well-trodden areas of contention

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Introductions

Attendees	Organisation
[redacted]	HR Wallingford
[redacted]	HR Wallingford
[redacted]	HR Wallingford
[redacted]	Head of Marine Operations
[redacted]	HES Harbour Master
[redacted]	HES Dock Master (Remote)
[redacted]	HES Project Team (Reomte)
[redacted]	ABP Project Team
[redacted]	ABP Project Team
[redacted]	HES Pilot Operations
[redacted]	VLS pilot (ABP)
[redacted]	Stena Marine Operations
[redacted]	Stena UK Operations
[redacted]	Stena PEC holder/master
[redacted]	Stena PEC holder/master
[redacted]	IOT Marine Superintendent
[redacted]	IOT Marine Consultant
[redacted]	DFDS Marine Operations
[redacted]	DFDS Marine Consultant
[redacted]	SMS towage
[redacted]	CLdN (Apologies)
[redacted]	Project Team Legal (C&C)
[redacted]	DFDS Legal Team

Aims and objectives

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Aims

- The proximity of the Eastern Jetty in relation to the IEERT terminal, in particular during manoeuvres at berth 3
- The effects of the current direction at berths 2 and 3
- The effect of the anecdotal variation observed with the flow speed and direction in the main river area compared to HR Wallingford flow models for the same area.

- NB - Berth 2, gusting and sheltering

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General plan

Date	Time	Content
7 – 8 Nov	09:00 – 09:30	Daily brief (on Day 1, this meeting may be extended)
	09:30 – 12:30	Simulation runs
	12:30 – 13:00	Break for lunch
	13:00 – 16:45	Resume simulation runs
	16:45 – 17:00	De-brief of day's simulation runs

Ship Simulator Etiquette

- Normal bridge Etiquette
- Max 2 persons on the bridge decided before each run
- The captain has ultimate control of the bridge in the simulator and can ask any stakeholder to leave.
- No stakeholder should talk to the captains during the simulations and must remain silent unless there is a critical need to relay something to the Captain.
- No stakeholder should approach the controls, or indeed, interfere with the controls.
- No photography on the bridge

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Simulation Rhythm

Brief

- Confirm objective
- Confirm start conditions
- Confirm strategy for tugs
- HM – confirm general approach

Execute

- Check Conditions
- Check sims working
- Monitor – report problems

Debrief

- Comment from HR Wallingford facilitator
- Comment from harbour master
- Comments from pilot/pec
- Comments from tug master
- Comments from Stakeholders
  - Including quantitative assessment
- Agree on objective assessment
  - Success
  - Marginal (with reason)
  - Fail (with reason)
- Agree record – HR Wallingford facilitator

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Debrief

Initial Summary HRW

HM Comment

PEC/Pilot Comment

Tug master Comment

APT/IOT

DFDS

Qualitative view if reqd

Draft TP if reqd- Carry on with next run

Propose assessment HRW

Agreement on assessment

Record any significant areas of variance

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Run Plan

Identify runs for Gusts, Sheltering and berth 2 close of play, Tue 7 Nov

Run ID	Manoeuvre	Wind	Flow
1	Approach to No3 berth in normal conditions	SW 15-20 knots	Peak ebb
2	Departure from No 3 berth in normal conditions	SW 15 – 20 knots	Peak ebb
3	Approach to No3 berth in normal conditions	NE 15-20 knots	Peak ebb
4	Departure from No 3 berth in normal conditions	NE 15 – 20 knots	Peak ebb
5	Approach to No3 berth in normal conditions	NE 15-20 knots	Peak flood
6	Departure from No 3 berth in normal conditions	NE 15 – 20 knots	Peak flood
7	Approach to No3 berth in normal conditions	SW 15-20 knots	Peak flood
8	Departure from No 3 berth in normal conditions	SW 15 – 20 knots	Peak flood
9	Approach to No3 berth in extreme conditions	NE 25-30 knots	Peak ebb
10	Departure from No 3 berth in extreme conditions	NE 25-30 knots	Peak ebb
11	Approach to No 3 berth in extreme conditions	NE 25-30 knots	Peak flood
12	Departure from No 3 berth in extreme conditions	NE 25-30 knots	Peak flood
13	Approach to No3 berth in extreme conditions	SW 25-30 knots	Peak ebb
14	Departure from No 3 berth in extreme conditions	SW 25-30 knots	Peak ebb
15	Approach to No3 berth in extreme conditions	SW 25-30 knots	Peak flood
16	Departure from No 3 berth in extreme conditions	SW 25-30 knots	Peak flood
17	Option for gusting conditions (1)	TBC	TBC
19	Option for sheltering conditions (1)	TBC	TBC

