Great Yarmouth Third River Crossing

Application for Development Consent Order

Document NCC/GY3RC/EX/072: preliminary Navigation Risk Assessment

Planning Act 2008

Infrastructure Planning

The Infrastructure Planning (Examination Procedure) Rules 2010

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Foreword

This preliminary Navigation Risk Assessment accompanies an application ("the Application") submitted by Norfolk County Council ("the Applicant") to the Secretary of State for a Development Consent Order ("DCO") under the Planning Act 2008.[1]

If made by the Secretary of State, the DCO would grant development consent for construction, operation and maintenance of a new bascule bridge highway crossing of the River Yare in Great Yarmouth, and which is referred to in the Application as the Great Yarmouth Third River Crossing ("the Scheme").

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) require that an application for a DCO be accompanied by the documents specified at Regulation 5(2)(a) to (r). This is one of those documents and is specified at Regulation 5(2)(q).

[1] Reference to legislation in this document are to that legislation as amended at the date of this document.

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Glossary of Abbreviations and Defined Terms

ALARP	As low as reasonably practicable
COLREGs	International Regulations for Prevention of Collision at Sea, 1972
DCO	Development Consent Order
DfT	Department for Transport
ES	Environmental Statement
GLA	General Lighthouse Authority
GYPA	Great Yarmouth Port Authority
GYPC	Great Yarmouth Port Company
IALA	The International Association of Marine Aids to Navigation and Lighthouse Authorities
LOA	Length Overall
LPS	Local Port Service
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
NRA	Navigation Risk Assessment
NCC	Norfolk County Council (as the Applicant)
NSBA	Norfolk and Suffolk Boating Association
NWG	Navigation Working Group
pNRA	preliminary Navigation Risk Assessment
RNLI	Royal National Lifeboat Institution
RYA	Royal Yachting Association
SHA	Statutory Harbour Authority

1 Introduction

1.1 Scope of the Assessments

1.1.1 This report covers the preparation of a preliminary Navigation Risk Assessment (pNRA) based on the design prepared for the DCO application. It covers both the construction and operational phases of the proposed scheme as designed at pre-tender stage. Any material changes to the bridge design or construction methodology will need to be considered and the Risk Assessment amended accordingly.

1.2 Objectives

1.2.1 The objectives of the pNRA were to establish;

- The hazards to navigation created by the presence of the scheme bascule bridge;
- The existing control and mitigation measures in place within the Port that will influence the identified risks;
- The risk levels associated with the identified hazards;
- Any additional control or mitigation measures that are required to ensure the risks identified are "as low as reasonably practicable".

2 Scheme Description

2.1 Overview

2.1.1 Chapter 2 of Volume I of the Environmental Statement (ES) (DCO Document **6.1**) provides a full description of the Scheme, and is accompanied by the General Arrangement Plan (DCO Document **2.2**). Both documents should be read alongside the preliminary Navigation Risk Assessment, as a detailed project description is not provided in this document to prevent unnecessary duplication.

2.1.2 The Scheme involves the construction, operation and maintenance of a new crossing of the River Yare in Great Yarmouth. The Scheme consists of a new dual carriageway road, including a road bridge across the river, linking the A47 at Harfrey's Roundabout on the western side of the river to the A1243 South Denes Road on the eastern side. The Scheme would feature an opening span double leaf bascule (lifting) bridge across the river, involving the construction of two new 'knuckles' extending the quay wall into the river to support the bridge. The Scheme would include a bridge span over the existing Southtown Road on the western side of the river, and a bridge span on the eastern side of the river to provide an underpass for existing businesses, enabling the new dual carriageway road to rise westwards towards the crest of the new crossing.

2.2 Port Operations

2.2.1 The location of the Scheme crosses the navigation waterway within the River Yare and the port has commercial quays both north and south of the location, access to the berths north of the Scheme will require an opening of the bridge should the air draft of the vessel exceed the clear height of the bridge in the lowered position.

2.2.2 The GYPA is a Trust Port, it is the Statutory Harbour Authority (SHA) for the port of Great Yarmouth and the revisionary landlord of the port estate. In 2007 GYPA leased the port of Great Yarmouth to GYPC for 99 years, GYPC becoming the owner and operator of the port business and acting as agent for GYPA in the discharge of its statutory duties.

2.2.3 The port handles a wide variety of cargos including aggregates, cement, grain, fertilisers, forest products, dry and liquid bulks, pipeline and onshore wind farm equipment as well as providing facilities for the offshore windfarm servicing industry. A total of 1.2 million tonnes of cargo passed through the port during 2017.

2.2.4 From historic data covering the period 2008 to 2016 received from GYPC, an average of 10,000 commercial vessel moves per year occurred within the Port, with approximately 40% of these involving movements to or from berths north of the Scheme location. This figure does not include Port operational vessel movements or recreational vessels.

2.2.5 The River Yare also provides access for recreational vessels to ~~the~~ Breydon Water via the Haven Bridge and subsequently the Norfolk Broads via the Breydon Bridge, along with a number of small commercial vessel movements to and from boatyards located inland of the Haven Bridge.~~for recreational vessels via Breydon Water. These vessels have to pass two existing lifting bridges, the Haven Bridge and the Breydon Bridge, during a passage between the sea and the Broads.~~

3 Methodology

3.1 Assessment Process

3.1.1 The preliminary Navigation Risk Assessment has been prepared to assess the additional and incremental risks to vessel navigation that will arise during and following construction of the proposed bridge. It does not look to assess existing risks present during navigation or risks outside the areas of influence of the bridge or its operation.

3.1.2 The process adopted has followed the general principals of risk assessment as set out in A Guide to Good Practice on Port Marine Operations, that being a 5-stage process comprising;

- Data Gathering
- Hazard Identification
- Risk Analysis
- Risk Assessment
- Risk Control

3.2 Consultation

3.2.1 In order to ensure a robust risk assessment process Navigation Risk Assessment workshops have been held to which the principal marine stakeholders were invited to attend to contribute to the preparation of the preliminary Navigation Risk Assessment.

3.2.2 The first workshop was undertaken on 26th March 2019 at the GYPC Offices at Vanguard House, Great Yarmouth.

3.2.3 This workshop was attended by;

- John Bayfield – GYPC Marine Operations Manager
- Luke Sebastian – GYPC Marine Operations Manager
- David Morrice – GYPC Port Pilot
- Peter Woolston – GYPC Launch Coxswain
- Michael Mackleworth – GYPC Port Compliance Officer
- Stephen Horne – WSP (on behalf of NCC) Principal Maritime Engineer

3.2.4 The workshop explained the Scheme proposal design and the proposed scheme of operations as well as the proposed methodology for preparation of this pNRA.

3.2.5 The workshop reviewed identified hazards and causational effects and gave some consideration to the likelihoods and severities associated with each based on various vessel classifications and Scheme phase.

3.2.6 The second workshop was held on 19th September 2019, again at the GYPC offices at Vanguard House, Great Yarmouth.

3.2.7 This workshop was attended by;

- Brian Forrest – GYPC Senior Manager - Marine Operations
- Luke Sebastian – GYPC Marine Operations Manager
- Martin Collins – GYPC Port Pilot
- Michael Nicholson – Shipmove Consultants Ltd (on behalf of NCC)
- Mark Kemp – NCC Project Manager
- Stephen Horne – WSP (on behalf of NCC) Principal Maritime Engineer
- Richard Hayman – BAM Farrans JV (on behalf of NCC) Construction Manager

3.2.8 This workshop reviewed an update on the Scheme proposal design, the proposed Scheme of Operations and the outcomes of vessel simulation works undertaken between 3rd and 5th September 2019, as well as confirming the agreed methodology for preparation of this pNRA.

3.2.9 The workshop reviewed the previously identified hazards and causational effects along with additional hazards and mitigations and gave some consideration to the likelihoods and severities associated with each based on various vessel classifications and Scheme phase.

3.2.10 It was agreed that all currently foreseeable risks had been identified and suitable mitigation and control measures proposed to reduce these to ALARP for the stage of design.

3.2.11 A third workshop was held on 21st January 2020, at the GYPC offices at Vanguard House, Great Yarmouth.

3.2.12 This workshop was opened, by invitation, to other interested parties, both those who had expressed an interest in participating and those suggested by the Applicant and GYPC. These parties were sent details of the event and afforded the opportunity to send delegates.

3.2.13 This workshop was attended by;

- Brian Forrest – GYPC Senior Manager – Marine Operations
- Luke Sebastian – GYPC Marine Operations Manager
- Lucy Burchnall & Graeme Hewitt – Broads Authority
- Sue Goodchild & Lisa Pierce – Goodchild Marine Ltd.
- Benvenuto Falat & Will Armour – RYA / NSBA
- Lindsey Wigmore – RNLI & Port Pilot
- Aston Goddard, Phil Crosston-Clegg – E.ON/RWE
- Mark Kemp – NCC Project Manager
- Michael Nicholson – Shipmove Consultants Ltd (on behalf of ~~NC~~the Applicant~~C~~)
- Stephen Horne – WSP (on behalf of ~~NCC~~the Applicant) Principal Maritime Engineer
- Richard Hayman – BAM Farrans JV (on behalf of ~~NCC~~the Applicant) Construction Manager

3.2.14 Invitations were also extended to Norfolk Fire and Rescue, ASCO Limited and Great Yarmouth Port Users Association, although they did not send representatives.

3.2.15 This workshop reviewed an update of the Scheme proposal design and~~,~~ the latest proposed Scheme of Operation set out within the DCO in light of the representations made during the DCO examination process ~~and the~~in relation to the methodology used for the risk assessment process.

3.2.16 The workshop reviewed the previously identified hazards, causational effects and mitigations along with potential additional hazards and gave consideration to the likelihoods and severities associated with each hazard, based on various vessel classifications and the different Scheme phases.

3.2.17 Generally, all parties agreed that all foreseeable risks had been identified and due consideration had been given to suitable mitigation.

3.2.18 GYPC agreed that, with the operational mitigations for a bridge failure set out in this document (which is secured by the DCO) and Scheme of Operation, a large vessel waiting facility would not be required.

3.2.19 It was agreed that the risk for small vessels approaching and berthing on the waiting pontoons should be separated out from the overarching waiting pontoon risk to emphasis the hazard associated with this particular element of manoeuvring (see hazard 63).

3.2.20 RYA raised the prospect of recreational vessels making use of the waiting pontoons as a secure berth without direction from the bridge operators and whether this presented a risk, both the Applicant and the GYPC considered this to be an operational management issue and similar to existing situations with unauthorised berthing; for which operational procedures already exist.

3.2.21 It was agreed to include a specific hazard for bridge failure during a recreational vessel flotilla movement (see hazard 64).

3.2.22 It was agreed that further workshops, following the format of this third workshop, would be undertaken at the following stages of Scheme development;

- Completion of detailed design
- Prior to completion of construction
- Additional review workshops may be required during the construction phase should specific issues be identified, these should be undertaken at the request of a relevant party.

3.3 Guidance and References

3.3.1 This preliminary Navigation Risk Assessment has been prepared with reference to the following documents;

- Port Marine Safety Code, DfT/MCA Nov 2016
- A Guide to Good Practice on Port Marine Operations, DfT/MCA Feb 2018
- The National Contingency Plan - A Strategic Overview for Responses to Marine Pollution from Shipping and Offshore Installations, DfT/MCA
- Methodology for Assessing the Marine Navigational Safety & Emergency Response of Risks of Offshore Renewable Energy Installations, DfT/MCA
- Peel Ports Marine Operations – Marine Safety Management System, Peel Ports July 2017
- Great Yarmouth Port Authority Navigation (Haven) Bye-Laws 1997, GYPC
- General Port and Pilotage Information P16 2014, GYPC
- Pilotage Information Sheet 2014, GYPC

3.4 Data Gathering

3.4.1 For the preparation of this preliminary Navigation Risk Assessment a variety of information sources have been reviewed and assessed for applicability, these included;

- Existing operational arrangements;
- Previous studies and assessments;
- Scheme studies and assessments;
- Previous bridge incident reports.

4 Hazard Identification

4.1 General

4.1.1 The following section outlines the hazards resulting specifically from navigation in the vicinity of an opening bridge and the primary causational effect which lead to such hazards, taking in account of its users and the Scheme design, including the waiting berths.

4.2 Collision

4.2.1 Collision is the uncontrolled coming together of 2 vessels underway. It is applicable to all sizes and types of vessels. Collision hazards are present during every vessel movement where other vessels are or could be present. The main factors affecting occurrence likelihood are vessel density, navigation constraints and vessel control.

4.3 Contact

4.3.1 Contact is the uncontrolled coming together of a vessel and either a fixed structure or a moored vessel. It is applicable to all sizes and types of vessels. Contact hazards are present whenever vessel movements occur in proximity to fixed structures and during berthing operations. The main factors affecting occurrence likelihood are navigation constraints and vessel control.

4.4 Grounding

4.4.1 Grounding is the unintentional coming together of a vessel and the bed of the river, sea or dock. While applicable to all types of vessel it is more likely for larger deeper draughted commercial vessels. Grounding hazards are more likely for vessels as draught increases. The main factors affecting occurrence likelihood are navigation chart accuracy, navigation planning and vessel control.

4.5 Primary Causes

Collision

Vessel Proximity

4.5.1 Restrictions on the width of navigable water inherently increases the proximity at which vessels will need to navigate.

Visibility

4.5.2 Reductions or obstructions to visibility will increase the risks of Masters not seeing other vessels in sufficient time to navigate safely.

Equipment Failure (Collision)

4.5.3 Failure of on-board equipment can render vessels adrift and unable to maintain navigational control thereby increasing the risks of collision. Failure of bridge operating equipment can result in vessels needing to perform evasive manoeuvres increasing the risks of collision.

Human Error (Collision)

4.5.4 Human error by the Master or pilot of a vessel is a contributory cause in a significant number of marine incidents and the potential for its occurrence requires consideration in all assessments.

Contact

Knowledge of Structure

4.5.5 A Master's lack of knowledge of the presence and nature of structures constraining navigation will increase the risk of contact between their vessel and a structure.

Current Pattern Changes

4.5.6 Familiarity with existing conditions and a failure to allow for potential changes caused by the presence of new structures will increase the risks of contact.

Wind Sheltering

4.5.7 Changes to the levels of wind exposure felt by a vessel navigating within the bridge passage can lead to an increased risk of contact, this risk increases as vessel dimensions increase.

Projections or Roll

4.5.8 Vessels with projecting cargo or flying bridges have greater potential to contact structures, similarly high vessels with a susceptibility to roll or traveling with a list produce a higher risk.

Equipment Failure (Contact)

4.5.9 Failure of on-board equipment can render vessels adrift and unable to maintain navigational control thereby increasing the risks of contact. Failure of bridge operating equipment can result in vessels needing to perform evasive manoeuvres increasing the risks of contact.

Human Error (Contact)

4.5.10 Human error by the Master or pilot of a vessel is a contributory cause in a significant number of marine incidents and the potential for its occurrence requires consideration in all assessments. Human error by the bridge operational staff could be a contributory factor in creating a hazardous situation for approaching vessels.

Grounding

Changes in Sedimentation Patterns

4.5.11 Changes to the patterns of current flow during and following construction of new structures can lead to changes in sediment deposition areas and rates with a subsequent reduction in accuracy of available navigation chart data. This will tend to increase the risk of groundings particularly for deeper draughted vessels.

4.6 Incident Frequencies

4.6.1 A review of Marine Accident Investigation Branch (MAIB) incident reports during the period 1999 to 2018 has identified 10 events related to bridge structures. Of these 9 were contacts with the remaining one a collision.

4.6.2 Of the 10 recorded events, five were on the Thames in Central London, two each on the Ouse and Trent and the final one on the Mersey. No incidents have been recorded within Great Yarmouth.

4.6.3 GYPC have confirmed that there has been one reported incident involving a vessel contact with the Haven Bridge recorded on the Ports Risk Management System. This involved a non-powered barge under tow becoming trapped under the bridge while attempting to transit without a lift. The barge was removed by the towing vessel without further assistance.

4.6.4 An assessment of the potential future traffic frequency for each class of vessel has been undertaken as part of the scheme preparation, the results of this assessment are presented in Appendix B.

4.6.5 This assessment indicated that the anticipated annual number of vessel passages of all types through the new bridge could be around 8,000. In total around 90% of movements are anticipated to be commercial traffic with the remaining 10% recreational. Further discussions with the GYPC have indicated that this value remains a reasonable base-line for the pNRA.

5 Existing Operational Measures

5.1 Navigation Control

5.1.1 Navigation within the Port is controlled by the local Harbour Master under the authority of GYPA, the SHA. Control of vessels is governed by Port Bye-Laws, general and special Directions and Notice to Mariners issued as required by the Harbour Master or Deputy as appropriate.

Commercial Vessels

5.1.2 Commercial vessels are categorised as any vessel operating on a commercial basis; they are generally motor driven as opposed to sail and range from small to very large.

Piloted Vessels

5.1.3 Pilotage is required for all vessels or tows of 40.0 metres Length Overall (LOA) or more (With a few exemptions).

Non-Piloted Vessels

5.1.4 Vessels below the LOA threshold and vessels whose Master holds a Pilot Exemption Certificate are not required to take a pilot.

Recreational Vessels

5.1.5 Recreational vessels are those used by private individuals for personal or entertainment purposes; they are typically very small to small and can be either motor, sail or non-propelled (paddle).

5.2 Vessel Control

5.2.1 All individual commercial vessels are required to notify the Statutory Harbour Authority of all intended movements within the Port, they are provided relevant safety information via a Local Port Service operated by the SHA. Control of vessel entry and exit from the Port is governed by navigation lighting. Further control of specific vessel movements is implemented via pilotage or Direction (under the Harbours Act) when assessed as required.

5.2.2 All vessels are governed by the requirements of the Port Bye-Laws and directions along with the “International Regulations for Prevention of Collision at Sea” (COLREGs).

5.3 Depth Control

5.3.1 Bed levels within the Port are monitored via biannual bathymetric surveys and maintained via dredging campaigns as required (currently annually).

5.3.2 The Statutory Harbour Authority publishes depths for vessel passages and produces navigation charts detailing the actual bed levels for vessel Masters to plan movements.

6 Risk Assessment

6.1 Scope of the Assessments

6.1.1 The Risk Assessment was conducted using a likelihood x severity matrix, in accordance with the methodology set out in Peel Ports Marine Safety Management System as used by GYPC.

- Likelihood;

1 Rare – occurrence frequency greater than project design life,
2 Unlikely – occurrence frequency between 2 years and project life,
3 Possible – occurrence frequency less than biennial,
4 Likely – annual occurrence frequency,
5 Almost Certain – multiple occurrences expected annually.

- Severity;

1 Negligible – no injuries or damage to property or environment,
2 Minor – injury not requiring hospitalisation, damage not affecting operations, Tier 1 pollution incident,
3 Moderate – injury requiring hospital treatment, damage requiring repair, localised Tier 2 pollution,
4 Major – major injury, structural damage affecting operation, widespread Tier 2 pollution,
5 Catastrophic – casualty, structural collapse/sinking or Tier 3 pollution.

(Pollution Tiers are as defined in "The National Contingency Plan - A Strategic Overview for Responses to Marine Pollution from Shipping and Offshore Installations").

6.1.2 The two values are used to form the Risk Matrix. Finally, the Risk Matrix score is assigned one of four colour coded classifications, Very Low, Low, High and Very High, as shown below.

	Negligible	Minor	Moderate	Major	Catastrophic
Rare	1	2	3	4	5
Unlikely	2	4	6	8	10
Possible	3	6	9	12	15
Likely	4	8	12	16	20
Almost Certain	5	10	15	20	25

6.1.3 This Risk Classification indicates the magnitude and acceptability of the risk and guides whether additional mitigating control measures may be required to bring the risk to ALARP (As Low As Reasonably Practicable) principles, in this case taken as being Low.

6.1.4 The initial outputs from the preliminary Navigation Risk Assessment are presented in Appendix A in the following format;

ID	Hazard	Cause	Phase	Traffic Type	Pre Mitigation				Existing Controls	New Mitigation	Post Mitigation			
					L	S	R	Rank			L	S	R	Rank

Where;

L – Likelihood, S – Severity, R – Risk.

6.1.5 The pre-mitigation assessment identified 1 very high, 19 high and 44 low risks. Risks assessed as very low in the pre-mitigation condition are not detailed in the outputs.

6.1.6 The identified mitigations change these to 37 low and 27 very low risks.

~~6.1.5~~

7 Additional Mitigation Measures

7.0.1 The following additional mitigation measures have been identified during the preparation of this pNRA and are recommended to be included within the delivery of the Scheme.

7.1 Planning and Design Phase

Vessel Simulations

7.1.1 Vessel simulations have been undertaken as part of the Planning Phase to inform the preliminary design and subsequent final designs. Reports on the simulations undertaken so far are included in Appendices C, D and E. Further simulations will be arranged, should conditions fundamentally change, as required.

Hydrodynamic and Sediment Modelling

7.1.2 The construction methodology and design of the final bridge must take account of the results of the hydrodynamic modelling and Sediment Transport Assessment (DCO Document **6.2 Appendix 11c**) and aim to reduce the potential impacts of changes to flow patterns and sediment deposition.

Design Development

7.1.3 The outputs of this pNRA are to be considered in all future design development, all future design decisions must consider the potential impacts on the identified risks and if they create any additional risks and any new controls or mitigation measures that may be required the pNRA should be updated to reflect this.

Fender Design

7.1.4 The design of fendering on the bridge abutments should be in line with the outcomes of the vessel simulations and recommendations of the pNRA, that is they should provide a continuous fender face for the full parallel length of the bridge passage.

7.2 Construction Phase

Updates

7.2.1 Prior to commencement of the Construction Phase, a complete update of the NRA will be undertaken by the Undertaker, in conjunction with the SHA and other interested parties, informed by an updated risk assessment workshop, to consider the implications of the precise methods of construction to be employed.

Monitoring

7.2.2 Monitoring of potential changes caused by the construction should be undertaken to ensure that early intervention can be commenced should any potentially hazardous conditions develop. This should include bathymetric surveys for potential sedimentation issues and may include vibration monitoring in relation to quay walls.

Notifications

7.2.3 During the Construction Phase Notice to Mariners should be issued to ensure all users are fully informed of the state of the works in relation to navigation, the frequency and format of these notices should be agreed with the SHA.

Communications

7.2.4 During the Construction Phase a detailed communications plan should be developed between the Contractor and the SHA to ensure adequate transfer of daily vessel movement plans and other safety related information.

Lights and Markings

7.2.5 During the Construction Phase all plant and works that could present a hazard to navigation will be required to exhibit suitable marks and lights as may be required by the SHA. These should be notified to all local operators via a Notice to Mariners.

7.3 Operational Phase

Updates

7.3.1 Prior to commencement of the Operational Phase, a complete update of the NRA will be undertaken, in conjunction with the SHA and other interested parties, informed by an updated risk assessment workshop, to consider any additional risks that may have become apparent during the Construction Phase. This update should be incorporated into the wider Port Navigation Risk Assessment and revised and updated in line with the Ports Marine Safety Management System. Updates should also be considered if requested by RYA or GYPA.

Notifications

7.3.2 In preparation for the Operation Phase, Notice to Mariners should be prepared and distributed detailing the operational regime for the final bridge, this should include all necessary details to ensure port users are adequately aware of the methods of communicating with the bridge operations and the meanings of the directions associated with the final bridge.

Familiarisation and Training

7.3.3 The implementation of a suitable training and familiarisation program for pilots and other applicable port users should be established to ensure all are conversant with the changes to navigation that will be experienced both during and after construction of the bridge. Amendments to the ports Pilotage Exemption Certification process should be considered in light of the altered passage conditions both during and after construction.

7.3.4 Consideration should be given to the establishment of a range of standard operational limitations, potentially based on vessel category and size, with a view to minimising risk exposure for the larger commercial vessels.

Bridge Operation Procedures

7.3.5 To mitigate the potential effects of a bridge mechanism failure the operational procedures implemented for the bridge should take account of the alternative manoeuvres each vessel could take in the event of a failure to open, for large vessels this should form part of the pilotage plan for the vessels passage taking into account all applicable factors such as vessel handling and environmental conditions. These alternative actions would include, proceeding to an alternative berth, holding station mid river, returning to sea and, if no other safe alternative is available, opening the bridge before the vessel enters the port.

7.3.6 To mitigate the potential risks associated with a large vessel passage while recreational vessels occupy the waiting facility, bridge operational procedures should provide a suitable mechanism to facilitate the safe timely release of recreational vessels before a large vessel transit.

7.3.7 Consideration of tidal conditions should be made before the direction of recreational vessels to the waiting pontoon, monitoring of berthing activity should be undertaken by the bridge operators and the procedures amended accordingly based on observed behaviour.

7.3.57.3.8 Arranged bridge lifts should be publicised to the recreational boating community, this could allow for more synchronisation of vessel movements and reduce requests for multiple openings in short timeframes.

7.3.67.3.9 To mitigate the potential risk of a vessel transiting the bridge coming into conflict with a vessel manoeuvring at a nearby berth the Harbour Authority will have to take due account of all river activity before permitting passage. The bridge operator should provide the SHA with information on observed craft and movements in the area to assist in the decision-making process.

Operator Training and Competence

~~7.3.7~~7.3.10 Provision should be made for the training and assessment of competence of the bridge operational staff, both in terms of the bridge operation and in marine safety and vessel management more generally to ensure they are capable of providing the required level of service to passing vessels and managing the required interaction with the SHA.

Inspections and Handover

~~7.3.8~~7.3.11 A handover period should be implemented to provide continuity for early stage fault rectification and minimise the potential for navigation disruption during the period directly after the bridge is commissioned.

~~7.3.9~~7.3.12 A programme of surveys and inspections should be established to ensure early identification of any potentially hazardous conditions, surveys should include bathymetric surveys of the River and structural surveys of the works as required.

Lights and Markings

~~7.3.10~~7.3.13 During the Operation Phase the bridge will be identified with suitable marks and lights agreed during the design development with the SHA and the GLA (Trinity House).

Information Systems

~~7.3.11~~7.3.14 Provision of real-time environmental condition monitoring systems to provide information to the bridge operator and vessel masters should be incorporated into the Scheme design, these would include wind measurements, current flow measurements, tide gauges and air draft boards.

Maintenance

~~7.3.12~~7.3.15 A suitable and sufficient maintenance regime should be established to ensure the mechanical reliability of the final bridge. Suitable training should be given to operational staff to allow them to safely manage the operation of the bridge.

Reviews

~~7.3.13~~7.3.16 All risk assessments are live documents and must be reviewed and revised in light of any changes in conditions to remain effective, as previously stated the final bridge Navigation Risk Assessment should therefore be incorporated into the wider Port Navigation Risk Assessment and revised and updated in line with the Ports Marine Safety Management System.

Appendix A – preliminary NRA

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment (Jan 2020)

Norfolk County Council

Hazard ID	Hazard Type	Cause	Phase	Traffic Type	Pre-Mitigation L	Pre-Mitigation S	Pre-Mitigation R	Pre-Mitigation Rank	Existing Controls	Additional Mitigation	Post-Mitigation L	Post-Mitigation S	Post-Mitigation R	Post-Mitigation Rank
62	All	The bridge will create a severance between the northern and southern portions of the port	Operation	All	5	4	20	1	None	Bridge designed to open, Scheme of Operation developed, operational requirements contained within DCO	2	4	8	3
1	Collision	Increased traffic proximity due to construction	Construction	Commercial (Large)	3	4	12	7	LPS System, Navigation directions, Compulsory Pilotage/PEC	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, establishment of Communications Plan for Construction phase.	2	4	8	3
2	Collision	Increased traffic proximity due to construction	Construction	Commercial (Small)	4	4	16	2	LPS System, Navigation directions	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, establishment of Communications Plan for Construction phase.	2	4	8	3
3	Collision	Increased traffic proximity due to construction	Construction	Recreation	3	3	9	22	LPS System, Navigation directions	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, establishment of Communications Plan for Construction phase.	1	3	3	39
4	Collision	Increased traffic proximity through bridge	Operation	Commercial (Large)	3	4	12	7	LPS System, Navigation directions, Compulsory Pilotage/PEC	Undertake simulations to assess the extent of potential changes to navigation, Traffic Control Signal lights, bridge operator competence.	1	4	4	21
5	Collision	Increased traffic proximity through bridge	Operation	Commercial (Small)	4	4	16	2	LPS System, Navigation directions	Undertake simulations to assess the extent of potential changes to navigation, Traffic Control Signal lights, bridge operator competence.	1	4	4	21
6	Collision	Increased traffic proximity through bridge	Operation	Recreation	3	3	9	22	LPS System, Navigation directions	Traffic Control Signal lights, bridge operator competence.	1	3	3	39
7	Collision	Obstruction to visibility	Operation	Commercial (Small)	3	4	12	7	LPS System, Navigation directions	Vessel control lights, bridge operational procedures, bridge operator competence.	1	4	4	21
8	Collision	Obstruction to visibility	Operation	Commercial (Large)	2	4	8	37	LPS System, Navigation directions	Vessel control lights, bridge operational procedures, bridge operator competence.	1	4	4	21
9	Collision	Obstruction to visibility	Operation	Recreation	2	3	6	42	LPS System, Navigation directions	Vessel control lights, bridge operational procedures, bridge operator competence.	1	3	3	39
10	Collision	Proximity of waiting pontoon	Operation	Recreation	2	3	6	42	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, operational procedure to vacate pontoon prior to large vessel transits.	1	3	3	39
11	Collision	Proximity of waiting pontoon	Operation	Commercial (Large)	2	3	6	42	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, operational procedure to vacate pontoon prior to large vessel transits.	1	3	3	39
12	Collision	Proximity of waiting pontoon	Operation	Commercial (Small)	2	3	6	42	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
13	Collision	Requirement to hold awaiting bridge operations	Operation	Recreation	3	2	6	42	LPS System, Navigation directions	Provision of waiting pontoon, scheduled bridge opening times.	1	2	2	59
14	Contact	Equipment failure - bridge mechanism fails to open	Operation	Commercial (Large)	2	3	6	42	LPS System	Mechanical redundancy within design, PUWER Assessment, bridge operating and emergency protocols to be established, operational handover and maintenance period.	1	3	3	39
15	Contact	Equipment failure - bridge mechanism fails to open	Operation	Commercial (Small)	3	3	9	22	LPS System	Mechanical redundancy within design, PUWER Assessment, bridge operating and emergency protocols to be established, operational handover and maintenance period.	2	3	6	9

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

					Pre-Mitigation						Post-Mitigation			
Hazard ID	Hazard Type	Cause	Phase	Traffic Type	L	S	R	Rank	Existing Controls	Additional Mitigation	L	S	R	Rank
16	Contact	Equipment failure - Failure of navigation lighting	Construction	Commercial (Large)	3	4	12	7	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme, Communications Plan.	1	4	4	21
17	Contact	Equipment failure - Failure of navigation lighting	Construction	Commercial (Small)	4	3	12	7	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme, Communications Plan.	1	3	3	39
18	Contact	Equipment failure - Failure of navigation lighting	Construction	Recreation	2	3	6	42	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme, Communications Plan.	1	3	3	39
19	Contact	Equipment failure - Failure of navigation lighting	Operation	Commercial (Large)	2	4	8	37	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	21
20	Contact	Equipment failure - Failure of navigation lighting	Operation	Recreation	2	2	4	62	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	21
21	Contact	Equipment failure - Failure of navigation lighting	Operation	Commercial (Small)	2	3	6	42	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	21
22	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Commercial (Large)	2	4	8	37	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV, operator training and competence.	1	4	4	21
23	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Commercial (Small)	3	3	9	22	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV, operator training and competence.	1	3	3	39
24	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Recreation	3	2	6	42	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV, operator training and competence.	2	2	4	21
25	Contact	Lack of knowledge of presence of structure	Construction	Commercial (Large)	3	4	12	7	Compulsory Pilotage/PEC	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, Notifications via Port LPS.	1	4	4	21
26	Contact	Lack of knowledge of presence of structure	Construction	Recreation	4	3	12	7	None	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, "River Works Ahead" signage, Notifications via Port LPS.	2	3	6	9
27	Contact	Lack of knowledge of presence of structure	Construction	Commercial (Small)	3	3	9	22	None	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, Notifications via Port LPS.	1	3	3	39
28	Contact	Lack of knowledge of presence of structure	Operation	Commercial (Large)	3	4	12	7	Compulsory Pilotage/PEC	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering, Pilot/PEC familiarisation	1	3	3	39
29	Contact	Lack of knowledge of presence of structure	Operation	Recreation	4	2	8	37	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering	2	1	2	59
30	Contact	Lack of knowledge of presence of structure	Operation	Commercial (Small)	2	3	6	42	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering	1	2	2	59
31	Contact	Loss of control due to changes in current patterns	Construction	Commercial (Large)	4	4	16	2	Compulsory Pilotage/PEC	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners.	2	4	8	3

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Hazard ID	Hazard Type	Cause	Phase	Traffic Type	Pre-Mitigation L	Pre-Mitigation S	Pre-Mitigation R	Pre-Mitigation Rank	Existing Controls	Additional Mitigation	Post-Mitigation L	Post-Mitigation S	Post-Mitigation R	Post-Mitigation Rank
32	Contact	Loss of control due to changes in current patterns	Construction	Recreation	3	3	9	22	None	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners.	2	3	6	9
33	Contact	Loss of control due to changes in current patterns	Construction	Commercial (Small)	3	3	9	22	None	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners.	2	3	6	9
34	Contact	Loss of control due to changes in current patterns	Operation	Commercial (Large)	4	4	16	2	Compulsory Pilotage/PEC	Undertake simulations to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, implement training programme, provision of flow monitoring equipment in control tower.	2	3	6	9
35	Contact	Loss of control due to changes in current patterns	Operation	Recreation	3	3	9	22	None	Issue Notice to Mariners, impact protection fendering, provision of flow monitoring equipment in control tower.	2	2	4	21
36	Contact	Loss of control due to changes in current patterns	Operation	Commercial (Small)	3	3	9	22	None	Undertake simulations to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, provision of flow monitoring equipment in control tower.	2	2	4	21
37	Contact	Loss of control due to wind sheltering	Operation	Commercial (Large)	3	4	12	7	Compulsory Pilotage/PEC	Undertake modelling to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, implement training programme.	2	3	6	9
38	Contact	Loss of control due to wind sheltering	Operation	Recreation	2	3	6	42	None	Issue Notice to Mariners, impact protection fendering, provision of wind indicator at bridge	1	2	2	59
39	Contact	Loss of control due to wind sheltering	Operation	Commercial (Small)	2	3	6	42	None	Undertake modelling to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering	2	2	4	21
40	Contact	Proximity of waiting pontoon to navigation channel	Operation	Commercial (Large)	3	4	12	7	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, operational procedure to vacate pontoon prior to large vessel transits.	1	3	3	39
41	Contact	Proximity of waiting pontoon to navigation channel	Operation	Commercial (Small)	2	3	6	42	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, operational procedure to vacate pontoon prior to large vessel transits.	1	3	3	39
42	Contact	Vessel contact with bridge attempting to proceed without an opening	Operation	Recreation	3	3	9	22	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, provision of air draft board.	2	3	6	9
43	Contact	Vessel contact with bridge attempting to proceed without an opening	Operation	Commercial (Small)	2	3	6	42	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, provision of air draft board.	1	3	3	39
44	Contact	Vessel projections or roll causes contact with bridge superstructure	Operation	Commercial (Large)	3	3	9	22	Compulsory Pilotage/PEC	Bridge designed with no oversailing when open, impact protection fendering	2	3	6	9
45	Contact	Vessel projections or roll causes contact with bridge superstructure	Operation	Commercial (Small)	2	2	4	62	None	Bridge designed with no oversailing when open, impact protection fendering	1	2	2	59
46	Contact	Vessel equipment failure	Operation	Commercial (Large)	2	4	8	37	None	Impact protection fenders	2	3	6	9
47	Contact	Vessel equipment failure	Operation	Commercial (Small)	2	3	6	42	None	Impact protection fenders	2	2	4	21

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment (Jan 2020)

					Pre-Mitigation						Post-Mitigation			
Hazard ID	Hazard Type	Cause	Phase	Traffic Type	L	S	R	Rank	Existing Controls	Additional Mitigation	L	S	R	Rank
48	Contact	Vessel equipment failure	Operation	Recreation	2	3	6	42	None	Impact protection fenders	2	2	4	21
49	Contact	Human error - Vessel operator	Construction	Commercial (Large)	3	4	12	7	Compulsory Pilotage/PEC	Liaison with HM over vessel movements, repositioning of equipment if required, vacation of cofferdam during large vessel transits, direct access to land from jack-up barge. Speed restrictions if appropriate.	3	3	9	1
50	Contact	Human error - Vessel operator	Construction	Commercial (Small)	3	3	9	22	None	Liaison with HM over vessel movements, repositioning of equipment and vacation of cofferdam if required, direct access to land from jack-up barge. Speed restrictions if appropriate.	3	2	6	9
51	Contact	Human error - Vessel operator	Construction	Recreation	3	3	9	22	None	Liaison with HM over vessel movements, vacation of cofferdam if required, direct access to land from jack-up barge. Speed restrictions if appropriate.	3	2	6	9
52	Contact	Human error - Vessel operator	Operation	Commercial (Large)	4	4	16	2	Compulsory Pilotage/PEC	Impact protection fenders, Pilot/PEC familiarisation	3	3	9	1
53	Contact	Human error - Vessel operator	Operation	Commercial (Small)	4	3	12	7	None	Impact protection fenders	4	2	8	3
54	Contact	Human error - Vessel operator	Operation	Recreation	3	3	9	22	None	Impact protection fenders	3	2	6	9
55	Grounding	Change in sediment regime leads to shoaling	Construction	Commercial (Large)	3	4	12	7	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	2	4	8	3
56	Grounding	Change in sediment regime leads to shoaling	Construction	Commercial (Small)	2	3	6	42	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	1	3	3	39
57	Grounding	Change in sediment regime leads to shoaling	Operation	Commercial (Large)	3	4	12	7	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	1	4	4	21
58	Grounding	Change in sediment regime leads to shoaling	Operation	Commercial (Small)	2	3	6	42	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	1	3	3	39
59	Grounding	Objects dropped into navigation channel during construction	Construction	Commercial (Large)	3	3	9	22	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and dropped object notification procedures	1	3	3	39
60	Grounding	Objects dropped into navigation channel during construction	Construction	Commercial (Small)	2	3	6	42	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and dropped object notification procedures	1	3	3	39
61	Grounding	Objects dropped into navigation channel during construction	Construction	Recreation	2	2	4	62	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and dropped object notification procedures	1	2	2	59
63	Collision	Equipment failure - bridge mechanism fails to open during flotilla movement	Operation	Recreation	2	3	6	42	LPS System	Mechanical redundancy within design, PUWER Assessment, bridge operating and emergency protocols to be established, operational handover and maintenance period.	1	3	3	39
64	Contact	Vessel unable to berth on waiting pontoon due to tidal conditions	Operation	Recreation	3	4	12	7	None	Consideration of tidal conditions and vessel handling before direction of vessels to waiting pontoons. Impact protection fendering. Provision of escape ladders and handholds onto pontoons in case of man-overboard situations.	2	2	4	21

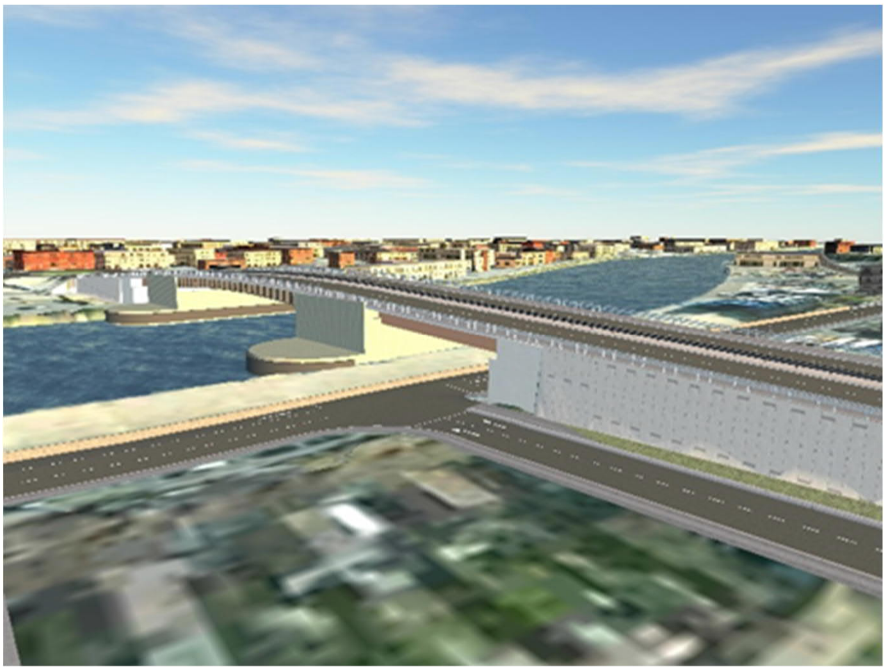
Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Appendix B – Existing and Future Requirements of Peel Ports Great Yarmouth and other Port Users

1073739-MOU-MAR-GY-RP-MA-0001 - Existing and Future Requirements of Peel Ports Great Yarmouth and other Port Users

Great Yarmouth Third Crossing

Existing and Future Navigation Requirements of Peel Ports Great Yarmouth and other Port Users



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Produced For:

Norfolk County Council

Prepared by:

Mouchel Maritime

1st Floor, Exchange Station
Tithebarn Street,
Liverpool,
L2 2QP
T +44 (0)151 243 9970

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Limitations on Reporting

This report is presented to Mouchel Transport Planning Division in respect of the maritime assessment of options for a third crossing at Great Yarmouth, with the anticipation of it informing an overall options report prepared by Mouchel Transport Planning Division. Should this report be presented to Norfolk County Council in respect of a third crossing at Great Yarmouth, it may not be used or relied on by any other person. It may not be used by Norfolk County Council in relation to any other matters not covered specifically by the agreed scope of this Report.

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Contents

Introduction

Great Yarmouth is a town in the English county of Norfolk. It is situated on the east coast of the United Kingdom and has a port with direct sea access to the North Sea. The port is owned and operated by Peel Ports Great Yarmouth and is made up of two sections; the inner harbour is formed on the banks of the River Yare whilst the outer harbour is constructed from breakwaters and comprises land reclaimed from the sea.
As can be seen in Figure 1 below the town is divided in a north south direction by the river which results in a spit of land approximately 4km long being effectively separated from the remainder of the town.

Figure 1 - Aerial photograph of Great Yarmouth Haven

To overcome this separation Norfolk County Council is proposing to construct a third river crossing approximately 1.5km south of the existing Haven Bridge, which is the most southerly of the current two crossings.
The aspirations of the scheme are to improve connectivity within the town thereby reducing traffic congestion and promoting redevelopment and growth.

1 Project Appreciation

Norfolk County Council have appointed Mouchel's Transport Planning Division to prepare an Outline Business Case for the proposed third river crossing at Great Yarmouth. The proposed scheme is a new road crossing to ease the current congestion around the town centre and the existing bridges. The type and location of the proposed new crossing has the potential to impact on existing and future maritime based operations in Great Yarmouth.

The proposals are to construct a new bascule bridge that will carry land traffic across the River Yare. The proposed bridge will cross the river near the apex of the river bend between Berths 12 and 13 on the Atlas Quay (also known as Fish Wharf) on the east bank, and Berths 31 and 32 on the Bollard Quay on the west bank, see Figure 2. With the current design parameters, when raised the bridge will have a 50m clear span for navigation and when closed it will have a clear height of approximately 4.5m above the mean high water springs level. An alternative design providing a clear height of 7.5m, the maximum achievable while still maintaining a tie-in to South Dene Road, has also been considered.

Figure 2 - Proposed Bridge Location

Ships will need to routinely pass through the raised bridge to access the various berths north of the bridge site. Furthermore, there are active berths immediately adjacent to the intended bridge's location on both sides of the river. Therefore an assessment of the likely frequency of operations and the effect of future port developments on this frequency is required.

2 Scope of Service

2.1 Scope

Mouchel's Maritime Division have been asked to provide support to Mouchel's Transport Planning Division by gathering available data on existing maritime operations based in Great Yarmouth and forecasting possible future maritime operations, that will have an influence on the proposed solutions for the third crossing. Mouchel Maritime were also requested to establish possible benefits / regeneration upsides available to Peel Ports and other port users from a third crossing. This will be achieved by completing the following tasks:

- Complete a desk top study and initial consultations to identify stakeholders
- Prepare a questionnaire to be used to gather information from stakeholders
- Schedule meetings with stakeholders in preparation for a visit to Great Yarmouth
- Collate information on existing and projected future Port usage
- Prepare a report on the existing and future requirements of the Port and other users to identify constraints and opportunities for the proposed crossing and to inform the Options Study
- Attendance at an optioneering workshop
- Ongoing support to develop and select option(s) for recommendation
- Input to final report to Client

3 Existing Stakeholders of the Port

3.1 Identification of Existing Stakeholders

Stakeholders are individuals, departments or organizations whose interests may be affected positively or negatively by the execution of the project. The identification of stakeholders was carried out using a variety of methods, electronic searches and consultations to determine individuals, departments and organizations that may be impacted by or have an impact on this project.

For the purpose of this study and the focus on the existing and future maritime operations at the Port, two levels of stakeholder were identified, primary and secondary. Primary stakeholders, those directly affected by this project, were considered to be the land owners and Port tenants who have quay operations north of the proposed bridge location. Secondary stakeholders, those indirectly affected by this project, were considered to be those who have quay operations south of the proposed bridge location or do not operate vessels from their berths north of the bridge. Table 1 below lists all stakeholders identified. Stakeholders who operate at berths falling in to both primary and secondary categories have only been consulted once.

An initial consultation meeting with Peel Ports was held on 18th October to outline the aims and nature of the proposed bridge, obtain any key concerns Peel Ports had over the scheme and to identify significant port users and others who may be affected by the bridge.

	Stakeholder Name	Status	Relationship
1	Peel Ports/Great Yarmouth Port	Primary	Land Owner and Quay User
2	G.Y. Borough Council	Primary	Land Owner
3	Asco	Primary	Port Tenant and Quay User
4	Gardline	Primary	Port Tenant and Quay User
5	Alicat	Primary	Port Tenant and Quay User
6	E-on	Primary	Port Tenant and Quay User
7	Trinity Marine Services	Primary	Port Tenant and Quay User
8	Seatrax Ltd	Primary	Port Tenant and Quay User
9	Atlantic Marine & Aviation	Primary	Port Tenant and Quay User
10	EMR	Primary	Port Tenant and Quay User
11	Brineflow Ltd	Primary	Port Tenant
13	CLS Global Solutions	Secondary	Port Tenant and Quay User
14	Silverton Aggregates	Secondary	Port Tenant

Table 1 List of Identified Stakeholders

The location of the principal operational berths of the above identified stakeholders, along with the major layby berths within the Haven, are shown on Figure 3, overleaf.

Figure 3 - Berth plan

3.2 Stakeholder Details

3.2.1 Peel Ports/Great Yarmouth Port

Peel Ports are the second largest port operator in the UK and are part of the Peel Group, one of the largest property investment companies in the UK. Peel Ports Great Yarmouth are the Statutory Harbour Authority for the Port and have statutory duties regarding safety of navigation within the port and its approaches. They are owners and operators of a number of berths within the port.

3.2.2 Great Yarmouth Borough Council

Great Yarmouth Borough Council are the land owners at berths 21 and 35. Consultation with the Borough Council is being undertaken directly by Norfolk County Council and as such they were not approached in connection with this report.

3.2.3 ASCO

ASCO are an international offshore support services business providing service vessel and crew transfers for oil and gas field operations. They currently operate from Berths 12A to 12D, 31 and 32 with additional layby at 21 when required, and have between 25 and 35 vessel movements per week.

3.2.4 Gardline Marine Sciences

Gardline provide marine geophysical and geotechnical surveys including bathymetry and operate a number of survey vessels from Berth 29. Movement rates are typically less than 1 per week.

3.2.5 Alicat Workboats

Alicat are a service vessel manufacturer and repairer based at Berths 29A and B, they are part of the Gardline Group. They have an average of 7 vessel moves per week.

3.2.6 E-on

E-on operate a wind farm maintenance base for the Scroby Sands from Berth 15, with layby facilities at Berth 29 when required. They currently operate 2 vessels with movements typically twice daily for each vessel.

3.2.7 Trinity Marine Services

Trinity Marine Services (a Dalby Offshore/Gardline joint venture company) operate an offshore supply service from Berth 16, with standby mooring at 21, running between 2 and 4 vessels on a typical daily movement pattern for each vessel.

3.2.8 Seatrax Ltd

Seatrax are an offshore crane manufacturing company, supplying lifting equipment for offshore oil and gas installations. They operate a facility at Berth 28, vessel movements are limited with an average of less than 1 per month.

3.2.9 Atlantic Marine & Aviation

Atlantic Marine & Aviation are a vessel chartering company operating in the offshore & subsea markets. They have an operations base at berth 28, and have vessel movements 2 to 3 times per month.

3.2.10 EMR

EMR (European Metal Recycling) are a global metal recycling business operating a depot on Berth 18. They have few vessel movements to the berth.

3.2.11 Brineflow Properties & Handling Ltd

Brineflow are a drilling fluid supply company who have commercial interests in 2 quays north of the proposed bridge location (berths 20 and 24) with aspirations to develop these as offshore support bases. They currently have limited ship movements within the port.

3.2.12 CLS Global Solutions

CLS Global Solutions provide engineering and project management services to the offshore oil, gas and renewables industries. They operate from berth 32C & D and 33. Vessel movements to these berths are infrequent.

3.2.13 Silverton Aggregates

Silverton Aggregates operate a material supply depot from berths 30D & E, although they have not had a vessel on berth for 4 years.

3.3 Stakeholder Consultations

In order to understand the business operations, both present and future, of the individual identified stakeholders a consultation exercise was undertaken. In the majority of cases stakeholders were contacted by telephone to explain the study and discuss details of the proposal and their opinions. Table 2 below summarises all stakeholders and the type of consultation conducted.

Stakeholder Name	Status	Meeting	Telephone	E-mail	Response
Peel Ports	Primary	✓			✓
G.Y. Borough Council	Primary	Not approached as part of this survey.			
ASCO	Primary		✓	✓	
Gardline / Alicat	Primary		✓	✓	

E-on	Primary		✓		✓
Trinity Marine / Dalby Offshore	Primary		✓		✓
Seatrax Ltd	Primary		✓		✓
Atlantic Marine & Aviation	Primary		✓	✓	
EMR	Primary		✓		✓
Brineflow Ltd	Primary		✓		✓
CLS Global Solutions	Secondary		✓		✓
Silverton Aggregates	Secondary		✓		✓

Table 2 Summary of Stakeholder Consultations

4 Results of Consultations

4.1 Stakeholder Consultations

4.1.1 Peel Ports

During the initial consultation meeting held at Peel Ports Great Yarmouth offices on 18th October, the general principles of the proposed bridge design were reviewed with representatives of the ports operational, engineering and marine management teams. A number of preliminary observations on the scheme were made by Peel Ports and a request for further detail was made to Norfolk County Council.

Peel Ports agreed to supply vessel movement data from the harbours records for a period covering 2010 to 2016, along with details of their future planning for berth redevelopments. This information was subsequently supplied on 31st October 2016, with additional information sent on 24th November 2016, and has been incorporated into the report.

Peel Ports supplied a berth occupancy plan showing operators and tenants for each berth within the harbour. This was used to confirm and refine the stakeholder consultation list and ensure the most accurate information available was used.

Amongst the items discussed during the meeting with Peel Ports, 3 potential items requiring further consideration were raised by Peel Ports; vessel navigation, channel sedimentation and land plant movements. Additional items that may provide potential benefit to the port were also discussed, including construction depth of walls for channel narrowing, potential to use the land created by the narrowing and abnormal load capacity of the new bridge in terms of both weight and height.

4.1.2 ASCO

ASCO were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.3 Gardline/Alicat

Both Gardline and Alicat were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.4 E-on

E-on were contacted by telephone; however their contact number reroutes to offices in Aberdeen and they no longer have operational staff in Great Yarmouth.

4.1.5 Trinity Marine Services/Dalby Offshore

No suitable contact details for Trinity Marine Services were found. Contact was made by telephone with Dalby Offshore. Following an outline of the proposal they confirmed that, provided no additional limitations on vessel sizes were caused by the new bridge, they could see no significant implications for their operations. They confirmed the extent of their shipping movements and stated that these could increase over the coming years with works on the East Anglia One Windfarm. They also stated that the improved road access for travel south would be of benefit for them as they have operations in both Great Yarmouth and Lowestoft. They requested that they be kept informed of any additional information regarding the bridge as and when it became available.

4.1.6 Seatrax Ltd

Seatrax were contacted by telephone. Following an outline of the proposal they confirmed that, provided no additional limitations on vessel sizes were caused by the new bridge, they could see no implications for their operations. They confirmed the extent of their shipping movements and also stated that these should remain fairly consistent over the coming years. They requested that they be kept informed of any additional information regarding the bridge as and when it became available.

4.1.7 Atlantic Marine & Aviation

Atlantic Marine & Aviation were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.8 EMR

EMR were contacted by telephone. They do not have any concerns regarding the new bridge and do not think it will have any impact on their operations in Great Yarmouth.

4.1.9 Brineflow Limited

Brineflow Limited were contacted by telephone. They raised concerns that if the bridge was constructed without sufficient clearance to allow unhindered passage of the smaller off-shore windfarm workboats it would restrict the access to the northern berths of the Port. This concern would not be present on the premise that commercial shipping movements would not be restricted, although they noted that this would increase the number of bridge operations and therefore disruption to road traffic. They estimated that, in total, around 15 movements per day passed the bridge location and believed that when the local wind farms were fully operational this could increase to 30 movements per day.

4.1.10 CLS Global Solutions

CLS Global Solutions were contacted by telephone. Following an outline of the proposal they confirmed that they could see no implications for their operations.

4.1.11 Silverton Aggregates

Silverton Aggregates were contacted by telephone. Following an outline of the proposal they confirmed that they could see no implications for their operations. They confirmed they have had no shipping movements for the past 4 years and stated they had recently surrendered their berth access agreement.

5 Options – Constraints and Opportunities

5.1 Current Operations

The inner River Port at Great Yarmouth has 97 distinctly identified berths, of these 51 are upstream of the proposed bridge location.

The assessment was initially undertaken assuming that any vessel accessing these 51 berths would require a bridge opening, which would certainly be the case for a bridge set at 4.5m above MHWS level. An additional assessment of vessel air drafts was also undertaken to quantify the benefit of constructing an elevated bridge with a clear height of 7.5m above high water. The related commentary is presented later in this section.

Peel Ports supplied copies of their vessel movement logs covering the period January 2008 through to August 2016. This data set comprised around 80,000 recorded **commercial** vessel moves. The data was filtered to identify those moves that were either to or from any of the 51 upstream berths and then further analysed to determine frequencies of bridge operation. The tables below detail the average and maximum numbers of vessels passing the proposed bridge locations by day and year, from 2010 onwards.

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2010	9.3	8.7	9.3	8.4	8.4	6.7	5.1
2011	11.4	10.3	10.7	11.5	11.2	7.3	6.3
2012	16.5	17.0	17.3	16.1	16.5	11.6	10.6
2013	10.8	10.7	11.7	10.5	11.1	6.9	5.7
2014	9.7	8.8	8.8	8.4	10.1	5.6	5.2
2015	8.9	8.1	9.2	9.0	9.4	5.7	4.5
2016	11.3	12.5	12.8	12.0	12.2	7.2	7.2

Table 3 - Average vessel movements passing proposed bridge location

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2010	18.0	19.0	22.0	15.0	17.0	14.0	20.0
2011	23.0	22.0	25.0	20.0	31.0	17.0	15.0
2012	36.0	29.0	38.0	33.0	31.0	26.0	27.0
2013	22.0	22.0	20.0	22.0	18.0	14.0	12.0
2014	23.0	20.0	21.0	18.0	19.0	17.0	12.0
2015	19.0	17.0	23.0	17.0	17.0	14.0	10.0
2016	21.0	29.0	23.0	23.0	22.0	19.0	18.0

Table 4 - Maximum number of vessel movements in a day passing proposed bridge location

Analysis was also undertaken to ascertain the distribution of numbers of vessel movements per day and the results of this are shown on Figure 4 below.

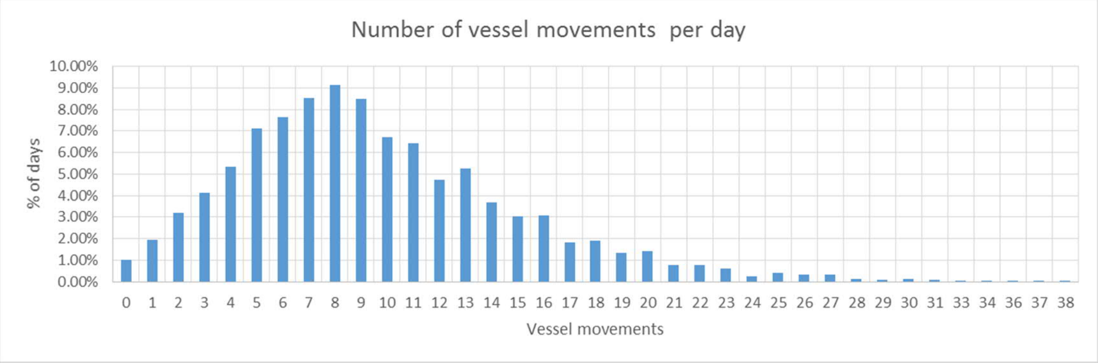

Figure 4 - Distribution of vessel movements per day

Consideration has also been given to the timing of vessel movements during the day. Figure 5, below, shows the distribution of timings of movements within the port from 2008 to 2016. This shows that the majority of movements occur during the working day, 82% between 6am and 6pm with distinct peaks occurring between 7 and 9am and 3 and 5pm.

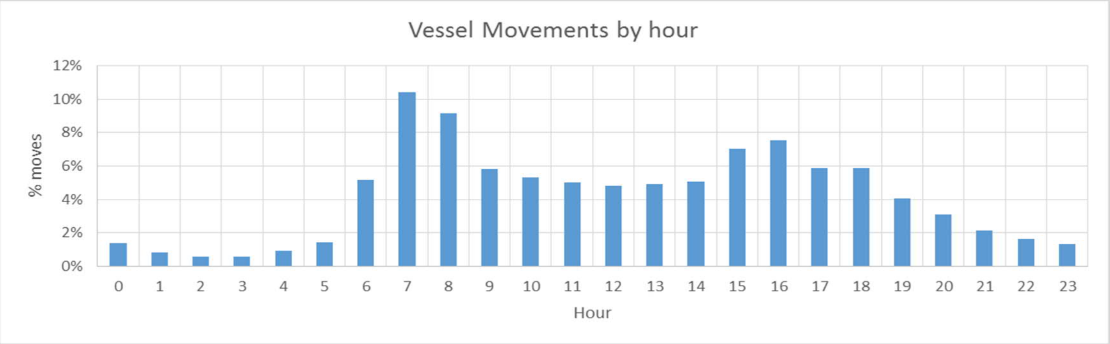

Figure 5 - % movements by hour 2010-2016

This general distribution pattern appears to hold constant for most days, Figure 6 below, showing vessel timings during August 2016, shows a good match to the overall averaged percentages.

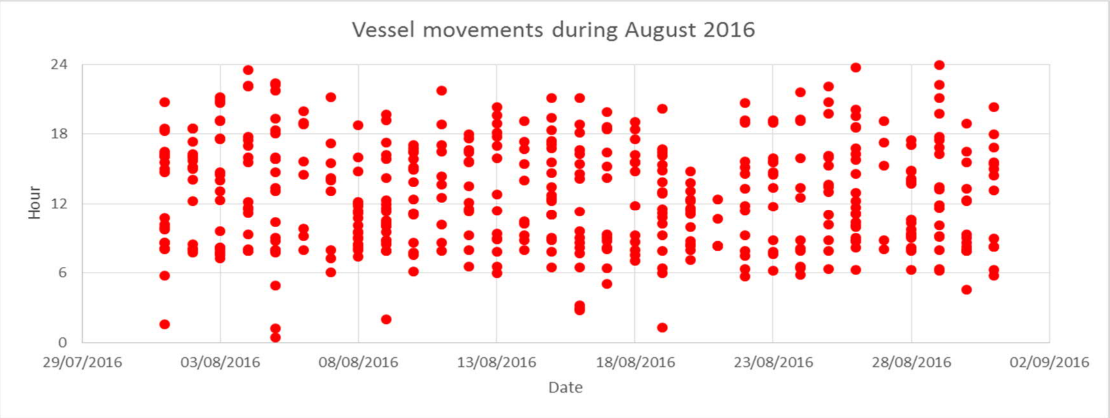

Figure 6 - Timing of vessel movements during August 2016

An analysis of vessel air drafts, for vessels historically using the port and for vessels in general, was undertaken to assess the benefits of elevating the bridge to reduce the number of openings. Constraints on the road approaches to the bridge location mean that the maximum clear height of the bridge above high water is limited to 7.5m and, allowing for safety clearance tolerances, this height would allow vessels with an air draft of less than 7m to pass under the bridge at high water without requiring an opening. Analysis of the vessels from 2008 to 2016 show that some 13% of movements past the bridge location were by vessels below 7m air draft, as shown on Figure 7, below.

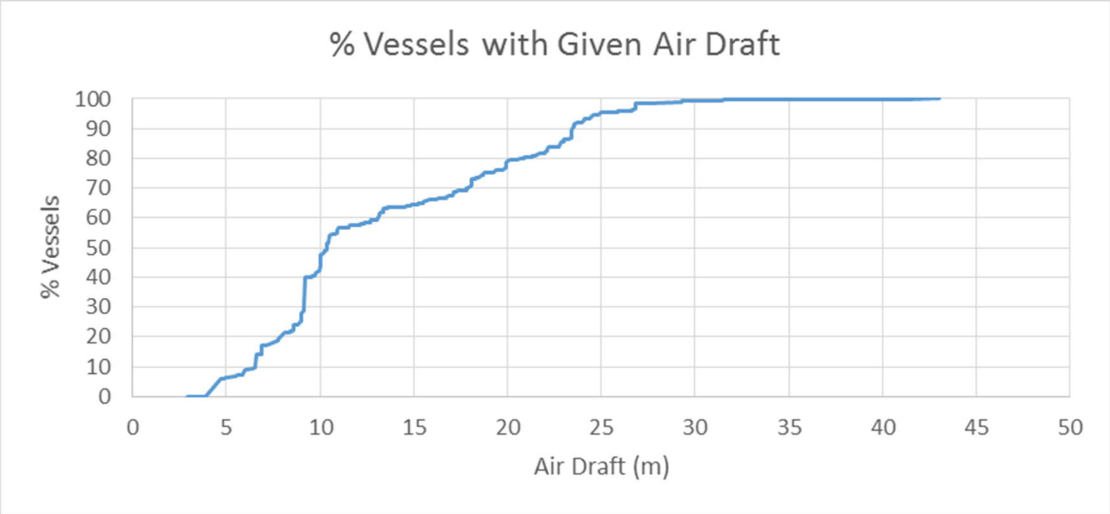

Figure 7 - Vessel passages with given air draft

Figure 8, below, shows the percentage of vessel movements with an air draft of less than 7m passing the bridge location per year. This indicates a general reduction in the number of vessels operating in the port capable of passing under a 7.5m bridge without requiring an opening.

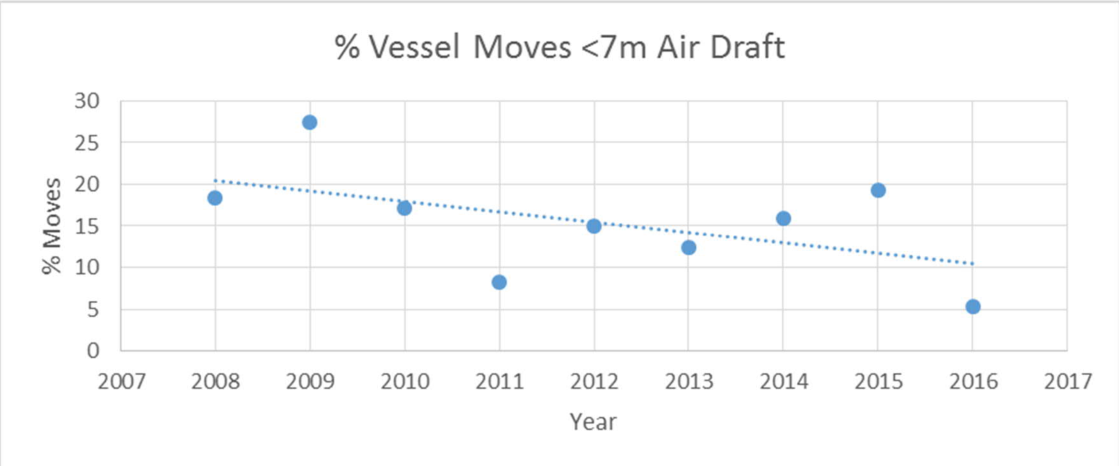

Figure 8 - Vessels <7m Air Draft per Year

A similar analysis was undertaken to assess the lengths and beams of vessels passing the proposed bridge location, this information will be used to assist in the selection of design vessels for bridge protection.

Figure 9, below, shows the percentage of vessels passing the bridge by beam, the 50%ile beam being 7.5m, the largest beam vessel to pass the location since 2008 has been the Toisa Warrior at 19m.

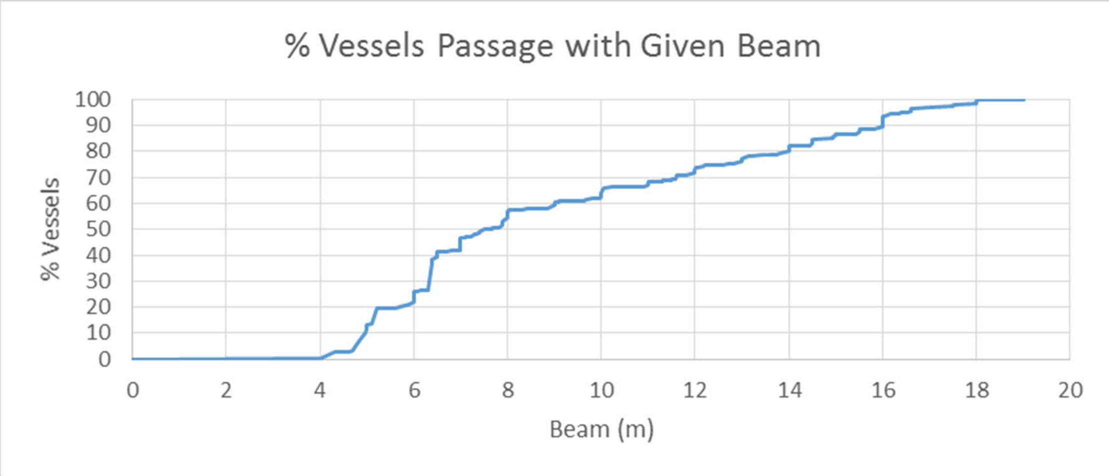

Figure 9 - Vessel passages with given beam

Figure 10, below, shows percentage passages by vessels by length, the 90%ile length being 72m and the longest vessel to transit has been the Salrix at 96.32m.

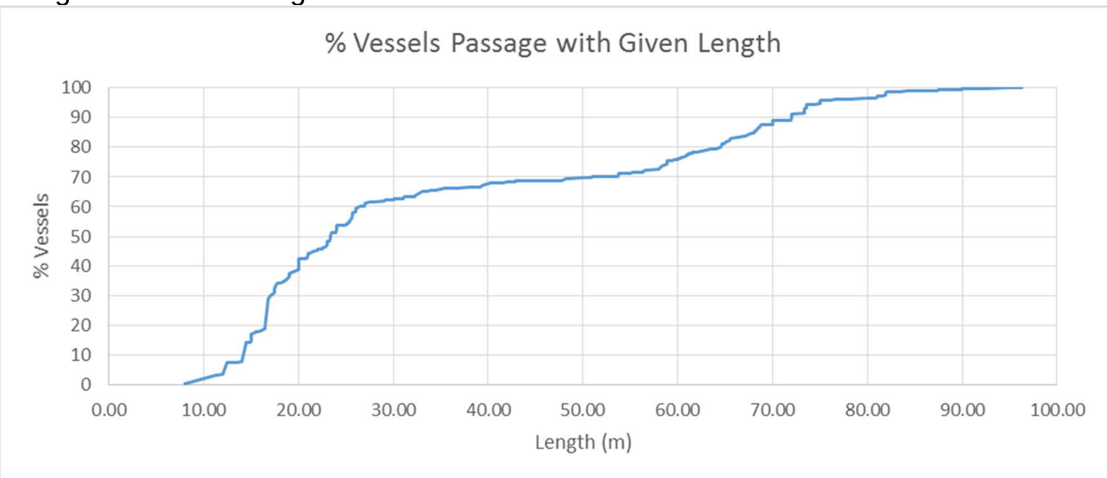

Figure 10 - Vessel passages with given length

From the data obtained and the analysis undertaken we can conclude that, currently, the long term average frequency of passage by a bascule bridge located between berths 31 and 32 would be 11 per day, with a one day per year exceedance number of 30. All of these vessel movements would require a bridge with a clear height of 4.5m to be lifted, raising the bridge to a clear height of 7.5m would reduce the openings to 87% of vessels, equating to 1 or 2 openings per day.

5.2 Future Developments

5.2.1 Vessel Size

The size of vessels entering the inner River Port is constrained by the natural width limit of the navigable channel and the length restriction of turning at the Brush Bend and, therefore, there is little prospect of the maximum size of vessels requiring transit increasing in the future. Given the existing constraints on vessel size and considering the number of berth structures that would be affected, it is not considered feasible that the depth within the river will be increased by dredging.

It is likely that the average vessel size within the port will increase, with offshore operators tending to employ larger vessels for operational efficiencies as the number of turbines serviced rises. This tendency was corroborated during the consultation with Brineflow Limited.

5.2.2 Vessel Frequency

With the future developments of further offshore windfarms in the southern North Sea, there is significant potential for an increase in the numbers of service craft accessing the port. The location of berths for these vessels clearly has the potential to affect the number of bridge openings required.

From the consultation with Peel Ports, it is apparent that there is an aspiration to increase use of the Outer Harbour Berths and it is foreseen that the provision of the new bridge will increase the potential for this by improving vehicle access to the south of the peninsular. Whether this leads to a long term reduction in the frequency of use of the Haven berths is uncertain at this stage and, as such, has not been factored into the opening frequency estimations.

From the consultation with Brineflow Limited, it is apparent that they have aspirations for the siting of two new off-shore windfarm support bases on berths north of the proposed bridge locations which could result in a significant increase in vessel movements. The vessels they envisage are the larger catamaran workboats of the 20 to 25m length class, with typical air drafts of between 10 and 14m.

5.2.3 Climate Change

The impacts of climate change on future sea levels may have an impact on the frequency of operation of the bridge, should an elevated solution be implemented. Current government models indicate a potential increase in water levels of up to +0.475m during the 21st century along the East Anglia coast. This would effectively reduce the clear height of the bridge and thus require openings for vessels with a smaller air draft than at current sea levels.

5.3 Navigation Constraints

The proposed location of the bridge, on a bend in the river, may cause visibility issues which could affect the timing of its operation. The navigation simulation, undertaken by HR Wallingford, drew certain conclusions over the operation and use of the adjacent berths during vessel transits but these were not confirmed with the Port at the time and therefore remain as potential constraints.

5.4 Bridge Operational Constraints

The opening duration of the bridge is dictated by 2 factors, bridge movement and vessel movement.

The time taken for the bridge to open and close comprises the time to clear the bridge of traffic and the time for the bridge to raise, while closing time includes the bridge lowering and the traffic controls lifting. The duration of this will vary depending on the nature of the traffic control system installed, with control of pedestrians being the probable limiting factor. In total a time of 240 seconds may be required to complete the operations of the bridge.

The vessel movement time includes the transit time, that is the time a vessel is manoeuvring through the bridge passage, and the approach time, the time taken for the vessel to approach the bridge following opening.

The initial navigation simulation, conducted by HR Wallingford, suggested an approach time equal to the travel time of a distance twice the overall length of the transiting vessel, until confirmed, or otherwise, by further simulations we have used this as a basis for calculating opening durations based on vessel lengths. Figure 11, below, shows the calculated percentage distribution of opening durations for the bridge.

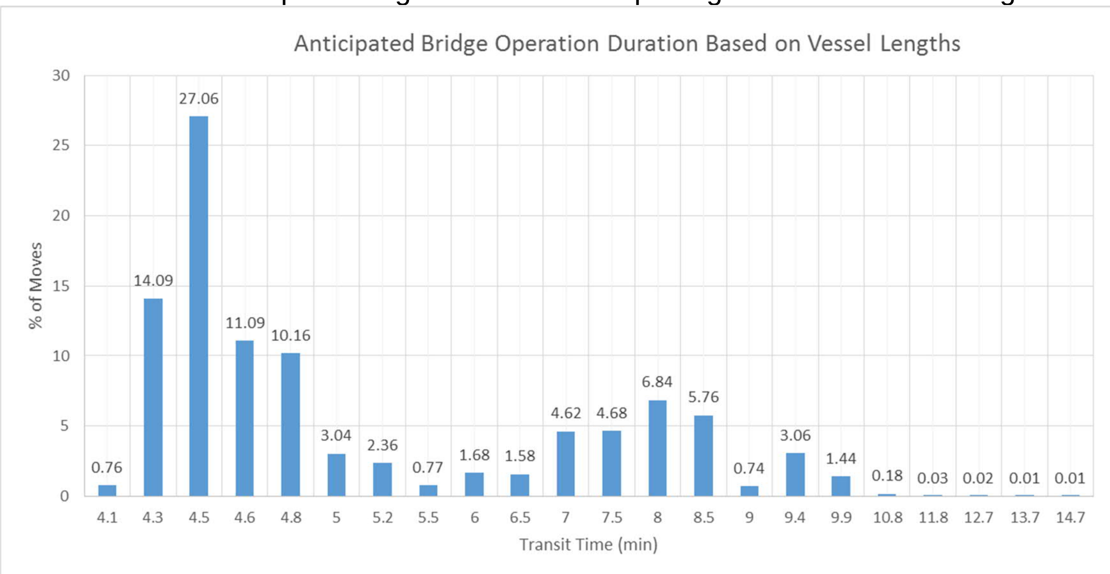

Figure 11 - Anticipated bridge operation durations

The above distribution does take into account vessels navigating with tug assistance, as determined from the vessel transit information supplied; it does not factor any platooning or marshalling of vessels outside those tug assisted manoeuvres.

This distribution has been used to produce a graph of cumulative percentage of opening durations, shown on Figure 12 overleaf. This shows that approximately 66% of bridge openings would take less than 5 minutes and 99.7% of openings would be completed in under 10 minutes. This would typically equate to only 10 moves per year taking longer than 10 minutes.

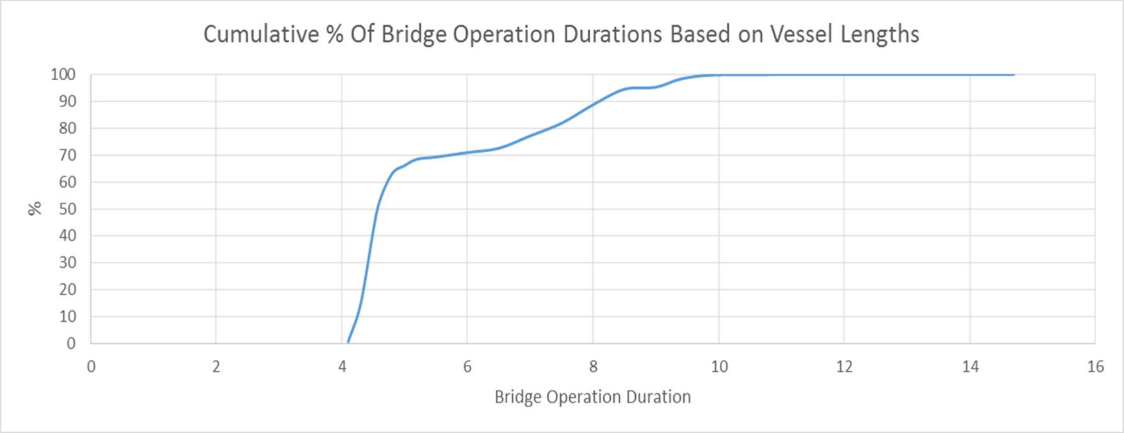

Figure 12 - Cumulative % bridge opening durations

5.5 Identified Opportunities

During the consultation process a number of potential additional benefits were identified by various stakeholder which may warrant further investigation. In particular Peel Ports enquiry on the ability of the new bridge to accommodate abnormal loads has the potential to both increase attractiveness of the port for undertaking transport of abnormal loads and reduce the traffic disruption caused during their movement.

The potential to utilise any additional land created as part of the channel narrowing may have the effect of mitigating operational land loss as a result of the bridge construction and may ameliorate the scheme for some of the affected stakeholders.

6 Summary and Conclusion

An initial assessment of the current nature and frequency of vessel movements within the River Port at Great Yarmouth has been undertaken. This assessed the vessels transiting the port between January 2008 and August 2016 in terms of dimensions and berths visited.

This assessment showed that on average 11 vessel movements per day passed the proposed location of the new bridge. All of these would require the bridge to open at the current design clear height of 4.5 while 87% were of a size that would require the new bridge to open if it were designed with a clear height of 7.5m.

A consultation exercise was undertaken with the major port stakeholders and users to ascertain the potential for increased vessel traffic within the port. This consultation showed that although the maximum size of vessels accessing the River Port was unlikely to increase due to natural constraints, the average vessel size could increase as more of the larger offshore support vessels were transferred to operations in this region.

The exercise also indicated that the number of vessels in operation and therefore the frequency of arrival and departures was likely to increase, particularly among the offshore windfarm service and support vessels.

Factoring in all potential movement increases identified in the consultation it can be estimated that the future average vessel movements at the proposed bridge location could increase to 20 movements per day. This level is a 25% increase on the maximum annual average daily movements recorded within the Port.

7 Recommendations

7.1 Navigation Simulation Modelling

While an initial navigation simulation has been carried out to assess the feasibility of the proposed bridge, it was undertaken independently of the Port Authority. From initial consultations, it is concluded that the Port Authority will require a re-run of the simulations with their own pilots, to confirm the suitability and operability of the proposed bridge. This is most likely the only way that such a proposal would be approved by Peel Ports, as the Statutory Port Authority, and the Harbour Master who have raised related concerns over the proposal. We would envisage this navigation simulation being undertaken during the next phase of the project being based on the design refinement and feeding into the scheme development prior to the application for planning permission. The principal risk associated with late commencement of a navigation simulation would be a requirement to redesign the works should the design be found to impact vessel movements more than expected, conversely a similar risk occurs with undertaking the simulations too soon as subsequent design refinements may require simulations to be re-run.

7.2 Sedimentation Transport Modelling

The effects of the new bridge on sediment transport within the Port will require further investigation to satisfy Peel Ports as the Statutory Port Authority that it will not have an adverse effect on siltation levels thus causing a hazard to navigation, or increase in their maintenance dredging requirements. We would envisage this modelling being undertaken during the next phase of the project during the design refinement and prior to the application for planning permission. As with the navigation simulation the principal risk with delaying the sedimentation transport modelling is the potential for unexpected results forcing either redesign or creating significant environmental issues requiring compensation. Likewise, the bridge design will have to have been completed to a relatively high confidence level before the modelling can be undertaken to avoid the potential for reworks due to design development.

7.3 Elevation Level of Bridge over Port Operational Areas

The elevation of the bridge while crossing operational areas of the port will need to be considered further in consultation with Peel Ports. Discussions over alternative transportation routes and plant crossings are currently being held and the outcomes will be incorporated into the design developments.

7.4 Traffic Sensitivity Analysis

Given the potential number of bridge openings required and the duration of each opening event, a worst case scenario could be used in the base case traffic assessment. A sensitivity analysis, based on various daily movement patterns, is being undertaken to establish the potential variability of effect on the road networks. It may show a potential improvement in benefits if constraints on the operation of the bridge, in terms of proximity of openings or openings during peak road traffic times, could be discussed and agreed with the Port Operator.

7.5 Recreational Vessel Movements

This report focuses on commercial vessel movements within the Haven, there are also movements of recreational vessels from within the Norfolk Broads to the North Sea, via the River Yare, and vice versa, which will have an effect on the frequency of operations of the bridge. The number of movements of these vessels is limited and they are currently controlled over the timings at which their passage through the port can occur. Discussions have taken place with Peel Ports over the requirements for staging pontoons for holding recreational vessels intending to traverse the Haven until such time as a bridge opening can be undertaken and the cost of these pontoons are presently being included within the scheme estimates.

8 References

Great Yarmouth Port Authority Navigation (Haven) Byelaws 1997

Great Yarmouth Port Company Pilot Information (River Port and Outer Harbour)

Great Yarmouth Third Crossing Navigation Simulation Study (HR Wallingford) 2009

UK Climate Projections 2009 (UKCP09)

Appendix C – Vessel Simulation Report

1073739-WSP-MAR-GY-RP-MA-0003 - Vessel Simulation Report

Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

1073739-WSP-MAR-GY-RP-MA-0003

Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

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Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

WSP

1st Floor Station House
Tithebarn Street, Exchange Station
Liverpool
L2 2QP

Phone: +44 151 600 5500

WSP.com

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FIGURES

GLOSSARY

Term	Definition
Ebb	tide flowing out to sea.
Flood	tide flowing in from sea.
GYPC	Great Yarmouth Port Company
Slack Water	the period either side of the change from Ebb to Flood tidal conditions when the flow velocity is lowest.
Squat	vessel increasing depth in water due to hydrodynamic effect (more associated with speed in shallow water)
Surge	tide flowing in from sea.
Sway	unplanned movement of vessel along short axis.
Yaw	rotation of vessel around vertical axis.

1 INTRODUCTION

1.1 GENERAL

WSP Limited have been commissioned to progress approvals, designs and agreements for a third highway crossing over the River Yare at Great Yarmouth.

1.2 SCOPE OF REPORT

This report details the commissioning, progression and outcome of a real-time vessel simulation exercise conducted to assess the navigation impacts of the third crossing.

1.3 OBJECTIVES

The objectives of the 1st vessel simulation were to establish;

- The navigability through and adjacent to the proposed bridge
- The suitability of the proposed passage width beneath the bridge
- Confirm the requirements for bridge protection
- Determine any aids to navigation that the bridge may require
- Establish the transit times for vessels through the new bridge.

The objectives of the 2nd vessel simulation were to establish;

- Any variance between navigation with the initial design and the design prepared for DCO application
- The effects of the calculated hydrodynamic modelling on navigation
- The usability of the adjacent berths post scheme construction.

1.4 LIMITATIONS

This report is presented to Norfolk County Council in respect of the Great Yarmouth Third River Crossing Project and may not be used or relied on by any other person. It may not be used by Norfolk County Council in relation to any other matters not covered specifically by the agreed scope of this Report.

Notwithstanding anything to the contrary contained in the report, WSP Limited is obliged to exercise reasonable skill, care and diligence in the performance of the services required by Norfolk County Council and WSP Limited shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by WSP Limited. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

2 PROJECT DESCRIPTION

2.1 OVERVIEW

Great Yarmouth is a town in the English county of Norfolk. It is situated on the east coast of the United Kingdom and has a port with direct sea access to the North Sea. The port is owned and operated by Great Yarmouth Port Company (GYPC) and is made up of two sections; the inner harbour is formed on the banks of the River Yare, covering approximately 4.3km (2.3 nautical miles) from the Brush Bend at the sea entrance in the south to the Haven Bridge in the north, whilst the outer harbour is constructed from breakwaters and comprises land reclaimed from the sea.

As can be seen in Figure 1 below the town is divided in a north south direction by the river which results in a spit of land approximately 4km long being effectively separated from the remainder of the town.

Figure 1 – Aerial photograph of Great Yarmouth Haven

To overcome this separation Norfolk County Council is proposing to construct a third river crossing approximately 1.5km south of the existing Haven Bridge, which is the most southerly of the current two crossings.

The aspirations of the scheme are to improve connectivity within the town thereby reducing traffic congestion and promoting redevelopment and growth.

2.2 LOCATION OF SCHEME

The proposed location for the new bridge is shown on Figure 2, below. It crosses the river between Bollard Quay on the west bank and Atlas Quay (also called Fish Wharf) on the east.

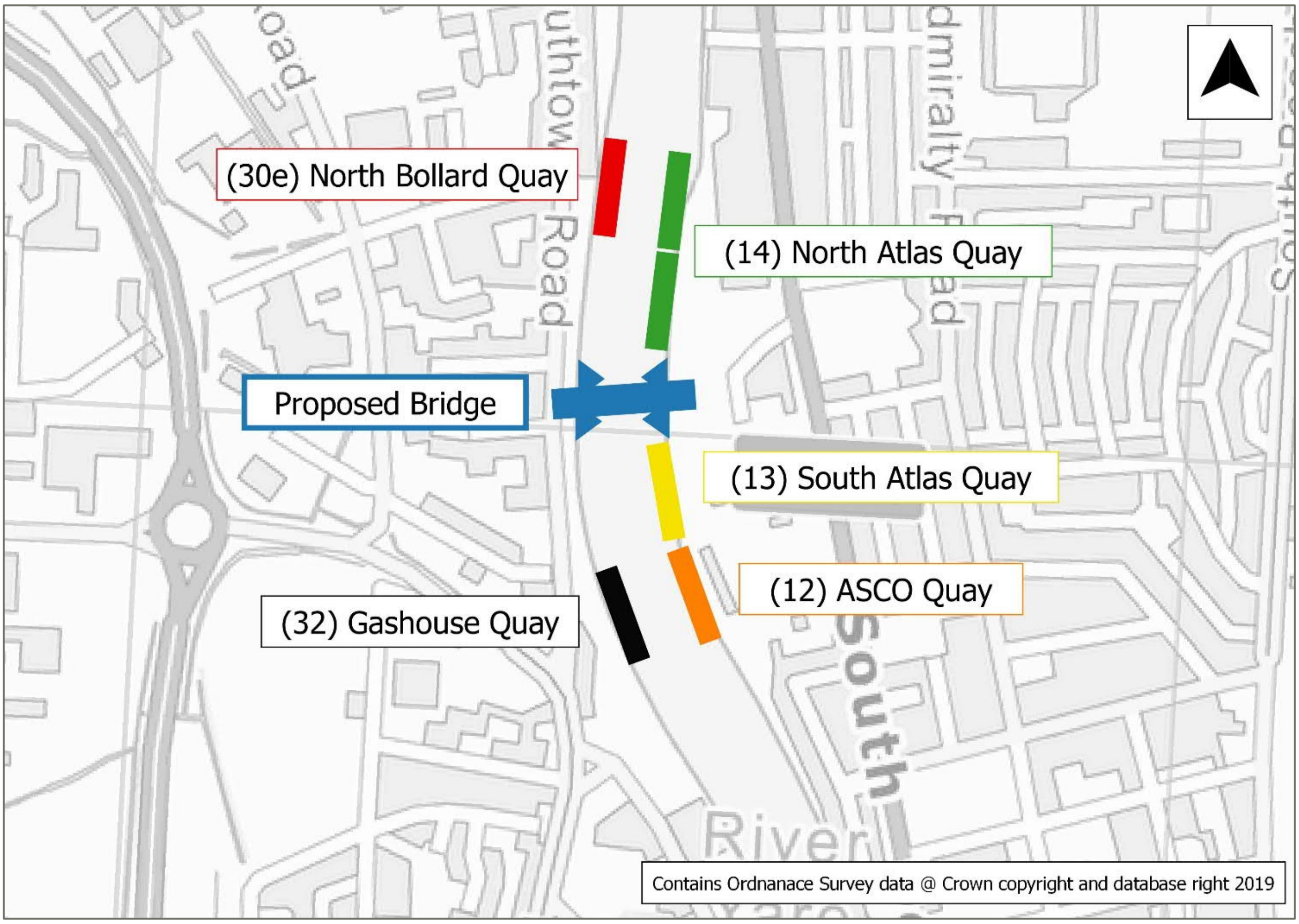


Figure 2 – New bridge location

2.3 BRIDGE DESIGN

The bridge will be constructed to provide a clear navigational channel, approximately central in the River, of 50m between fenders. The bridge deck will have a minimum clear height over water of 4.5m above Mean High Water Springs when lowered and will raise to provide infinite clearance across the whole of the navigation channel. Any fixed over water sections of the bridge will be protected from navigation impacts by passage and approach fendering.

The opening bridge will be connected to the existing road network by approach ramps and a number of fixed spans. An indicative section showing the bridge outline in both the “raised” and “lowered” position are shown in Figure 3, below.

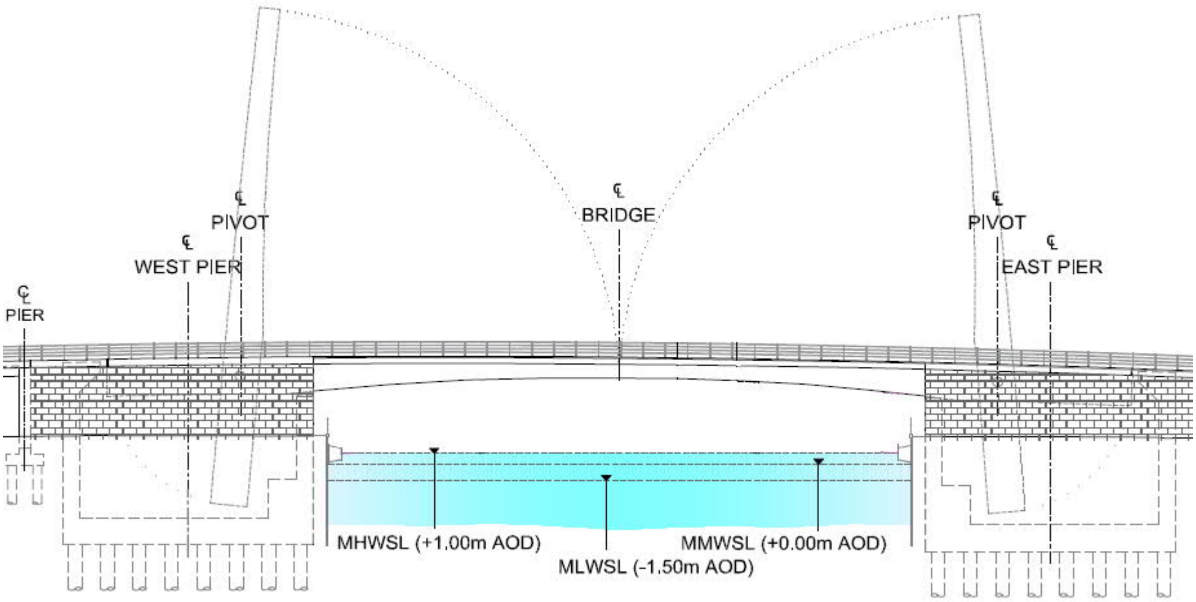


Figure 3 – Bridge cross section

2.4 PORT OPERATIONS

The location of the Scheme crosses the navigation waterway within the River Yare and the port has commercial quays both north and south of the location. Access to the berths north of the Scheme will require an opening of the bridge should the air draft of the vessel exceed the clear height of the bridge in the closed position.

The port handles a wide variety of cargos including aggregates, cement, grain, fertilisers, forest products, dry and liquid bulks, pipeline and onshore wind farm equipment as well as providing facilities for the offshore windfarm servicing industry. A total of 1.28 million tonnes[1] of cargo passed through the port during 2016.

From historic data covering the period 2008 to 2016 received from GYPC, an average of 10,000 vessel moves per year occurred within the Port, with approximately 40% of these involving movements to or from berths north of the Scheme location.

[1] Department for Transport Statistics, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/640984/port0418.ods

The River Yare also provides access to the Norfolk Broads for recreational vessels via Breydon Water. These vessels have to pass two existing lifting bridges, the Haven Bridge and the Breydon Bridge, during a passage from the sea to the Broads.

3 VESSEL SIMULATION

3.1 SIMULATION FACILITY

WSP commissioned East Coast College, Lowestoft, to use their Kongsberg vessel simulator to create a real-time navigation simulation.

The Kongsberg Polaris Full Mission Bridge Simulation Suite consists of a realistic mock-up of a ship's bridge with all conventional controls and instruments you would expect to find on a modern bridge.

These include manoeuvring and throttle controls, navigation instruments including GPS, LORAN and NAVTEX, an ARPA radar and ECDIS plotter. In addition, visuals are provided by realistic 150° visual of the outside world.

Two secondary bridges provide entry-level controls with GPS, ECDIS ARPA and Plotter, for use as tug control stations if required.

Each of these bridges can be designated as a vessel including offshore supply vessel, container vessel, ferry, fast patrol craft, bulk carriers etc. Movement, controls and instruments will then balance and respond precisely as the real ship.

All aspects of the vessel can be controlled from the instructor station. Weather, tide, visibility and sea state can be changed and varied. Facets can be introduced, including failure of the engines, steering, thrusters etc. Also included in the system is assessment software that will enable detailed evaluation of all aspects of the use of the system.

Figure 4 – Lowestoft College Kongsberg Simulator

3.2 EXISTING SITUATION MODEL

A base model of the Port of Great Yarmouth in its current form was created by Kongsberg from mapping data supplied by GYPC. This model covers an area extending approximately 1.5km downstream and 1km upstream of the proposed bridge location as shown on Figure 5, overleaf. Bathymetric data for the model was taken from the latest navigation charts produced by GYPC.

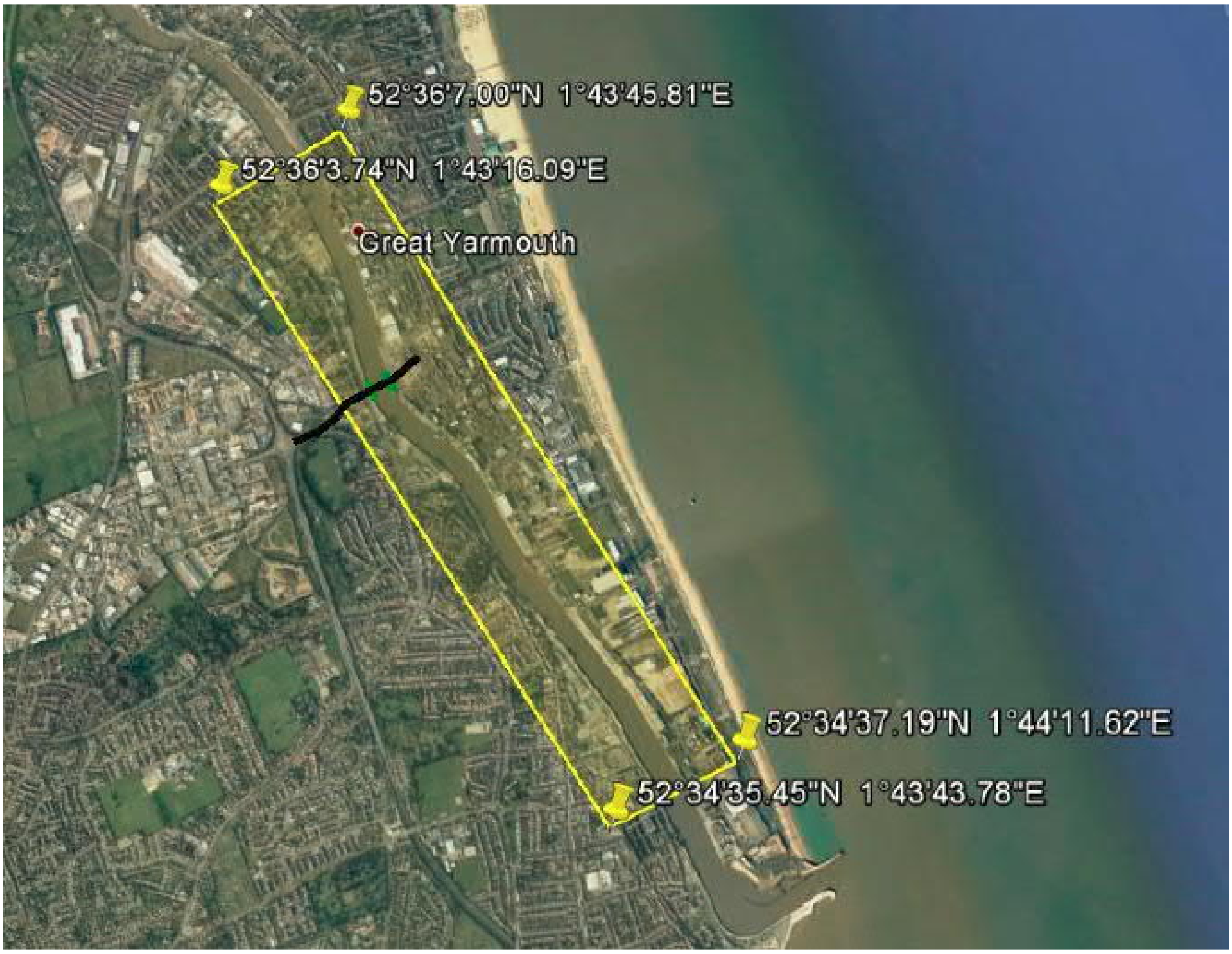


Figure 5 – Simulation model extents

3.3 THIRD RIVER CROSSING MODEL

A bridge model for the bascule design, shown on Figure 6 below, was created and run in the simulator to assess the effects on navigation during the first stage simulation.

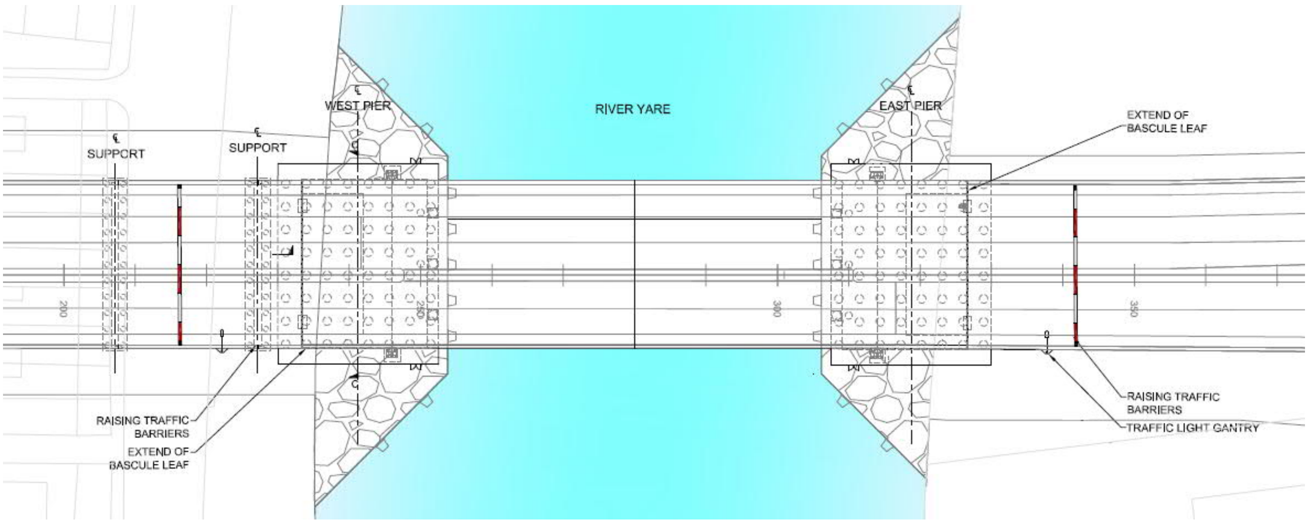


Figure 6 – Bridge plan

The same visual model was used during the second stage simulation although the hydrodynamic inputs were based on the design prepared for DCO application.