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DFDS proposed amend

Rapid Track plot production to assist

DFDS requests that ABP consider the following parameters when determining if each run is characterised as a 'success', 'marginal' or 'failure':

1. 100% Bow thruster use in excess of 3 minutes (continuously or nearly continuously) should be deemed to be 'marginal' as it indicates a vessel on the very limit of what should be considered a 'safe' manoeuvre.

2. 'Engine use in excess of 60% is deemed 'marginal' as from experience out masters know this is the limit of what should be considered a 'safe' manoeuvre.

3. If either of the first 2 criteria were met whilst working with the assistance of a tug they were deemed a failure due to the danger to the tug and her crew by the excessive wash this amount of machinery would cause.

4. Tug power in excess of 100% for more than 3 minutes were considered marginal as again they do not represent 'safe' manoeuvres.

In relation to 'aborts'- the master or pilot needs to demonstrate the vessel is in a state where it could safely escape to the river before the simulation can be stopped.

Qualitative | Quantative

Evaluation criteria - Success

Standard manoeuvres:

- The ship remains under full control at all times without resorting to aggressive manoeuvring techniques;
- The ship stays within safe water areas with acceptable clearances to all port and other structures, and other berthed ships;
- Tugs are operating safely and within sustainable limits;
- For berthing manoeuvres, the ship ends the run alongside, or in such a position that lines would be ashore without appreciable difficulty, at zero speed, with an acceptable sway velocity and no appreciable yaw rate;
- For departure manoeuvres the ship exits smoothly, without risk of drifting onto port structures or other ships.

Emergency/failure situations:

- The ship is brought back under full control without encountering significant hazards, with the risk of only minor damage;
- The ship may leave the designated manoeuvring area boundaries, but still has acceptable under keel clearance and maintains acceptable clearances to other ships/structures throughout the recovery;
- Tugs are neither endangered nor asked to operate in an unsafe manner;
- The ship can be moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated / resolved.

Evaluation criteria - Marginal

Standard manoeuvres:

- The Pilot considers the ship is at the limit of control during standard manoeuvres;
- The ship stays within the safe water area boundaries, but with unacceptable clearances;
- The ship clears all port structures, and other berthed ships, but with unacceptable clearances;
- Tugs are operating safely, but approaching their sustainable operating limits (e.g. being used at 100% power for more than 15 minutes);
- For approach manoeuvres, the ship ends up alongside, but may have a high approach velocity. The manoeuvre can be concluded, but minor damage may occur;
- On departure, the ship is manoeuvred off the berth but with some difficulty. The manoeuvre is completed with the potential for minor damage only.

Emergency/failure situations:

- The ship is at the limits of control during the recovery from the failure;
- The ship has marginal under keel clearance or marginal clearances to other ships/structures during the recovery;
- Tugs operate at the limits of safety;
- The ship is at the limits of controllability as it is moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated/resolved.

Evaluation criteria - Fail

Standard manoeuvres:

- The Pilot loses control of the ship;
- The ship strays outside the safe water area boundaries and/or grounds;
- The ship either contacts, or has a near-miss with port structures and/or other berth ships;
- Tugs are required to operate in an unsafe manner, or exceed sustainable operating limits (e.g. being used at 100% power for more than 30 minutes);
- For approach manoeuvres, the ship cannot get alongside at all, or contacts the berth with sufficient force that severe damage may have occurred;
- On departure, the ship either cannot be manoeuvred off the berth, or encounters significant difficulty in manoeuvring, such that severe damage may have occurred.

Emergency/failure situations:

- The Pilot cannot regain control of the ship before the ship is endangered;
- The ship cannot be prevented from entering dangerously shallow water and/or grounds;
- The ship either contacts or has a near-miss with a known hazard, port structures, and/or other berth ships;
- Tugs are endangered or are asked to operate in an unsafe manner;
- The ship cannot be moved into safe, deep water or to a position suitable to anchor safely.