3.4 SIMULATION DATA

3.4.1 WIND

Wind conditions for each simulation run can be set for both direction and speed, constant velocity or gusting as required by the simulator operator. To ensure the model was conservative, no sheltering effects from surrounding structures other than the new bridge has been included. This sheltering is simulated by introducing a reduction in wind speed at the appropriate point in the simulation.

3.4.2 CURRENT

During the first stage simulation tidal current modelling was based on flow vectors input into the simulator directly. A hydrodynamic model was produced to ascertain the predicted changes in flow patterns which would result from the presence of the new bridge. The predicted uplift in current strengths was applied to velocities measured during an Acoustic Doppler Current Profile survey undertaken and used to calibrate the hydrodynamic model.

For the second stage simulation, a multipoint tidal profile file was produced from the calibrated hydrodynamic model for a typical spring tide condition. This file was imported into the simulator and the start time of the simulation runs varied to match the desired tidal conditions.

3.4.3 TIDE

Within the simulation, the water depths were represented by a rectangular grid divided into square cells giving the local values of seabed level throughout the study area, derived from the navigation bathymetry charts plus an appropriate height of tide, selected by the Pilot.

3.4.4 WAVE

It is anticipated that waves within the river will be limited, being considered navigationally negligible for the size of vessels under consideration, and were not included within the simulation.

3.5 SIMULATION VESSELS

Table 1 shows some details of the design vessels, taken from the Kongsberg vessel simulation models catalogue, which were agreed with GYPC as representative of the size of vessels which call at the Port of Great Yarmouth and which were available for use in the navigation simulation trials.

The longest vessel reported to have transited the proposed Scheme location in the past 10 years was the AMUR 2520, with an overall length of 115.7m, the widest vessel was the Toisa Warrior with a beam of 19m. Both of these dimensions are comparable to those of vessels available within the simulation.

Table 1 – Simulation Vessels

Vessel Designation	Vessel Description	Displacement (T)	Length between perpendiculars (m)	Length Overall (m)	Beam (m)	Draught (m)
BULKC11L	Typical small laden CCP coastal bulker	5906.00	84.98	89.99	14.00	5.68
FERRY50	Medium size ferry	5415.00	108.00	117.00	20.00	4.39
PRODC04L	Small laden product tanker	5800.00	86.34	92.8	13.60	6.16
SUPLY10L	Large laden offshore supply vessel	6550.00	75.40	86.20	19.00	6.00
TUG05A	Harbour class tugboat	550.00	30.50	32.00	10.97	2.50
PATRL19	Small shallow draughted launch	31.00	14.10	17.00	4.60	0.95
SUPLY05L	Medium laden offshore supply vessel	2302.00	57.80	66.00	14.00	4.55
TUG15	High performance ocean tug	575.00	28.00	29.50	11.00	2.78

The ship manoeuvring models include for motions in three degrees of freedom (3DOF), representing surge, sway and yaw motions (i.e. those directly affecting horizontal motions). However, the models also include representations of vessel squat and shallow water behaviour to ensure representative manoeuvring behaviour in relatively shallow water, where appropriate.

During the navigation simulation runs, the behaviour and performance of the controlled ships, in terms of responses to any helm, engine or tug control, and the local wind, wave and current conditions, is governed by a mathematical ship manoeuvring model. The mathematical model of each ship is calibrated to ensure it behaves in such a way that the position, velocity, swept path and heading of the simulated ship are representative of real ship behaviour. All models used in the simulation were Pilot Grade, these models are of the highest fidelity and are compared to the results of actual sea trials of the vessels on which the ships model is based to verify their accuracy.

4 SIMULATION EXERCISE

4.1 SIMULATION PARAMETERS

4.1.1 NUMBER OF BERTHED VESSELS

The simulation runs were carried out with a variety of different berthed vessels. The figures below indicate the position of berthed vessels in each of the quays adjacent to the proposed bridge. The figure headings describe the notation used in describing the simulation runs.

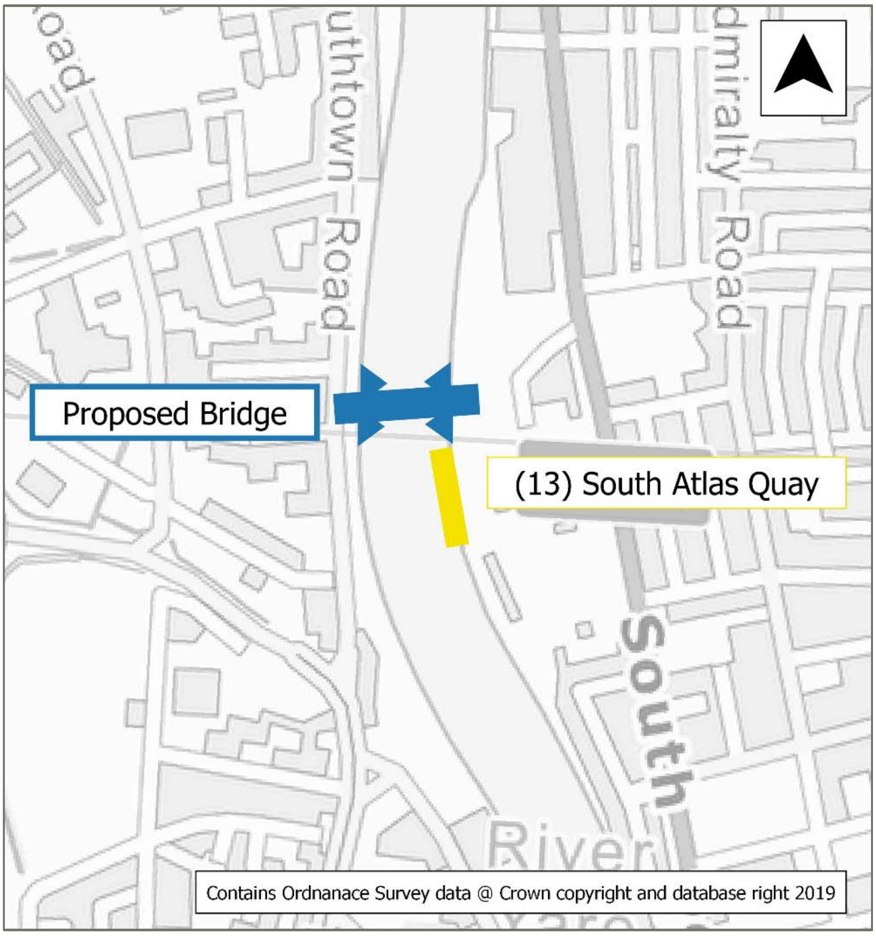


Figure 7 - Atlas Quay

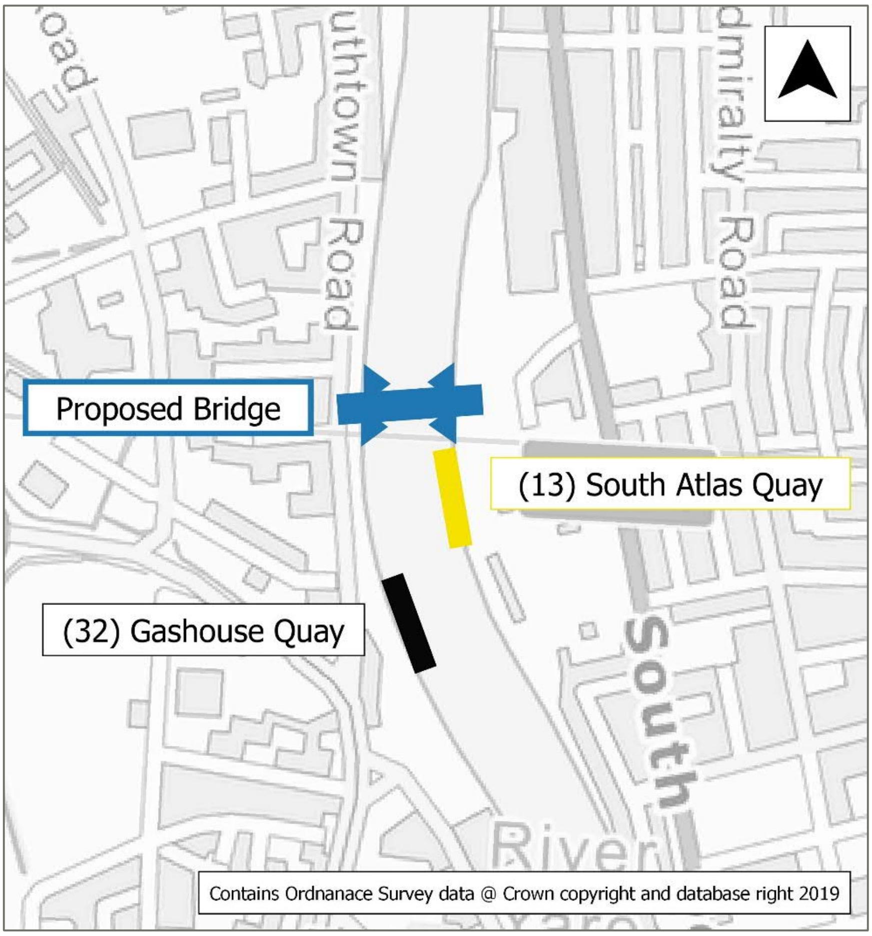


Figure 8 - Atlas & Gashouse Quays

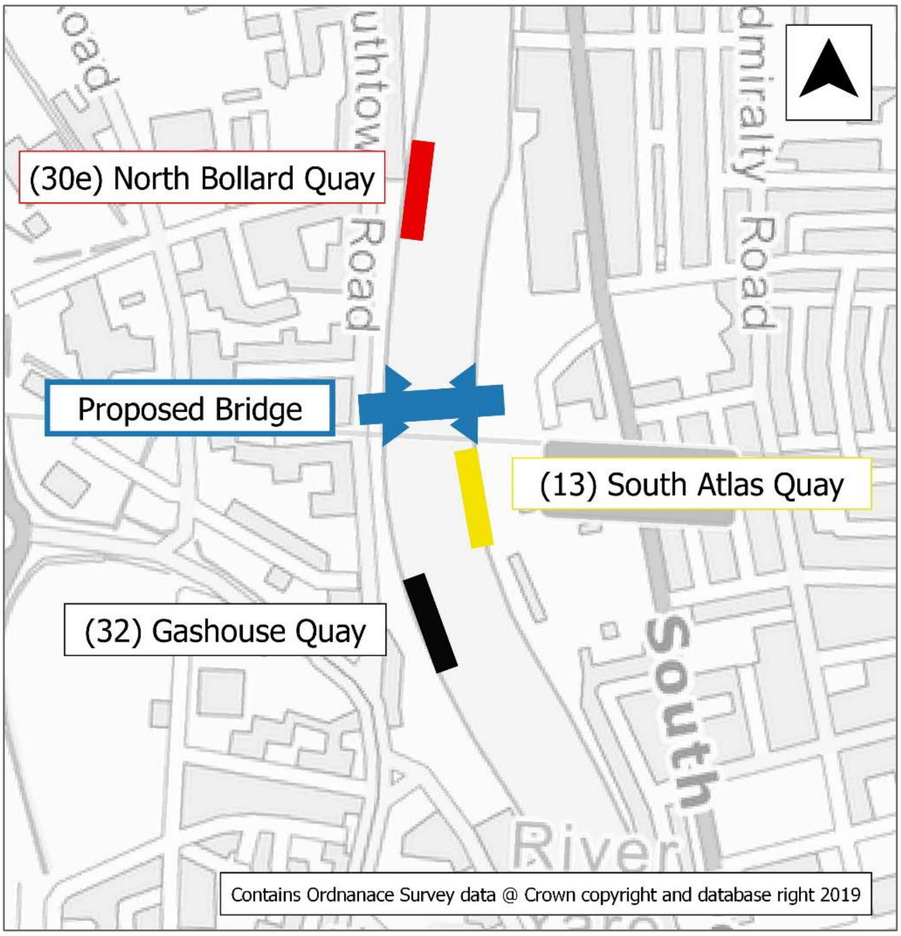


Figure 9 - Atlas, Gashouse & North Bollard Quays

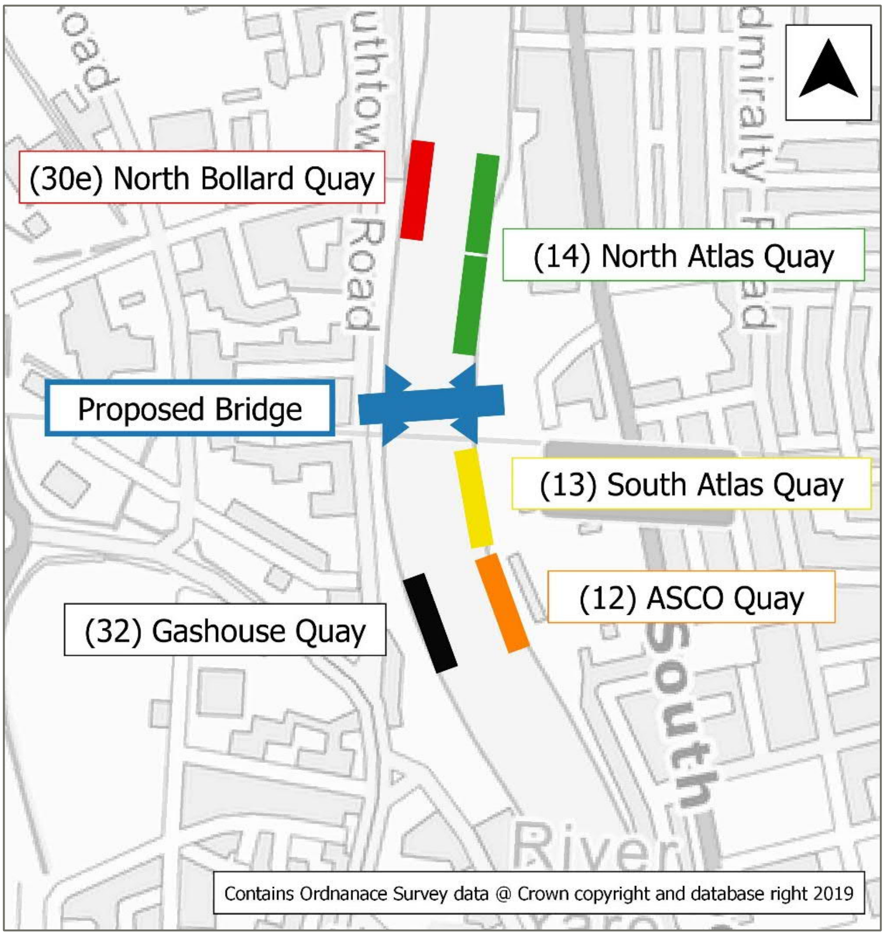


Figure 10 - All Quays

4.1.2 TYPE OF VESSEL

Table 2 below describes the vessels available within the simulation software.

Table 2 - Visual description of modelled vessels

Vessel	Visual Representation
Bulk 11	

Ferry 50	
Prodc 04	
Suply05	
Tug05	

Tug15	
Suply10	
Patrl19	

4.2 FIRST STAGE SIMULATIONS

4.2.1 GENERAL

The first stage simulation took place on 30th May 2018 and was conducted by two of the pilots from GYPC, Mr David Morrice and Mr Lindsey Wigmore.

4.2.2 SIMULATION MANOEUVRES

Firstly an initial trial run on the model with the bulk cargo ship (BULKC11L) was undertaken to ensure the simulator performed as expected, replicating the handling and responses the pilots would expect from this class of vessel. This was performed under a slack water condition, with the current set at 0.5 knots, and no wind.

Further simulations were then performed using different vessel and environmental combinations as shown on Table 3, below. Both pilots undertook simulations alternately, with some runs being repeated when sub-optimal passages were experienced.

Table 3 – List of first stage simulation runs

Run	Vessel	Tide	Wind	Transit	Notes
1	BulkC11L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse
2	BulkC11L	0.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage
3	ProdC04L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse
4	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
5	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
6	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
7	Suply10L	3kts Ebb	N/A	In	Vessels on Atlas and Gashouse
8	Suply10L	3kts Ebb	N/A	Out	Vessels on Atlas and Gashouse
9	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse
10	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse Increased current resolution
11	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse
12	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas
13	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
14	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
15	Suply10L	3kts Ebb	20kts NE	In	Vessels on Atlas and Gashouse

4.3 SECOND STAGE SIMULATIONS

4.3.1 GENERAL

The second stage simulation was undertaken on 6th March 2019 with pilot Mr David Morrice from GYPC.

4.3.2 SIMULATION MANOEUVRES

Again, an initial trial run on the model with the bulk cargo ship (BULKC11L) was undertaken to ensure the simulator performed as expected, replicating the handling and responses the pilots would expect from this class of vessel. This was performed under a moderate ebb tide, with the current set at 1 knot, and no wind.

Further simulations were then performed using different vessel and environmental combinations as shown in Table 4, below, with some runs being repeated when sub-optimal passages were experienced.

Table 4 – List of second stage simulation runs

Run	Vessel	Tide	Wind	Transit	Notes
1	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
2	Suply10L	1.5knts Flood	N/A	In	Vessels on Atlas and Gashouse
3	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas and Gashouse Backed through passage
4	Suply10L	1.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage
5	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas, Gashouse and N Bollard
6	BulkC11L	1.3kts Flood	N/A	Out	Vessels on Atlas and Gashouse
7	BulkC11L	1.3kts Flood	N/A	In	Vessels on Atlas and Gashouse
8	Suply05L	1.8knts Flood	N/A	In/Out	Vessels on Atlas and Gashouse Bow first inbound, stern outbound
9	BulkC11L	1.1knts Flood	N/A	Out	Vessels on Atlas and Gashouse
10	BulkC11L	1knt Ebb	N/A	Out	Vessels on Atlas and Gashouse
11	PRODC04L	1knt Ebb	N/A	-	Vessel on Atlas Transfer from Gashouse to ASCO
12	Suply05L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge
13	Suply10L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge

14	Suply10L	1knts Flood	N/A	In	Vessels on all berths N&S of bridge

5 DISCUSSION OF RESULTS

5.1 FIRST STAGE SIMULATIONS

Run	Vessel	Tide	Wind	Transit	Notes	Observations
1	BulkC11L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse	Runs with the bulk and product carriers were undertaken in both directions, all runs were conducted with vessels berthed on Atlas and Gashouse Quays constricting the space available for manoeuvring south of the Third Crossing. The second run simulated a large vessel backing through the bridge following unberthing from North Atlas Quay. **The first 3 runs with low currents indicate that transits of the new bridge during slack water periods would not significantly increase the difficultly of navigating the River.**
2	BulkC11L	0.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage	
3	ProdC04L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse	
4	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	The current in the simulator was then increased to 2 knots flood on the approach to the Third Crossing and accelerated to 2.5 knots through the bridge passage, in line with the increase predicted by the hydrodynamic model. Three inbound runs were undertaken using the large supply vessel, travelling with the tide; during the first two runs contact between the piloted vessel and one of the vessels moored on Atlas Quay occurred. During the first run, the Third Crossing was transited satisfactorily following the contact but the second run was abandoned following the contact and before the bridge transit. The
5	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	
6	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	

						third passage was successful with no contacts on any vessels. **The progressive improvements in passage on subsequent runs indicates the extent knowledge and familiarity contribute to successful navigation in constrained situations and hence the necessity for suitable and sufficient familiarisation training for the port pilots on the effects of the Scheme on navigation conditions prior to its construction.**
7	Suply10L	3kts Ebb	N/A	In	Vessels on Atlas and Gashouse	The current was then further increased to 3 knots ebb, accelerating to 3.7 knots within the bridge passage. Two runs, one inbound the other out, were undertaken using the supply vessel. **Both runs showed a further increase in the difficulty of navigation although both runs resulted in a successful transit of the bridge passage.**
8	Suply10L	3kts Ebb	N/A	Out	Vessels on Atlas and Gashouse	
9	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse	Following this, three runs were undertaken outbound at a moderate flood current of 1 knot, 1.3 knots in the bridge passage, utilising the bulk carrier, again with vessels on both banks. During the first of these runs a discernible draw to the east bank (the inside of the bend) was experienced
10	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse Increased current resolution	

11	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse	following a successful bridge transit. Resulting from this, the resolution of the modelling of the current stream was increased within the simulator and the run repeated. This repeat run showed an improvement in the transit, although the draw was still evident. A third run, commenced from a location earlier in the River, allowed the pilot to better position the vessel for the bridge transit and this resulted in a further improvement in the passage. **Vessel draw towards the east bank of the River is evident during the flood tides, this effect is known to occur under current conditions.**
12	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas	A single run was then undertaken using the same parameters as the previous three but without a vessel berthed on the west bank at Gashouse Quay. **This run showed an improvement on the previous runs potentially indicating that the draw effect may be a result of hydrodynamic interaction between the bridge passage and the hull of a vessel moored on Gashouse Quay.** This effect was subsequently investigated further within the Hydrodynamic model to ascertain if it was a product of the operation of the simulator model or something that is likely to be experienced during real vessel transits and is

						discussed in greater detail in Section 5.2 Overall Outcomes.
13	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	Two inbound runs with the bulk carrier under an ebb current of 1 knot were undertaken with vessels moored on Atlas Quay north and south of the bridge. **There were no significant issues with these simulations.**
14	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	
15	Suply10L	3kts Ebb	20kts NE	In	Vessels on Atlas and Gashouse	A final inbound simulation run using the supply vessel was then undertaken with the current set at 3 knots ebb combined with a 20 knot north easterly wind. **This showed similar outcomes to the earlier run with this current velocity suggesting that the level of wind simulated would not be a limiting factor in most bridge transits.**

5.2 SECOND STAGE SIMULATION

Run	Vessel	Tide	Wind	Transit	Notes	Observations
1	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	The initial run replicated the basic runs from the first stage simulation, albeit with a marginally stronger current. **The outcome was the same as during the first stage simulation with no issues presented during this run.**
2	Suply10L	1.5knts Flood	N/A	In	Vessels on Atlas and Gashouse	Following this, a series of runs utilising the larger supply vessel was undertaken. The simulation time was set to produce an initial main stream current of 1.5 knots on the flood tide and vessels were placed on both South Atlas and Gashouse Quays. Two runs were undertaken inbound with a bow first transit; as in the first stage simulation, a noticeable draw to the east bank occurred after the bridge transit, the second run to a lesser extent that the first. A third run tried the same manoeuvre stern first; this showed a noticeable improvement in transit. A fourth run using the same initial settings simulated an outbound stern first transit and showed no problems. A fifth run replicated the first two runs, with the eastern draw still being noticeable. A final run, with an additional vessel moored on North Bollard Quay,
3	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas and Gashouse Backed through passage	
4	Suply10L	1.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage	
5	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas, Gashouse and N Bollard	

						produced an improved transit over the earlier attempts. **These simulation runs showed the same draw towards the eastern bank as experienced during similar manoeuvres in the first stage simulation. Some permutations produced better outcomes indicating need for consideration duration passage planning.**
6	BulkC11L	1.3kts Flood	N/A	Out	Vessels on Atlas and Gashouse	Following these runs, the vessel was changed to the cargo vessel and the current lowered to 1.3 knots. **A run taking the vessel outbound showed no issues. A second run, bringing the vessel inbound stern first, indicated passage was possible in this configuration but it was slow and control was difficult.**
7	BulkC11L	1.3kts Flood	N/A	In	Vessels on Atlas and Gashouse	
8	Suply05L	1.8knts Flood	N/A	In/Out	Vessels on Atlas and Gashouse Bow first inbound, stern outbound	Next, a single simulation was performed using the smaller supply vessel with the current increased to 1.8 knots. The simulation included a bow first inbound bridge transit, a berthing manoeuvre onto North Atlas Quay, a swing in the River north of the bridge, a second bow first passage through the bridge and finally a berthing south of the bridge.

						All operations were completed successfully.
9	BulkC11L	1.1knts Flood	N/A	Out	Vessels on Atlas and Gashouse	Two runs were then undertaken to simulate the cargo vessel departing from North Atlas Berth for an outbound transit on a 1.1 knots flood tide. **In both runs the vessel had difficulty departing the berth and came relatively close to the vessel berthed on North Bollard Quay, although no contacts occurred.**
10	BulkC11L	1knt Ebb	N/A	Out	Vessels on Atlas and Gashouse	The same manoeuvre was then undertaken with the tide set to 1 knot ebb**; this showed no issues with the passage under these conditions.**
11	PRODC04L	1knt Ebb	N/A	-	Vessel on Atlas Transfer from Gashouse to ASCO	The next run simulated a product vessel (tanker) transferring from Gashouse Quay to ASCO Quay on a 1 knot ebb tide; **this showed no issues in the manoeuvre.**
12	Suply05L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge	Following this, the current was increased to 3.3 knots (the maximum main stream flow from the hydrodynamic model) flood tide and vessels were

						placed on Gashouse, Asco, South Atlas, North Atlas and North Bollard Quays, to replicate the most extreme conditions possible. Two runs were attempted inbound with the smaller supply vessel; **as expected control of the vessel was difficult and in both runs although the vessel passed the bridge without contacting the passage, the eastward drift after the passage caused contact with the vessel moored on North Atlas.**
13	Suply10L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge	The vessel was then changed for the larger supply vessel and the above manoeuvre attempted again. In all, five attempts were made with contacts occurring in all runs, 4 with the vessel on North Atlas and one with a contact on the bridge. **These, combined with the two previous runs suggest that inbound transits at peak flood tides would not be possible for this size of vessel without tug assistance; this is consistent with the outcome of the initial vessel simulation undertaken in 2009.**
14	Suply10L	1knts Flood	N/A	In	Vessels on all berths N&S of bridge	A final inbound run was undertaken with all berths occupied but the current lowered to 1 knot flood using the larger supply vessel.

						The passage, although challenging, was completed without contacts.

5.3 OVERALL OUTCOMES

While the presence of the new bridge had a discernible effect on the navigation of vessels in the area, during slack water conditions the effects were small and did not appear to increase the risk to navigational safety. This applied even with a number of vessels berthed on the quays immediately south of the bridge location.

As expected the effects of the narrowing at the bridge became more significant as the current increased. This appeared to be amplified by the presence of a moored vessel on Gashouse Quay.

Key Point: In slack water conditions the effects of the proposed bridge were minimal. The effects of the narrowing increased as currents and the number of moored vessels increased.

Further investigation of the hydrodynamic effects with vessels on berth was undertaken after the first stage simulation. This indicated that while there is a change in the location of the current stream the magnitude of acceleration of flow with vessels berthed on both sides of the River is reduced by the presence of the Scheme, with velocities of up to 50% higher indicated within the base model under matching conditions as can be seen in Figure 11, below.

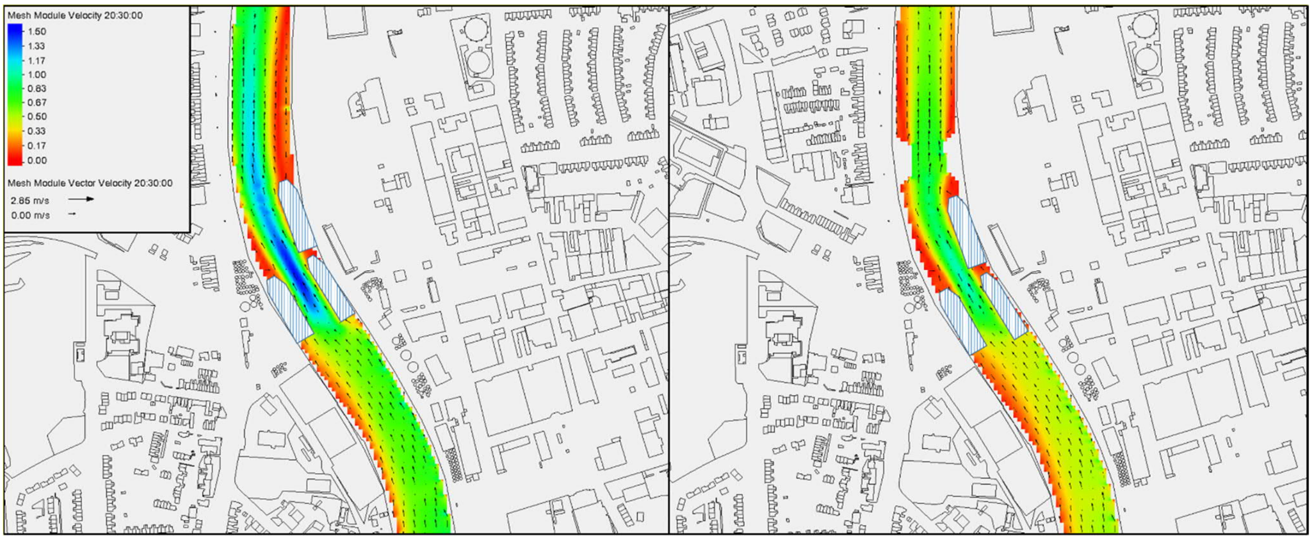


Figure 11 – Hydrodynamic Model Comparison

Key Point: The magnitude of acceleration of flow with vessels berthed on both sides of the river, decreases with the proposed bridge in place.

The change in the current stream caused by the presence of the bridge has the effect of straightening the flow earlier in the bend when compared to the baseline, this straightening combined with the reduction in velocity could result in the pilots compensating for an anticipated effect on the vessel, based on their experience of the current baseline conditions, resulting in the vessel turning more towards the east than they were expecting. Again, this effect highlights the need for a comprehensive familiarisation programme to be put in place for pilots prior to the scheme construction.

Key Point: A comprehensive familiarisation programme for pilots is necessary to compensate for the effects of flow straightening and velocity changes.

For smaller vessels, those less than 30m in length, the narrowing of the channel at the proposed Third Crossing is not considered to be navigationally significant. For these vessels the bridge opening regime will likely be the dictating factor in relation to operational conditions.

Key Point: For vessels less than 30m in length the narrowing of the proposed bridge is not navigationally significant.

5.4 COMMENTS RECEIVED FROM GYPC

Following the second stage simulation, comments were received from GYPC. These comments can be separated into 3 distinct topics, ones relating to the capability of the simulator, ones relating to the inputs and runs undertaken, and ones covering the outcomes of the simulation runs undertaken.

5.4.1 ISSUES RELATING TO THE CAPABILITY OF THE SIMULATOR

5.4.1.1 GYPC's Concerns

- Unable to load a full suite of vessels within the system reflecting the traffic using the port e.g. the simulator has a laden tanker, but not a tanker in ballast (the same applies to cargo vessels).
- The simulator cannot fully mirror the control systems of an Offshore Supply Vessel, especially when backing up. The simulator reverses the bow thruster to a stern thruster, which also does not accurately reflect the manoeuvring characteristics of vessels using the port.
- The simulator is not able to handle the granularity of variables such as tidal conditions or flow model beyond a number of tidal stream positions. This is not sufficient in order to capture the true nature of tidal streams and eddies around the proposed bridge piers.
- The tidal model is very binary in its application within the simulator.

5.4.1.2 Response

Looking at those related to the simulator facility itself, the range of vessels available within the simulations is limited by the models available from the simulator manufacturer. The vessels selected were chosen from the full range of vessels currently available, through discussion with GYPC, prior to the first stage simulation. While it is possible to have other vessel models created, without specific real-world performance testing undertaken using the actual vessel on which the model is to be based, it would not be possible to calibrate the simulator model and therefore ensure the accuracy of the resulting outputs.

Of the vessels that pass the bridge location 60% of movements were of vessels less than 30m in length, of which the scheme is not navigationally significant. 80% were less than 66m, equivalent to the medium offshore support vessel, and less than 1% of movements were for greater than 90m. As explained in section 4.5, the largest recorded vessels are represented.

In terms of the simulators ability to take varying tidal inputs, the simulator can accept any number of tide input positions and is capable of running with multi-layer tidal streams. The input file developed for the second stage simulation was prepared using an upper layer depth averaged tidal stream on the basis that all the principal test vessels were of similar draughts. The number and position of tidal data points to be used within the hydrodynamic model outputs was shared with GYPC prior to the simulation and no comments were received. Should it be considered that the number of data points was insufficient, this could be increased.

Key Point: Both the vessel and tidal data used in modelling was shared or discussed with GYPC prior to assessment, with no objection. The vessels used are representative of recorded vessels passing the bridge and the tidal data uses sufficient data points to accurately replicate tidal conditions.

Lastly, in relation to the control mechanism of the supply vessel, this comment relates to the fact that when set up with a stern facing bridge the physical controls for the bow thruster are reversed within the control panel. This has the effect of requiring the pilot to reverse his inputs on the power control over that which would normally be expected; it does not change the bow thruster into a stern thruster and does not fundamentally change the manoeuvring characteristics of the vessel model.

Key Point: With regards to the control mechanism of the supply vessel, a stern facing bridge does not fundamentally change the manoeuvring characteristics of the vessel model. It is able to replicate the control systems of an Offshore Supply Vessel.

5.4.2 ISSUES RELATING TO THE INPUTS AND RUNS

5.4.2.1 GYPC's Concerns

- No runs with any wind were conducted in the assessment which would make manoeuvring and berthing more difficult.
- No full runs from entry to berth and berth to exit were conducted to highlight the effect on the tidal flow as whole within the River.
- No runs were conducted with tug assistance for larger laden and unladen vessels through the bridge.
- It should be noted that these manoeuvres were conducted with a 3 knots tidal stream. Streams have been known to reach 6 knots in extreme conditions within the River.
- The tidal model only extended for 300m either side of the bridge. It is not known what effect the revised current flows will have on points further North and South. In particular the effects at Brush Bend and whether there will any delay or advancement of the slack water periods in this location.

5.4.2.2 Response

While no runs were undertaken with wind conditions during the second stage simulation, a run with wind of 20 knots was undertaken during the first stage simulation. In all but the most extreme wind conditions, the tidal currents will be the limiting factor on timing of vessel movements. Further testing of limiting wind conditions could be undertaken during a pilot familiarisation programme.

Key Point: Wind conditions were considered during the first simulation. Results showed tidal currents were the limiting timing factor in most instances, except for extreme wind conditions.

With regard to the next points, relating to the extent of the tidal model and equally the length of vessel movements simulated, the hydrodynamic modelling undertaken as part of the Environmental Impact Assessment (EIA) cover the entire River Yare, from outside the entrance to Breydon Water. This shows that the Scheme would have negligible effect on tidal velocities, timings or water heights beyond around 300m from the edge of the Scheme construction. For this reason, the simulations were focused on this area. The simulator model itself covers the entire River. The simulator has the facility to model vessel movements with tug assistance. No suggestion was made by the pilots during either the first or second stage simulations that they believed tug operations would have been used in the movements simulated.

Key Point: Whilst the model covers the entire river, the simulations were focused on an area 300m from the edge of the scheme construction as the EIA found the limit of change to be at this distance.

Lastly the tidal model used in the simulation was for a typical spring tide with a peak main stream velocity of 3.3 knots. The statement that flows can reach 6 knots in certain conditions is not known to apply to the whole of the River; indeed GYPC's General Port and Pilotage Information states "Out-going stream begins. Full flow normally 3 to 4 knots but can reach 6 knots with accelerated flows between the buttresses of Haven Bridge."

Key Point: The tidal model was based on a typical spring tide with a velocity of 3.3 knots. The 6 knot maximum has been recorded in a different part of the river, it is therefore not necessary to model a velocity of 6 knots for this assessment of the proposed bridge.

5.4.3 ISSUES RELATING TO THE OUTCOMES

5.4.3.1 GYPC's Concerns

- Berth 14 (North Atlas Quay) was difficult to berth on, but more hazardous to depart from.
- While attempting to berth on 31A/B (North Bollard Quay) the vessel became locked in the centre of the channel and was unable to power through to the berth.

5.4.3.2 Response

Finally, there are the comments relating to the outcomes of the simulation runs, both relating to the ability to berth and depart from the quays north of the bridge location. A number of the simulation runs in which berthing was problematic were undertaken with high current velocities. Given the restrictions on when certain vessels can safely transit the Brush Bend at the mouth of the River, it is not necessarily the case that a vessel could be in a position to require these manoeuvres at the tidal states used in the simulation.

Key Point: The difficulties encountered when berthing and departing from some quays occurred under high current velocities. In reality, existing restrictions would prevent vessels from manoeuvring at these times.

6 CONCLUSION

A navigation simulation was undertaken to assess the effects of the proposed Third Crossing of the River Yare in Great Yarmouth. The simulation involved the construction of a computer model of the approaches to the location of the proposed Third Crossing and allowed a variety of vessel passages to be attempted in various environmental conditions.

6.1 KEY FINDINGS

The following summarises the key findings:

- In slack water conditions the effects of the proposed bridge were minimal, even with vessels berthed directly adjacent to new bridge. Therefore, the 50m navigation channel is sufficient for vessels accessing the port.
- The effects of the narrowing increased as currents and the number of moored vessels increased.
- The magnitude of acceleration of flow with vessels berthed on both sides of the river, decreases with the proposed bridge in place.
- A comprehensive familiarisation programme for pilots is necessary to compensate for the effects of flow straightening and velocity changes.
- For vessels less than 30m in length the narrowing of the river by the proposed bridge when the bridge is raised is not navigationally significant.
- Both the vessel and tidal data used in modelling was shared or discussed with GYPC prior to assessment, with no objection. The vessels used are representative of recorded vessels passing the bridge and the tidal data uses sufficient data points to accurately replicate tidal conditions.
- With regards to the control mechanism of the supply vessel, a stern facing bridge does not fundamentally change the manoeuvring characteristics of the vessel model. It is able to replicate the control systems of an Offshore Supply Vessel.
- Wind conditions were considered during the first simulation. Results showed tidal currents were the limiting timing factor in most instances, except for extreme wind conditions.
- Whilst the model covers the entire river, the simulations were focused on an area 300m from the edge of the scheme construction as the EIA found the limit of changes to be at this distance.
- The tidal model was based on a typical spring tide with a velocity of 3.3 knots. The 6 knot maximum has been recorded in a different part of the river, it is therefore not necessary to model a velocity of 6 knots for this assessment of the proposed bridge.
- The difficulties encountered when berthing and departing from some quays occurred under high current velocities. In reality, restrictions would prevent vessels from manoeuvring at these times.
- While the option to use tug assistance was available within the simulation, no runs were undertaken with vessels using tug assistance as neither pilot indicated that they would have envisaged employing tugs with the vessels used during the simulation.
- During the simulations, the average time that vessels overlapped the bridge was approximately 1.5 minutes. This is consistent with the bridge opening durations derived from the vessel movements supplied by Peel Ports and used within the Scheme traffic assessments.

6.2 RISK SUMMARY

The following table details the principal risks identified during the vessel simulations and proposes potential solutions that could be adopted to better quantify or mitigate them during the design development.

Factor	Issue	Severity	Solution	Risk
Moored Vessels	For larger vessels during higher tidal flow conditions, the simulations showed that, while navigating the proposed Third Crossing with the tidal flow is possible up to certain speeds, difficulties could be experienced in manoeuvring when vessels are berthed on both banks of the River immediately north and south of the bridge.	Medium	Even though larger vessels make up less than 1% of port traffic, the removal of one of the berthed vessels improved the ease of transit in the simulations and further consideration of this fact should be included in the Navigation Risk Assessment for the Scheme when it is prepared.	Medium
Wind Conditions	Wind conditions were not represented on all simulation runs.	Low	Apart from extreme wind conditions, tidal currents were the limiting factor on timing of vessel movements. The impact of standard wind conditions has been understood and has minimal effect on navigation through the proposed bridge.	Low
Tidal Currents	The effect of bridge narrowing was found to be velocity reduction and flow straightening, which requires both familiar and unfamiliar pilots having to compensate for the tidal changes.	Medium	A comprehensive familiarisation programme for pilots is necessary to appraise them of the potential effects of flow straightening and velocity reduction.	Medium
Tug Assistance	No simulations were ran with tug-assistance therefore the effects have not been fully understood.	Low	Neither pilot indicated they would employ tugs with the simulation vessels, additionally, there have been very few movements over the past eight years that have taken tugs.	Low

Departing / Berthing	Departing and berthing difficulties were encountered for some larger vessels from certain quays under high current velocities.	Low	Restrictions apply for when vessels can depart and berth in difficult tidal conditions. In reality, few vessel would be making these manoeuvres. Therefore, most manoeuvres are able to occur without difficulty.	Low

The following summarises the outcomes of the assessments, the impacts to activity in the port, and possible next steps:

- The removal of one of the berthed vessels improved the ease of transit in the simulations and further consideration of this fact should be included in the Navigation Risk Assessment for the Scheme when it is prepared.
- All of the simulation runs resulted in passages through the bridge that were reasonably parallel with the abutments, this indicates that the assumption of no more than 12.5° heading error during a passage used for the preliminary sizing of the passage fendering could be considered conservative.
- It is envisaged that the Scheme will be marked with standard Aids to Navigation i.e. red and green channel markers, amber fixed hazard lights and sets of traffic control signals (either stop/go or IALA E111 signals). Any additional requirements should be identified in consultation with the Great Yarmouth Port Authority as Statutory Harbour Authority and Trinity House as General Lighthouse Authority during the Navigation Risk Assessment process.
- A number of aspects of the simulations indicated that benefits could be realised by the implementation of a familiarisation programme for pilots and other designated river users prior to the commencement of construction of the scheme, the potential form and attendees for this should be considered further as part of the Navigation Risk Assessment process.

The outcomes from these simulations are not dissimilar to those from a previous simulation undertaken in 2009 during the early planning stage for the Scheme.

We consider that, with the information available at the current stage of the design process, the simulations show that the proposed Third Crossing would be unlikely to create an unacceptable level of hazard to navigation nor require the imposition of excessive restrictions on navigation within the Port of Great Yarmouth.

1st Floor Station House
Tithebarn Street, Exchange Station
Liverpool
L2 2QP

wsp.com

Appendix D – Stage 3 Simulation Shipmove Report

GY3C 3rd STAGE SIMULATIONS

HR WALLINGFORD

3rd – 5th SEPTEMBER 2019

Mike Nicholson
mike@shipmove.co.uk
V2 11/10/2019

Contents

Definitions and Abbreviations

3nd Stage	These 3rd stage simulations follow the 1st Stage (HR Wallingford June 2009 and 2nd stage (East Coast College Lowestoft March 2019) simulations.
Azimuth / Azipod	Azimuth Props / Azimuth Drive a propulsion unit able to direct thrust 360º
B / Beam	Breadth / Width (of a vessel)
Ballast / Light	A vessel with no cargo, only water (ballast) for stability / efficiency
CPA	Closest Point of Approach
CTV	Crew Transfer Vessel (For Windfarms)
Dimensions / Units	Unless otherwise stated, vessel / wind speeds are in Knots (Kts) = Nautical Miles per hour. 1 knot = 0.5144 m/s Nautical mile = 1852m; Distances in metres (m). Weights (vessel) and force in Tonnes (t)
Draft	Depth of vessel below water line. Can be either maximum, forward, or aft.
DWT Deadweight	Measurement of the cargo carrying capacity of a vessel. Tonnes
Displacement / Δ	Measurement of the total displacement of a vessel. Ship + Cargo
GY3C	Great Yarmouth third crossing. The proposed new bridge
GYPC	Great Yarmouth Port Company (Peel Ports) the managers of the port.
HRW	HR Wallingford. Designers, owners and operators of the simulation facility.
Length / L	Length of the vessel, further defined by:-
LOA	Length Over All – includes masts, flare of bow etc. Extreme length
Loaded / Laden	A vessel loaded with cargo
N S E W	North South East West etc
Own Ship	Own ship is the model being piloted.
PEC	Pilotage Exemption Certificate, granted to ship's masters based on local experience
PSV	Platform Supply Vessel
Shipmove	The consultant company, author of this report.
Speed	Measured in knots, usually qualified by speed over the ground (G) or through the water (W)
WSP	Consultant Engineers engaged by Norfolk County Council (NCC)
V/L	Vessel

1 INTRODUCTION

1.1 GENERAL

Shipmove have been engaged by WSP to provide independent observation and comment on the real time navigation simulations held at HR Wallingford on 3rd – 5th September 2019.

These 3rd Stage simulations follow on from previous simulations held at HR Wallingford in June 2009 (1st Stage) and East Coast College Lowestoft in May 2018 and March 2019 (2nd Stage). (see reports).

1.2 AIMS

The aims of these 3rd stage simulations and Shipmove's participation was to;

- Provide an opinion on the conduct of the simulations, and their robustness.
- Verify the navigability of the bridge
- Identify any risks that may be introduced by its installation
- Identify potential mitigation measures.

Fig 1 HR Wallingford Simulator Bridge Representation

2 CONDUCT OF THE SIMULATIONS

2.1 SIMULATION FACILITY & PORT MODELLING UPDATES

The port model used in the facility has been updated since the previous simulations;

1) Following observation made during the 1st Stage simulations, the proposed bridge alignment was altered to make the crossing more perpendicular to the river channel. This new alignment was used in both the 2nd and 3rd stage simulations.
2) A new tidal model was introduced for these the 3rd stage simulations.

2.2 ATTENDEES

The following persons attended this third stage simulation.

Name	Organisation	Position / Title	Task / Function
Vincent Crockett[1]	HR Wallingford	Technical Director	Facilitator[1]
Gillian Watson[2]	HR Wallingford	Project Manager	Facilitator[2]
John Gurton	HR Wallingford	Pilot	Observer / Pilot
Roberta Riva	HR Wallingford	Simulation Co-ordinator	Simulation Operator
Brian Forrest[2]	GYPC	Senior Operations Manager	Observer
David Morrice	GYPC	Pilot	Pilot
Richard Gavin	GYPC	Pilot	Pilot
Luke Sebastian[1]	GYPC	Marine Operations Manager	Observer
Steve Horne	WSP	Principal Engineer Maritime	Observer
Michael Nicholson	Shipmove	Principal	Independent Observer
[1] Attended 1st Day Only	*[2] Attended 2nd & 3rd days only*		

2.3 Robustness of the Simulations

With respect to the performance of the simulator, the following observations were made;

2.3.1 The Simulator

Aspect	Observer	Notes
Charted Depths	Pilots	The hydrographic model input was from 2016. Even allowing for the age the Pilots felt they were overstated by some 0.5m to 1.0m. Without sight of the source information this could not be verified. As currents were input independently of depth this was not considered to affect the simulation model.
Tidal Current & Ebb /Flood Strengths	Pilots	The tidal / current model input into the simulator (provided by WSP), showed that flood tide strengths were stronger than ebb tide. The GYPC pilots stated that this was not the case and that (extreme fluvial events and tidal surges aside), the Ebb tide was always greater than the flood.
Slack Water	Pilots	The tidal / current model (see above) shows that slack water is nearly co-incident with HW / LW, however the GYPC pilots assured us that slack water in this location is approximately 1.5 Hrs after HW and 2 hrs after LW. Allowances were made by running the simulator to produce the desired current conditions. That is; for slack water the simulator Tide time was set a HW, rather than HW +1.5hrs.
Wind Shielding	HRW	HRW confirmed that the model contained no wind shielding, so while bridge, berthed vessels & structures were visible, they had no sheltering effect. In real life this sheltering would reduce the wind experienced by the vessel (when compared to open locations - such as the harbour entrance) by a factor of 2-3. So, in effect, when the wind was 15 knots in open locations it would be only 5-7 knots in the river at this location.
Current Shielding / Effects	HRW	While the bridge structure alters the current flow, and "own ship" causes equivalent effects; Target (stationary vessels) vessels, are transparent to both wind and current, i.e. they do not affect the conditions around them, they only serve to reduce the available width.
Wind Shear / change	HRW	While the wind strength and direction can be adjusted for location and time; for the runs the wind was the same throughout. Wind acts on a single point on the vessel so shear (different wind at different points on the vessel causing a shear or turning moment) cannot be modelled.
Current Shear		Current acts on multiple point on the vessel, so current moves vessel but changes of current (shears or changes of direction and strength) can also produce a turning moment or shear.

2.3.2 The Vessel Models

Model	Observer	Notes
A 80m PSV	Pilots	Performed as expected. Difficulty with reversal of controls when simulating stern-first manoeuvre was mostly overcome by the Pilot operating the model.
B 88m Cargo	Pilots + Observers	High-lift ("Becker" or flap) rudder, initially did not seem to be as effective as similar types / real life. Adjustments made from Run 28 onwards seemed more true-to life.
C 93m Tanker	Pilots + observers	Bow thrust effectiveness in wind was initially poorer than would be expected. This was altered from Run 12 onwards and improved.

2.3.3 Robustness - Summary

Notwithstanding the above limitations it was considered that

- The simulation model represented a realistic basis for assessment of the likely navigational regime should the scheme be constructed.
- The vessel models included in the simulations provided an adequate representation of the critical design vessels for the scheme.

3.0 SCENARIOS & SIMULATION

3.1 METHODOLOGY

HRW provided an outline programme as a starting point, this was further developed during the visit by GYPC (Pilots & Senior Operations Manager), Shipmove and WSP.

The choice of scenarios tested a variety of conditions, intended to supplement the previous simulations, but also concentrating on testing the changes to the current model. These tested a variety of vessel types and conditions. Up to, and in excess of, normal limits.

Some marginal or unsuccessful runs were made to further test limits or to ascertain optimum navigation strategies.

3.2 SCENARIOS

In all 33 runs were simulated, though not all resulted in passage of the new bridge as it was desirable to assess current effects at the berths close to the bridge as well as the bridge transit itself.

If solely due to technical issues with the simulator or the model, some runs were re-set during the early stages of the passage, these were generally not recorded here.

A record for each simulation run is annexed to this report but the summary is tabulated in s3.4 below. An attempt was made to quantify the ease of Navigation through the bridge, this assessed in the last column below.

Except when wishing to test wind limits, most scenarios were run with a moderate SW wind (being the predominant wind direction), to add some difficulty to the manoeuvres.

3.3 EASE OF PASSAGE

The subjective assessment of ease of passage (See last column in the table 3.4 below and also the individual run records annexed to this report), are based on the following guide;

Score	Brief	Description
1	**Good**	Straightforward, Comparatively easy.
2	**Fair**	Significant effort & close monitoring required, but vessel not close to danger
3	**Satisfactory**	Less than optimal. Times when vessel not proceeding as desired.
4	**Near-Miss**	Vessel close to edge of set limits, significant force on structure or ropes.
5	**Fail**	vessel out of channel, struck object, parted ropes, in irrecoverable position.

3.4 3RD STAGE SIMULATIONS SUMMARY

3.4.1 Day One (04/09/2019)

Run #	Brief Description	V/L	Condition		Arrive / Sail		Vessel Direction		Bridge Current (Kts)	Wind		Ease
			Light	Load	Arr	Sail	Bow	Stern		Dir'n	Knots	
1	PSV Arrival near slack water. Bow 1st	A		X	X		X		Slack	SW	10-15	2
2	PSV Arrival moderate flood tide. Bow 1st	A		X	X		X		With 1.5	SW	10-15	2
3	PSV Arrival moderate flood tide. Bow 1st	A		X	X		X		With 1.7	SW	10-15	1
4	PSV Arrival strong flood tide. Bow 1st	A		X	X		X		With 4.2	SW	10-15	3
5	PSV Arrival strong flood tide. Stern 1st	A		X	X			X	With 4.2	SW	10-15	1
6	PSV Arrival strong ebb tide. Bow 1st	A		X	X		X		Against 3.1	SW	10-15	1
7	PSV Sailing, moderate ebb tide. Bow 1st	A		X		X	X		With 2.8	SW	10-15	3
8	PSV Sailing, strong ebb tide. Bow 1st	A		X		X	X		With 3.1	SW	10-15	4
9	PSV Sailing, strong ebb tide. Bow 1st. Repeat.	A		X		X	X		With 3.1	SW	10-15	2
10	PSV Sailing, strong ebb tide. Stern 1st	A		X		X		X	With 3.1	SW	10-15	1
11	PSV Arrival strong flood tide. Bow 1st, E Wind	A		X	X		X		With 4.2	E	25-30	3

All of the above detailed individual run records and files are contained in Annexe A.

3.4.2 Day Two (05/09/2019)

Run #	Brief Description	V/L	Condition		Arrive / Sail		Vessel Direction		Bridge Current (Kts)	Wind		Ease
			Light	Load	Arr	Sail	Bow	Stern		Dir'n	Knots	
12	Arrival Tanker, slack Water Berth @ 32 Quay*	C		Part	X		X		Slack	SW	10-15	2
13	Shift Tanker from 32 to 12 Berth. Strong Ebb*	C		Part	Shift			X	With 3.2	SW	10-15	1
14	Tanker Arrival, first of Ebb tide	C		Part	X		X		Against 0.5	SW	5-7	2
15	Tanker Sailing, stern first, last of flood.	C		Part		X		X	Against 0.7	SW	5-7	4
16	Tanker Sailing, stern first, last of flood. Repeat	C		Part		X		X	Against 0.7	SW	5-7	5
17	Tanker Sailing, stern first, last of flood. Repeat	C		Part		X		X	Against 0.7	SW	5-7	5
18	Tanker Sailing, stern first, last of flood. Repeat	C		Part		X		X	Against 0.7	SW	5-7	3
19	Cargo Sailing, stern first, last of flood.	B		X		X		X	Against 0.7	SW	5-7	3
20	Cargo Sailing, stern first, loaded, ebb tide.	B		X		X		X	With 1.8	SW	5-7	5
21	Cargo Sailing, stern first, loaded ebb tide. Repeat	B		X		X		X	With 1.8	SW	5-7	2
22	Cargo Sailing, stern first, ebb tide. Repeat Light	B	X			X		X	With 1.8	SW	5-7	5
23	Cargo Sailing, stern first, ebb tide. Repeat Light	B	X			X		X	With 1.8	SW	5-7	2
24	Tanker Sailing, stern first, last of ebb tide.	C	X			X		X	With 1.8	SW	5-7	5

* Runs marked so did not require a bridge transit.

All of the above detailed individual run records and files are contained in Annexe A.

3.4.3 Day Three (06/09/2019)

Run #	Brief Description	V/L	Condition		Arrive / Sail		Vessel Direction		Bridge Current (Kts)	Wind		Ease
			Light	Load	Arr	Sail	Bow	Stern		Dir'n	Knots	
25	Tanker sailing, stern first, last of ebb. Repeat.	C	X			X		X	With 1.8	SW	5-7	2
26	Cargo sailing, stern first, light, ebb tide. +Wind	B	X			X		X	With 1.8	SW	15-17	4/5
27	Cargo sailing, stern first, light, ebb tide, wind. Rpt	B	X			X		X	With 1.8	SW	15-17	3/4
28	Cargo sailing, stern first, light, ebb tide, NW wind.	B	X			X		X	With 1.8	NW	15-17	3
29	Cargo sailing, stern first, light, ebb tide, NE wind.	B	X			X		X	With 1.8	NW	15-17	3
30	Cargo sailing, stern first, light, ebb tide, SE wind.	B	X			X		X	With 1.8	NW	15-17	2
31	Cargo, arrival, back through bridge. Flood	B	X		X			X	With 1.6	SW	5-7	2
32	Cargo, arrival, back through bridge. Flood, Wind+	B	X		X			X	With 1.6	SW	15	4
33	Cargo, sailing, stern first, last of flood. R'pt of 19	B		X		X		X	Against 1.3	SW	5-7	3

All of the above detailed individual run records and files are contained in Annexe A.

4.0 ANALYSIS

4.1 GENERAL

The runs were chosen to simulate realistic scenarios, that is representing movements that currently take place with the informal restrictions already in place namely;

- PSV's move at nearly any state of tide / current
- Cargo vessel and tankers generally move under benign current conditions

(See also S5.4 & 5.5 below).

Within those parameters the scenarios were undertaken in predominantly challenging conditions to find (and in some cases exceed) the operational envelopes. For example more runs were undertaken with a following (with) tide than a counter (against) tide, as this is generally more difficult. Similarly, more runs were undertaken stern-first than bow first. As such the runs do not lend themselves easily to statistical analysis (not an even spread of conditions), but some general conclusions can be made;

Parameter	Selection	Average "Ease" Score	Notes
Vessel Type	**A** (PSV)	**2.1**	This is as expected; PSV's are very manoeuvrable, the other vessels less so.
	B (Cargo)	**3.2**	
	C (Tanker)	**3.2**	
PSV - Direction	Bow First	**2.3**	Manoeuvrability is similar regardless of direction, however visibility (and so control) is better stern-first
	Stern First	**1.0**	
Tanker	Bow First	**2.0**	As expected, conventional vessel are far more manoeuvrable when going ahead.
	Stern First	**4.0**	

4.2 CURRENT STRENGTH

The strength of the current had a significant effect on transits, as well as increasing in velocity, the rate of change (of velocity and / or direction) increased near the bridge opening. This change of direction and velocity was more pronounced upstream (South on a flood tide – North on an ebb tide) of the bridge, whereas downstream the resumption of "normal" flow was more gradual.

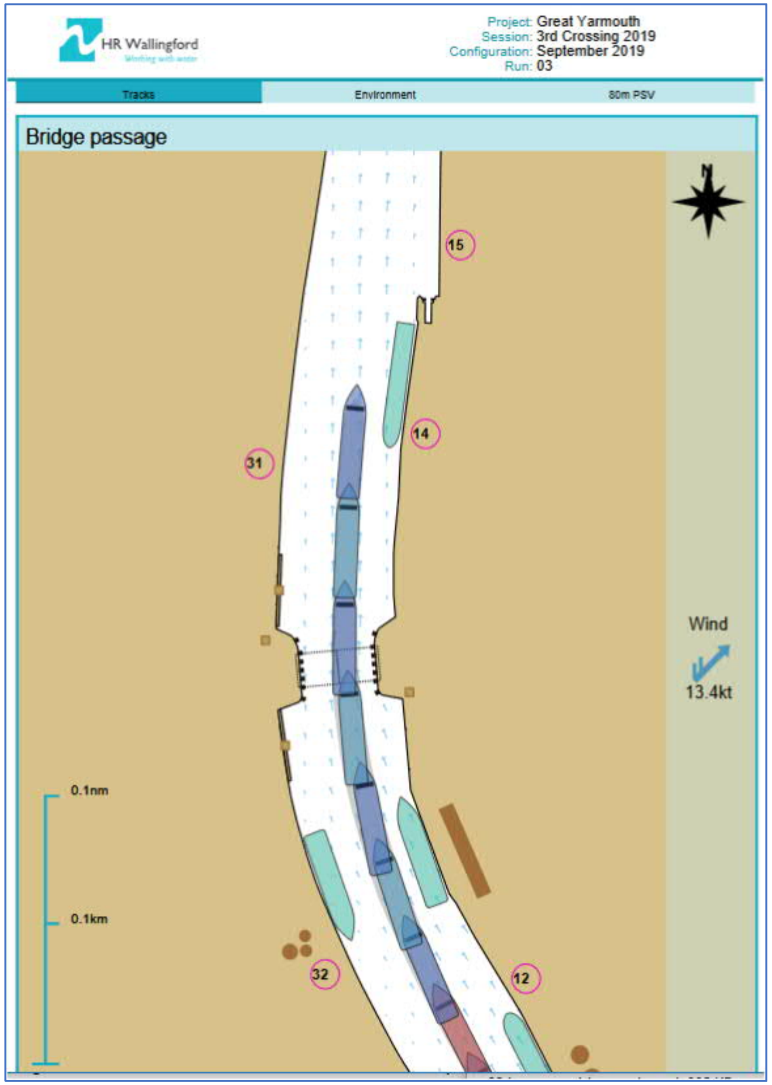
This bet illustrated by comparison of two otherwise similar runs (one moderate tide, one strong tide)

Run #	Brief Description	Vessel Direction		Bridge Current (Kts)	Wind		Ease
		Bow	Stern		Dir'n	Knots	
3	PSV Arrival **moderate** flood tide. Bow 1st	X		With 1.7	SW	10-15	**1**
4	PSV Arrival **strong** flood tide. Bow 1st	X		With 4.2	SW	10-15	**3**

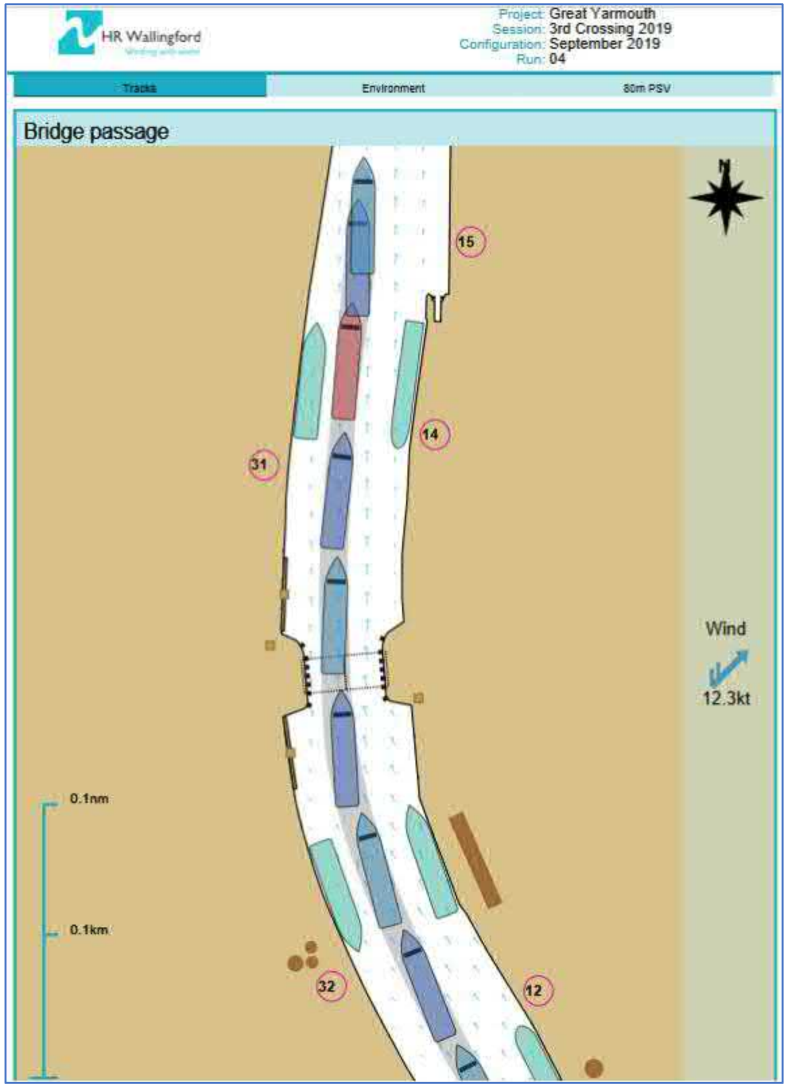
Note that the stronger tide had the effect of "pushing" the vessel to the outside of the bend and the berthed ships. Azipods and thruster were used more extensively in Run 4. See figs on next page.

It should also be noted that as well as increasing difficulty and potential for loss of control, the strength of the current can affect potential severity of incidents;

- A vessel travelling with the current, in order to maintain steerage; will normally be traveling faster relative to the bridge structure than one travelling against the current. In line impacts (in the North/South direction), are likely to be of a greater magnitude.
- A vessel travelling against the flow, in order to maintain progress; will have to travel at a greater speed through the water, any deviation from the desired track will impart a greater transverse component over the ground. Transverse impacts (in the East/West direction), are likely to be of a greater magnitude.



Run 3 (Current 1.7kts) Ease 1



Run 4 (Current 1.7kts) Ease 3

4.3 CHANNEL POSITION

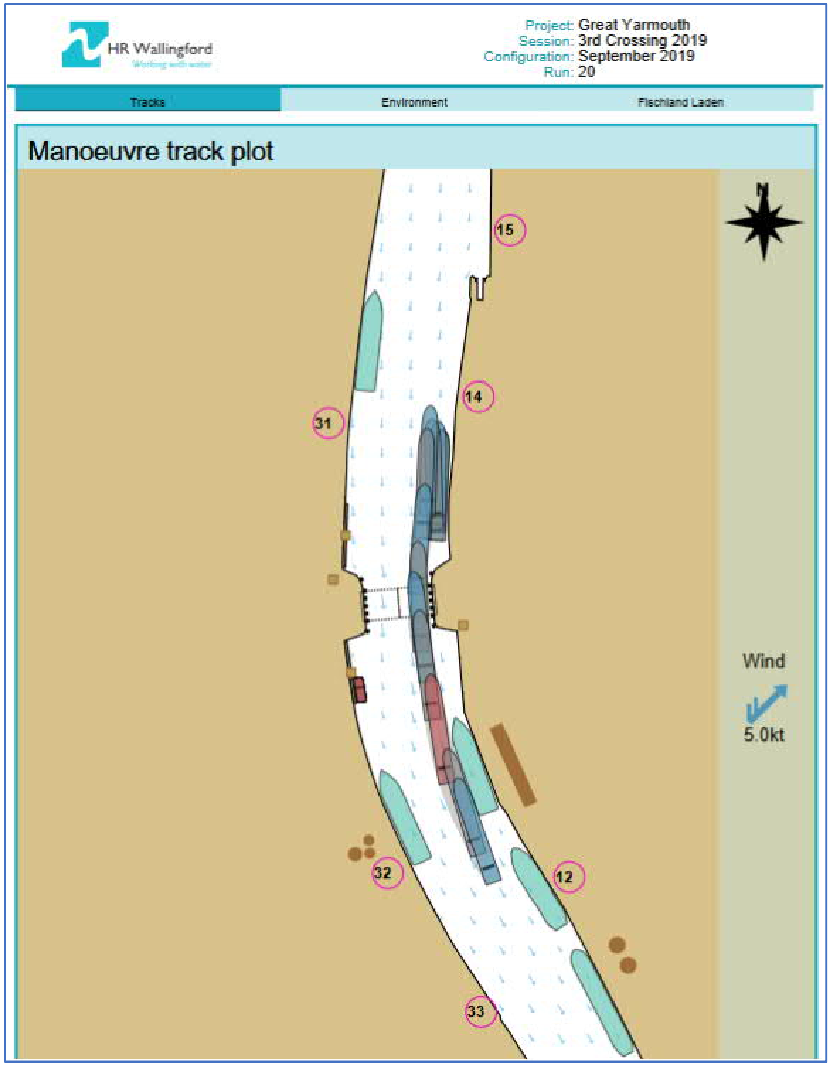
While current velocity wind strength and vessel type & direction all played important parts; bearing in mind that challenging conditions were simulated, the one pilot/ operator affected factor that seemed to play an important part in the outcomes of the transits (successful or none) was the vessel's channel position before the bridge transit.

This can de best represented by comparison of some selected runs;

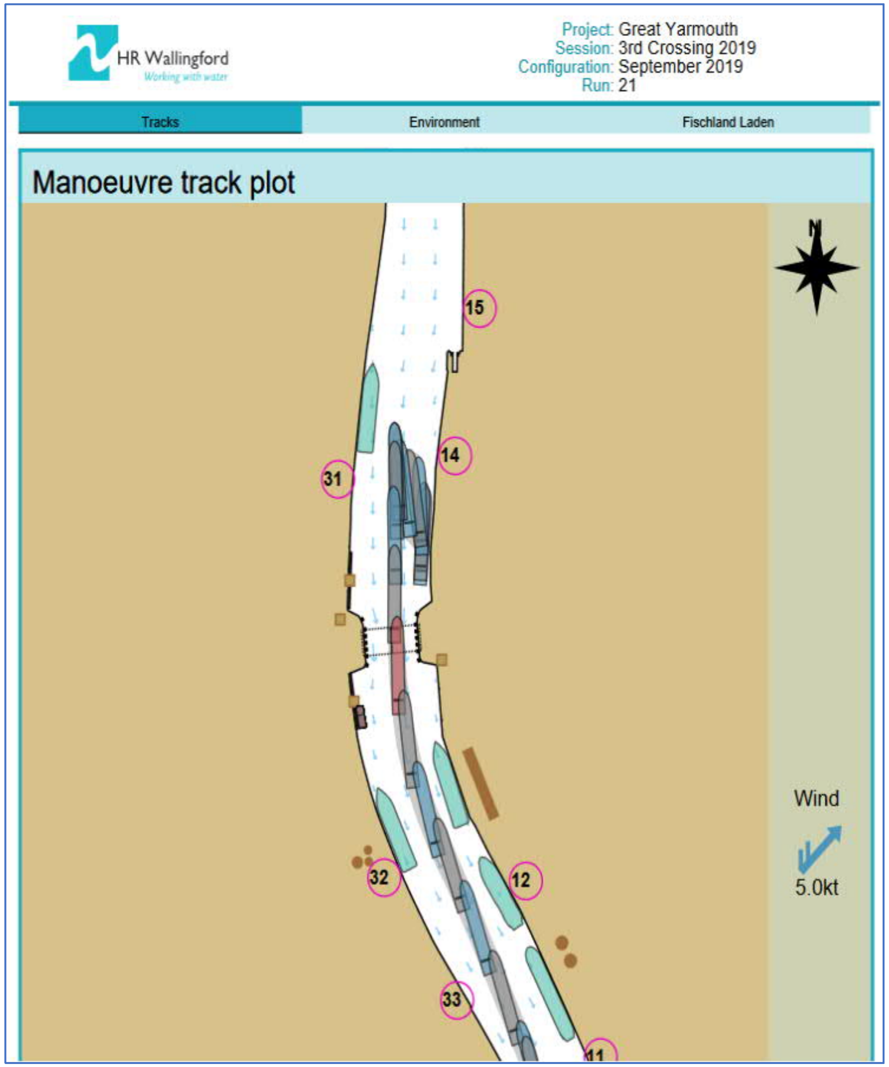
Run #	Brief Description	Arrive / Sail		Vessel Direction		Bridge Current (Kts)	Wind		Ease
		Arr	Sail	Bow	Stern		Dir'n	Knots	
20	Cargo Sailing, stern first, loaded, ebb tide.		X		X	With 1.8	SW	5-7	5
21	Cargo Sailing, stern first, loaded ebb tide.		X		X	With 1.8	SW	5-7	2
22	Cargo Sailing, stern first, ebb tide. Repeat Light		X		X	With 1.8	SW	5-7	5
23	Cargo Sailing, stern first, ebb tide. Repeat Light		X		X	With 1.8	SW	5-7	2

See figs on next pages

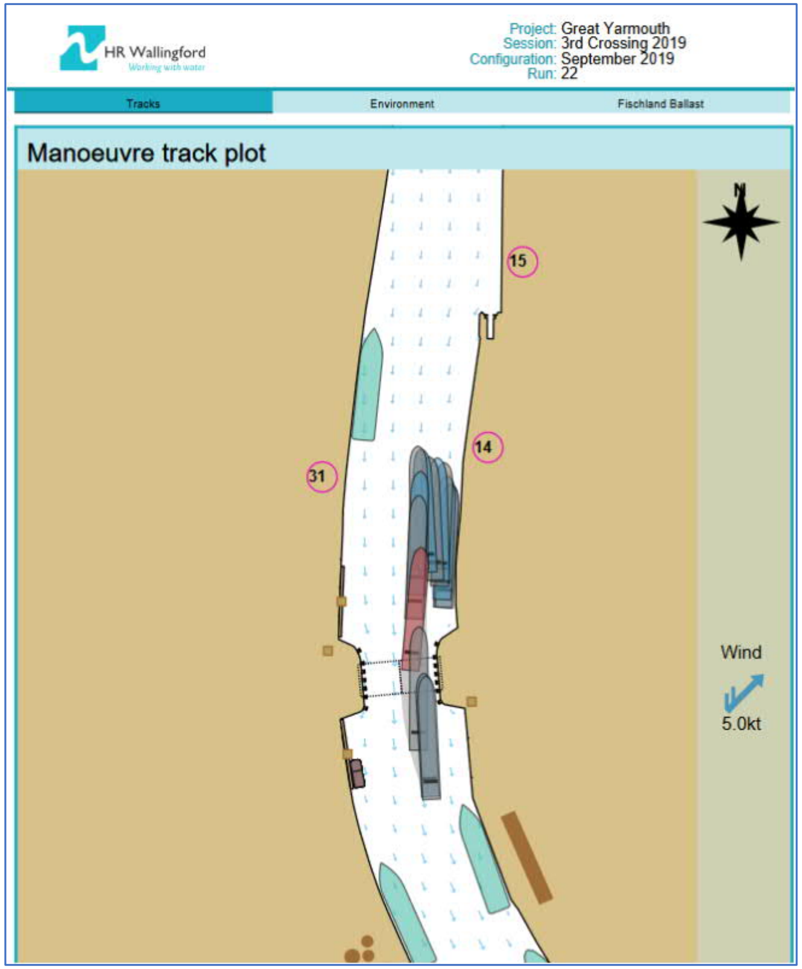
Indeed, the vast majority of "Failing" runs occurred when the vessel attempted transit before being aligned with the tide and fairly centrally in the river.



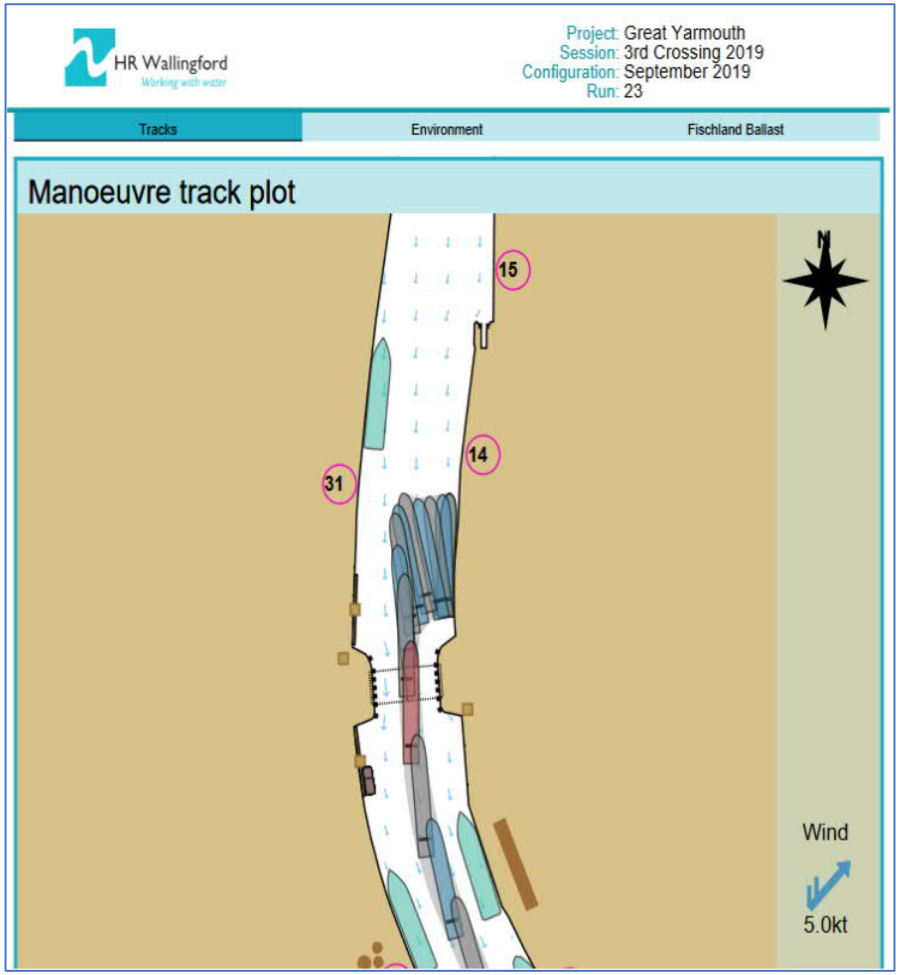
Run 20 Ease 5. Commence transit too far to the East



Run 21 Ease 2. Commence transit mid-stream



Run 22 Ease 5. Commence transit too far to the East



Run 23 Ease 2. Commence transit mid-stream

4.4 CONCLUSIONS

- While the presence of the bridge does make navigation in the area more challenging, these effects are of a similar order to those already existing; such as when vessels are berthed both sides of the river.
- The effects are more noticeable when current flows are strong and for certain vessel types.
- Navigation through the bridge is achievable.
- To ensure Navigation takes place with an acceptable degree of safety, the current conditions need to be within acceptable limits. These limits will depend on;
    - The type of vessel and it's manoeuvrability
    - The direction of travel;
        - With respect to the current (with / against)
        - With respect to the ship (ahead / astern)
    - Other climatic conditions (wind, visibility etc)
- It is vital that before a transit of the bridge is attempted;
    - The vessel is under full control
    - The vessel is centrally positioned and aligned with the prevailing current
- Training and familiarisation for pilots (covering at least the above aspects) will be required.

5.0 OBSERVATIONS

5.1 MAXIMUM CURRENT FLOWS

Previous reports and pilot's responses state that the normal maximum currents in the river are 2-3 knots on a spring tide, but that during flood / storm-surge events peak rates of 4-5 knots can be experienced. These are not measurements per-se but estimates.

The narrowing of the river through the new bridge is expected to increase these rates by 60% or more, so that normal maxima may be in the order of 5 knots, while peak rates during surge or flood events could theoretically approach **8 knots or more,** though it is predicted that due to the "throttling" effect of the bridge it is expected that peak rates will be in the order of 6 knots.

The rate of current through the bridge passage; and its associated acceleration, change of direction and deceleration in the approaches, are the factors that make navigation in the area challenging. Higher rates will only increase the difficulty.

Note that the maximum rates that have been modelled (in the bridge passage) thus far are; Stage 1 = 4.8kts, Stage 2 = 3.7 kts, Stage 3 = 4.2 kts.

5.2 EXTENT OF BRIDGE EFFECTS

All bridge effects appeared very localised. The "Jet" stream of increased water flow seemed only to travel upstream 150 metres or so, and downstream of the bridge the effects (a funnelling toward the hole and acceleration), were apparent over perhaps only about 50 metres. It follows that shifting berths, other than DIRECTLY adjacent to the bridge (berths 14A and 13A), is hardly affected.

5.3 MAXIMUM SPEEDS THROUGH THE BRIDGE

The bridge abutments are specified to be designed to withstand impacts from a vessel travelling at 7 knots (7 knots ground speed is the maximum under the byelaws). This for a large vessel (assumed to be approximately 7.500 tonnes displacement). The approach knuckles are designed to be sacrificial so that any impact forces are not transferred to the bascule supporting structure.

To maintain steerage a vessel normally requires a certain speed through the water (3-4 knots not being uncommon for conventional vessels). It follows then that when currents are very large there could be circumstances when a vessel transiting through the bridge, when strong currents are present, may be compelled to travel at a speed higher than the design speed to maintain steerage.

5.4 VESSEL LIMITS AND ENTRY TIMES

While there are set entry criteria for the outer harbour (in terms of vessel type and length and state of tide), there are no formal limits for the inner harbour. The pilots assess each vessel on a case by case basis, though some consistent but informal procedures apply. For example;

Cargo ships are always turned in ballast / light:-

Arrival loaded = Swing on departure (or back out if too large to turn)

Arrival light = Swing on arrival and steam out.

PSV vessels berth according to requirements at berth, will swing or back into port if required. They normally don't swing as its just as easier (or easier) to travel stern-first.

5.5 SELF LIMITING FACTORS

5.5.1 Brush Bend

Passage around brush bend is challenging, especially when the tide is flowing strongly. The pilots already operate informal limits to the sizes and types of vessel that may transit brush bend. These are related to the times of tide and strength of current.

Any vessel arriving at the bridge (that require a previous or subsequent passage around brush bend), and which are limited to rounding Brush bend with benign currents, would also be arriving at the bridge with low current rates.

5.5.2 Bascule Operation

There will be limits in terms of wind speed to the operation of the bascule leaves. This dictates that vessel will not be physically able to transit the bridge during extreme winds.

5.6 BRIDGE FAILURE CONTINGENCIES

Some discussions took place during the simulations on this aspect.

It was proposed that a vessel should not pass a “trigger point” till the bridge is open or confirmed to be opening. This was suggested as 500m. This when inwards is coincidentally about the location that you pass a previous corner and first see the bridge structure (adjacent no 9 berth).

The question of what may occur if the bridge fails was discussed. GYPC staff indicated a waiting berth may be required either side of the bridge. Other mitigation however would be available;

1) PSV’s & Standby Vessels (the majority of vessels and making up 80% of traffic) can normally stop, hold and go backwards, and could depart the port without the need for a waiting berth.
2) Less manoeuvrable vessels will likely be approaching at slack or counter current and so can wait for a short while.
3) Frequency of ALL suitable berths full should be taken into account.
4) If all berths were full and a vessel cannot wait, then another mitigation would be to
    a. Ensure a suitable existing berth was vacant and could be used before passage was commenced
    b. Or ensure that the bridge was open before entering (or passing the last abort point)

5.7 SLACK WATER TRANSITS

As could be seen large and less manoeuvrable vessels had difficulty passing through the bridge when the tide was strong or from an adverse direction. It follows that some vessels might prudently require slack water at the bridge for a safe transit.

Slack or nearly slack water at Brush bend or the berth may also be desired. Depending on how long it takes to transit between these points, it could mean that sufficiently benign conditions may not exist at all locations to allow a single continuous passage. This would have to be considered during the preparation of each vessels passage plan.

Therefore, it could not be ruled out that a vessel may require more than one “slack” period to transit; Berth – Bridge – Brush Bend - Port Entrance (or vice versa).

5.8 EXISTING NAVIGATION

The present topography of the port is such that the channel width, from entrance to new bridge location varies from about 76m to 92m. While vessels berth on both sides of the river, there are limitations in place (both in terms of location and beam) such that the minimum theoretical channel width is around 50 metres.

The new bridge passage will leave a passage of no less than 50m.

It follows that the pilots are already experienced in Navigating vessels through similar restrictions, and the record of safe transits indicates this is feasible.

The new bridge however, with abutments extending from sea-bed to above water level, will have a greater effect on flow, as berthed ships inevitably have an under keel clearance below which the water may pass.

The abutments are also more abrupt than the bow or stern of a vessel, so the effects of the current through the bridge is expected to be more marked than present conditions, even when vessels are berthed on both side of the river. The acceleration of the flow and the change of direction near the abutments is also expected to be greater than that currently experienced. In short the bridge is likely to make Navigation more challenging than is currently experienced.

6.0 RECOMMENDATIONS

6.1 CURRENT MEASUREMENTS

As the strength of current is a critical factor, and bearing in mind the comments from the pilots regarding the apparent discrepancy between ebb and flow rates and timings of slack water;

6.1.1 Current Modelling

It is recommended that a more detailed study of present current flows is undertaken. This over a greater tidal cycle covering spring and neap ranges at various locations.

6.1.2 Current Measuring

As current flows and the potential requirement for benign conditions or limiting strengths are likely to be important. It is recommended that current measuring equipment is installed at the bridge both during construction and once completed. This would enable the port and pilots to ascertain real-time currents at the bridge location.

It is unlikely that current estimation simply based on tidal heights and ranges will be sufficiently accurate or reliable.

6.2 BERTH OCCUPANCY

The port should consider which (if any berths) may require to be vacant for passage of certain vessels and under what conditions.

6.3 TRAINING & FAMILIARISATION

6.3.1 Pilots

Once the bridge design has been finalised, it is recommended that the Port devises a training programme to familiarise the pilots with the bridge and its effect on navigation during both the construction and installed phases. This can be further used to develop the most effective strategies for safe passage.

6.3.2 PEC Holders

It is recommended that present PEC certificates exclude new bridge transits. PEC's with bridge transits included should be issued subject to the holder conducting an appropriate number of new bridge transit trips with an experienced pilot.

6.4 SPEED & CONTROL

The port should consider what measures or procedures are necessary to ensure;

(1) Vessel have adequate control before transiting the bridge passage.

(2) The design speed of the bridge cannot be exceeded by transiting vessels.

(3) The current is within suitable limits for the vessel type and size.

6.5 MISCELLANEOUS

6.5.1 Waiting Pleasure Craft

Once the bridge opens, waiting yachts & pleasure craft should transit the bridge first to reduce obstructions on the waiting berths near the bridge.

6.5.2 Bridge Abutments

Consideration should be given to methods of reducing the rates of change of both current strength and direction close to the bridge

APPENDIX A RUN RECORDS

The Appendix contains all of the Run records; This being a set of observations by the author, including scenario details and objectives. Timings are approximate.

The subjective assessment of ease of manoeuvre are based on the following guide;

Score	Brief	Description
1	**Good**	Straightforward, Comparatively easy.
2	**Fair**	Significant effort & close monitoring required, but vessel not close to danger
3	**Satisfactory**	Less than optimal. Times when vessel not proceeding as desired.
4	**Near-Miss**	Vessel close to edge of set limits, significant force on structure or ropes.
5	**Fail**	vessel out of channel, struck object, parted ropes, in irrecoverable position.

Run # (Sequence)	**1**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:35 / 10:45		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arrival near slack water			
Objective	Safe Bridge Passage			
Notes	10:10 Had some initial tech issues with controls, stopped and restarted twice. See note regarding slack water times.			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**Slack**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW +15m		**Wind Dir'n / kts**	SW	10-15 kts
Current (River)	Flood	0.3 knots	**Current (Bridge)**	Flood	0.3 knots

Berths Occupied			
31 (Bollard)		**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
10:36 Bridge Lifting	
10:43 Transit Bridge (slack water)	
Closest CPA 9m on starboard side	

Assessment of ease of manoeuvre;	***2 (Fair)**

Notes	10:10 Had some initial tech issues with controls, stopped and restarted twice.
Dead slow indicated as 1.6 knots, actually nearer 5.0 knots	
In reality Slack Water occurs about 1.5hrs after HW/LW. Noted that in the model, slack water and HW were nearly coincident. All runs therefore performed with appropriate tidal conditions. Sim HM being adjusted to give target conditions – ON THIS AND **ALL** SUBSEQUENT RUNS OVER THE THREE DAYS	

Run # (Sequence)	**2**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:54 / 11:12		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arriving with moderate flood tide			
Objective	Safe Bridge Passage			
Notes	To berth at 31 after clearing bridge.			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW+1.5h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Flood	1.0 kts	**Current (Bridge)**	Flood	1.5 kts

Berths Occupied			
31 (Bollard)		**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√ √

~Timeline;	10:45 Start, proceeding at 5 kts (Ground)
11:08 passing Asco 3.8 kts (G) 2.8kts (W) (21m clear of ship)	
11:10 Bridge transit, 10m CPA to port	
11:12 Berthed alongside N' Bollard Quay	
Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes	
68 rpm gave 5.5 knots (G), engine control very sensitive to small movements	
Tide tended to push the vessel to the outside of the bridge hole	

Run # (Sequence)	**3**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	11:23 / 11:39		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arriving with moderate flood tide			
Objective	Safe Bridge Passage			
Notes	Re-run of 2, started in slightly different channel position, and vessel on berth 32 nearer the bridge.			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW+1.5h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Flood	1.0 kts	**Current (Bridge)**	Flood	1.7 knots

Berths Occupied			
31 (Bollard)		**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√ *	**12 (Asco)**	√

~Timeline;

11:23 Start. Speed 4.6 kts (G)	
11:35 Bridge open, speed 3.8 kts (G)	
11:37 Approach bend, speed 3.5kts (G)	
11:39 Passed bridge CPA 11m (starboard)	

Assessment of ease of manoeuvre;	*** 1 (Good)**
Notes	Vessel on 32 berth moved closer to the bridge.

Run # (Sequence)	**4**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	12:00 / 12:15		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arriving with strong flood tide			
Objective	Safe Bridge Passage			
Notes	All berths occupied			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW -3h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Flood	2.7 kts	**Current (Bridge)**	Flood	4.2 kts

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
12:00 Start. 5.2 Knots (G)	
12:07 Bridge open	
12:09 Passing Asco (5.6kts G)	
12:10 Bridge Transit, 5.7kts (G)	

Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
CPA 9m to ship berthed on 12 berth.
CPA 8m off bridge abutment (port).
Pilot "With that strength of tide, and that many vessels berthed, it may be a slack water only job"

Run # (Sequence)	**5**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	13:30 / 13:52		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arriving with strong flood tide, **STERN-FIRST**			
Objective	Safe Bridge Passage			
Notes	Stern first			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW -3h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Flood	2.7 kts	**Current (Bridge)**	Flood	4.2 kts

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
13:30 Start, Speed 4.1 kts (G)	13:50 Passing 12 berth Speed 4.9kts (G)
13:43 Speed 6.1 kts (G),	13:55 Bridge Transit – Plumb Centre
13:45 Speed 4.3kts (G) now only using bowthrust, not azipods.	

Assessment of ease of manoeuvre;	*** 1 (Good)**

Notes

There was significant difficulty with the engine controls, as although the view and conning position was as if we were navigating stern-first, the controls themselves were as if still facing forwards. The pilot had to put the azimuths in the opposite direction to that which was instinctive. That said he made a good job of this mental adjustment so that while challenging it did not seem to affect the result.*

*Controls aside, stern-first seemed easier as the visibility was better.

Run # (Sequence)	**6**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	14:20 / 14:38		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arriving with strong **ebb** tide.			
Objective	Safe Bridge Passage			
Notes	2 knots ebb, / 3 hrs after slack water / HW*			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m HW +3h		**Wind Dir'n / kts**	SW	10-15 kts
Current (River)	Ebb	1.7 kts	**Current (Bridge)**	Ebb	3.1 kts

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√ √	**12 (Asco)**	√

~Timeline;	
14:20 Start 4.3 kts (G)	14:35 Approach bridge fairly central 3.1 kts (G)
14:30 Bridge Open	
14:33 Passing 32 Berth 4.8 kts (G)	14:37 Bridge Transit – Speed 2.5kts (G). With tide of 3.1kts, water track 6.1 kts
14:33 In centre of channel	

Assessment of ease of manoeuvre;	*** 1 (Good)**

Notes	Pilot "4 knots (Water Track) needed for steerage".
The tidal model input into the HR Wallingford simulator (provided by WSP), indicates that peak flood (approx 2.7 knots in the main channel), is stronger than peak ebb (2.0 knots in the main channel). Pilots indicate this is not the case, as Ebb tides are nearly always (surge events excepting) stronger that flood tides. See also recommendations.	
Fishing vessels added to model (35 Berth) for this and subsequent runs. CTV also on waiting pontoon (immediately SW of bridge).	

Run # (Sequence)	**7**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	14:50 / 15:00		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	L.Sebastian

Scenario	Sail PSV from 31 berth, moderate ebb tide.			
Objective	Safe Bridge Passage			
Notes	Bow first			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics

Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions

Tide	Range 1.2m. HW +1h		**Wind Dir'n / kts**	SW	15 kts
Current (River)	Ebb	1.8 kts	**Current (Bridge)**	Ebb	2.8 kts

Berths Occupied

31 (Bollard)	Sail from	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;

14:50 Start, alongside 31 berth.	
14:55 Speed 3.5 kts (G)	
14:56 Speed 5.0 kts (G)	
14:56 Transit bridge centrally	
14:57 Pass vessel on 12 berth **CPA 5m**	

Assessment of ease of manoeuvre;	***3 (Satisfactory)**

Notes

Built up speed quickly to pass through bridge with steerage.

Tide pushed vessel towards ship on 12 berth once through bridge

Run # (Sequence)	**8**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	15:08 / 15:15		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	L.Sebastian

Scenario	Sail PSV from 31 berth, strong ebb tide.			
Objective	Safe Bridge Passage			
Notes	Bow first			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics

Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions

Tide	Range 1.2m. HW +3h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Ebb	1.9 kts	**Current (Bridge)**	Ebb	3.1 kts

Berths Occupied

31 (Bollard)	Sail from +√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;

15:08 Start	15:13 Clearing bridge but passing 2m off
15:10 Mid-river	15:14 CPA to vessel on 12 berth 1m.
15:11 Speed 3.9kts (G)	
15:12 Bridge Transit speed 4.8 kts (G) CPA 8m from East Side.	

Assessment of ease of manoeuvre;	*** 4 (Near Miss)**

Notes

Hard to lift bow even with full thrust.

CPA to bridge and vessel 1-2metres. Too close for comfort.

Run # (Sequence)	**9**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	15:20 / 15:30		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	L.Sebastian

Scenario	Sail PSV from 31 berth, strong ebb tide.			
Objective	Safe Bridge Passage			
Notes	Straight repeat of Run 8 above			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW +3h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Ebb	1.9 kts	**Current (Bridge)**	Ebb	3.1 kts

Berths Occupied			
31 (Bollard)	Sail from +√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline; 15:20 Start	
15:23 Middle of river	15:27 Passed vessel (on 12) at 9m CPA
15:24 Speed 2.1 kts (G)	
15:25 Speed 2.9 kts (G)	
15:26 Bridge Transit, speed 4.5kts (G) CPA 7m (East Side)	
Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
Vessel moved out more centrally before proceeding
Still a noticeable push to the inside of the bend.

Run # (Sequence)	**10**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	15:36 / 15:50		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	L.Sebastian

Scenario	Sail PSV from 31 berth, strong ebb tide. **Stern-first**			
Objective	Safe Bridge Passage			
Notes	Repeat of Run 8 & 9 above, but stern-first			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW +3h		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Ebb	1.9 kts	**Current (Bridge)**	Ebb	3.1 kts

Berths Occupied			
31 (Bollard)	Sail from +√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
15:40 Start	
15:43 Mid-river	
15:45 Passing first vessel, speed 4.8kts (G)	
15:47. Bridge transit. Speed 6 kts (G) CPA 11m from east abutment	

Assessment of ease of manoeuvre;	*** 1**

Notes
Same issue as previous stern-first runs with control, reversal
As before, notably more straight-forward than bow first.

Run # (Sequence)	**11**	**Sim Facilitators / Operators (HRW)**		V.Crockett / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	03/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	15:36 / 15:50		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	L.Sebastian

Scenario	PSV Arrival, bow first, **strong E' Wind, strong flood tide.**			
Objective	Safe Bridge Passage			
Notes	Change of wind direction and strength			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**With**

Vessel Characteristics			
Type	PSV	**Model – (A,B,C,D)**	**A**
LOA	80m	**Beam**	16.2m
Draft	6.15m	**Light / Loaded**	Loaded
Propulsion	2 x Azimuth Props	**Bow Thrust**	YES (2000hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW -2h		**Wind Dir'n / kts**	E	25-30 kts
Current (River)	Flood	1.5 kts	**Current (Bridge)**	Flood	2.4 kts

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	√
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
16:10 Start Speed 5.1 kts(G), 3.5 kts(W)	
16:18 Bridge Opening Speed 5.5kts (G)	
16:20 "Feeling" wind, Speed 4.5kts (G)	
16:22 Bridge Transit, passed close. Speed 4.0kts (G), 2.0 kts (W)	

Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
As current with vessel water speed was low, wind affected the vessel significantly.
Berthed just past the bridge (14 berth), satisfactorily.
Last run of the day.

Run # (Sequence)	**12**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:10 / 10:35		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	B.Forrest

Scenario	Arrival tanker part loaded. Berthing at 32 Gashouse Quay			
Objective	Safe Arrival			
Notes	**No bridge transit!**			
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**Slack**

Vessel Characteristics

Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	4.5m	**Light / Loaded**	Part Loaded
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions

Tide	Range 1.2m. HW+		**Wind Dir'n / kts**	SW	10-15kts
Current (River)	Flood*	0.2 kts	**Current (Bridge)**	Slack*	0.0

Berths Occupied

31 (Bollard)		**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)		**12 (Asco)**	√

~Timeline;

10:12 Start	Tide slack at first then slight ebb (1.0kts) on berthing
10:20 Passing Fishing V/L's Speed 3.2 kts (G),Current 0.6kts Ebb	
10:30 Alongside	

Assessment of ease of manoeuvre;	***2 (Fair)**

Notes Bridge presence seemed to have no effect on manoeuvre at 32 Berth

This was a re-run of two previous attempts, in the earlier attempts the wind effects on the vessel (1169m^2 windage area) seemed excessive. At 5.0kts (G) the vessel was still making 1 knots sideways and requiring 10º leeway, and difficult to get alongside against the wind. The "friction" was reduced to counter this perception and re-run as above.

Pilot; "Tankers always arrive for slack water entry (after HW) and berthing on 1st of Ebb, occasionally on neap tides (& draft /depth ok) they berth near Low Water slack."

Run # (Sequence)	**13**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:45 / 11:00		**WSP**	S.Horne
Arrive / Sail	**Shift**		**GYPC**	B.Forrest

Scenario	Move Tanker from 32 (Gashouse) to 12 (Asco) berth. **Full Ebb**			
Objective	Safe shift, assess effects from bridge.			
Notes	**No bridge transit!**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	4.5m	**Light / Loaded**	Part Loaded
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW+3h		**Wind Dir'n / kts**	SW	10-15 kts
Current (River)	Ebb	1.9kts	**Current (Bridge)**	Ebb-N/A	3.1 kts

Berths Occupied			
31 (Bollard)		**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	Sail From	**12 (Asco)**	Arrive At

~Timeline;	
10:45 Start	
11:00 Berthed.	

Assessment of ease of manoeuvre;	***1 (Good)**

Notes
No issues, no effects from bridge experienced.

Run # (Sequence)	**14**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)		
		Pilot	**GYPC**	R.Gavin / D.Morrice		
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson		
Start / End	11:15 / 11:45		**WSP**	S.Horne		
Arrive / Sail	**Arrival**		**GYPC**	B.Forrest		
Scenario	Tanker Arrival, Transit Bridge first of Ebb					
Objective	Safe Bridge Transit					
Notes	93m Tanker as equivalent for large cargo v/l. (Tankers rarely pass bridge)					
Direction	**Bow/Stern 1st**	**Bow**	**With /Against tide**	**Against**		
Vessel Characteristics						
Type	Tanker		**Model – (A,B,C,D)**	**C**		
LOA	93m		**Beam**	14.6m		
Draft	4.5m		**Light / Loaded**	Part Loaded		
Propulsion	1 Screw. Flat Rudder		**Bow Thrust**	YES (500hp)		
Weather & Tidal Conditions						
Tide	Range 1.2m.		**Wind Dir'n / kts**	SW	5 knots	
Current (River)	Ebb	0.3	**Current (Bridge)**	Ebb	0.5	
Berths Occupied						
31 (Bollard)	√		**14 (Atlas)**	Berth Here		
BRIDGE LOCATION						
32 (Gashouse)	√		**12 (Asco)**	√√√		

~Timeline;	11:18 Start.
11:18 Speed 4.4 kts (G) 0.3 kts ebb 11:30 Request Bridge opening	11:37. Transit bridge to stb'd of centre line. 7m off East Side
11:34 Passing 12 berth, Speed 3.5kts (G) 11:34 Bridge Open.	11:38 CPA Bridge closes to 4m, during approach to berth
11:36 Vessel tracking to starboard, wind and tide on port bow.	11:40 Berthed
Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
Bridge Opening time approx 60 seconds – as design.

Run # (Sequence)	**15**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	11:55 / 12:25		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out, 93m Conventional Vessel **(Light)** Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	Need last of flood or ebb to transit brush bend with benign tide.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Flood	1.3 kts	**Current (Bridge)**	Flood	1.6 - 0.7 kts*

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline; 12:00 Start – Bridge Opening	
12:06 Stern entering bridge hole. 17m off	12:20 Through bridge
12:07 Commence transit bridge	12:22 Passed clear, current now slack.
12:10 9m off East Side	12:22 Bridge closed.
12:11 Stern moving to port, kick ahead	

Assessment of ease of manoeuvre;	*** 4 (Near miss)**

Notes
* At start current at bridge was 1.6 knots flood, falling to 0.7 knots flood during transit. The same conditions being present for runs 16,17,18.
CPA to bridge 6m to stb'd, 8m to port.
Difficult to keep stern "true" to tide, kicks ahead made vessel "romp" ahead.
Manoeuvre was challenging. Bridge was open for 22 minutes.

Run # (Sequence)	**16**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	13:20 / 13:30		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 93m Conventional Vessel. Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	Re-run of **15**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Flood	1.3 kts	**Current (Bridge)**	Flood	1.6 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
13:25 start springing off	
13:27 Vessels port quarter contacted the bridge abutment. Stop	

Assessment of ease of manoeuvre;	*** 5 (Fail)**

Notes
Vessel started to back up before being central and in line with tide.
Manoeuvre was challenging.

Run # (Sequence)	**17**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	13:33 / 13:45		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 93m Conventional Vessel. Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	Re-run of **15 & 16**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Flood	1.3 kts	**Current (Bridge)**	Flood	1.6 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
13:37 start springing off	13:43 Speed 2.6kts (G) 1.3kts (W)
13:40 Let go spring	13:45 Contact – Stop.
13:43 Stern enters bridge hole, 11m off stb'd quarter.	

Assessment of ease of manoeuvre;	*** 5 (Fail)**

Notes
It was noted that without a bow thrust, stern-first passage would not be possible without external (Tug) assistance.
Manoeuvre was challenging.

Run # (Sequence)	**18**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	13:50 / 14:20		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 93m Conventional Vessel. Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	Re-run of **15 & 16 & 17**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Flood	1.3 kts	**Current (Bridge)**	Flood	1.6 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
13:54 Springing off and moving ahead.	14:10 Through bridge and clear.
14:00 Astern Speed 1.4kts(W) 2.7kts(G)	14:18 Stop
Thruster use significant & continuous	
CPA 3m on port bow.	

Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
After springing off, moved vessel ahead to tray and get clear of the accelerated flow close upriver of the bridge and to align the vessel with the current flow before going stern-first
Manoeuvre was challenging.

Run # (Sequence)	**19**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	14:34 / 14:50		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	Same manoeuvre as 15-8 but with smaller vessel. **Becker/Flap Rudder**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	5.0m	**Light / Loaded**	Loaded
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Flood	1.3 kts	**Current (Bridge)**	Flood	1.6 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
14:35 Start	14:45 Clear of bridge
14:40 Mid-river	
14:43 Transit Bridge.	
14:43 Speed.8kts(G) 2.2kts(W)	

Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
Would not normally back out loaded vessels (normally only in light condition).
Although High-lift rudder on model all marine staff present agreed that the vessel did not act as if a high lift rudder was fitted.!
Transit challenging and slow, bow thrust on full for long periods.

Run # (Sequence)	**20**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	14:52 / 15:05		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. First of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	Same manoeuvre as 19, but with Ebb Tide			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics

Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	5.0m	**Light / Loaded**	Loaded
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions

Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied

31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;

14:52 Start	
15:00 Struck bridge with stb'd bow	
15:01 Struck vessel on Asco Quay (12)	

Assessment of ease of manoeuvre;	*** 5 (Fail)**

Notes

Pilot; "If you need to back down a vessel fully loaded, you will need a Tug"

Run # (Sequence)	**21**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	15:15 / 15:30		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. First of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	**Straight Re-Run of Run 20 above**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	5.0m	**Light / Loaded**	Loaded
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
15:17 Start	15:28 All clear
15:23 Mid-river	
15:26 Bridge Transit, 15m off each side	
15:26 Speed 2.0kts (G), 0.5kts (W)	

Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
Placed vessel more centrally and in-line with the tide, before attempting transit.
Great improvement on run 21. CPA 15m.

Run # (Sequence)	**22**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	14:53 / 16:05		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. First of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	**Re-Run of Run 21 above but with BALLAST vessel**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.0m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
15:54 Start Alongside	
15:57 Commence transit	
15:58 Struck East Side abutment	

Assessment of ease of manoeuvre;	*** 5 (Fail)**

Notes
It appeared the pilot started to go astern too soon, before the vessel was mid river and in line with the tide. Struck abutment.

Run # (Sequence)	**23**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	16:10 / 16:22		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. First of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	**Straight Re-Run of Run 22 above**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.0m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
16:12 Start Alongside	
16:15 Mid-river	
16:17 Stern enters bridge hole	
16:20 Passed close but clear.	

Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
16:17 Tide ebb 1.6 knots bridge. Speed 0.6kts Ahead (G) 1.0kts ahead (W)
Went much better than previous run, though still passed fairly close to bridge.

Run # (Sequence)	**24**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	04/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	16:25 / 16:40		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **93m** Conventional Vessel. Last of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	Re-run of 18 but in ballast and with last of Ebb tide.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
16:30 Start Alongside	16:37 Speed 1.3kts (G), Tide 1.6kts Ebb
16:31 Let go spring	16:40 Contact with bridge
16:37 Stern enters bridge hole.	
16:37 Starboard quarter - 11m off	

Assessment of ease of manoeuvre;	*** 5 (Fail)**

Notes
Not quite central when entering bridge hole. Stern was pushed by tide onto East side.
Last Run of Day

Run # (Sequence)	**25**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	08:40		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **93m** Conventional Vessel. Last of Ebb Tide.			
Objective	Safe Bridge Transit			
Notes	Straight Re-run of 24 above.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Tanker	**Model – (A,B,C,D)**	**C**
LOA	93m	**Beam**	14.6m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 Screw. Flat Rudder	**Bow Thrust**	YES (500hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	5 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
08:40 Start Alongside	
08:48 12m off West Side, moving astern	
08:50 Transit bridge astern 0.7kts (G)	
08:52 Passing closer but clear.	

Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
Vessel was central at start of transit, worked quite well
Berth occupancy was pretty much worst case, except no vessel on 33.
A vessel on 33 berth may have been very challenging.

Run # (Sequence)	**26**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	09:10 / 09:30		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **88m** Cargo Vessel. Last of Ebb Tide. More Wind			
Objective	Safe Bridge Transit			
Notes	Now increasing the wind, and subsequent runs from other directions.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	SW	15 – 17 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
09:14 Start	
09:27 Struggling to gain good channel position for bridge transit	
09:30 Aborted*	

Assessment of ease of manoeuvre;	*** 4 (near Miss) / 5 (Fail)** (no passage)

Notes
* Abort is what would happen in reality as vessel was not under full control / optimum position for transit.
Bow thruster still felt sluggish, and Becker Rudder still noted not particularly effective.

Run # (Sequence)	**27**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	09:40 / 09:55		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **88m** Cargo Vessel. Last of Ebb Tide. More Wind			
Objective	Safe Bridge Transit			
Notes	Straight re-run of 26, but starting from further upstream.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics

Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions

Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	**SW**	15 – 17 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied

31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;

09:43 Start Mid Stream (16 berth)	Speed 1.9kts Astern (G)
09:47 Pass previous start position.	09:49 – 09:51 Bridge Transit

Assessment of ease of manoeuvre;	*** 3 / 4 Fair / Near Miss**

Notes

Passed vessels and bridge CPA 7m

Pilots; No wind sheltering on, so a 15knot wind in this location, probably equates to a 30 knot wind or more in exposed locations (Harbour Entrance).

Vessel carried considerable leeway, so despite a 13m beam, the swept path was around 35m. (14º degrees leeway/cant). Distance between berthed ships was 46m.

Pilot: "If tug was used would go astern against flood tide".

Run # (Sequence)	**28**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:15 / 10:35		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **88m** Cargo Vessel. Last of Ebb Tide. More Wind			
Objective	Safe Bridge Transit			
Notes	Re-run of 27 but with wind from **NW.**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	**NW**	15 – 17 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
10:17 Start	
10:25 Passing 14A, Stern Speed 0.3Kts (G)	
10:30 Transit bridge 1.4kts (G) a 10m off	
10:35 Cleared; CPA bridge 4m, vessel 6m	
Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
Swept path around 25m
Rudder effectiveness was improved on Simulator for this and all subsequent runs with this model.(See comments on Runs 19 & 26). All agreed this was closer to "real" life.

Run # (Sequence)	**29**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	10:45 / 11:00		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **88m** Cargo Vessel. Last of Ebb Tide. More Wind			
Objective	Safe Bridge Transit			
Notes	Re-run of 27 & 28 but with wind from **NE.**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	**NE**	15 – 17 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
10:48 Start adjacent 16 berth	
10:53 Passing 14 berth. (G) 2.3kts Astern	
10:55 Transit bridge centrally	
10:58 Bridge Cleared	

Assessment of ease of manoeuvre;	*** 3 (Satisfactory)**

Notes
Swept path around 25m
Rudder effectiveness was improved on Simulator for this and all subsequent runs with this model.(See comments on Runs 19 & 26). All agreed this was closer to "real" life.

Run # (Sequence)	**30**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	11:27 / 11:35		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, **88m** Cargo Vessel. Last of Ebb Tide. More Wind			
Objective	Safe Bridge Transit			
Notes	Re-run of 27 & 28 but with wind from **SE**			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW-45m		**Wind Dir'n / kts**	**SE**	15 – 17 kts
Current (River)	Ebb	1.1 kts	**Current (Bridge)**	Ebb	1.8 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	Sail from
		BRIDGE LOCATION	
32 (Gashouse)	√	**12 (Asco)**	√

~Timeline;	
11:27 Approach Bridge. Astern 1.4kts (G)	
11:30 Transit Bridge (6m off East Side)	
11:32 Stop	

Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes	

Run # (Sequence)	**31**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	11:40/ 12:00		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	B.Forrest

Scenario	Swing on arrival, back through bridge. **88m** Cargo Vessel. First of flood			
Objective	Safe Bridge Transit			
Notes	Vessel would swing at brush bend with start of flood tide.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW+45m		**Wind Dir'n / kts**	**SW**	5kts
Current (River)	Flood	1.1 kts	**Current (Bridge)**	Flood	1.6 kts (Start)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√√√

~Timeline;	
11:41 Start	
11:46 Passing berth 10. Speed 1.8kts (G)	
11:52 Stopped moving astern, using engines and thrust to regain channel position.	
11:57 Transit Bridge centrally	

Assessment of ease of manoeuvre;	*** 2 (Fair)**

Notes
Bridge Transit Speed 2.5kts (G), Current 2.7 knots flood.
IF abort was required (bridge not opening), this would have been straightforward.

Run # (Sequence)	**32**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	12:12/ 12:30		**WSP**	S.Horne
Arrive / Sail	**Arrival**		**GYPC**	B.Forrest

Scenario	Swing on arrival, back through bridge. **88m** Cargo Vessel. Flood + Wind			
Objective	Safe Bridge Transit			
Notes	A Re-run of 31, but with stronger wind.			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**With**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. LW+45m		**Wind Dir'n / kts**	**SW**	15 kts
Current (River)	Flood	1.5 kts	**Current (Bridge)**	Flood	2.7 kts (Transit)

Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√√√

~Timeline;	
12:12 Start Berth 8	
12:15 Passing 32 berth, 6m off parked vessel	
12:21 Bridge Transit, speed 2.6 (G)	
12:23 Passing 31 Berth, 4m off vessel	

Assessment of ease of manoeuvre;	*** 4 (Near Miss)**

Notes
It was noted that the vessel accelerated when transiting the bridge, in the narrowed flow.

Run # (Sequence)	**33**	**Sim Facilitators / Operators (HRW)**		G.Watson / R.Riva J. Gurton (Pilot)
		Pilot	**GYPC**	R.Gavin / D.Morrice
Date	05/09/2019	**Obs'vrs**	**Shipmove**	M.Nicholson
Start / End	13:00/ 13:25		**WSP**	S.Horne
Arrive / Sail	**Sailing**		**GYPC**	B.Forrest

Scenario	Backing out from berth, 88m Cargo Vessel. Last of Flood Tide.			
Objective	Safe Bridge Transit			
Notes	A Re-Run of 18/19* But with improved rudder			
Direction	**Bow/Stern 1st**	**Stern**	**With /Against tide**	**Against**

Vessel Characteristics			
Type	Cargo	**Model – (A,B,C,D)**	**B**
LOA	88m	**Beam**	13m
Draft	3.5m	**Light / Loaded**	Light
Propulsion	1 screw High-Lift Rudder	**Bow Thrust**	YES (250hp)

Weather & Tidal Conditions					
Tide	Range 1.2m. HW-45m		**Wind Dir'n / kts**	**SW**	5 kts
Current (River)	Flood	1.0kts	**Current (Bridge)**	Flood	1.3 kts

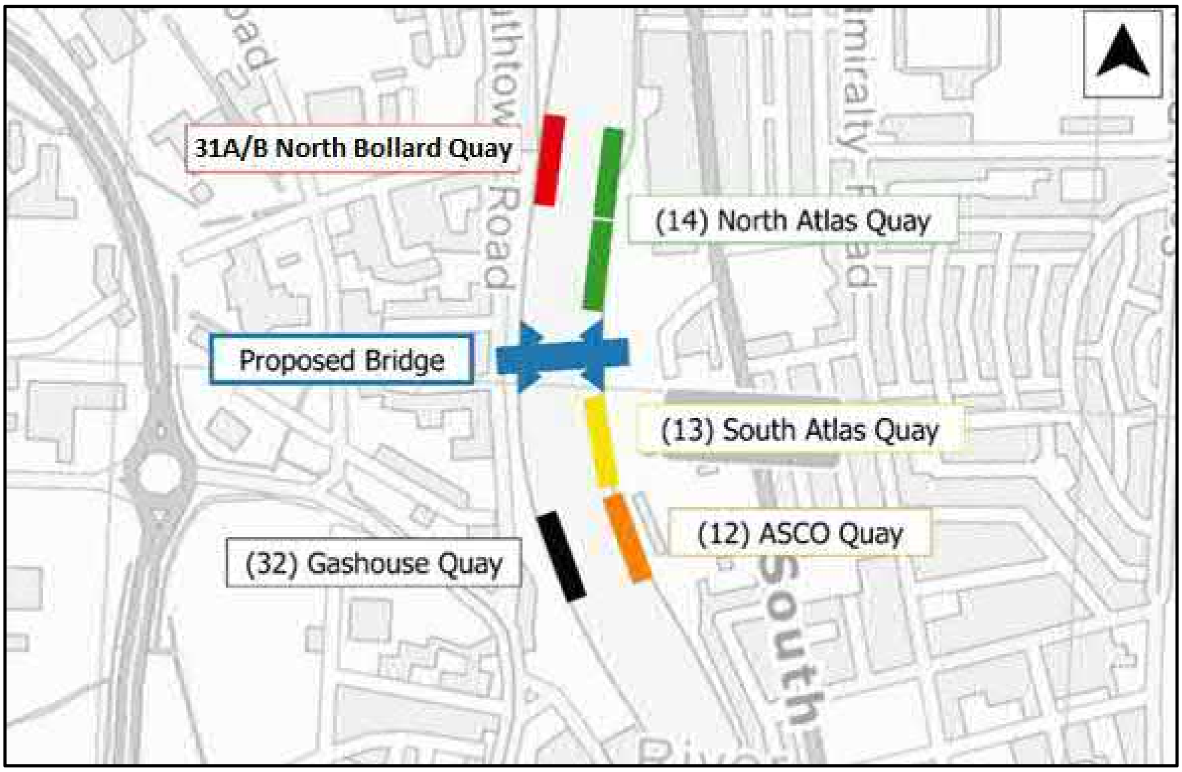
Berths Occupied			
31 (Bollard)	√	**14 (Atlas)**	
BRIDGE LOCATION			
32 (Gashouse)	√	**12 (Asco)**	√√√

~Timeline;	
13:05 Start alongside 14 Berth	13:35 Stop. END
13:07 Spring off & Let go	
13:11 West of centre.	
13:11 Speed; 0.7kts (G) 1.7 kts (W)	
13:16 Transit	

Assessment of ease of manoeuvre;	* 3 (Satisfactory)

Notes	*18 & 19 Runs were unsuccessful, with the less effective rudder.
Challenging, went through bridge hole west of centre, had to stop to straighten.	
CPA – Bridge 6m, Pontoon 8m, V?L on 32 Berth 8m	
END - Last run of the visit.	

APPENDIX B BRIDGE LOCATION & QUAY NAMES



APPENDIX C SHIP MODELS

Pilot card A

80m x 16.2m PSV “Diamond World”

PILOT CARD

Ship's name **80m PSV** Date **26/08/2016**

Call sign **----** Year built **2017** Deadweight **3,500** tonnes

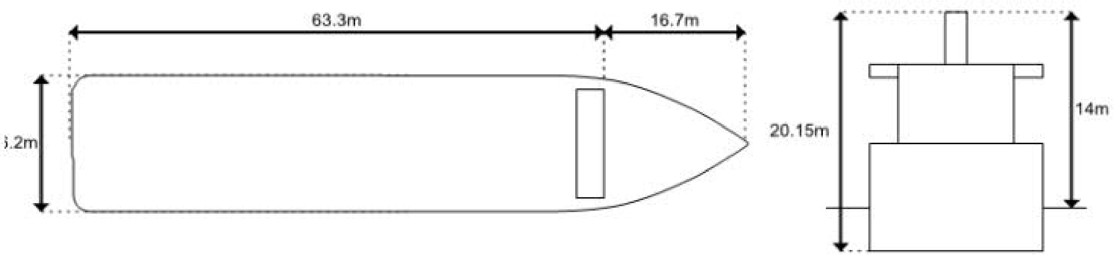
Draught aft **6.15** m Forward **6.15** m Displacement **4,916** tonnes

SHIP'S PARTICULARS

Length overall **80.03** m Anchor chain: Port **12** shackles Starboard **12** shackles

Breadth **16.2** m Stern **12** shackles

Bulbous bow **No** Yes/No (1 shackle = **27.432** m / **15** fathoms)



Type of engine **2 x Diesel-electric** Maximum power **3,000** kW (**4,079** HP)

Manoeuvring engine order	RPM/Pitch	Speed (knots)
Full Ahead	300	12.3
Half Ahead	225	9.3
Slow Ahead	165	6.8
Dead Slow Ahead	110	4.5
STOP	0	0.0
Dead Slow Astern	0	
Slow Astern	0	
Half Astern	0	
Full Astern	0	

Time limit astern **----** min

Full ahead to full astern **11** s

Max. no of consec starts **12**

Maximum RPM **----** knots

Astern power **----** % ahead

STEERING PARTICULARS

Type of rudder **None** Maximum angle **0** °

Hard-over to hard-over **0** s

Rudder angle for neutral effect **0** °

Thruster: Bow **1471 kW (2000 hp)** KW Stern **none fitted** KW

Pilot card B

88m x 12.8m Cargo vessel “Fischland” Draft 5.0 m or 3.5m

PILOT CARD

Ship's name **Fischland** Date **07/05/2014**

Call sign **----** Year built **2019** Deadweight **3,560** tonnes

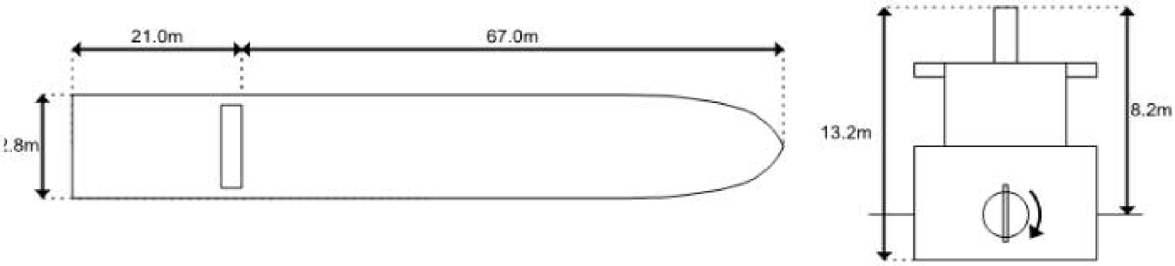
Draught aft **5** m Forward **5** m Displacement **4,437** tonnes

SHIP'S PARTICULARS

Length overall **87.9** m Anchor chain: Port **12** shackles Starboard **12** shackles

Breadth **12.8** m Stern **12** shackles

Bulbous bow **No** Yes/No (1 shackle = **27.432** m / **15** fathoms)



Type of engine **MSD**	Propeller type **1 x CPP**	Maximum power **1,500** kW (**2,039** HP)
Manoeuvring engine order	**RPM/Pitch**	**Speed (knots)**
Full Ahead	100	10.0
Half Ahead	75	7.5
Slow Ahead	50	5.0
Dead Slow Ahead	25	2.5
STOP	0	0.0
Dead Slow Astern	-25	Time limit astern ---- min
Slow Astern	-50	Full ahead to full astern ---- s Max. no of consec starts **12**
Half Astern	-75	Maximum RPM ---- knots
Full Astern	-100	Astern power **60** % ahead

STEERING PARTICULARS

Type of rudder **Semi-balanced** Maximum angle **35** °

Hard-over to hard-over **18** s

Rudder angle for neutral effect **0** °

Thruster: Bow **185 kW (248 hp)** KW Stern **none fitted** KW

Pilot card C

93m x 15m Tanker "Loya" Draft 3.5m or 4.5m

PILOT CARD

Ship's name **Loya** Date **04/09/2014**

Call sign **----** Year built **2010** Deadweight **3,913** tonnes

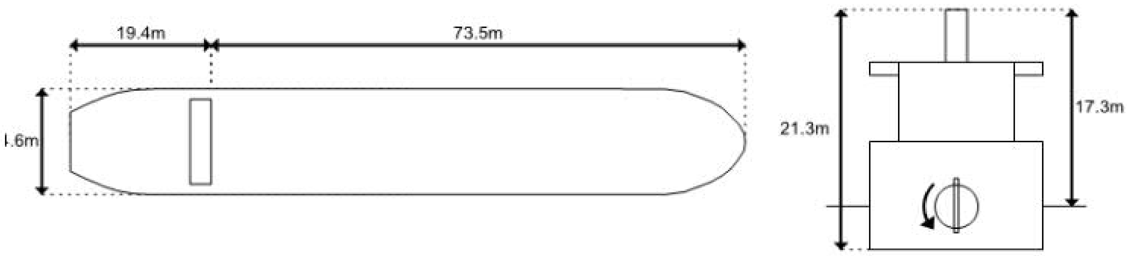
Draught aft **4** m Forward **4** m Displacement **3,869** tonnes

SHIP'S PARTICULARS

Length overall **92.96** m Anchor chain: Port **10** shackles Starboard **10** shackles

Breadth **14.6** m Stern **--** shackles

Bulbous bow **Yes** Yes/No (1 shackle = **27.432** m / **15** fathoms)



Type of engine **MAN BW 8L28/32A**	Propeller type **1 x CPP**	Maximum power **1,960** kW (**2,665** HP)
Manoeuvring engine order	**RPM/Pitch**	**Speed (knots)**
Full Ahead	100	13.0
Half Ahead	75	9.8
Slow Ahead	50	6.5
Dead Slow Ahead	25	3.3
STOP	0	0.0
Dead Slow Astern	-25	Time limit astern **----** min
Slow Astern	-50	Full ahead to full astern **----** s Max. no of consec starts **----**
Half Astern	-75	Maximum RPM **----** knots
Full Astern	-100	Astern power **37** % ahead

STEERING PARTICULARS

Type of rudder **Standard** Maximum angle **35** °

Hard-over to hard-over **18** s

Rudder angle for neutral effect **0** °

Thruster: Bow **370 kW (500 hp)** KW Stern **none fitted** KW

Appendix E – Stage 3 Simulation HR Wallingford Report

DJR6162-RT001-R02-00 – Great Yarmouth Third River Crossing Navigation Simulation Study

HR Wallingford
Working with water

Great Yarmouth Third River Crossing

Navigation Simulation Study

DJR6162-RT001-R02-00

October 2019

Document information

Document permissions	Confidential - client
Project number	DJR6162
Project name	Great Yarmouth Third River Crossing
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Report number	RT001
Release number	R02-00
Report date	15 October 2019
Client	WSP
Client representative	Stephen Horn
Project manager	Gillian Watson
Project director	Dr Mark McBride

Document history

Date	Release	Prepared	Approved	Authorised	Notes
15 Oct 2019	02-00	VPC	MMCB	MMCB	Revised to incorporate client comments.
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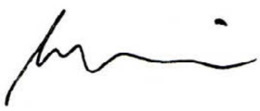
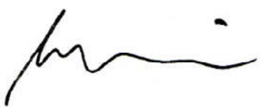
Document authorisation

Prepared

Approved



Authorised



Summary

There are long standing proposals to construct a new highway bascule bridge that will across the River Yare at Great Yarmouth. WSP UK Limited are providing consultancy services for the planning and engineering design of the bridge. Previously, in 2009 HR Wallingford undertook a real time navigation simulation study to assess navigation for an earlier, "signature" crossing which has now apparently been superseded by the current, more conventional scheme.

To support and inform the further development of the current scheme WSP commissioned HR Wallingford to undertake a further real time navigation simulation assessment with the proposed bridge in place, as an "independent demonstration" that the proposed design is navigationally feasible. In this respect, it is understood that the location and alignment of the crossing are fixed. This report describes the study carried out and presents the principal results, conclusions and recommendations.

The study concluded that the introduction of the bridge clearly modifies navigation conditions in the river. However, in overall terms, in addressing the objective described in Section 1, the simulations demonstrated that navigation through the bridge is feasible in a reasonably wide range of flow and wind conditions for bow first, head in, and stern first transits.

The simulations were also completed with the relevant active berths being occupied by moored vessels upstream and downstream of the bridge.

For supply vessel operations, the simulations clearly demonstrated that the effects of the bridge being in place are significantly reduced for more manoeuvrable ships such as platform supply vessels, compared with the less manoeuvrable ships. Out of the 11 simulations completed to examine supply vessel operations, only 1 run was rated as being a marginal/fail grading and this transit was carried out in peak ebb conditions at the bridge site.

For the simulated product tanker, no difficulties were encountered with an inbound transit with the products tanker, but several attempts were required to refine a strategy for lifting off from Berth 14 and positioning the ship correctly for a stern first transit through the bridge. Once the strategy was developed, the ship was able to transit through the bridge opening with good clearances.

Broadly similar results to the product tanker simulations were obtained with dry cargo ship, although all transits with this ship were completed stern first.

It was evident from several simulations, particularly with the tanker and the dry cargo ship,, that the ships were subject to oblique sets that were apparently stronger than the pilots were expecting. It is possible that these oblique flows are realistic, but it is recommended that the flow modelling is revisited, particularly around the bridge knuckles, as these may have led to several of the contacts with the knuckles that occurred in the simulations.

It is recommended that the plan shape of the bridge abutments/knuckles is reviewed. A more swept design and/or flow deflectors may reduce the effect of oblique flows, although it is recognised that these may reduce the length of berthing and/or waiting pontoon frontage available.

The proposed protective fendering scheme is considered unsuitable, primarily because there is no load transfer between units and individual cone fenders are likely to be subject to significant sliding forces and/or oblique impacts for which they are not usually designed.

Supply vessels are often fitted with rubbing strakes and large tractor tyres which may catch the ends of the fender units, potentially damaging the vessel and/or the fender units.

Real time monitoring of flow speed/direction/level at the bridge should be provided to ship handlers.

Suitable communication protocols will need to be developed between ship handlers and the bridge and port VTS staff.

Once a final scheme is developed, a programme of simulator based pilot familiarisation should be carried out.

Sight lines to existing visual features should be maintained if possible. If this is not possible, due to landscaping requirements for example, then supplementary aids to navigation should be considered.

Contents

Figures

Tables

1. Introduction

There are long standing proposals to construct a new highway bascule bridge that will across the River Yare at Great Yarmouth (Figure 1.1 and Figure 1.2). WSP UK Limited are providing consultancy services for the planning and engineering design of the bridge. Previously, in 2009 (Reference 1), HR Wallingford undertook a real time navigation simulation study to assess navigation for an earlier, "signature" crossing which has now been superseded by the most recent, more conventional scheme.

It is understood that real time navigation simulation work has already been carried out by others to support and inform the development of the present scheme. WSP commissioned HR Wallingford to undertake a further real time navigation simulation assessment with the proposed bridge in place, as an independent demonstration that the proposed design is navigationally feasible. In this respect, it was understood that the location and alignment of the crossing were fixed.

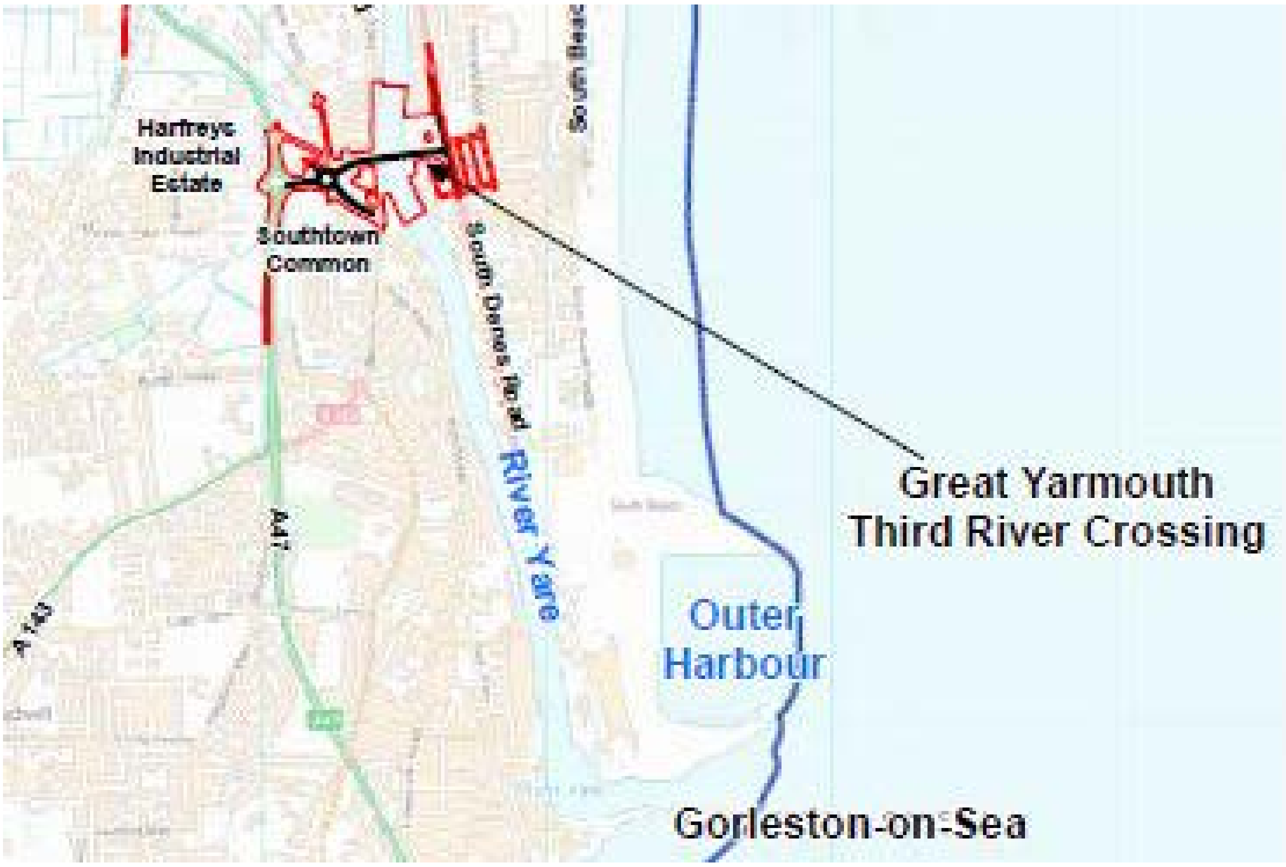


Figure 1.1: Key plan of proposed third crossing

Source: WSP Drawing GYTRC-WSP-LSI-XX-DR-GI-1001, Revision P00, 8th April 2019

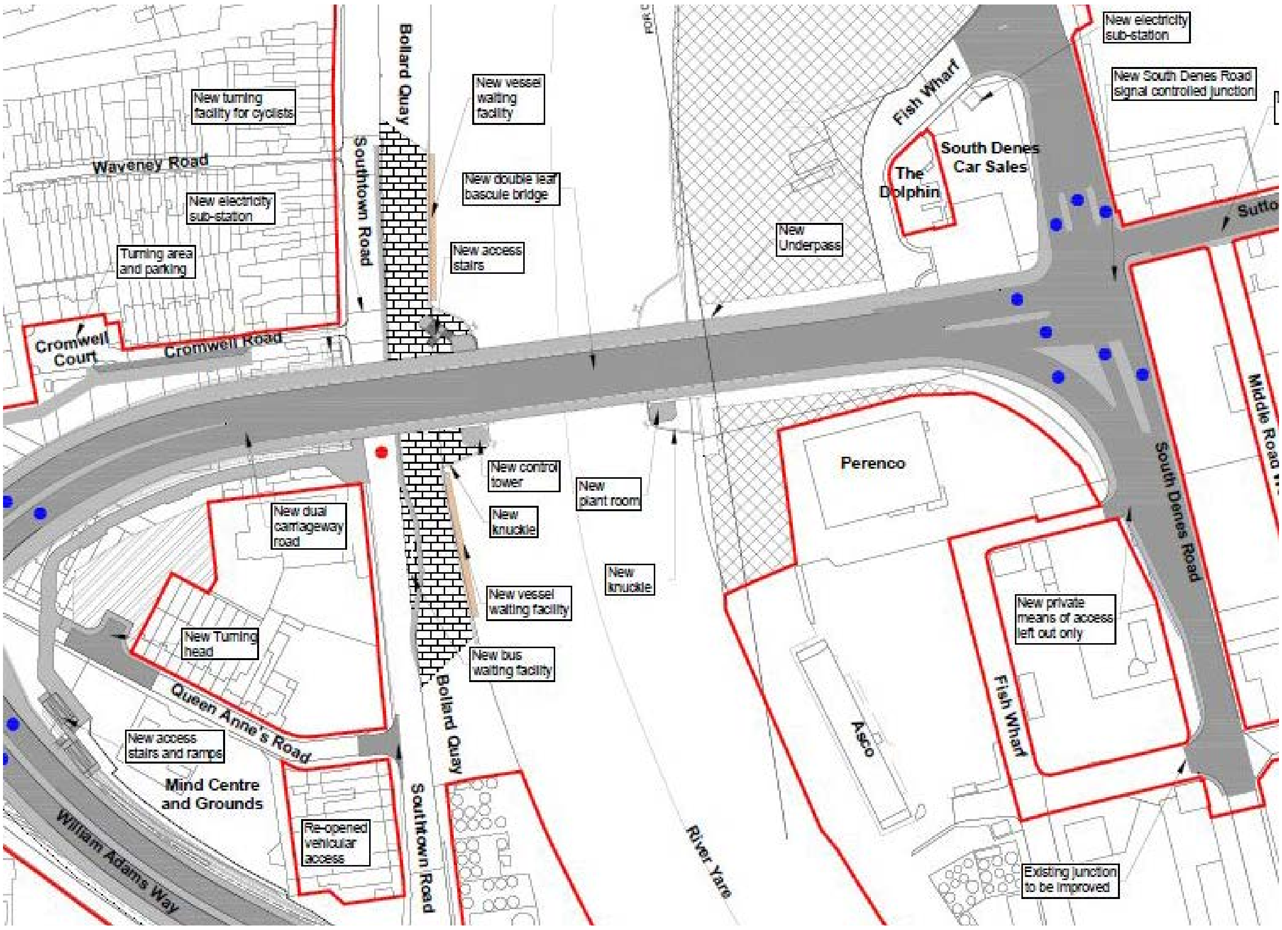


Figure 1.2: General layout of proposed third crossing

Source: WSP Drawing GYTRC-WSP-HGN-XX-DR-CB-1004, Revision P00, 12th April 2019

2. Site characteristics

The River Yare at Great Yarmouth, between Brush Bend and Breydon Water, is aligned roughly north-south for approximately 2 nautical miles. This section of the river is mostly straight, although there are a series of minor, concatenated bends about half way along the section. The river is relatively narrow, at between approximately 80 and 100m wide, and is lined on both sides by a series of active quayside berths and hards.

An aerial image of this section of the river is shown in Figure 2.1. The principal characteristics of the River Port, from a navigation standpoint, are described in terms of "River Port South" and "River Port North" in Sections 1.4 and 1.5 in Reference 2 and may be summarised as follows:

- The river is maintained to an average depth of 5.7m, assumed to be below Chart Datum
- The river is accessible to vessels with a draught of less than 6m
- Flow velocities can reach 4 knots on a spring ebb tide and 3 knots on a spring flood tide in both river port areas
- Prevailing winds are general offshore (from the south west).

Figure 2.1: Aerial view of Port of Great Yarmouth

Source: Reference 2

The riverside berths accommodate a range of types of ships up to 125m length and 6m draught. Reference 3 indicates that there are three designated swinging areas in the river, but each is subject to length restrictions as follows:

- Atlas: maximum length 85m
- Berth 3: maximum length 92m
- Brush Bend: maximum length 100m.

This means larger ships visiting the River Port may to need manoeuvre astern along the river, either on arrival or departure.

3. Proposed crossing

As noted in Section 1, the bridge is located at approximately the apex of the minor river bend in the vicinity of Berth 13 on the Atlas Quay (also known as Fish Wharf) on the east bank, and Berth 31 on Bollard Quay on the west bank, as shown in Figure 3.1. The river is approximately 84m wide at this location.

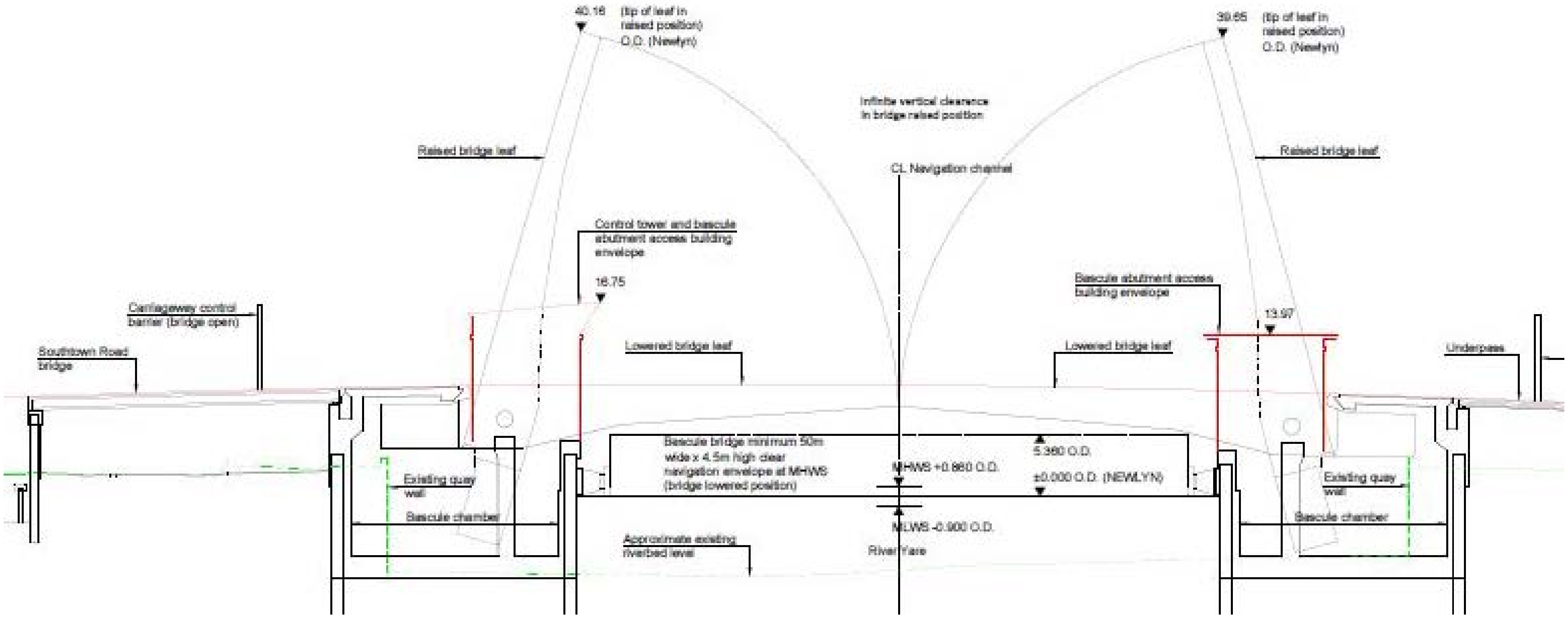


Figure 3.1: Longitudinal section through the proposed bridge

Source: WSP Drawing GYTRC-ROD-SBR-XX-DR-CB-1041, Revision P00, 12th April 2019

The bridge has three spans comprising two fixed side spans and a central span with a twin leaf bascule, supported on two main piers. These are located with “knuckle” structures in the river, which are protected by fendering, in the form of super cone fender units as shown in Figure 3.2.

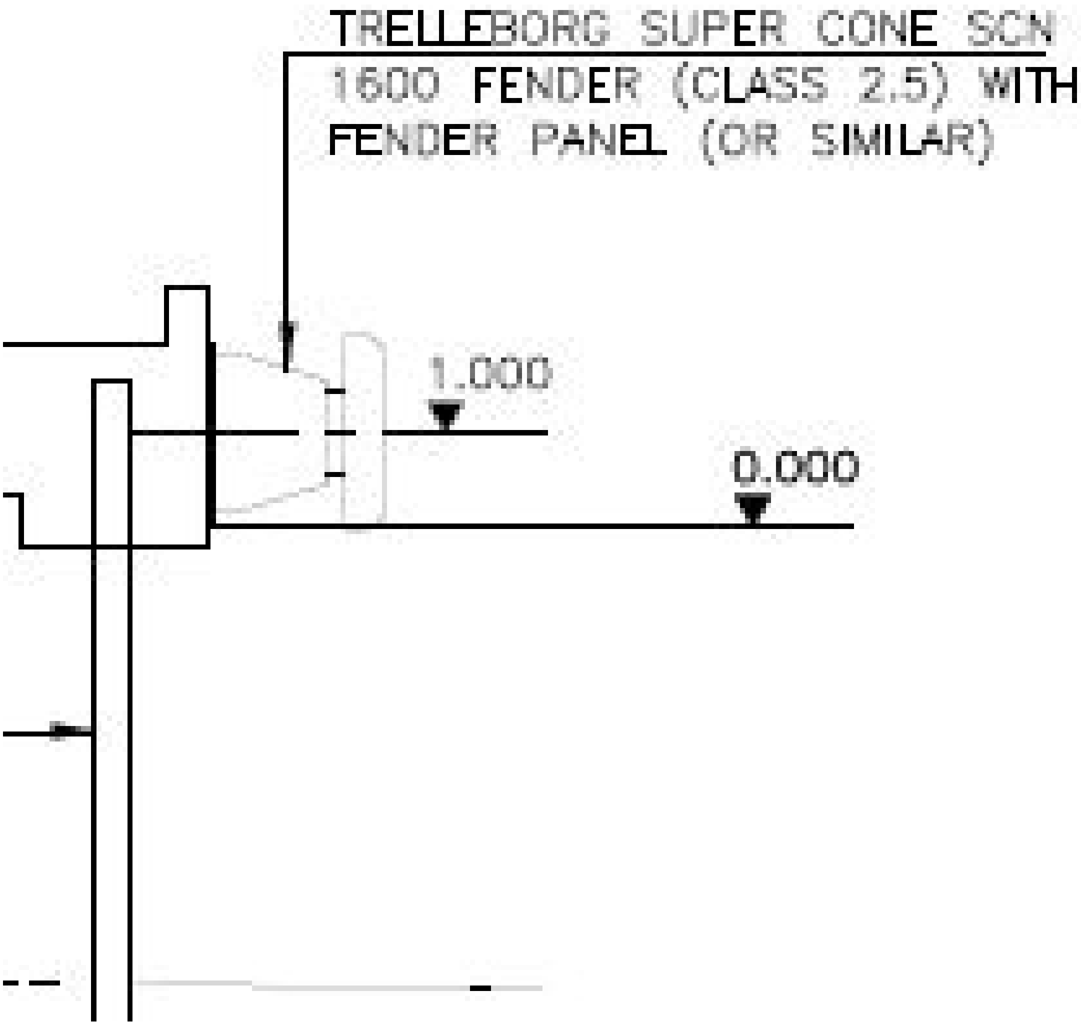


Figure 3.2: Section through proposed super cone fender ship impact protection

Source: WSP Drawing GYTRC-ROD-SBR-S01-DR-CB-1033 Revision P03 October 2018

4. Design ships

The 3 design ships used for the study comprised the following vessels:

- Platform support vessel
- Products tanker
- Short sea dry cargo ship

These are described in more detail in the following sections:

4.1. Platform support vessel

For this study, an existing manoeuvring model for the 80m long platform supply vessel "Diamond World" was retrieved from HR Wallingford's manoeuvring model library. The principal characteristics of the vessel are summarised in Table 4.1.

Table 4.1: Principal particulars of PSV "Diamond World"

Particular	Value	
Length (m)	80.0	
Length between perpendiculars (m)	75.7	
Beam (m)	16.2	
Distance bridge to stern (m)	65.2	
Depth (m)	7.5	
Draught summer (m)	6.2	
Displacement (t)	6,000	
Propulsion		
Main engines	Diesel electric 690 V, 60 HZ	
Propulsion power	2 x 1500 ekW	
Propellers	2 x 2300 mm, FPP, Azimuth in nozzle	
Bow thrusters	2 x 735 ekW, 1740 mm, FPP	
Manoeuvrability	DP Class 2 DP (AA)	
Manoeuvring engine order	**Pitch**	**Speed (knots)**
Full ahead	267	12.3
STOP	0	0.0
Full astern	0	12.1
Windage		
Wind speed (knots)	**Beam wind force (t)**	
15	4	
20	7	
25	11	
30	16	

Because of their specialist role in offshore operations, offshore support vessels are usually designed to provide a high degree of slow speed manoeuvring capability and, more particularly, station keeping capability. This capability is usually provided by a combination of effectors including:

- Twin, often ducted, propellers and rudders
- Transverse bow thrusters
- Transverse stern thrusters
- Azimuthing, often ducted, thrusters.

Depending on a particular vessel's design, the effectors are usually designed to be centrally controlled using a dynamic positioning (DP) system, as and when required. The specification for the dynamic positioning system usually depends on the vessel's primary role. For example, a dive support vessel is likely to have a higher system specification, DP3, than a PSV or AHTS which would commonly have a DP2 specification. DP is not normally used, or permitted to be used, when manoeuvring in port, but indicates a good level of slow speed controllability.

4.2. Products tanker

A ship manoeuvring model representative of a small chemical products tanker, such as the "Loya", was retrieved from HR Wallingford's manoeuvring model library for the study. The ship was modelled at two draughts and the particulars for each are shown in Table 4.2.

Table 4.2: Manoeuvring characteristics of Products tanker "Loya"

Characteristic	Units	Value	
Length overall	m	93	
Length between perpendiculars	m	88.6	
Beam overall	m	14.6	
Distance bridge to stern	m	19.41	
Modelled conditions		**Laden**	**Ballast**
Draught forward	m	4.5	3
Draught aft	m	4.5	4
Displacement	t	4,000	3,000
Propulsion			
Main engine type		MAN BW 8L28/32A	
Engine power (total)	kW	1,960	
No. of propellers, type		1 x CPP	
Bow thrusters	t	5	
Rudder type		Standard	
Max rudder angle	°	35	
Manoeuvring engine order	**Pitch**	**Speed (knots)**	**Speed (knots)**
Full Ahead	153	12.9	13.6
STOP	0	0.0	0.0
Full Astern	153	-9.7	-10.2
Windage			
Windage lateral	m^2	1074	1169
Windage frontal	m^2	345	352
Wind speed (knots)		**Beam wind force (t)**	**Beam wind force (t)**
15		4	4
20		7	8
25		11	12
30		16	17

These ships are usually considered to have good manoeuvrability as their trading patterns often include calls to confined river berths or berths within confined basins. The ship is equipped with a controllable pitch propeller and a bow thruster.

4.3. Short sea dry cargo ship

A ship manoeuvring model representative of a small, short sea dry cargo ship, such as the (now decommissioned) "Fischland", was retrieved from HR Wallingford's manoeuvring model library for the study. The particulars for the ship are summarised in Table 4.3.

Table 4.3: Manoeuvring characteristics of short sea dry cargo ship

Characteristic	Units	Value
Length overall	m	87.9
Length between perpendiculars	m	81
Beam overall	m	12.8
Distance bridge to stern	m	14
Modelled conditions		Laden
Draught	m	5
Block coefficient		0.84
Displacement	t	4,000
Propulsion		
Main engine type		MAN BW 6L28/32A-DVO
Engine power (total)	kW	1,470
No. of propellers, type		1 x CPP
Bow thrusters	t	3
Rudder type		Hinged flap
Max rudder angle	°	35
Manoeuvring engine order	**Pitch**	**Speed (knots)**
Full Ahead	400	11.4
STOP	0	0.0
Full Astern	400	-6.9
Windage		
Windage lateral	m^2	714
Windage frontal	m^2	110
Wind speed (knots)		**Beam wind force (t)**
15		4
20		8
25		12
30		17

Again, these ships are usually considered to have reasonable manoeuvrability. The ship is equipped with a controllable pitch propeller, a high lift rudder and a (relatively weak) bow thruster.

5. Simulator configuration

5.1. Overview

For this study, one of the Ship Simulators at HR Wallingford was used to provide a realistic representation of the River Yare and the associated design ships.

The Ship Simulators at HR Wallingford are specifically designed for port design and ship operations applications. They have been used successfully in many studies worldwide and have proved to be a reliable, flexible and cost-effective design and evaluation tool that can be used for optimising port and harbour layouts, establishing an operational strategy and training in safe manoeuvring procedures. More information is presented in Appendix A.

The aim of the simulators is to present to Pilots and/or mariners the visual and other information, such as the coastline and port infrastructure, which they would experience in bringing a ship into a port. In this way the essential features of the human input can be retained. Ship manoeuvring models of the design vessels are produced/used so that the Pilot receives realistic positioning cues during manoeuvres. The vessels can then be operated in a realistic manner.

More details of the simulator configuration are given in the following sections.

5.2. Ship manoeuvring models

In the simulation, the behaviour and performance of the design ship, in terms of its response to any helm, engine or tug control, and the local wind, wave and current conditions, was governed by mathematical ship manoeuvring model. The model must behave in such a way that the position, velocity, swept path and heading of the simulated ship is always representative of real ship behaviour.

The ship manoeuvring model includes motions in six degrees of freedom and in particular surge, sway and yaw motions (i.e. those directly affecting horizontal motions). The model also includes representations of vessel squat and shallow water behaviour to ensure representative manoeuvring behaviour in relatively shallow water, where appropriate.

5.3. Simulated bridge layout

The simulated port layout was based on drawing information received from WSP by HR Wallingford. Figure 5.1 shows a view of the bridge in its closed position.

Figure 5.1: View downstream on to bridge with bascules lowered

Source: HR Wallingford Ship Simulation System

5.4. Visual scene

The provision of a realistic visual scene is an essential part of the navigation simulation, as it provides the pilot with important visual cues which are used to make decisions about manoeuvring the ship.

The visual scene was based on retrieval of the visual database developed for the 2009 study described in Reference 1. Figure 5.2 shows the proposed bridge in the context of the original 2009 visual scene.

Figure 5.2: Sample view of visual scene

Source: HR Wallingford Ship Simulation System

5.5. Flows

For the navigation simulation, flows were imported from the outputs of TUFLOW modelling carried out by WSP. Sample spring tide flows are shown in Figure 5.3 and Figure 5.4.

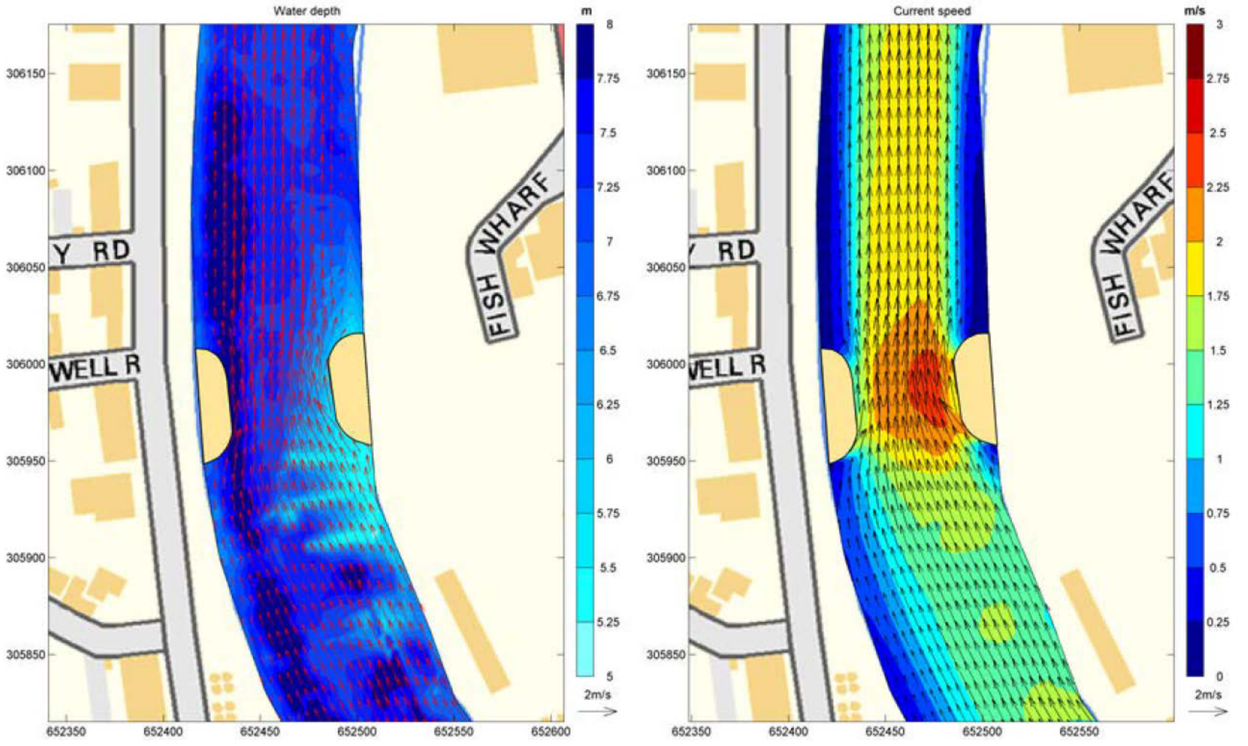


Figure 5.3: Depth and current magnitude at max flood tide current (time=36.5h in TUFLOW results)

Source: WSP TUFLOW output

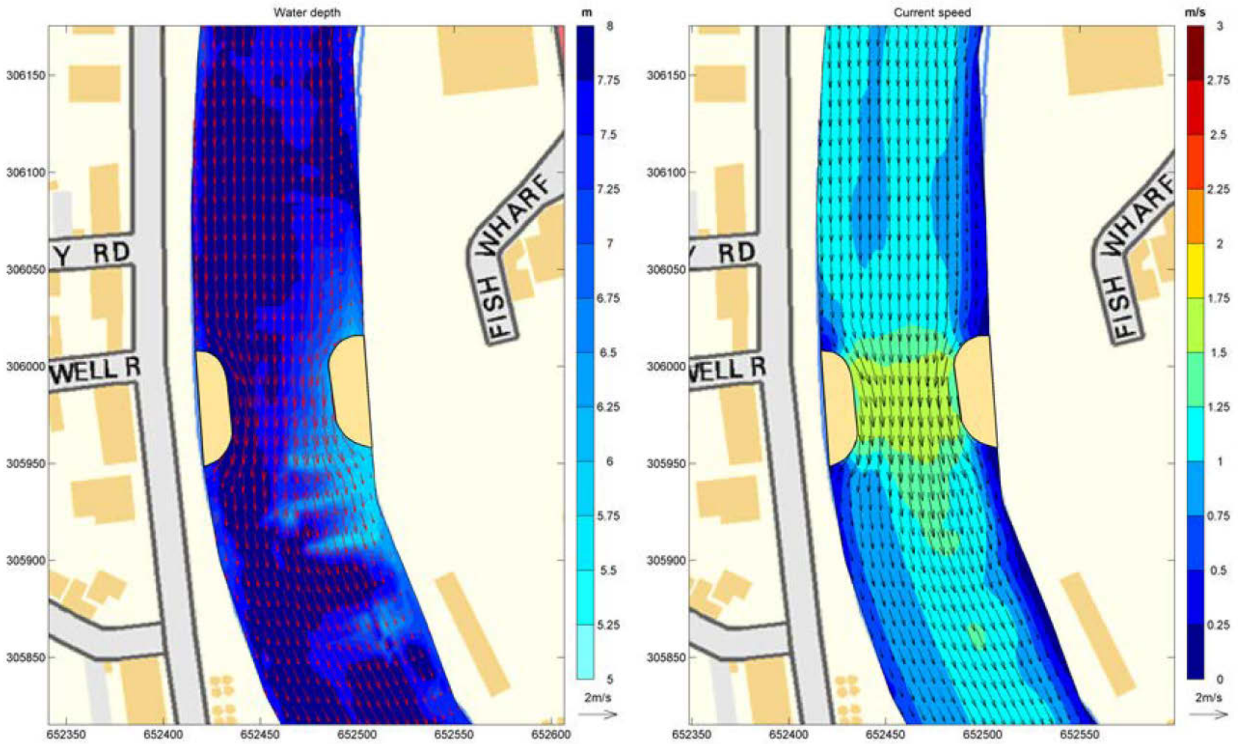


Figure 5.4: Depth and current magnitude at max ebb tide current (42.75h in TUFLOW results)

Source: WSP TUFLOW output

5.6. Wind

Wind speed and direction were selected at the start of each simulation run to suit the requirements of the particular run. All runs were conducted using a steady wind speed.

The wind speeds used in the simulation represent a 30 second gust. This is generally accepted as the minimum gust duration required to generate a noticeable ship response.

5.7. Waves

Waves were not considered relevant, as the river is well sheltered from wave activity that would affect large ship navigation, so waves were not included in the simulation.

5.8. Visibility

The simulation considered manoeuvres during day time, with good visibility of 25 nautical miles.

5.9. Verification of simulator configuration

Prior to the simulation session, the simulator layout and ship manoeuvring models were tested to ensure that the complete simulation was as expected.

The ship manoeuvring models were tested using standard trials such as Manoeuvring area and emergency stop tests. The results of these tests were considered to be consistent with the known and assumed behaviour of similar ships. The HR Wallingford Pilot also verified the performance of the modelled ship using a series of test manoeuvres in a range of environmental conditions.

A series of standard simulator set-up verification tests were undertaken to confirm that all components of the simulation were configured correctly and were interacting as expected. These included:

- Engine and helm control tests;
- Effect of wind, waves and/or current on stationary ships;
- Wind force on ship versus tug forces to check the balance of forces;
- Spatial and orientation checks on the relative positions of the infrastructure, channel boundaries and aids to navigation;
- Spatial checks on water depths;
- Confirmation of the ship footprint and location with the simulation visual scene and situation display.

6. Simulation programme

A 3 day duration real time navigation simulation session was held between 3 and 5 September 2019 at HR Wallingford's United Kingdom Ship Simulation Centre in Oxfordshire.

The simulation was attended by the following people at various times:

- Brian Forrest — Peel Ports Great Yarmouth Senior Operations Manager
- Luke Sebastian — Peel Ports Great Yarmouth Marine Operations Manager
- Captain David Morrice — Peel Ports Great Yarmouth Marine Pilot
- Captain R Gavin — Peel Ports Great Yarmouth Marine Pilot
- Stephen Horne — WSP Project Manager
- Captain Mike Nicholson — WSP (Shipmove Consultants)
- Gillian Watson — HR Wallingford Project Manager
- Vincent Crockett — HR Wallingford Technical Director Ships and Dredging Group
- Roberta Riva — HR Wallingford Simulation Coordinator
- Captain John Gurton — HR Wallingford Pilot
- Dr Mark McBride — HR Wallingford Project Director.

The following general simulation procedures were followed:

- The Pilot was briefed before the simulation run and debriefed afterwardsl
- Tugs were not used in the simulations.

7. Presentation of results

7.1. Pilot questionnaires

Immediately after each simulation run, the pilot was debriefed and his opinions on various aspects of the run were recorded via a questionnaire. These were used in the discussion and assessment of the results.

7.2. Simplified grading

Immediately after completion, each simulation run was graded by the simulation team as successful, marginal or fail, according to the evaluation criteria described as follows:

- Successful: A successful outcome was characterised by the following:
  - The ship remains under full control at all times without resorting to aggressive manoeuvring techniques;
  - The ship transits through the bridge with acceptable clearances to the bridge knuckles and moored vessels;
  - For departure manoeuvres the ship exits smoothly with acceptable clearances to the bridge knuckles and other moored vessels.
- Marginal: A marginal outcome was characterised by the following:
  - The Pilot considers the ship is at the limit of control during standard manoeuvres;
  - The ship stays within safe water, but with unacceptable clearances;
  - The ship clears the bridge knuckles, but with unacceptable clearances.
- Fail: A fail outcome was characterised by the following:
  - The Pilot loses control of the ship;
  - The ship either contacts, or has a near-miss, with the bridge knuckles or berth structures, and/or other moored vessels.

7.3. Simulation track and data plots

The results from 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 B.

The vessel data and track plots show:

- The position of the vessel at one minute intervals indicated by a succession of grey and blue vessel outlines. Red vessel outlines indicate the vessel's position every 5 or 10 minutes from the start of the run, as appropriate.
- 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. These plots comprise:

- Ship's heading in °N;

- Ship's drift angle in degrees;
- Ship's speed over the ground in knots, expressed in terms of longitudinal and lateral components relative to the ship's head;
- Ship's rate of turn (°/min), rudder angle and engine rpm;
- Ship's under keel clearance(s) in metres;
- Current speed in knots acting on the ship along the ship's track;
- Speed (knots) and direction (°N) of the wind acting on the ship.

Where there are no plots for a particular parameter, this indicates that the particular parameter was not relevant for the particular run.

8. Discussion of results

8.1. Platform support vessel transits

8.1.1. Simulations completed

Table 8.1 summarises the results of the 11 simulations completed with the 80m long platform support vessel. With the exception of Run 08, all the simulated transits were recorded as being successful. Run 08 was rated as marginal/fail because the ship approached too close to other moored vessels. No bridge fender contacts were recorded.

8.1.2. Inbound transits

Run 01 Bow first (familiarisation run)

For the first run with the platform supply vessel, the pilot took the opportunity to familiarise himself with the controls and the flow conditions. The simulation started from just upstream of Brush Bend (Figure 8.1). A test on the ship's acceleration/deceleration was carried out by the pilot between 7 minutes and 9 minutes into the run.

The ship maintained a clearance of about 18m from the moored vessels at Berths 12 South and 32, with a water speed around 3.5 knots. A clearance of 7m was maintained from the moored vessel on 12 North with a passing speed of 3.5 knots through the water.

The ship was well positioned entering the bridge opening with a clearance of about 14m to the east knuckle (Figure 8.2). The minimum clearance to the east knuckle was recorded as about 11m. It should be noted that the yellow dot in the image represented a centre span light and was removed for subsequent simulations.

Table 8.1: Platform support vessel transit simulation summary

Run no.	Pilot	Transit direction	Bow first/stern first	Flow (Spring tide)	Wind	Outcome
01	RG	Inbound	Bow first	HW at Brush Bend	225°N (SW) 10-15 knots	Successful
02	DM	Inbound	Bow first	HW-1hr at Brush Bend	225°N (SW) 10-15 knots	Successful
03	RG	Inbound	Bow first	HW-1hr at Brush Bend	225°N (SW) 10-15 knots	Successful
04	DM	Inbound	Bow first	Peak flood, 4.4 knots at the bridge	225°N (SW) 10-15 knots	Successful
05	RG	Inbound	Stern first	Peak flood, 4.4 knots at the bridge	225°N (SW) 10-15 knots	Successful
06	DM	Inbound	Bow first	Peak ebb, 3.0 knots at the bridge	225°N (SW) 10-15 knots	Successful
11	DM	Inbound	Bow first	Mid flood	090°N (N) 25-30 knots	Successful
07	RG	Outbound	Bow first	Peak ebb-1hr	225°N (SW) 10-15 knots	Successful
08	DM	Outbound	Bow first	Peak ebb (3.1 knots)	225°N (SW) 10-15 knots	Marginal/Fail
09	DM	Outbound	Bow first	Peak ebb (3.1 knots)	225°N (SW) 10-15 knots	Successful
10	RG	Outbound	Stern first	Peak ebb (3.1 knots)	225°N (SW) 10-15 knots	Successful

Notes: Pilots: RG – R Gavin, DM – David Morrice

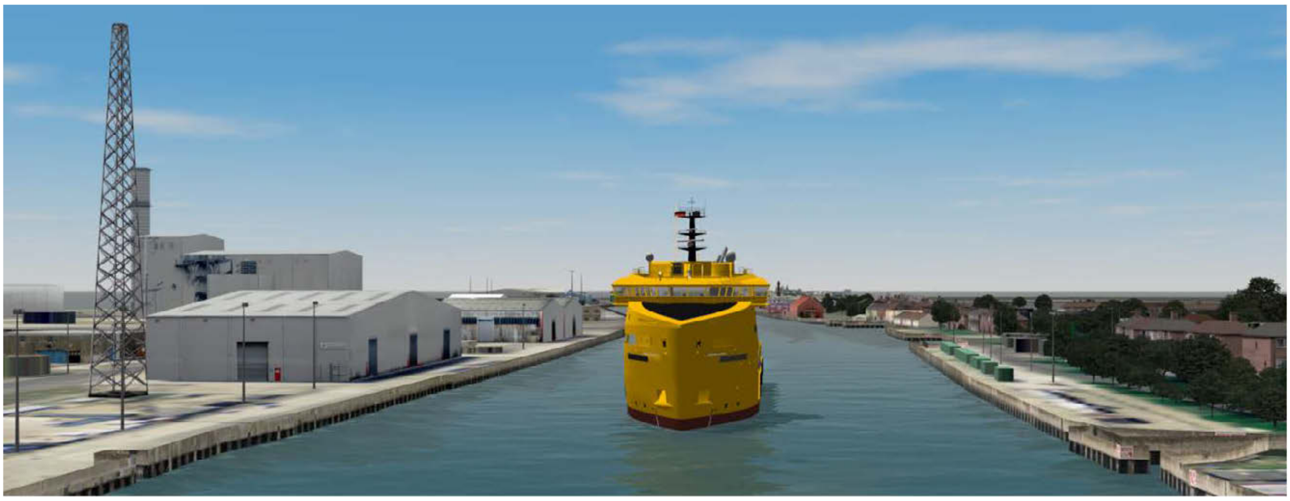


Figure 8.1: Run 01: Inbound PSV, 11 minutes elapsed simulation time

Source: HR Wallingford Ship Simulation System

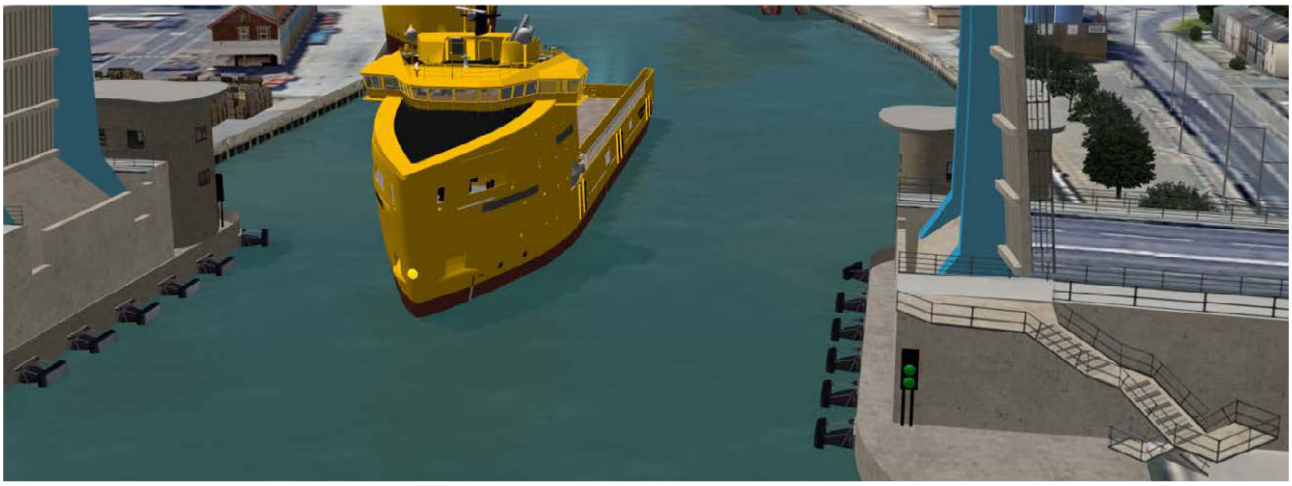


Figure 8.2: Run 01, Inbound PSV entering bridge opening, 16 minutes, 14m to E knuckle

Source: HR Wallingford Ship Simulation System

No significant difficulties were encountered in the simulation, although the pilot commented that he was not expecting an ebb stream at this stage of the tide and a discussion followed on the basis of the flow model. It was agreed that flows would be adjusted at selected locations to provide the required flow field for the particular manoeuvre being simulated. The track plots show both flood and ebb streams.

The pilot also commented that refinement of the sensitivity of the controls would be beneficial as the ship appeared to respond too quickly and went “too fast”.

Run 02 Bow first Repeat of Run 01

For Run 02, a flow field corresponding to 1 hour before high water at Brush Bend was selected so that the ship was manoeuvred inbound with a following flow throughout the transit.

The ship maintained a clearance of about 22m from the moored vessel on Berth 12 south and was positioned centrally between the moored vessels on Berth 12 North and 32, with clearances of about 15m to each vessel and a speed through the water of about 3 knots.

The ship passed through the bridge opening with ground speed of 4 knots with minimum clearances of about 9m and 24m to the west and east knuckles, respectively.

Selected images for the transit are shown in Figure 8.3 to Figure 8.7.

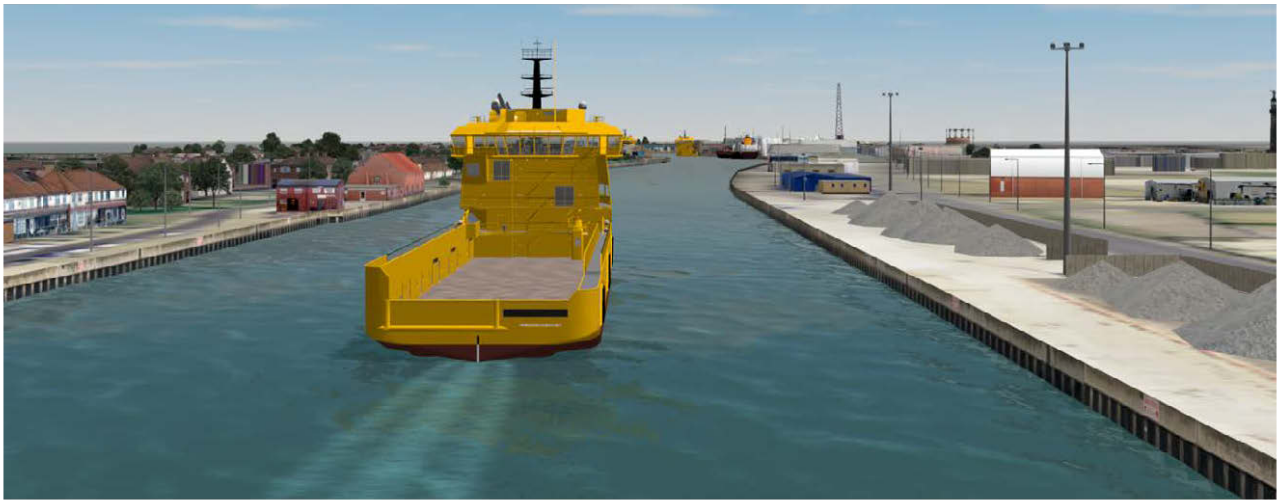


Figure 8.3: Run 02: Inbound PSV at 3 minutes elapsed simulation time

Source: HR Wallingford Ship Simulation System

Figure 8.4: Run 02 PSV entering opening 12 minutes

Source: HR Wallingford Ship Simulation System

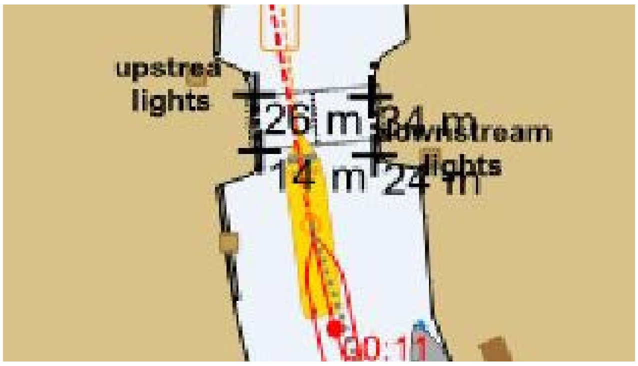


Figure 8.5: Run 02: Clearances at 12 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.6: Run 02 PSV between knuckles

Source: HR Wallingford Ship Simulation System

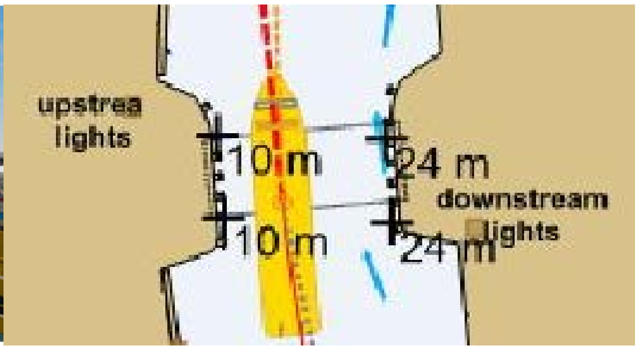


Figure 8.7: Run 02 Clearances at 12 minutes

Source: HR Wallingford Ship Simulation System

Run 03 Bow first

In Run 03 the ship approached the bridge opening with a clearance of about 9m to the moored vessel on Berth 12 North and a speed of about 3.5 knots, increasing to about 4 knots over the ground. The pilot noted that the effect of the following flow was not as strong as he expected. The ship passed through opening with a speed over the ground of about 4.5 knots.

The ship was well positioned passing through the bridge opening with a minimum clearance of abut 10m to the east knuckle and 20m to the west knuckle.

The pilot noted that he used a garage roof as a visual reference while passing through the bridge opening and that the bridge architectural elevation drawings apparently showed the roof obscured by trees.

Figure 8.8: Run 03 Inbound PSV 5 minutes elapsed simulation time

Source: HR Wallingford Ship Simulation System

Figure 8.9: Run 03 PSV stern view 250m from bridge

Source: HR Wallingford Ship Simulation System

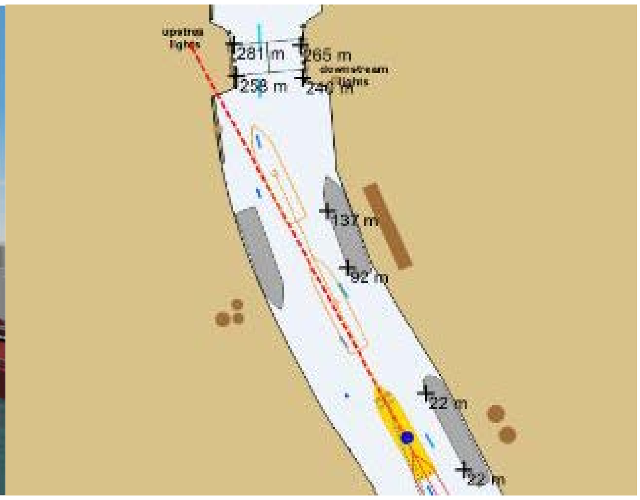


Figure 8.10: Run 03 Map view at 250m from bridge

Source: HR Wallingford Ship Simulation System

Figure 8.11: Run 03: Stern view at 17 minutes

Source: HR Wallingford Ship Simulation System

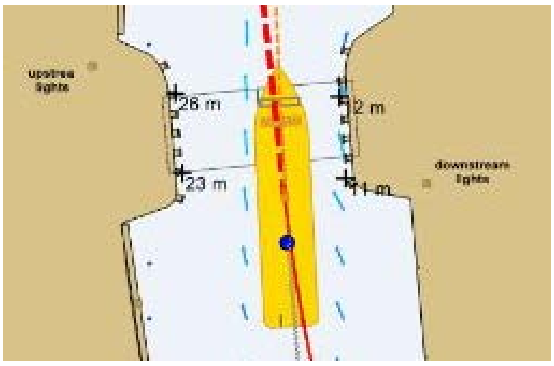


Figure 8.12: Run 03 Clearances at 17 minutes

Source: HR Wallingford Ship Simulation System

Run 04 Bow first

For Run 04, peak flood following flow conditions were represented at the bridge site. An additional moored ship, a PSV moored on the west bank, was included in the simulation.

The ship was set towards the west bank approaching the bridge opening, but passed through the opening with a minimum clearance of 7m to the west knuckle. The ship's speed over the ground passing through the bridge opening was about 5.7 knots.

Downstream of the bridge, the ship maintained a minimum clearance of 9m from the moored vessel on Berth 32 and, upstream of the bridge, 7m from the vessel on Berth 31.

The run was rated as successful, but it was noted that the environmental conditions were at the limit for safe operations.

Selected images from the transit are shown in Figure 8.13 to Figure 8.15.

Figure 8.13: Run 04: Stern view at 9 minutes elapsed simulation time

Source: HR Wallingford Ship Simulation System

Figure 8.14: Run 04 Stern view at about 10 minutes

Source: HR Wallingford Ship Simulation System

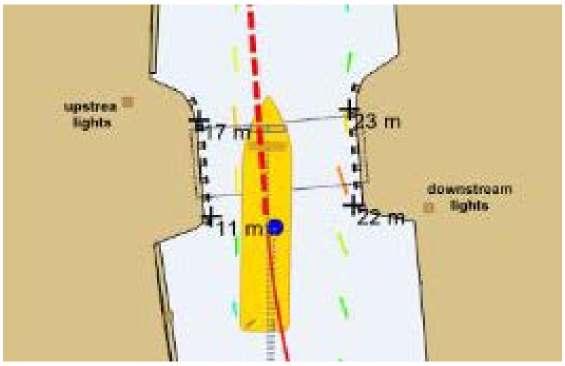


Figure 8.15: Run 04 Clearances at 10 minutes

Source: HR Wallingford Ship Simulation System

Run 05 Stern first

For Run 05, a stern first approach was examined with peak flood flow conditions again being represented at the bridge site. For a stern first approach, the significant power available from the bow thrusters was required to control the ship's heading.

The track plots show a smooth swept path for the transit with the ship generally well positioned towards the centre of the river passing the moored PSVs on Berth 12 North and 32.

The ship passed through the bridge opening with a minimum clearance of about 12m to the east knuckle with a speed of about 6 knots over the ground.

The pilot considered that the ship felt more under control due to the ability to move ahead if needed. The pilot was also familiarising himself with the use of the aft view.

Selected images for the transit are shown in Figure 8.16 to Figure 8.19.

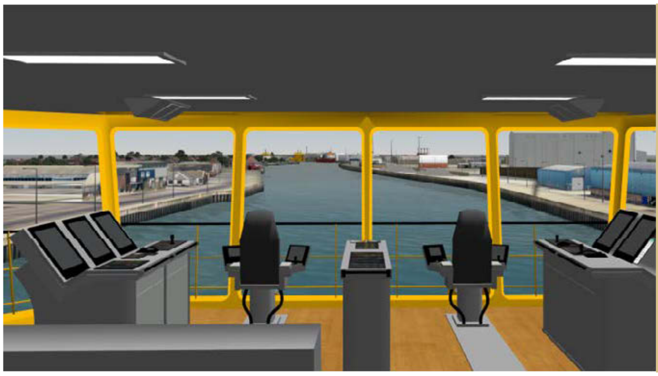


Figure 8.16: Run 05 Aft bridge view at 3 minutes

Source: HR Wallingford Ship Simulation System

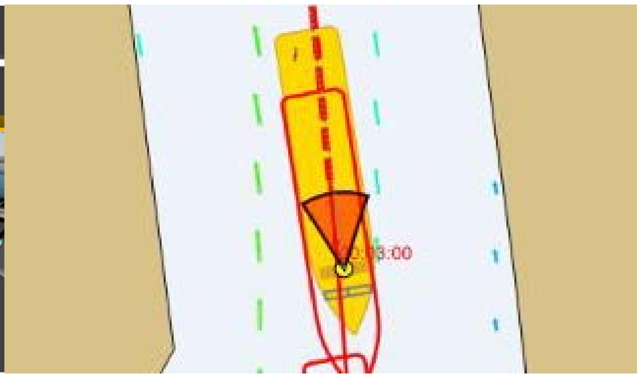


Figure 8.17: Run 05: Map view at 3 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.18: Run 05 Approaching, 100m from bridge

Source: HR Wallingford Ship Simulation System

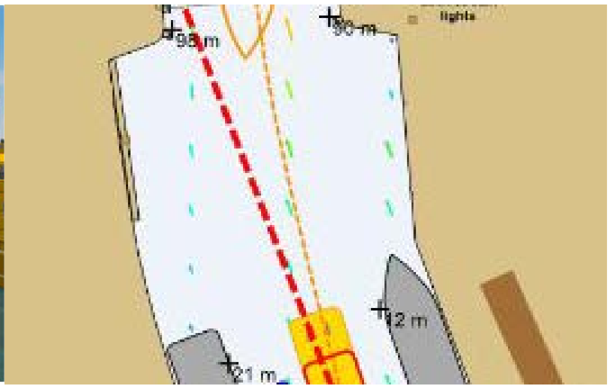


Figure 8.19: Run 05 Map view at 14 minutes

Source: HR Wallingford Ship Simulation System

Run 06 Repeat of Run 04 in peak ebb conditions

For Run 06, peak ebb conditions were simulated at the bridge.

Again, the track plots show a smooth swept path for the transit, with the ship well positioned throughout. The ship was at the bridge opening with a speed of just over 7 knots through the water, about 4.5 knots over the ground, with the speed reducing quickly once the ship was passing through the opening.

Selected images for the transit are shown in Figure 8.20 to Figure 8.24.

Figure 8.20: Run 06: PSV Inbound from Brush Bend, start of simulation

Figure 8.21: Run 06, 12 minutes, bridge opening

Source: HR Wallingford Ship Simulation System

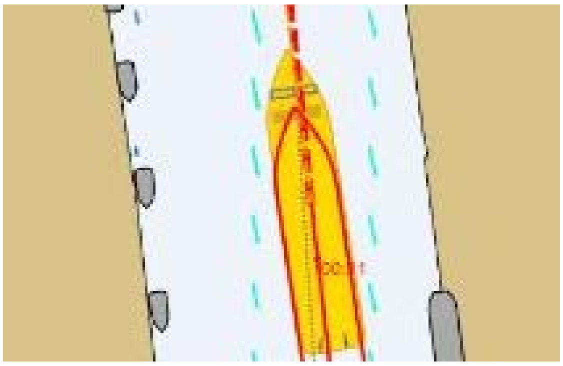


Figure 8.22: Run 06: Map view at 12 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.23: Run 06, 15 minutes, PSV at bridge

Source: HR Wallingford Ship Simulation System

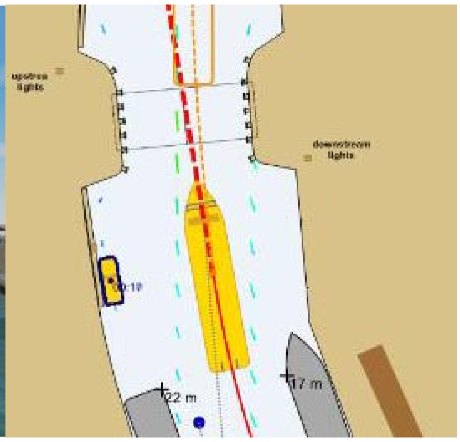


Figure 8.24: Run 06: Map view at 15 minutes

Source: HR Wallingford Ship Simulation System

Run 11 Bow first mid flood

The track plot for Run 11 shows a smooth swept path for the transit with the ship generally well positioned. It may be noted from the track plot that because the ship was bound for Berth 31, it passed close, with 2m clearance, to, but clear of, the west knuckle. It passed the west knuckle with a speed over the ground of about 1.8 knots.

The pilot noted that wind effects were apparently stronger than flow effects, which was contrary to his experience.

Selected images for the transit are shown in Figure 8.25 to Figure 8.28.

Figure 8.25: Run 11: Inbound PSV, 3 minutes 30 seconds elapsed time

Source: HR Wallingford Ship Simulation System

Figure 8.26: Run 11 PSV entering bridge, 14 minutes

Source: HR Wallingford Ship Simulation System

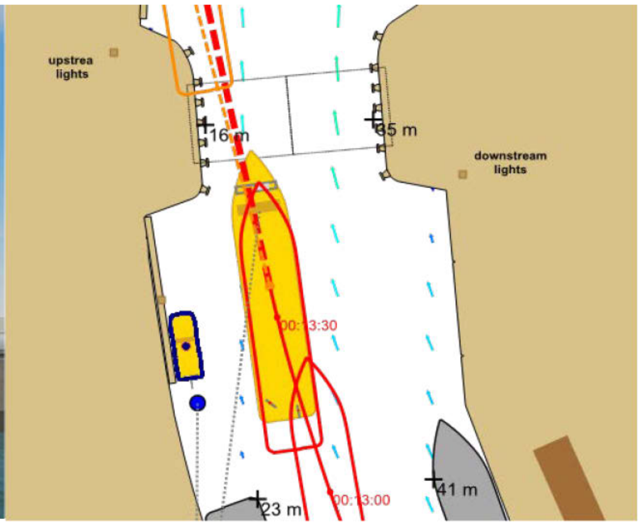


Figure 8.27: Run 11: Clearances at 14 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.28: Run 11: Inbound PSV clearing bridge, 16 minutes elapsed time

Source: HR Wallingford Ship Simulation System

8.1.3. Outbound transits

Run 07 Bow first

Run 07 simulated a departure with the ship starting starboard side alongside Bollard Quay. The ship was lifted off the berth astern, so that could be correctly positioned for the transit through the bridge opening.

The tidal effect was slightly less than expected while passing the bridge. The ship passed the bridge opening with a speed over the ground of about 5.5 knots.

It was noted that the bridge should be open before the last mooring line is released, due to the proximity of the berth to the bridge.

Once clear of the bridge, the ship passed close to a moored PSV on the east bank.

Selected images for the transit are shown in Figure 8.29 to Figure 8.32.

Figure 8.29: Run 07 Outbound PSV leaving berth with bridge opening

Source: HR Wallingford Ship Simulation System

Figure 8.30: Run 07: PSV entering opening

Source: HR Wallingford Ship Simulation System

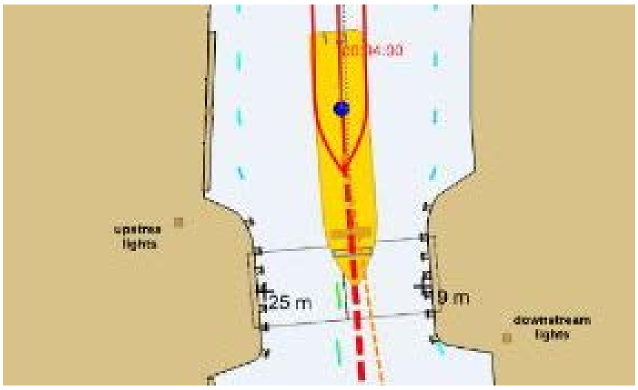


Figure 8.31: Run 07: Map at 4 minutes 30 seconds

Source: HR Wallingford Ship Simulation System

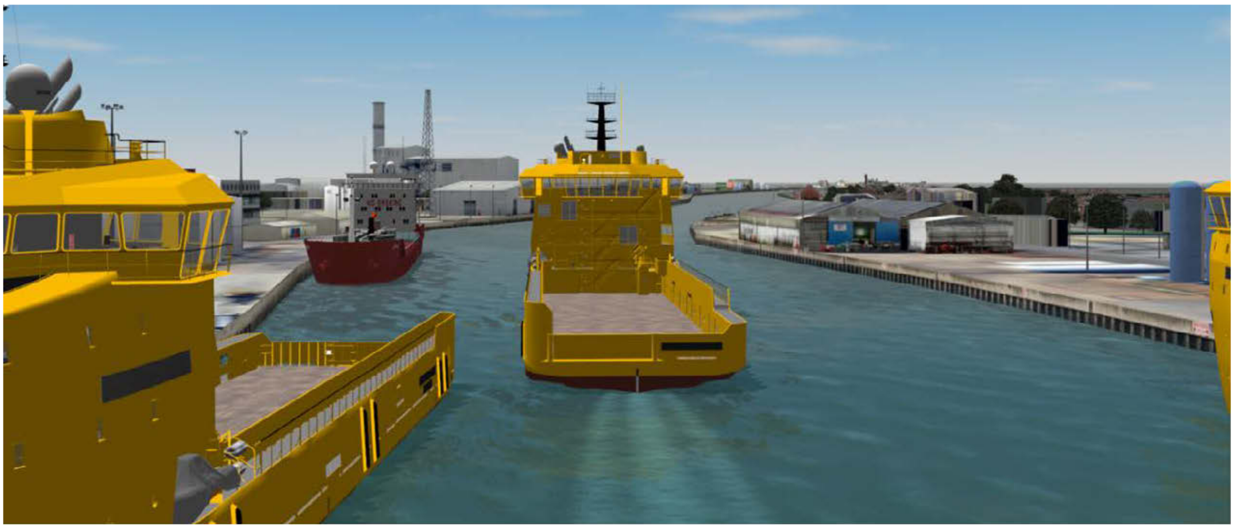


Figure 8.32: Run 07: Outbound PSV passing close to moored PSV, 06 minutes elapsed

Source: HR Wallingford Ship Simulation System

Run 08 Bow first peak ebb conditions

Run 08 repeated Run 07, but in peak ebb flow conditions at the bridge site and with a ship moored to the south on Bollard Quay. The track plot shows that the ship passed close, with 5m clearance, to the east knuckle and almost made contact with the PSV on Berth 12 North. It also passed close to the tanker on Berth 12 South.

The pilot was not anticipating that the outgoing flow would set the ship towards the east bank as was experienced and the run was rated as a marginal/fail.

Selected images for the transit are shown in Figure 8.33 to Figure 8.36.

Figure 8.33: Run 08: Outbound PSV leaving Bollard Quay

Source: HR Wallingford Ship Simulation System

Figure 8.34: Run 08 4 minutes and 30 seconds

Source: HR Wallingford Ship Simulation System

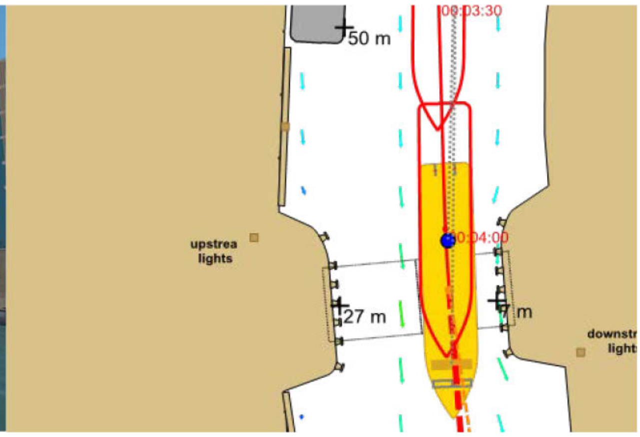


Figure 8.35: Clearances at 4 minutes 30 seconds

Source: HR Wallingford Ship Simulation System

Figure 8.36: Run 08: Outbound PSV passing close to moored PSV

Source: HR Wallingford Ship Simulation System

Run 09 Repeat of Run 08

Run 09 was carried out as a repeat of Run 08. The track plot shows a smooth swept path for the transit with significantly improved clearances to moored vessels south of the bridge.

The ship passed through the bridge opening with a minimum clearance of about 7m from east knuckle with a ground speed of about 4.5 knots.

Figure 8.37: Run 09: Outbound PSV approaching bridge

Source: HR Wallingford Ship Simulation System

Figure 8.38: Run 09: PSV about 40m from bridge

Source: *HR Wallingford Ship Simulation System*

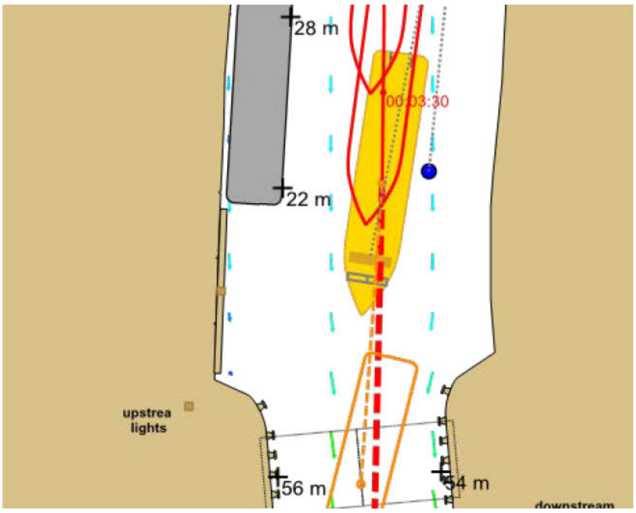


Figure 8.39: Run 09: Map view 40m from bridge

Source: *HR Wallingford Ship Simulation System*

Figure 8.40: Run 09: PSV downstream of bridge

Source: *HR Wallingford Ship Simulation System*

Run 10 Stern first

Run 10 examined a stern first departure in peak ebb conditions at the bridge site. The track plot shows a smooth swept path with good clearances during the transit through the bridge opening and when passing moored vessels.

The ship passed through the bridge opening with a speed over the ground of about 6.5 knots with clearances of 11 m and 19 m to the west and east knuckles, respectively.

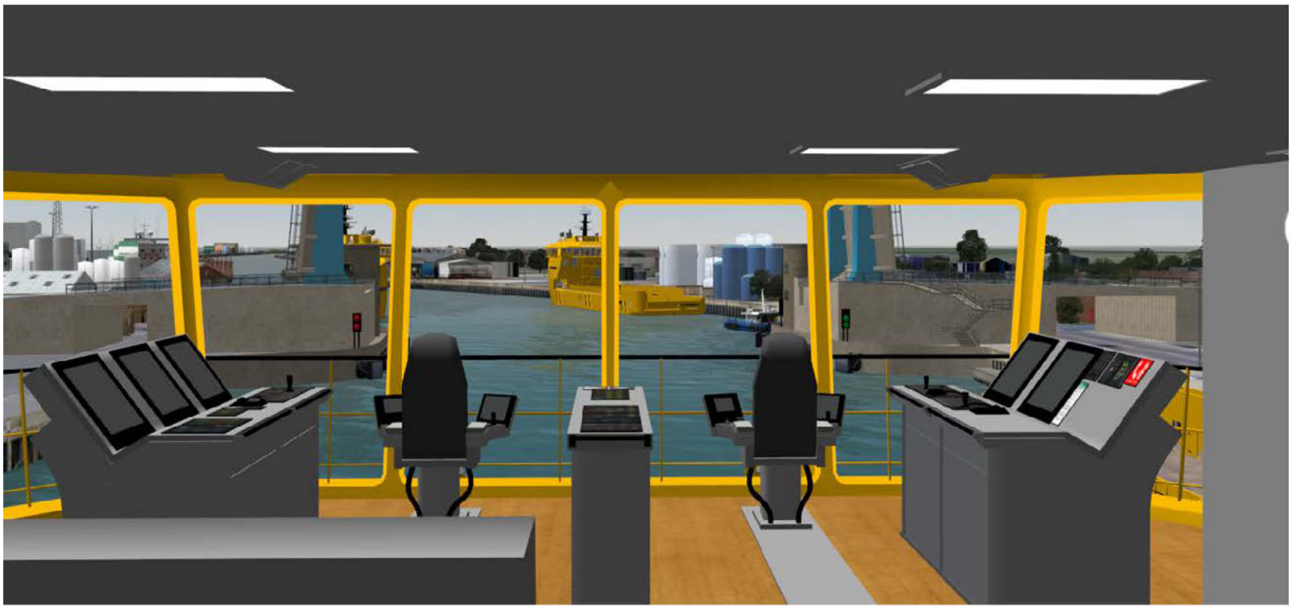


Figure 8.41: Run 10: Aft control station view approaching

Source: HR Wallingford Ship Simulation System

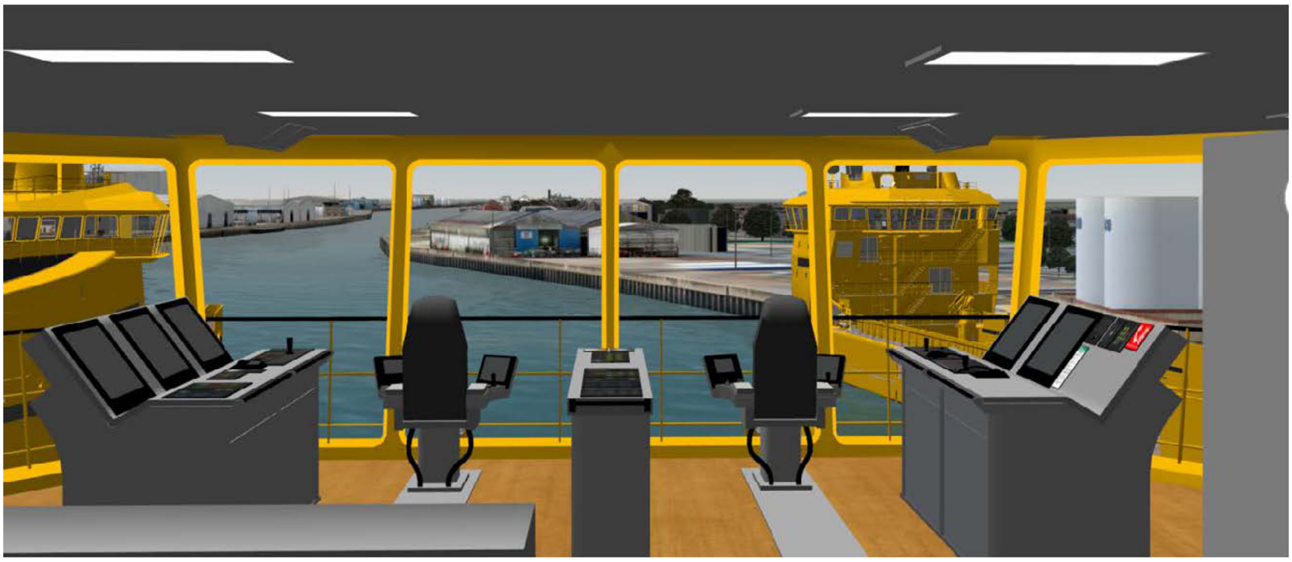


Figure 8.42: Run 10: Aft control station view passing moored PSVs

Source: HR Wallingford Ship Simulation System

8.2. Berth 14 product tanker

8.2.1. Simulations completed

Berth 14 is located immediately above the bridge and is therefore a potentially more difficult berth to operate to and from, for conventional ships that are not equipped with the platform support vessel's azimuthing and transverse thrusters.

Table 8.2 summarises the results of the 7 transit simulations undertaken that comprised 1 inbound transit and 6 outbound transits completed with the products tanker for Berth 14.