DFDS proposed amend

DFDS requests that ABP consider the following parameters when determining if each run is characterised as a ‘success’, ‘marginal’ or ‘failure’:

1. 100% Bow thruster use in excess of 3 minutes (continuously or nearly continuously) should be deemed to be ‘marginal’ as it indicates a vessel on the very limit of what should be considered a ‘safe’ manoeuvre.

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4. Tug power in excess of 100% for more than 3 minutes were considered marginal as again they do not represent ‘safe’ manoeuvres.

In relation to ‘aborts’- the master or pilot needs to demonstrate the vessel is in a state where it could safely escape to the river before the simulation can be stopped.

Comparison with tidal diamond B

Tidal Stream Table tidal diamond B	Model Peak Spring			Model mean spring			Indicative flows based on tidal diamond			
Time (hours)	Current Direction (degN)	Current Speed (kts)	Current Speed (kts) x 1.2	Current Direction (degN)	Current Speed (kts)	Current Speed (kts) x 1.2	Directions of Streams (degN)	Rates at Spring Tides (kts)	Rates at Neap Tides (kts)	
HW-6	129	2.9	3.5	132	2.7	3.3	132	2.6	0.8	
HW-5	135	0.6	0.7	148	0.2	0.3	239	0.2	0.2	
HW-4	305	2.5	3	308	2.5	2.9	303	2.2	1.1	
HW-3	304	3.7	4.4	307	3.5	4.1	305	3.3	1.7	(SH –125)
HW-2	305	3.9	4.7	308	3.7	4.5	314	3.2	1.7	(SH –135)
HW-1	305	2.9	3.4	308	2.9	3.5	315	3	1.1	
HW	302	1.7	2	306	1.6	1.9	319	1.3	0.3	
HW+1	265	0.2	0.2	210	0.1	0.1	122	1.3	0.7	
HW+2	134	2	2.4	137	1.9	2.2	133	3.3	1.4	
HW+3	131	3.4	4.1	133	3.1	3.7	129	4	2.4	(SH –309)
HW+4	129	3.8	4.6	131	3.6	4.3	132	4.4	2.8	(SH –312)
HW+5	129	3.7	4.4	132	3.5	4.2	126	3.5	2.6	(SH –306)
HW+6	129	3.4	4	132	3.1	3.7	132	2.9	1.6	