As may be expected, the inbound transit was completed successfully, but developing a suitable strategy for a stern first departure from the berth required several attempts before a successful departure was completed in Run 25. In 3 of the simulations, Runs 16, 17 and 24, the ship made contact with the knuckles.

Runs 12 and 13 were carried out as familiarisation runs, to examine berthing and berth shifting, respectively, downstream of the bridge site and did not simulate bridge transits. The primary purpose of the simulations was to examine whether introduction of the bridge would have any adverse effect on manoeuvres that are currently carried out on a regular basis. The simulations confirmed as expected that there were no adverse effects.

Table 8.2: Product tanker transit simulation summary

Run no.	Pilot	Laden/ballast	Transit direction	Bow first/stern first	Flow	Wind (from)	Outcome
14	RG	Laden	Inbound, to Berth 14	Bow first,	Slack – beginning of the ebb	225°N (SW) 5 knots	Successful
15	DM	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Marginal
16	RG	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Fail
17	RG	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Fail
18	DM	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Marginal
24	DM	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Fail
25	DM	Ballast	Outbound from Berth 14	Stern first	Last of flood	225°N (SW) 5 knots	Successful

8.2.2. Run 14 Inbound bow first transit

For Run 14, the track plot shows a smooth swept path for the transit to Berth 14. The ship passed through the bridge opening with a 5m clearance to the east knuckle.

The ship kept a clearance of 5m from the eastern knuckle of the bridge while passing with a speed through the water of about 4.7 knots.

Selected images for the transit are shown in Figure 8.43 and Figure 8.44.

Figure 8.43: Run 14: Downstream view inbound tanker approaching bridge, 15 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.44: Run 14 Upstream view inbound tanker approaching bridge, 15 minutes

Source: HR Wallingford Ship Simulation System

8.2.3. Outbound transits

Run 15

For Run 15, the track plot shows that the ship was lifted off the berth successfully, using the forward spring line, but the ship then encroached close to the west knuckle before being better aligned for the remainder of the transit through the bridge. The ship then approached close to a moored PSV on Berth 12 before control was regained.

No contact was made with the knuckle or moored ships, but the pilot noted that the departure strategy needed refinement.

Selected images for the transit are shown in Figure 8.45 to Figure 8.49.

Figure 8.45: Run 15: Outbound products tanker lifting off Berth 14

Source: HR Wallingford Ship Simulation System

Figure 8.46: Run 15: Encroaching to west knuckle

Source: HR Wallingford Ship Simulation System

Figure 8.47: Run 15:Close proximity to west knuckle

Source: HR Wallingford Ship Simulation System

Figure 8.48: Run 15: Repositioning within bridge opening

Source: HR Wallingford Ship Simulation System

Figure 8.49: Run 15: Ship better aligned in bridge opening

Source: HR Wallingford Ship Simulation System

Run 16

The track plot of Run 16 confirms that the ship was again successfully lifted off the berth, but the stern could not be controlled and made contact with the west knuckle.

Run 17

In Run 17, the track plot showed an improved swept path compared with Run 16, but again, the ship made contact with the west knuckle.

Run 18

In Run 18 the ship went ahead, upstream, about half a ship's length, to be better positioned for the transit through the opening. The track plot shows that the ship did not contact either of the knuckles, but came close, at 2m clearance, to the east knuckle. The remainder of the run was completed without incident.

Run 24

In Run 24, the track plot shows that the ship was well positioned upstream of the bridge but was then set down on to the east knuckle by the outgoing oblique flow, as shown in Figure 8.50.

Figure 8.50: Run 24: 4m minimum clearance to east knuckle

Source: HR Wallingford Ship Simulation System

Run 25

The track plot for Run 25 shows the results of the experience gained from the previous runs, with the ship well positioned for the transit through the bridge opening, with good clearances to the knuckles.

8.2.4. Downstream manoeuvres

The track plot for Run 12 shows a smooth swept path for an inbound transit from just upstream of Brush Bend to berth port side alongside Berth 32. The manoeuvre was completed successfully although the pilot considered that the wind effect on the ship was more than might have been expected in practice.

The track plot for Run 13 shows a smooth manoeuvre across the river from port side alongside Berth 32A to starboard side alongside ASCO Berth 12B. The duration of the manoeuvre accorded with the pilot's experience.

8.3. Short sea dry cargo ship transits

8.3.1. Simulations completed

Table 8.3 summarises the stern first transit simulations completed with a short sea dry cargo ship, as represented by a ship such as the "Fischland".

Table 8.3: Short sea dry cargo ship transit simulation summary

Run no.	Pilot	Laden/ballast	Transit direction	Bow first/stern first	Flow	Wind (from)	Outcome
31	DM	Ballast	Inbound	Stern first	First of flood	225°N (SW) 5 knots	Successful
32	RG	Ballast	Inbound	Stern first	First of flood	225°N (SW) 13-17 knots	Successful
19	RG	Laden	Outbound	Stern first	Last of flood	225°N (SW) 5 knots	Fail
20	DM	Laden	Outbound	Stern first	Last of ebb	225°N (SW) 5 knots	Fail
21	DM	Laden	Outbound	Stern first	Last of flood	225°N (SW) 5 knots	Successful
22	RG	Ballast	Outbound	Stern first	Last of flood	225°N (SW) 5 knots	Fail
23	RG	Ballast	Outbound	Stern first	Last of flood	225°N (SW) 5 knots	Successful
26	RG	Ballast	Outbound	Stern first	Last of flood	225°N (SW) 13-17 knots	Fail
27	DM	Ballast	Outbound	Stern first	Last of flood	225°N (SW) 13-17 knots	Marginal
28	RG	Ballast	Outbound	Stern first	Last of flood	325°N (NW) 13-17 knots	Marginal
29	DM	Ballast	Outbound	Stern first	Last of flood	45°N (NE) 13-17 knots	Successful
30	RG	Ballast	Outbound	Stern first	Last of flood	135°N (SE) 13-17 knots	Successful
33	DM	Ballast	Outbound	Stern first	First of flood	225°N (SW) 5 knots	Marginal

8.3.2. Inbound

Run 31 Stern first following flood flow

In Run 31 the ship passed through the bridge opening with a speed over the ground of about 2.5 knots, with a minimum clearance of 14m to the western knuckle. The ship was stopped and repositioned off Berth 33. The ship was under control throughout the run with the following flood tide assisting control. Selected images for the transit are shown in Figure 8.51 to Figure 8.55.

Figure 8.51: Run 31: Inbound Fischland stern first approach to bridge

Source: HR Wallingford Ship Simulation System

Figure 8.52: Run 31: 16 minutes elapsed time

Source: HR Wallingford Ship Simulation System

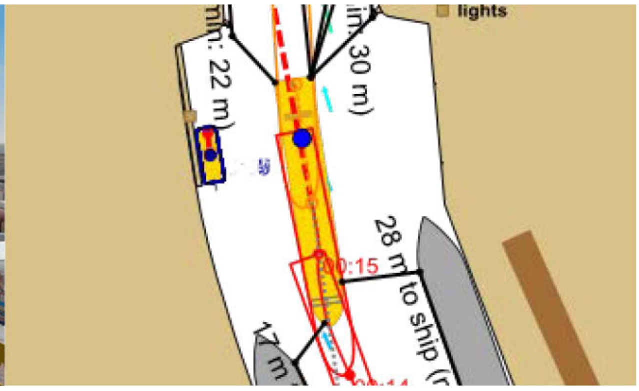


Figure 8.53: Clearances at 16 minutes

Source: HR Wallingford Ship Simulation System

Figure 8.54: Run 31: 17 minutes elapsed time

Source: HR Wallingford Ship Simulation System

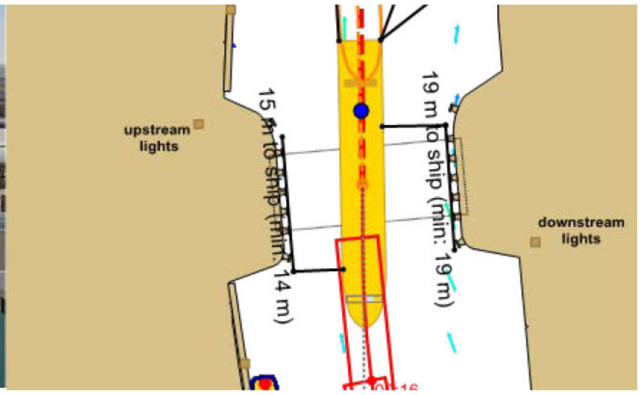


Figure 8.55: Run 31: clearances at 17 minutes

Source: HR Wallingford Ship Simulation System

Run 32 Stern first with following flood flow

The bow thruster was used on full power in Run 32, and the ship maintained a speed over the ground of about 3 knots, with a clearance of 8m to the western knuckle. The acceleration through the bridge opening was noticeable, but manageable. The ship passed close to a moored ship near Berth 31, but this was clear of the bridge. Selected images for the transit are shown in Figure 8.56 to Figure 8.58.

Figure 8.56: Run 32: Inbound Fischland stern first approach to bridge

Source: HR Wallingford Ship Simulation System

Figure 8.57: Run 32: well positioned, 11 minutes

Source: HR Wallingford Ship Simulation System

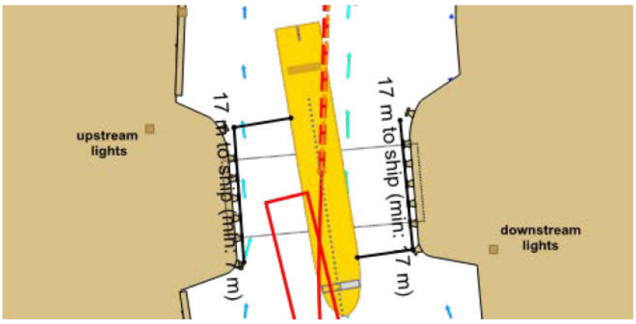


Figure 8.58: Run 32: clearances at 11 minutes

Source: HR Wallingford Ship Simulation System

8.3.3. Outbound

Run 19 Slack water flood

The ship was lifted off Berth 14 in Run 19, for about one beam before coming astern through the bridge opening (Figure 8.59). The thruster was used on full power for a prolonged period to maintain control. The ship was out of position passing the bridge opening and approached close to the PSV on Berth 32.

Figure 8.59: Run 19 Outbound Fischland stern first approach to bridge

Source: HR Wallingford Ship Simulation System

Run 20 Approaching slack water ebb

In Run 20 the ship was manoeuvred astern from Berth 14 (Figure 8.61), and made continuous, sliding contact with the fenders on the eastern knuckle and also contacted the PSV moored on Berth 12 north.

Figure 8.60: Run 20: Fischland stern first approach to bridge

Source: HR Wallingford Ship Simulation System

Run 21 Approaching slack water flood

In Run 21 the ship left the berth without using lines and moving ahead upstream to better align with the ebb flow. The ship passed through the bridge opening with clearances of 12m and 20m to the eastern and western knuckles, respectively. Departing with a following current improved control.

Figure 8.61: Run 21: Outbound Fischland stern first, about 30m from the bridge

Source: HR Wallingford Ship Simulation System

Run 22 Approaching slack water flood

In Run 22, on departure from Berth 14, the ship contacted the downstream fenders on the eastern knuckle. A more powerful bow thruster would have been beneficial. Positioning the ship more centrally in the river was required before going astern.

Run 23 Approaching slack water flood

In Run 23, on departure from Berth 14, the ship was positioned more centrally in the river before moving astern. The ship passed the bridge with a speed of about 2 knots over the ground and clearances of about 13m and 18m from the east and west knuckles, respectively.

Figure 8.62: Run 23: Outbound Fischland manoeuvring into centre of the river

Source: HR Wallingford Ship Simulation System

Figure 8.63: Run 23: Outbound Fischland well positioned downstream of bridge

Source: HR Wallingford Ship Simulation System

Run 26 Approaching slack water flood

Run 26 simulated a departure from Berth 14 (Figure 8.64). A spring line was used to depart the berth. The pilot was concerned by the strong effect of the wind and the ship was not correctly positioned for departure.

Figure 8.64: Run 26: Outbound Fischland lifting off from Berth 14

Run 27 Approaching slack water flood

Run 27 examined a departure from the vicinity of Berth 30 as a potentially safer place to better align the ship with the flow and before passing through the bridge opening. The strong wind generated a high drift angle that determined a clearance of about 3m from each knuckle. The environmental conditions were considered at the limit and the manoeuvre was not considered safe to perform in practice. The effects of the high drift angle within the bridge opening may be seen in Figure 8.65 and Figure 8.66 and the ship's approach to the moored PSVs downstream of the bridge may be seen in Figure 8.67 and Figure 8.68.

Figure 8.65: Run 27: High drift angle in opening

Source: HR Wallingford Ship Simulation System

Figure 8.66: Run 27: Minimal clearance to east

Source: HR Wallingford Ship Simulation System

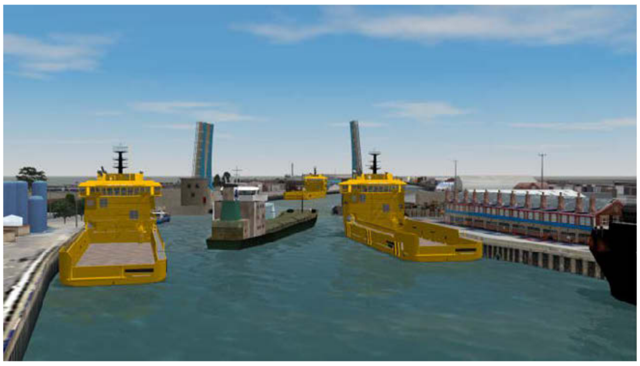


Figure 8.67: Run 27: High drift angle near PSVs

Source: HR Wallingford Ship Simulation System

Figure 8.68: Run 27: High drift angle near PSVs

Source: HR Wallingford Ship Simulation System

Run 28 Approaching slack water flood

The ship was initially well positioned for the transit in Run 28 (Figure 8.69), but passed through the bridge opening with a clearance of 3m to the eastern knuckle. Although the run was initially recorded as successful, it may be seen that there was minimal margin for error and the ship approached close to a moored PSV downstream of the bridge.

Figure 8.69: Run 28: Outbound Fischland approaching the bridge

Source: HR Wallingford Ship Simulation System

Run 29

In Run 29, the ship passed the bridge at 2.5 knots, 14m from the western knuckle with the bow thruster on 95%. The ship maintained a heading of 359°N once clear of the bridge. The moored ship on Berth 31 influenced the ship's initial track, but the ship was well positioned during the transit through the bridge opening. The ship drifted close to the moored ship on Berth 32, but no contact was made. It was of interest to note that for this run, the wind was the critical factor and although the presence of the bridge was important, it did not influence the outcome. The manoeuvre was considered to be at the limit.

Run 30

In Run 30, the ship passed the bridge with a ground speed of about 2 knots, with a minimum distance of 4m from the eastern knuckle. Figure 8.70 shows the ship with a clearance of 11m to the eastern knuckle.

Figure 8.70: Run 30 Outbound Fischland well positioned in bridge opening

Source: HR Wallingford Ship Simulation System

Run 33

In Run 33, the ship passed through the bridge opening with a minimum clearance of 3m to the western knuckle. Figure 8.71 shows the ship passing through the bridge opening with a minimum clearance of 6m to the eastern knuckle.

Figure 8.71: Run 33: Outbound Fischland with 6m clearance to eastern knuckle

Source: HR Wallingford Ship Simulation System

9. Conclusions

9.1. Overall

The introduction of the bridge clearly modifies navigation conditions in the river. However, in overall terms, in addressing the objective described in Section 1, the simulations demonstrated that navigation through the bridge is feasible in a reasonably wide range of flow and wind conditions for bow first, head in, and stern first transits.

The simulations were also completed with the relevant active berths being occupied by moored vessels upstream and downstream of the bridge.

9.2. Supply vessel operations

The simulations clearly demonstrated that the effects of the bridge being in place are significantly reduced for more manoeuvrable ships such as platform supply vessels, compared with the less manoeuvrable ships. Out of the 11 simulations completed to examine supply vessel operations, only 1 run was rated as being a marginal/fail grading and this transit was carried out in peak ebb conditions at the bridge site.

9.3. Product tanker operations

No difficulties were encountered with an inbound transit with the products tanker, but several attempts were required to refine a strategy for lifting off from Berth 14 and positioning the ship correctly for a stern first transit through the bridge. Once the strategy was developed, the ship was able to transit through the bridge opening with good clearances.

It was noticeable that a more powerful bow thruster would have improved control during stern first transits.

9.4. Short sea dry cargo ship operations

Broadly similar results to the product tanker simulations were obtained with dry cargo ship, although all transits with this ship were completed stern first. Again, the need for a more powerful bow thruster was clearly demonstrated.

10. Recommendations

10.1. Flow modelling

It was evident from several simulations, particularly with the tanker and the dry cargo ship, that the ships were subject to oblique sets that were apparently stronger than the pilots were expecting.

It is possible that these oblique flows are realistic, but it is recommended that the flow modelling is revisited, particularly around the bridge knuckles, as these may have led to several of the contacts with the knuckles that occurred in the simulations.

10.2. Hydraulic design of bridge knuckles

It is recommended that the plan shape of the bridge abutments/knuckles is reviewed. A more swept design and/or flow deflectors may reduce the effect of oblique flows, although it is recognised that these may reduce the length of berthing and/or waiting pontoon frontage available.

10.3. Protective fendering to knuckles

It is understood that the proposed ship impact system, based on discrete, cone fender units arranged around the perimeter of each bridge knuckle, was developed for planning purposes only and that the selected contractor will need to develop a more suitable scheme.

However, it is important to note that the proposed scheme is unsuitable, primarily because there is no load transfer between units and individual cone fenders are likely to be subject to significant sliding forces and/or oblique impacts for which they are not usually designed.

Supply vessels are often fitted with rubbing strakes and large tractor tyres which may catch the ends of the fender units, potentially damaging the vessel and/or the fender units.

10.4. Real time flow information

Real time monitoring of flow speed/direction/level at the bridge should be provided to ship handlers.

10.5. Communications

Suitable communication protocols will need to be developed between ship handlers and the bridge and port VTS staff.

10.6. Pilot familiarisation

Once a final scheme is developed, a programme of simulator based pilot familiarisation should be carried out.

10.7. Sight lines

Sight lines to existing visual features should be maintained if possible. If this is not possible, due to landscaping requirements for example, then supplementary aids to navigation should be considered.

11. References

1. HR Wallingford, Report EX5990, Release 2.0, “Great Yarmouth Third Crossing Navigation Simulation Study,” Release 2.0, June 2009.
2. Peel Ports Great Yarmouth, Document GYPC-PG 2019, Version 2019 D 1.0, “Great Yarmouth Port Guide,” April 2019.
3. Peel Ports Great Yarmouth, “Pilotage Information (River Port and Outer Harbour),” Version 5, October 2014.

Appendices

A. Ship and tug simulation at HR Wallingford

Ship and tug simulation at HR Wallingford

Overview

At HR Wallingford, we operate ten real time simulators from our Ship Simulation Centres in Wallingford, UK and Fremantle, Australia. Our simulators are full bridge, real time manoeuvring simulators specifically designed for port design and ship operations applications, but are also used for training and pilot familiarisation purposes.

They have been developed over 25 years and have been used successfully in over 350 studies world-wide in the last 15 years alone. They have proved to be reliable, flexible and cost-effective design and evaluation tools that can be used for optimising harbour layouts, establishing operational strategy, and training in safe manoeuvring procedures.

We operate a combination of ship simulators and dedicated tug simulators, and to maximise the flexibility of our simulation capability, all of our ship simulators can also be adapted to represent tugs with suitable consoles and controls.

Our simulators are fully integrated such that they can be used to represent one or more piloted ships, or a ship and independently manned tugs, all within the same simulated environment. Alternatively the simulators can be used independently, which enables more "hands-on" time for pilots and tug masters during training or familiarisation sessions. When operating in this mode, an independent ship can also be controlled from another simulators to maximise the training opportunities for tug masters.

The system is capable of real time simulation of vessel behaviour in a range of environmental conditions making the simulators suitable for a wide range of design, assessment and training tasks including:

- Pre-feasibility studies, in the form of desk studies or simulation aided desk studies
- Optimisation of site specific terminal/port/harbour and approach channel designs
- Assessment of safety standards and procedures for shipping and port management operations
- Feasibility studies for new vessels using existing harbours / ports
- Effective training in manoeuvring procedures for pilots, tug masters and ships' officers

A mobile version of the real-time simulator can be used for on-site pilot training and port design.

Ship Simulation Centres

Our Ship Simulation Centres in the UK and Australia house the simulators within a dedicated suite of rooms including separate ship's bridges with their own briefing/observation rooms, control rooms, a dedicated tug bridge, and a conference room.

The ship simulator bridges

For the Ship Simulators the main room in each facility provides a representation of the bridge of a ship. From the bridge, a pilot can view and control ship manoeuvres and monitor the vessel's status throughout the simulation. A wide range of controls can be provided to represent conventional, azipod or other ship specific control systems. The console also provides radar and electronic chart display (ECDIS).

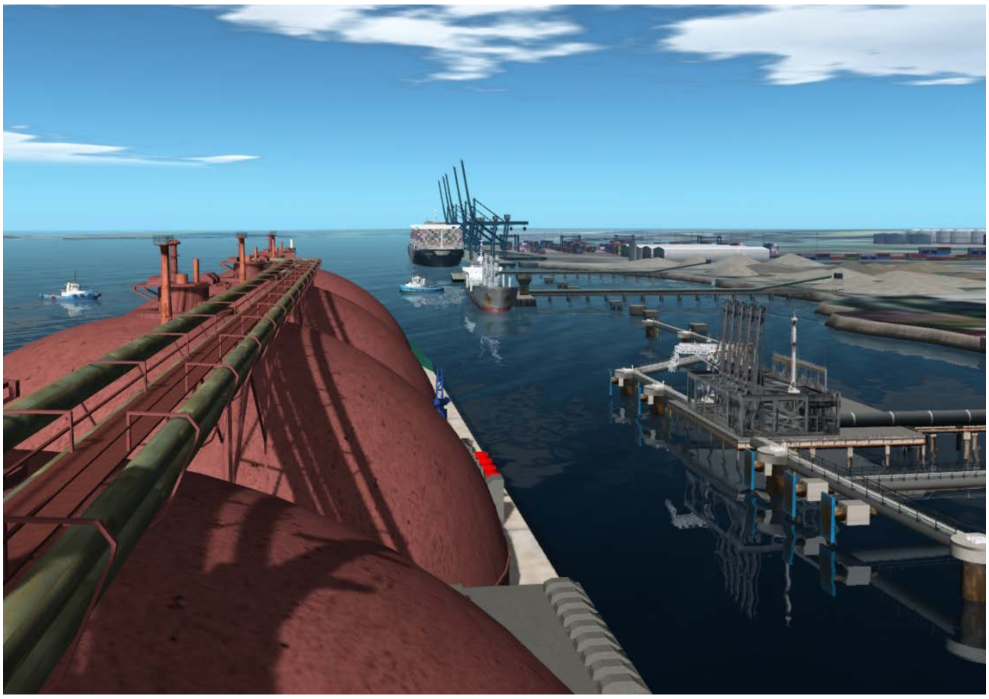
Ship Simulator bridge

Visual scene

The visual scene is a major component of navigation simulation, as piloting a ship or tug is essentially a visual process. Most manoeuvring decisions are made by interpretation of the view from the bridge windows. It is therefore essential that this information is presented in a realistic manner.

Photograph taken at study site

Simulator visual scene



Example visual scene for LNG terminal from ship's starboard bridge wing

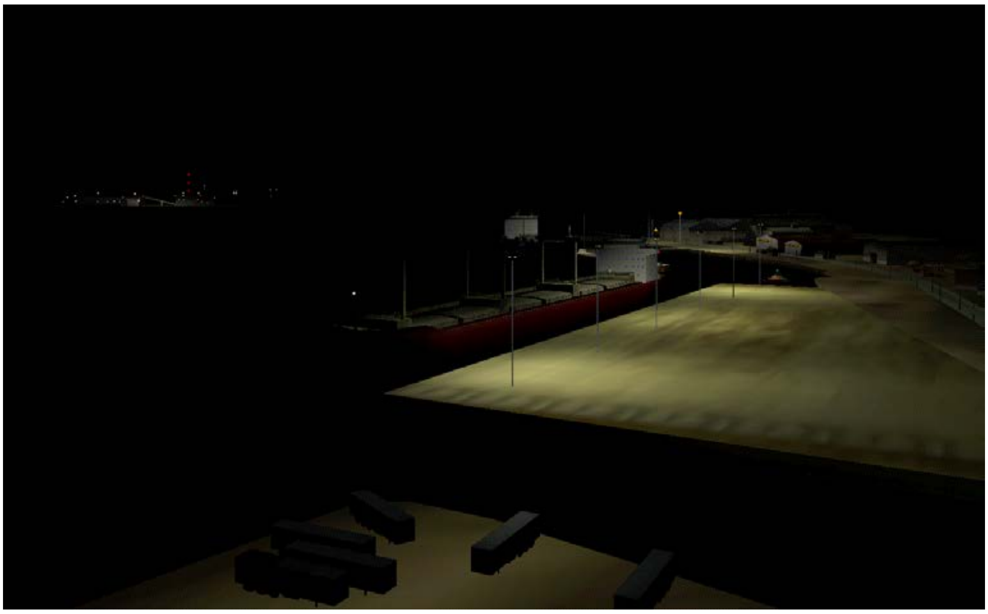
Example visual scene for cruise terminal

The screens wrap around the bridge console and provide a continuous visual angle of 280°, in addition to an astern view presented on a 42" TFT monitor. A "look-around" facility is also incorporated that allows the pilot's viewpoint to be moved from the centre of the bridge to either bridge wing, and all around the ship allowing 360° vision, along with viewing down along the ship's side.

Example visual scene for container terminal

Realistic tug modelling

The lighting level can be adjusted between full daylight and full night time, in a range of visibility conditions, from excellent, long range visibility to thick fog. In night time simulations, shore lights and other vessel lights can be included, and all navigation marks can be set with the correct light configuration and characteristics.



Example visual scene of bulker terminal at night, with ship lights in distance

Example visual scene in mist

Control consoles

The control console on each bridge is flexible, but the conventional configuration has ship helm, engine and thruster controls along with instrument, radar, ECDIS/situation displays.

A range of helm and engine controls are available including:

- Wheel, tiller or joystick or twin rudder controls
- Single or twin engine telegraph controls
- Azipod propulsor controllers
- Bow and stern thruster controls.

Alternative control consoles can also be provided if required.

The instrument display presents information on the ship status including:

- Ground or water speed ahead and athwartships at midships or at bow, stern and midships
- Heading
- Rate of turn in graphical or digital display form
- Depth under the keel in graphical or digital display form
- Relative wind speed and heading
- Engine settings
- Helm indicator, showing applied wheel
- Rudder indicator, showing actual rudder angle.

There is also an electronic situation display available, in place of the ECDIS, where required, which enables the pilot to monitor the ship's position relative to key features. This displays information in the form of a plan view, similar to an electronic chart/ECDIS display, and includes a scaled ship outline and any planned developments in the area of interest.

Tug bridges

The dedicated Tug Simulators comprises a bridge with a chair and two consoles. Similarly to the Ship Simulators, from the bridge a tug master can view and control tug manoeuvres in a realistic manner and can monitor the vessel's status throughout the simulation.

A wide range of controls can be provided to represent ASD, (Aquamaster) type controls, throttle and joystick or Voith Schneider type controls. The consoles also provide radar and electronic chart display (ECDIS), along with line tension meters, where applicable.

In addition, a winch control panel is also provided and the simulated winch can represent a standard, static type winch or a dynamic, render recovery type winch.

As with the Ship Simulators, the tug visual scene is generate using three dimensional, fully textured, computer generated graphics, which are projected onto three large screens at the front of the bridge, and an array of 13 x 50" plasma monitors, to provide a full 360 degree view.

A 3 channel intercom system is available to enable communications with the central Control Room, and the simulated ship when operating in the integrated mode.

Tug Simulator bridges

Tug Simulator bridges

Simulator control room

Each simulation scenario is configured and initiated by a Simulator Operator, who is stationed at a dedicated console in one of the Control Rooms, immediately adjacent to the bridge on each of the Ship Simulators. There is a window and intercom system between the bridge and Control Room allowing full visual and verbal communications at all times. During a simulation run, the operator can monitor the simulation but can also control the application of the tugs (that are not independently controlled), anchors and mooring lines, and adjust light and environment settings as required. The operator can also introduce failures at any time, along with other vessels in the simulation.

Briefing / observation and meeting rooms

Immediately adjacent to each bridge are Briefing/Observation Rooms, with a suite of monitors that relay the instrument and situation displays from the bridge control console, along with simulation visuals, as seen from the bridge.

These enables project team members to observe and monitor the simulation runs without disturbing either the pilot. There are also meeting rooms nearby, which can act as a base for the Client's project team, and where all members of the Simulation Team can gather to discuss each simulation in detail and to consider any issues raised by the runs.

Ship and tug manoeuvring models

Within the simulators, the behaviour of the ship or tug, in terms of its response to any helm and engine actions and the local environmental effects, is governed by a mathematical manoeuvring model which includes the following effects:

- Shallow water effects including increase in turning radius and drag
- Squat
- Bank effects
- Wind response allowing for both lift and drag
- Response to waves
- Response to current
- Tug operations
- Ship to ship interaction
- Collision/contacts with any fixed structure or another vessel
- Mooring lines
- Anchors
- Lock blockage.

Mathematical manoeuvring models are tailored to particular studies based on the design ship(s)/tug(s) dimensions, drawings and, whenever possible, ship trials data. HR Wallingford also has an extensive library of ship and tug models for vessels of different sizes and hull forms.

All ship manoeuvring models are verified by professional mariners/pilots and navigation experts.

Real time navigation simulation runs

During the simulation runs, a professional mariner or pilot is in command of the simulated ship. This may be either a visiting, local pilot, who is familiar with the particular ship or study site, or one of HR Wallingford's experienced pilots.

At the start of each run, the desired scenario (vessel, port layout, tidal state, wind and wave conditions, lighting level and visibility) are configured within the simulator and the ship is initialised with a suitable position, heading, and forward and transverse speeds. During the run, the wind, waves, light levels and visibility can be altered as required. Furthermore, the pilot can call upon the assistance of tugs, which are controlled in response to verbal commands from the pilot.

Effective and appropriate use of tugs is often essential to safe manoeuvring at slow speed. Consequently the performance of assisting tugs needs to be realistically simulated. This is achieved in the Ship Simulators by representing the interaction of a complex series of factors including the type of tug, the number, type and position of the tug's propulsors, the prevailing wind and wave conditions, the location of the tug with respect to the ship (ie. it may be protected from some wave activity by the ship), the ship's speed, the current speed and direction, and the operating mode of the tug.

Alternatively, the Ship Simulator(s) can be integrated with the Tug Simulator so that one or two of the tugs are operated independently by a tug master.

Of particular importance at many sites is the effectiveness of tugs in waves. HR Wallingford has considerable experience of this issue based on detailed discussions and simulated trials with a range of tug operators. This has resulted in a series of tug efficiency curves for varying wave heights and periods for each operational mode.

Any number of other vessels can also be present in the simulation. These can be used as vessels on berths or in passing ship manoeuvres. The position and behaviour of these ships are either controlled in a simplified manner or the two Ship Simulators can be integrated so that a pilot can operate the other ship from other Ship Simulator bridge.

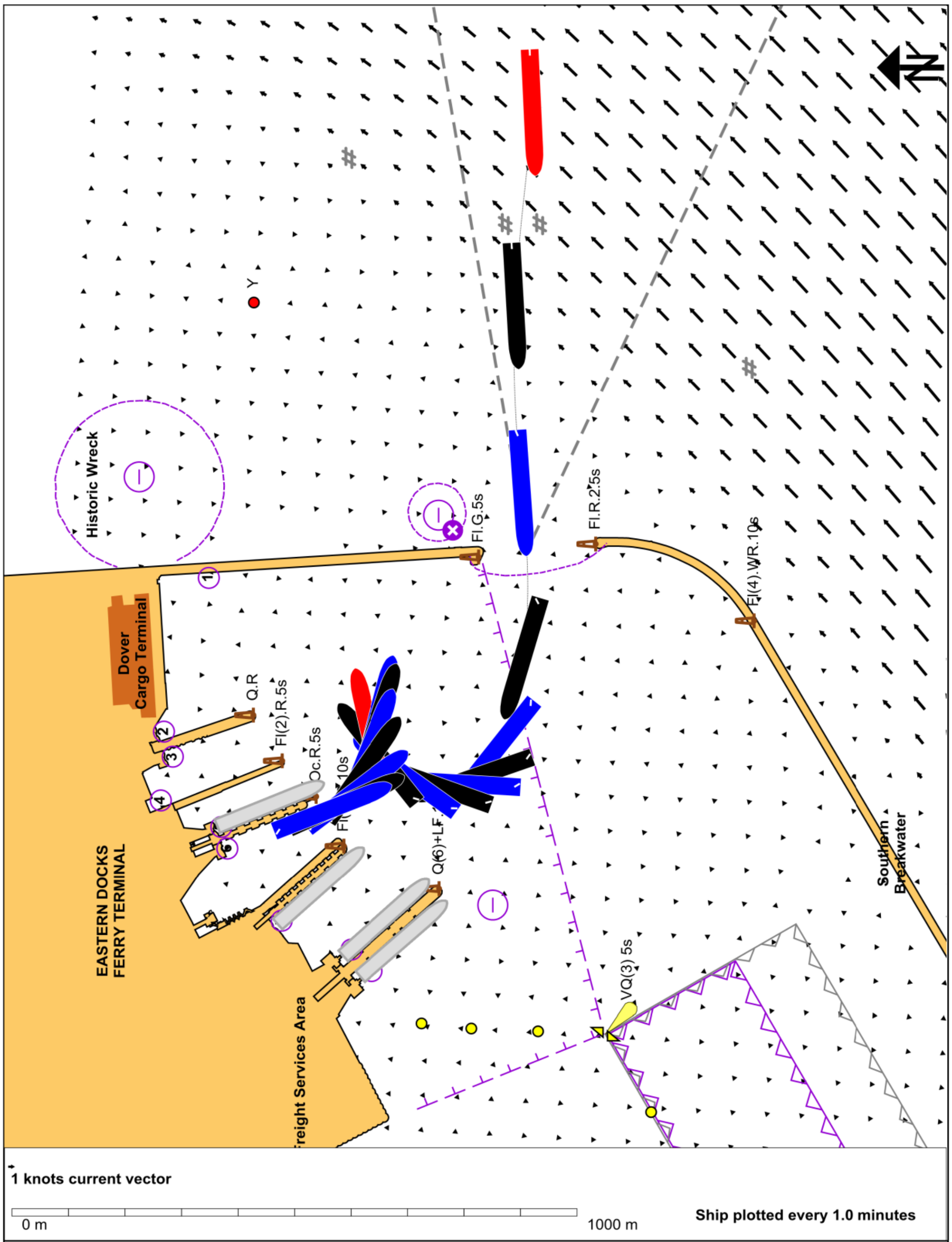
As each simulation run proceeds, the pilot is presented with the visual and other information that allow representative ship handling decisions to be made, based on accepted navigation practice, skill and experience. In particular, the use of experienced mariners ensures that realistic limits of ship controllability are reproduced and accounted for within the simulation.

Simulation data is recorded at an appropriate frequency (typically every 1 second) for later analysis and reporting. The list of data parameters recorded can vary, but typically includes:

- Elapsed time
- Ship position and heading
- Speed and rate of turn
- Rudder and engine settings
- Under keel clearance
- Tug and thruster activity
- Current and wave conditions at the ship
- Position and heading of any target ships.

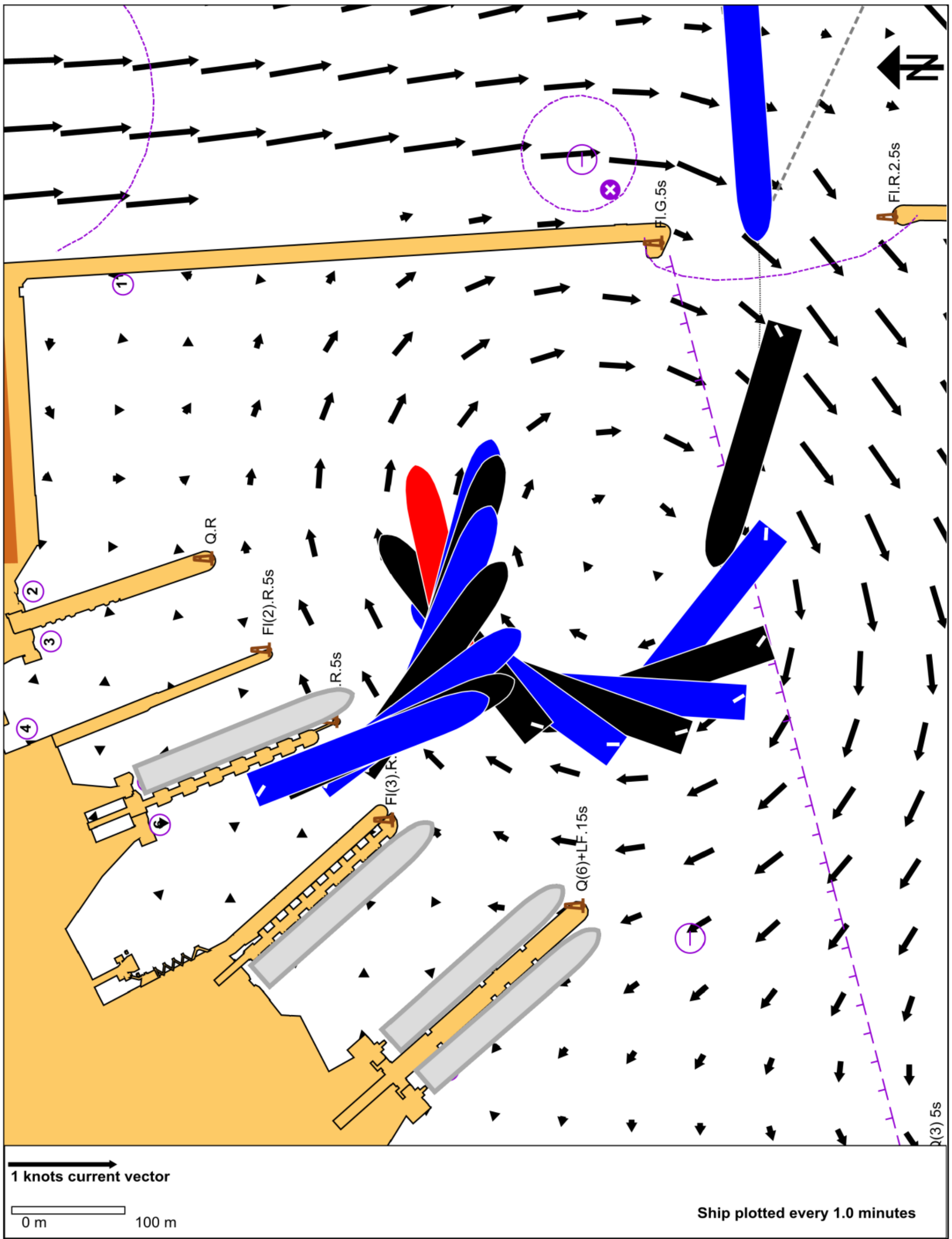
This information is presented in a series of vessel track and data plots as shown in the Figures below.

Demo
Track and Data Plots



Demo		
Run: Example	Pilot: A Smith	Ship: 225m Dover Max Ferry
Initial wind: 045°N 20 knots	Configuration: Dover_HW+1	Type (Condition): RoRo Ferry (none)

Demo
Track and Data Plots
HR Wallingford

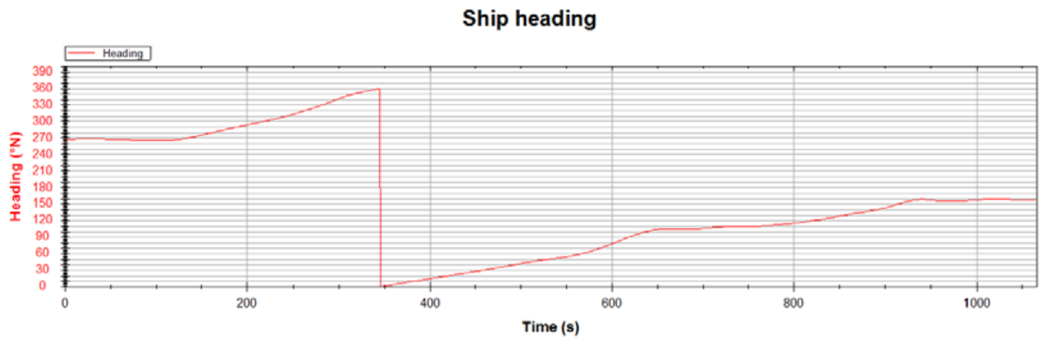


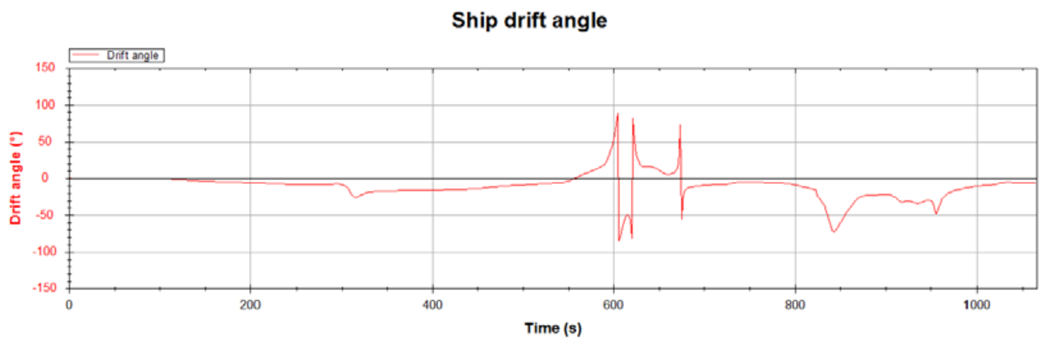
Demo		
Run: Example	Pilot: A Smith	Ship: 225m Dover Max Ferry
Initial wind: 045°N 20 knots	Configuration: Dover_HW+1	Type (Condition): RoRo Ferry (none)

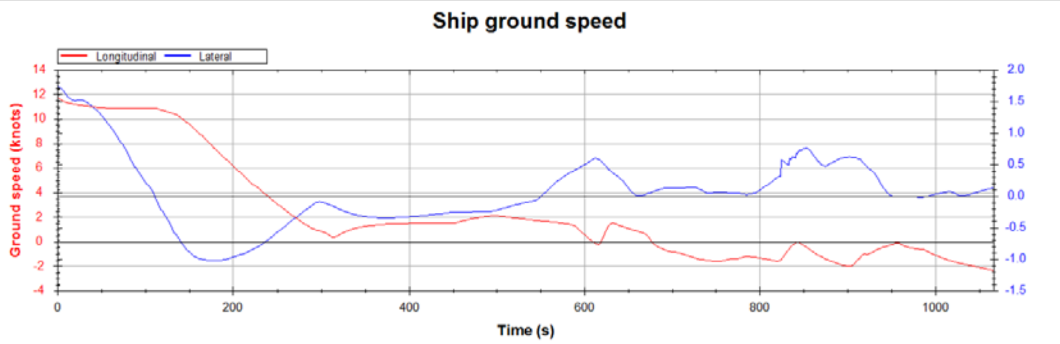
Run: Example Page 2 of 5

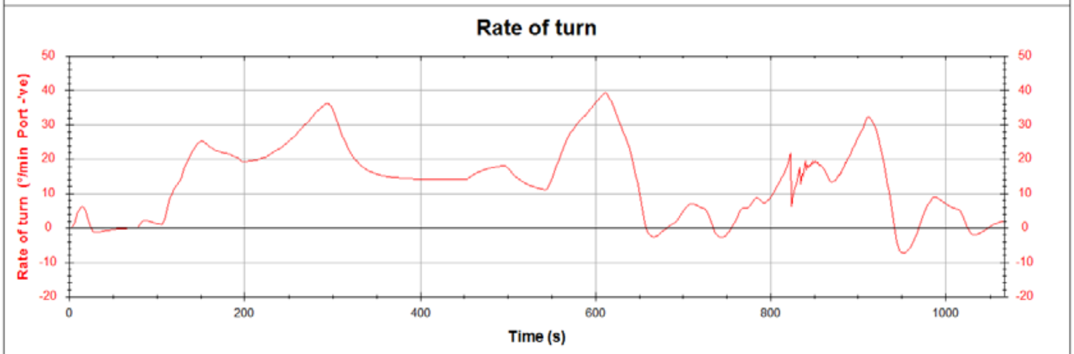
Demo
Track and Data Plots

HR Wallingford









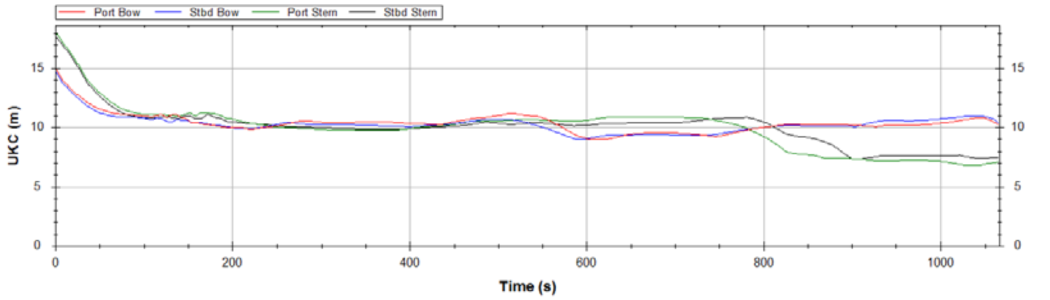
Demo

Run: Example	Pilot: A Smith	Ship: 225m Dover Max Ferry
Initial wind: 045°N 20 knots	Configuration: Dover_HW+1	Type (Condition): RoRo Ferry (none)

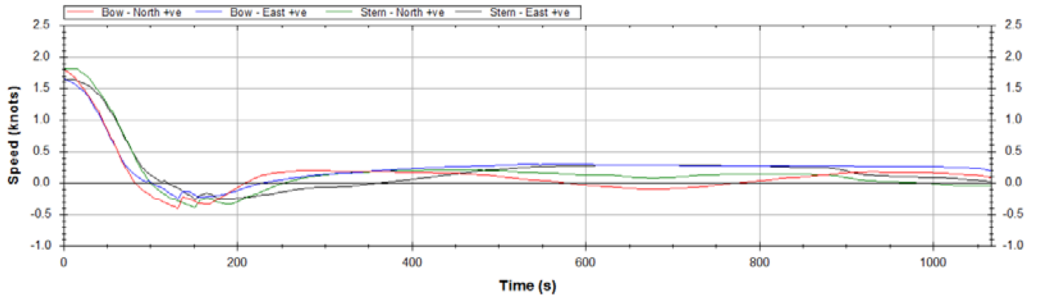
Run: Example Page 3 of 5

Demo
Track and Data Plots
HR Wallingford

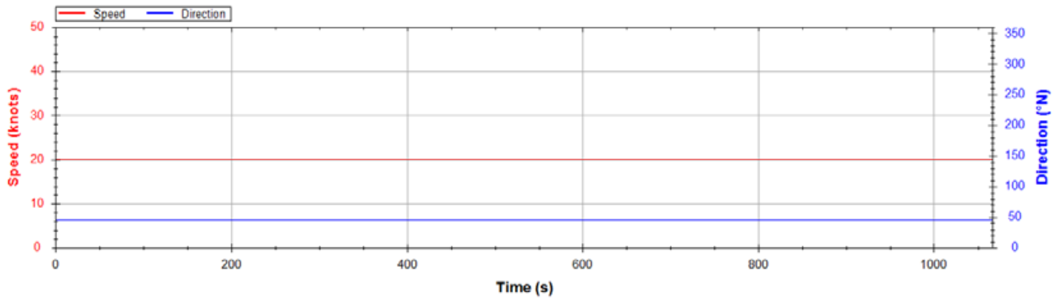
Underkeel clearance



Currents



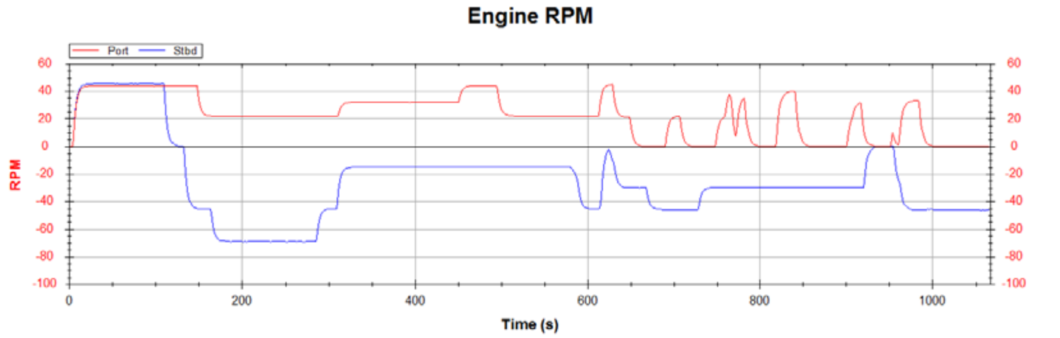
Wind speed and direction

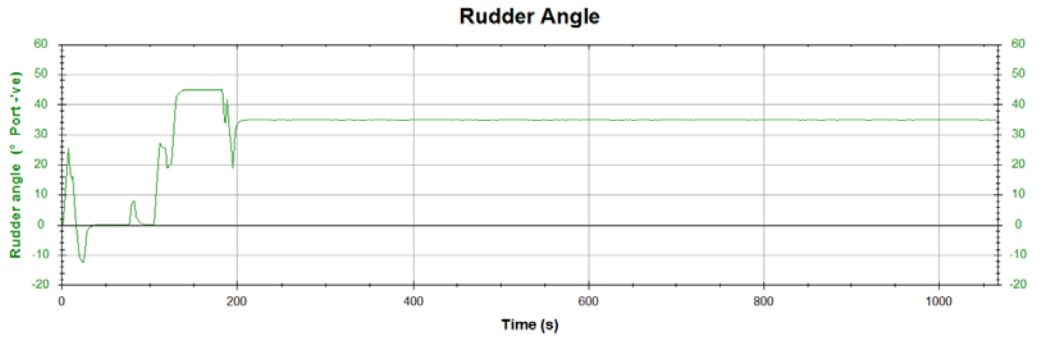


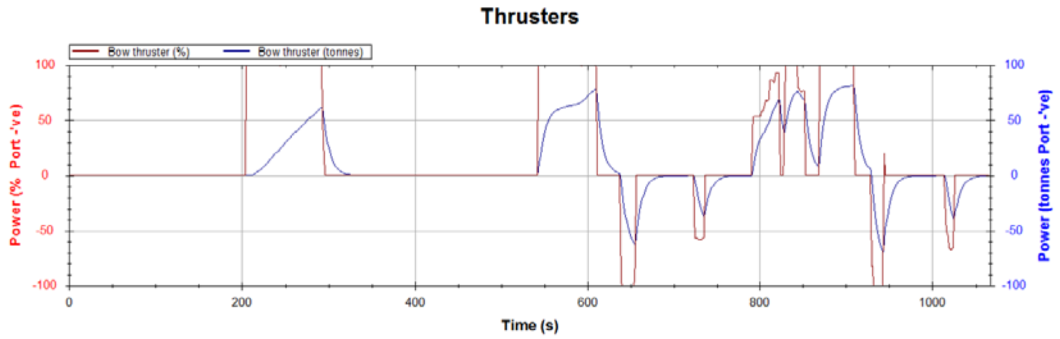
Demo		
Run: Example	Pilot: A Smith	Ship: 225m Dover Max Ferry
Initial wind: 045°N 20 knots	Configuration: Dover_HW+1	Type (Condition): RoRo Ferry (none)

Run: Example Page 4 of 5

Demo
Track and Data Plots







Demo		
Run: Example	Pilot: A Smith	Ship: 225m Dover Max Ferry
Initial wind: 045°N 20 knots	Configuration: Dover_HW+1	Type (Condition): RoRo Ferry (none)

B. Simulation track and data plots

C. CDM Regulations 2015 considerations

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:

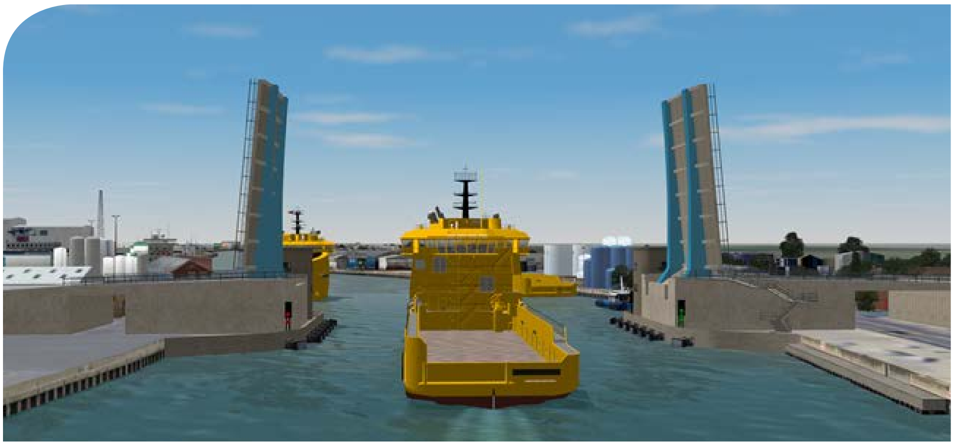
http://www.hse.gov.uk/construction/cdm/2015/index.htm

This project consists of modelling work, real time navigation simulation studies 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 but there are 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. These issues are as follows:

- The proposed protective fendering system is considered unsuitable. Several of the simulations resulted in oblique or sliding contacts (impacts) with the fender system which individual fenders are not normally designed for
- Approach speeds of 7 knots were noted at the bridge
- The plan shape of the abutments may result in oblique flows which may impair a ship handler’s ability to control the vessel
- Landscaping may obscure visual reference points that are currently used by ship handers.

It is assumed that the appointed principal designer will review the information produced in this study when discharging his duties under the CDM 2015.

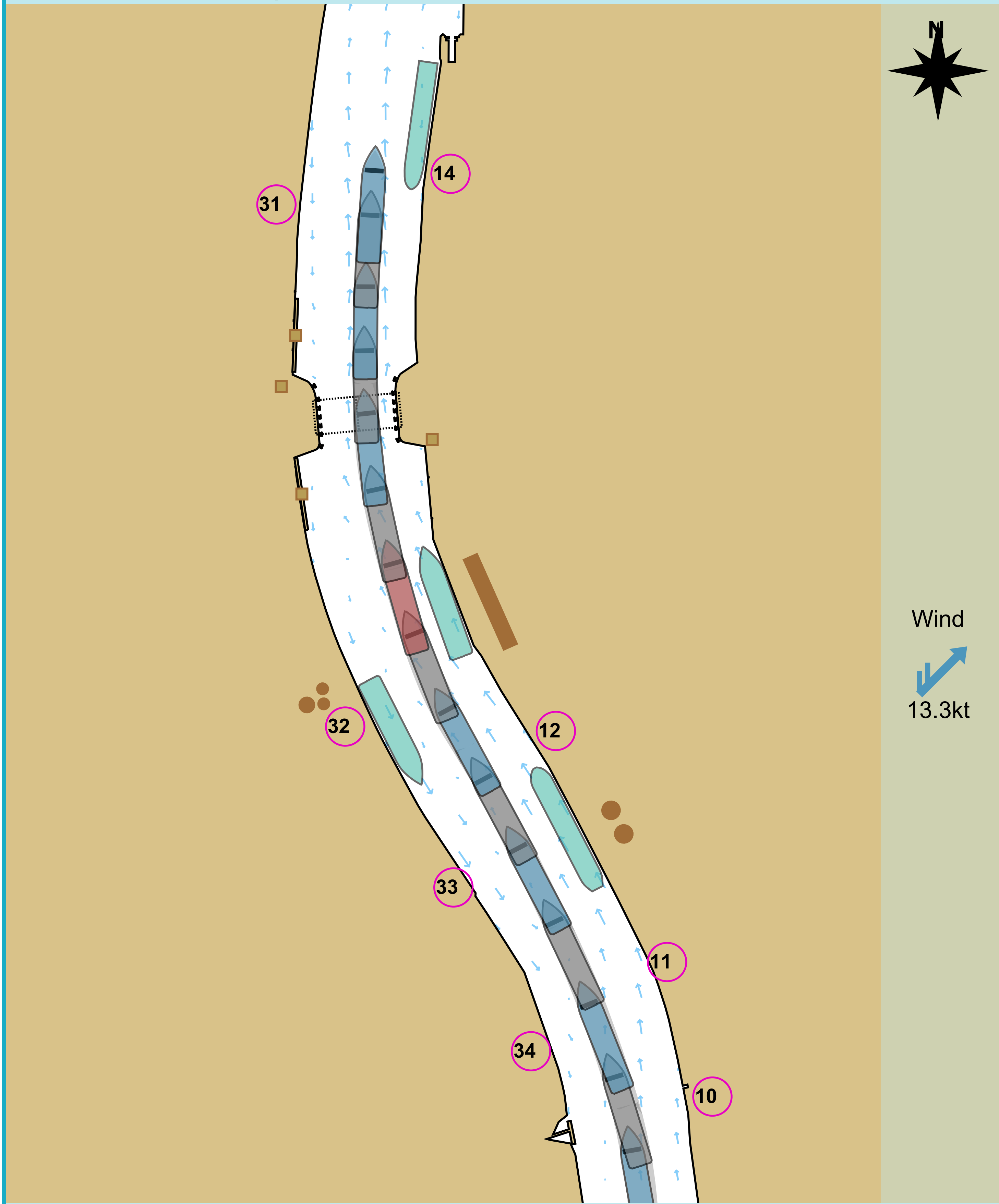
HR Wallingford
Working with water



HR Wallingford is an independent engineering and environmental hydraulics organisation. We deliver practical solutions to the complex water-related challenges faced by our international clients. A dynamic research programme underpins all that we do and keeps us at the leading edge. Our unique mix of know-how, assets and facilities includes state of the art physical modelling laboratories, a full range of numerical modelling tools and, above all, enthusiastic people with world-renowned skills and expertise.

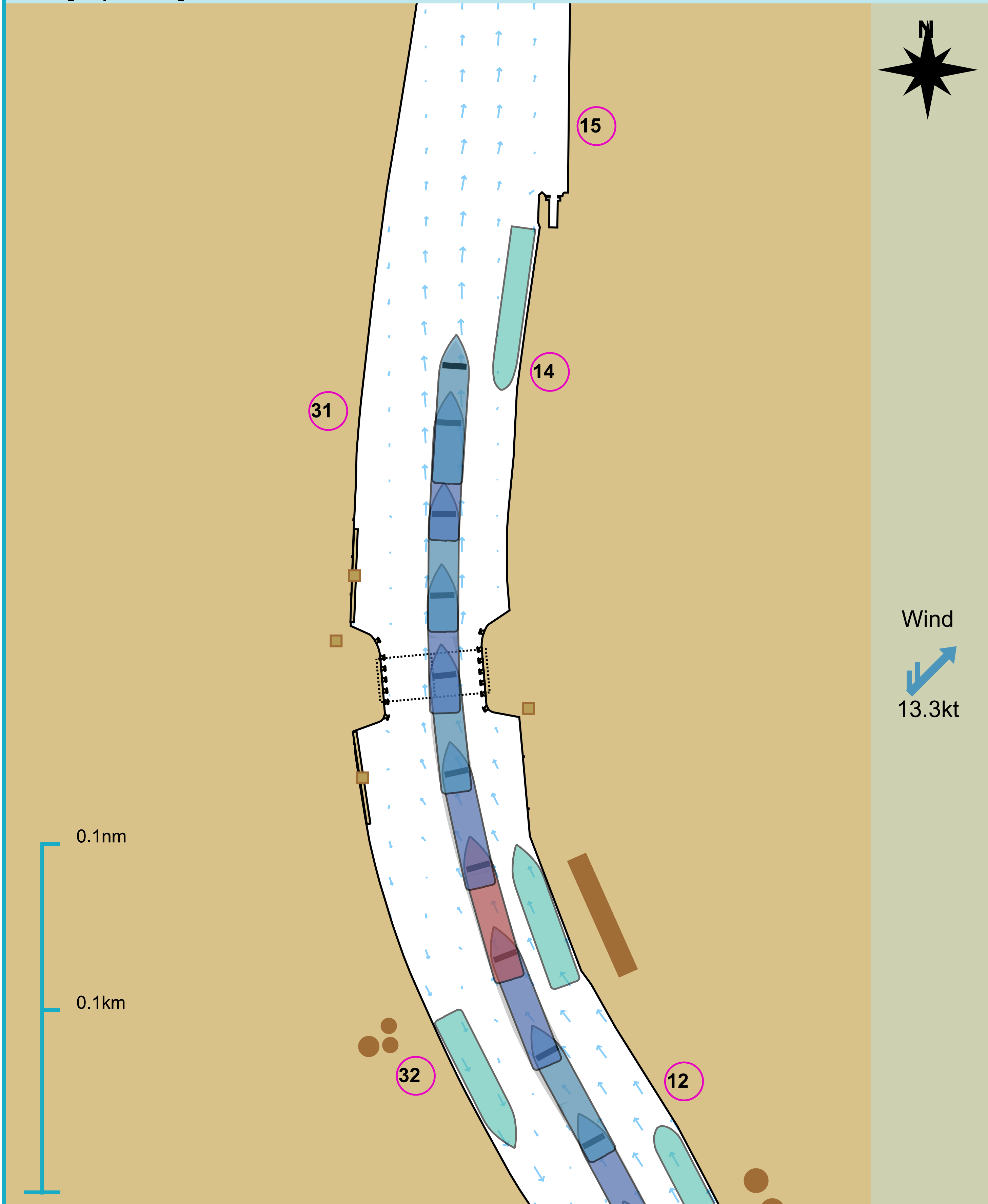
HR Wallingford, Howbery Park, Wallingford, Oxfordshire OX10 8BA, United Kingdom
tel +44 (0)1491 835381 fax +44 (0)1491 832233 email info@hrwallingford.com
www.hrwallingford.com

Manoeuvre track plot

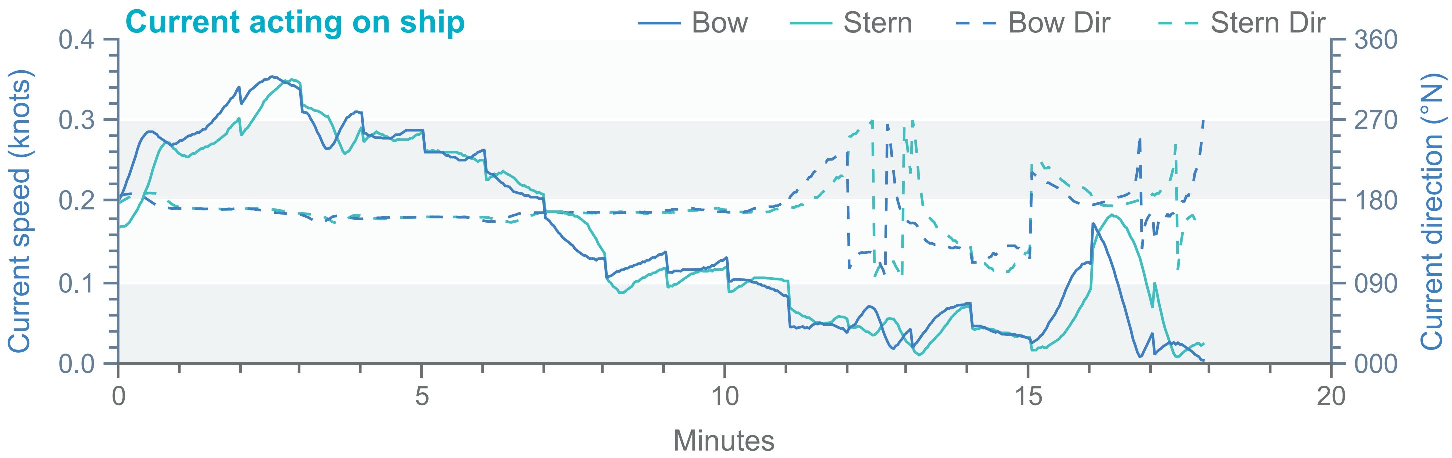


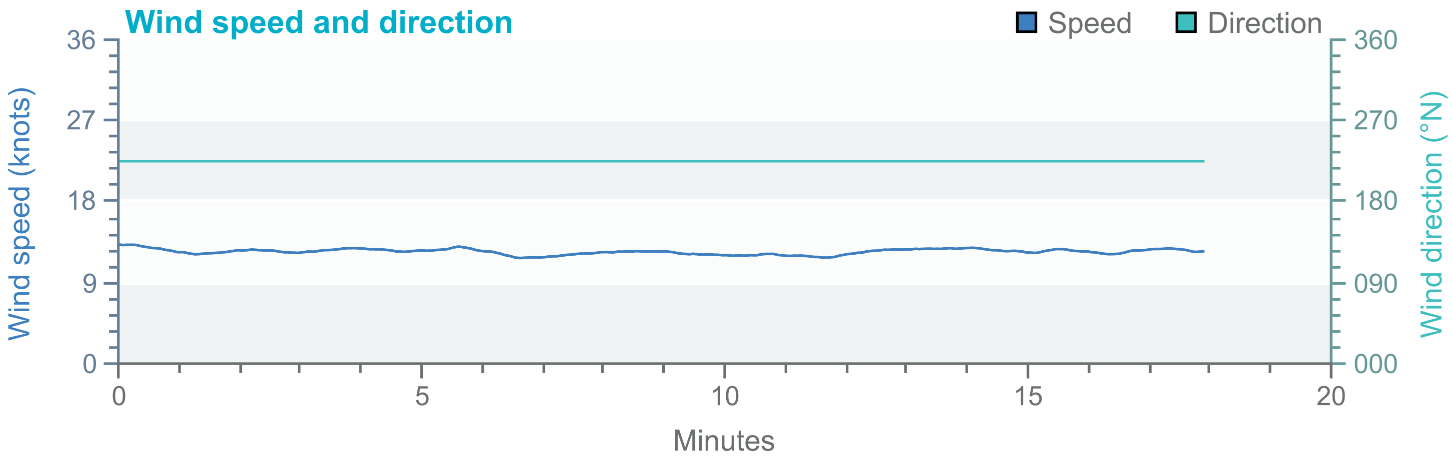
Ships plotted every 0 mins, highlight every 5 mins

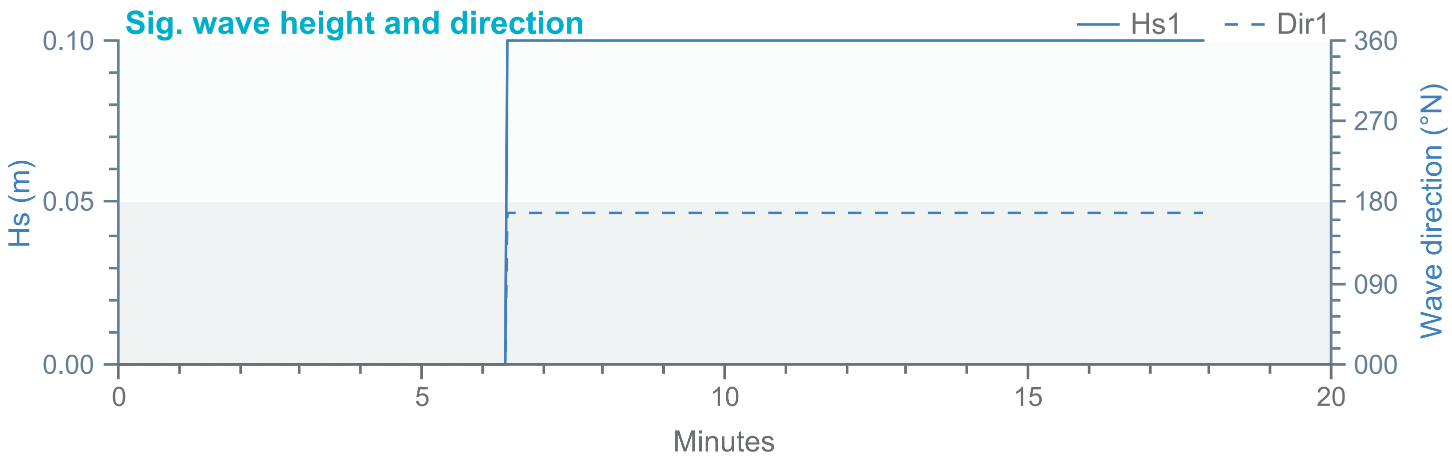
Bridge passage

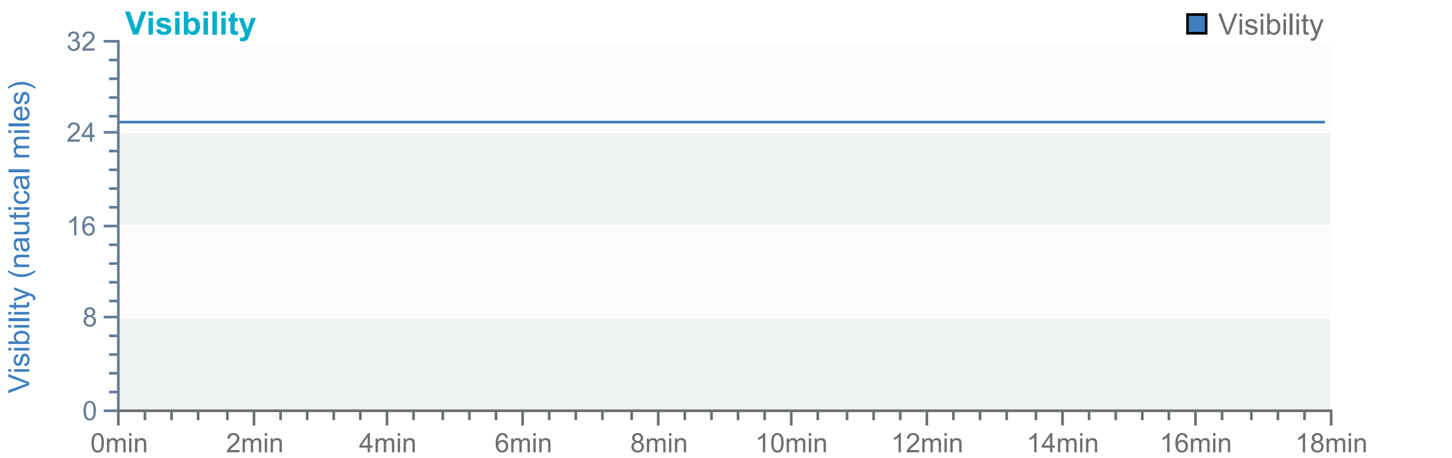


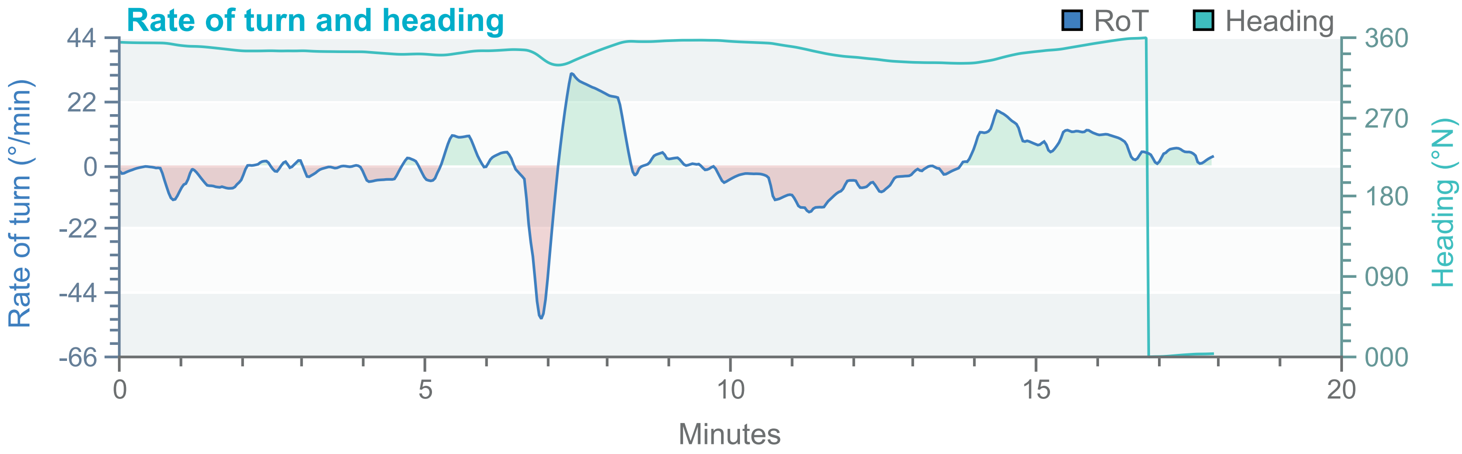
Ships plotted every 0 mins, highlight every 5 mins

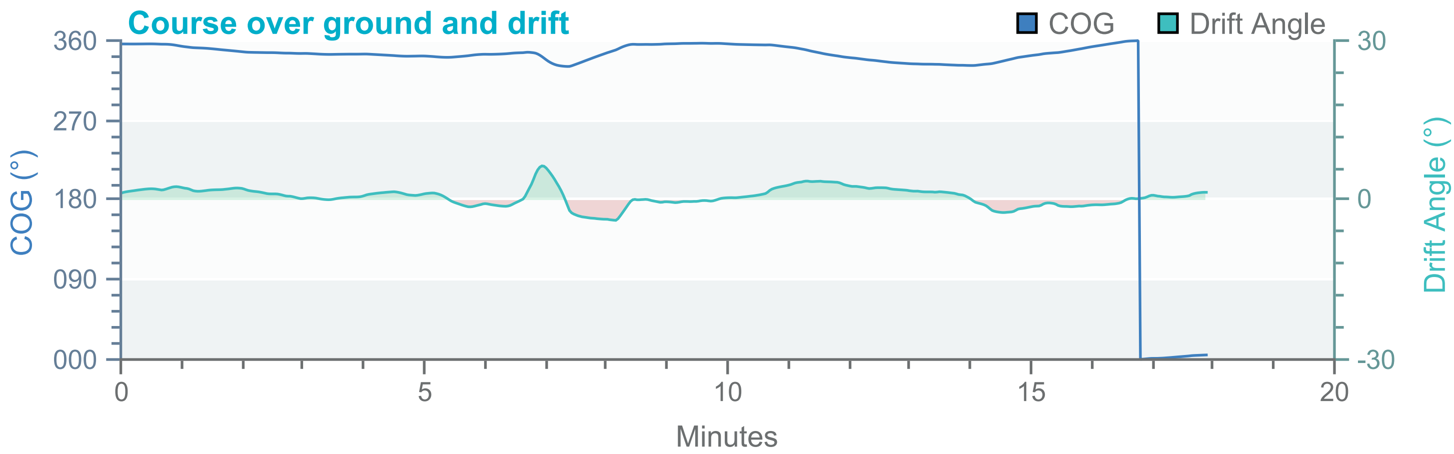

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
0.4
0.3
0.2
0.1
0.0
360
270
180
090
000
0
5
10
15
20

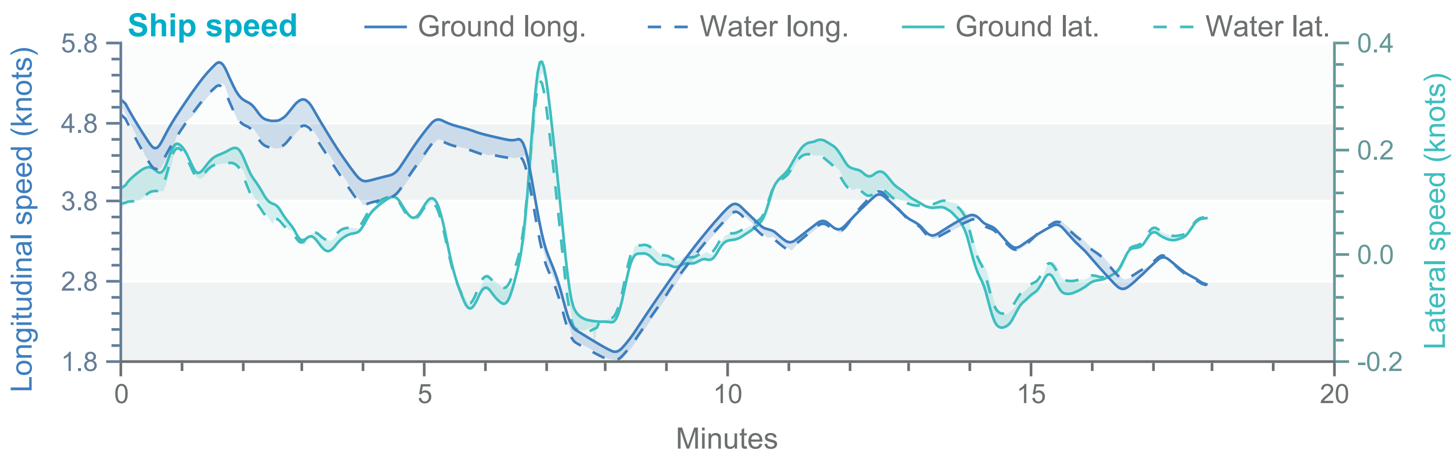

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20

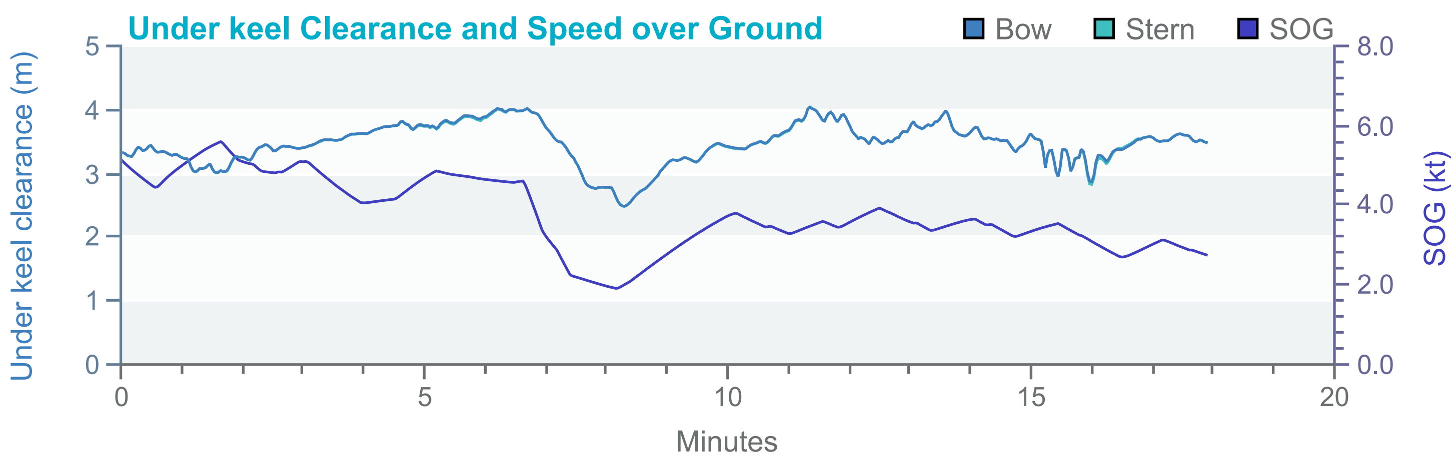

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min

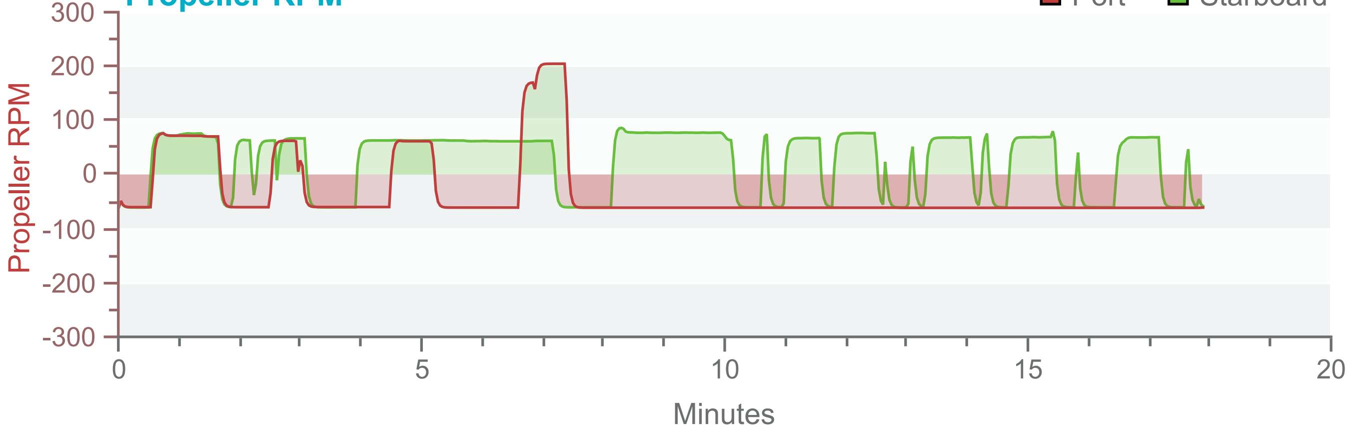

Rate of turn and heading
RoT
Heading
44
22
0
-22
-44
-66
Rate of turn (°/min)
360
270
180
090
000
Heading (°N)
0
5
10
15
20
Minutes


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

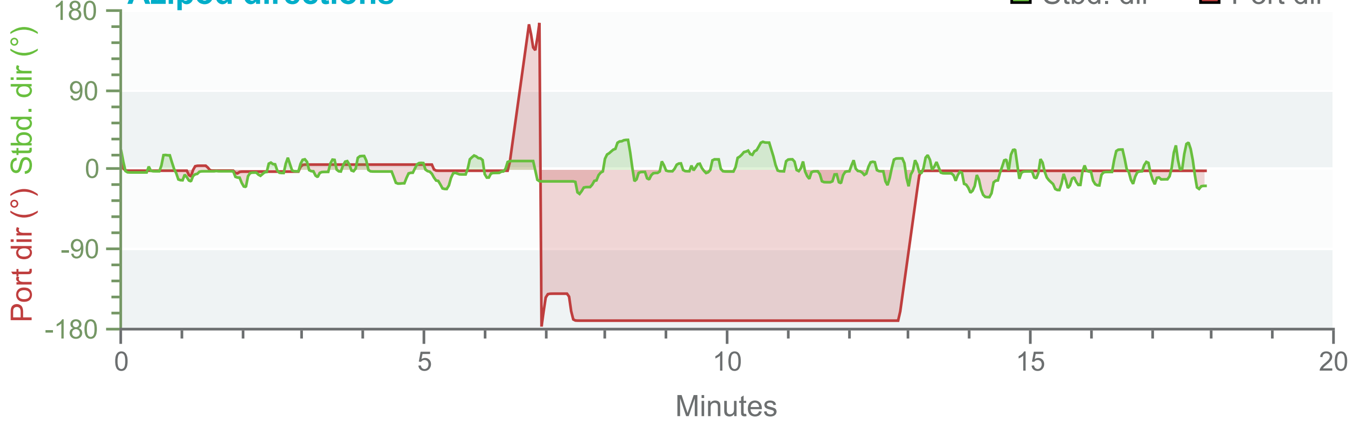

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
5.8
4.8
3.8
2.8
1.8
Longitudinal speed (knots)
0.4
0.2
0.0
-0.2
Lateral speed (knots)
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
5
4
3
2
1
0
Under keel clearance (m)
8.0
6.0
4.0
2.0
0.0
SOG (kt)
0
5
10
15
20
Minutes

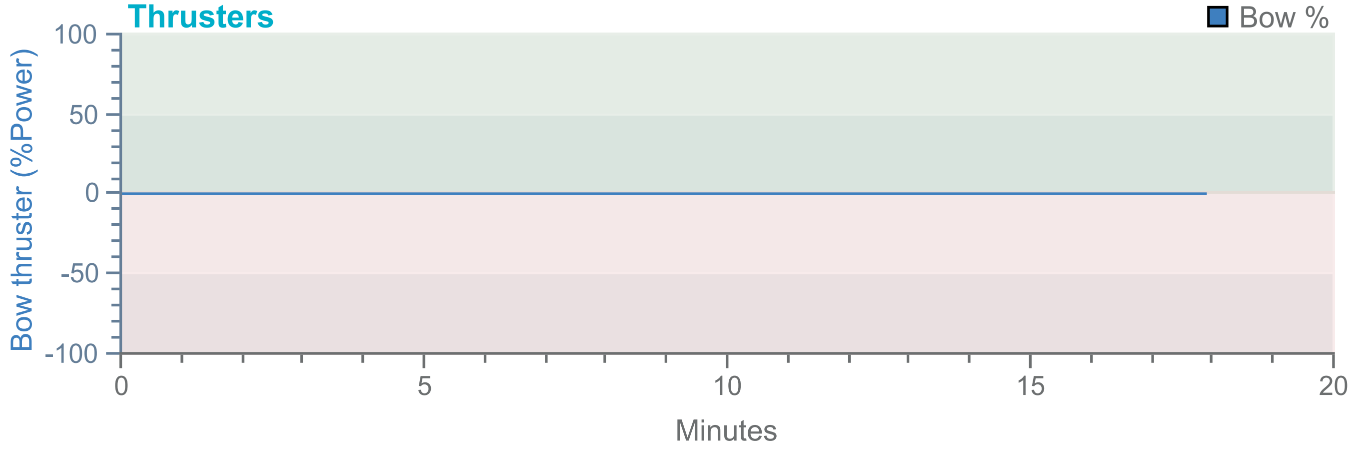
Propeller RPM



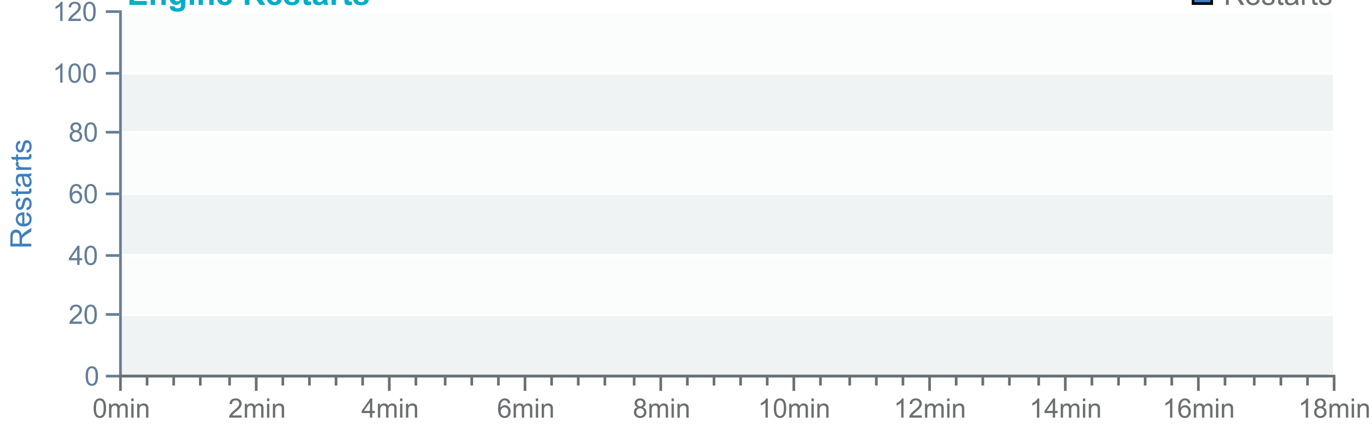
Azipod directions



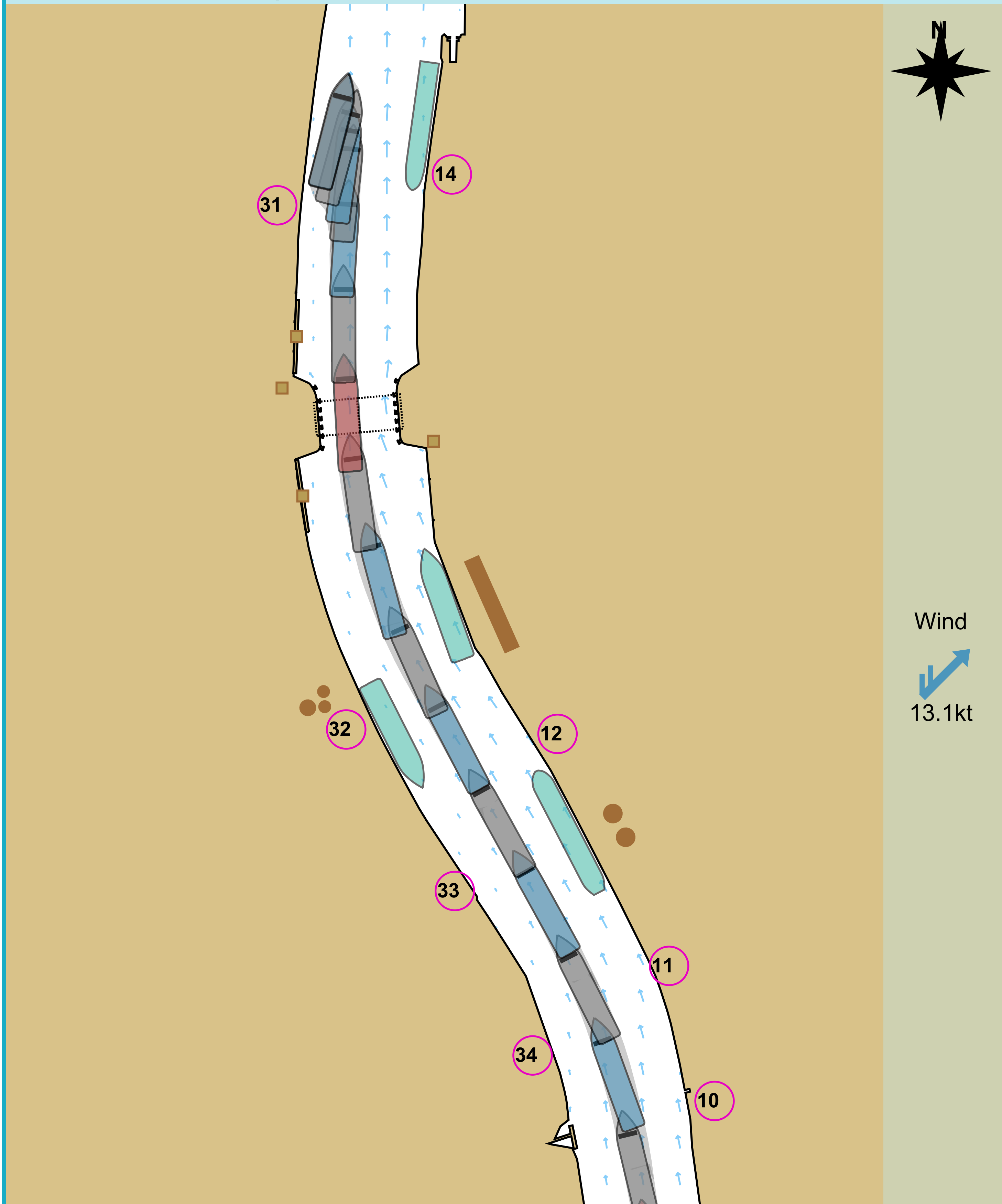
Thrusters



Engine Restarts

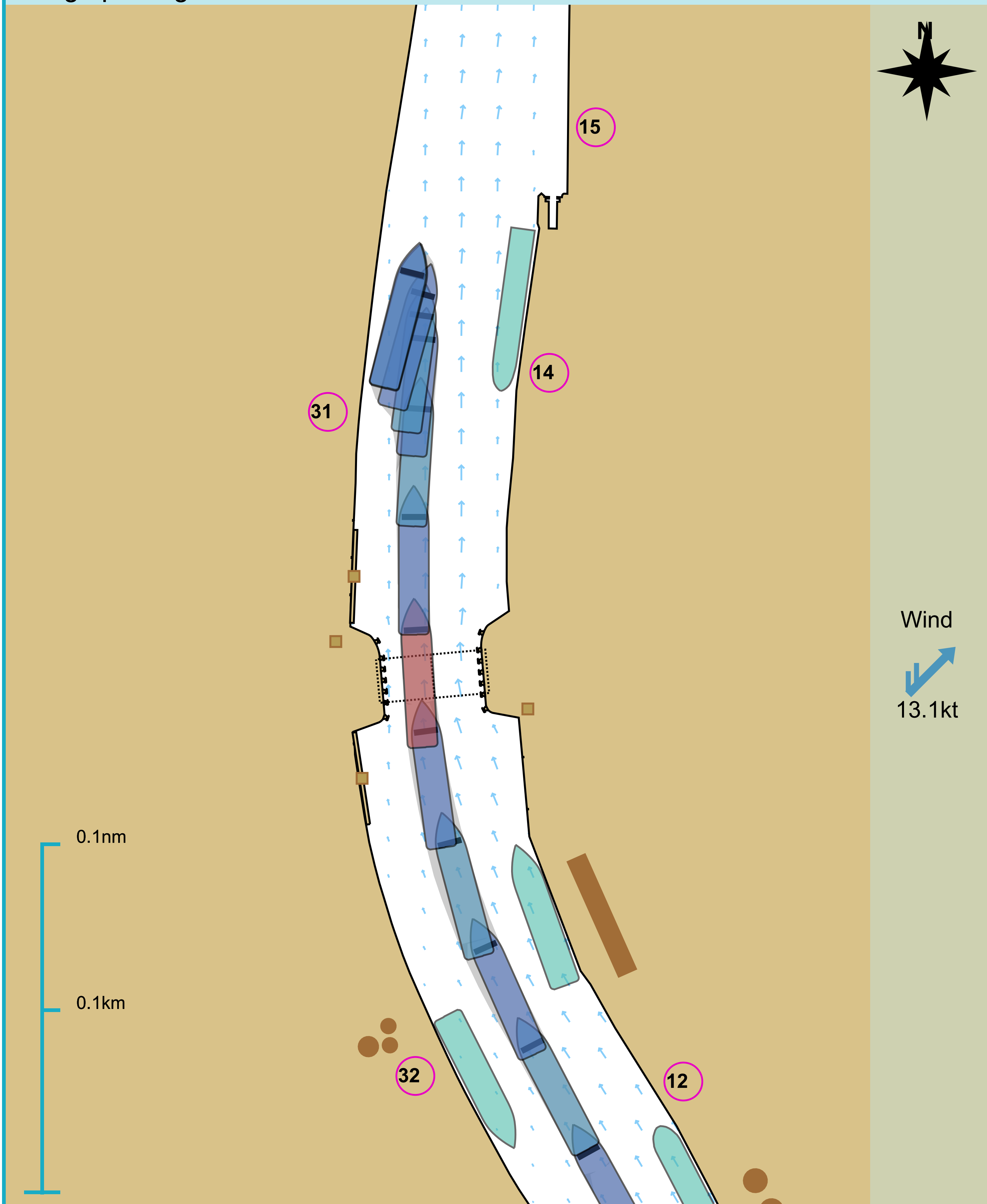


Manoeuvre track plot

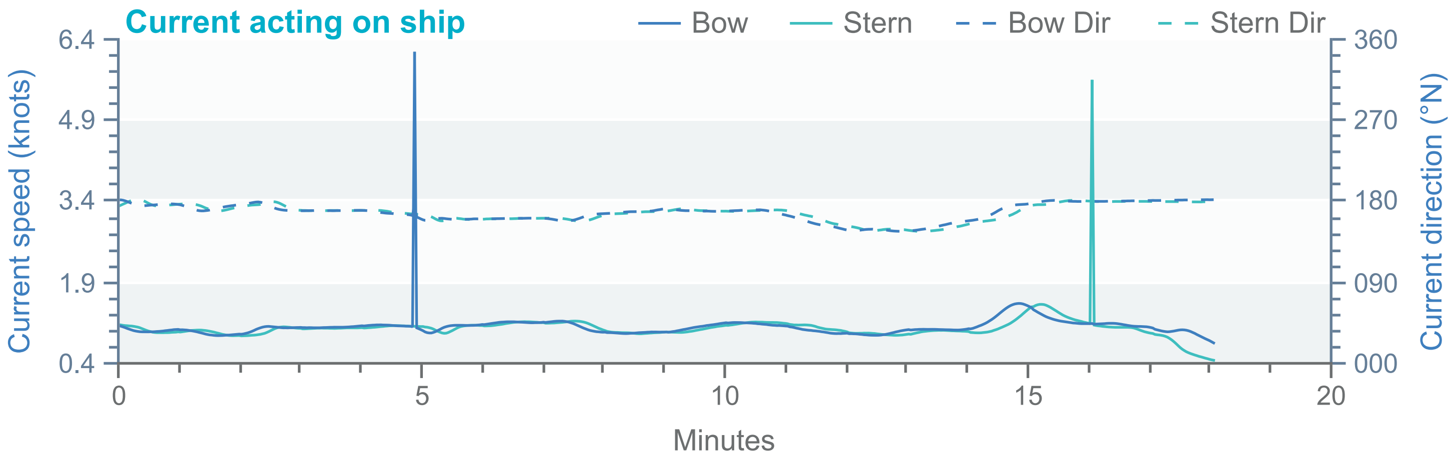


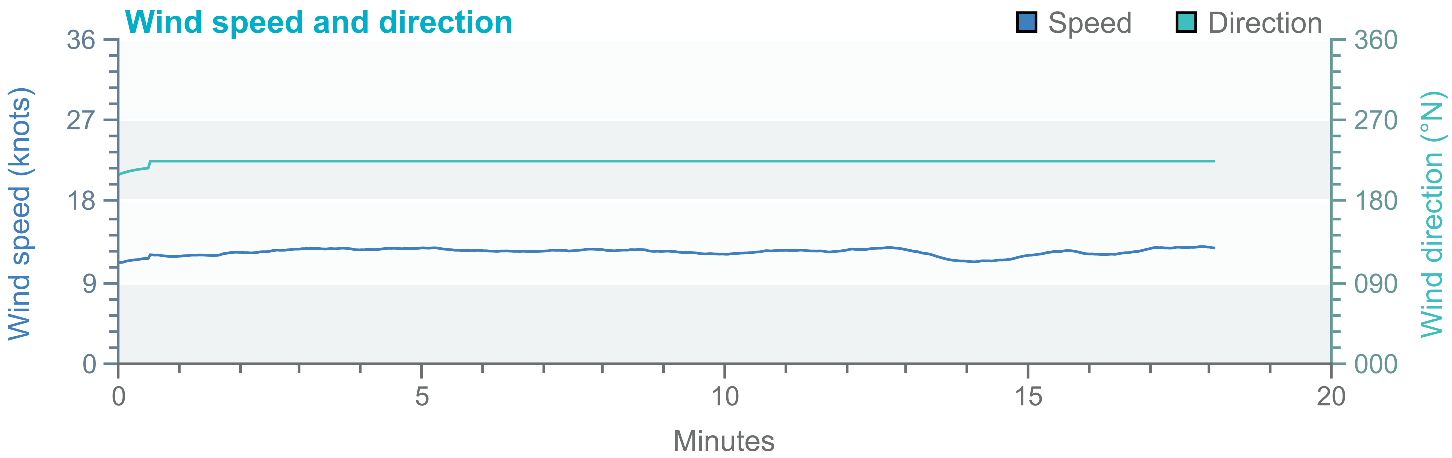
Ships plotted every 0 mins, highlight every 5 mins

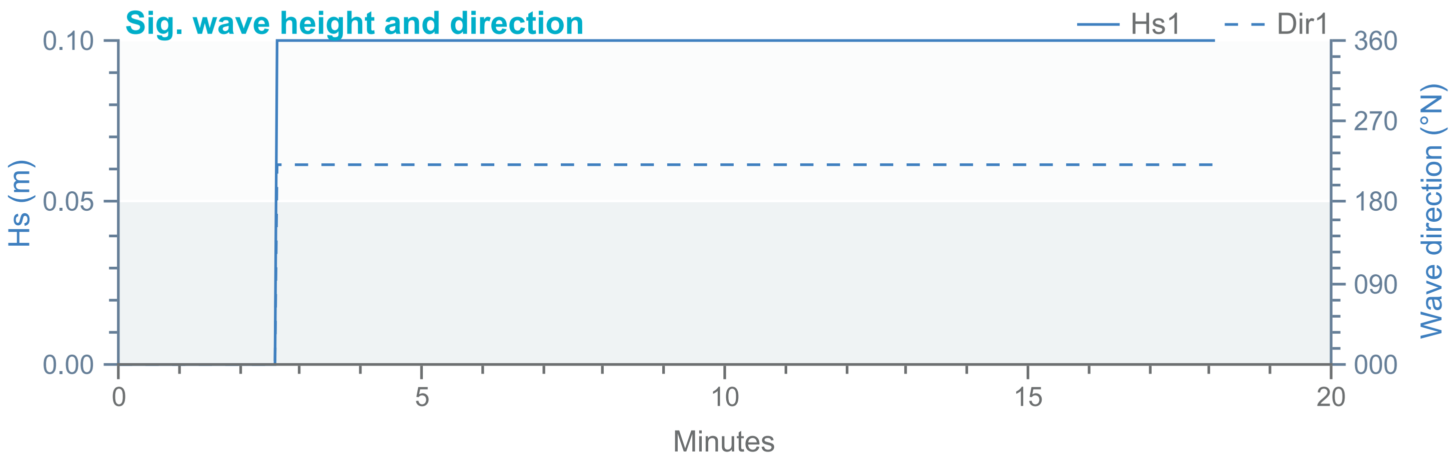
Bridge passage

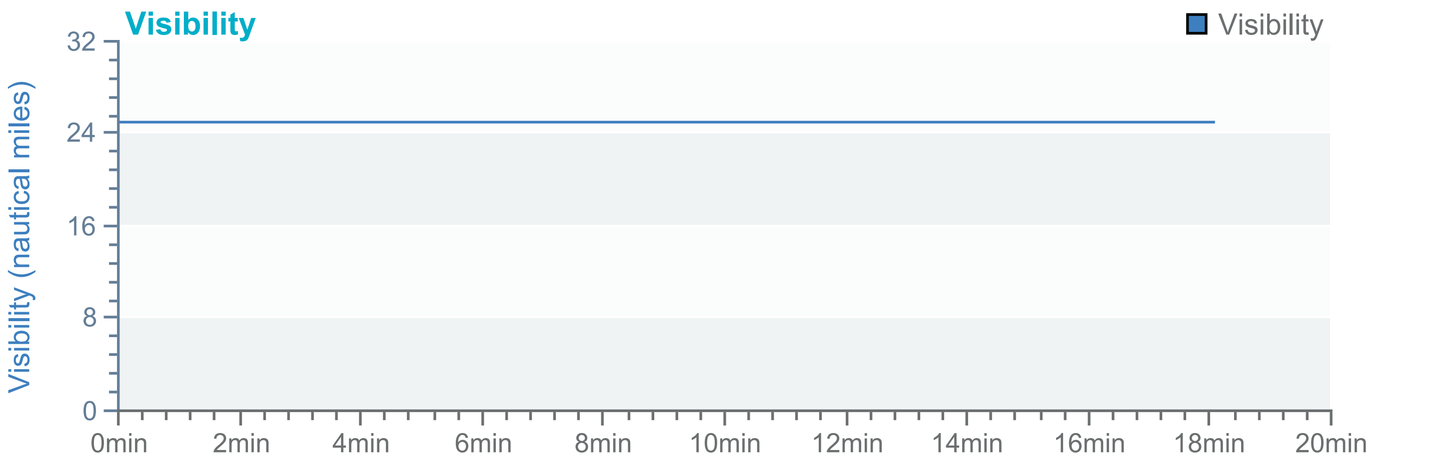


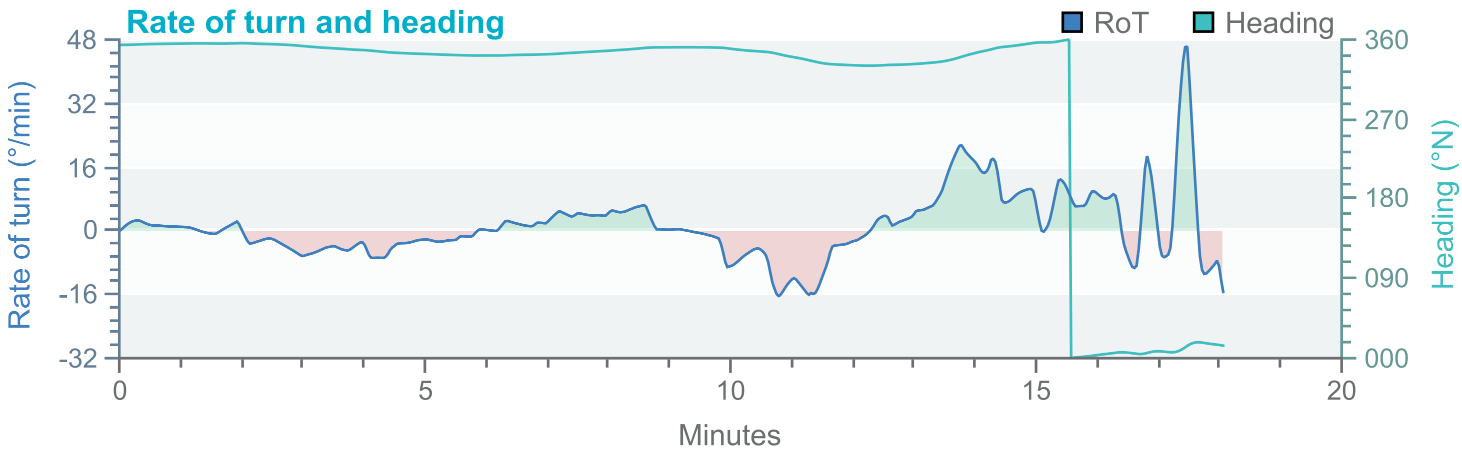
Ships plotted every 0 mins, highlight every 5 mins

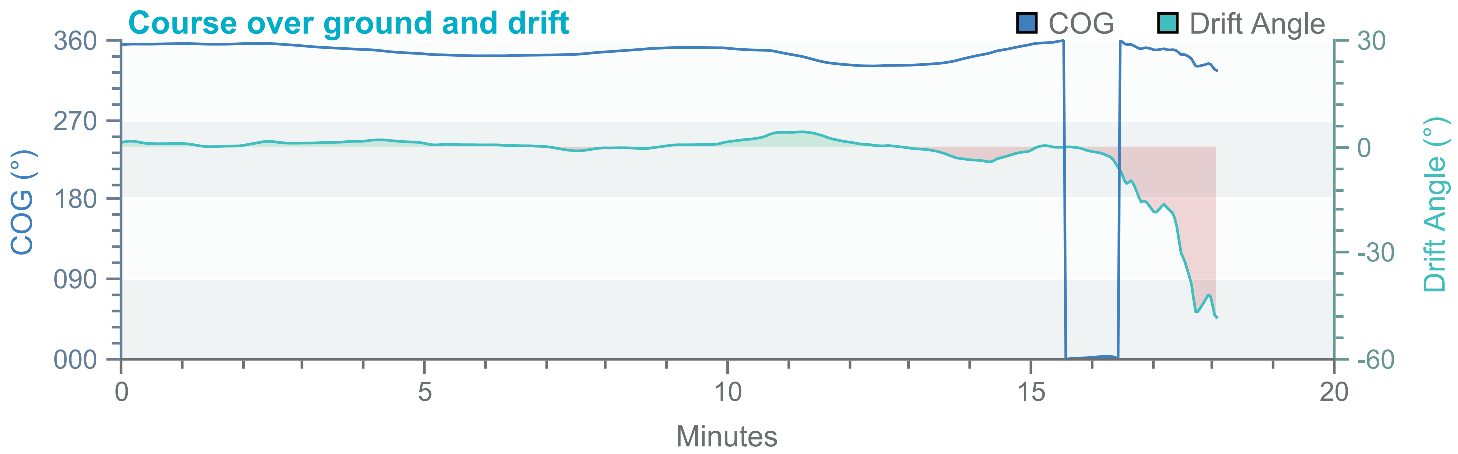

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
6.4
4.9
3.4
1.9
0.4
360
270
180
090
000
0
5
10
15
20
Minutes

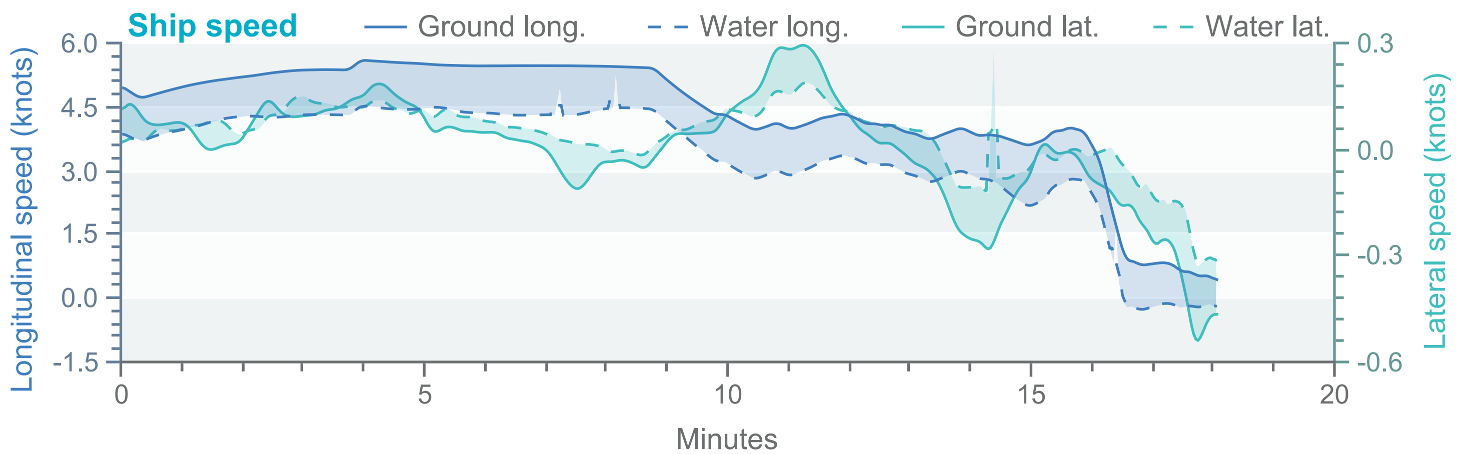

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
Minutes

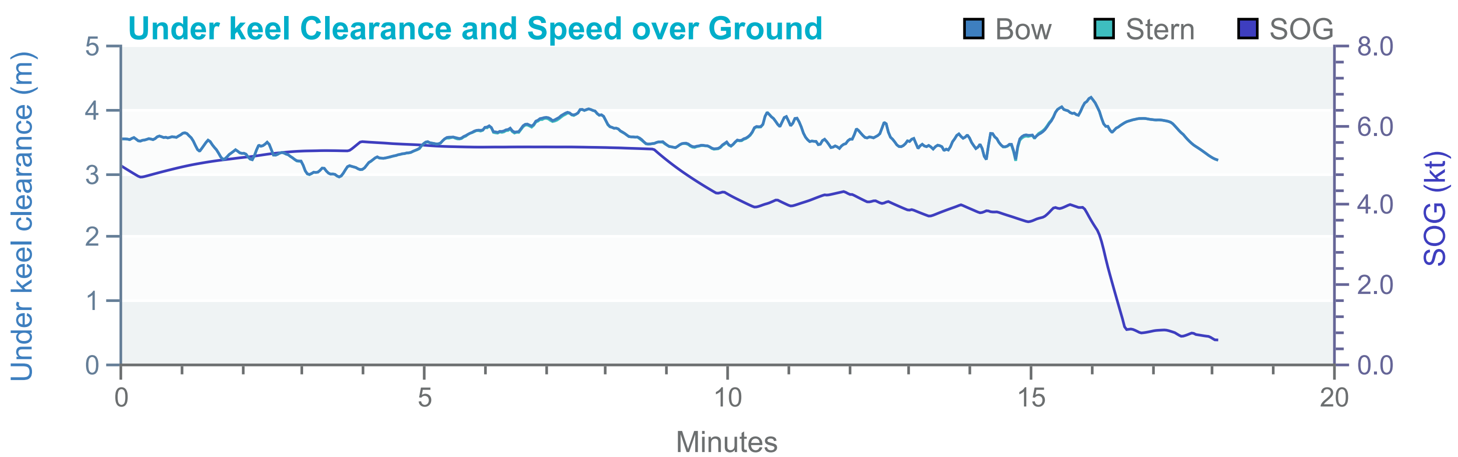

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
Minutes

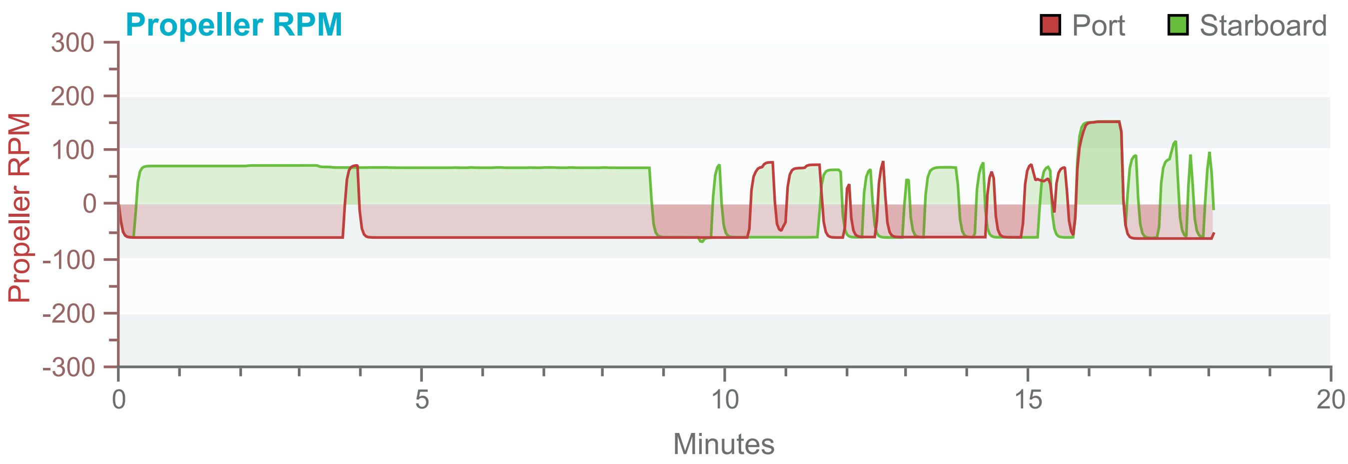

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

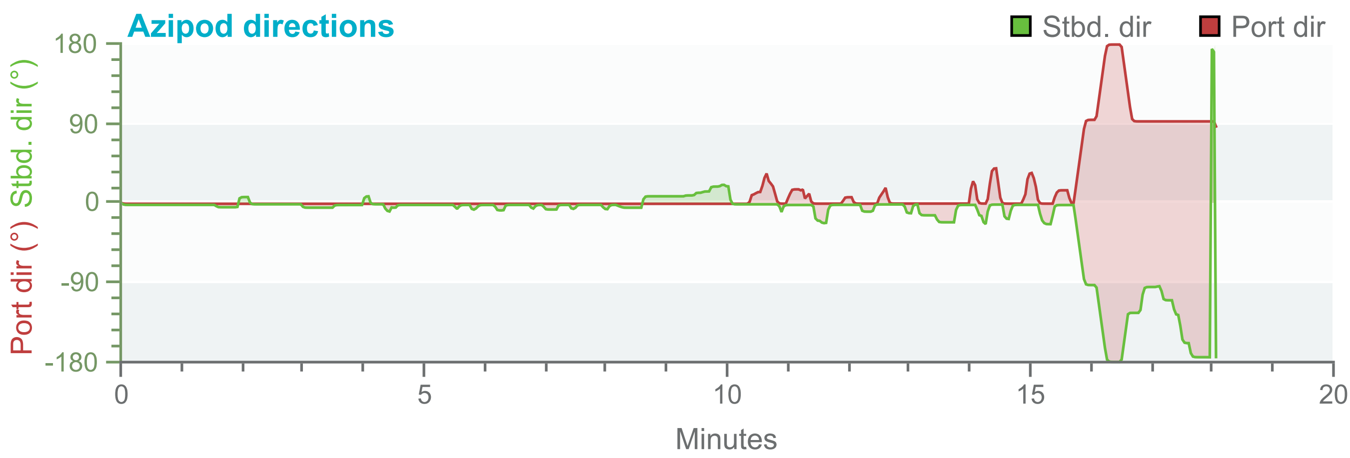

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
Minutes
48
32
16
0
-16
-32
360
270
180
090
000
0
5
10
15
20

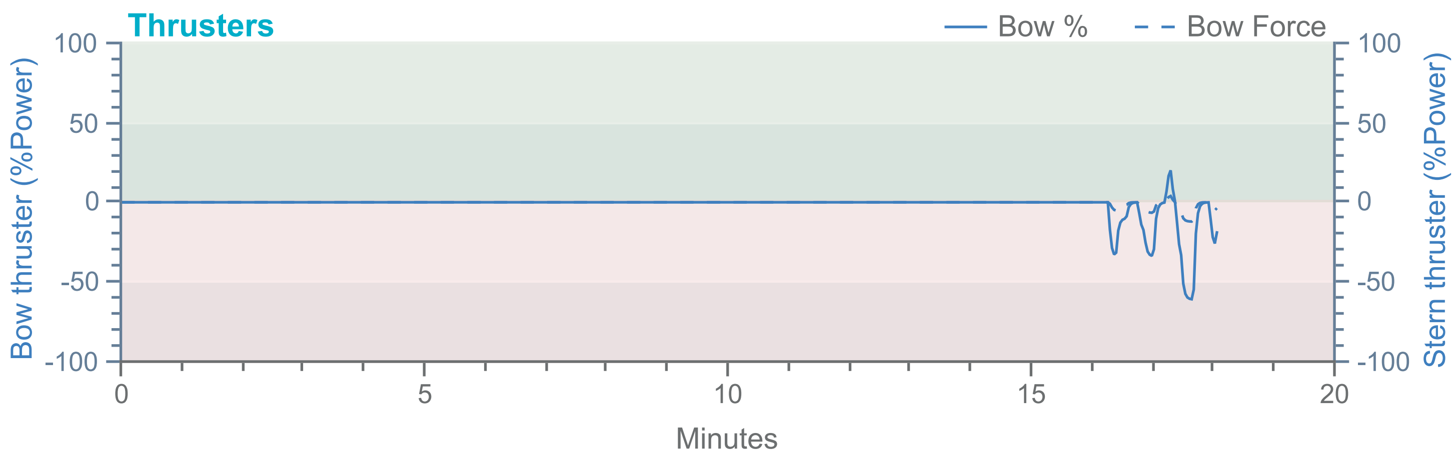

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Minutes
360
270
180
090
000
30
0
-30
-60
0
5
10
15
20

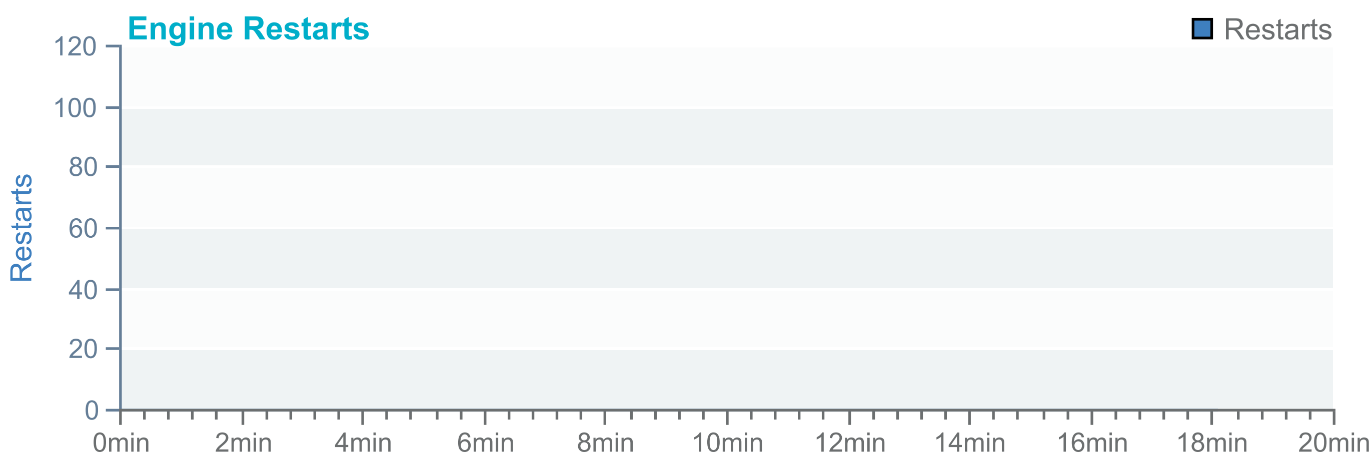

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
Minutes
6.0
4.5
3.0
1.5
0.0
-1.5
0.3
0.0
-0.3
-0.6
0
5
10
15
20


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
Minutes
5
4
3
2
1
0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20

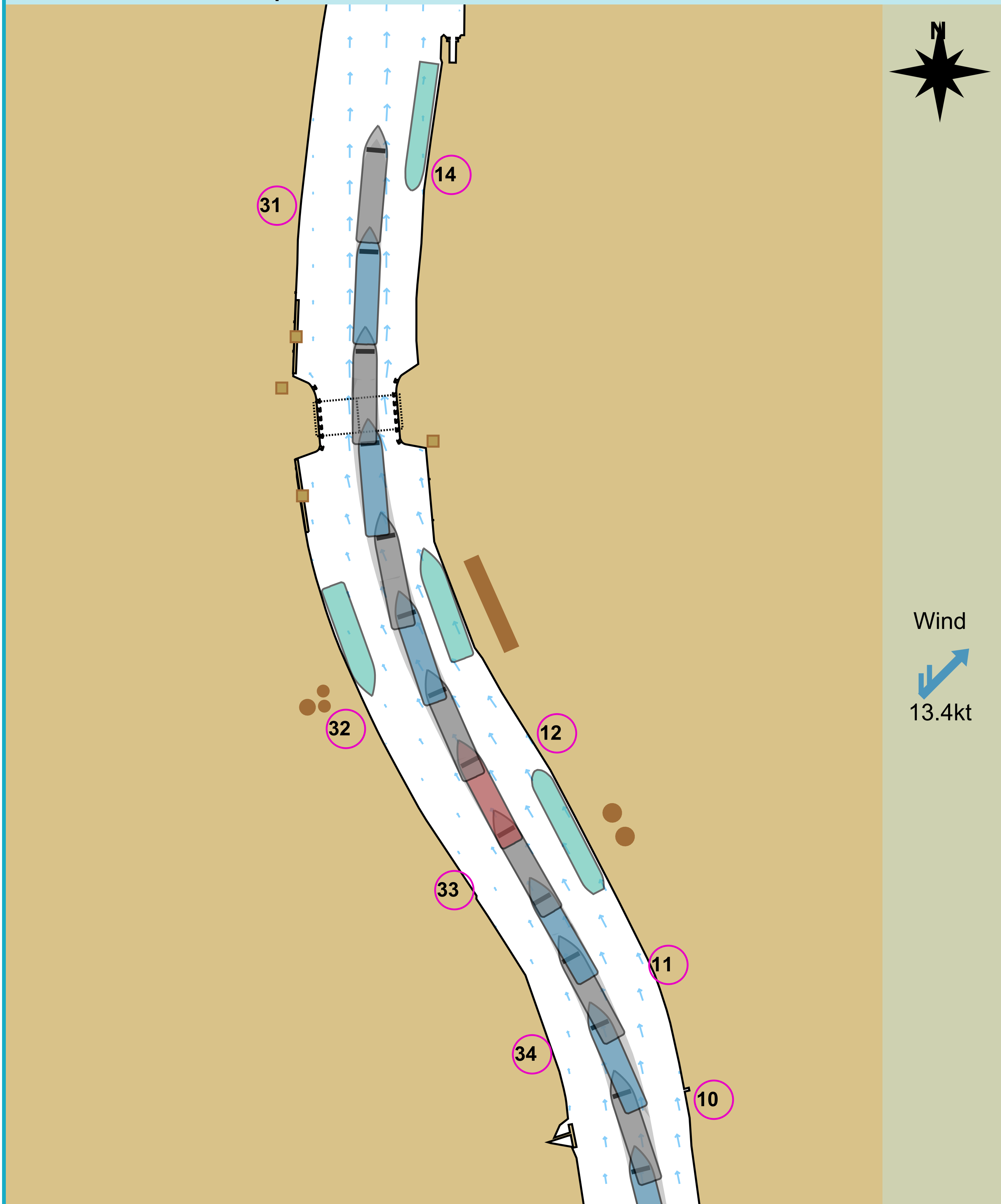

Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
15
20
Minutes


Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
180
90
0
-90
-180
0
5
10
15
20
Minutes


Thrusters
Bow %
Bow Force
Bow thruster (%Power)
Stern thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
Minutes

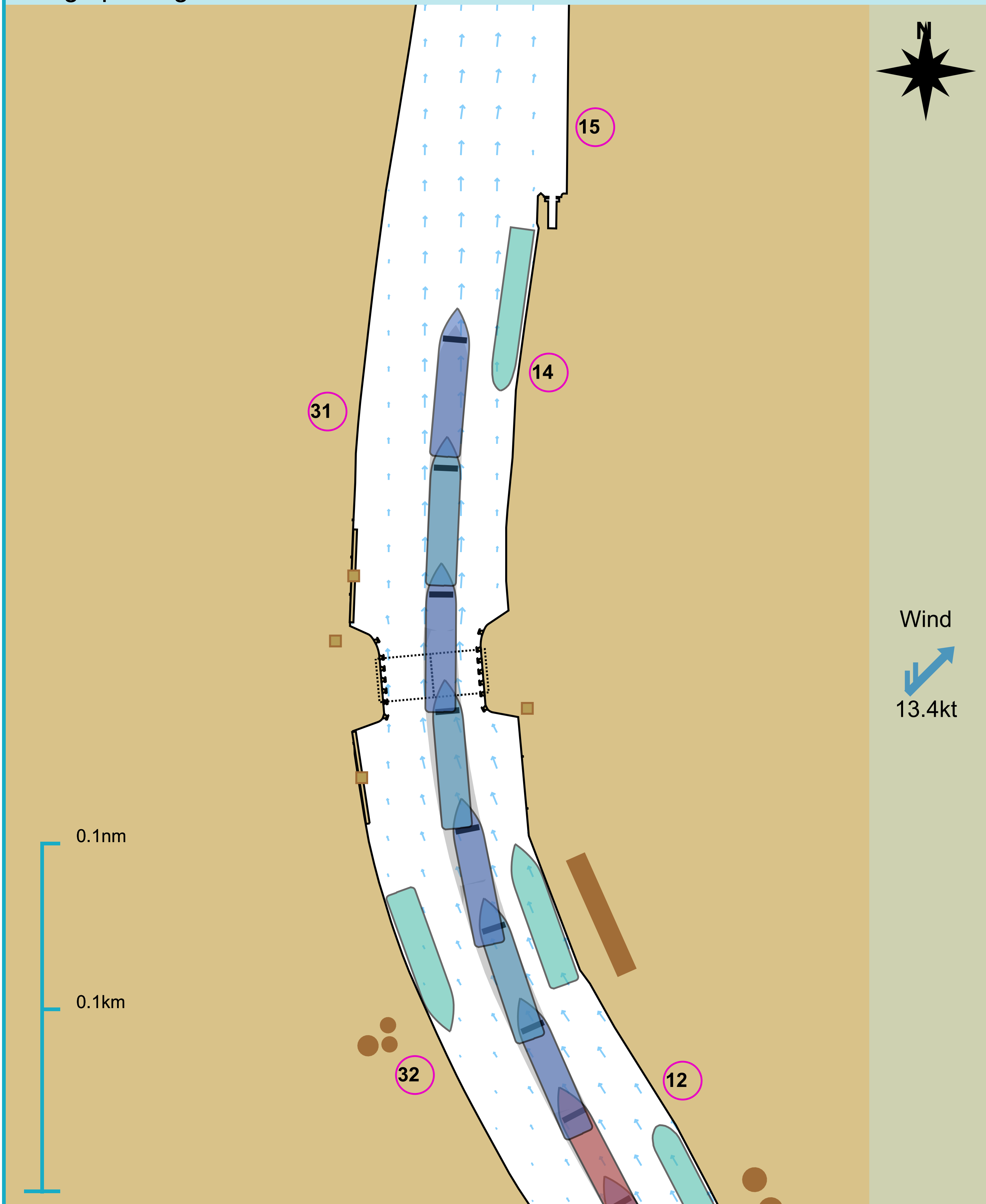

Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

Manoeuvre track plot

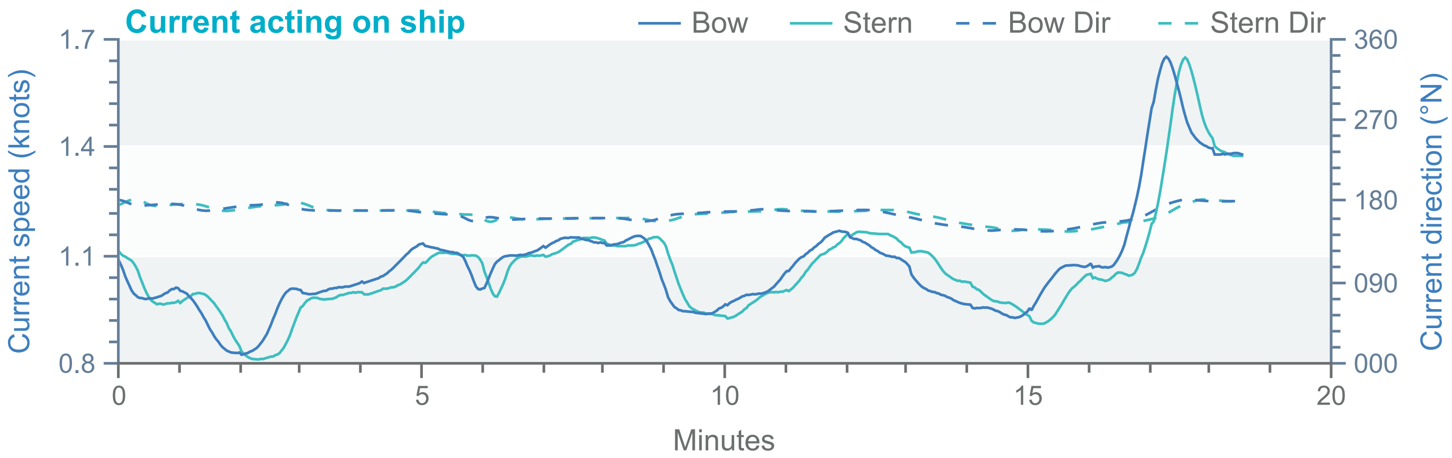


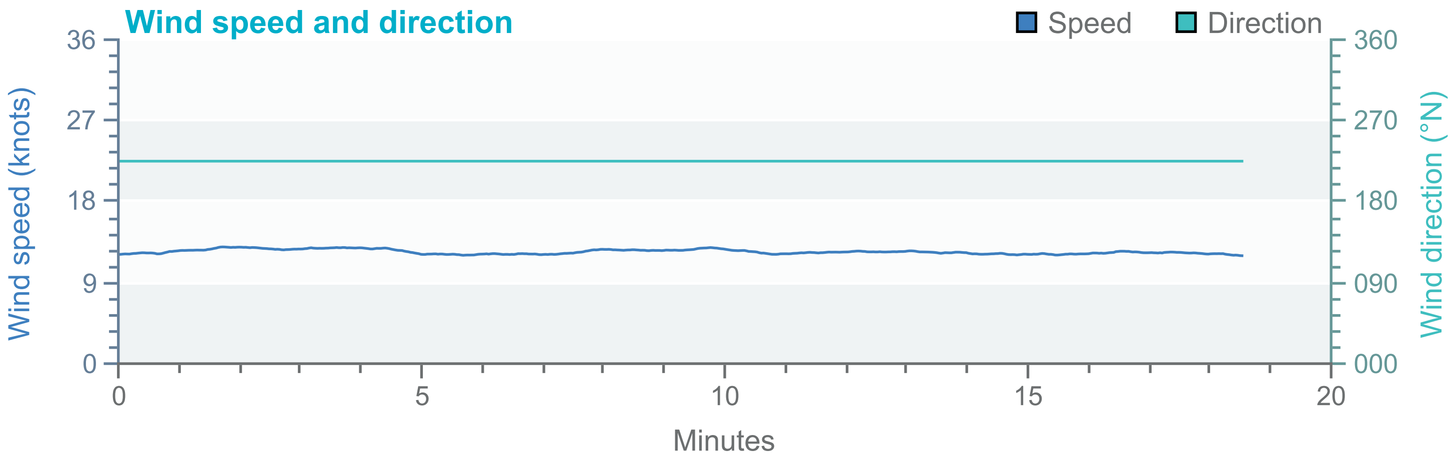
Ships plotted every 0 mins, highlight every 5 mins

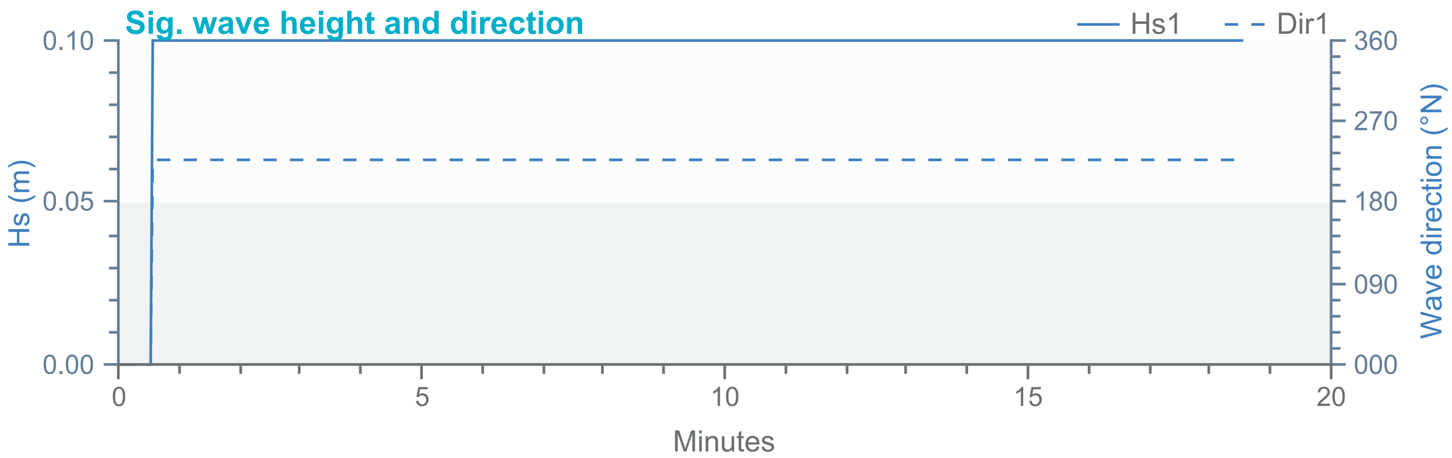
Bridge passage

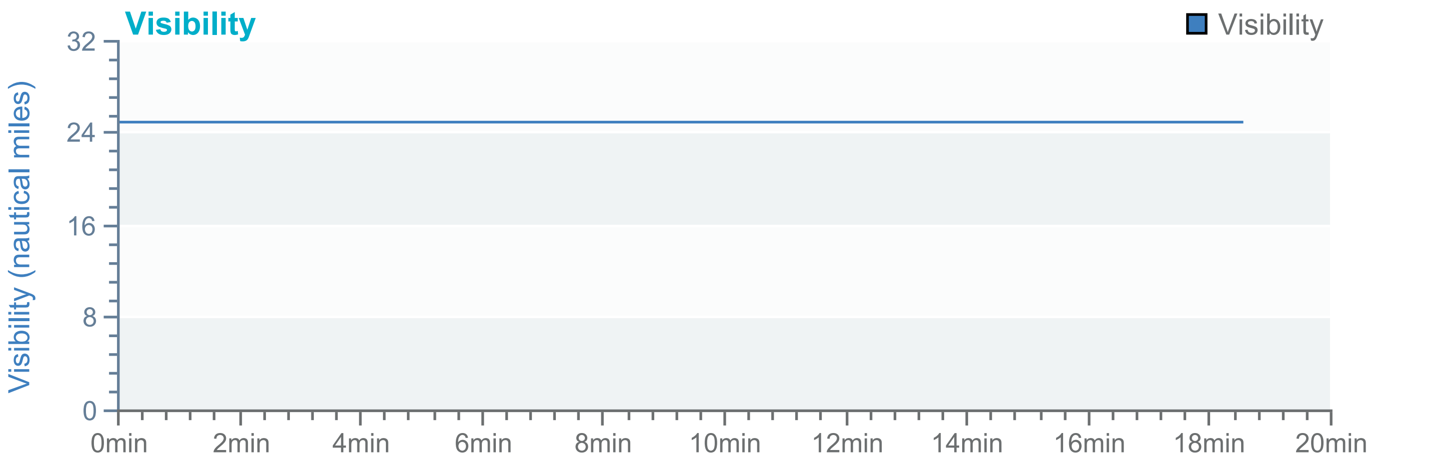


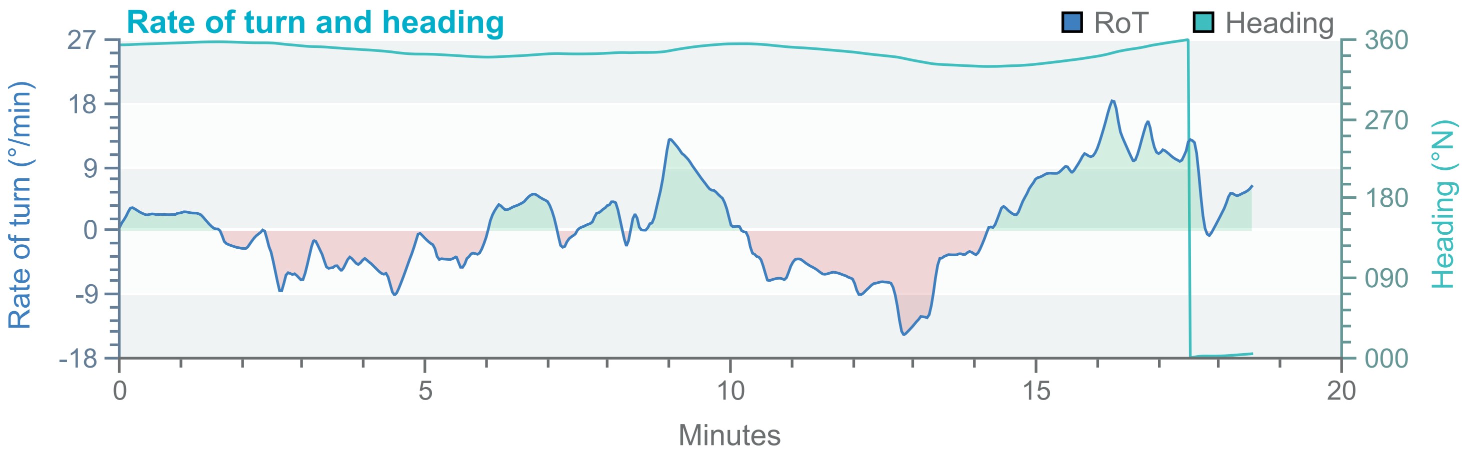
Ships plotted every 0 mins, highlight every 5 mins

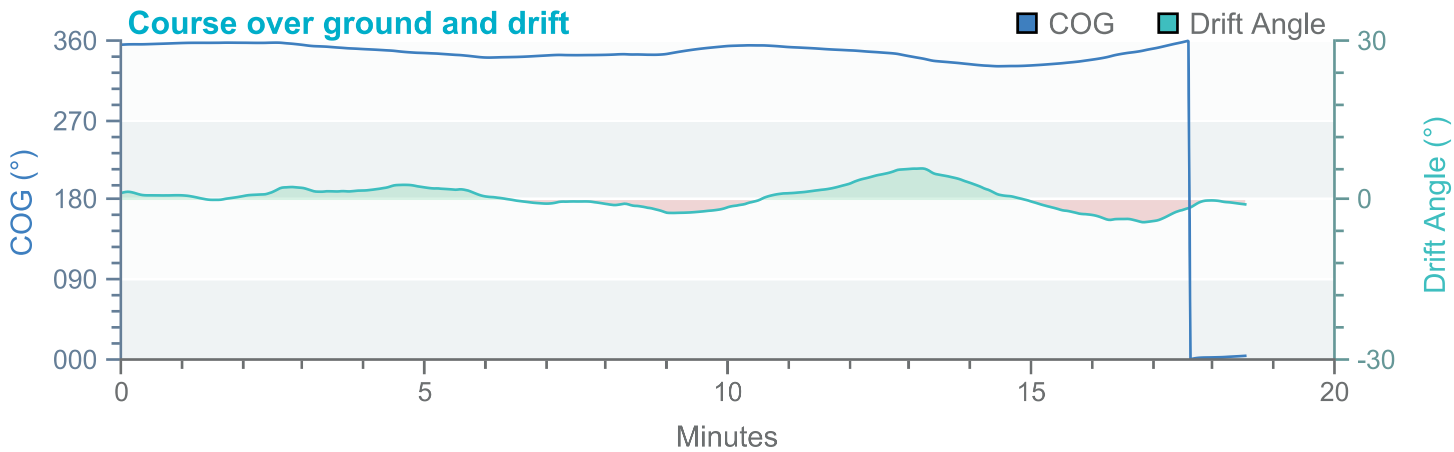

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
1.7
1.4
1.1
0.8
360
270
180
090
000
0
5
10
15
20
Minutes

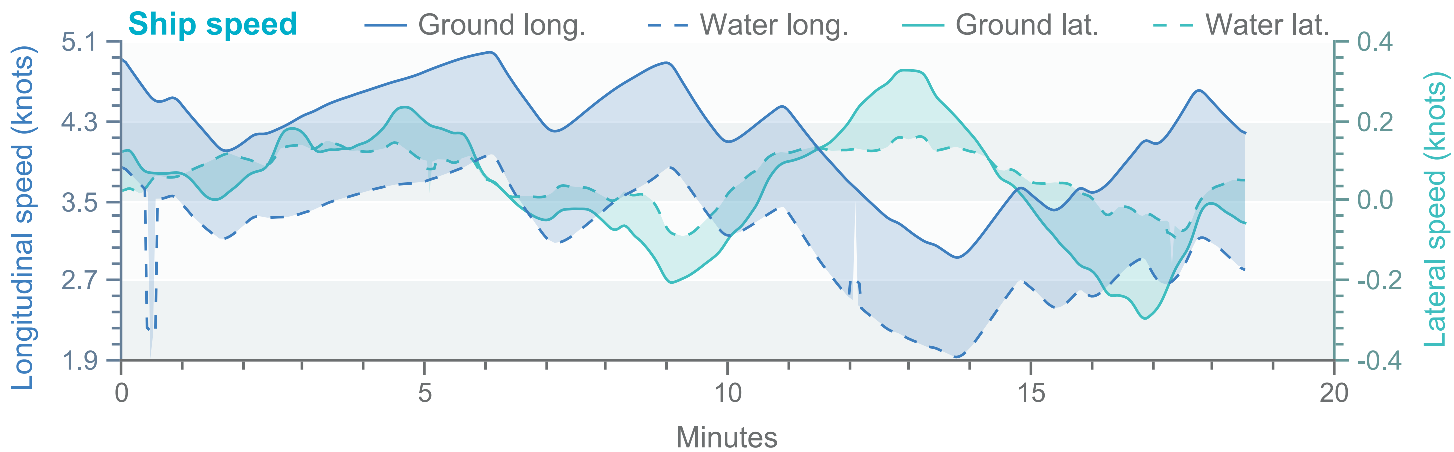

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
Minutes

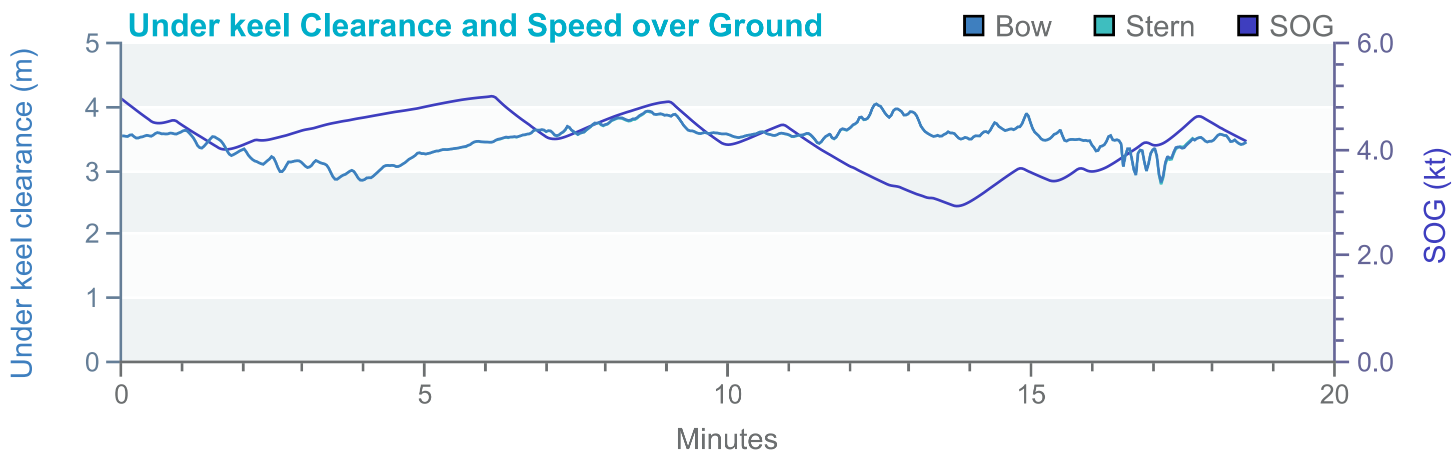

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
Minutes

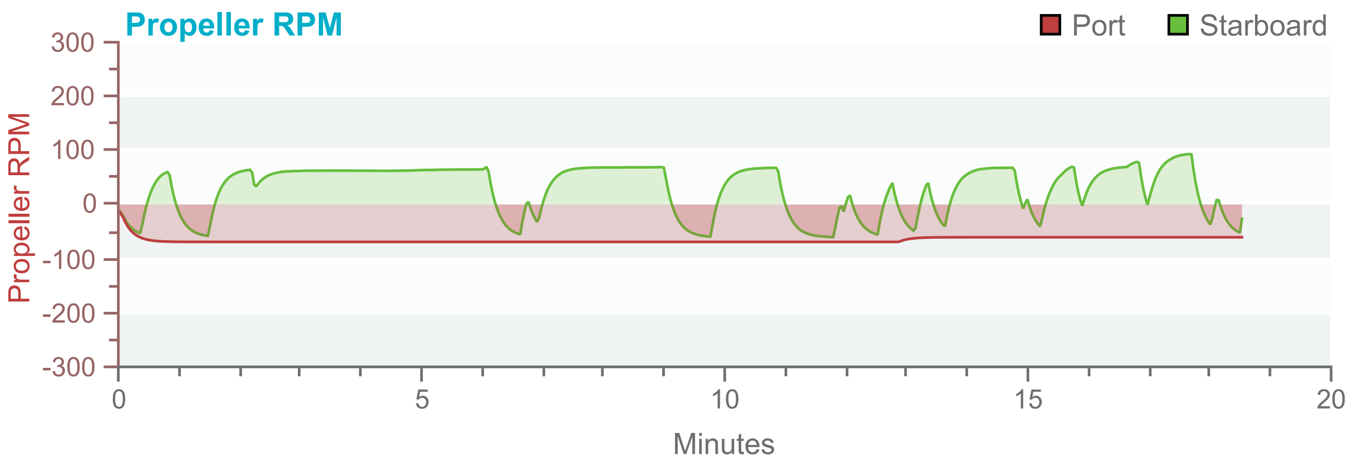

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

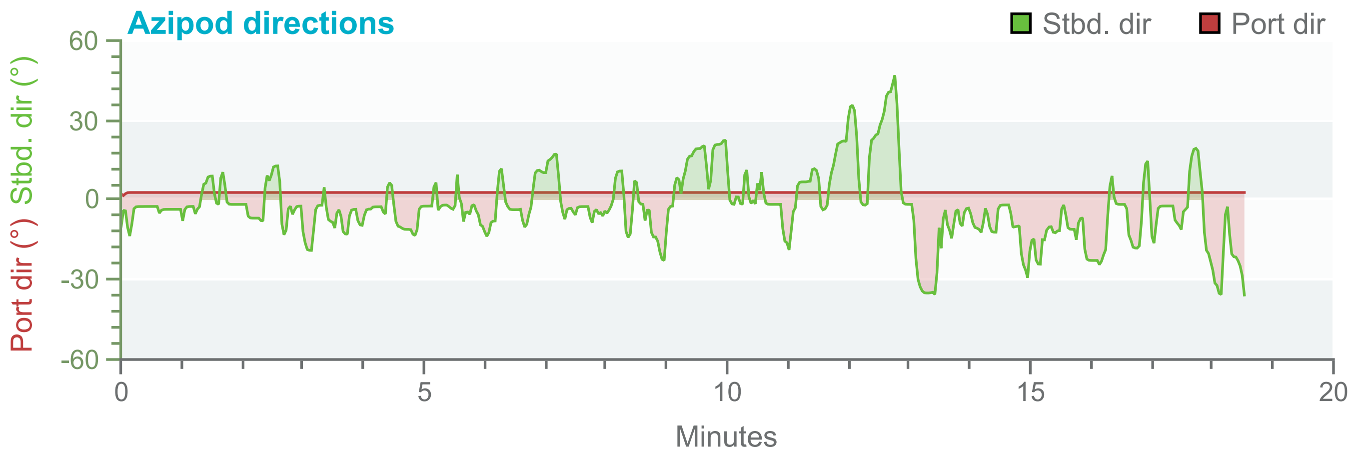

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
27
18
9
0
-9
-18
360
270
180
090
000
0
5
10
15
20
Minutes

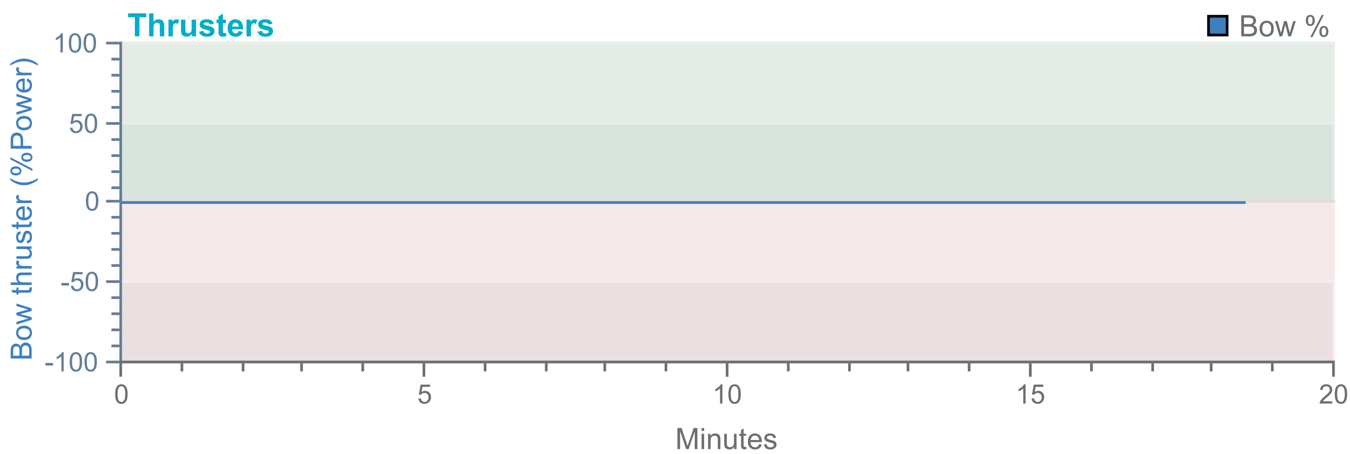

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
30
0
-30
0
5
10
15
20
Minutes

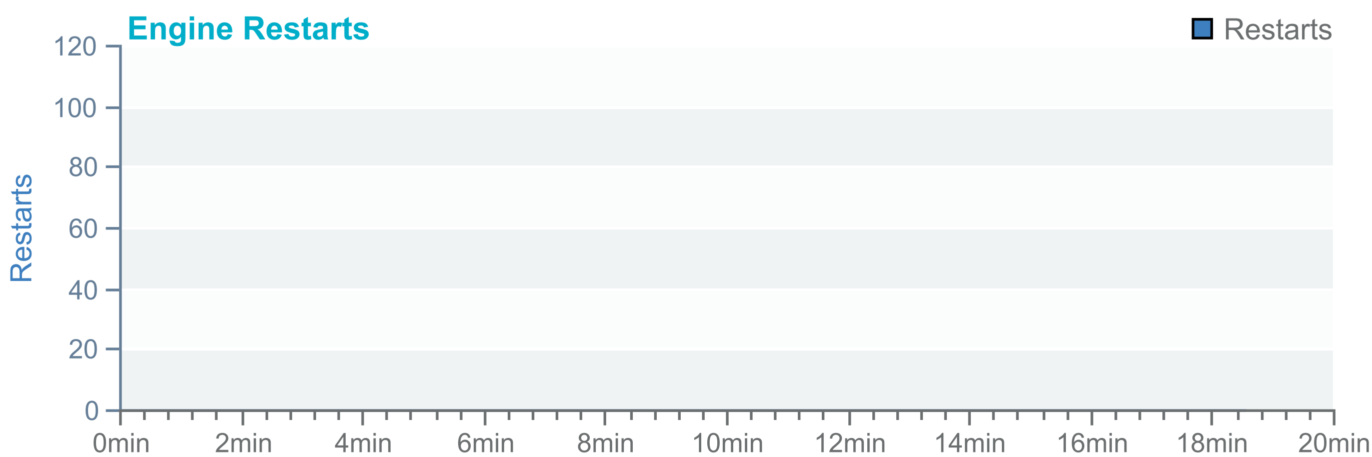

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.1
4.3
3.5
2.7
1.9
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
5
4
3
2
1
0
6.0
4.0
2.0
0.0
0
5
10
15
20
Minutes

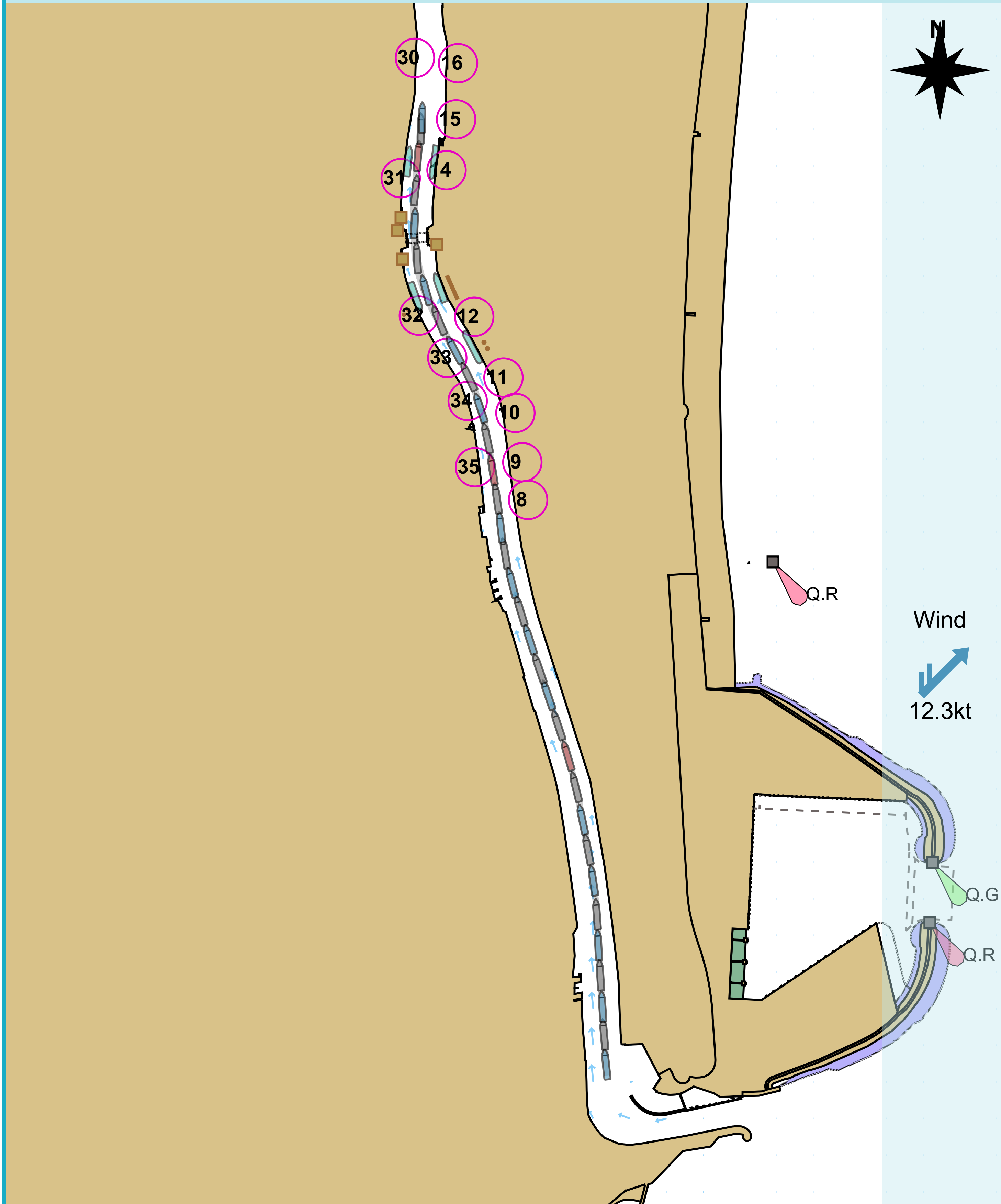

Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
15
20
Minutes


Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
60
30
0
-30
-60
0
5
10
15
20
Minutes


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


Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

Manoeuvre track plot



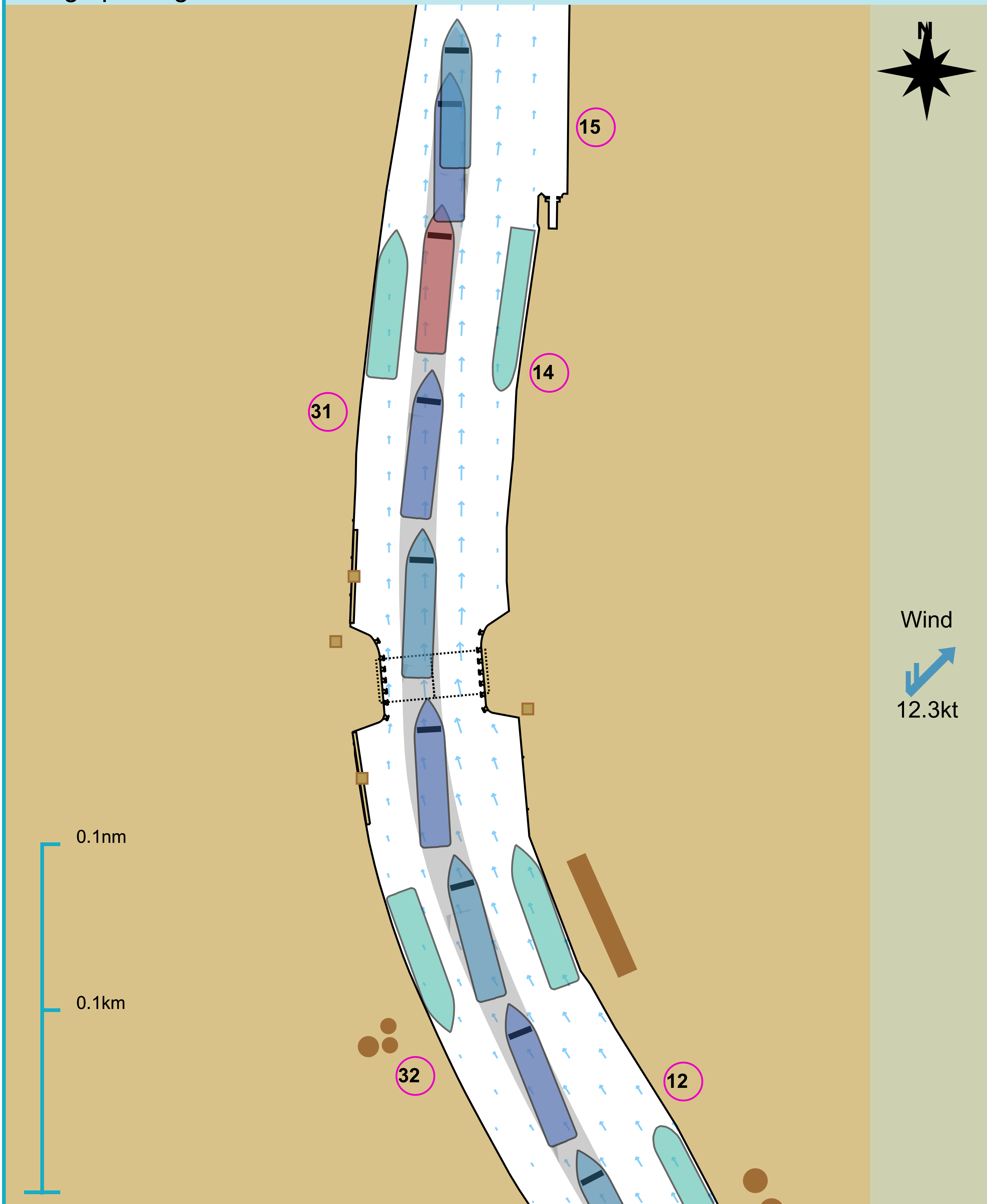
Ships plotted every 0 mins, highlight every 5 mins

HR Wallingford
Working with water

Project: Great Yarmouth
Session: 3rd Crossing 2019
Configuration: September 2019
Run: 04

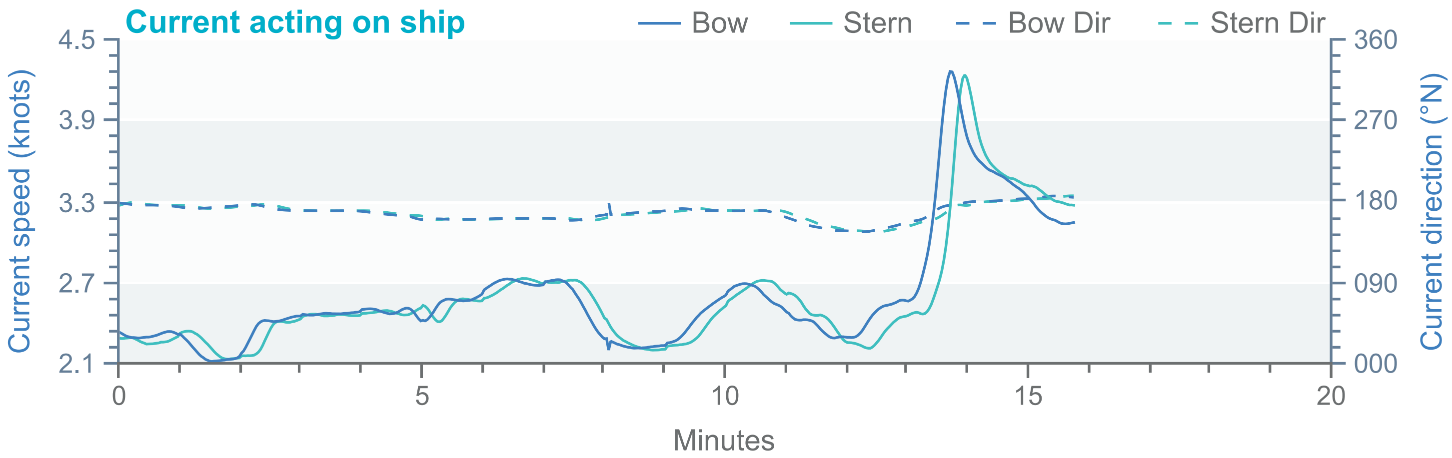
Tracks	Environment	80m PSV

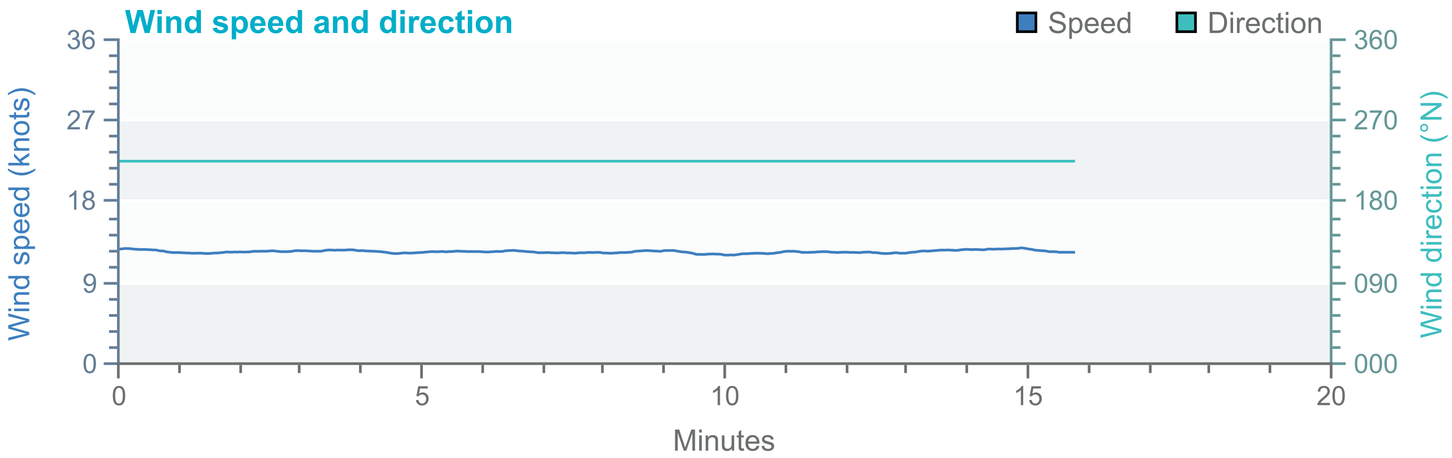
Bridge passage

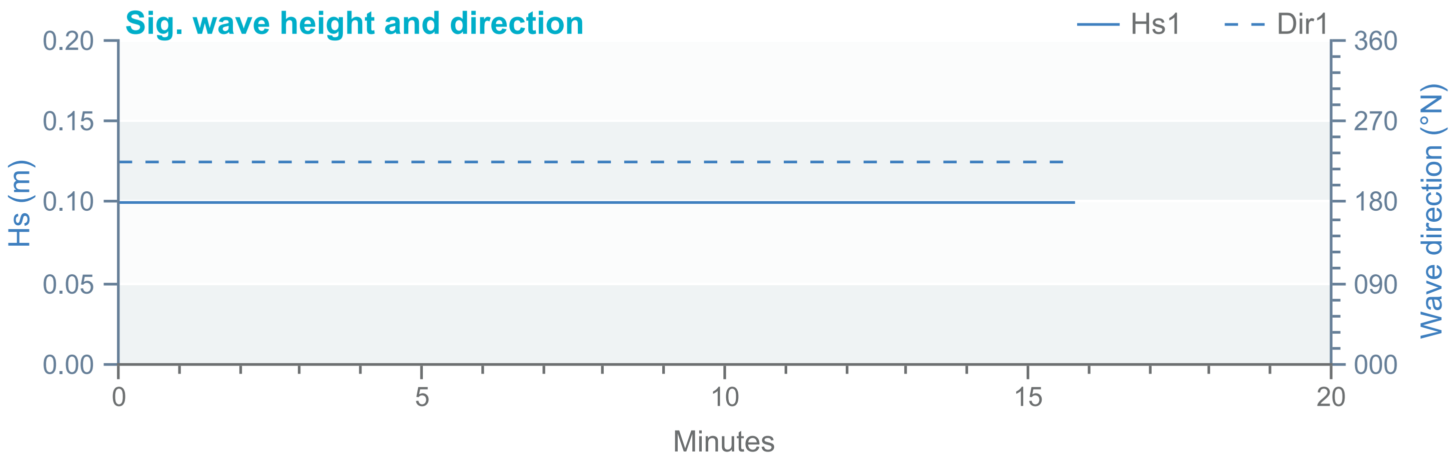


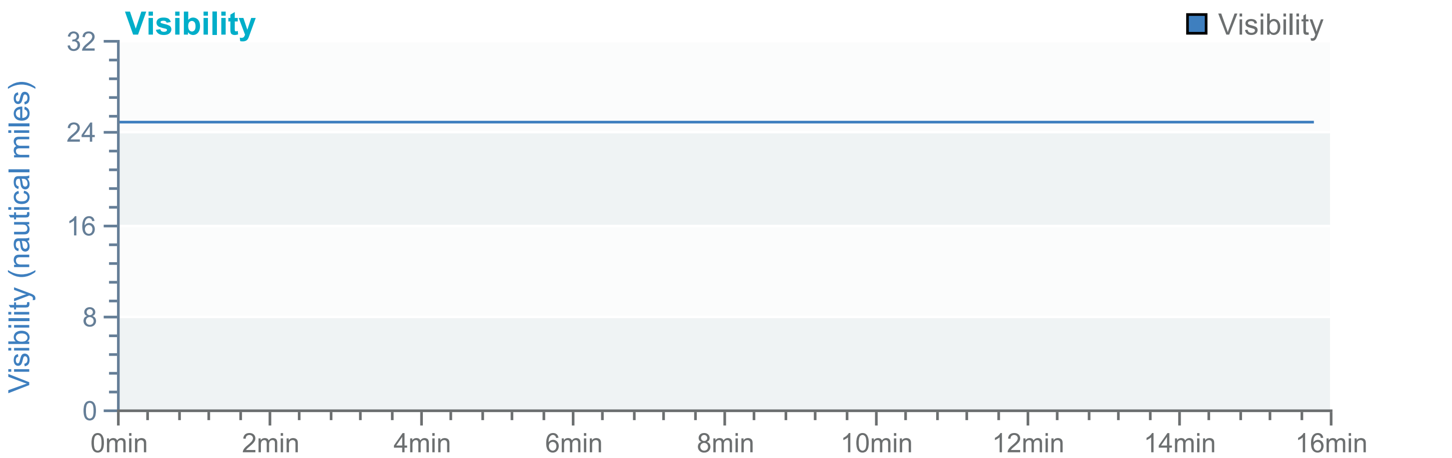
Ships plotted every 0 mins, highlight every 5 mins

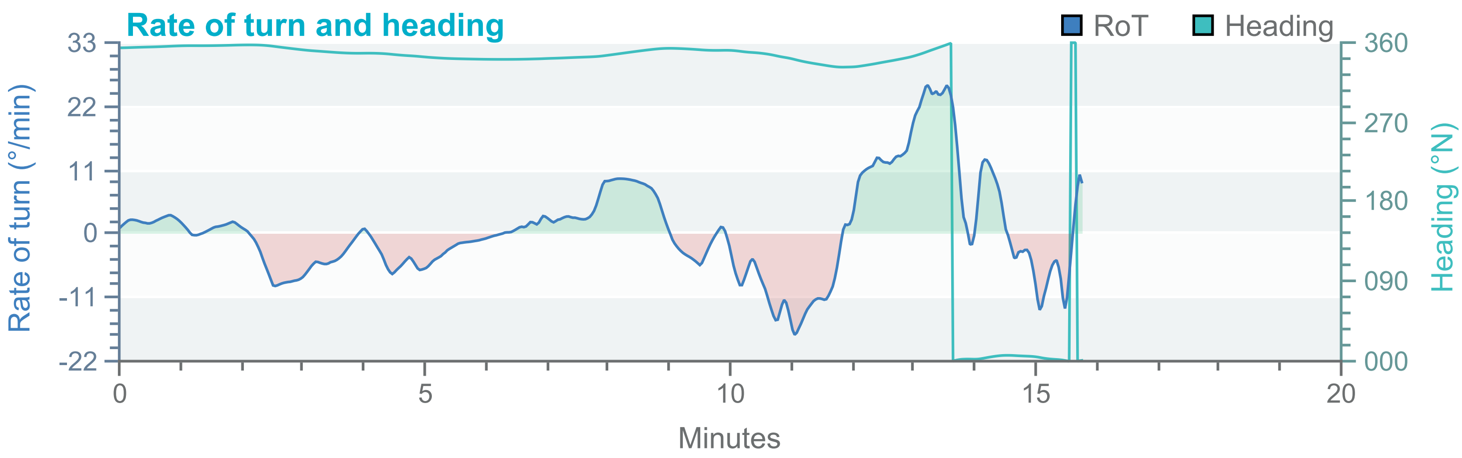
Pilot: DM
Manoeuvre: Arrival

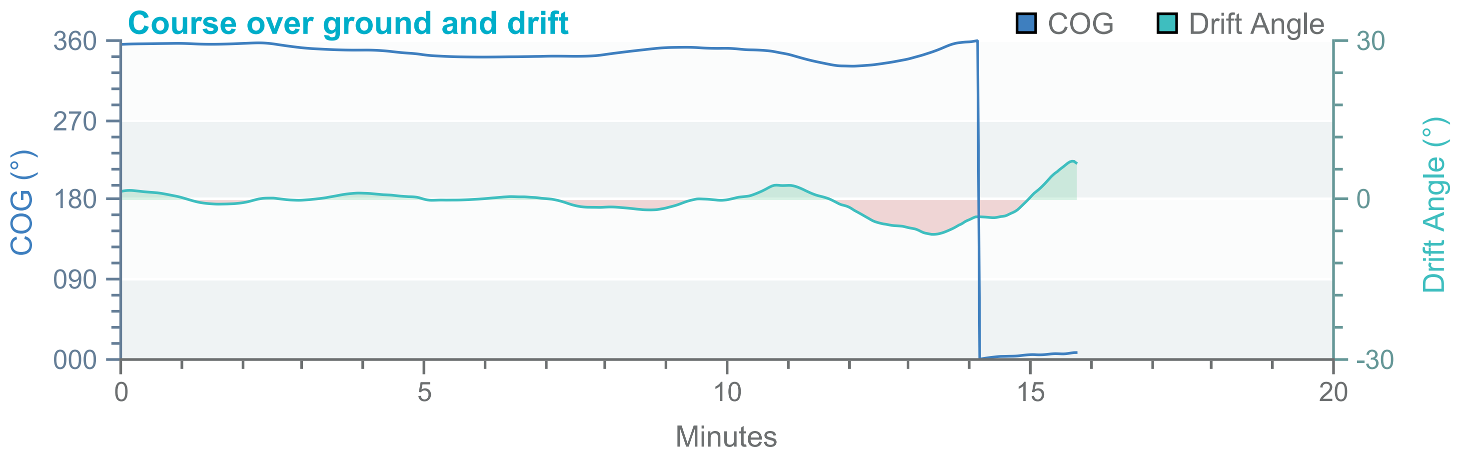

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
4.5
3.9
3.3
2.7
2.1
360
270
180
090
000
0
5
10
15
20

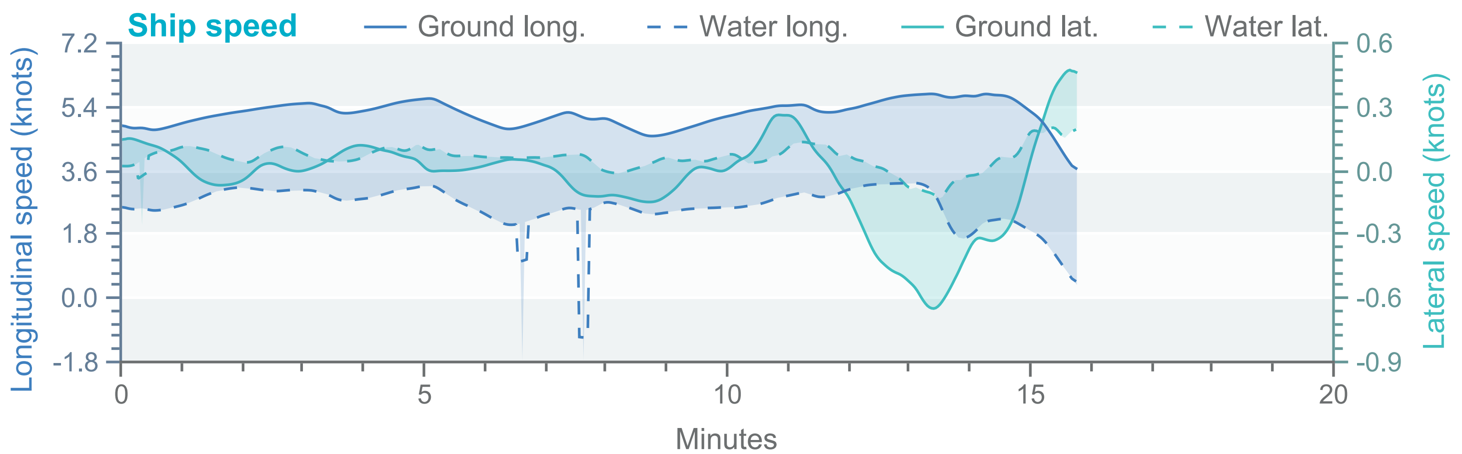

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20

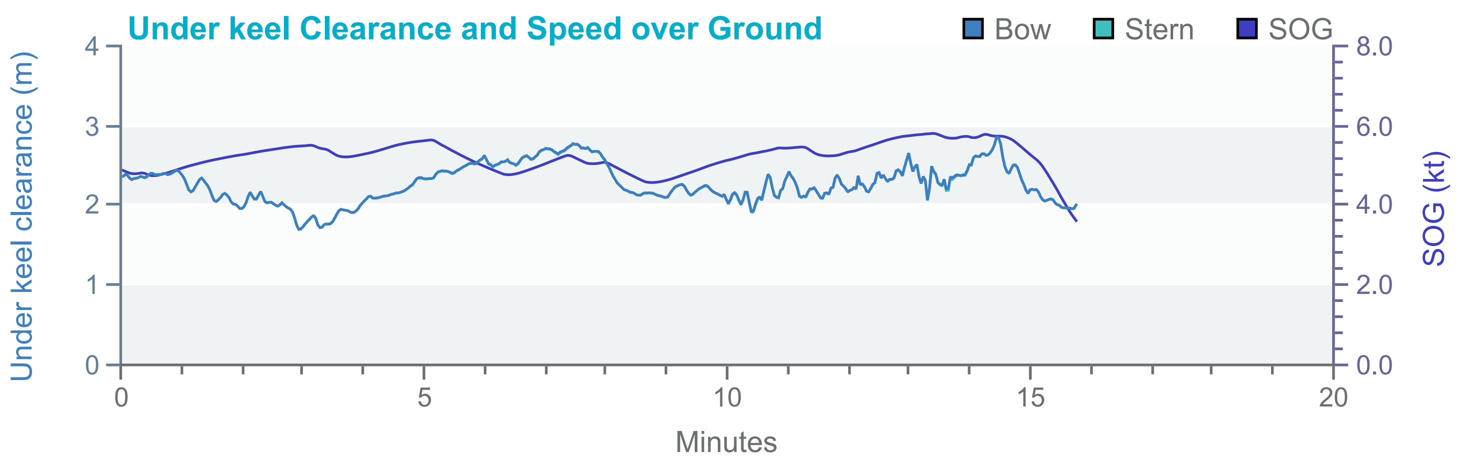

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20

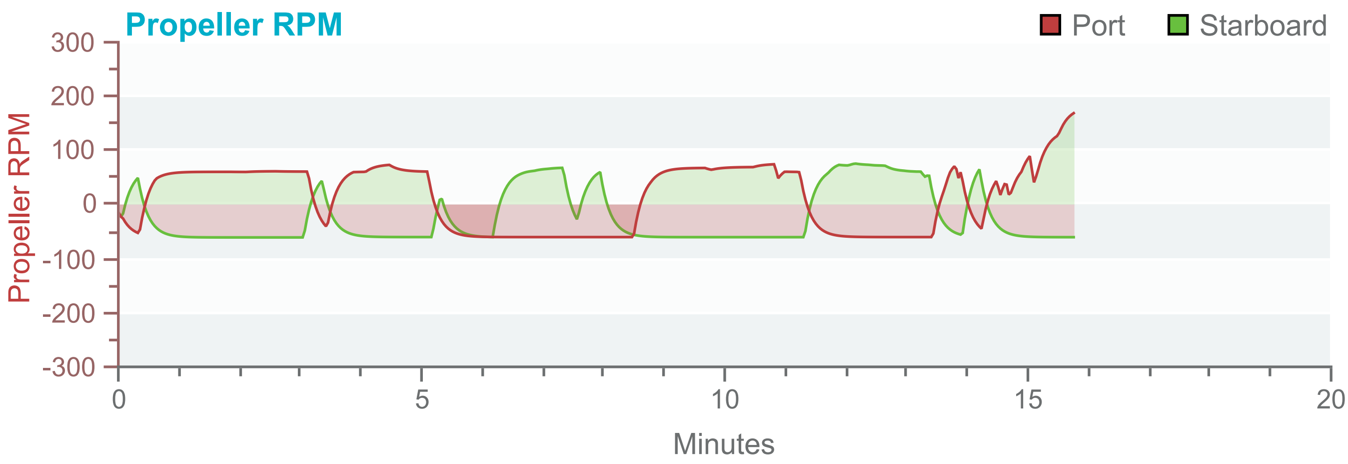

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min

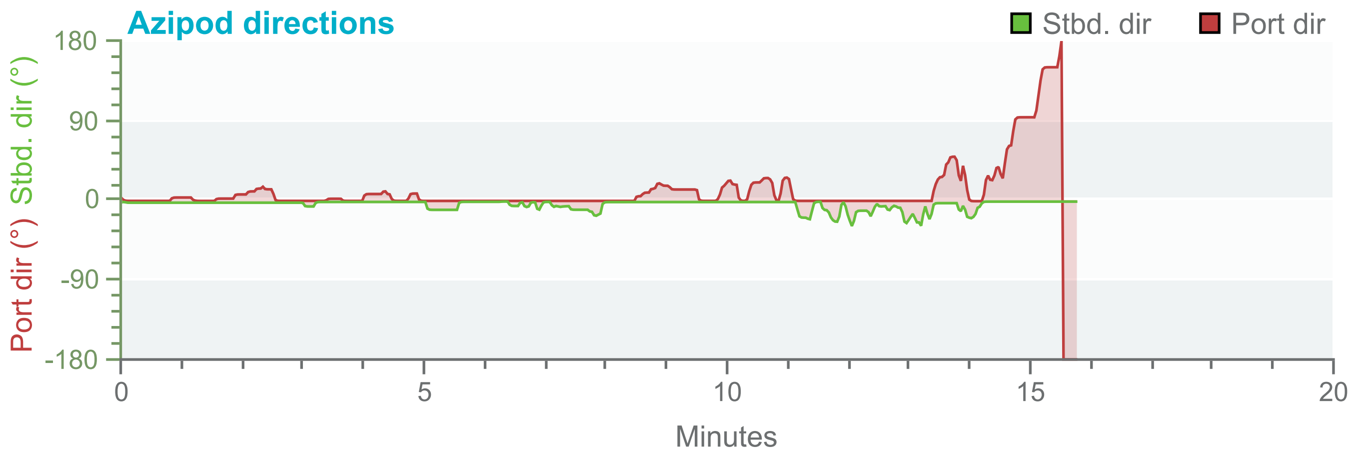

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
33
22
11
0
-11
-22
360
270
180
090
000
0
5
10
15
20
Minutes

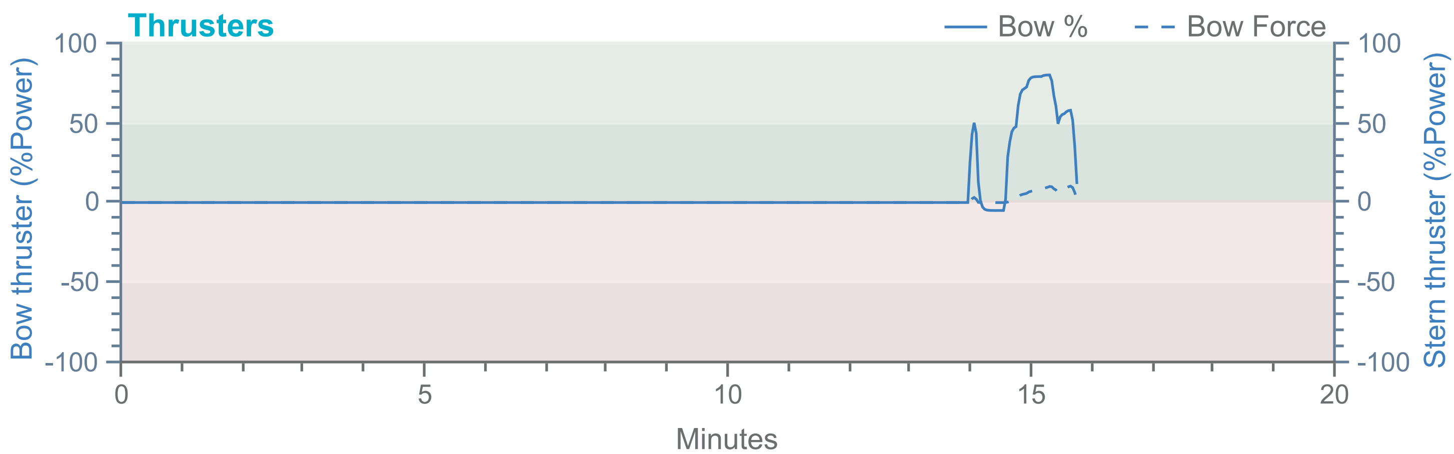

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
30
0
-30
0
5
10
15
20
Minutes

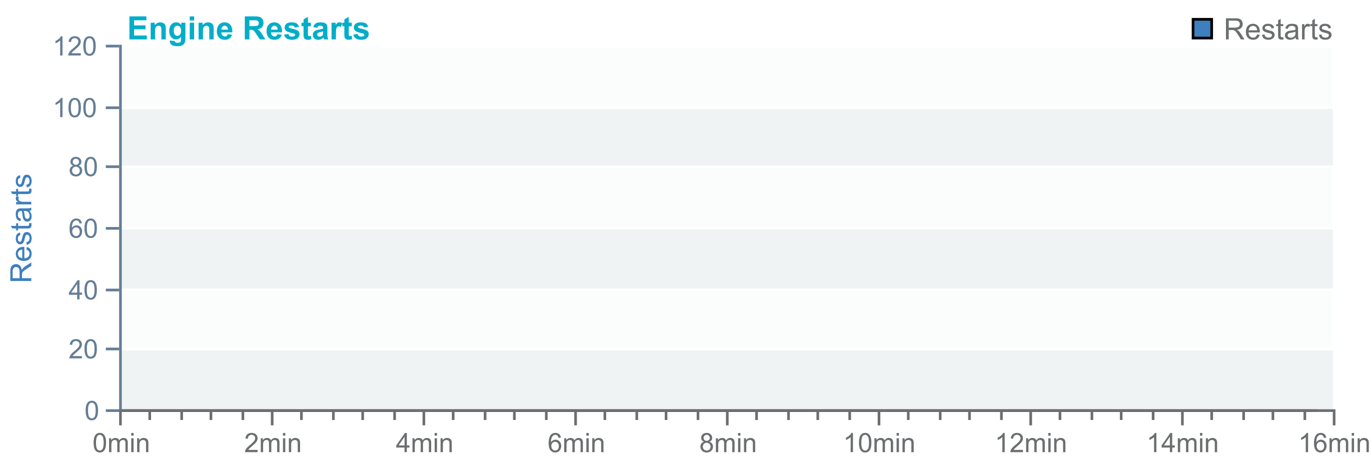

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
7.2
5.4
3.6
1.8
0.0
-1.8
0.6
0.3
0.0
-0.3
-0.6
-0.9
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
4
3
2
1
0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
Minutes

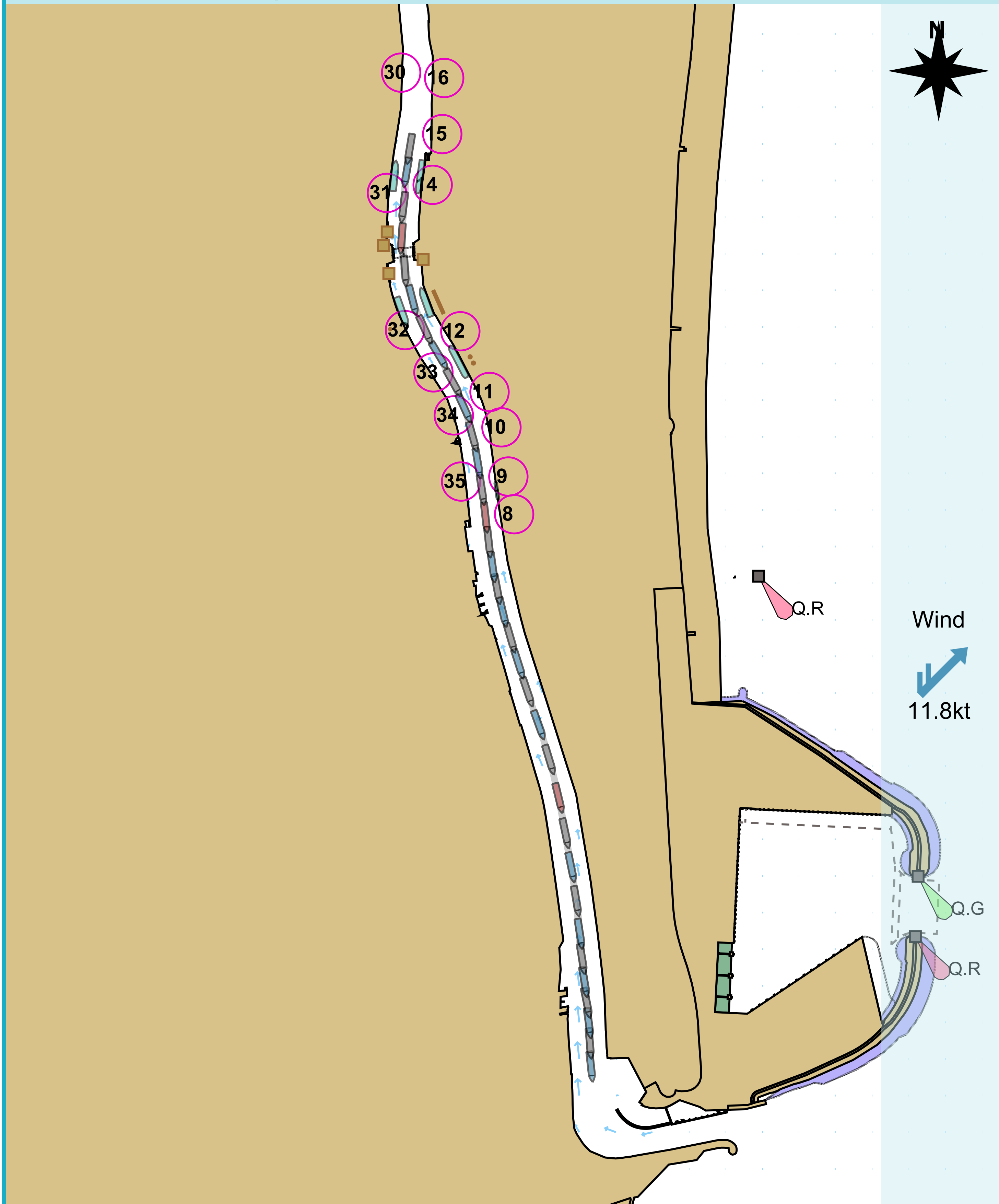

Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
15
20
Minutes


Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
180
90
0
-90
-180
0
5
10
15
20
Minutes


Thrusters
Bow %
Bow Force
Bow thruster (%Power)
Stern thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
Minutes


Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
2min
4min
6min
8min
10min
12min
14min
16min