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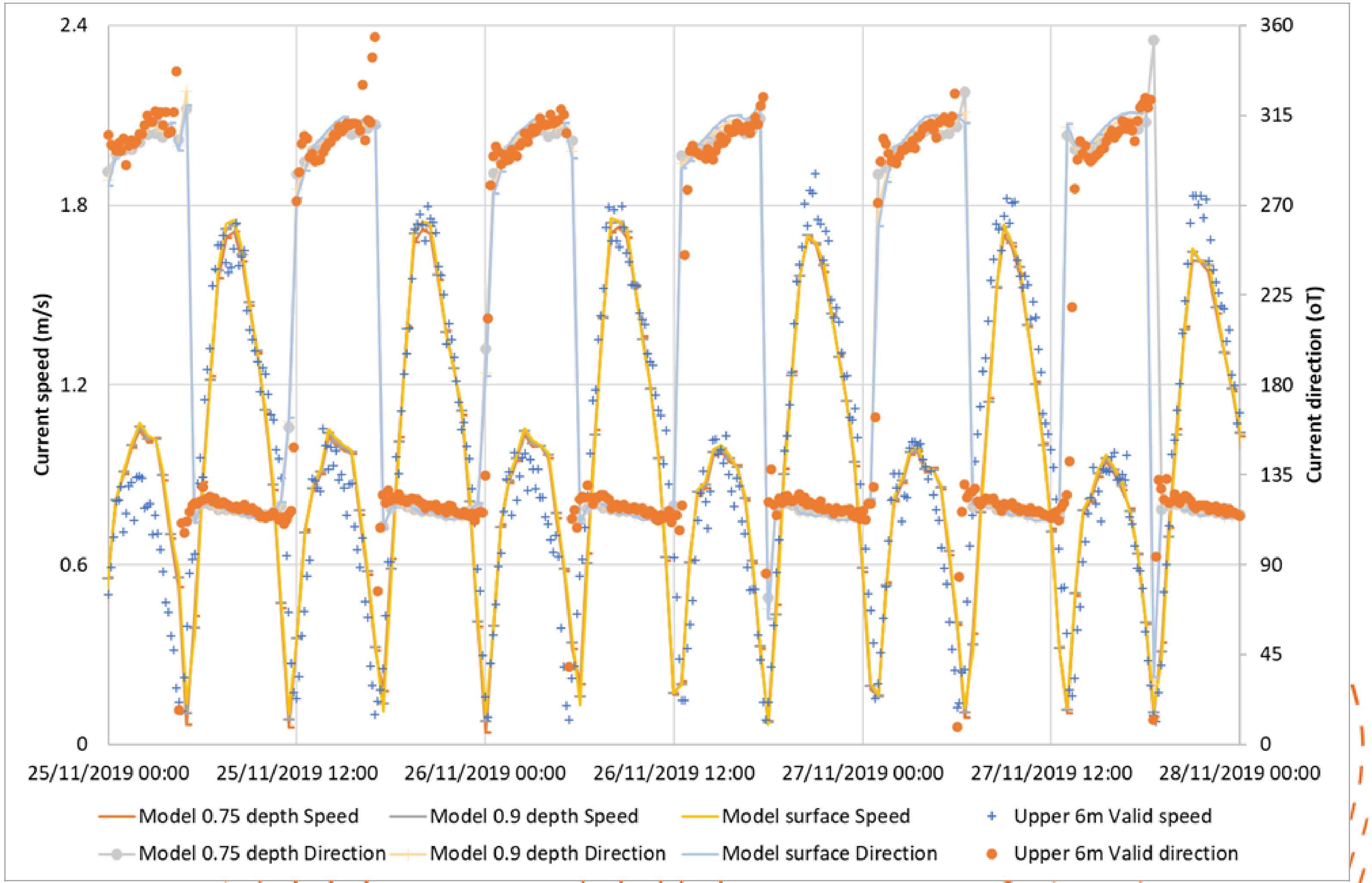
Comparison of AWAC data for similar period to model data based on range – remains valid between Bellmouth and IERRT



Wind analysis

Scaled to 10m AMSL

Return period (years)	Wind speed (10 minute mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	20	17	10	10	8	5	14	17	14	12	13	14
1	33	26	23	14	12	9	19	26	20	17	21	26
2	37	28	28	16	14	10	20	29	22	18	23	30
5	42	31	34	18	16	11	22	32	24	20	26	35

Return period (years)	Wind speed (1 minute mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	23	20	12	14	12	9	19	20	16	15	15	16
1	38	29	27	22	20	16	25	30	24	22	24	30
2	43	32	32	25	22	17	27	33	26	24	27	34
5	48	35	39	28	25	19	28	37	29	28	31	40

Return period (years)	Wind speed (30 second mean, knots) by sector (°N)											
	0	30	60	90	120	150	180	210	240	270	300	330
0.1	24	21	13	15	13	10	20	21	17	16	16	17
1	40	31	29	23	21	17	27	32	25	23	25	32
2	46	34	34	27	23	18	29	35	28	25	29	36
5	51	37	41	30	27	20	30	39	31	30	33	42