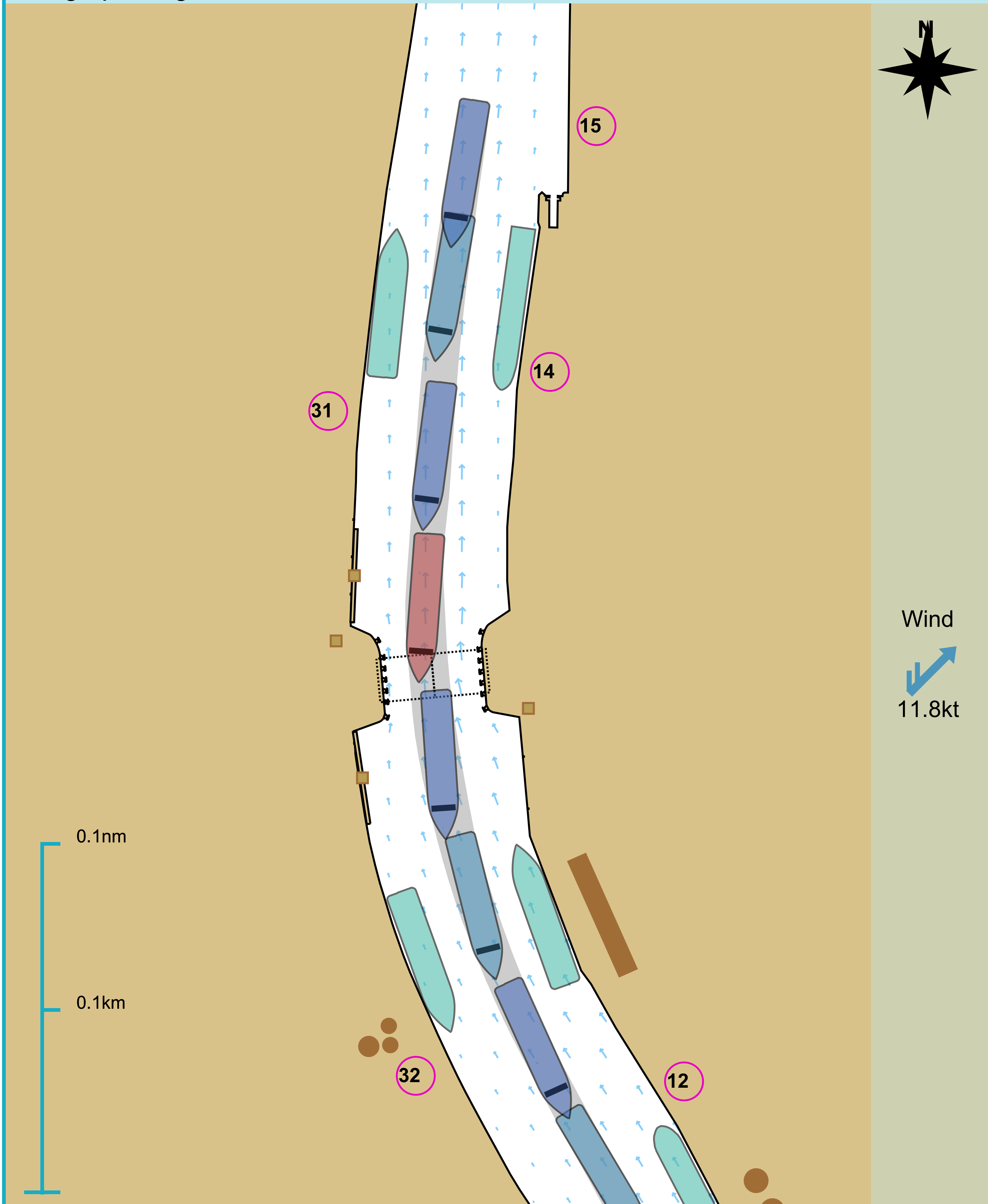
Manoeuvre track plot



Ships plotted every 0 mins, highlight every 5 mins

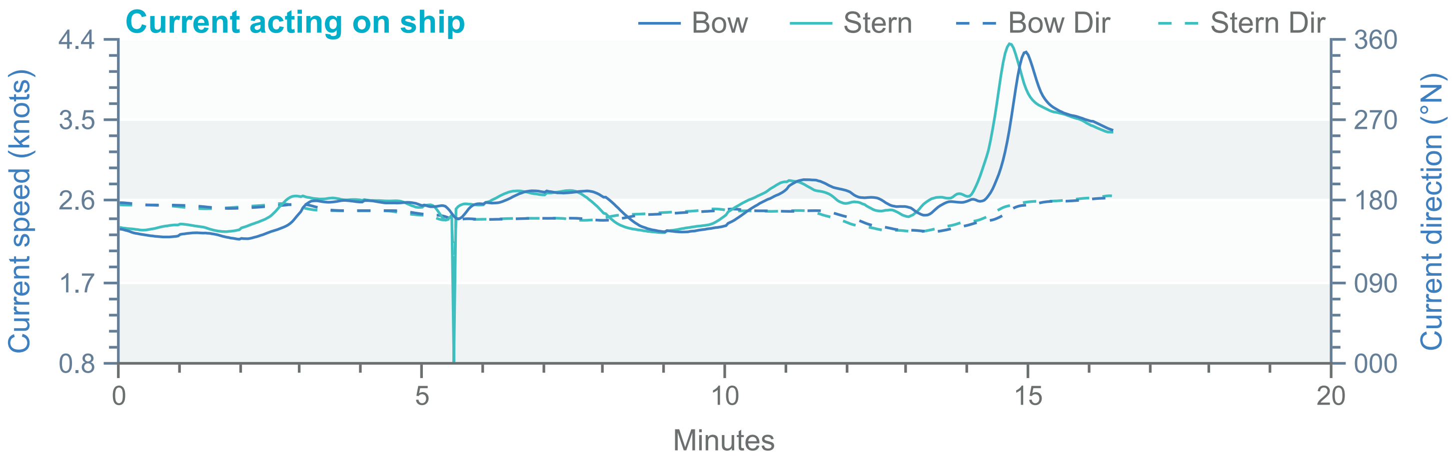
Tracks	Environment	80m PSV

Bridge passage

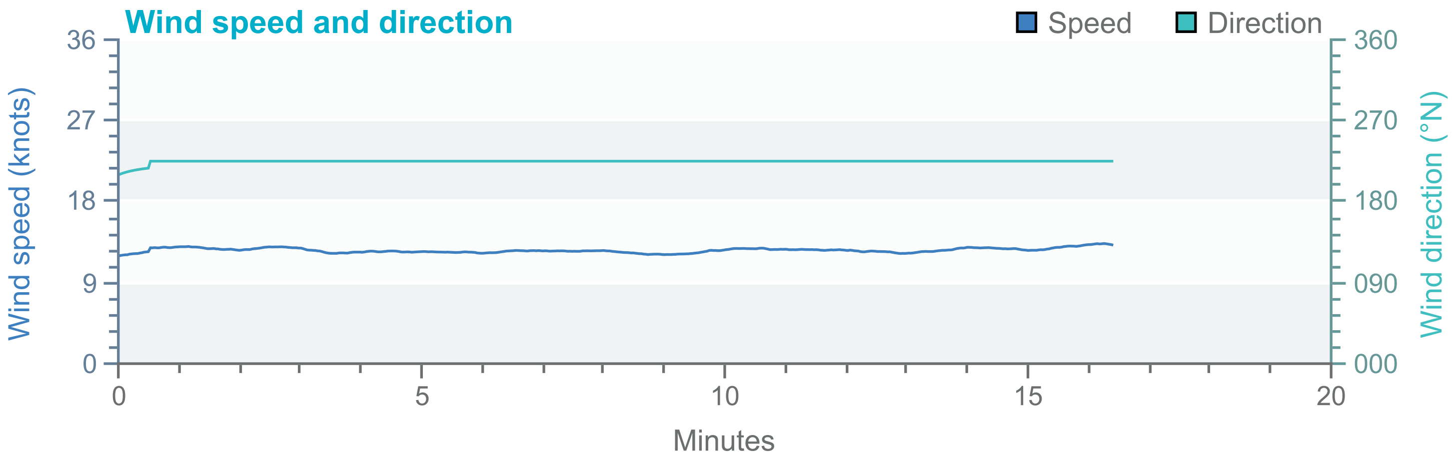


Ships plotted every 0 mins, highlight every 5 mins

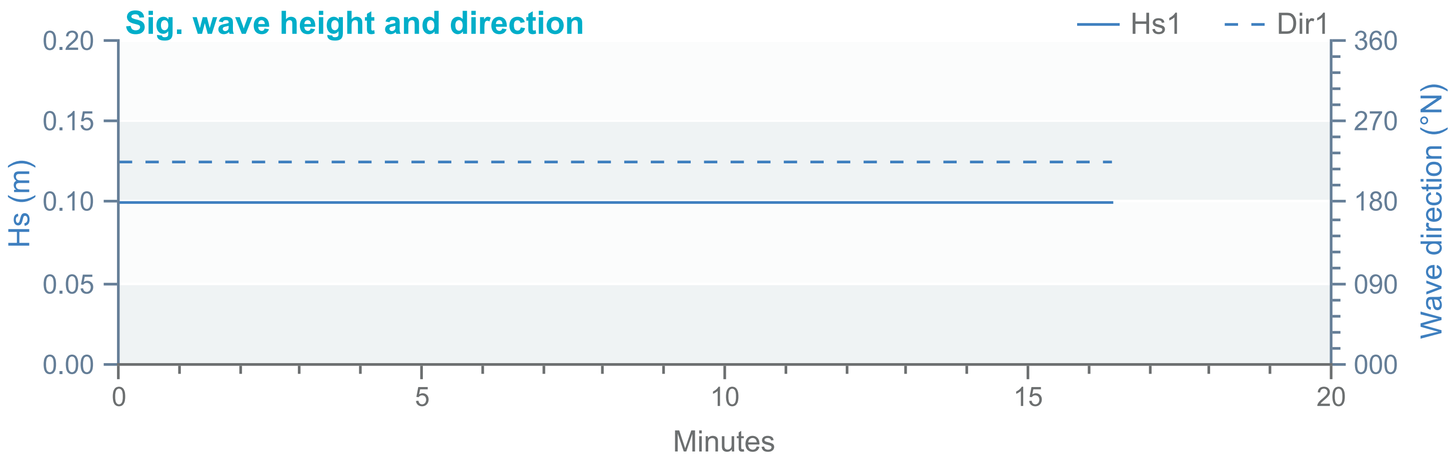
Current acting on ship



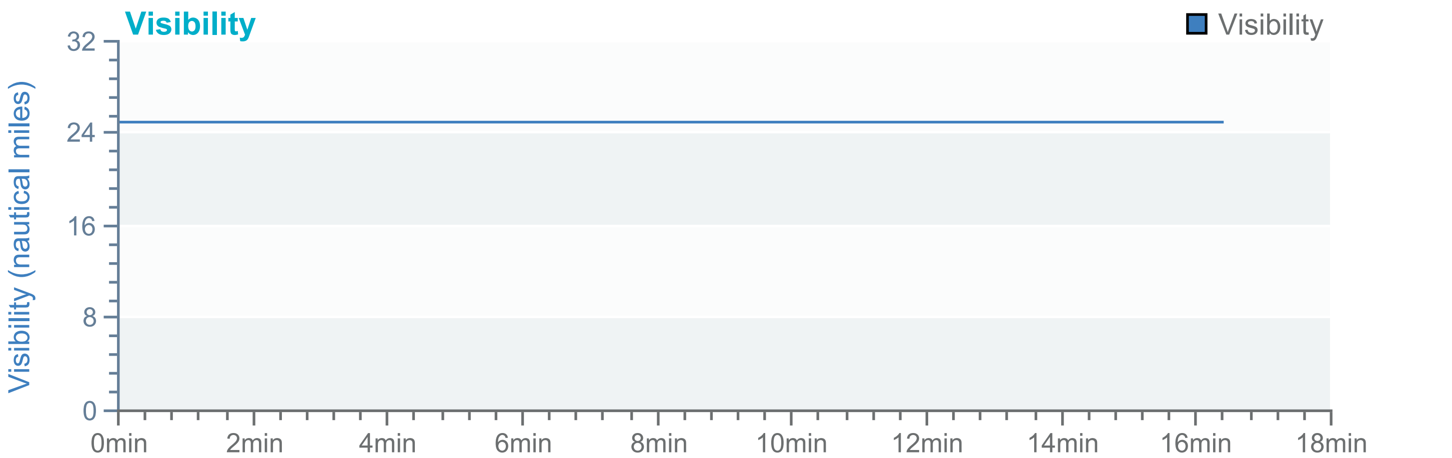
Wind speed and direction

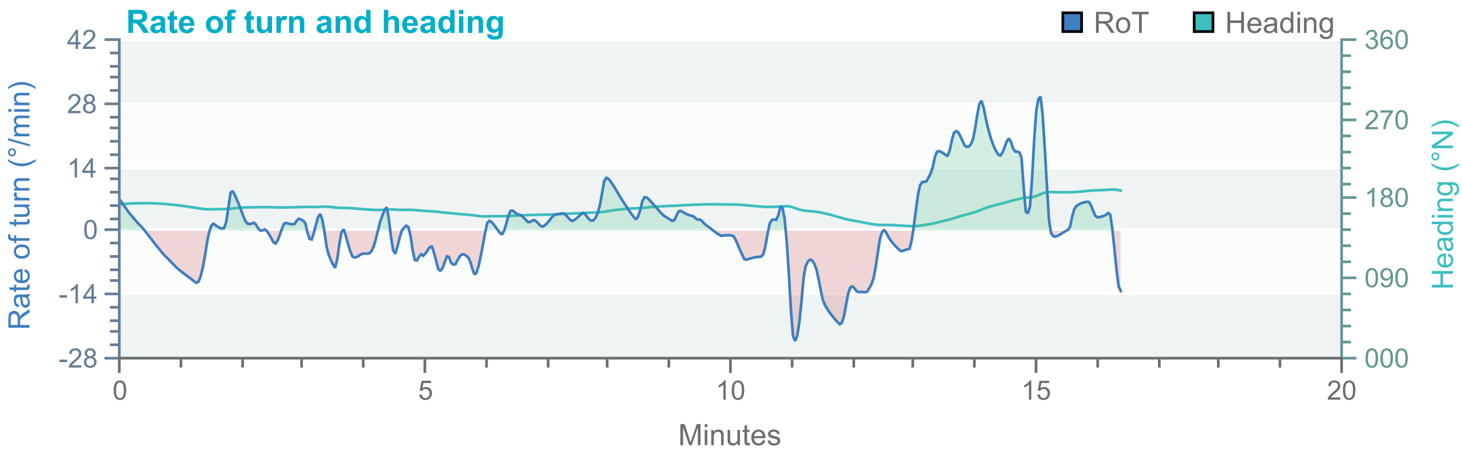


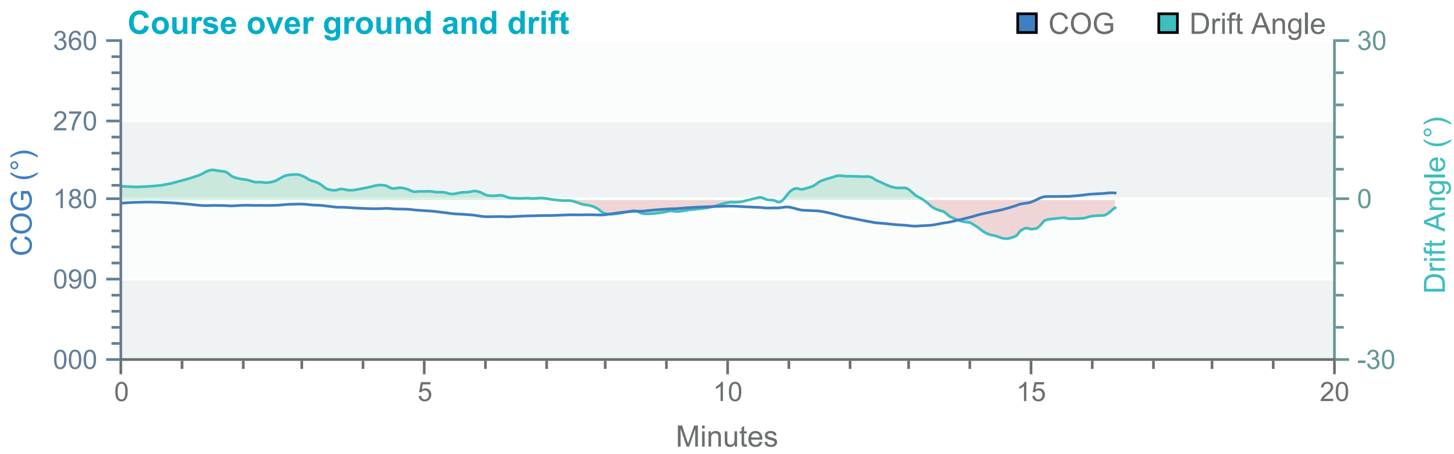
Sig. wave height and direction

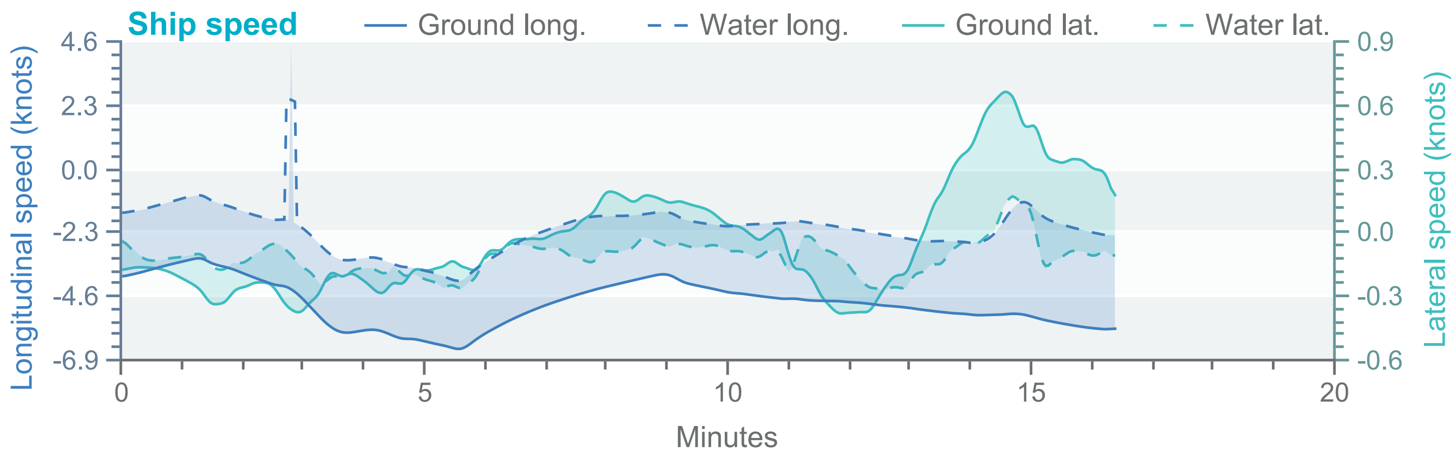


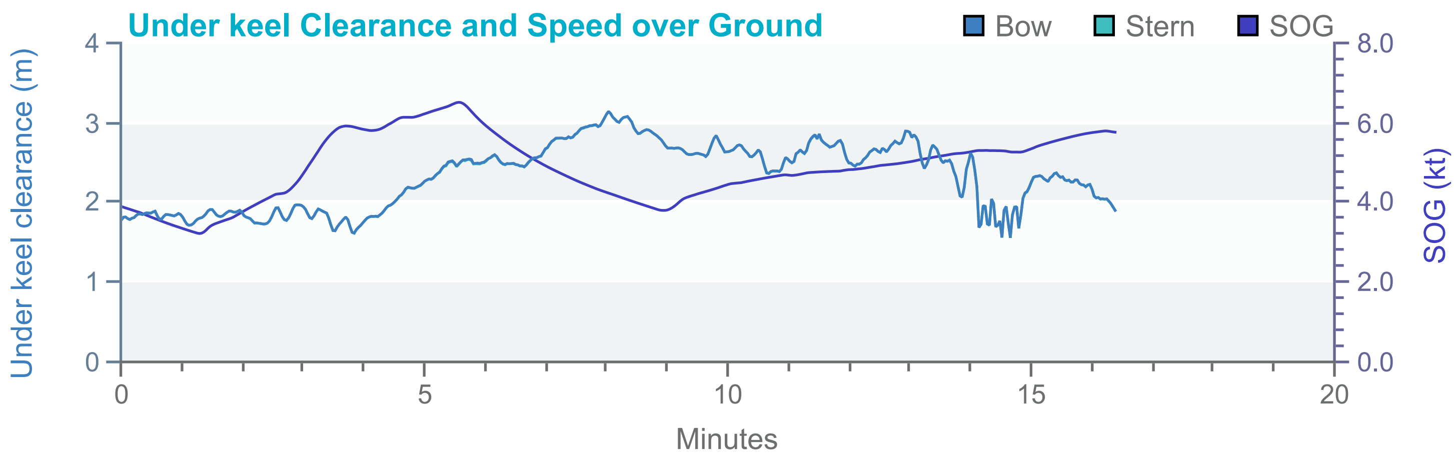
Visibility



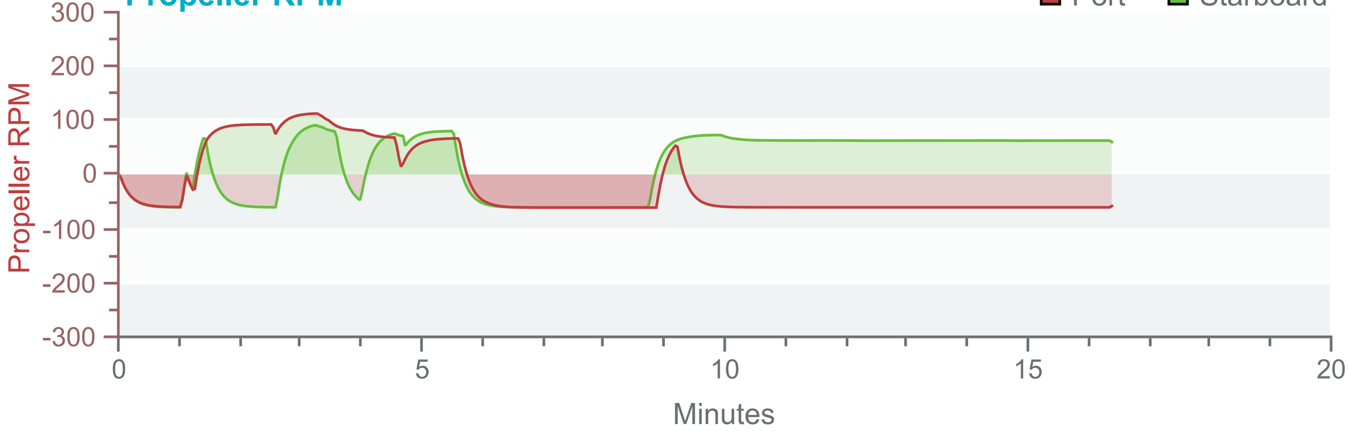

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
42
28
14
0
-14
-28
Heading (°N)
360
270
180
090
000
0
5
10
15
20
Minutes


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

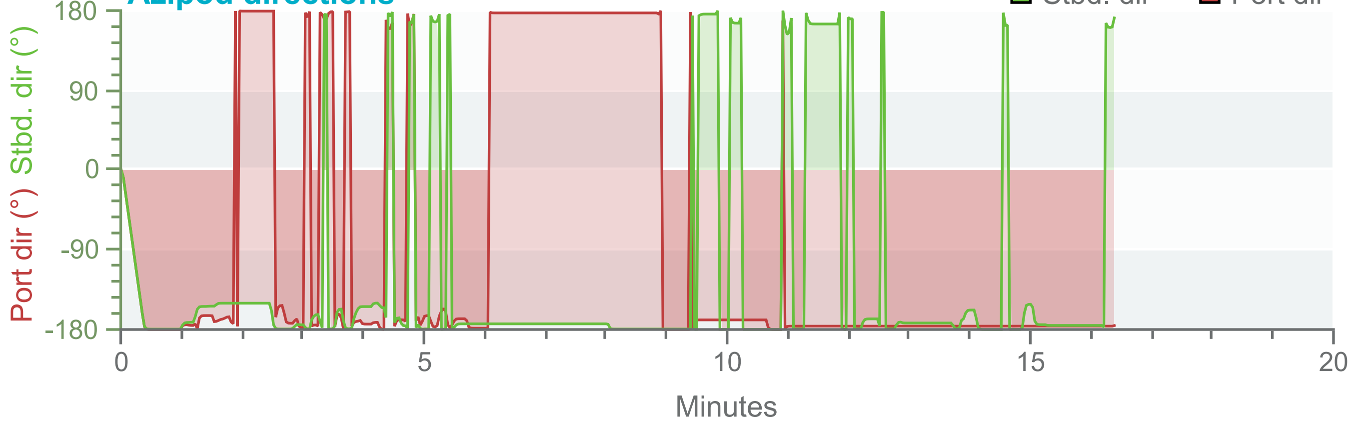

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
4.6
2.3
0.0
-2.3
-4.6
-6.9
Lateral speed (knots)
0.9
0.6
0.3
0.0
-0.3
-0.6
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
4
3
2
1
0
SOG (kt)
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
Minutes

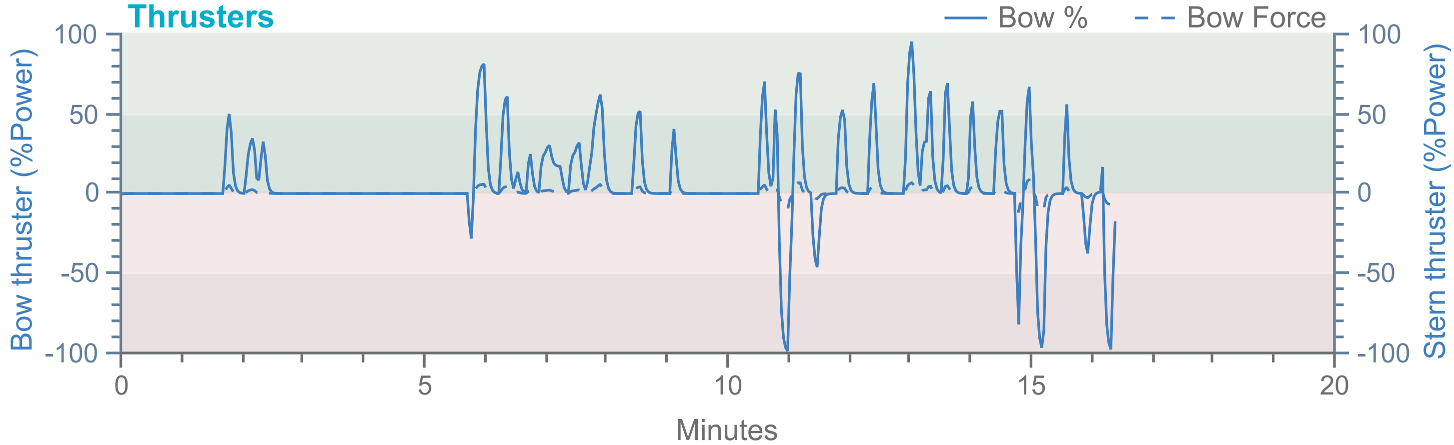
Propeller RPM



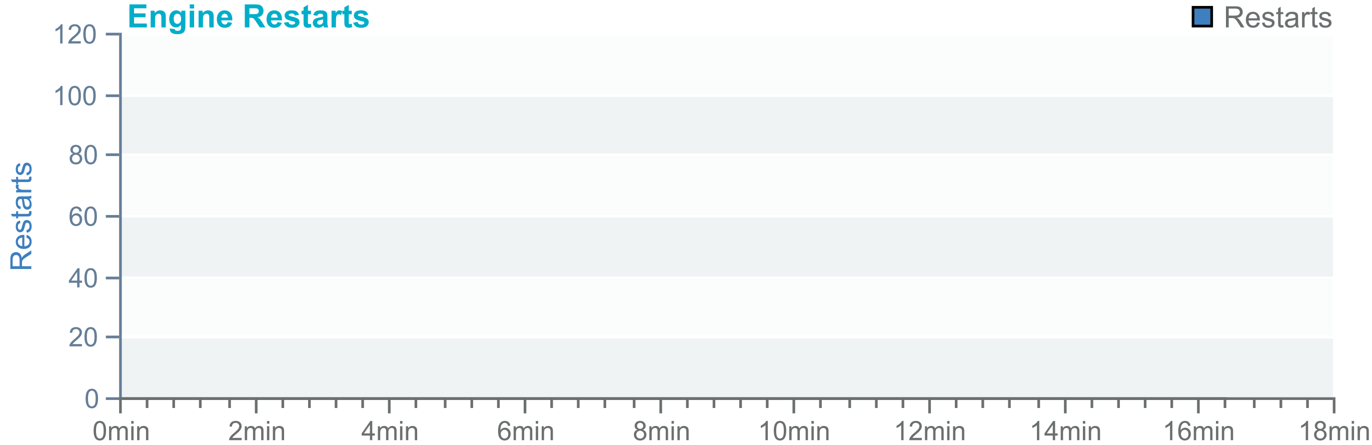
Azipod directions



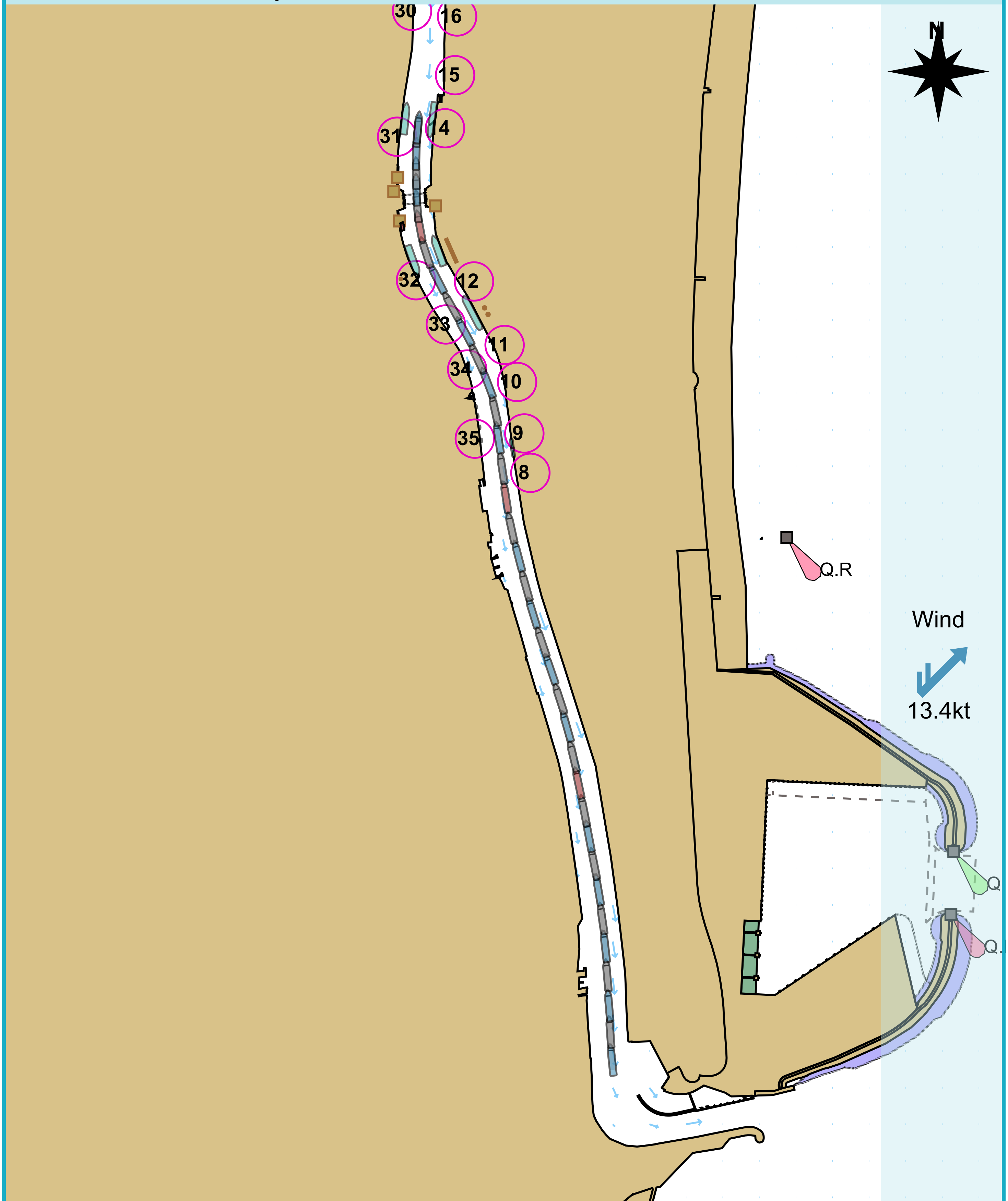
Thrusters



Engine Restarts

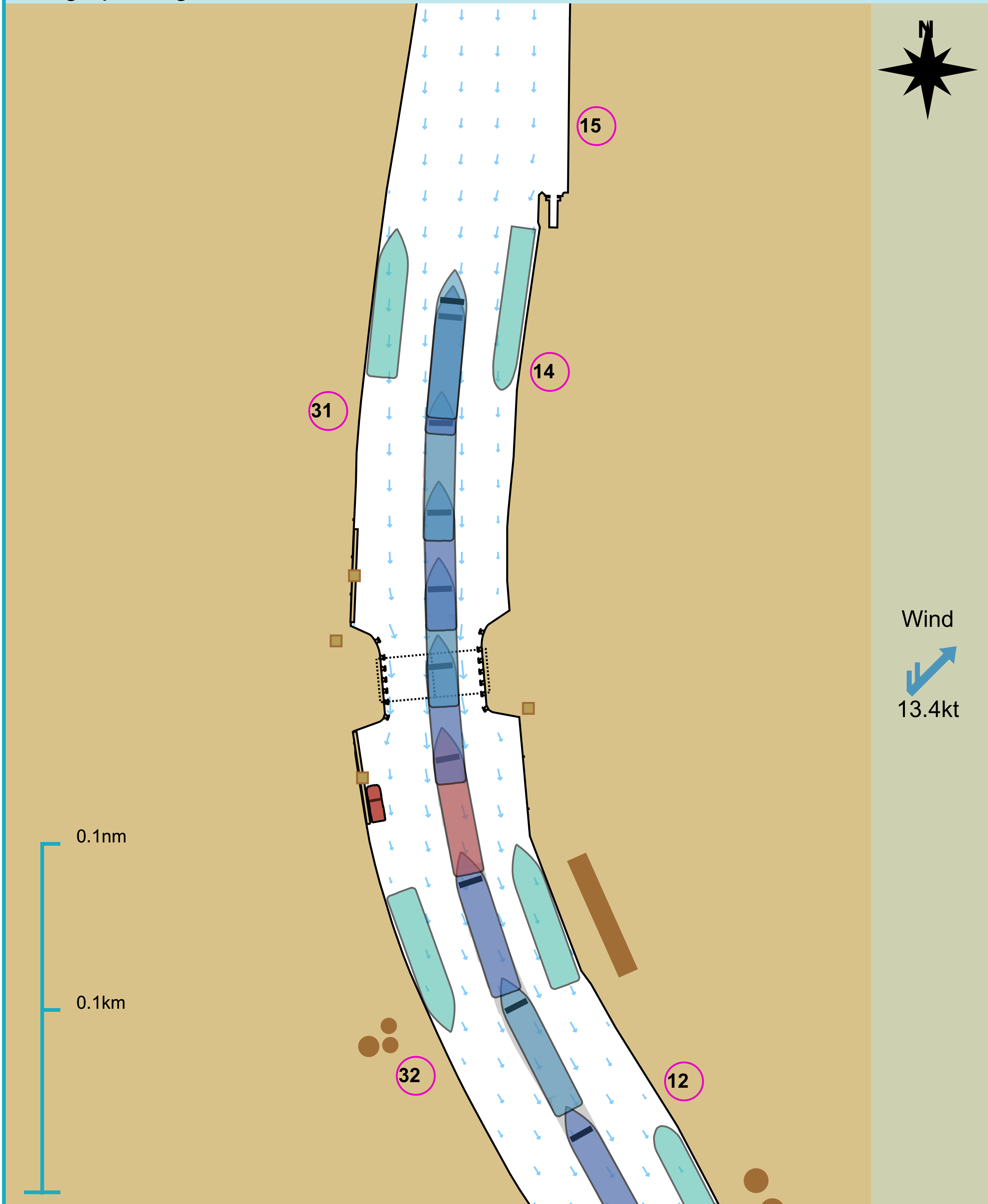


Manoeuvre track plot

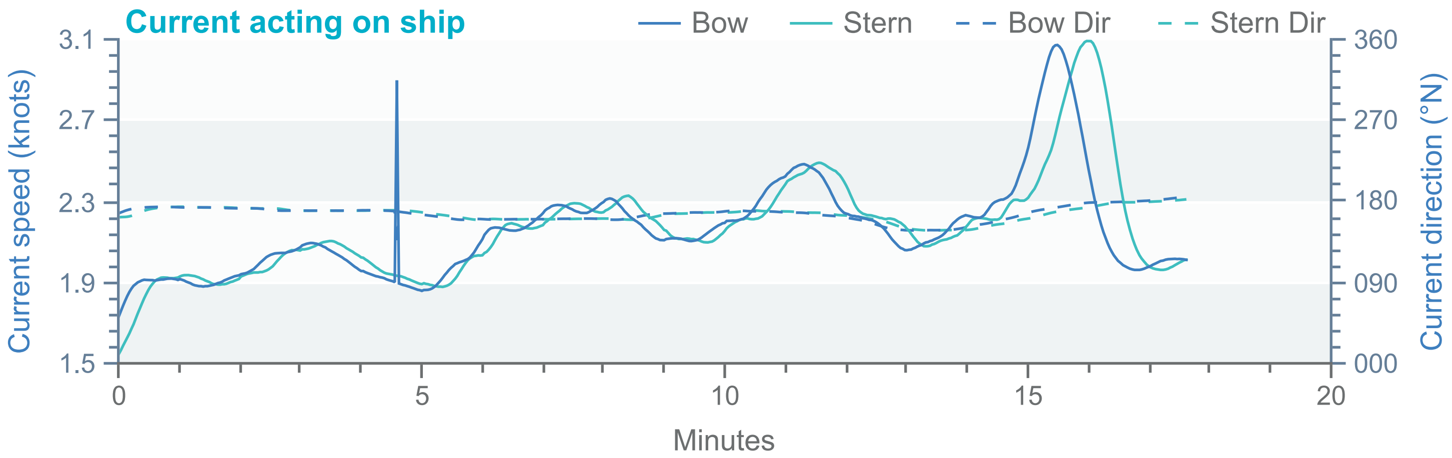


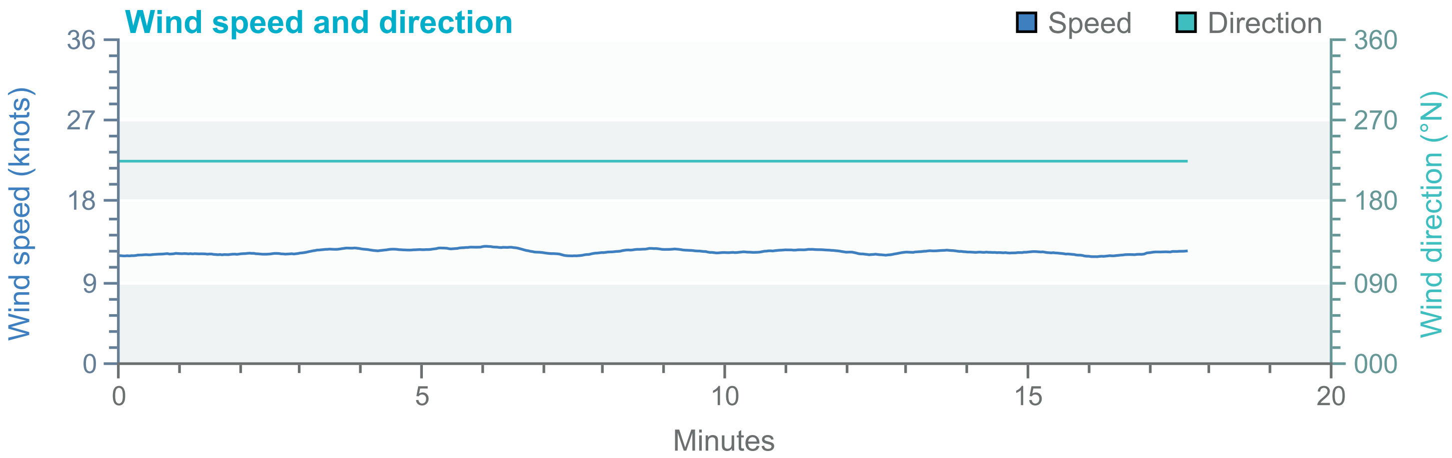
Ships plotted every 0 mins, highlight every 5 mins

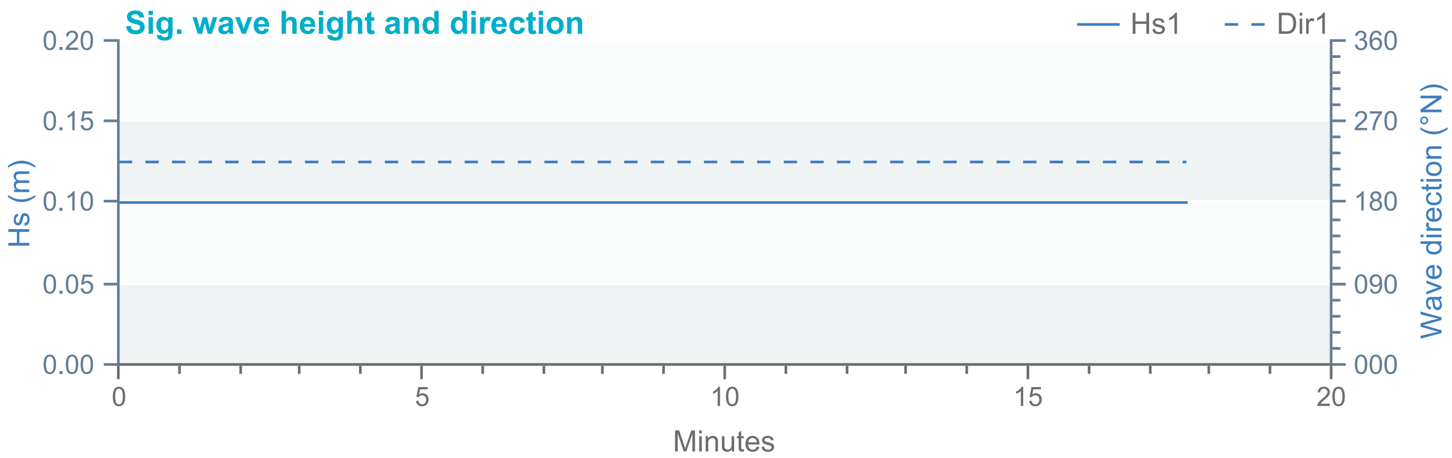
Bridge passage

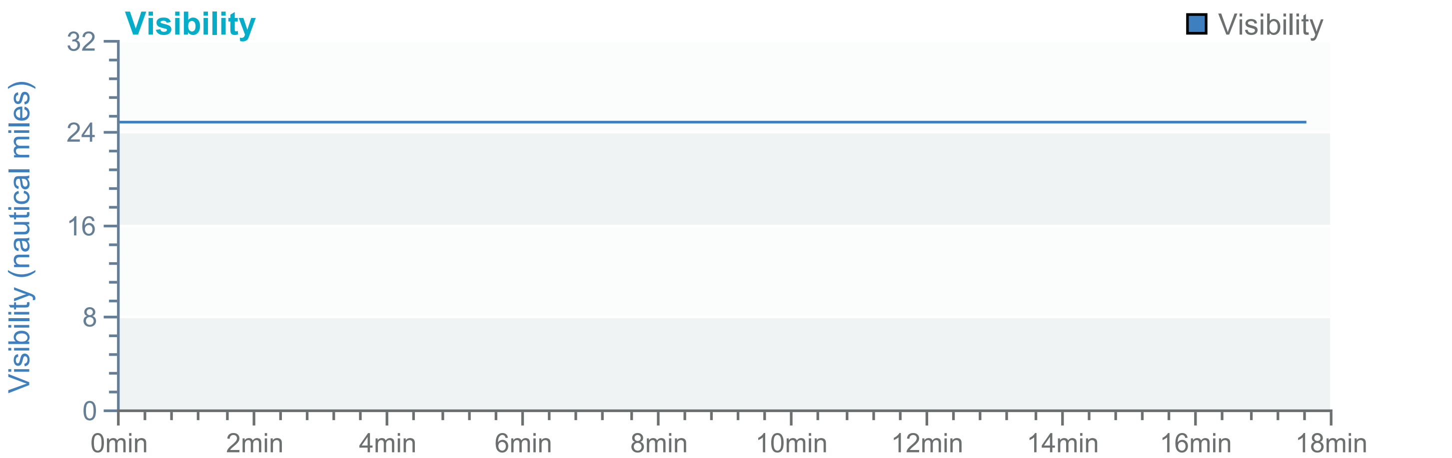


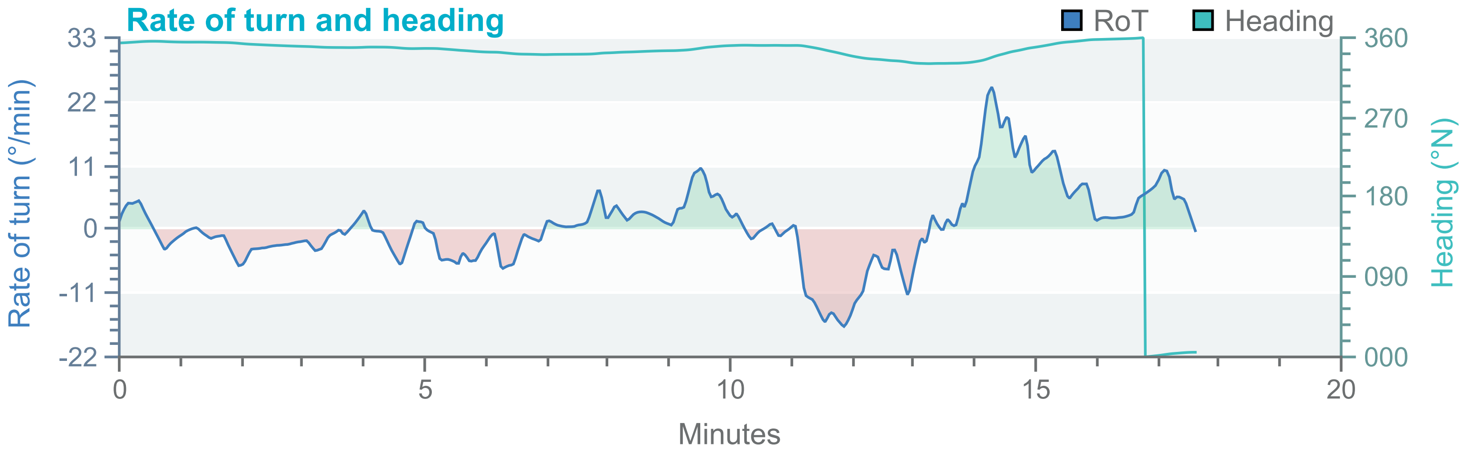
Ships plotted every 0 mins, highlight every 5 mins

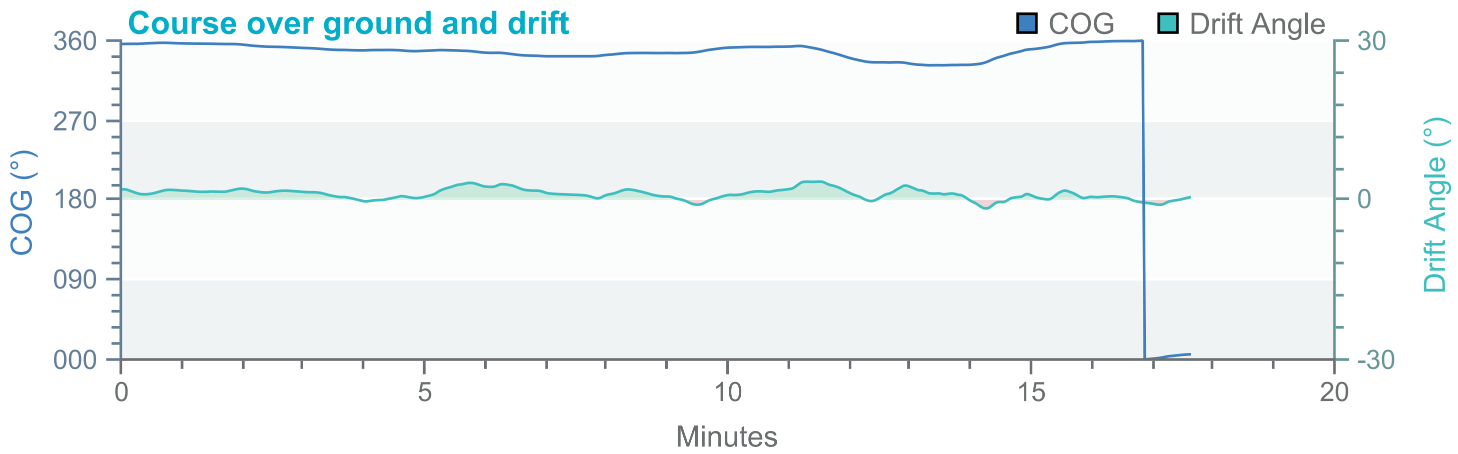

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes

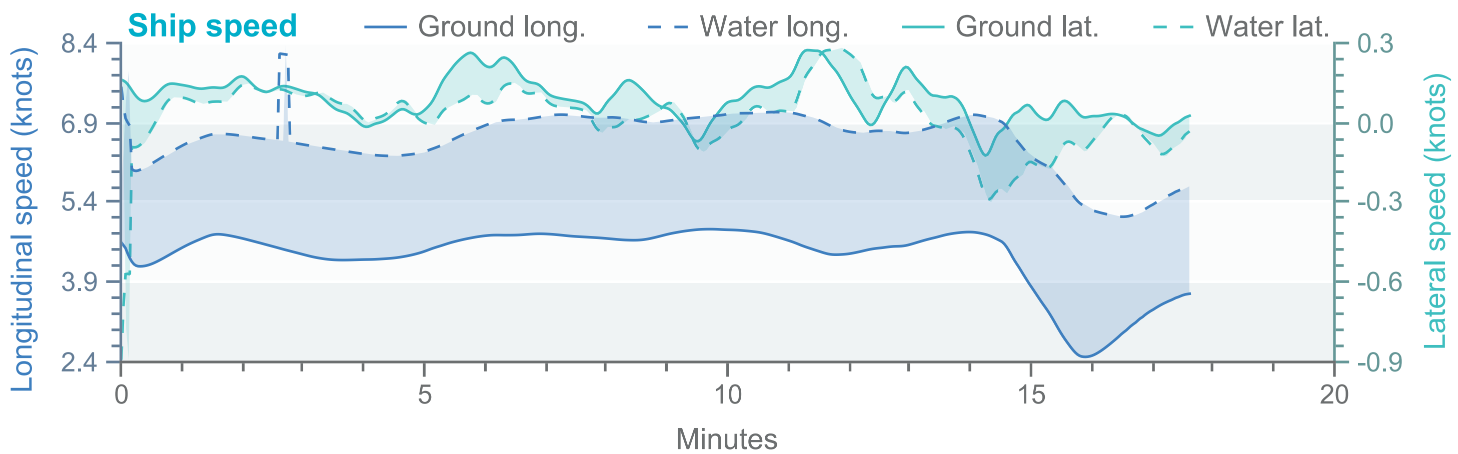

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes

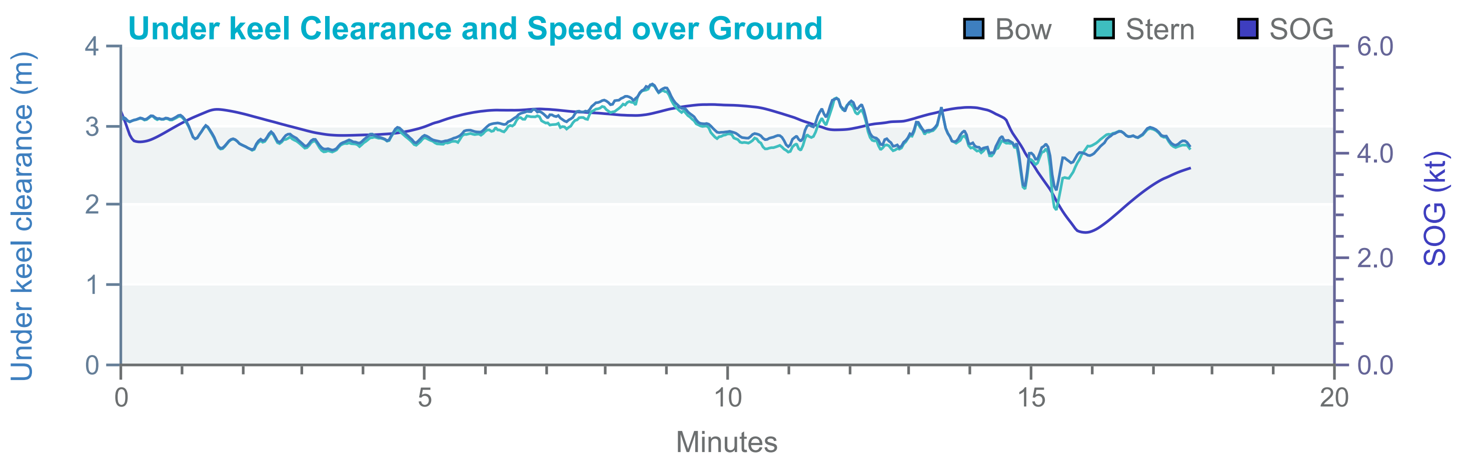

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes

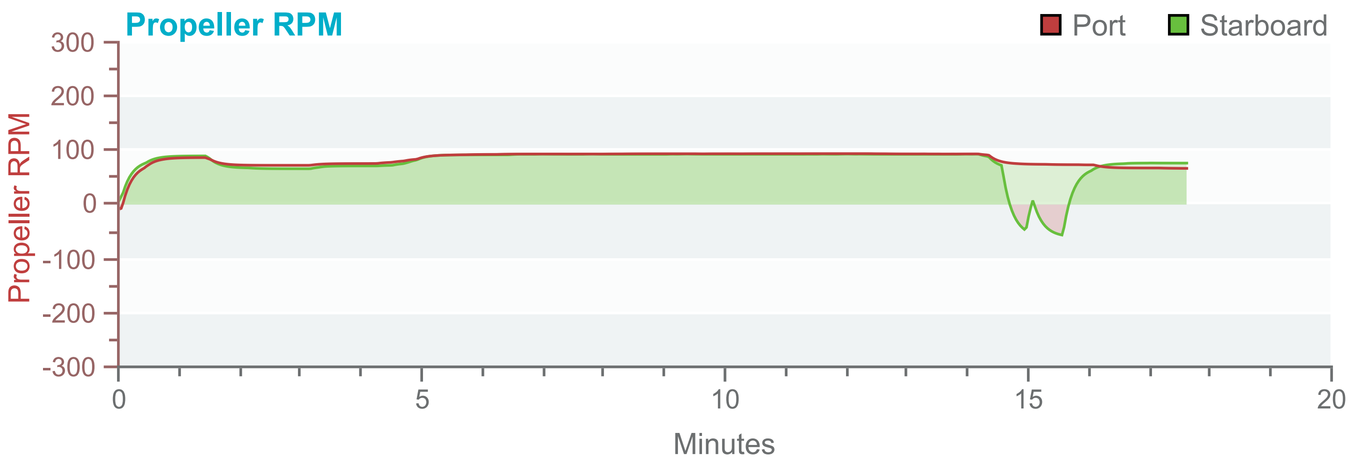

Visibility
Visibility
Visibility (nautical miles)

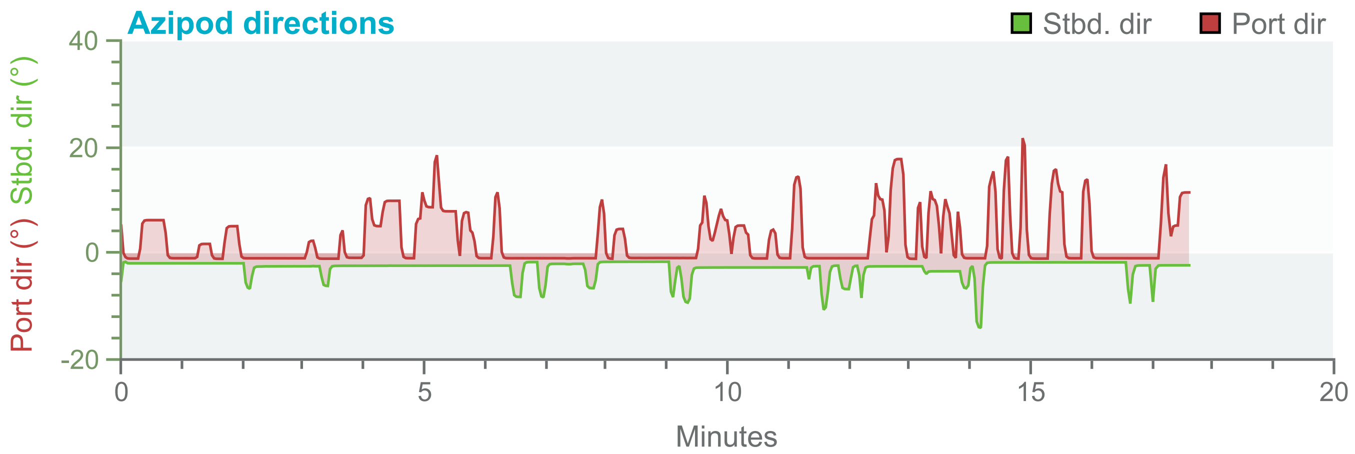

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
33
22
11
0
-11
-22
360
270
180
090
000
0
5
10
15
20
Minutes

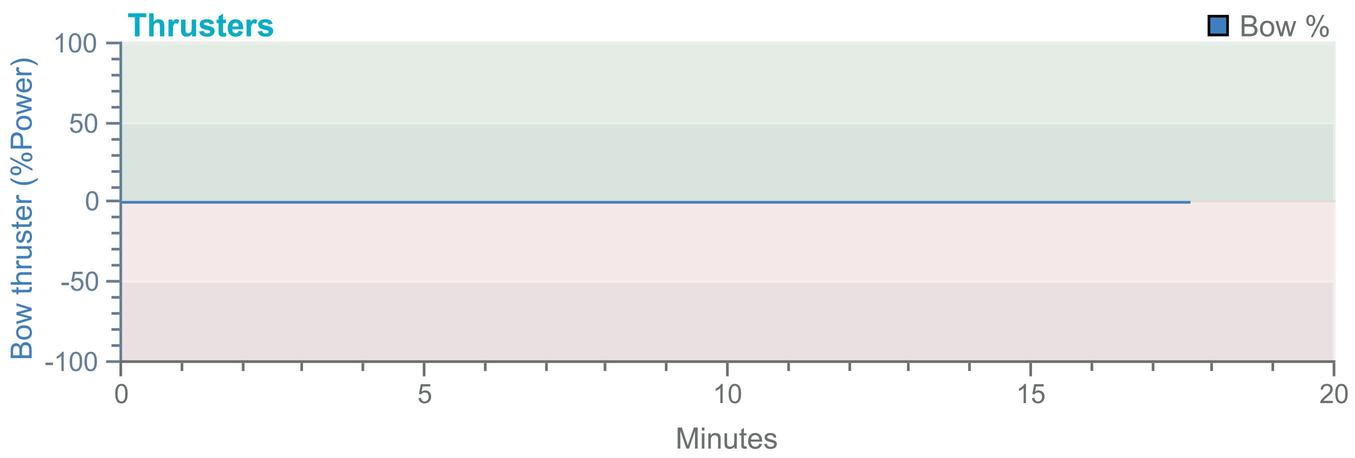

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
30
0
-30
0
5
10
15
20
Minutes

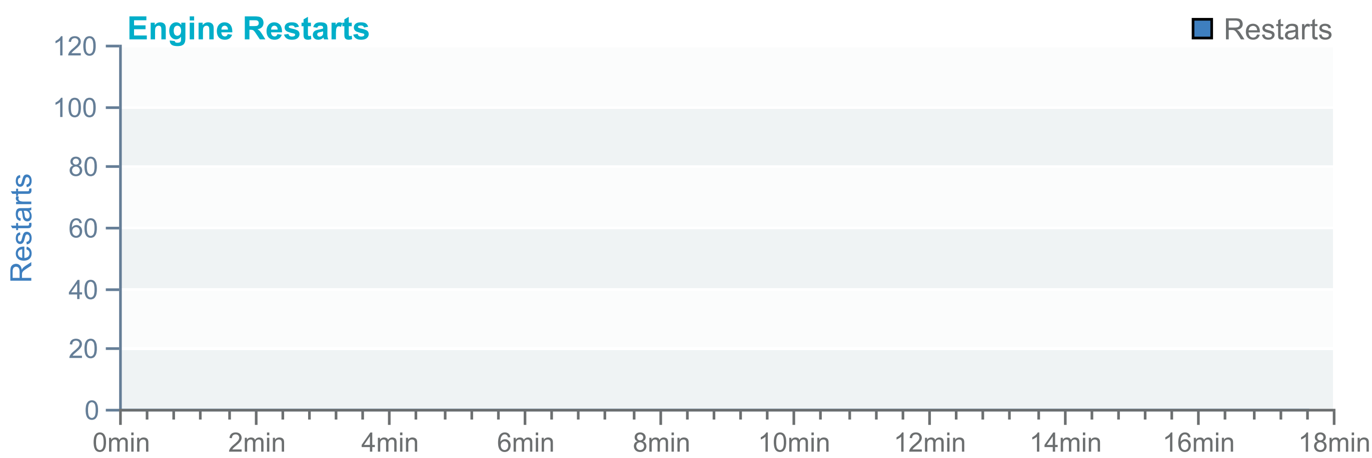

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
8.4
6.9
5.4
3.9
2.4
0.3
0.0
-0.3
-0.6
-0.9
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
4
3
2
1
0
6.0
4.0
2.0
0.0
0
5
10
15
20
Minutes


Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
15
20
Minutes

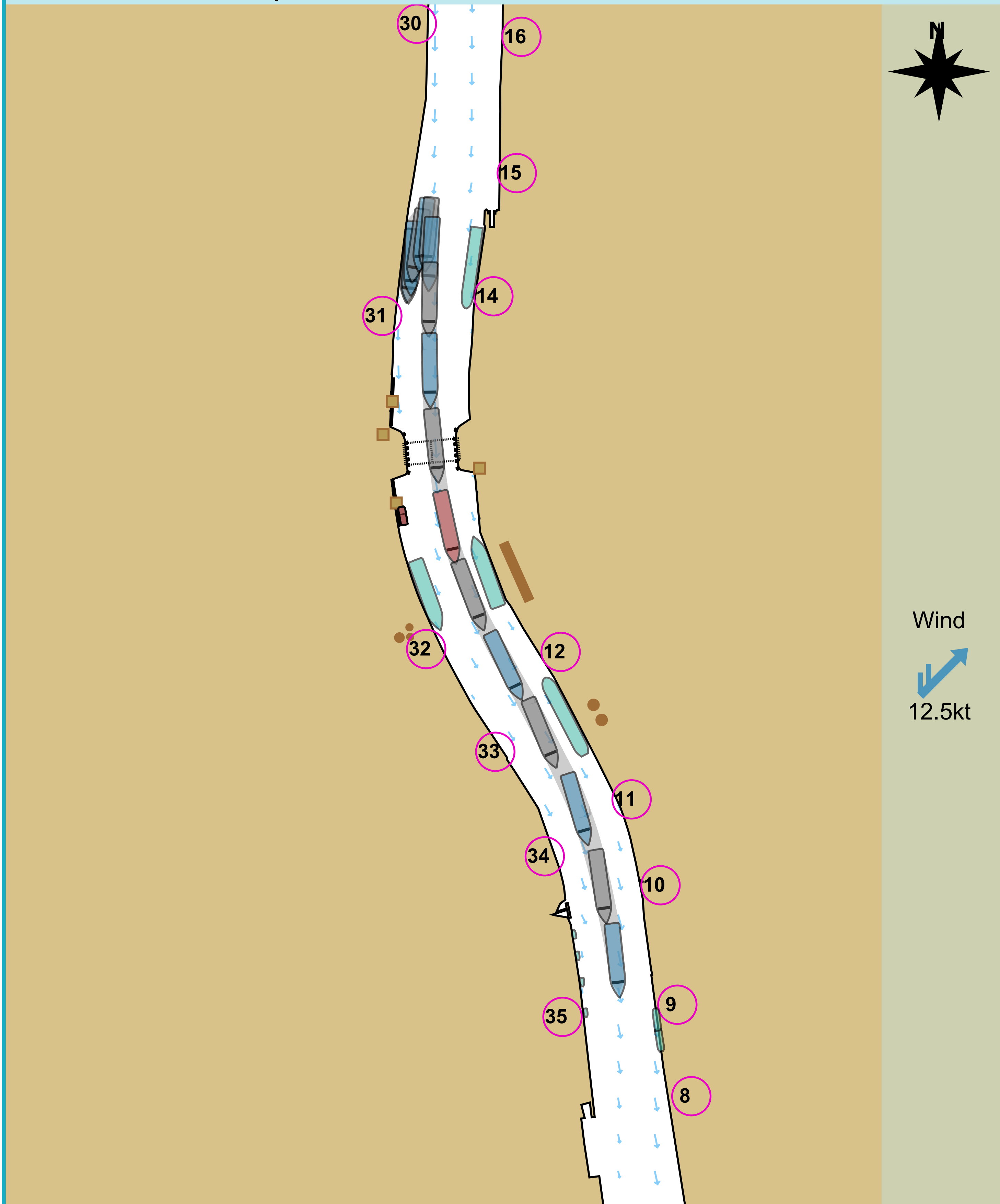

Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
40
20
0
-20
0
5
10
15
20
Minutes


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


Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min

Tracks	Environment	80m PSV

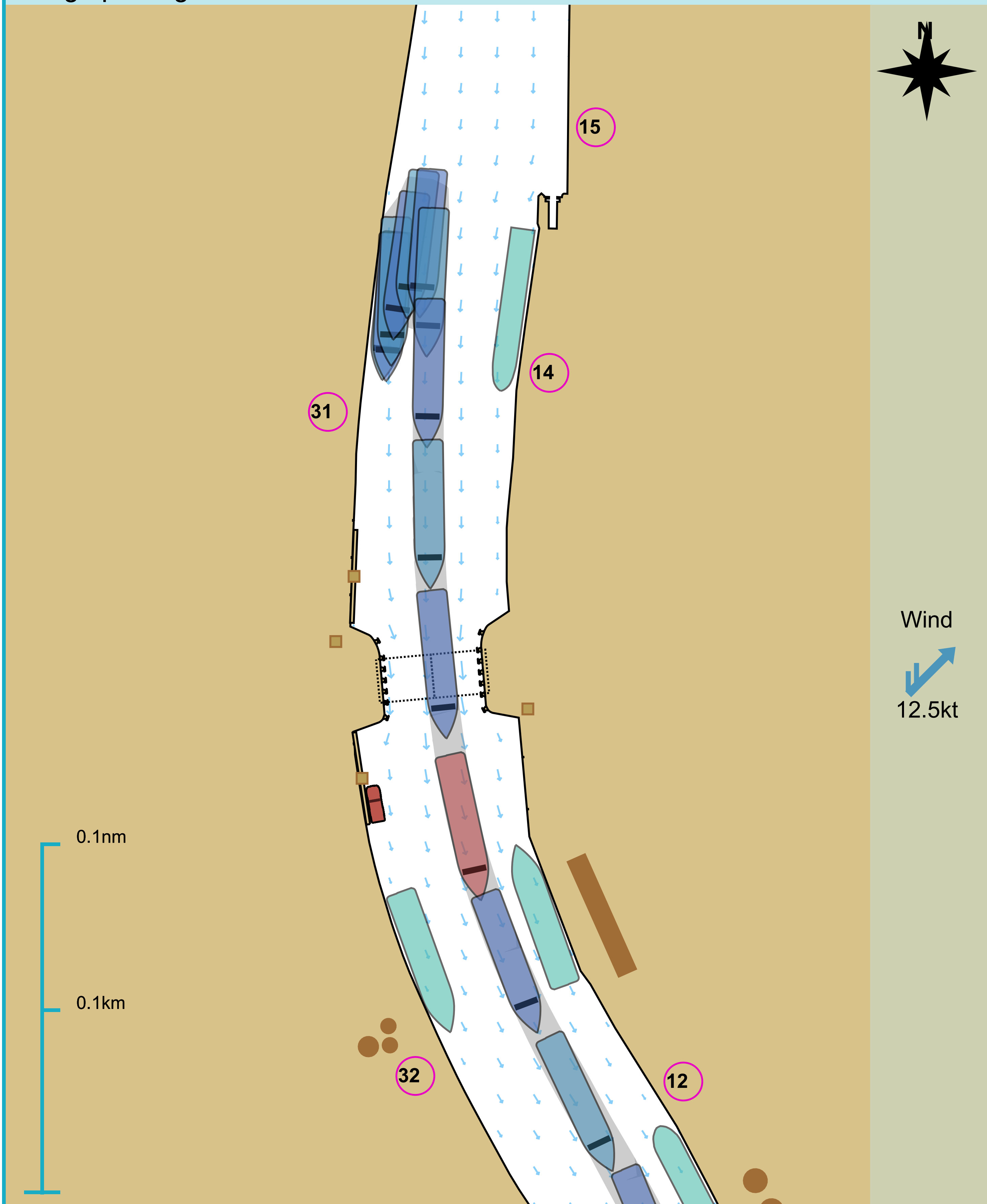
Manoeuvre track plot



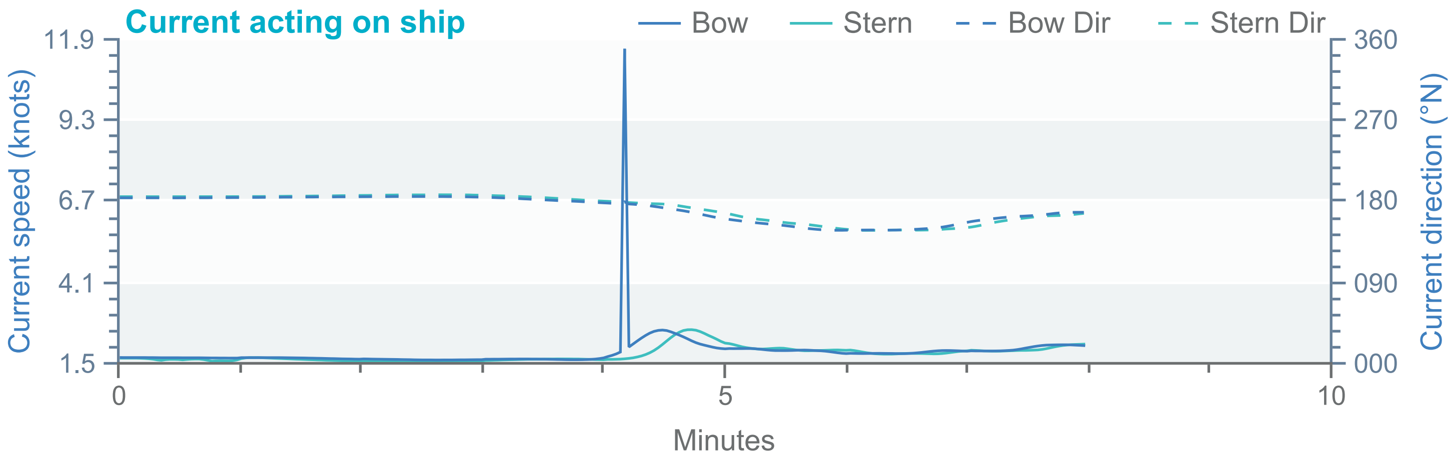
Ships plotted every 0 mins, highlight every 5 mins

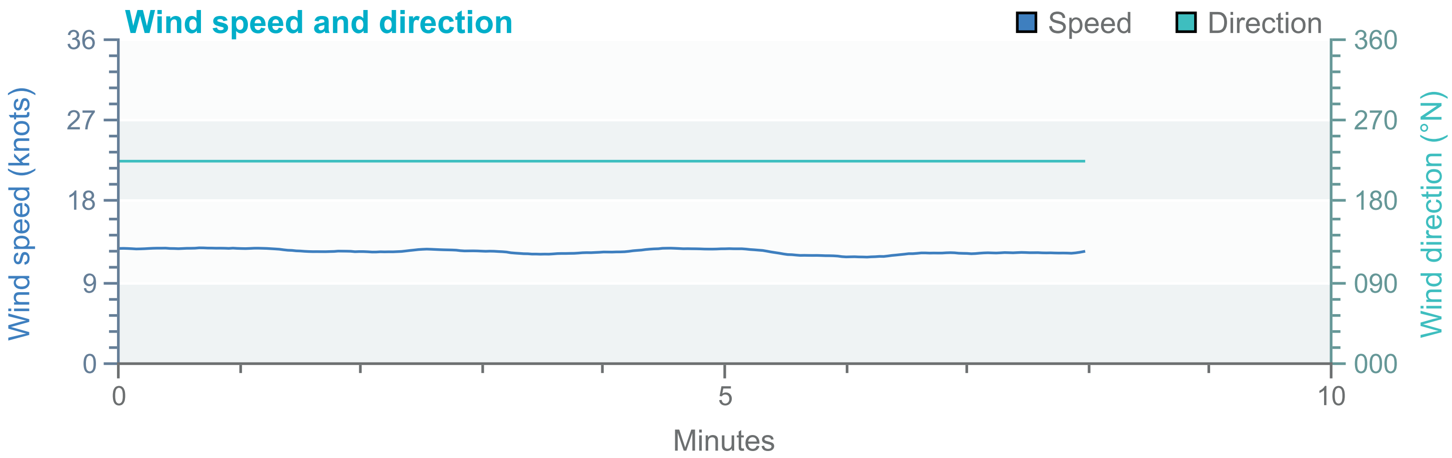
Tracks | Environment | 80m PSV

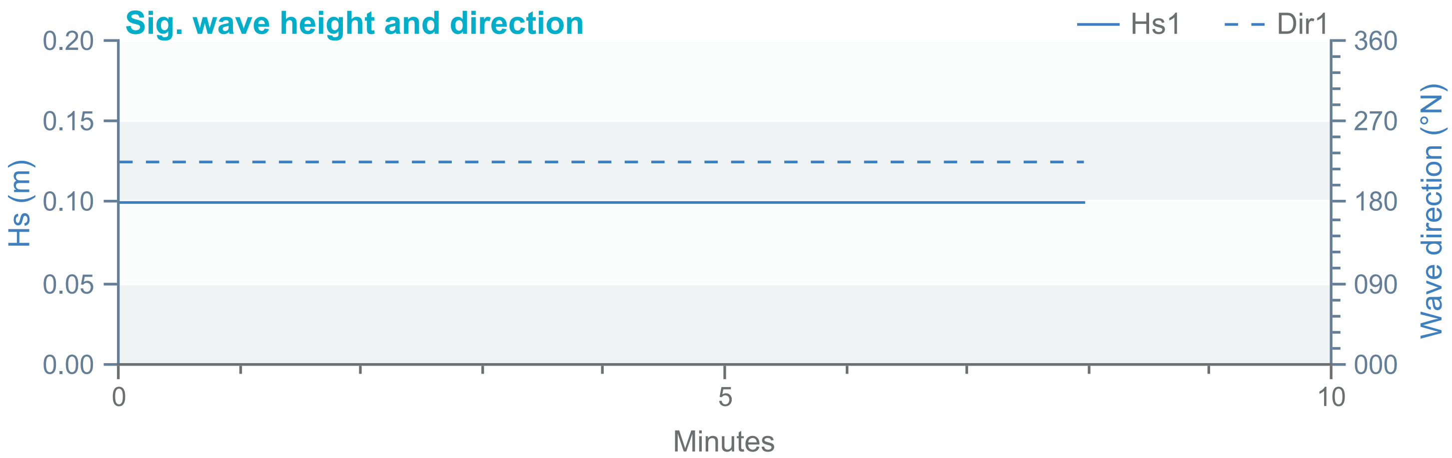
Bridge passage

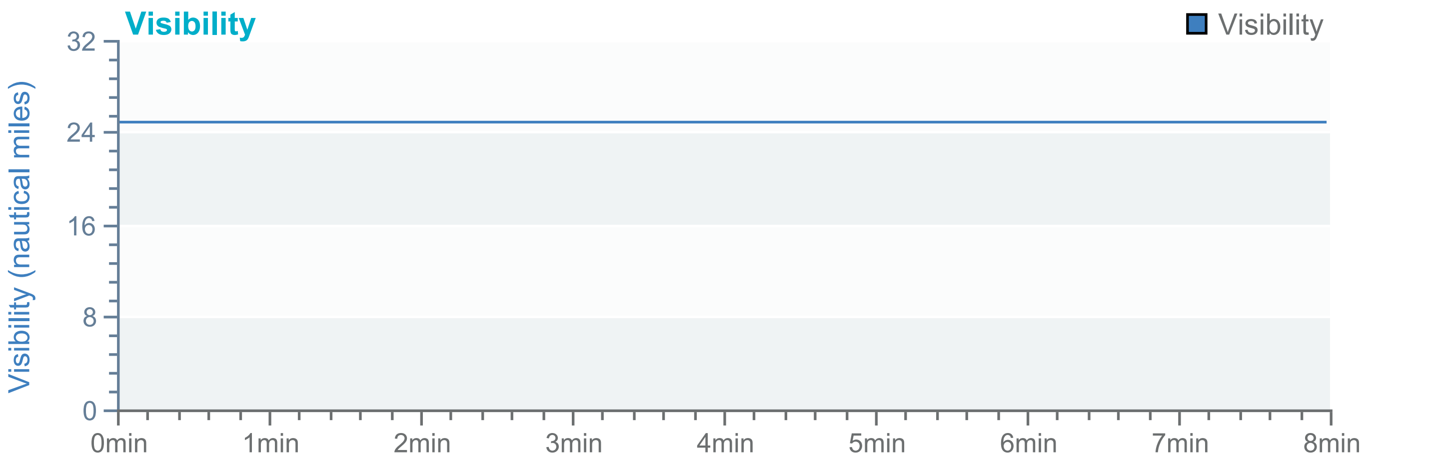


Ships plotted every 0 mins, highlight every 5 mins

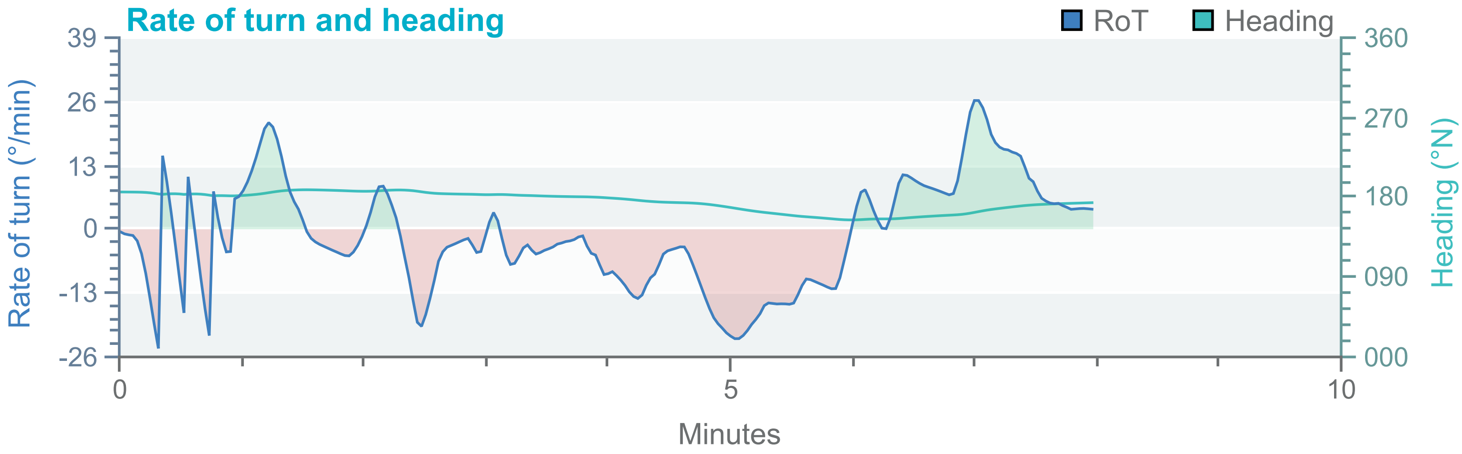

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
11.9
9.3
6.7
4.1
1.5
Current direction (°N)
360
270
180
090
000
0
5
10
Minutes


Wind speed and direction
Speed
Direction
Wind speed (knots)
36
27
18
9
0
Wind direction (°N)
360
270
180
090
000
0
5
10
Minutes

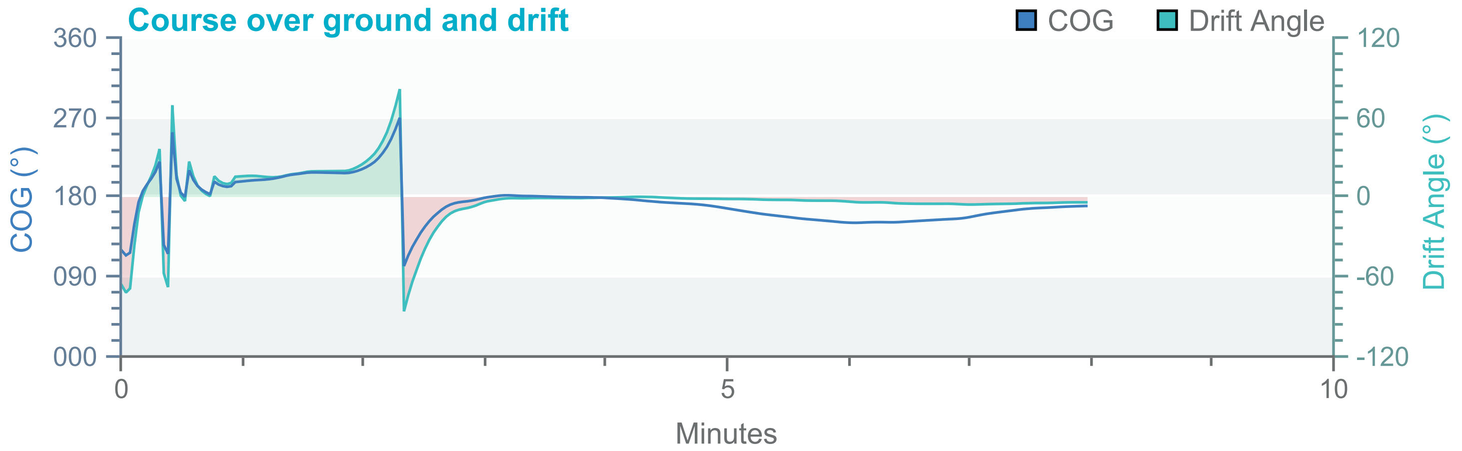

Sig. wave height and direction
Hs1
Dir1
Hs (m)
0.20
0.15
0.10
0.05
0.00
Wave direction (°N)
360
270
180
090
000
0
5
10
Minutes


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
1min
2min
3min
4min
5min
6min
7min
8min

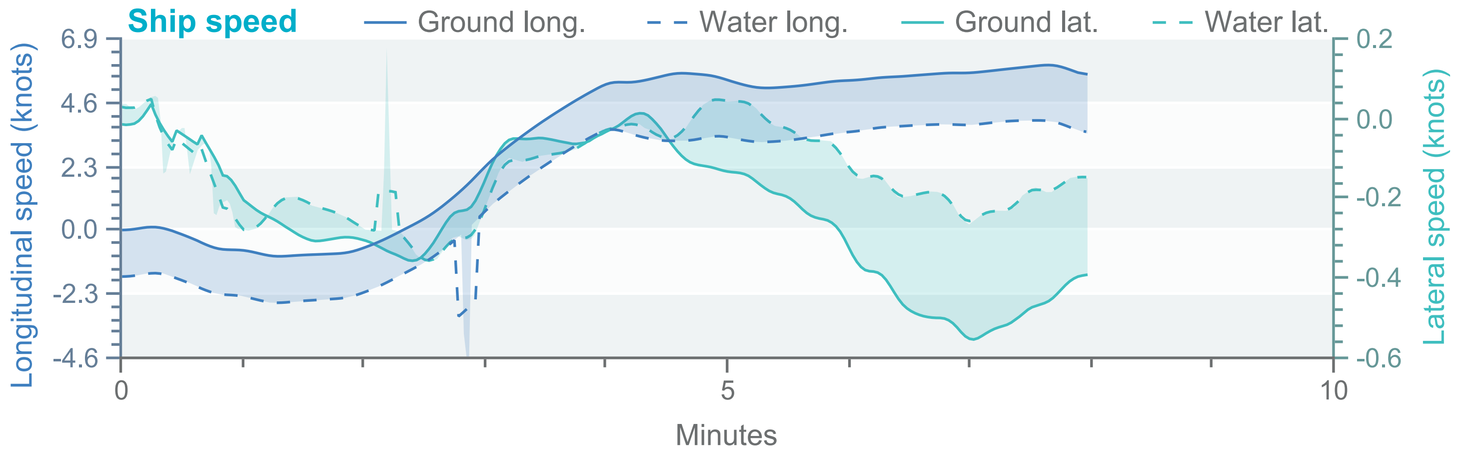
Rate of turn and heading



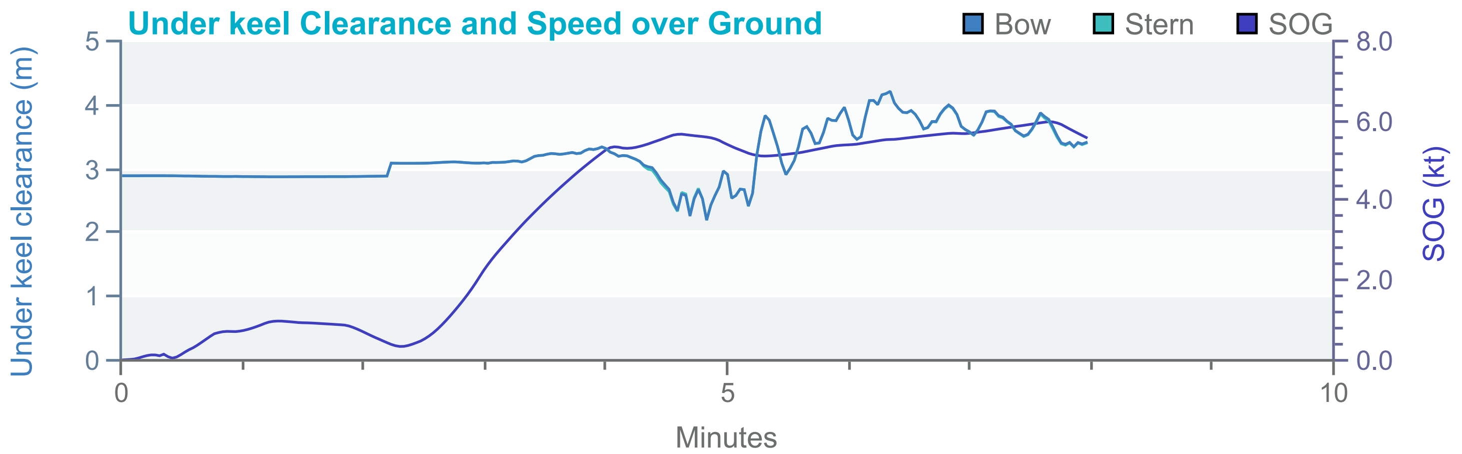
Course over ground and drift

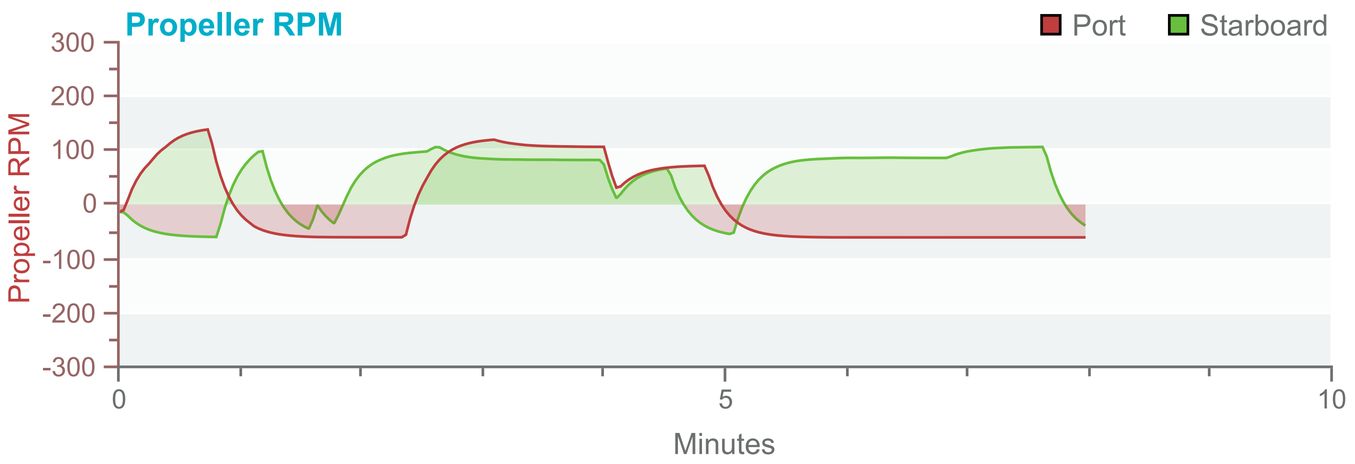


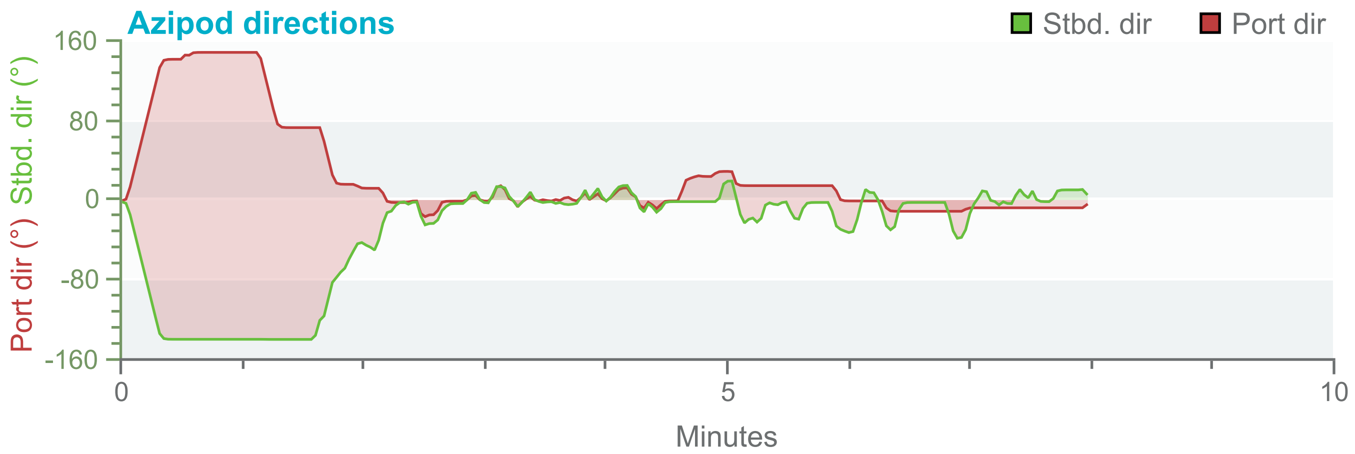
Ship speed

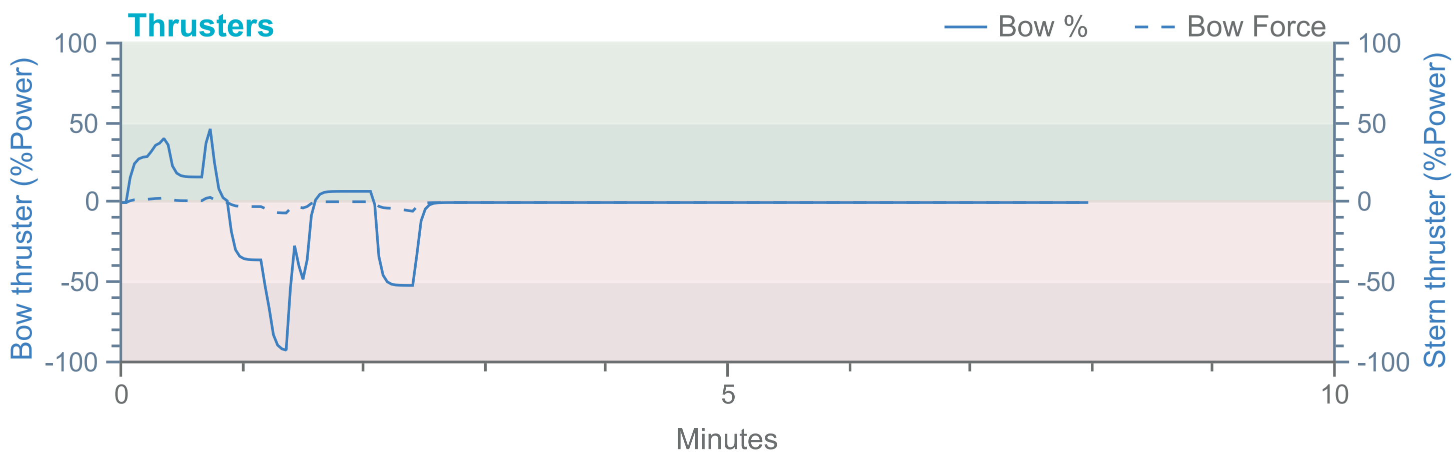


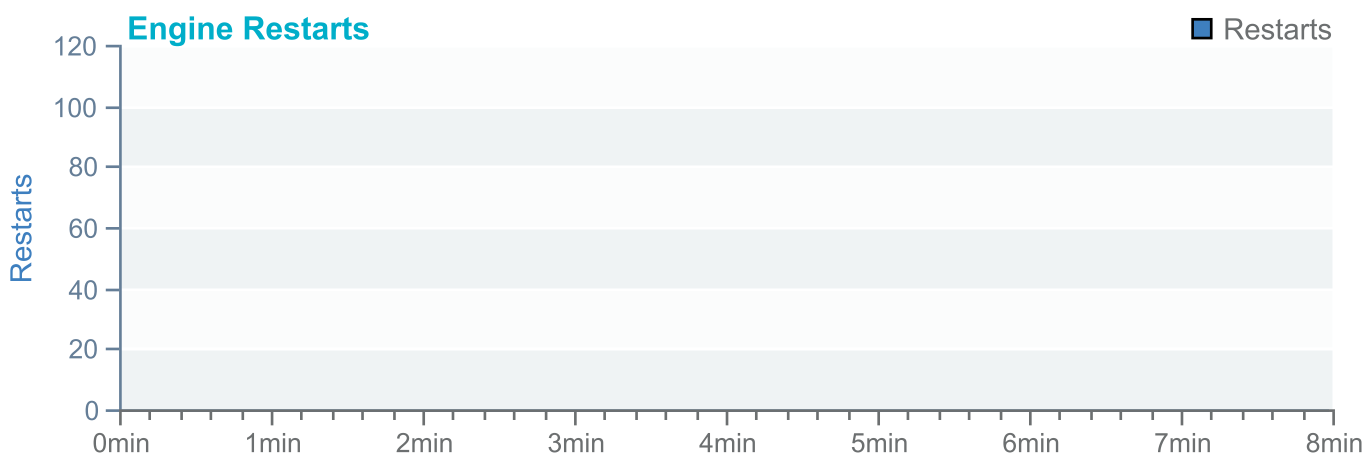
Under keel Clearance and Speed over Ground



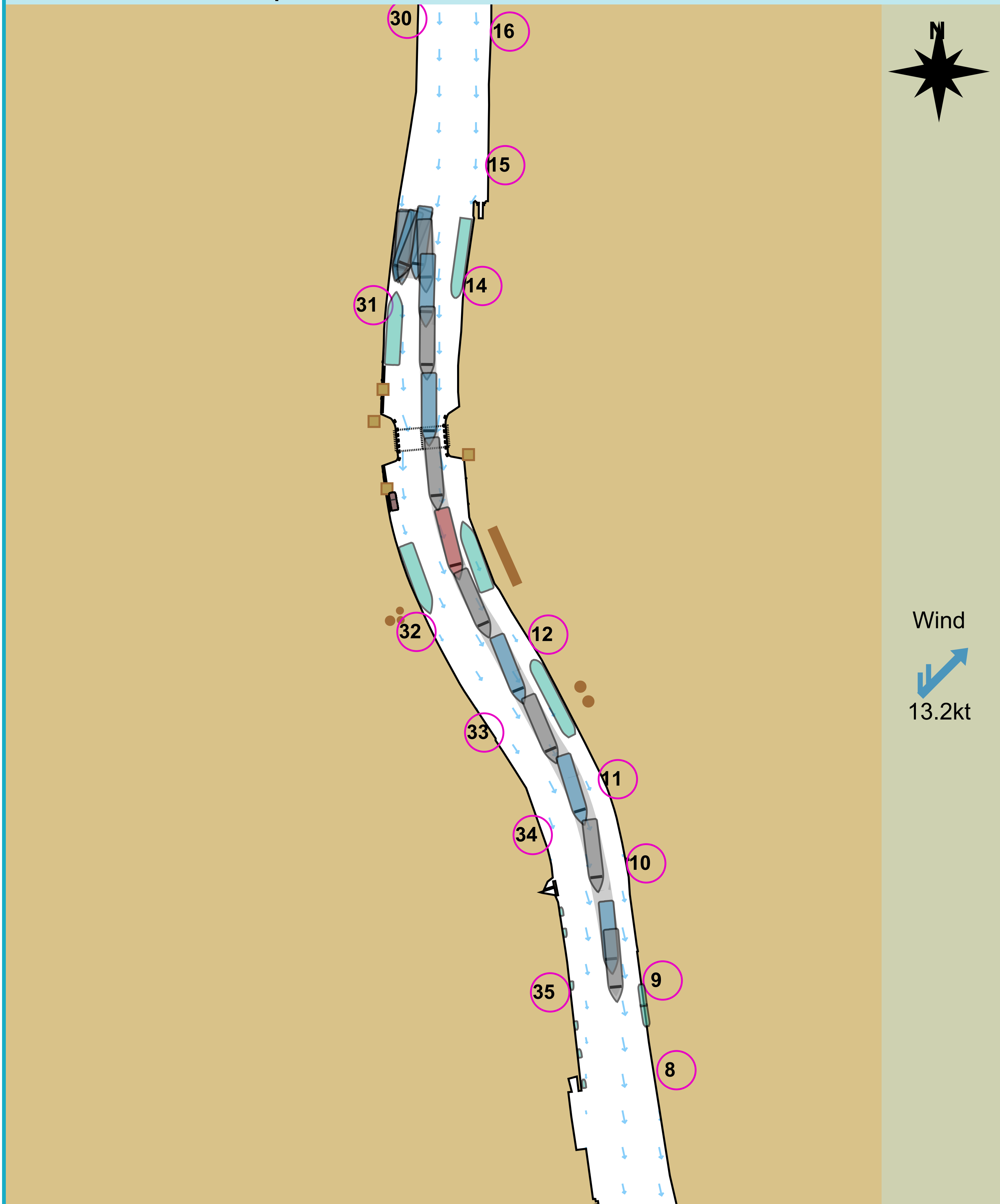

Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
Minutes


Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
160
80
0
-80
-160
0
5
10
Minutes


Thrusters
Bow %
Bow Force
Bow thruster (%Power)
Stern thruster (%Power)
100
50
0
-50
-100
0
5
10
Minutes


Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
1min
2min
3min
4min
5min
6min
7min
8min

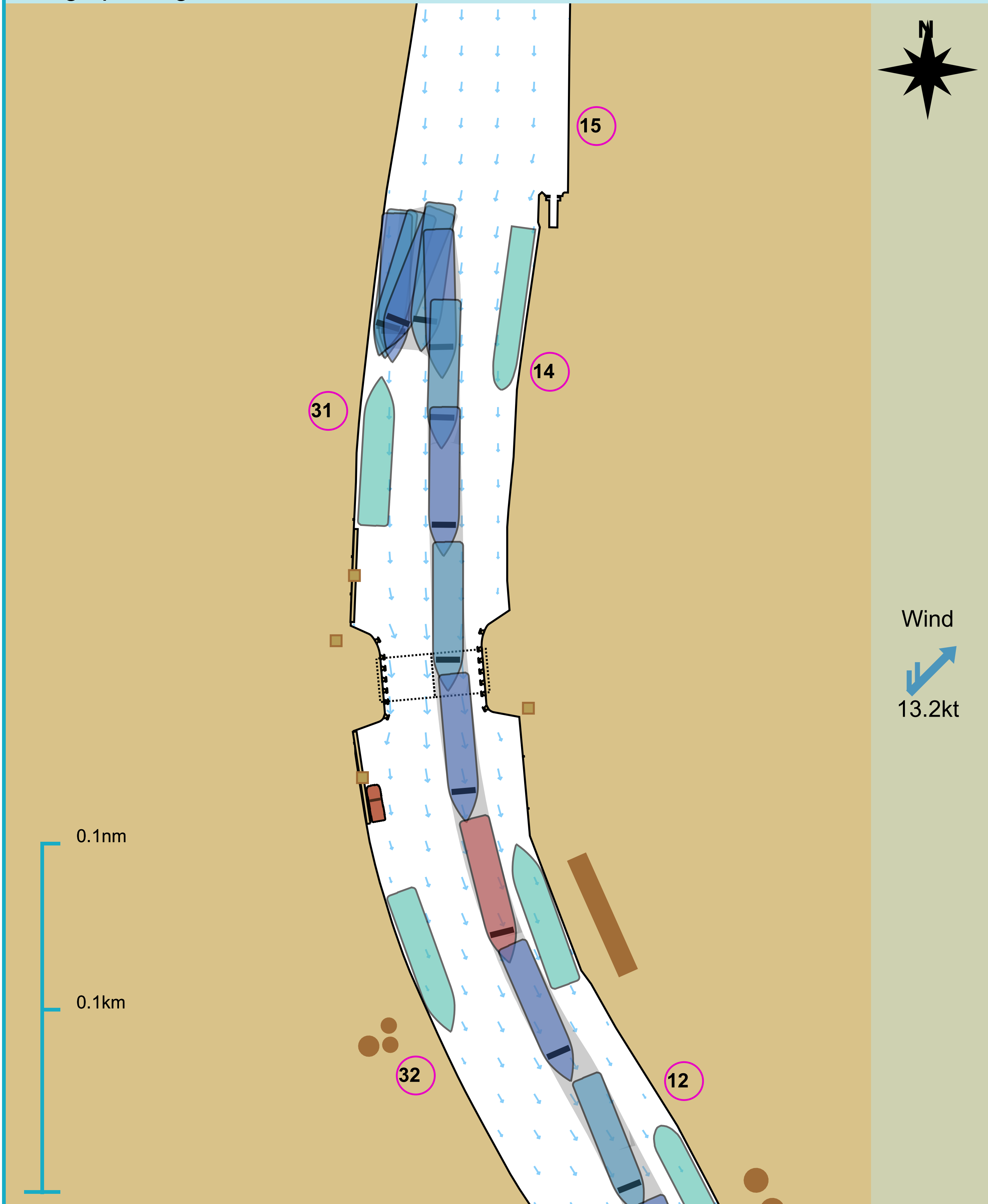
Manoeuvre track plot



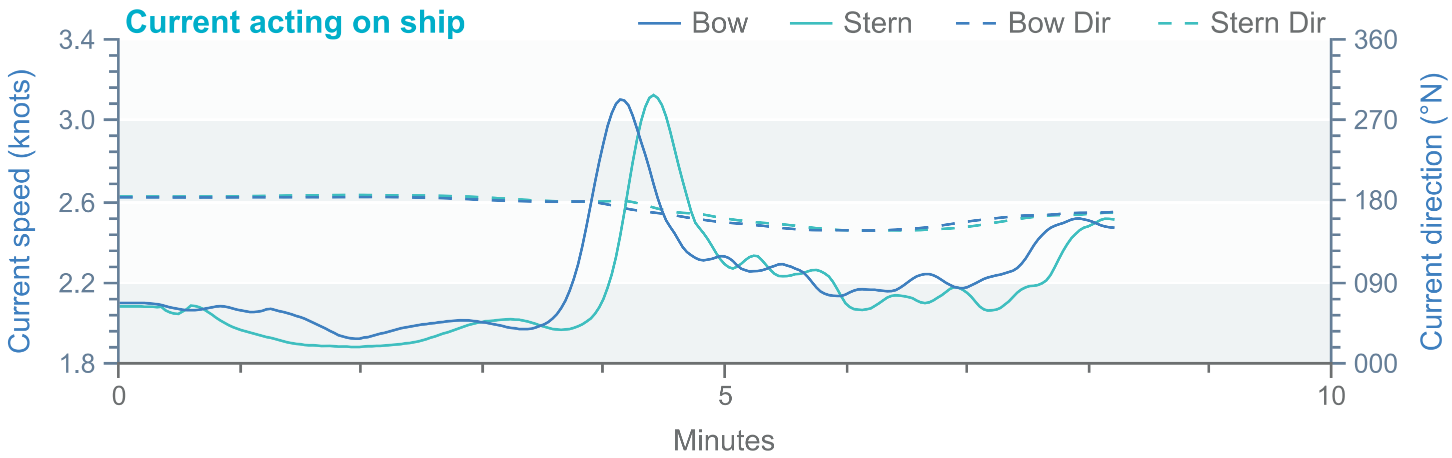
Ships plotted every 0 mins, highlight every 5 mins

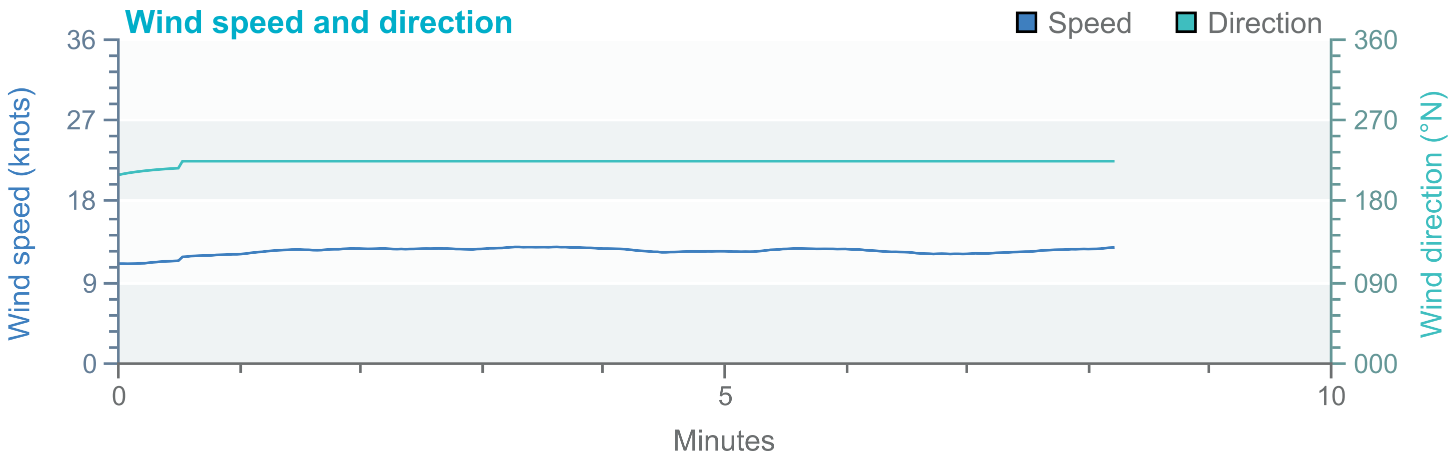
Tracks | Environment | 80m PSV

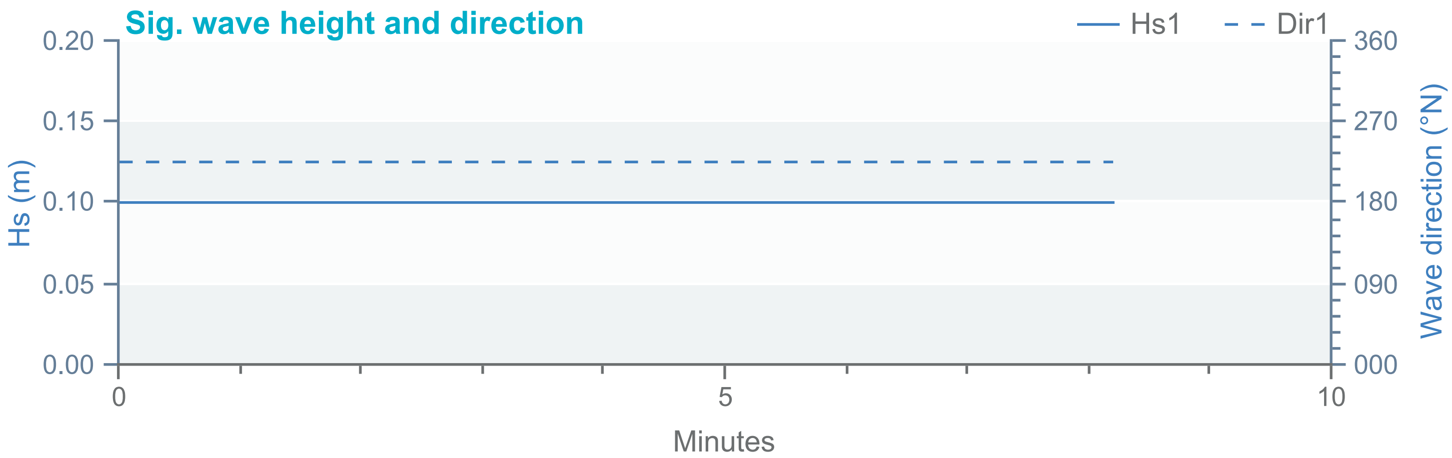
Bridge passage

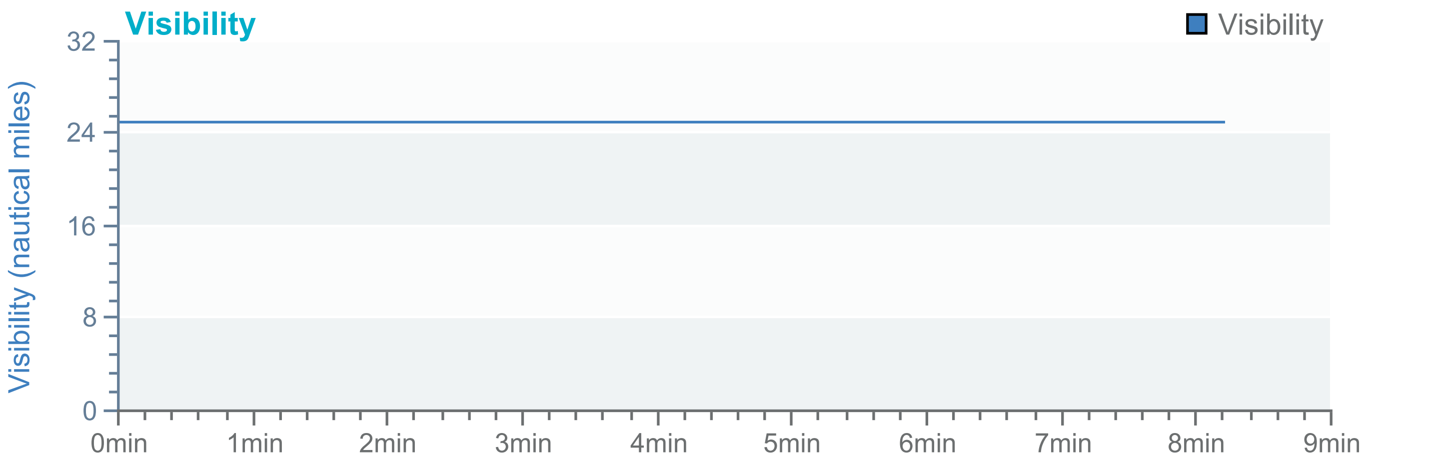


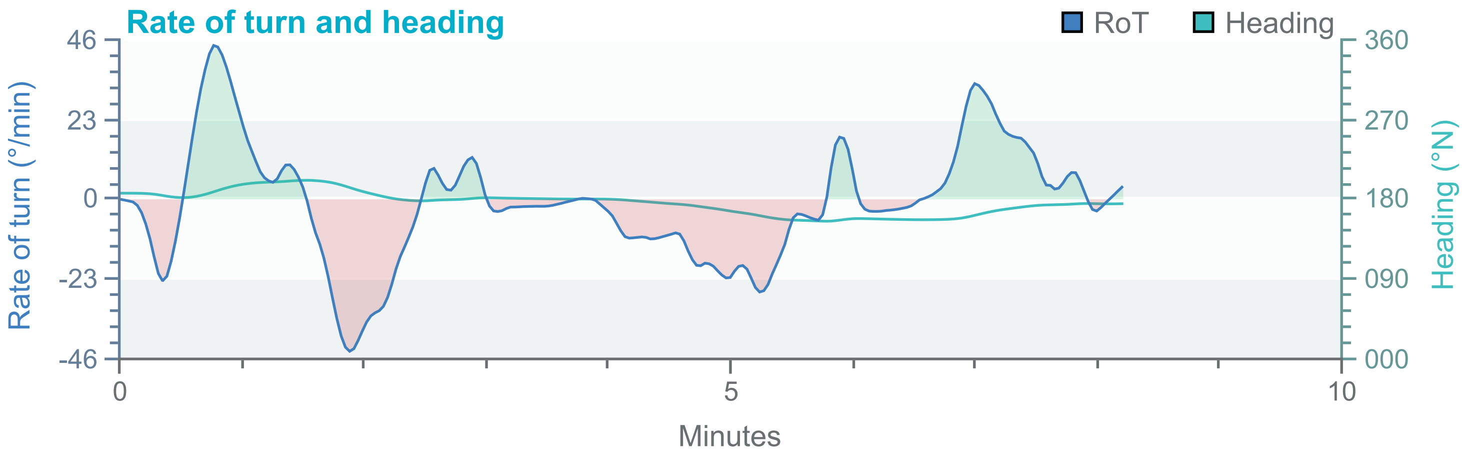
Ships plotted every 0 mins, highlight every 5 mins

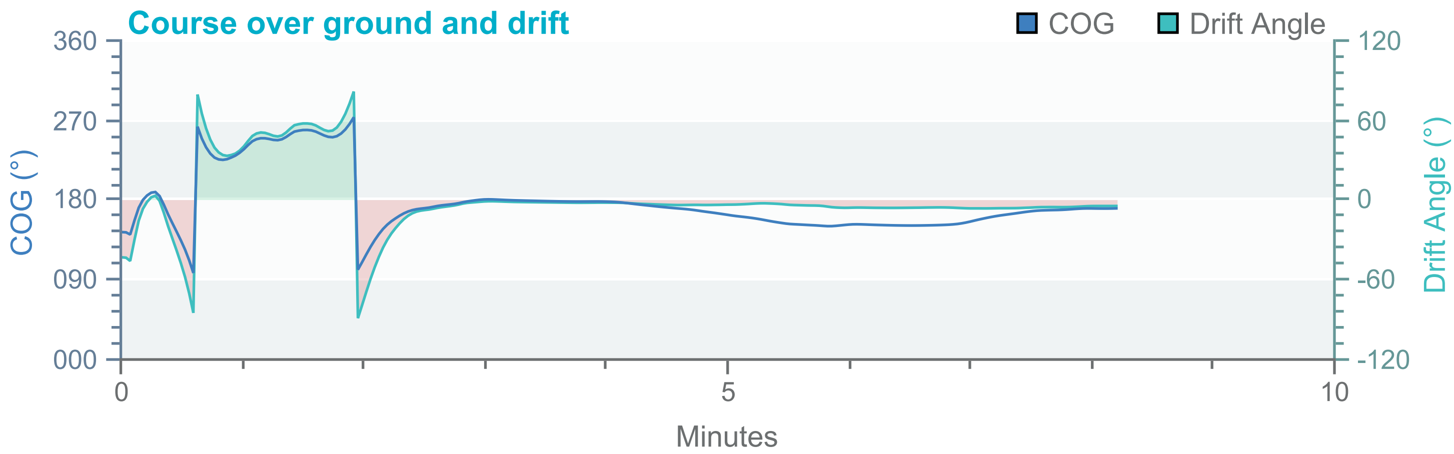

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
3.4
3.0
2.6
2.2
1.8
360
270
180
090
000
0
5
10
Minutes

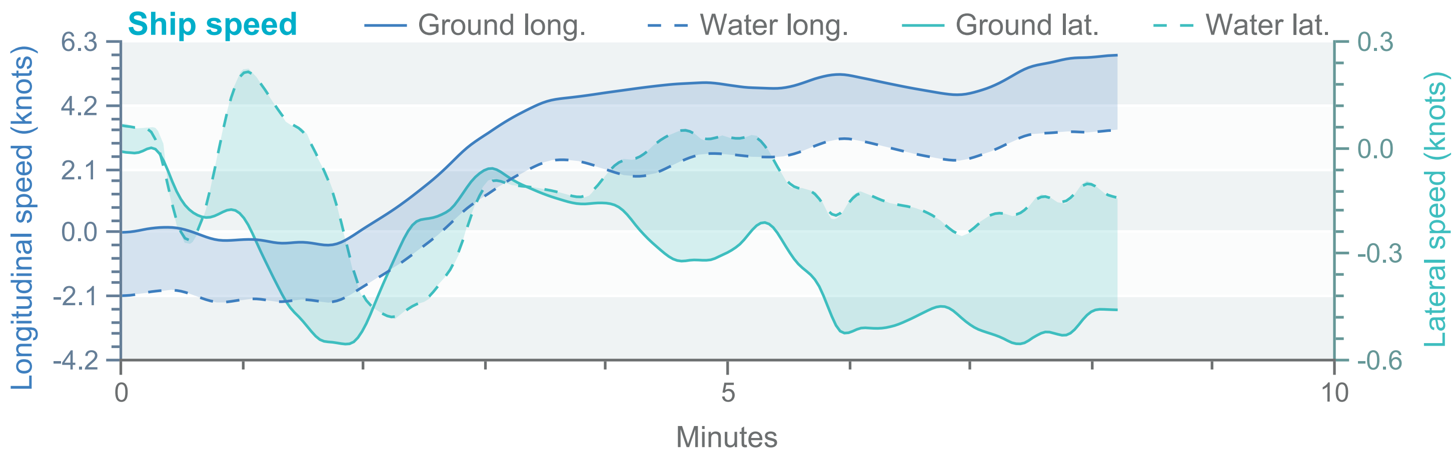

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
Minutes

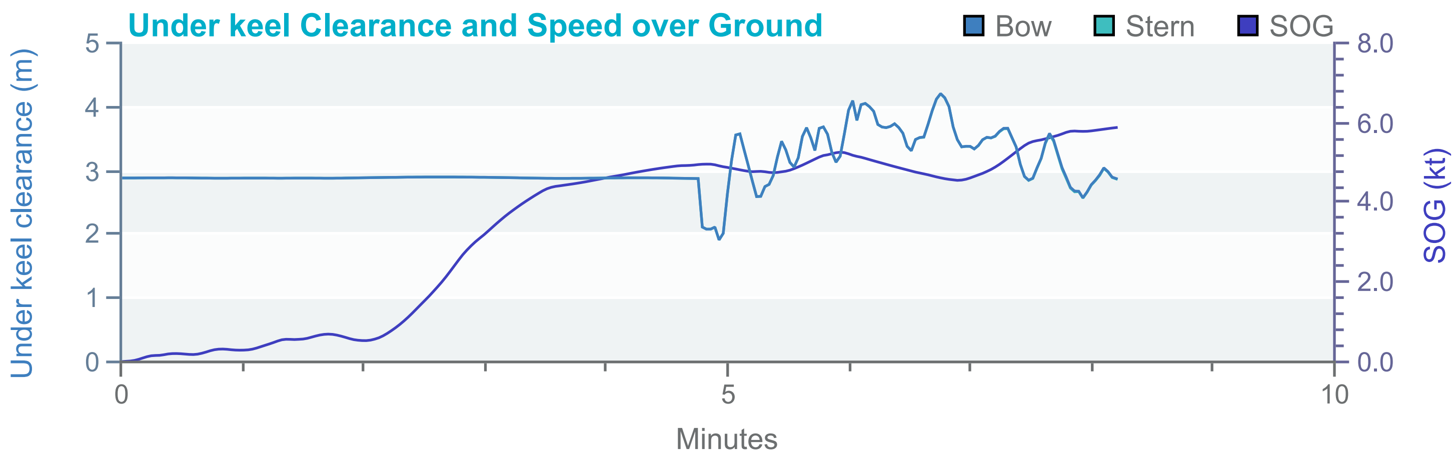

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
Minutes

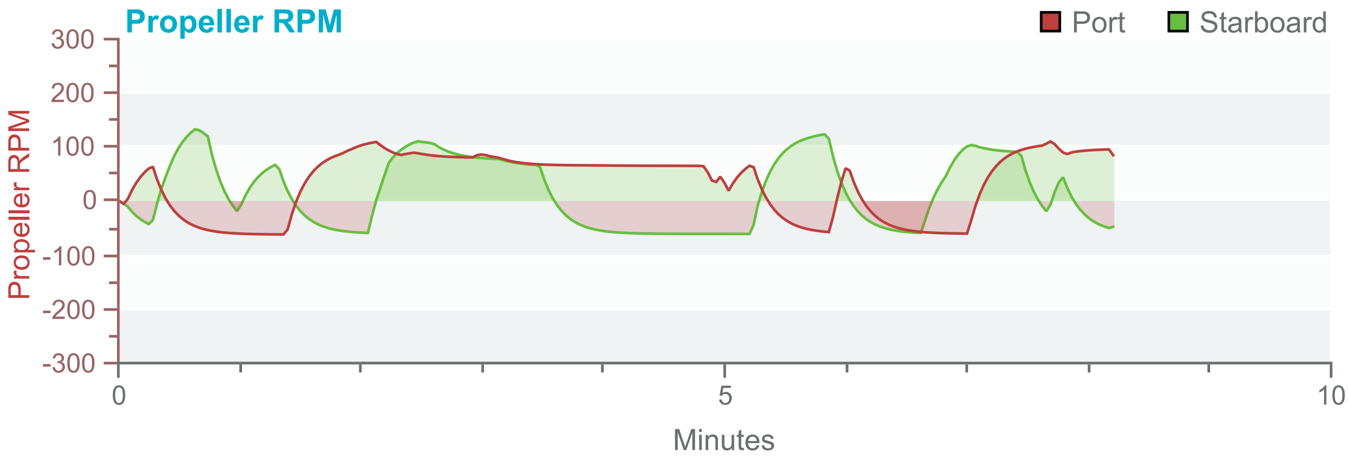

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
1min
2min
3min
4min
5min
6min
7min
8min
9min

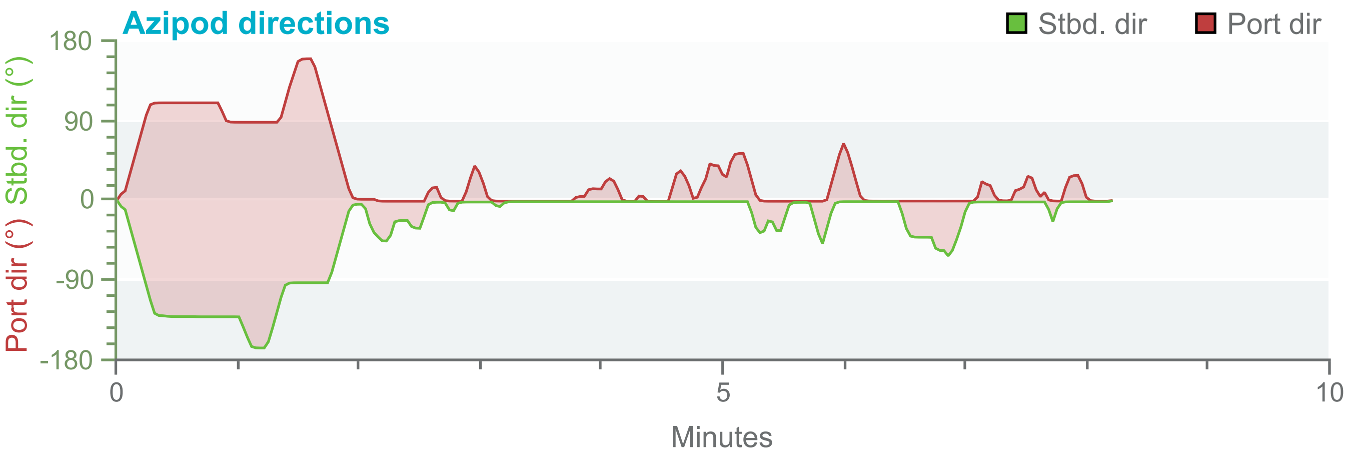

Rate of turn and heading
RoT
Heading
46
23
0
-23
-46
Rate of turn (°/min)
360
270
180
090
000
Heading (°N)
0
5
10
Minutes

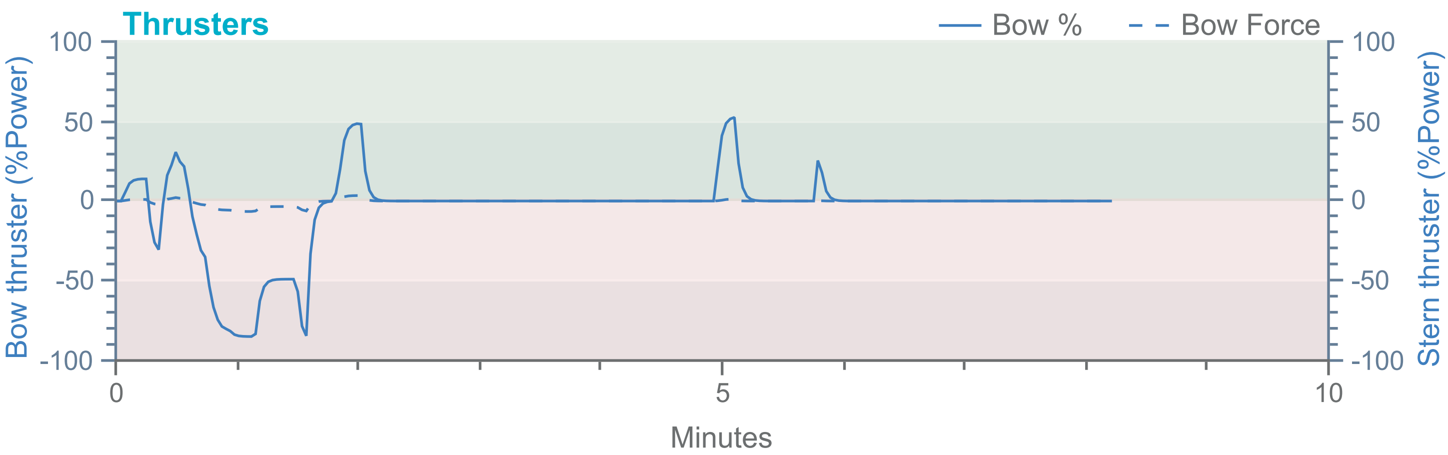

Course over ground and drift
COG
Drift Angle
360
270
180
090
000
COG (°)
120
60
0
-60
-120
Drift Angle (°)
0
5
10
Minutes

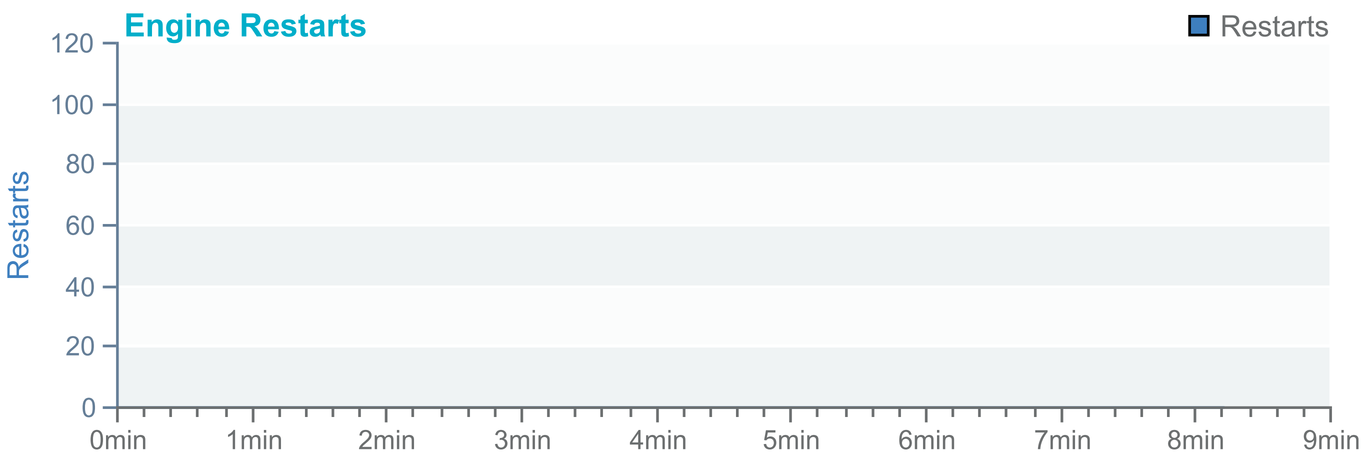

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
6.3
4.2
2.1
0.0
-2.1
-4.2
Longitudinal speed (knots)
0.3
0.0
-0.3
-0.6
Lateral speed (knots)
0
5
10
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
5
4
3
2
1
0
Under keel clearance (m)
8.0
6.0
4.0
2.0
0.0
SOG (kt)
0
5
10
Minutes

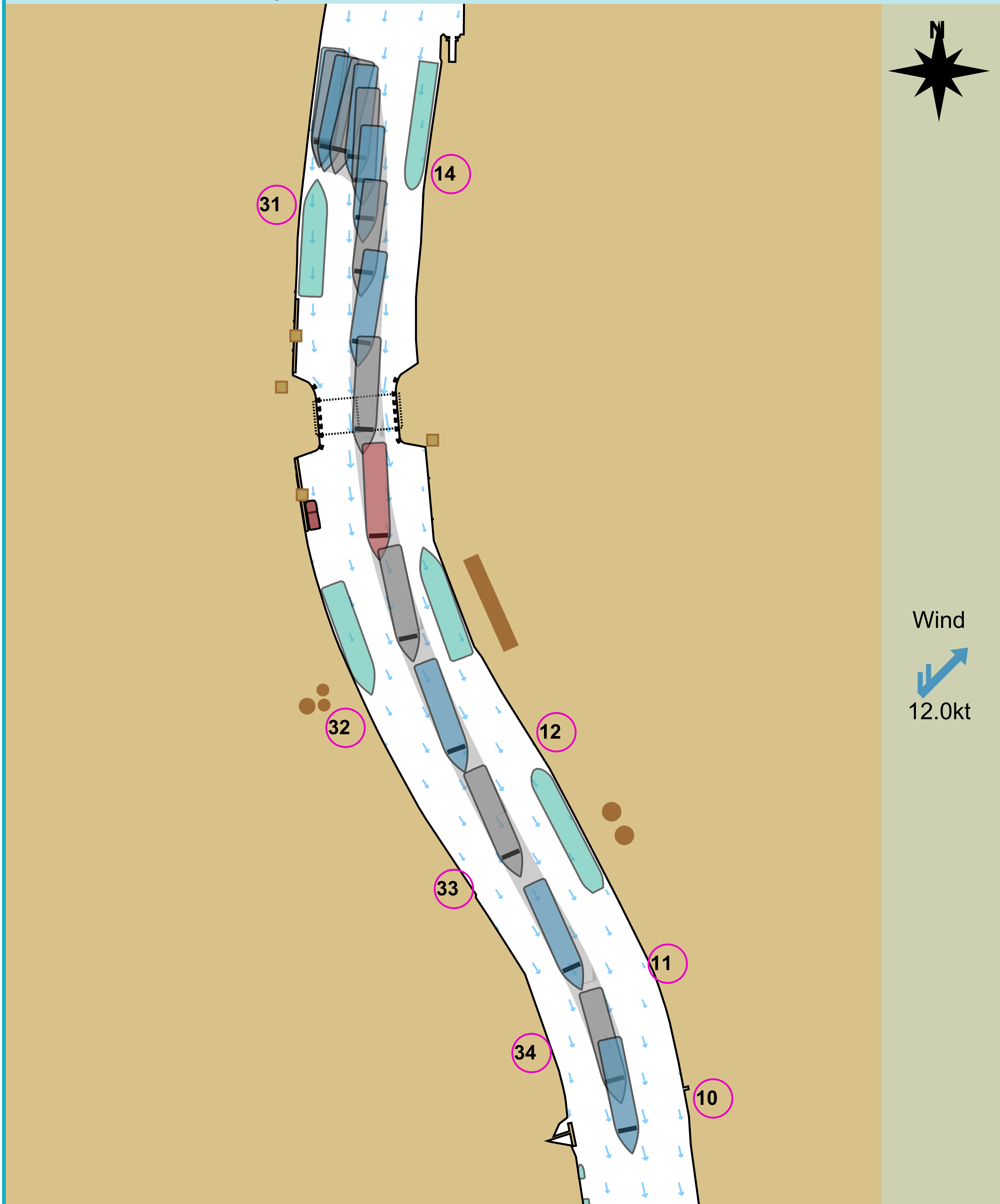

Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
Minutes


Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
180
90
0
-90
-180
0
5
10
Minutes

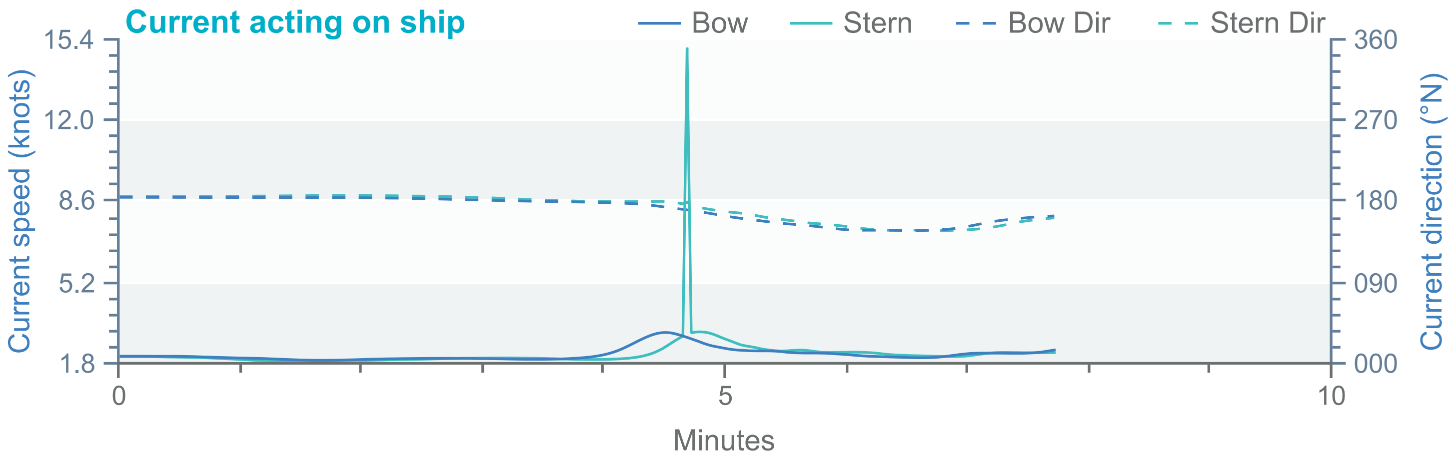

Thrusters
Bow %
Bow Force
Bow thruster (%Power)
Stern thruster (%Power)
100
50
0
-50
-100
0
5
10
Minutes

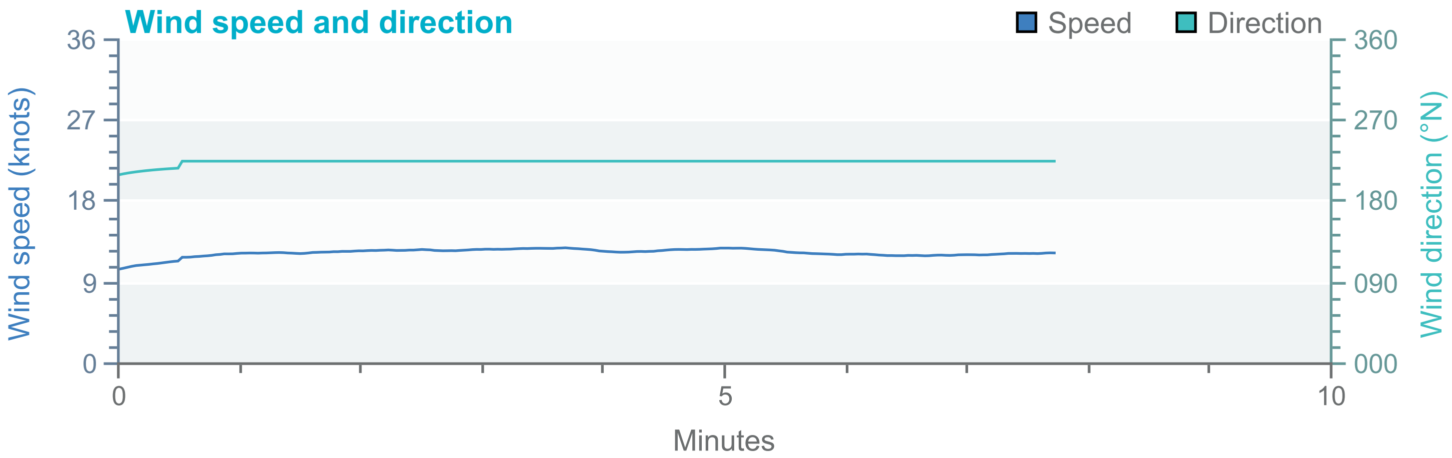

Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
1min
2min
3min
4min
5min
6min
7min
8min
9min

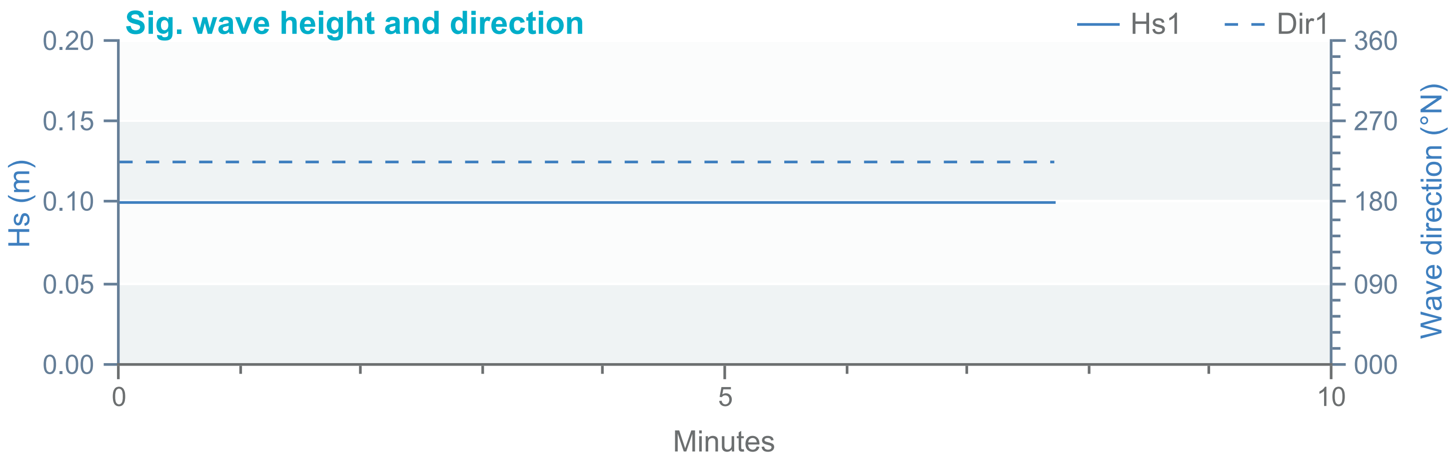
Manoeuvre track plot

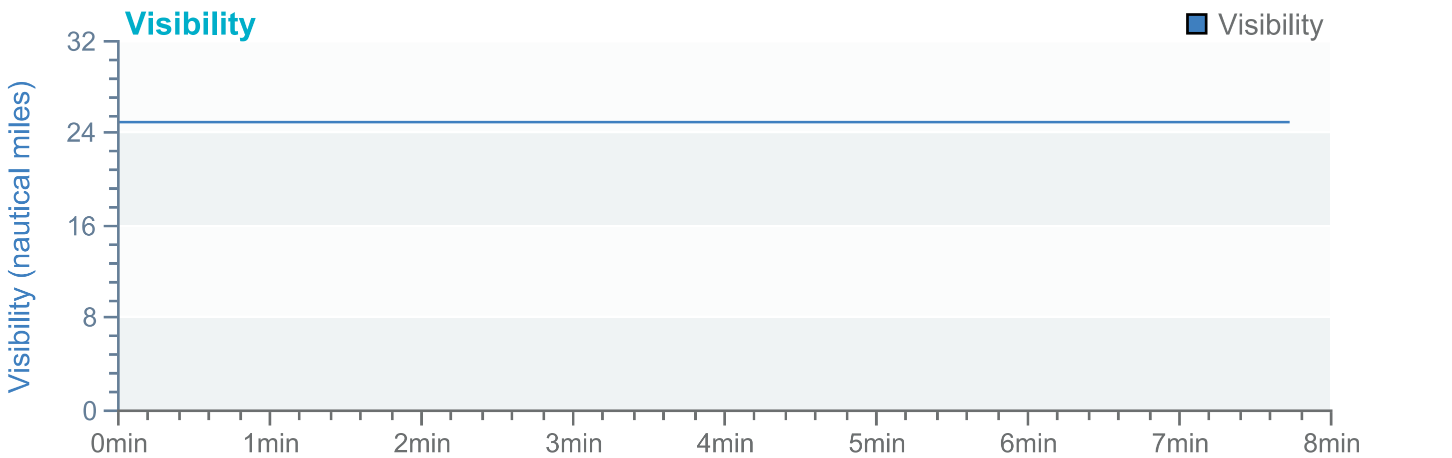


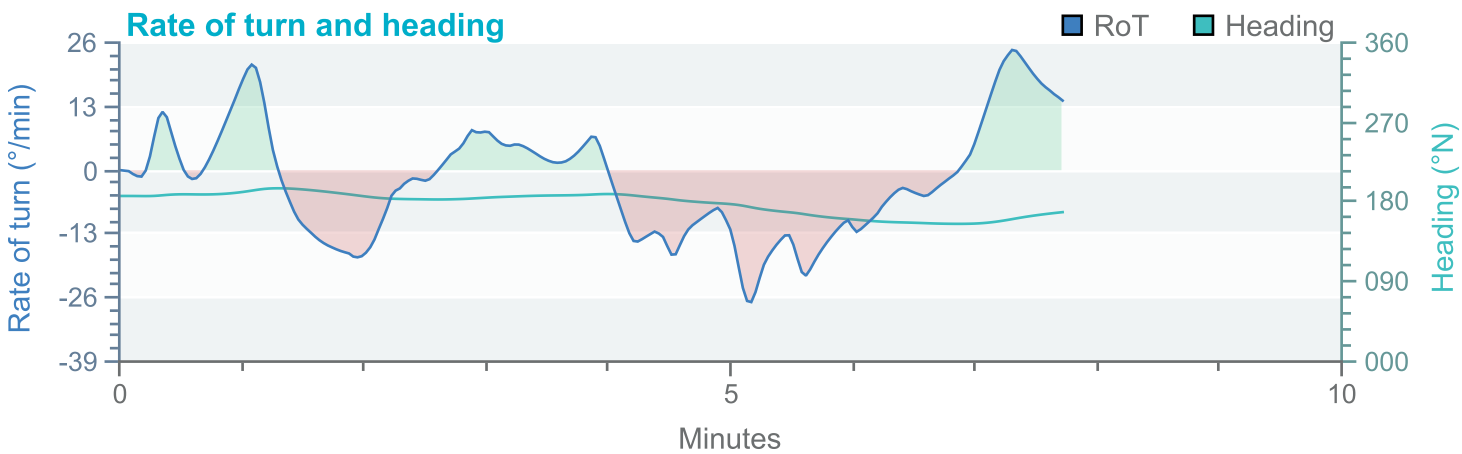
Ships plotted every 0 mins, highlight every 5 mins

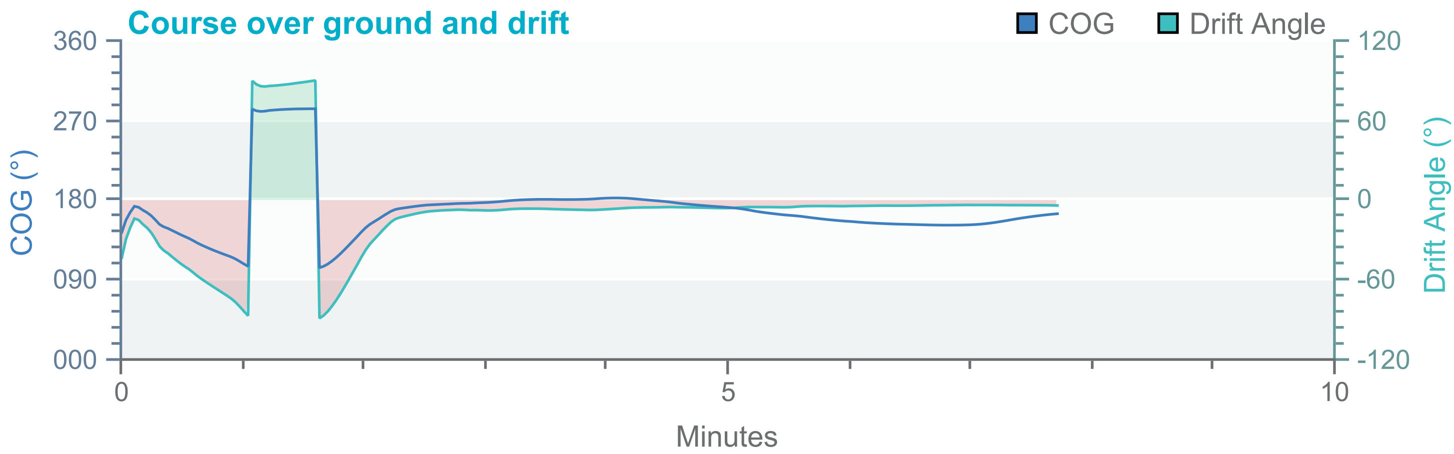

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
15.4
12.0
8.6
5.2
1.8
Current direction (°N)
360
270
180
090
000
0
5
10
Minutes

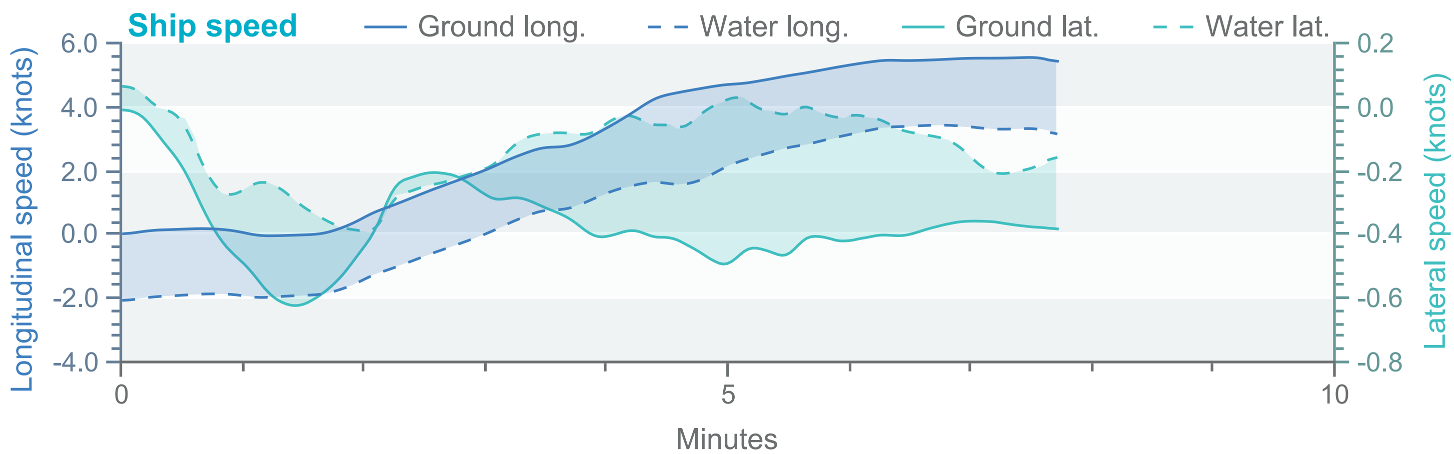

Wind speed and direction
Speed
Direction
Wind speed (knots)
36
27
18
9
0
Wind direction (°N)
360
270
180
090
000
0
5
10
Minutes

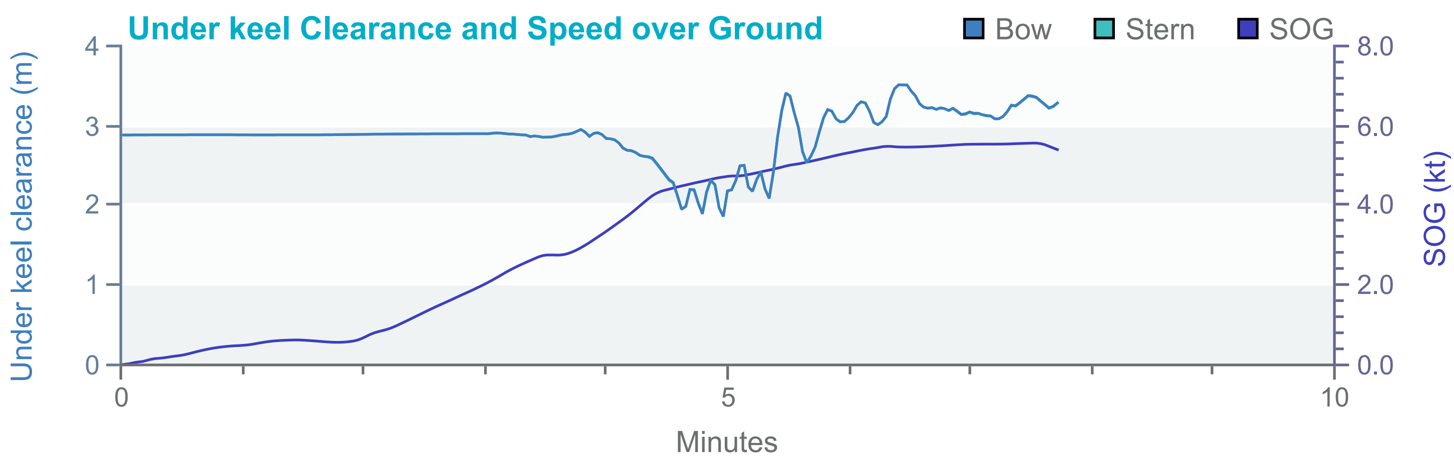

Sig. wave height and direction
Hs1
Dir1
Hs (m)
0.20
0.15
0.10
0.05
0.00
Wave direction (°N)
360
270
180
090
000
0
5
10
Minutes

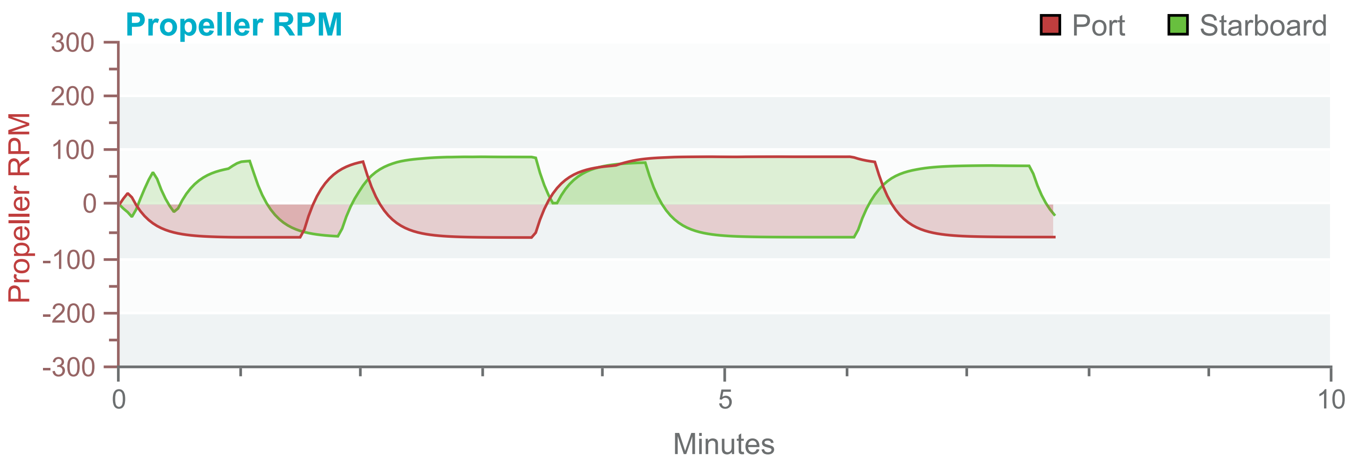

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
1min
2min
3min
4min
5min
6min
7min
8min

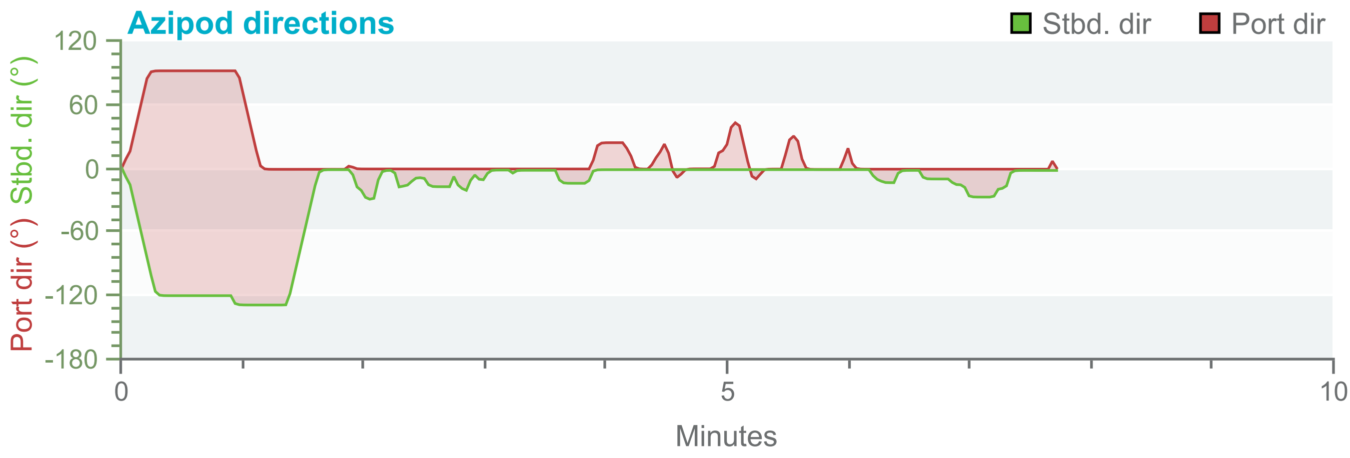

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
26
13
0
-13
-26
-39
360
270
180
090
000
0
5
10
Minutes

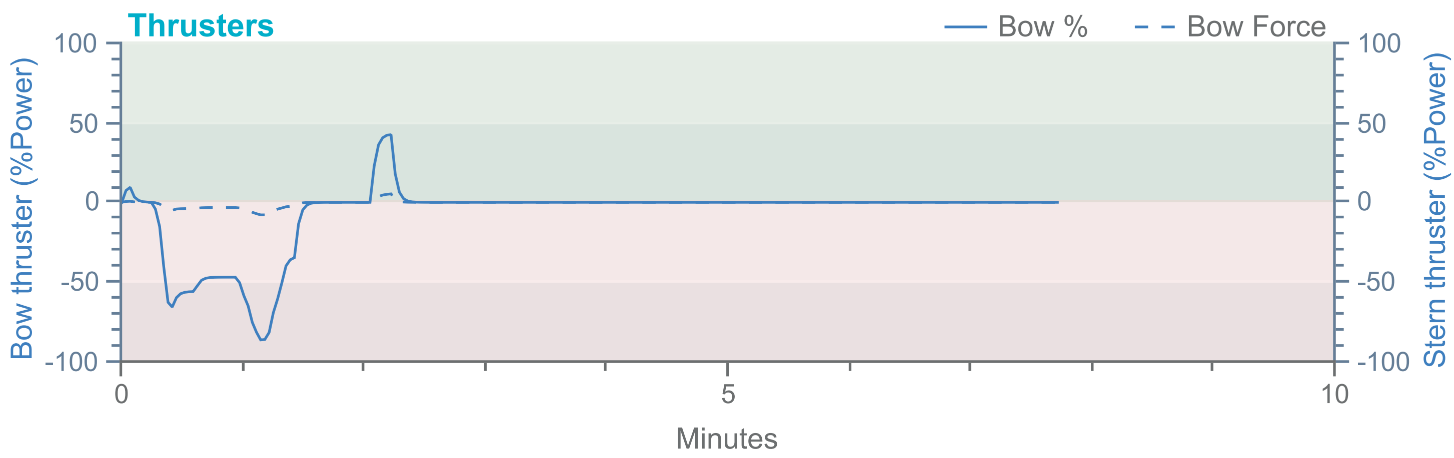

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
Minutes


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
6.0
4.0
2.0
0.0
-2.0
-4.0
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0
5
10
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
4
3
2
1
0
8.0
6.0
4.0
2.0
0.0
0
5
10
Minutes


Propeller RPM
Port
Starboard
300
200
100
0
-100
-200
-300
Propeller RPM
0
5
10
Minutes


Azipod directions
Stbd. dir
Port dir
120
60
0
-60
-120
-180
Port dir (°) Stbd. dir (°)
0
5
10
Minutes

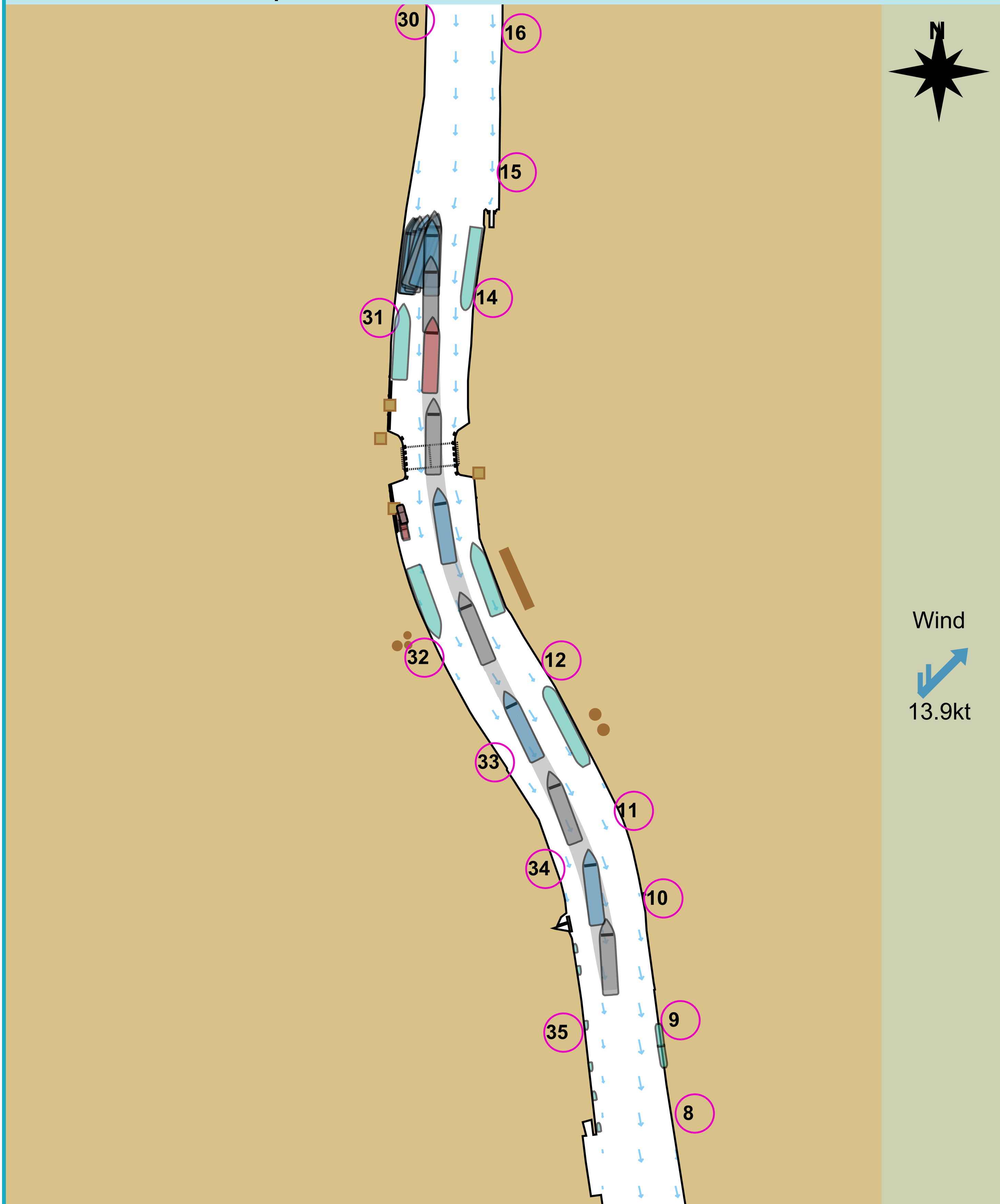

Thrusters
Bow %
Bow Force
100
50
0
-50
-100
Bow thruster (%Power)
Stern thruster (%Power)
0
5
10
Minutes

HR Wallingford
Working with water

Project: Great Yarmouth
Session: 3rd Crossing 2019
Configuration: September 2019
Run: 10

Tracks	Environment	80m PSV

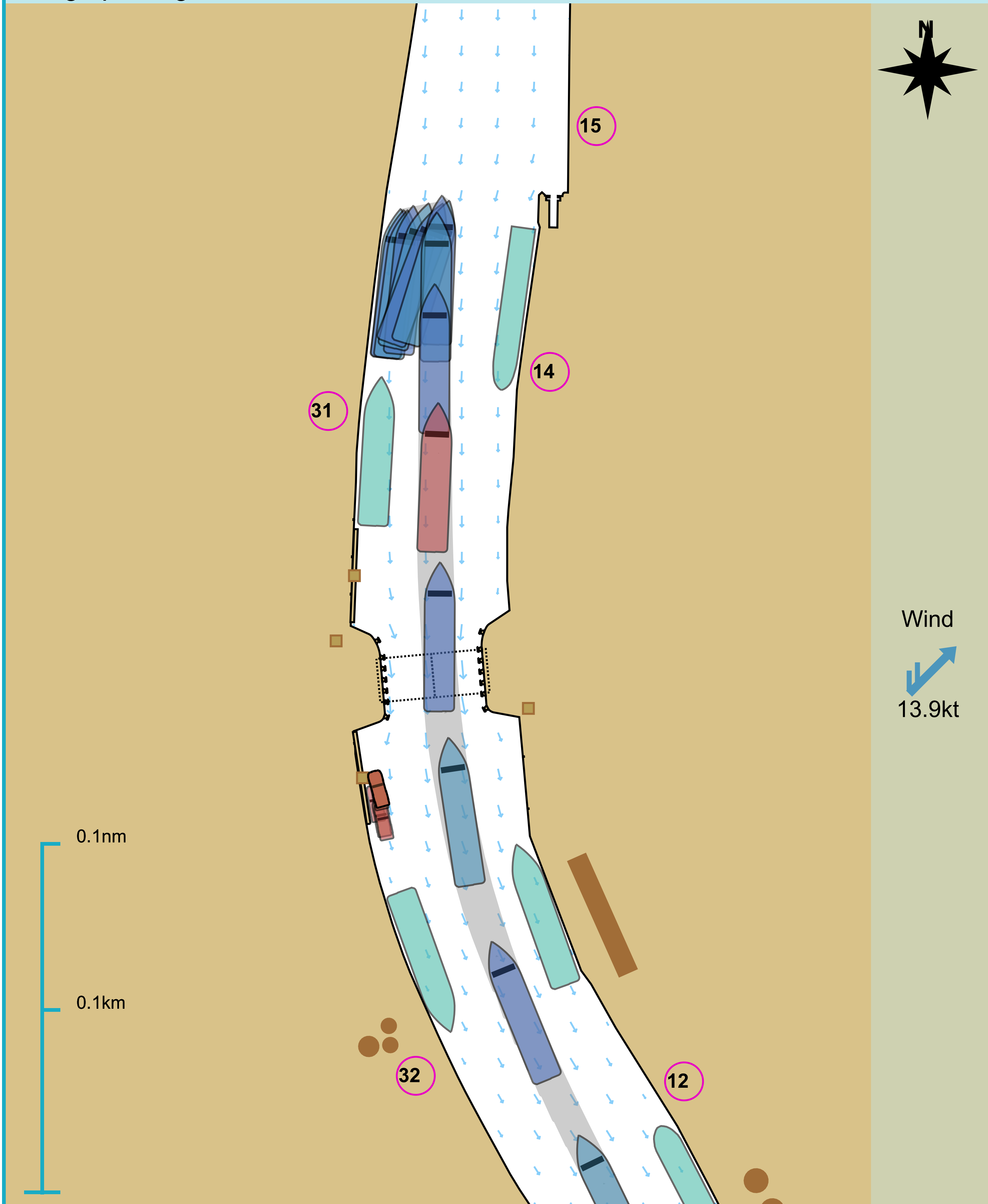
Manoeuvre track plot



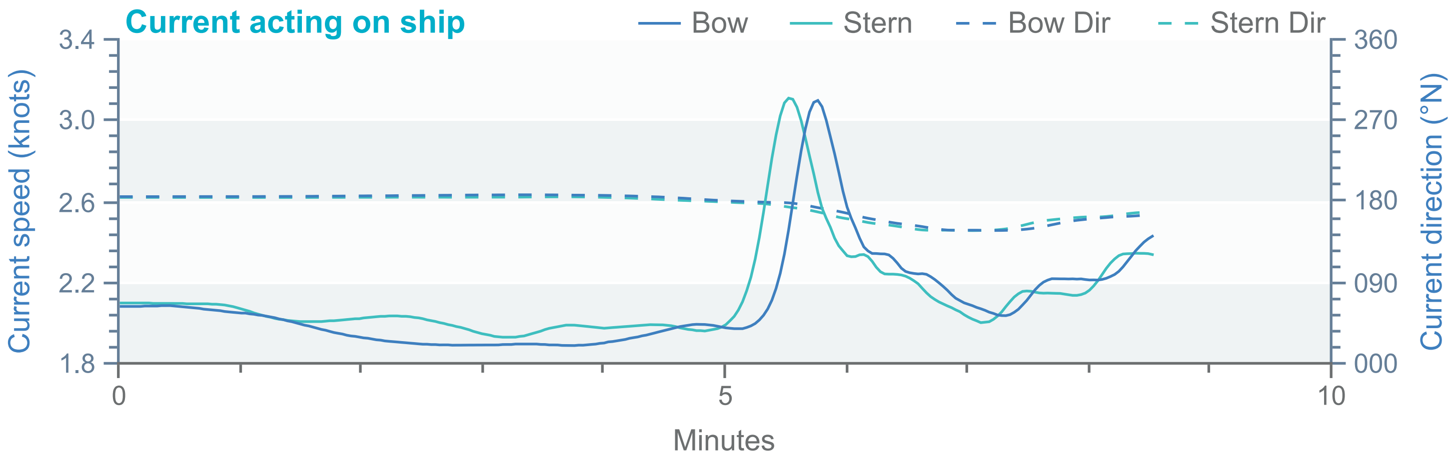
Ships plotted every 0 mins, highlight every 5 mins

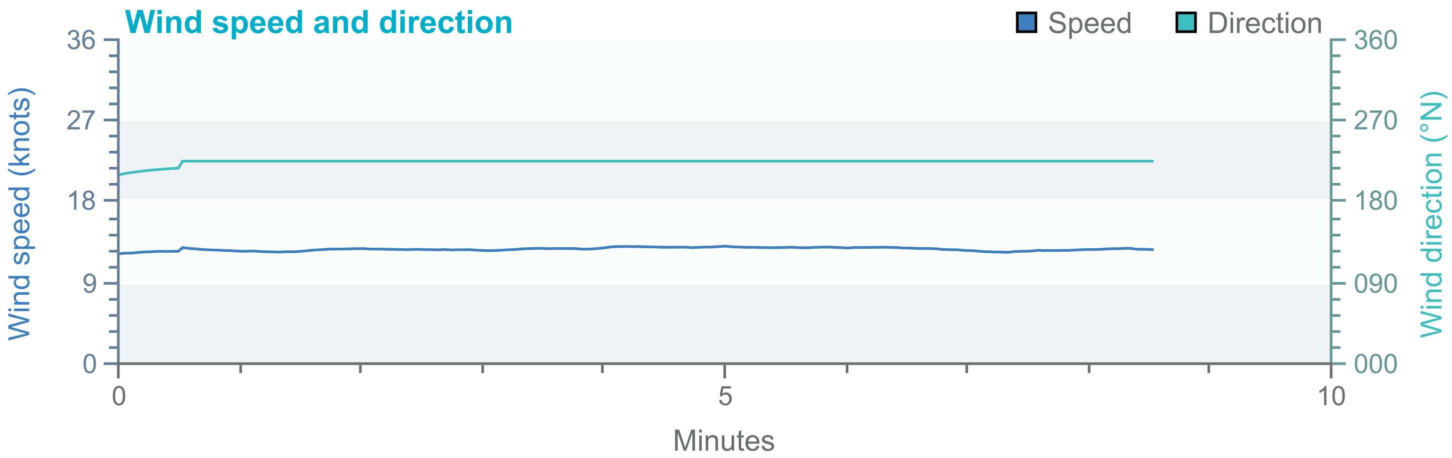
Pilot: RG
Manoeuvre: Departure

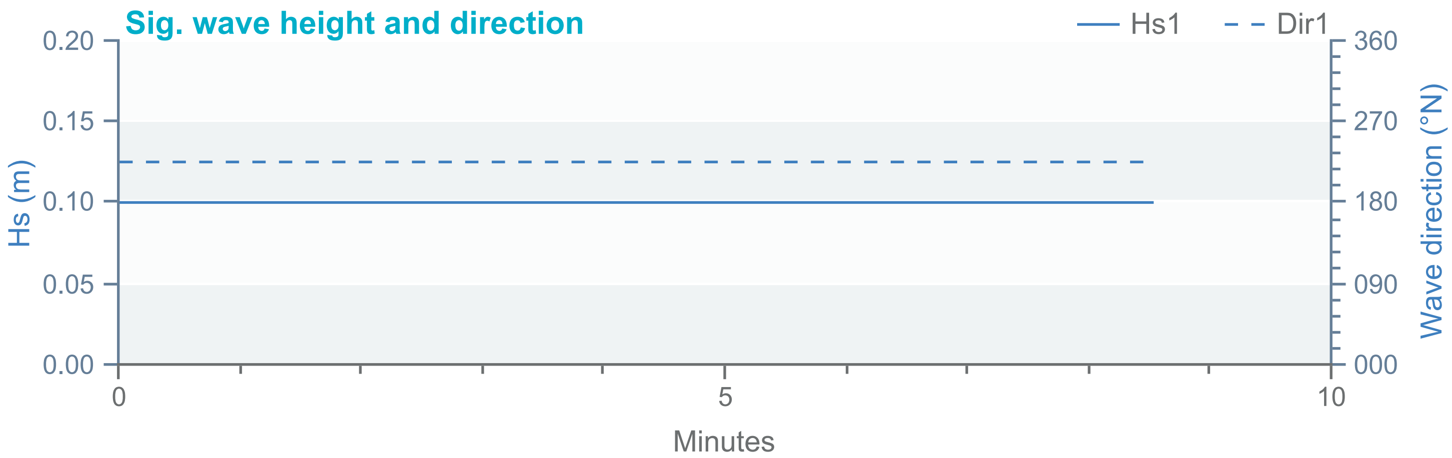
Bridge passage

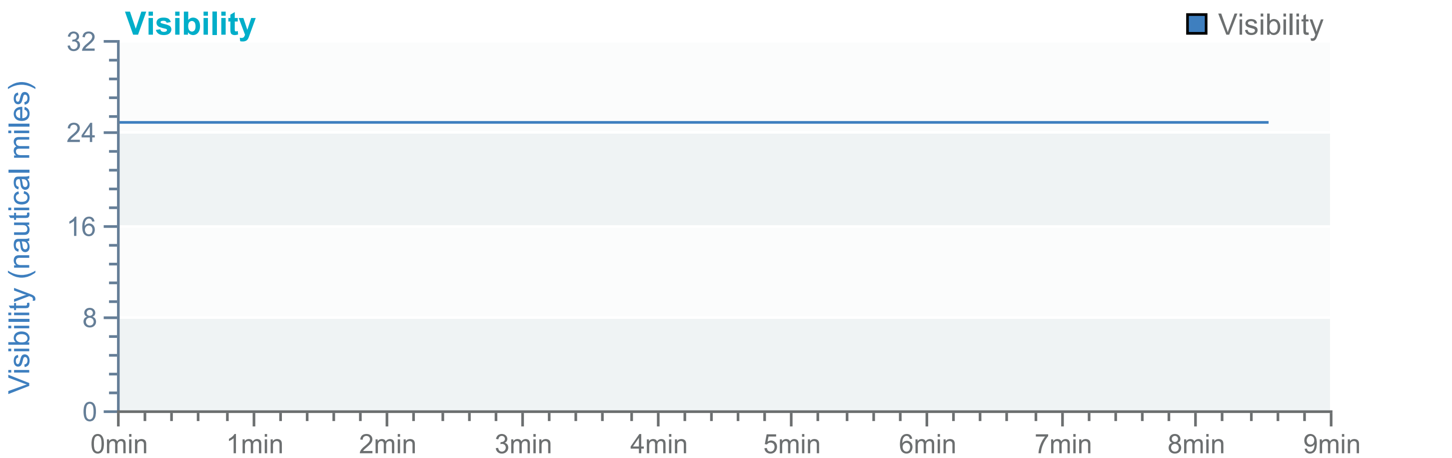


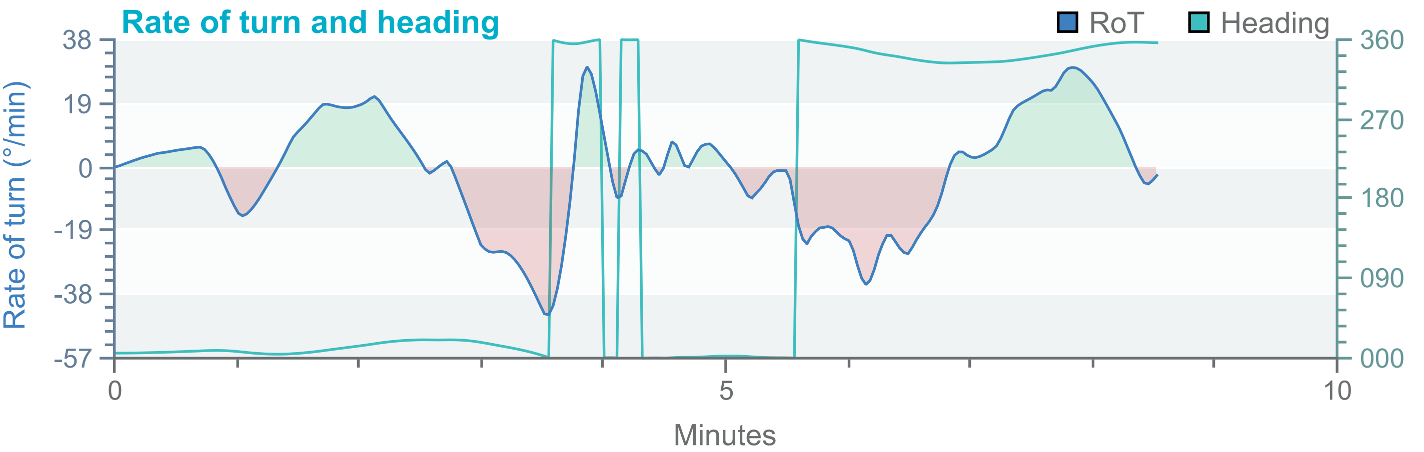
Ships plotted every 0 mins, highlight every 5 mins

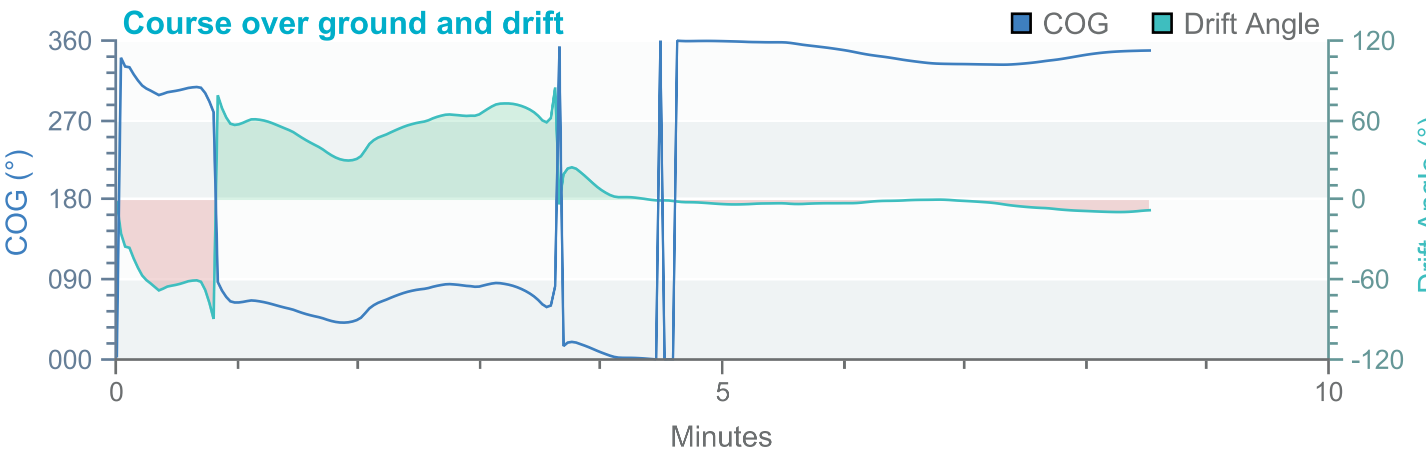

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
3.4
3.0
2.6
2.2
1.8
360
270
180
090
000
0
5
10
Minutes

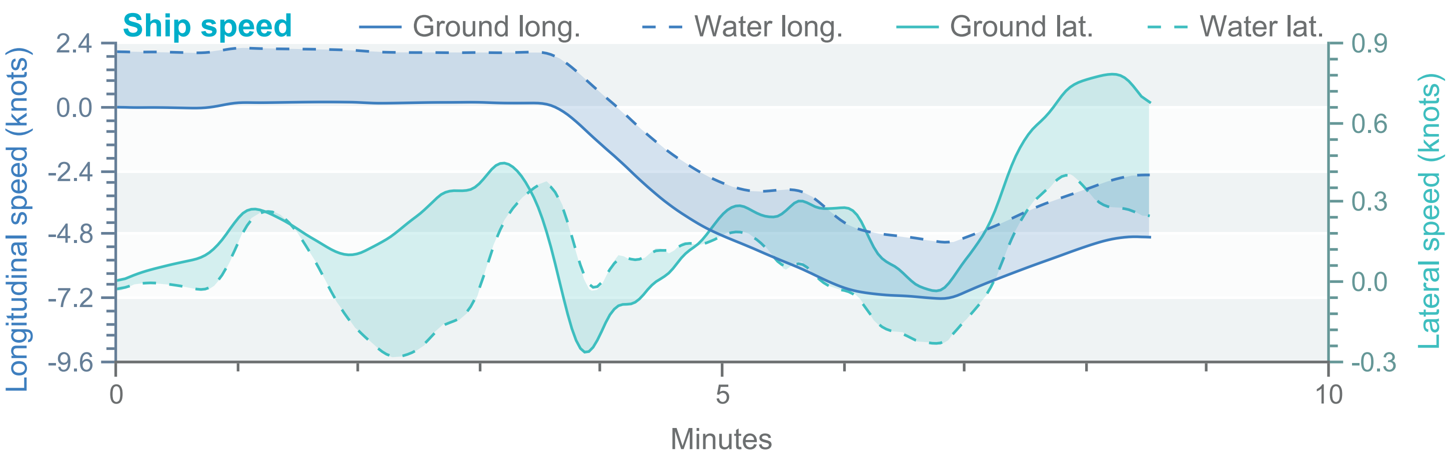

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
Minutes

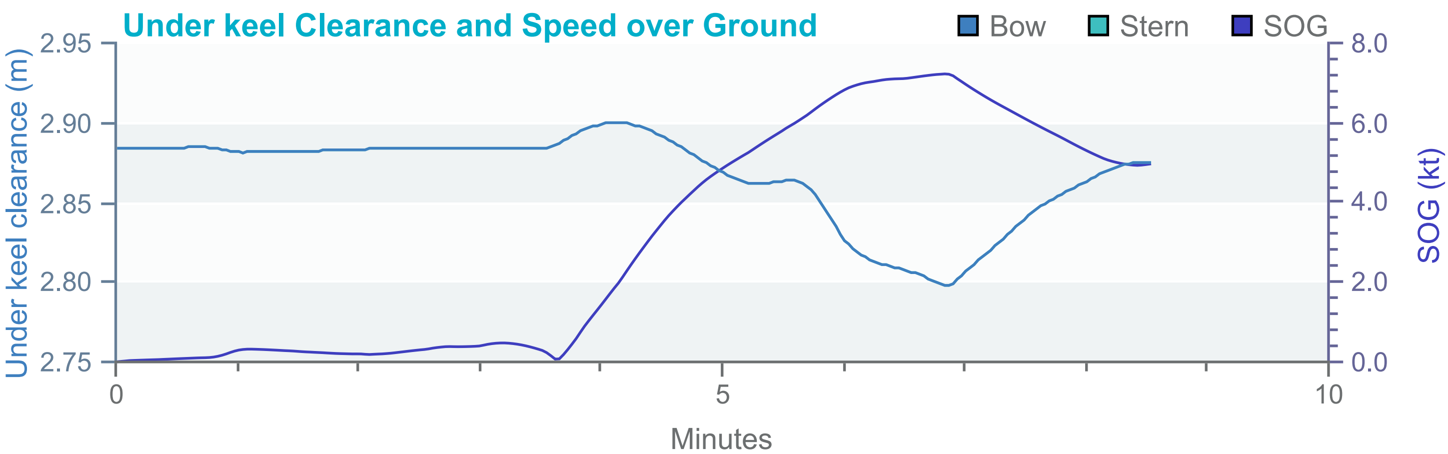

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
Minutes

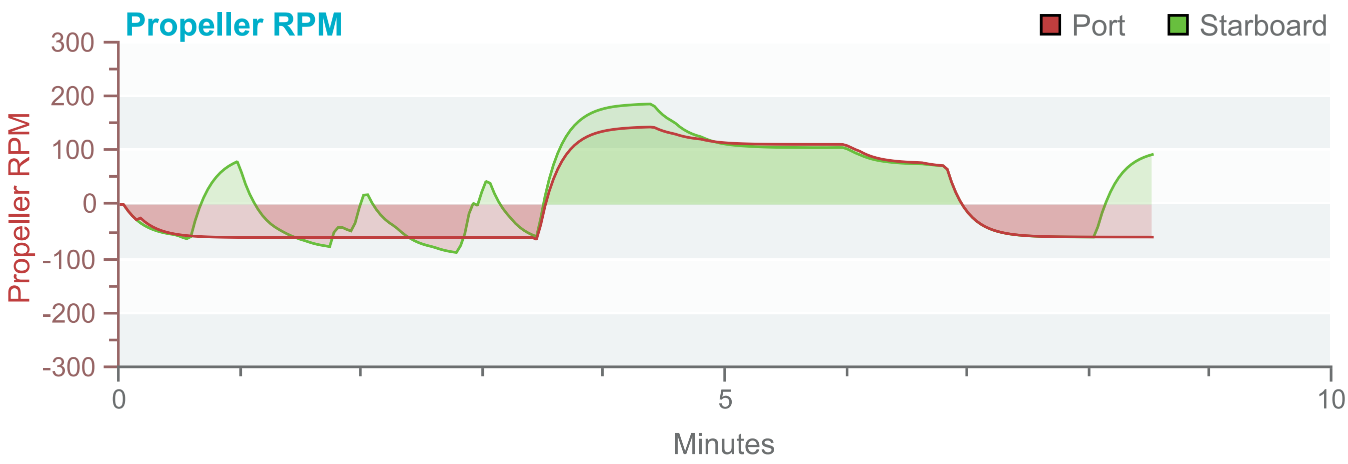

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
1min
2min
3min
4min
5min
6min
7min
8min
9min

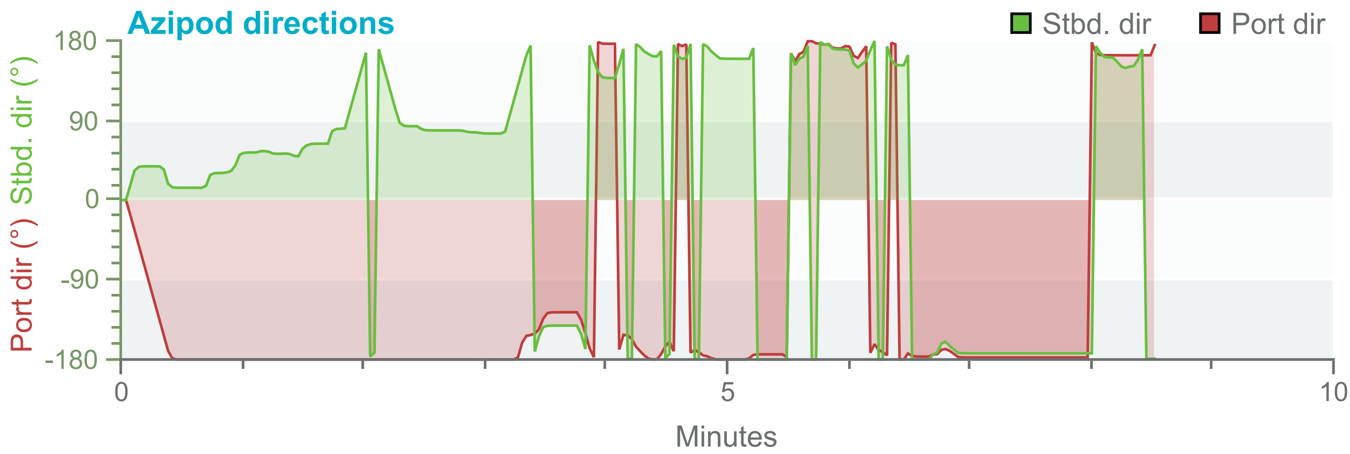

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
38
19
0
-19
-38
-57
Heading (°N)
360
270
180
090
000
0
5
10
Minutes

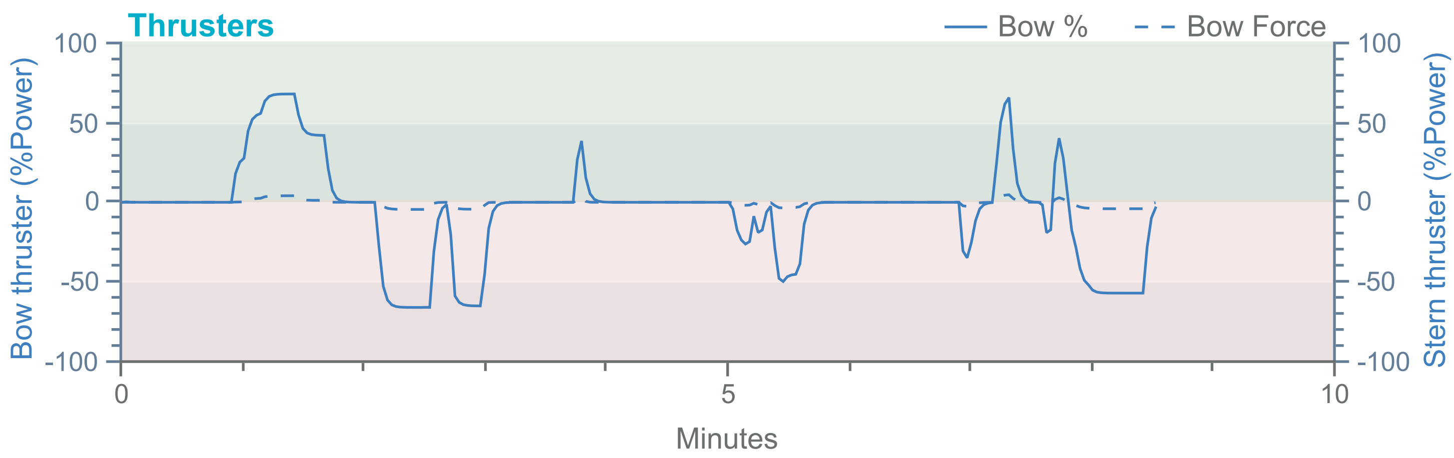

Course over ground and drift
COG
Drift Angle
COG (°)
360
270
180
090
000
Drift Angle (°)
120
60
0
-60
-120
0
5
10
Minutes

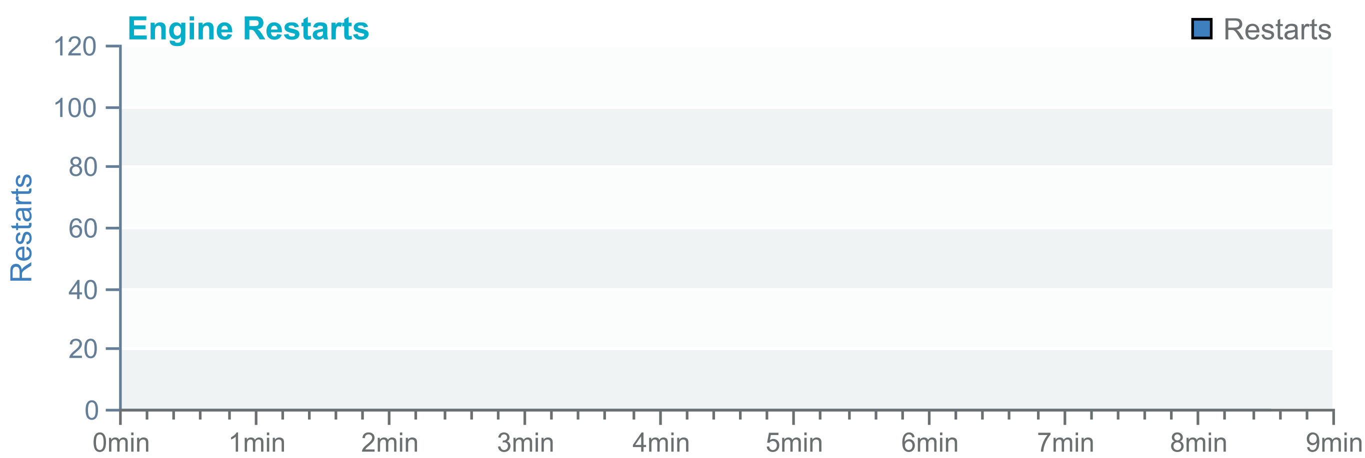

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
2.4
0.0
-2.4
-4.8
-7.2
-9.6
Lateral speed (knots)
0.9
0.6
0.3
0.0
-0.3
0
5
10
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
2.95
2.90
2.85
2.80
2.75
SOG (kt)
8.0
6.0
4.0
2.0
0.0
0
5
10
Minutes


Propeller RPM
Port
Starboard
Propeller RPM
300
200
100
0
-100
-200
-300
0
5
10
Minutes

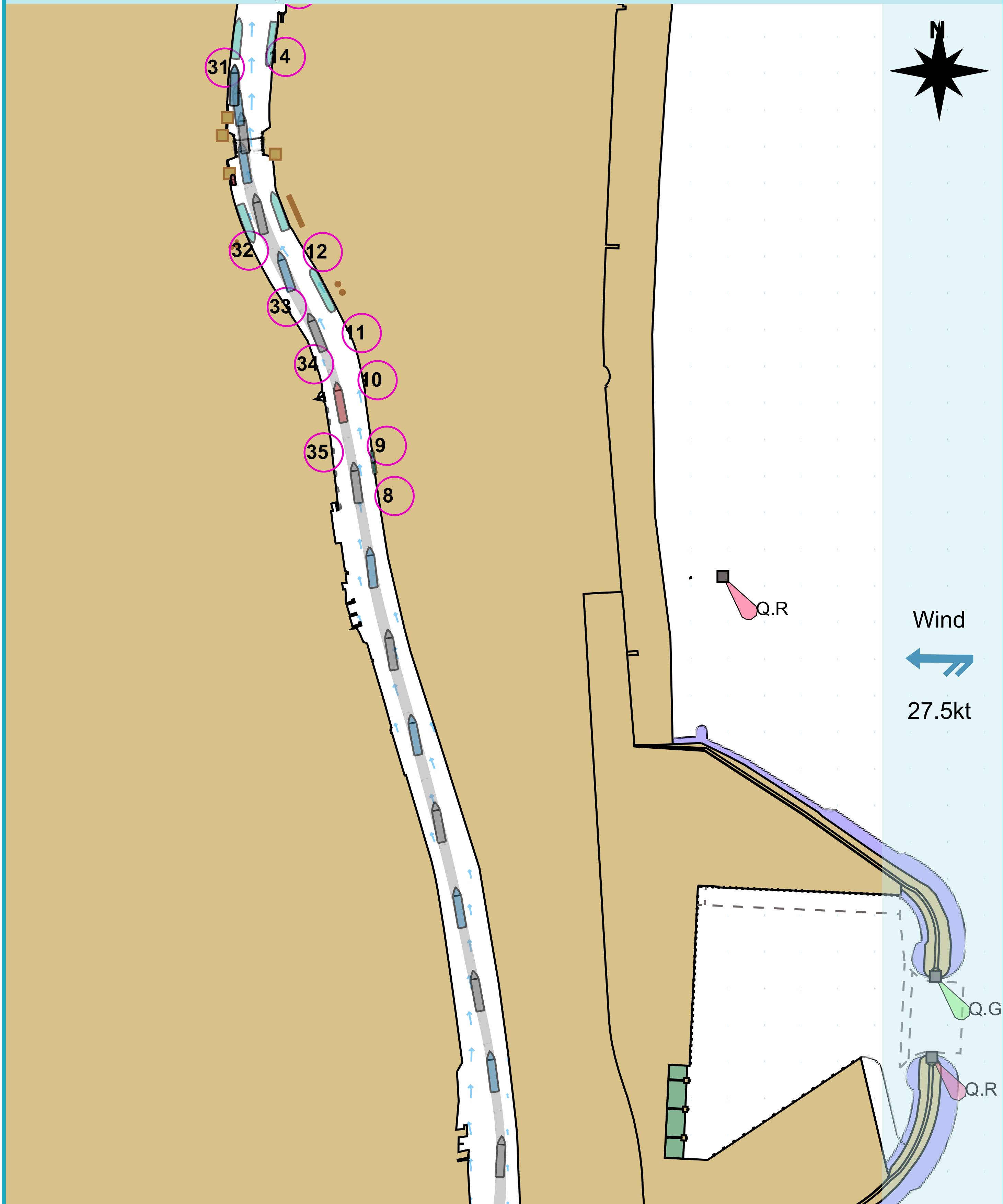

Azipod directions
Stbd. dir
Port dir
Port dir (°) Stbd. dir (°)
180
90
0
-90
-180
0
5
10
Minutes


Thrusters
Bow %
Bow Force
Bow thruster (%Power)
Stern thruster (%Power)
100
50
0
-50
-100
0
5
10
Minutes


Engine Restarts
Restarts
Restarts
120
100
80
60
40
20
0
0min
1min
2min
3min
4min
5min
6min
7min
8min
9min

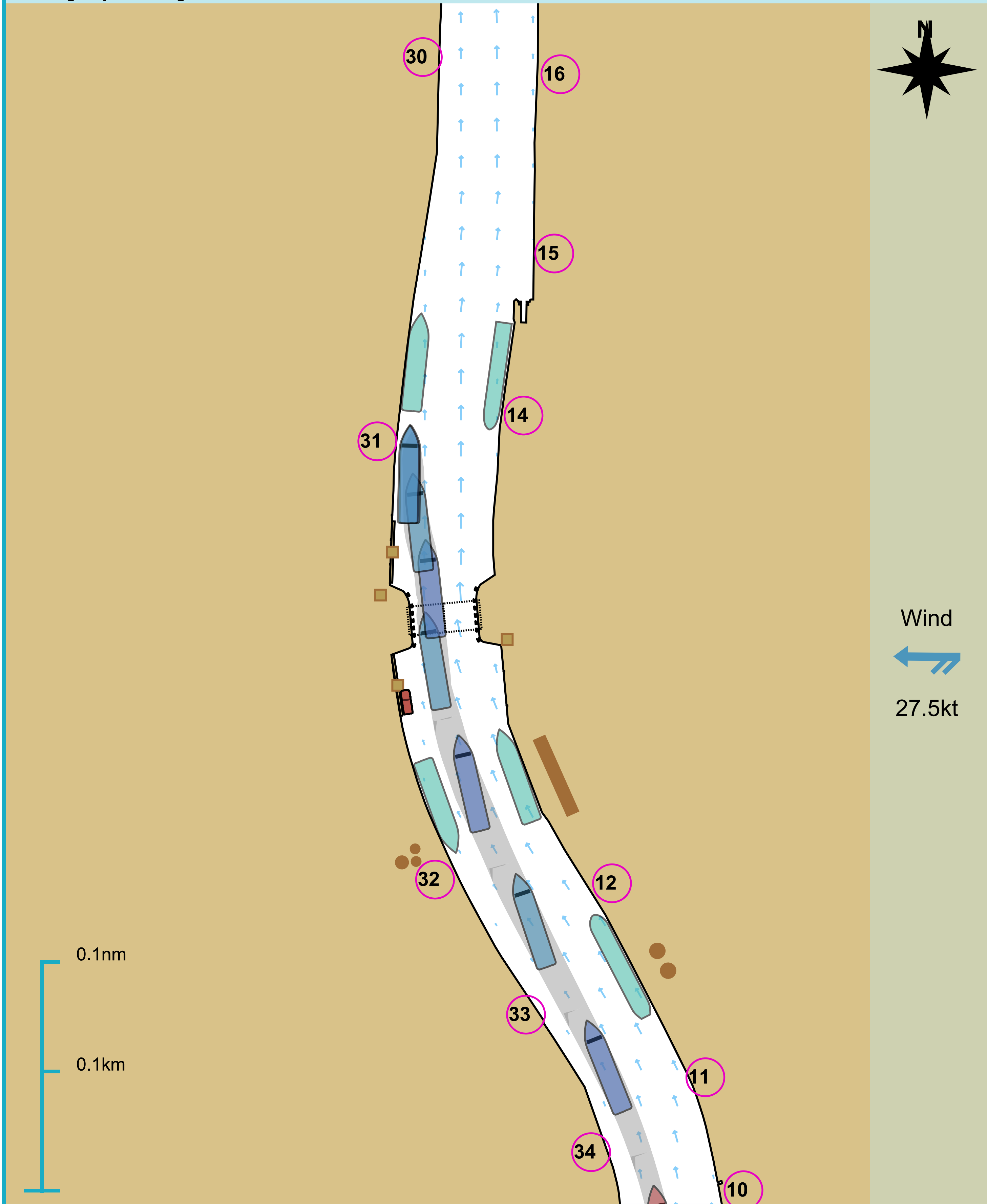
Tracks | Environment | 80m PSV

Manoeuvre track plot

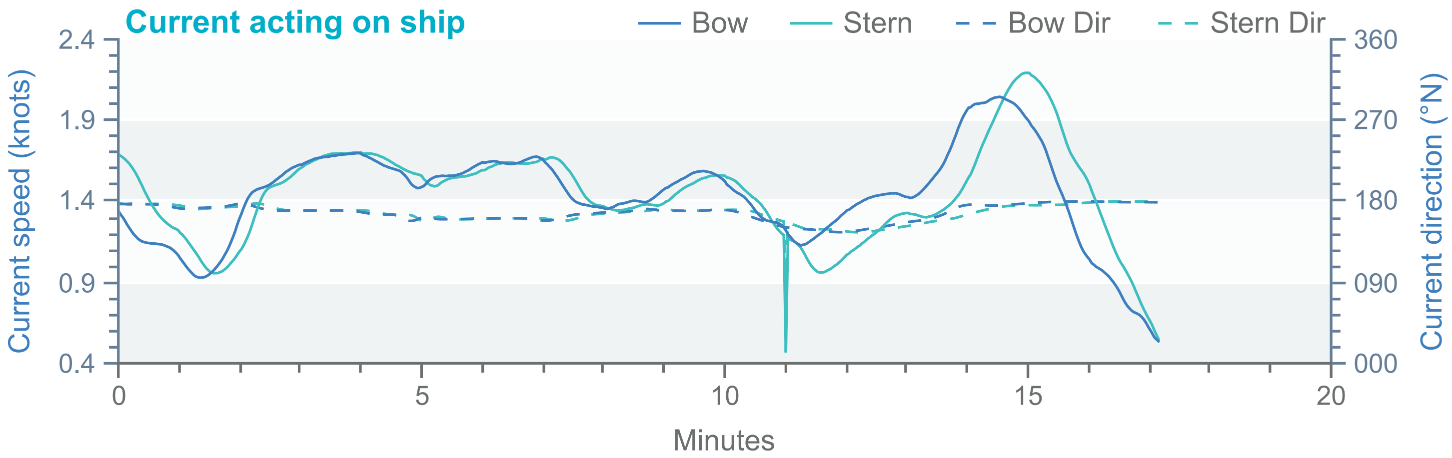


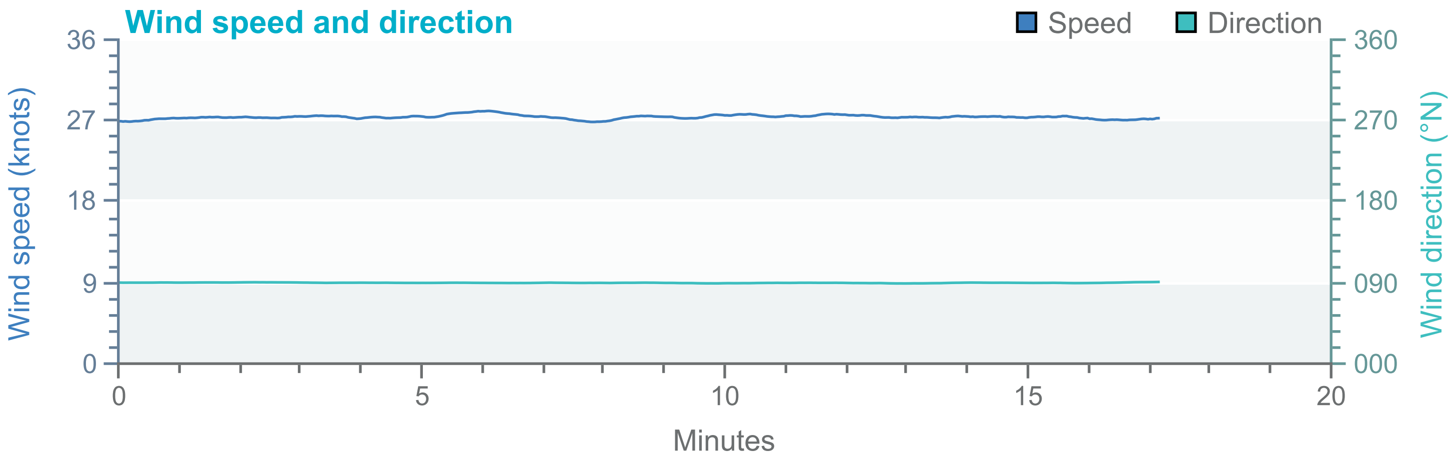
Ships plotted every 1 mins, highlight every 10 mins