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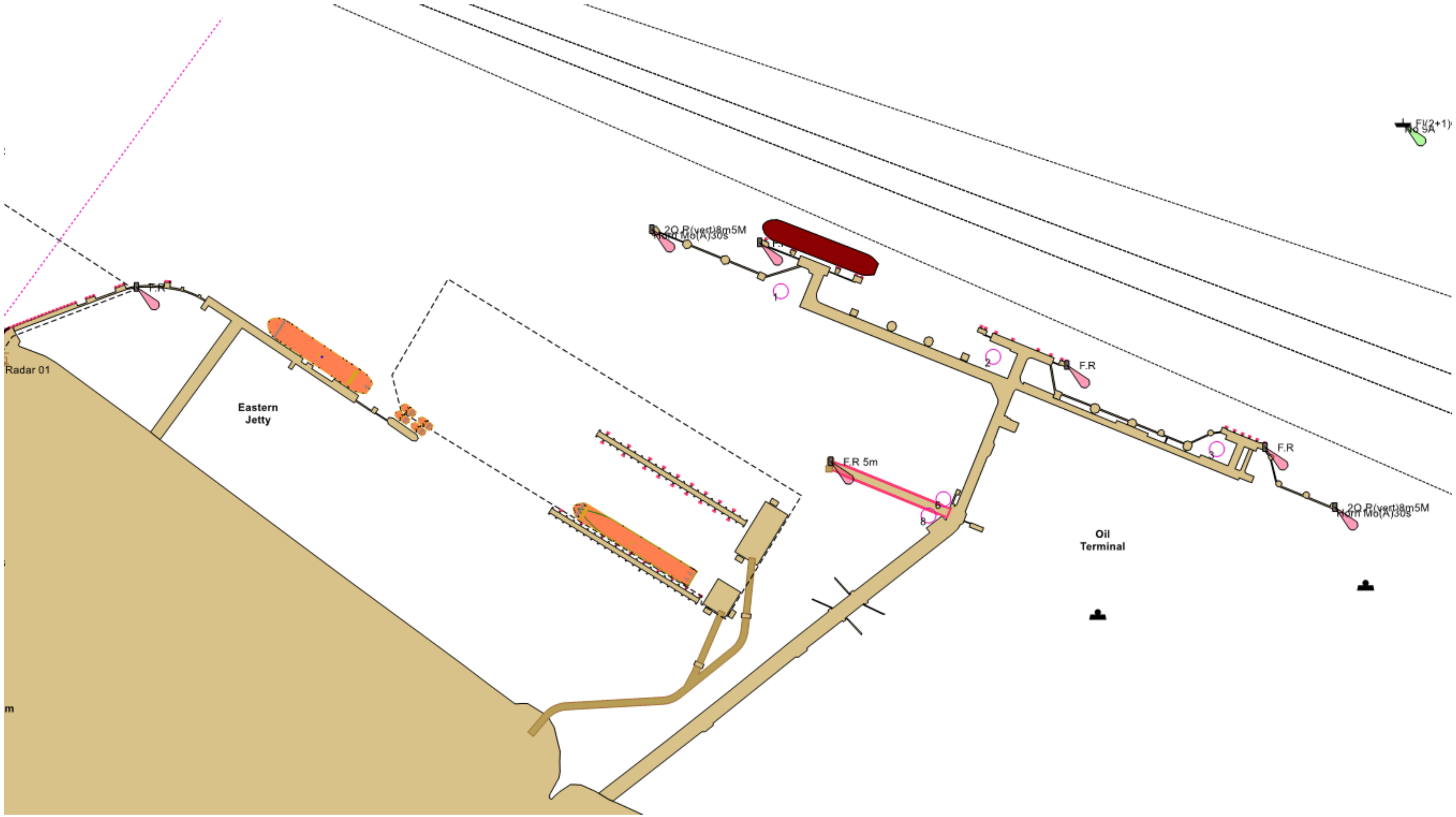
Layout showing eastern jetty and tug pontoon



Run Plan

Identify runs for Gusts, Sheltering and berth 2 close of play, Tue 7 Nov

Run 10 incl, sheltering.

Run 13 Approach to berth 2 sheltering

Run ID	Manoeuvre	Wind	Flow
1	Approach to No3 berth in normal conditions	SW 15-20 knots	Peak ebb
2	Departure from No 3 berth in normal conditions	SW 15 – 20 knots	Peak ebb
3	Approach to No3 berth in normal conditions	NE 15-20 knots	Peak ebb
4	Departure from No 3 berth in normal conditions	NE 15 – 20 knots	Peak ebb
5	Approach to No3 berth in normal conditions	NE 15-20 knots	Peak flood
6	Departure from No 3 berth in normal conditions	NE 15 – 20 knots	Peak flood
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11	Approach to No 3 berth in extreme conditions	NE 25-30 knots	Peak flood
12	Departure from No 3 berth in extreme conditions	NE 25-30 knots	Peak flood
13	Approach to No3 berth in extreme conditions	SW 25-30 knots	Peak ebb
14	Departure from No 3 berth in extreme conditions	SW 25-30 knots	Peak ebb
15	Approach to No3 berth in extreme conditions	SW 25-30 knots	Peak flood
16	Departure from No 3 berth in extreme conditions	SW 25-30 knots	Peak flood
17	Option for gusting conditions (1)	TBC	TBC
19	Option for sheltering conditions (1)	TBC	TBC

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Ship Manoeuvring Model Stena Transit

Characteristic	Unit	Stena Transporter	
Ship type		Ferry	
Length overall	m	212	
Length between perpendiculars	m	194.8	
Beam overall	m	26.7	
Distance bridge to stern	m	196	
Modelled conditions			
Draught forward	m	6.3	
Draught aft	m	6.3	
Block coefficient		0.643	
Displacement	t	21600	
Propulsion			
Main engine type		2 x STX MAN 9L48/60B	
Engine power (total)	kW	21600	
No. of propellers, type		2 x CPP	
Bow thrusters	t	55	
Stern thrusters	t	none	
Rudder type		Becker flap	
Max rudder angle	°	35	
Manoeuvring engine order		RPM	Speed (knots)
Full Ahead		100	21.1
Half Ahead			
Slow Ahead			
Dead Slow Ahead			
STOP		0	0
Dead Slow Astern			
Slow Astern			
Half Astern			
Full Astern		100	- 13.7
Windage			
Windage lateral	m²	4050	
Windage frontal	m²	770	
Wind speed (knots)		Beam wind force (t)	
15		15	
20		26	
25		41	
30		59	
35		80	
40		105	
45		133	

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Tugs
50t 2411 ASD

BP (tonnes)	Number of tugs on Humber
50 to 59	8
59 to 69	3
69 +	6

Characteristic	Unit	50t ASD2411 Tug	
Ship type		Tug	
Length overall	m	24.55	
Length between perpendiculars	m	22.16	
Beam overall	m	11.33	
Distance bridge to stern	m	13.52	
Modelled conditions			
Draught forward	m	5.56	
Draught aft	m	5.56	
Block coefficient		0.335	
Displacement	t	480	
Propulsion			
Main engine type		2 x Caterpillar 3516C TA HD	
Engine power (total)	kW	2700	
No. of propellers, type		2 x Azipod	
Bow thrusters	t	none	
Stern thrusters	t	none	
Rudder type		n/a	
Max rudder angle	°	0	
Manoeuvring engine order		RPM	Speed (knots)
Full Ahead		212	11.1
Half Ahead			
Slow Ahead			
Dead Slow Ahead			
STOP		0	0
Dead Slow Astern			
Slow Astern			
Half Astern			
Full Astern		0	10.9
Windage			
Windage lateral	m²	83	
Windage frontal	m²	58	
Wind speed (knots)		Beam wind force (t)	
15		0	
20		1	
25		1	
30		1	
35		2	
40		2	
45		3	

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Any questions?

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F Construction Design and Management Regulations (CDM, 2015)

The Construction (Design and Management) Regulations 2015 (CDM 2015) require a designer to avoid foreseeable risks to those involved in construction and future use of the structure, and in doing so, they should eliminate hazards (so far as is reasonably practicable, taking into account other design considerations) and reduce and control risks associated with those hazards which remain. It is essential that, where required to do so, a principal designer and principal contractor are appointed to fulfil their respective duties under the CDM 2015. It is also essential to highlight and record the impacts of the works on health, safety and welfare which should feed into the Health and Safety File (if required). Further details of the requirements of CDM 2015 can be found on:

http://www.hse.gov.uk/construction/cdm/2015/index.htm

This project consists of desk assessments, numerical and physical modelling work and/or simulation work which may be used by others in the design process. No design work, as defined in the CDM 2015, has been undertaken by HR Wallingford. If during the navigation simulation process we identify any particular issues that should be drawn to the attention of the principal designer and principal contractor in any ultimate construction work which may be undertaken, we will do so in our client discussions and reports. It is assumed that the appointed principal designer will review the information produced in this study when discharging their duties under the CDM 2015.

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We design smarter, more resilient solutions across both the natural and built environment to help everyone live and work more sustainably with water.

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