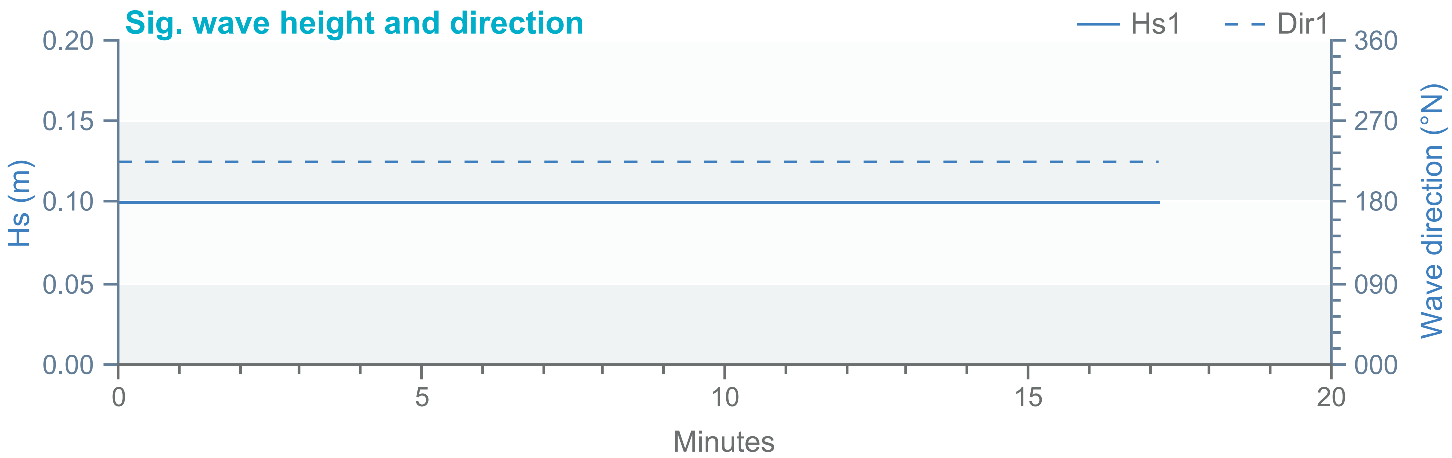
Bridge passage

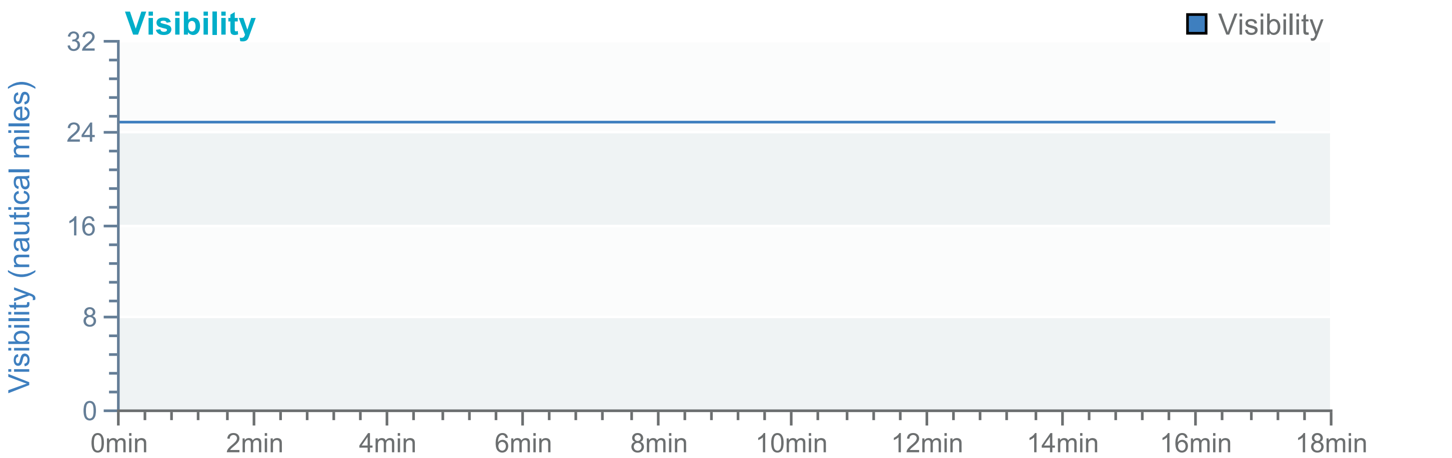


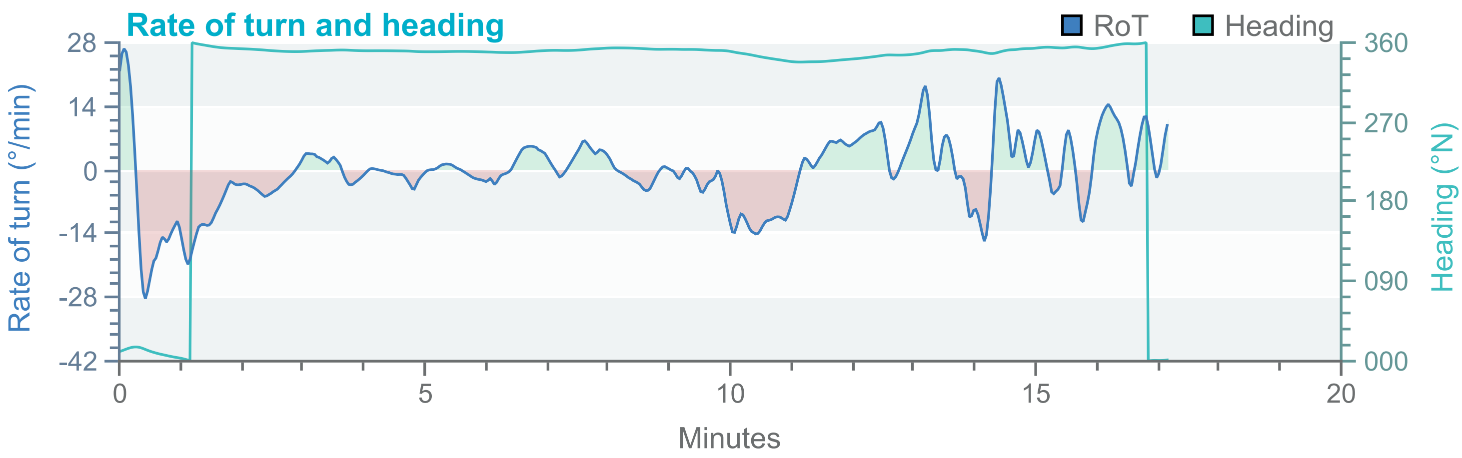
Ships plotted every 1 mins, highlight every 10 mins

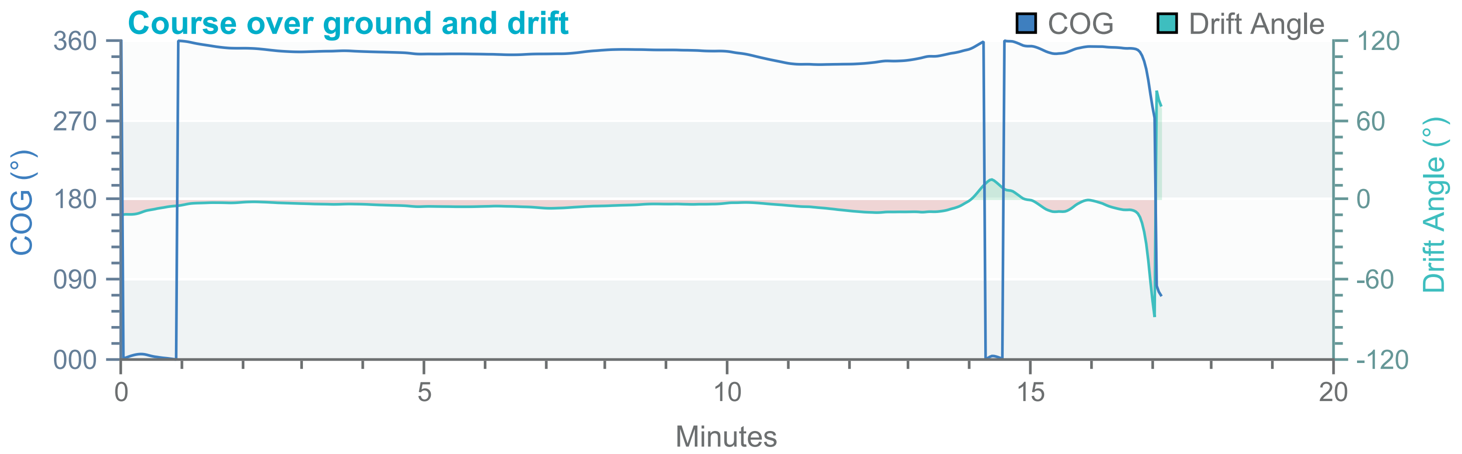

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
2.4
1.9
1.4
0.9
0.4
360
270
180
090
000
0
5
10
15
20

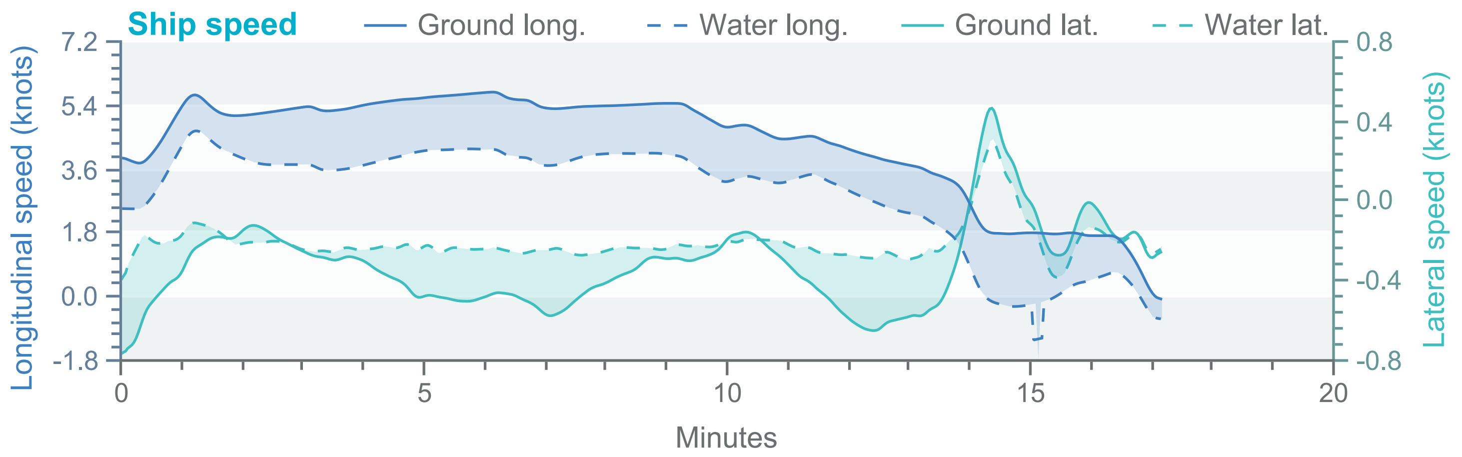

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20

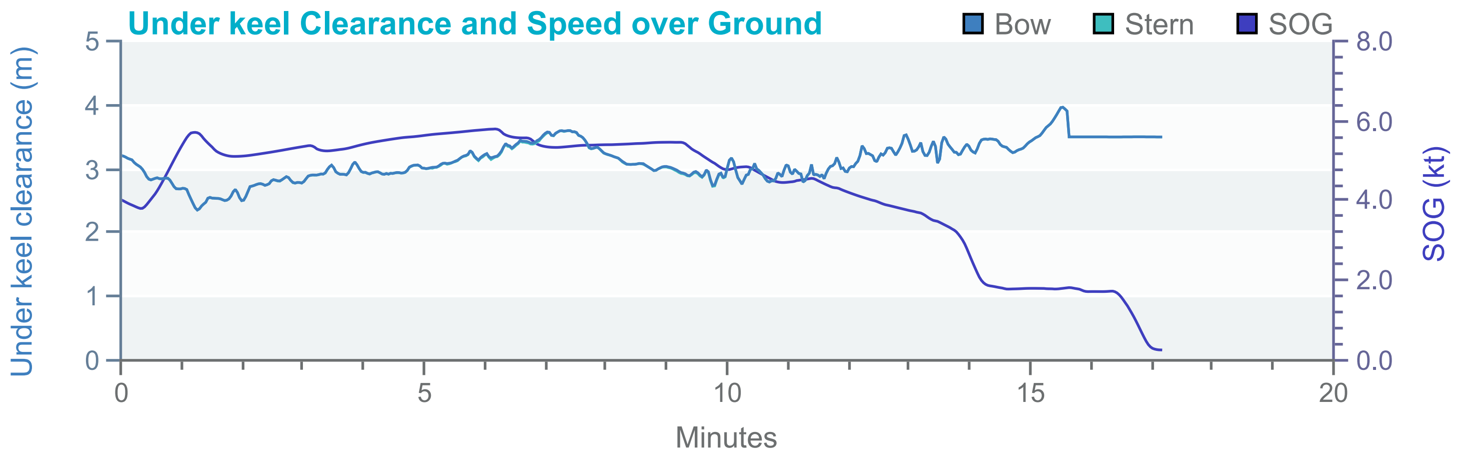

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min

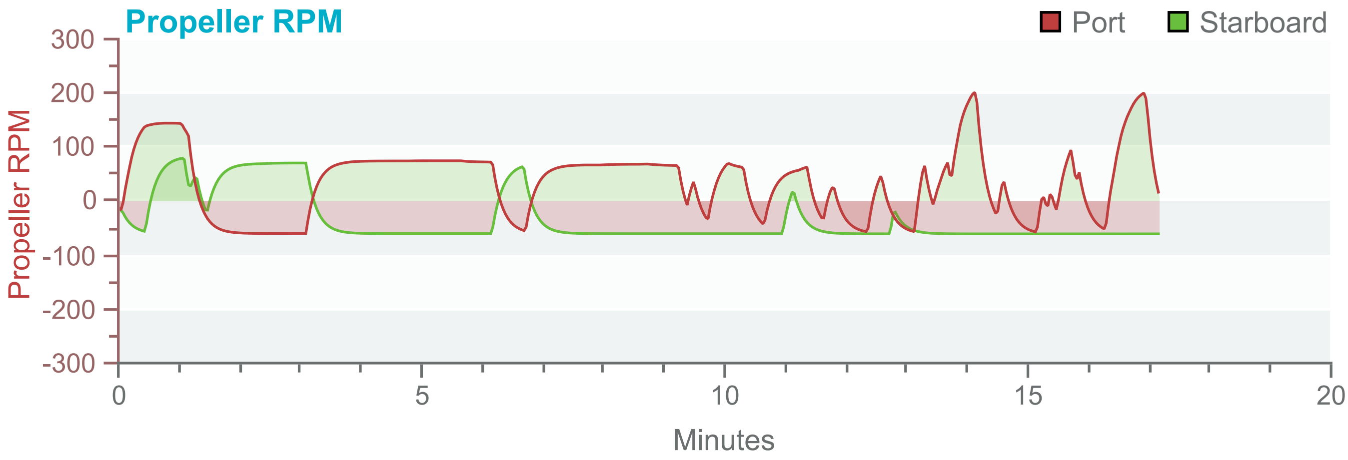

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
Minutes
28
14
0
-14
-28
-42
360
270
180
090
000
0
5
10
15
20

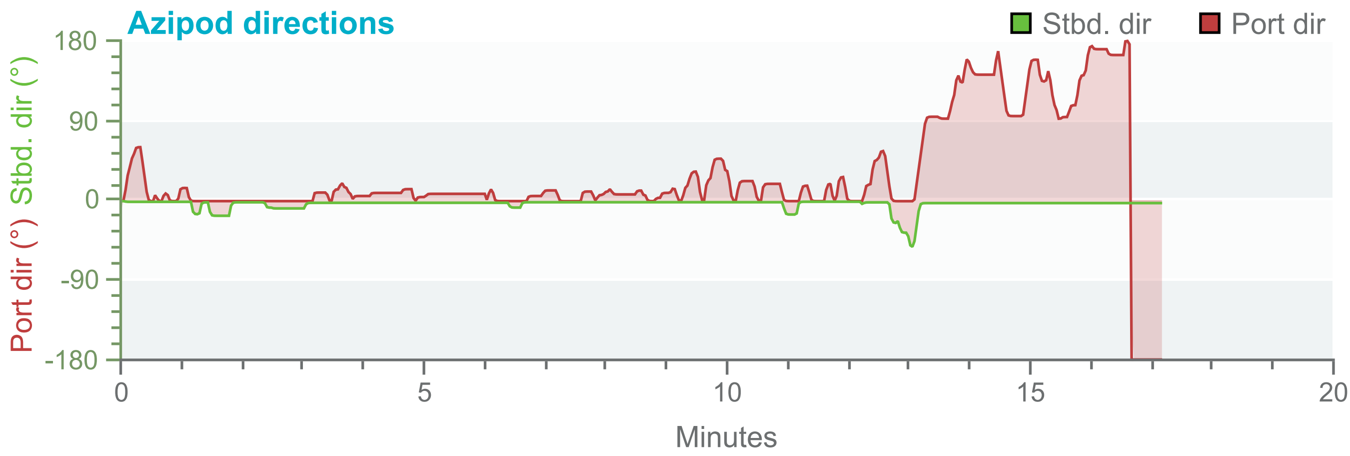

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Minutes
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20

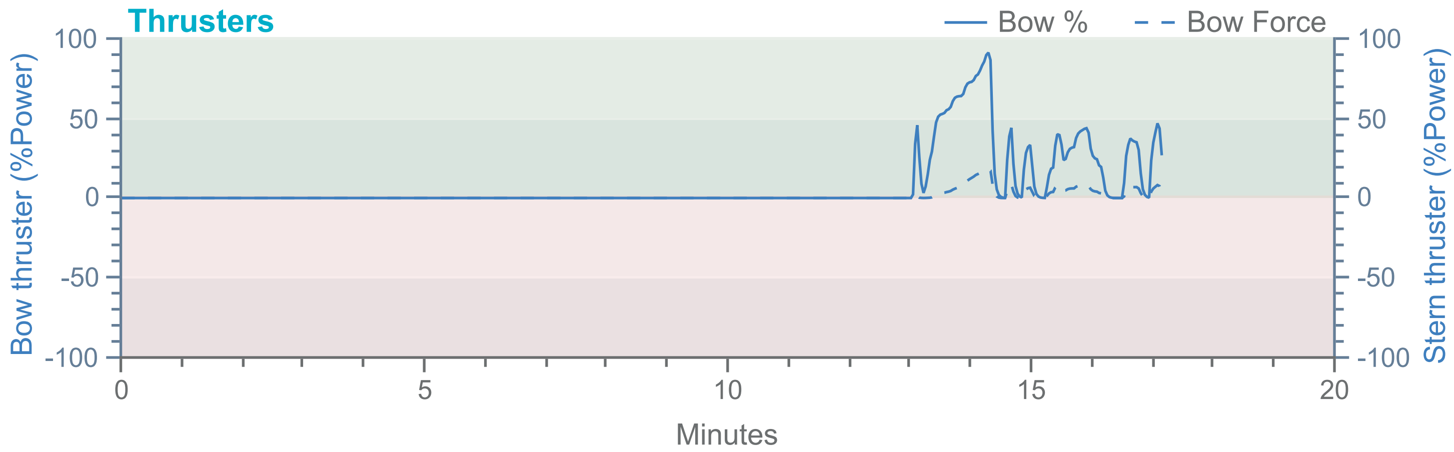

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
Minutes
7.2
5.4
3.6
1.8
0.0
-1.8
0.8
0.4
0.0
-0.4
-0.8
0
5
10
15
20

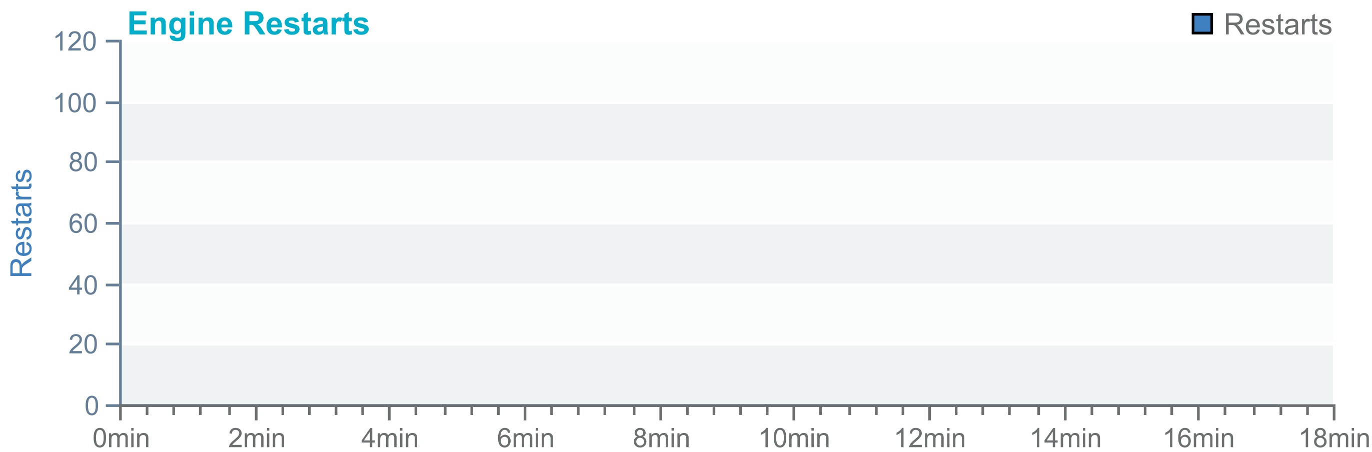

Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
Minutes
5
4
3
2
1
0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20

Tracks | Environment | 80m PSV

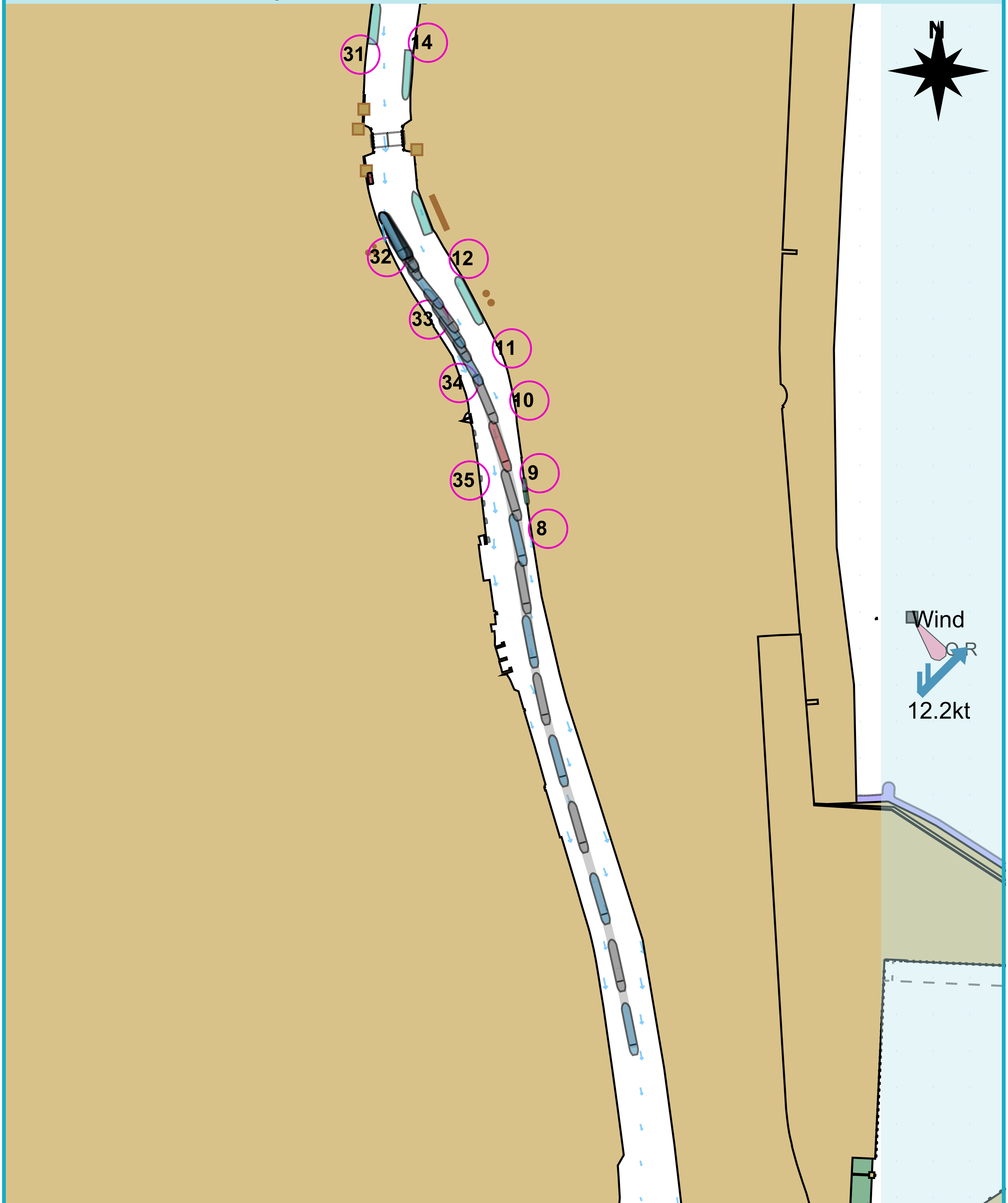






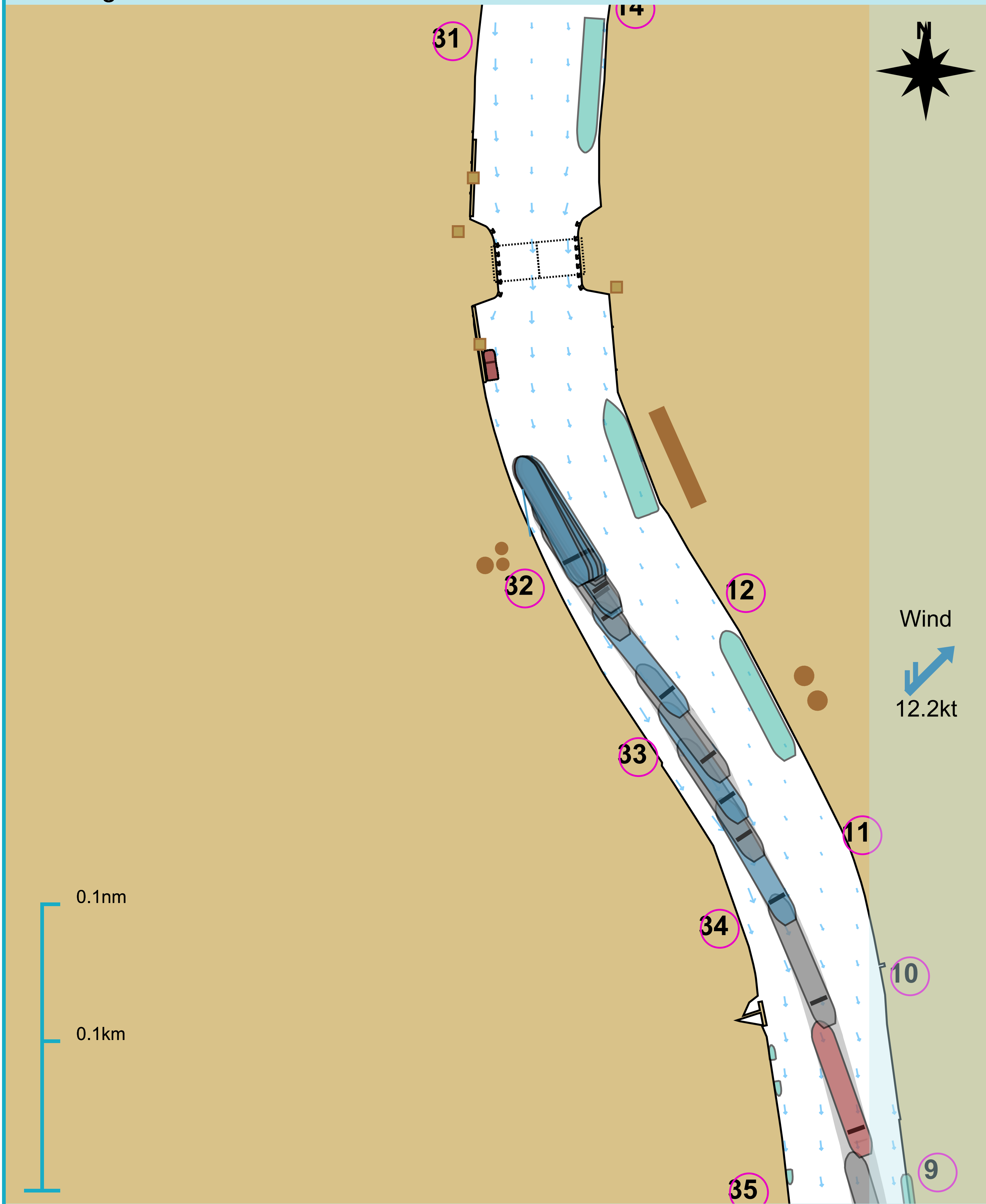


Manoeuvre track plot



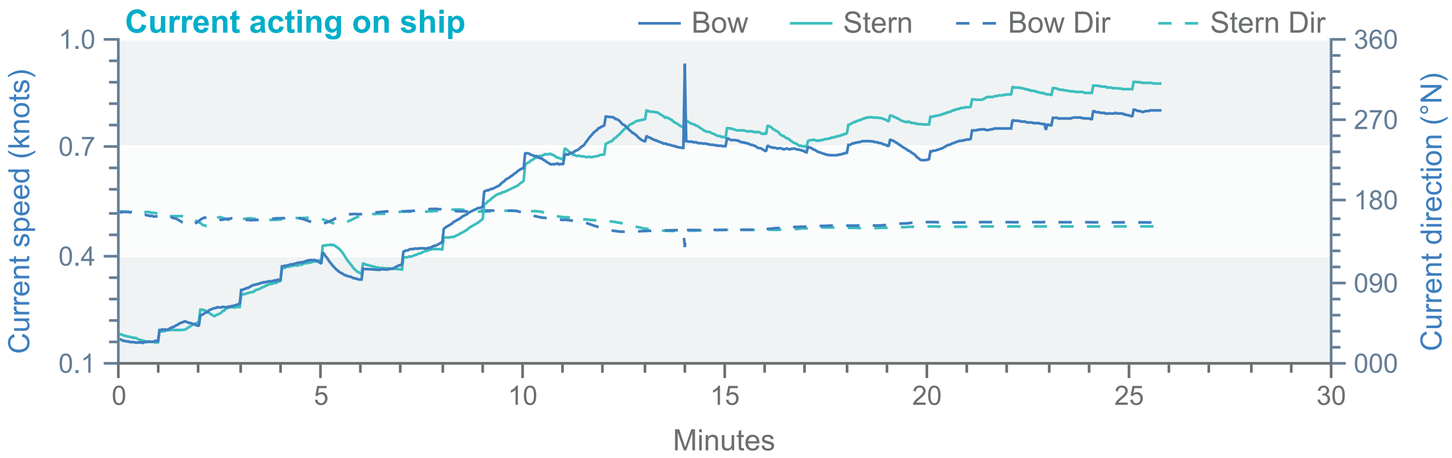
Ships plotted every 1 mins, highlight every 10 mins

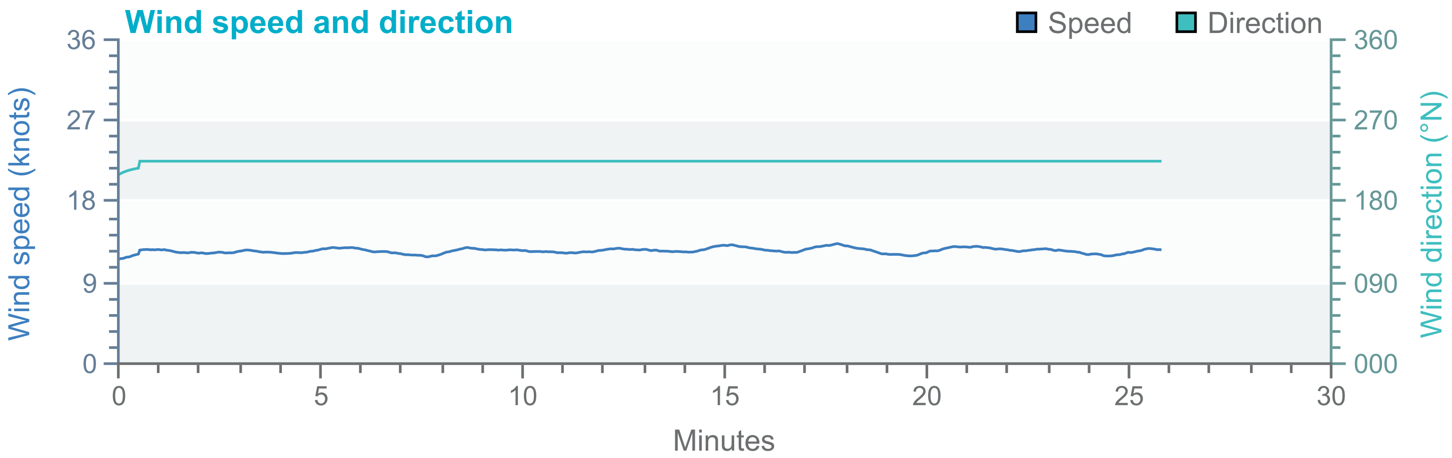
Berthing

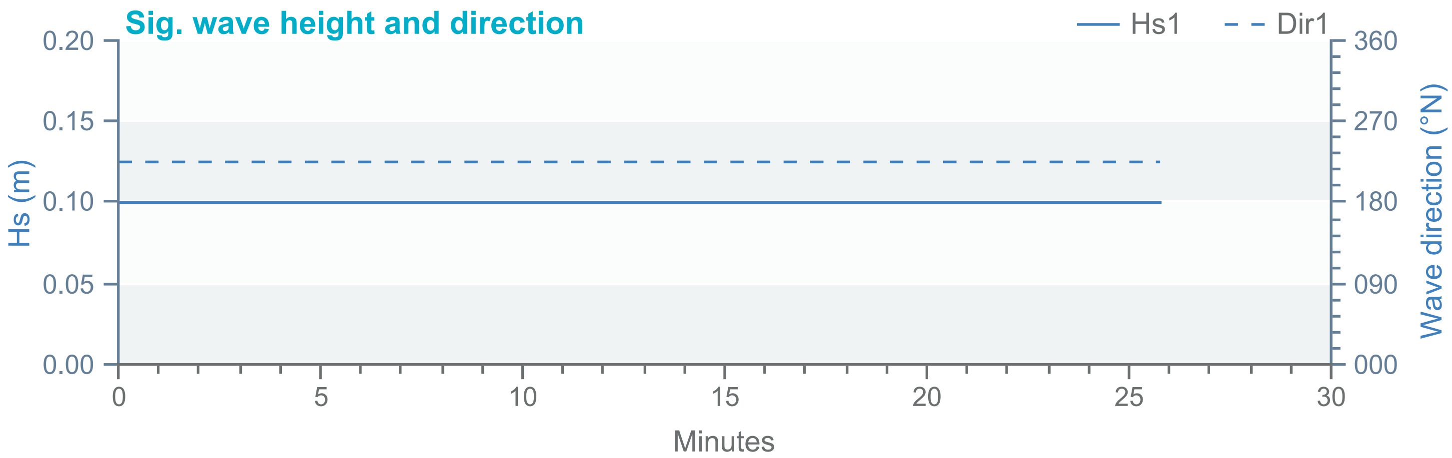


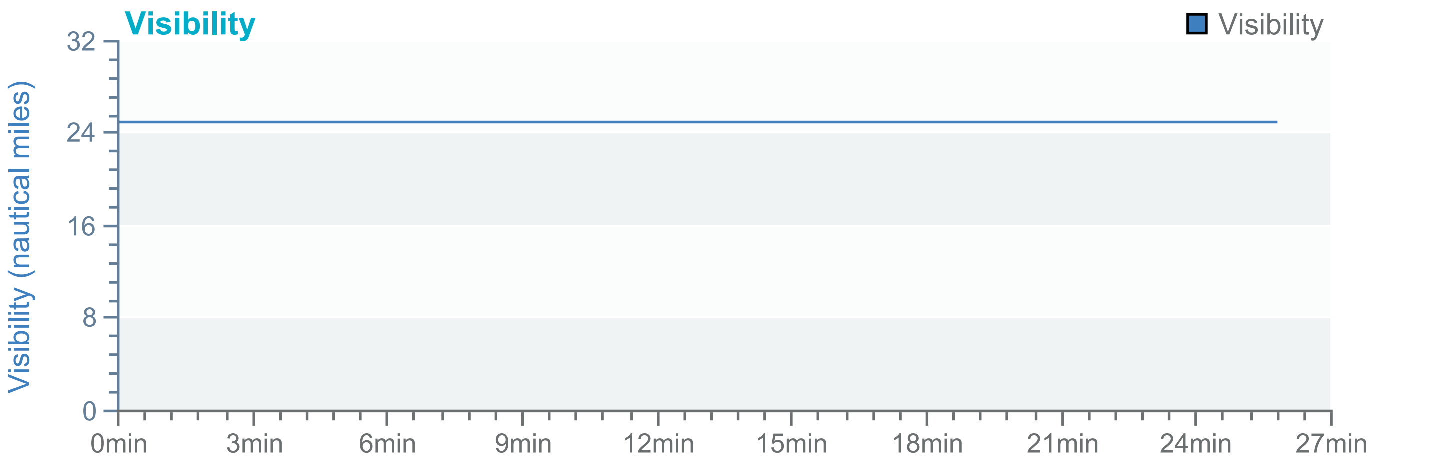
Ships plotted every 1 mins, highlight every 10 mins

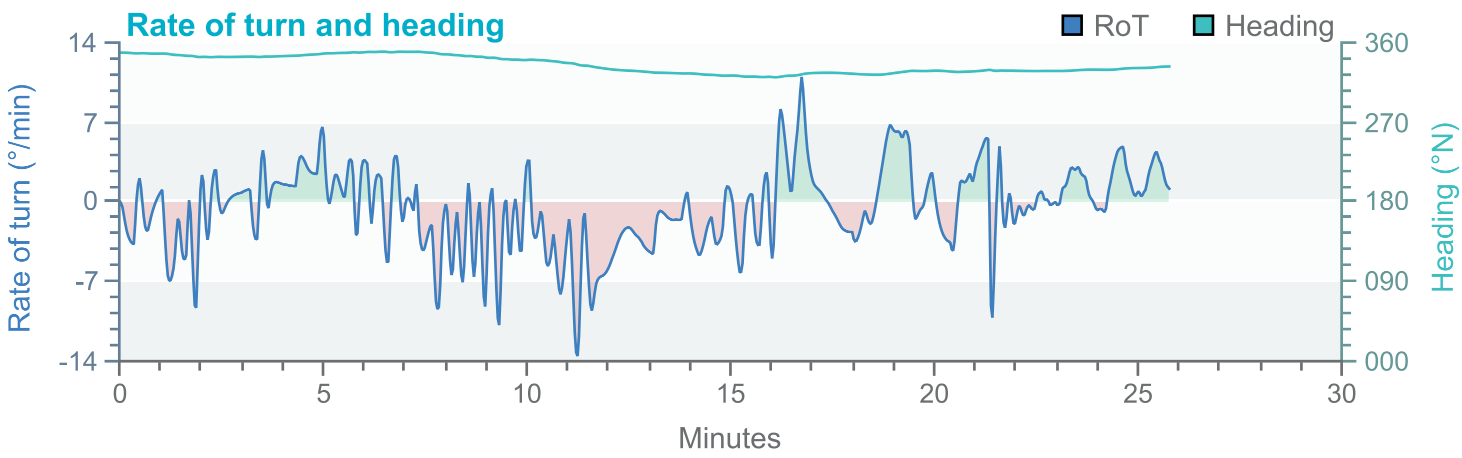
Tracks | Environment | Loya Part Laden

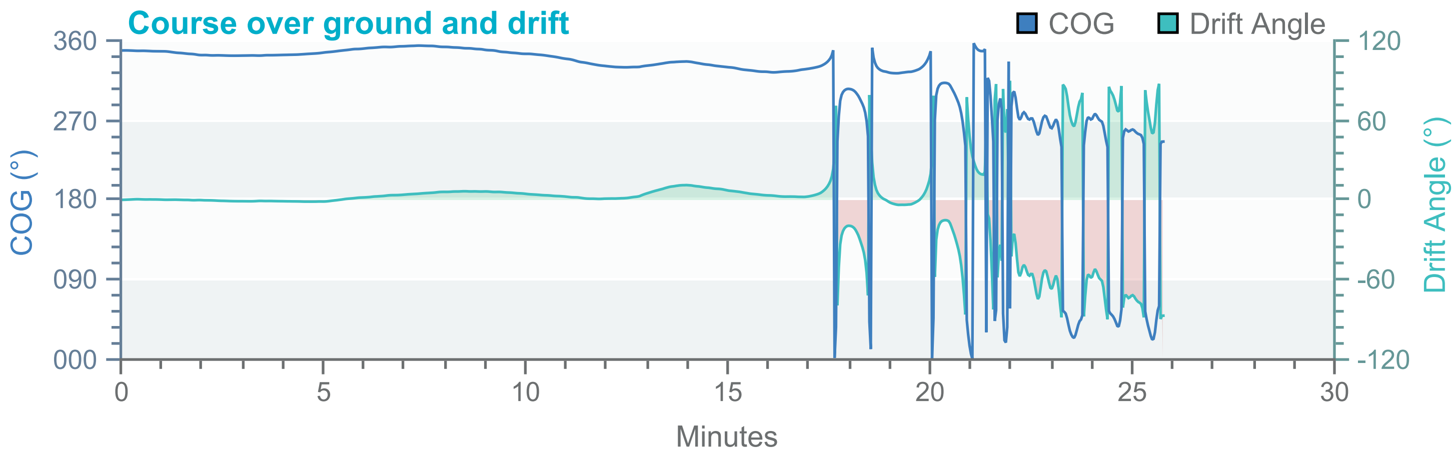


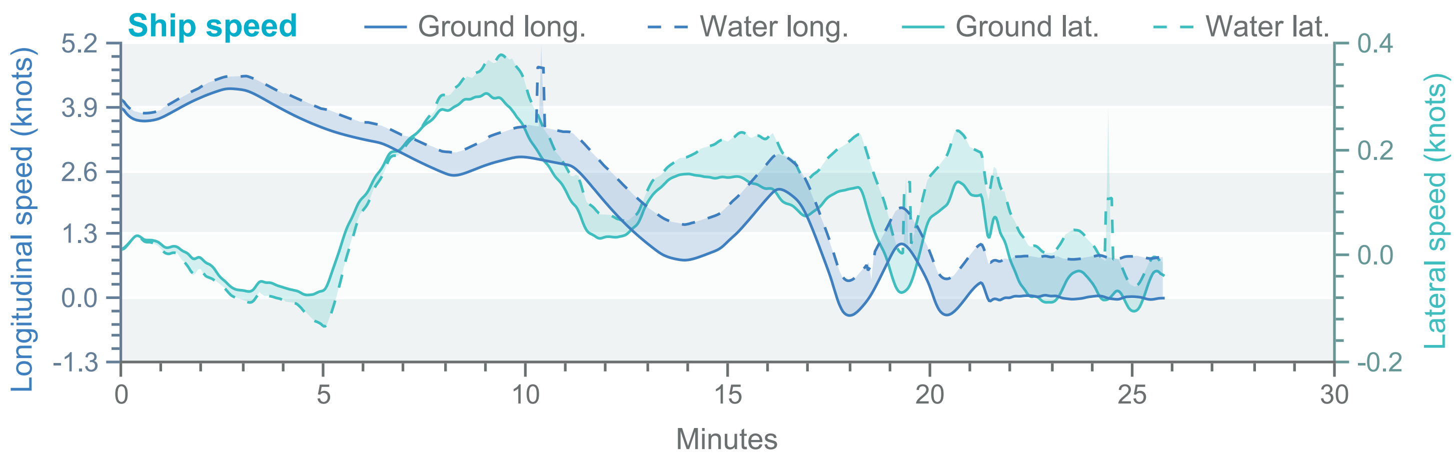


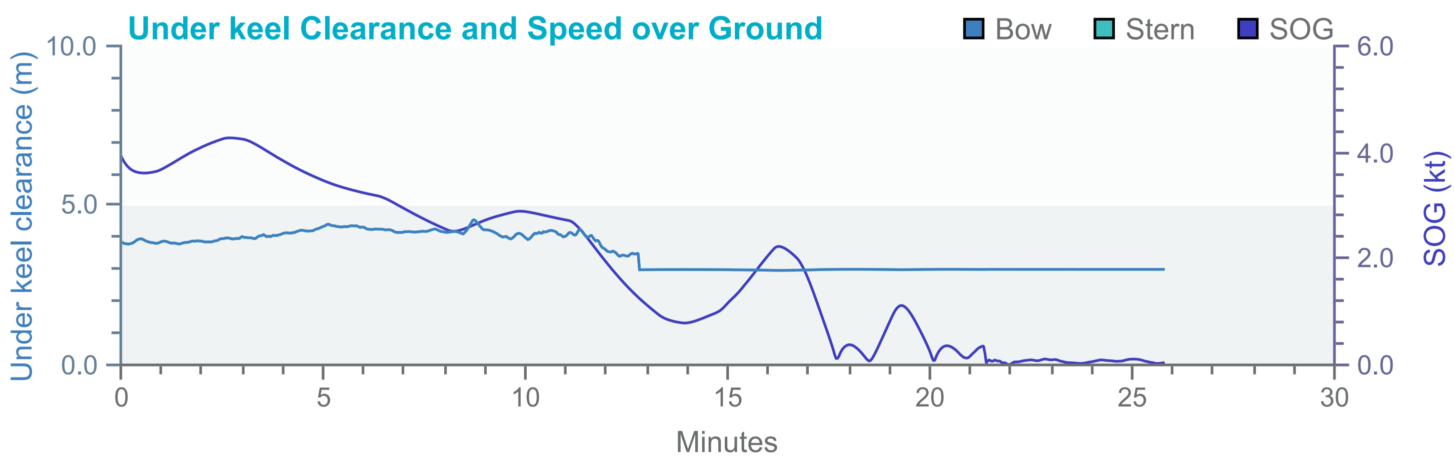


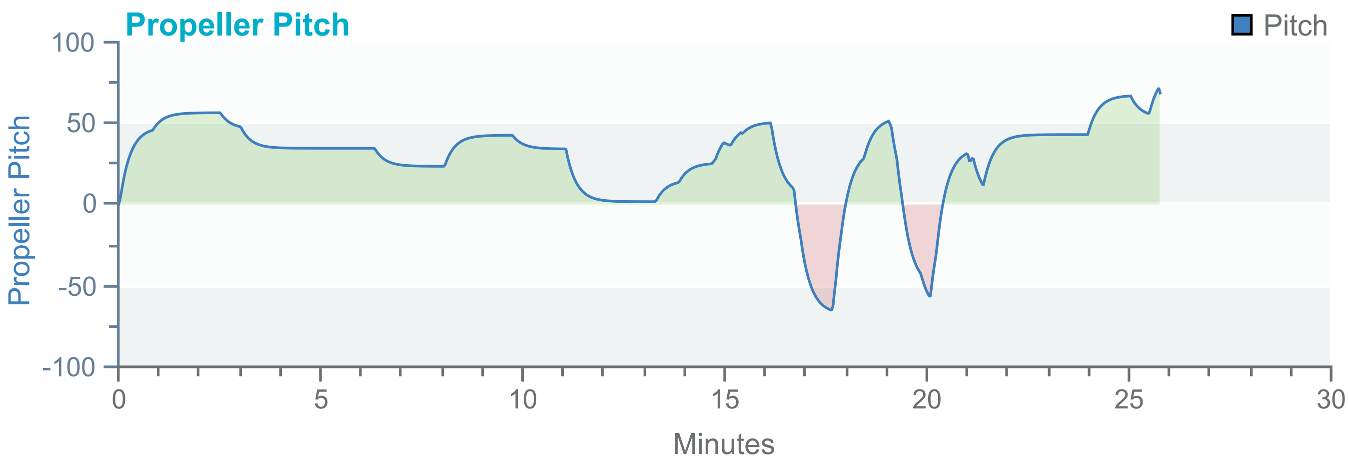


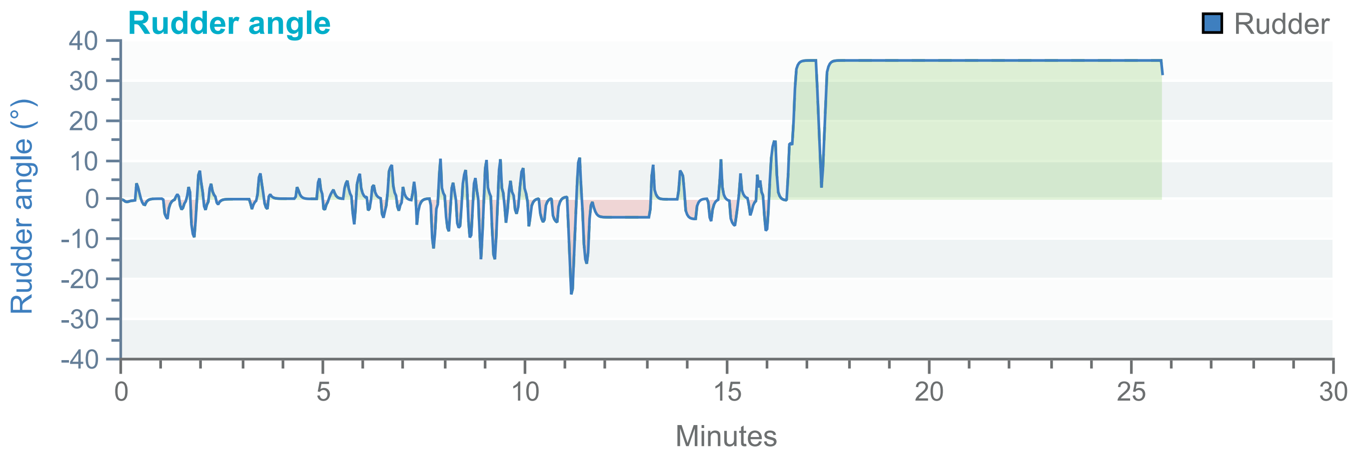

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
14
7
0
-7
-14
360
270
180
090
000
0
5
10
15
20
25
30
Minutes

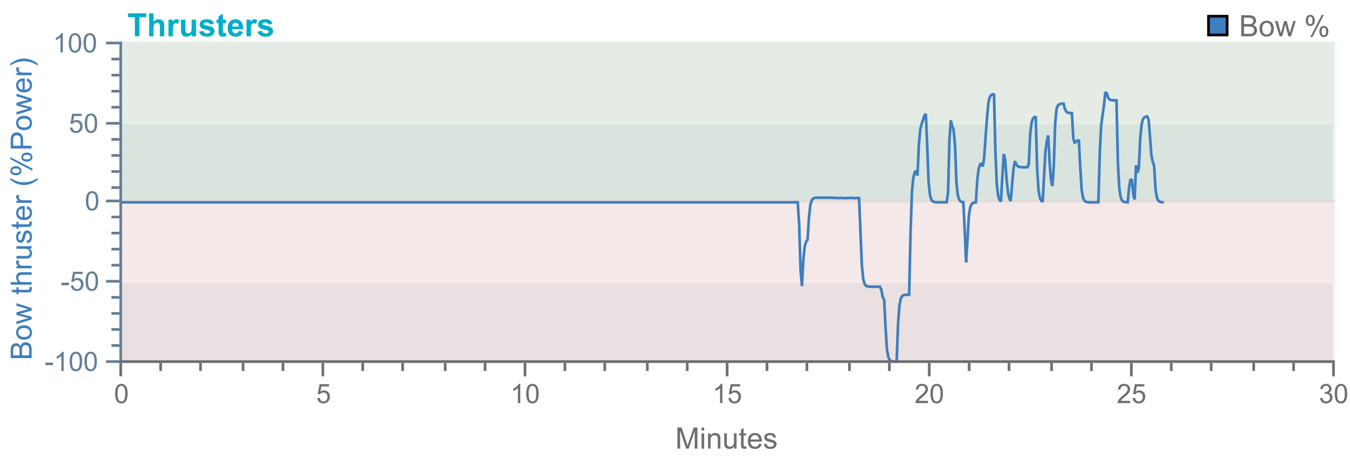

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
25
30
Minutes

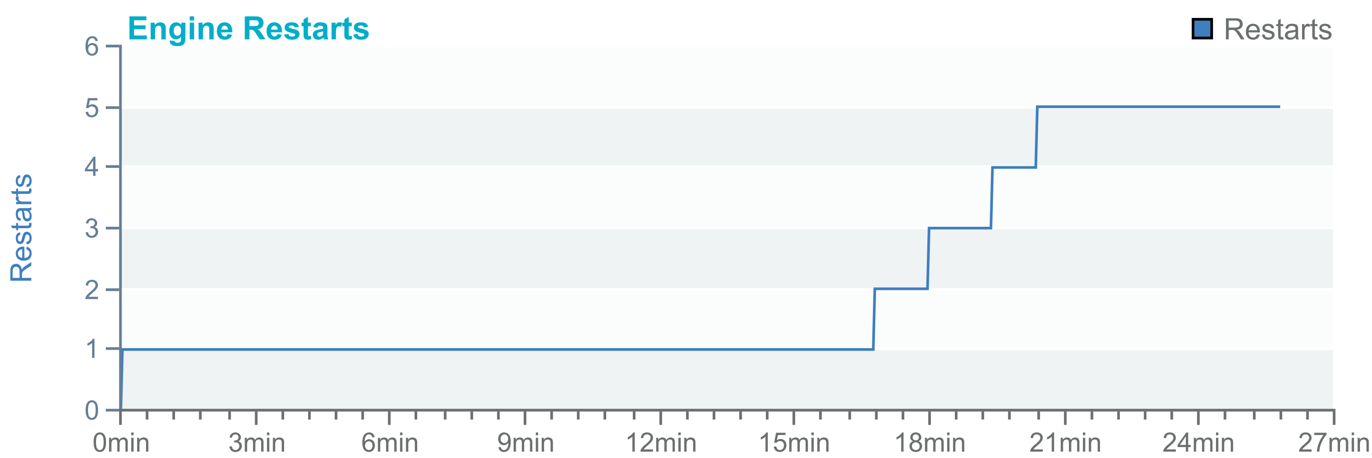

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.2
3.9
2.6
1.3
0.0
-1.3
0.4
0.2
0.0
-0.2
0
5
10
15
20
25
30
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
Minutes

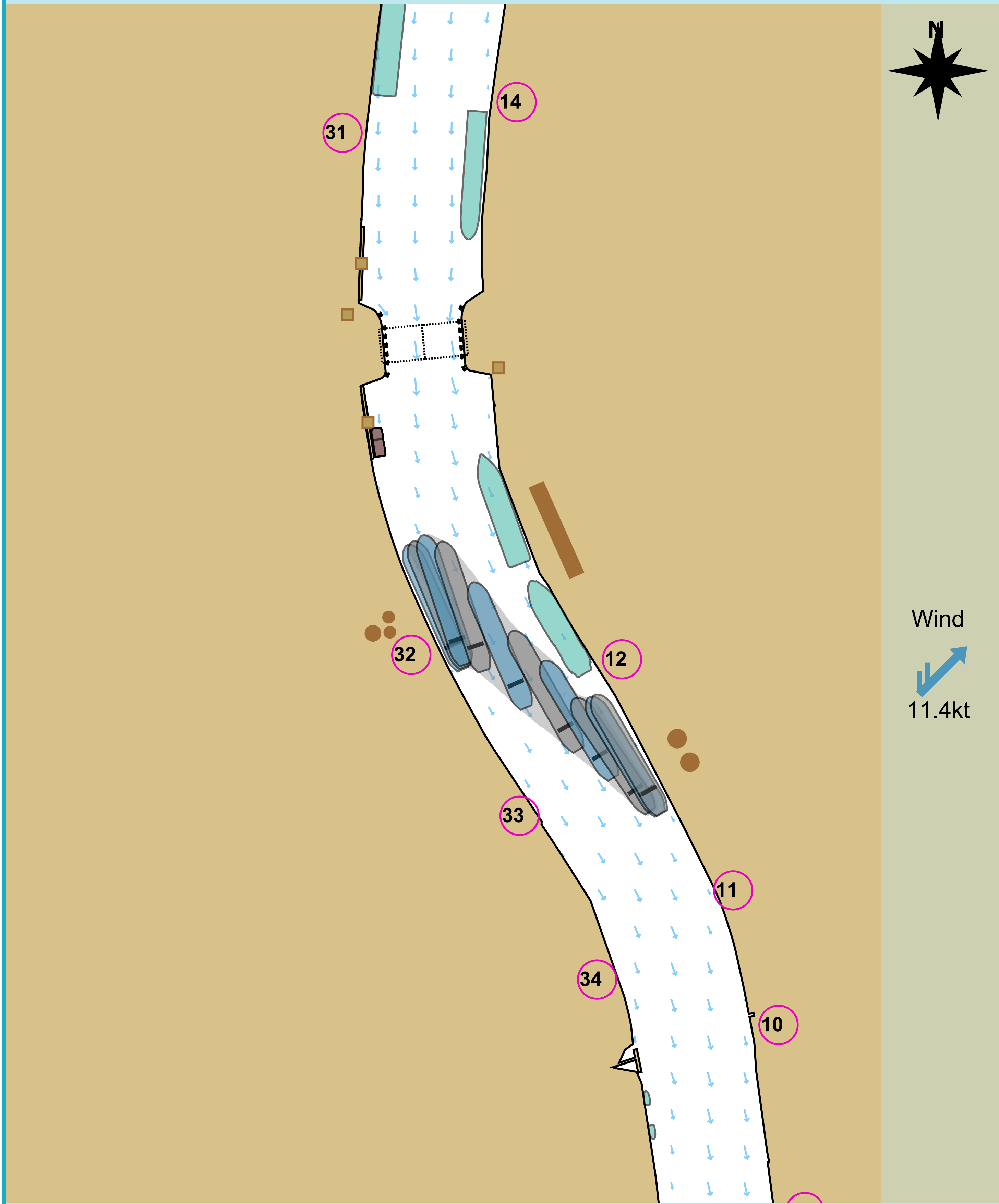

Propeller Pitch
Pitch
100
50
0
-50
-100
Propeller Pitch
0
5
10
15
20
25
30
Minutes


Rudder angle
Rudder
40
30
20
10
0
-10
-20
-30
-40
Rudder angle (°)
0
5
10
15
20
25
30
Minutes


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

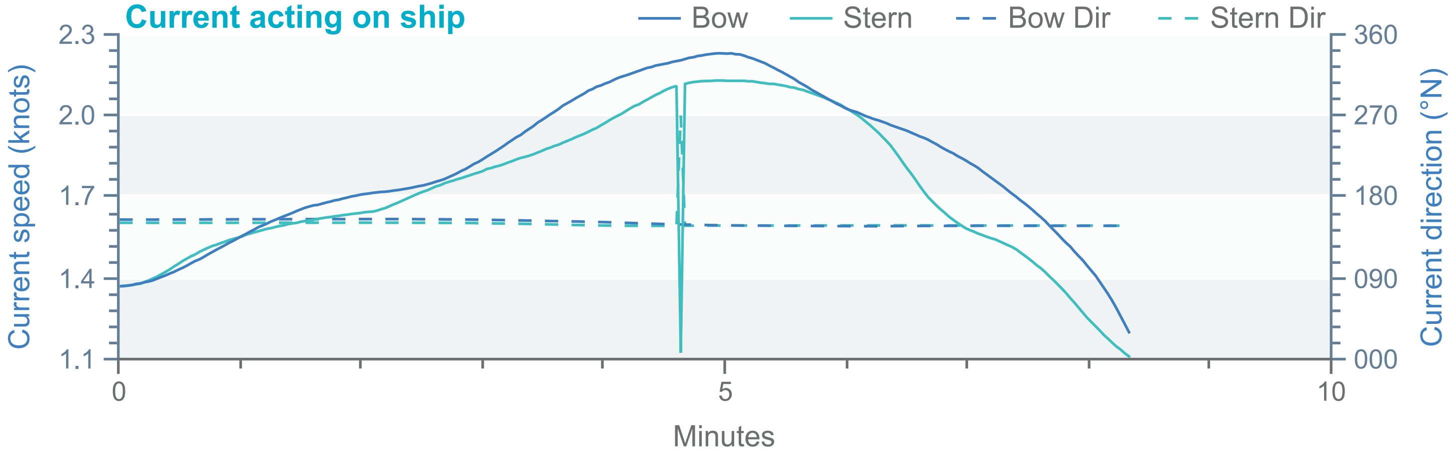

Engine Restarts
Restarts
6
5
4
3
2
1
0
Restarts
0min
3min
6min
9min
12min
15min
18min
21min
24min
27min

Manoeuvre track plot

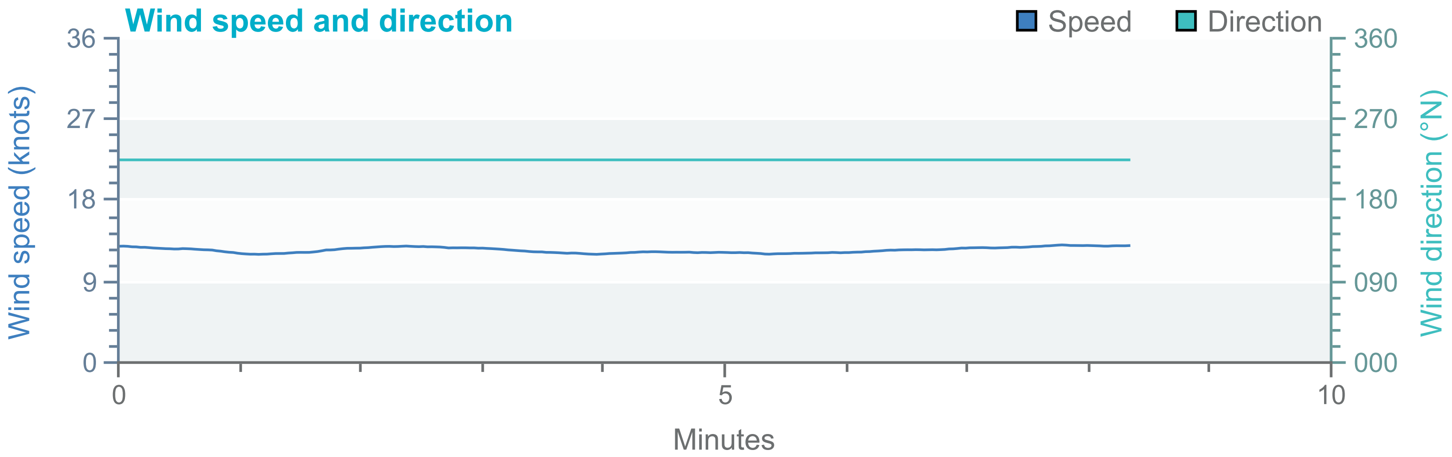


Ships plotted every 1 mins, highlight every 10 mins

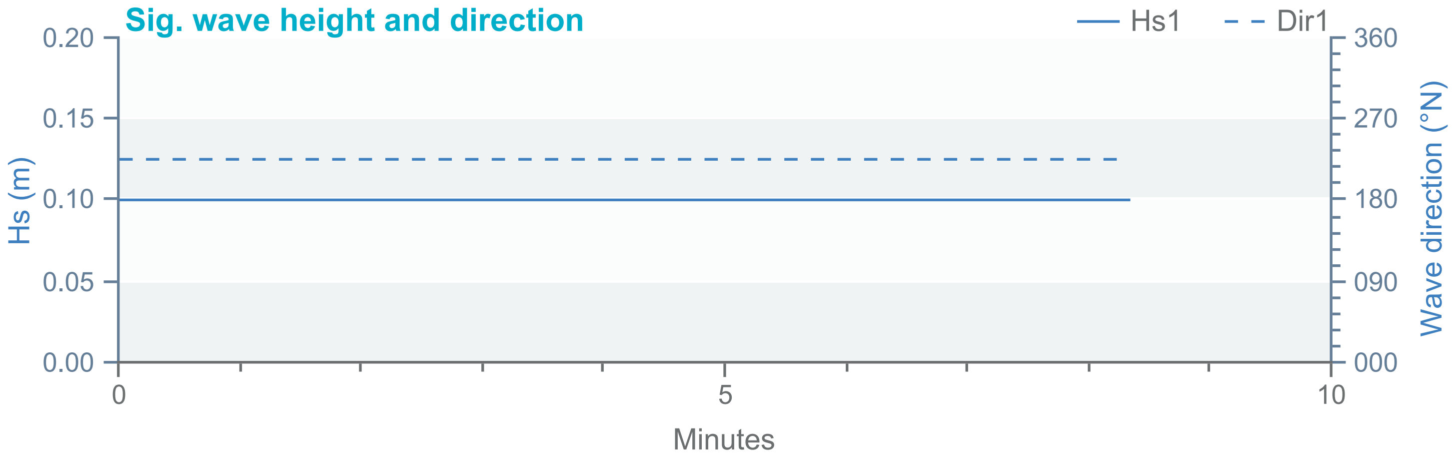
Current acting on ship



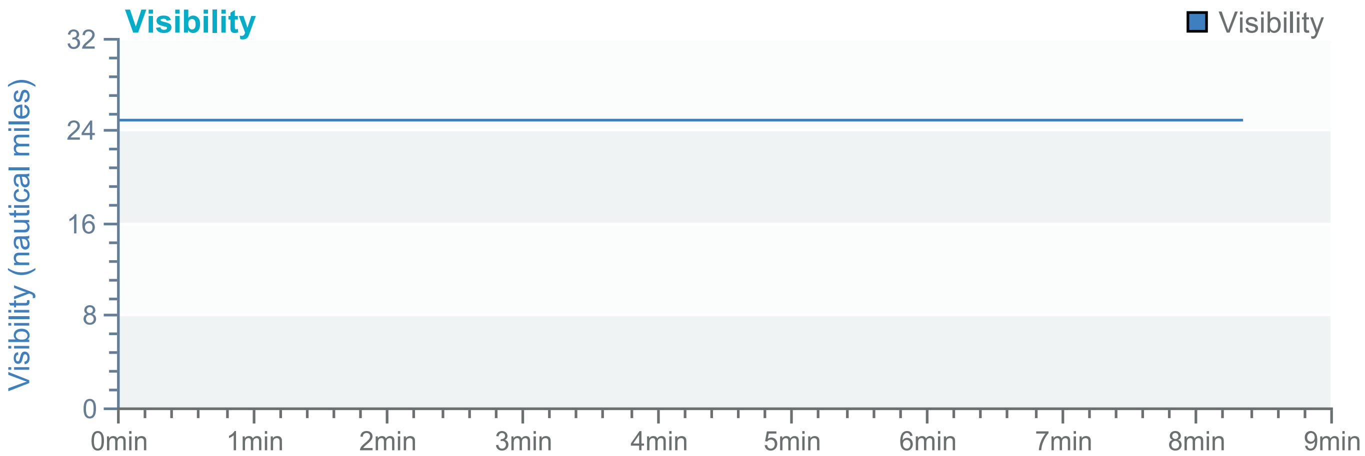
Wind speed and direction



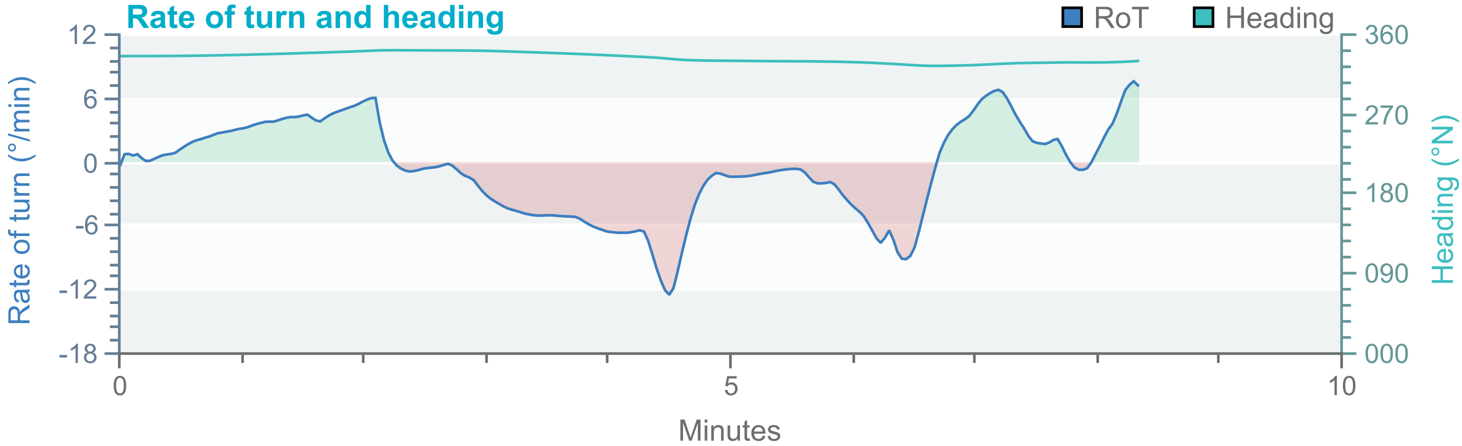
Sig. wave height and direction



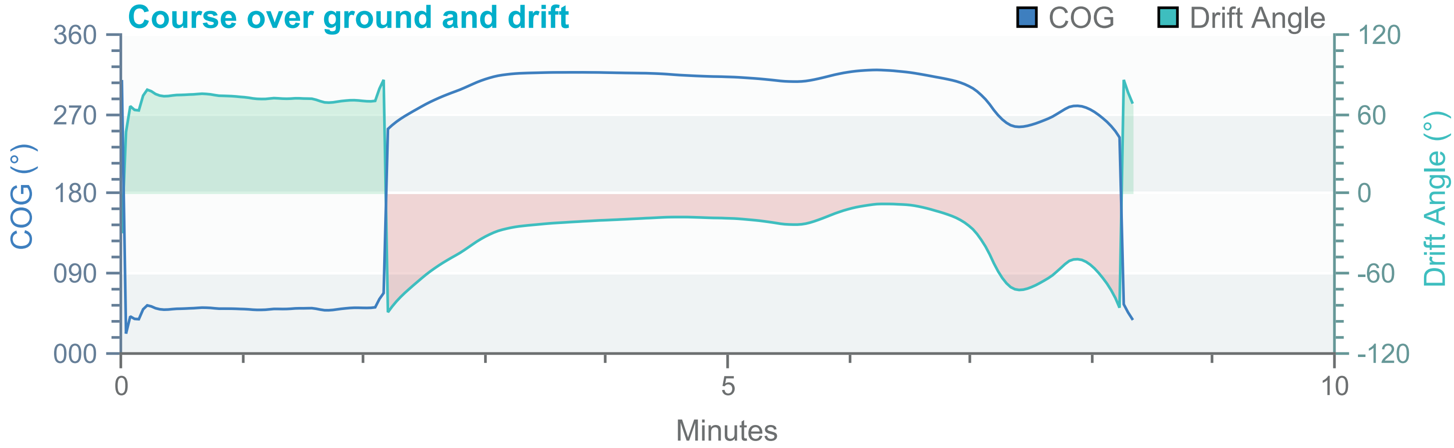
Visibility



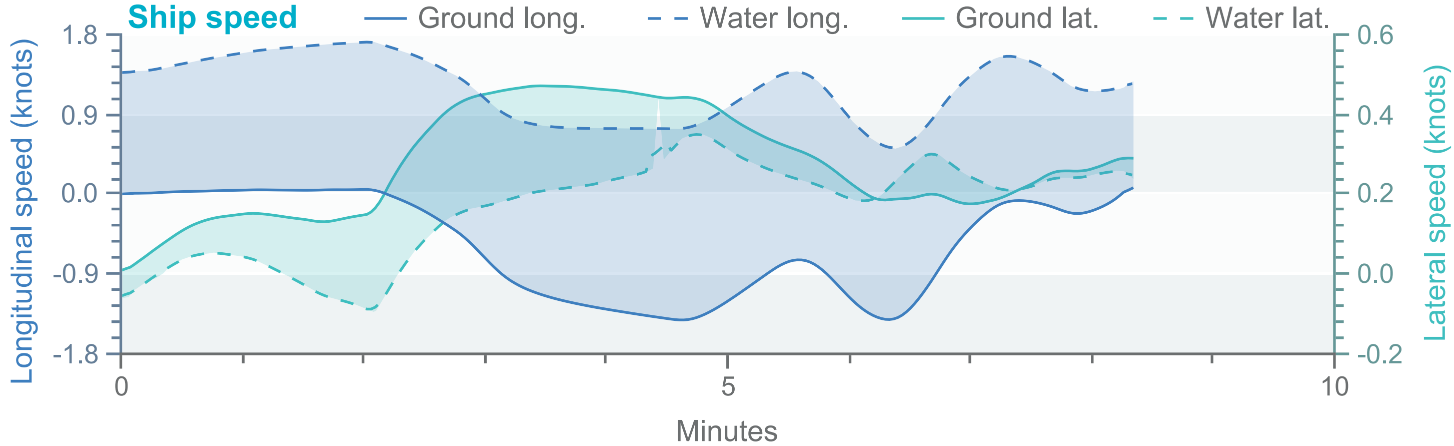
Rate of turn and heading



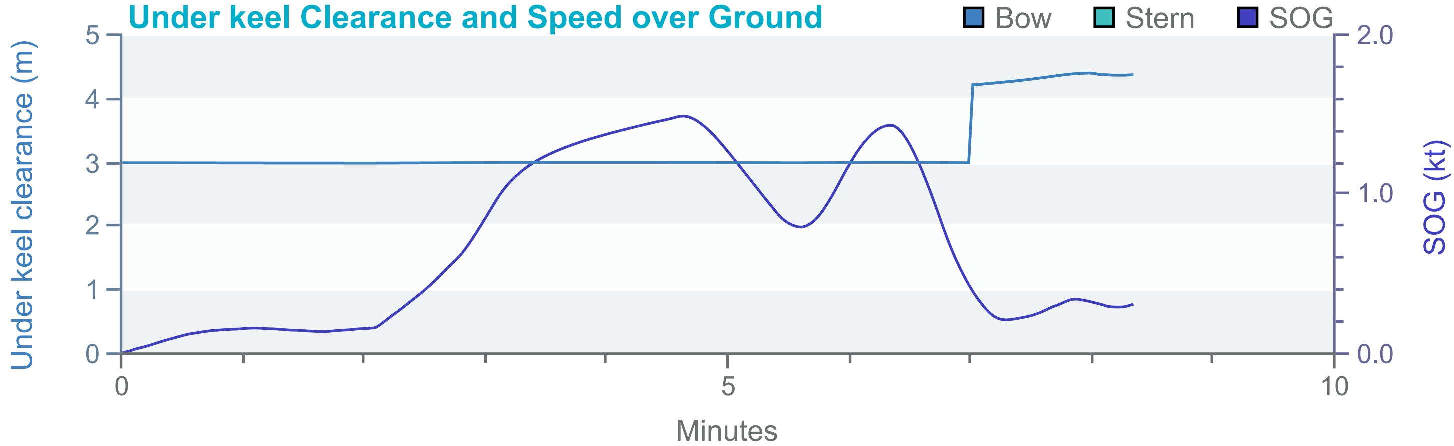
Course over ground and drift



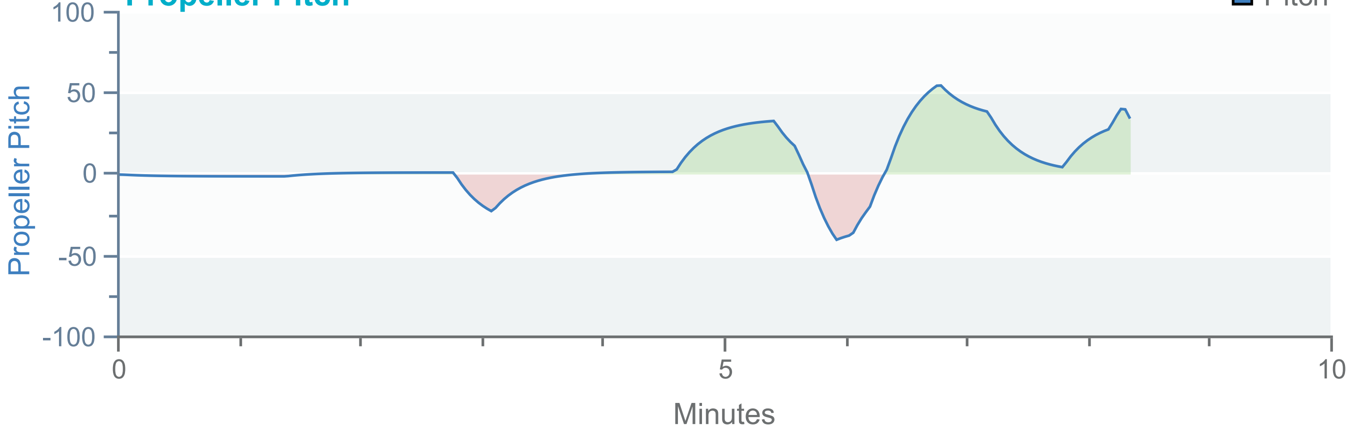
Ship speed



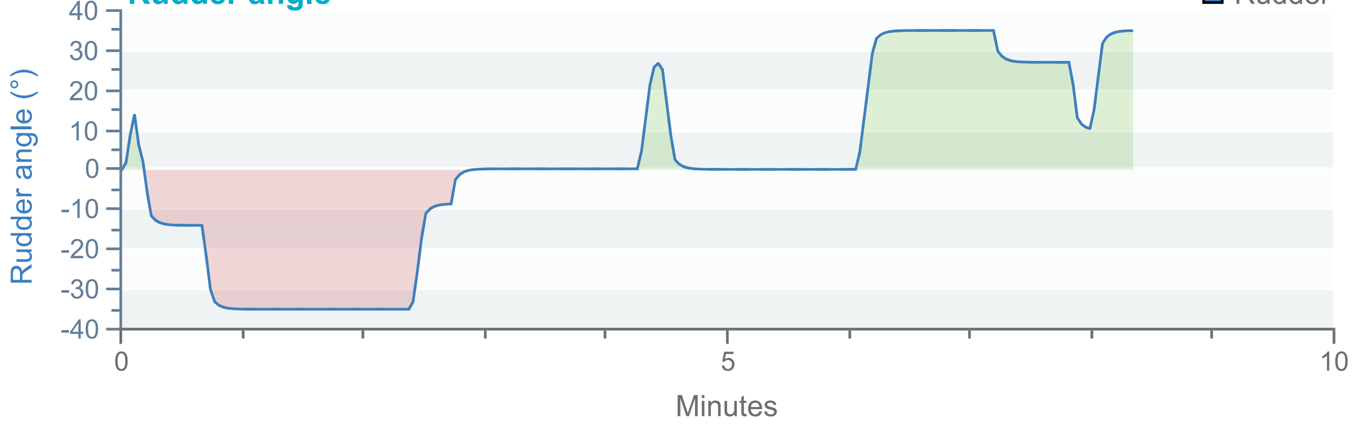
Under keel Clearance and Speed over Ground



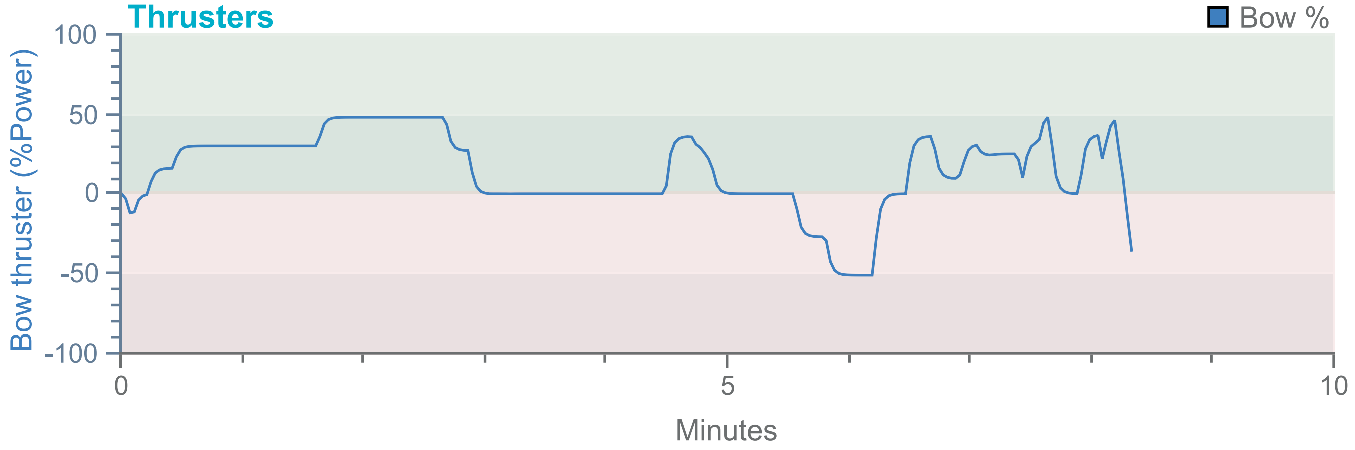
Propeller Pitch



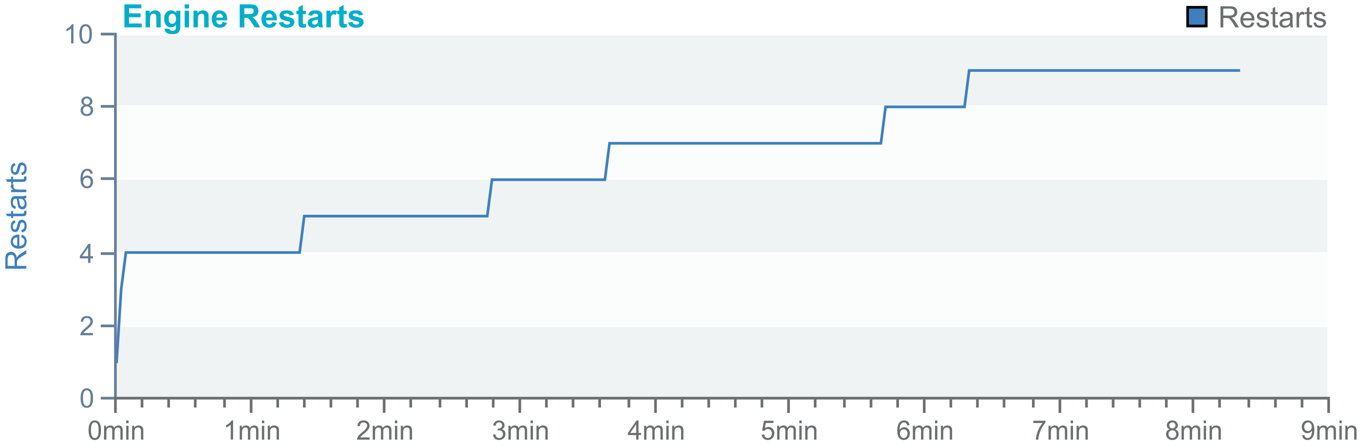
Rudder angle



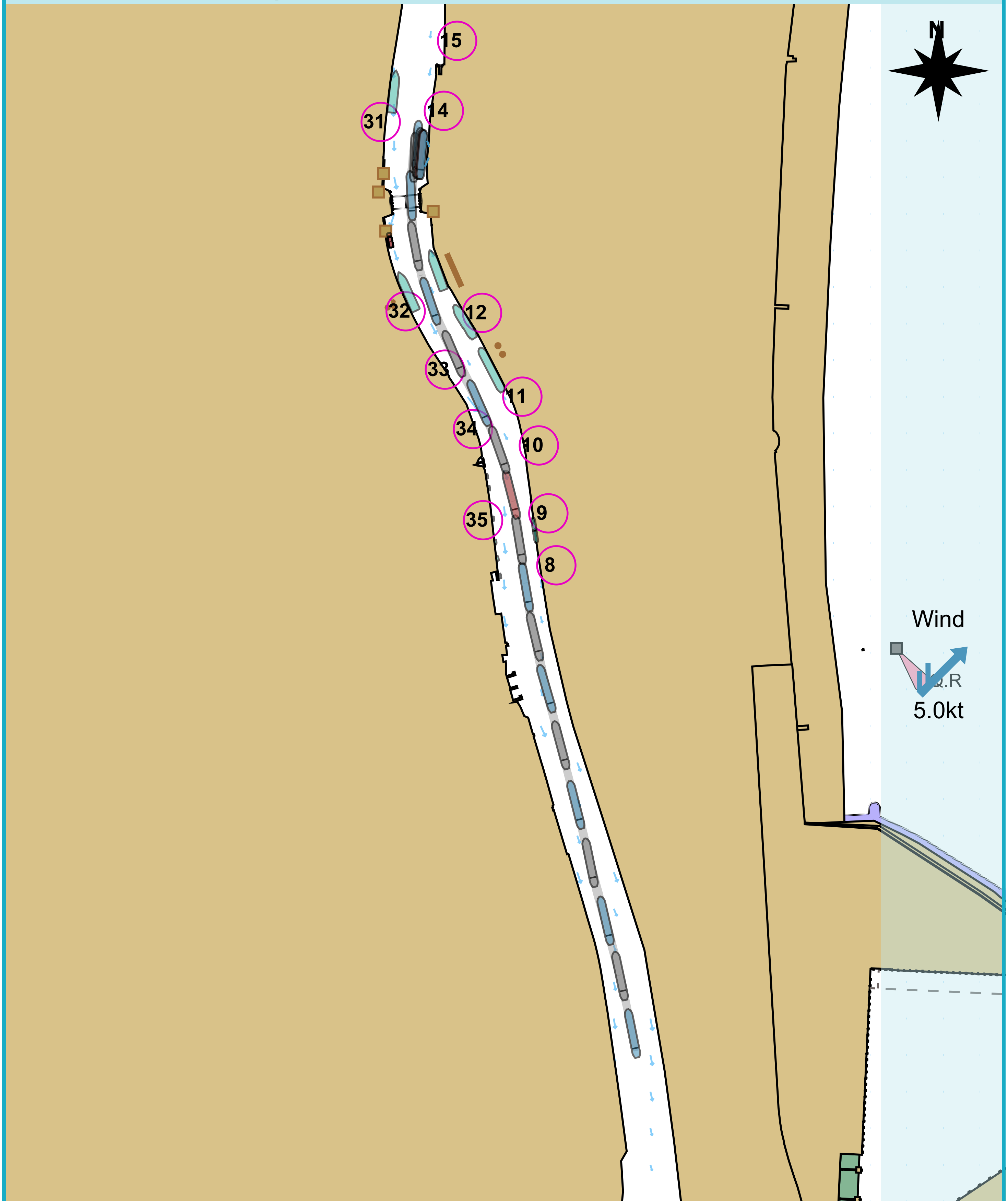
Thrusters



Engine Restarts

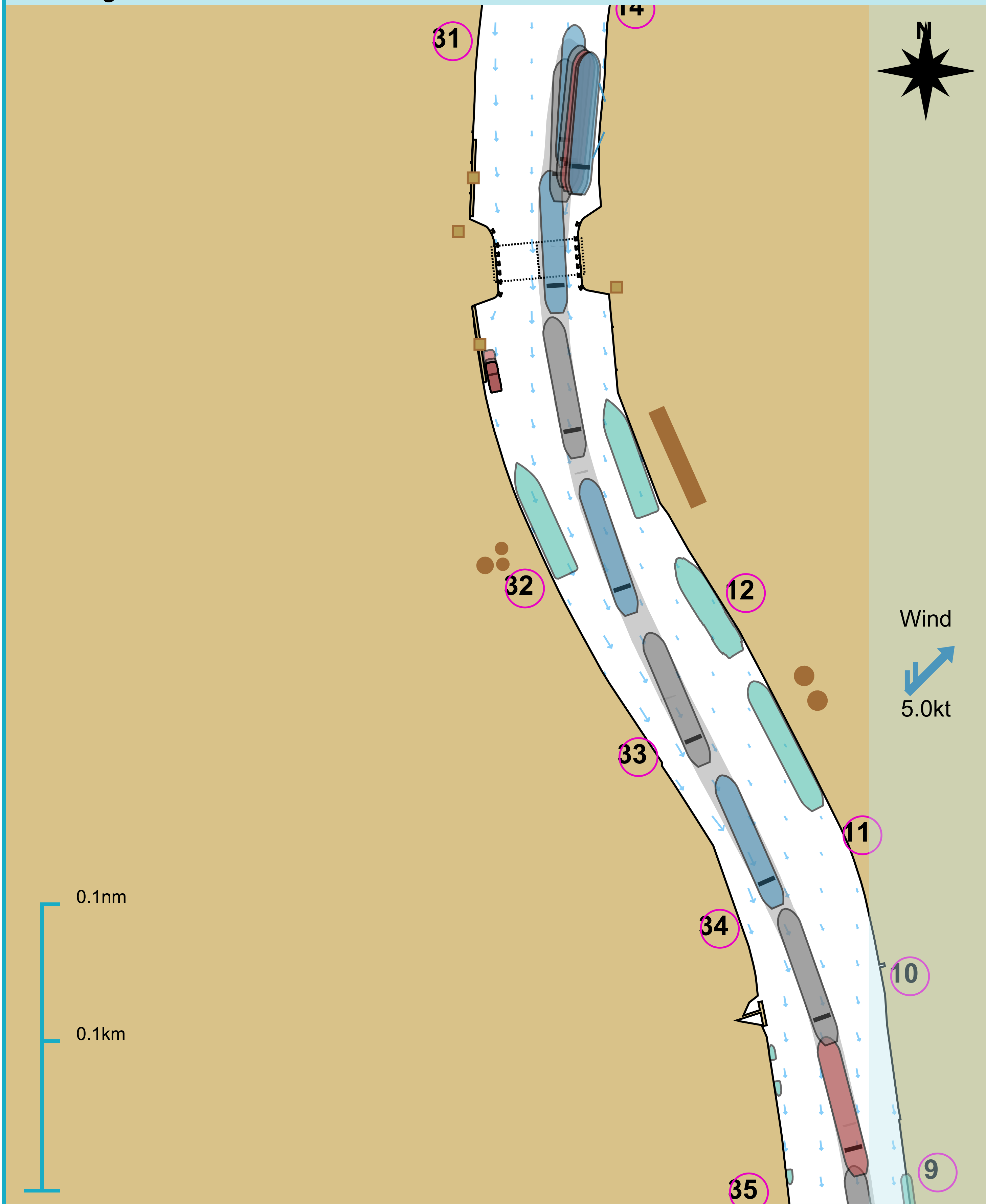


Manoeuvre track plot

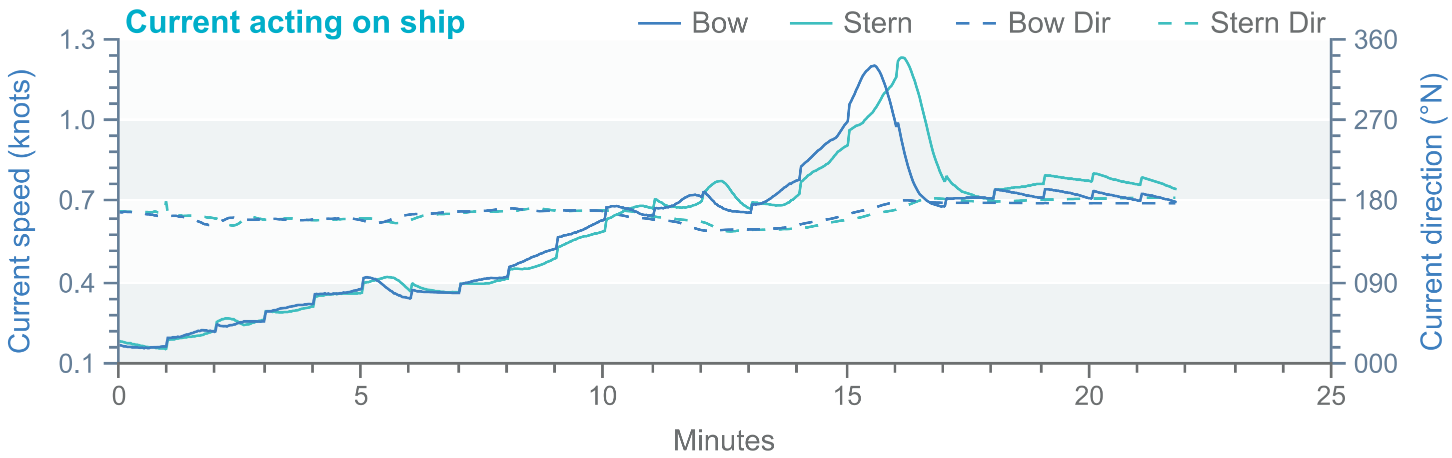


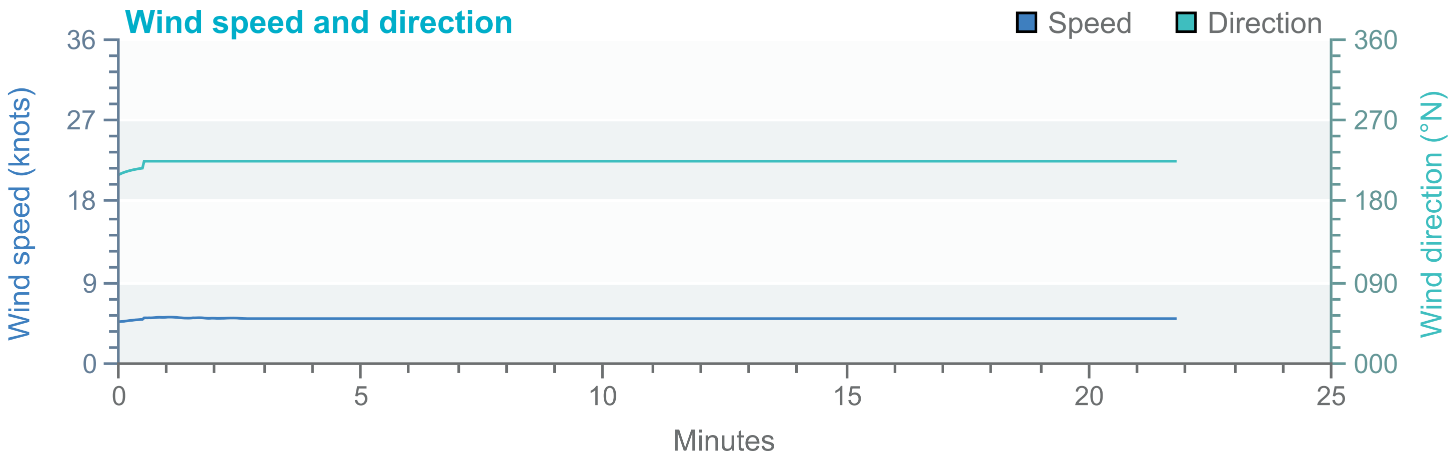
Ships plotted every 1 mins, highlight every 10 mins

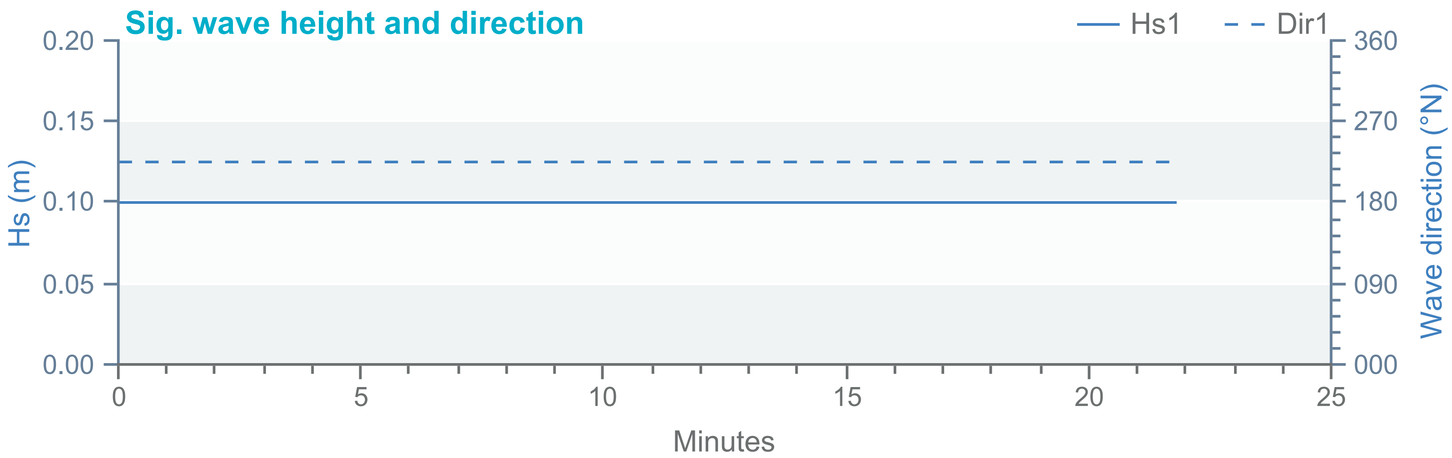
Berthing

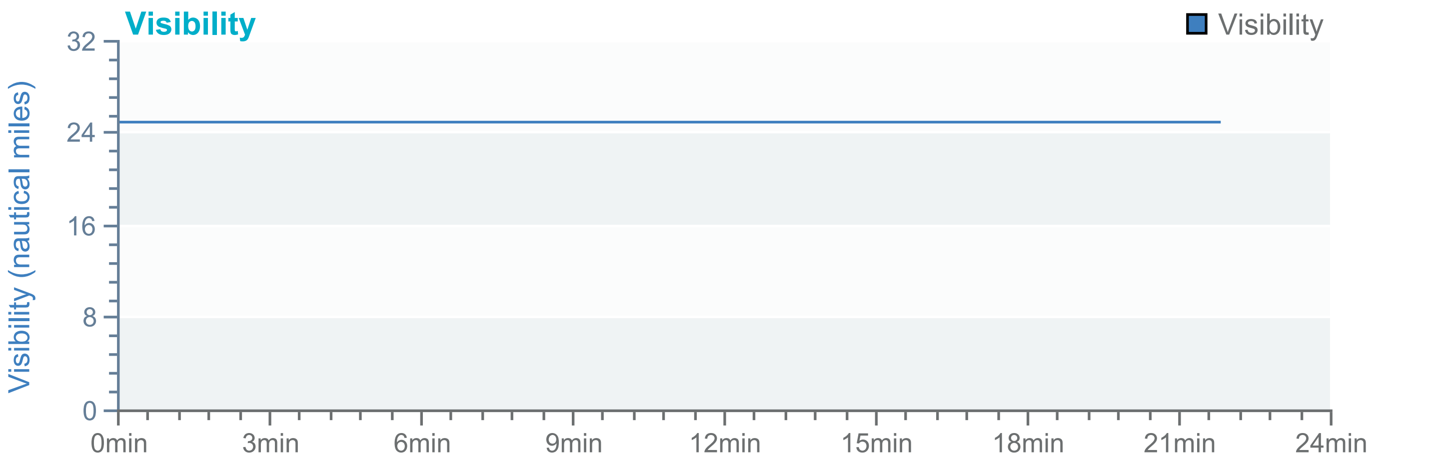


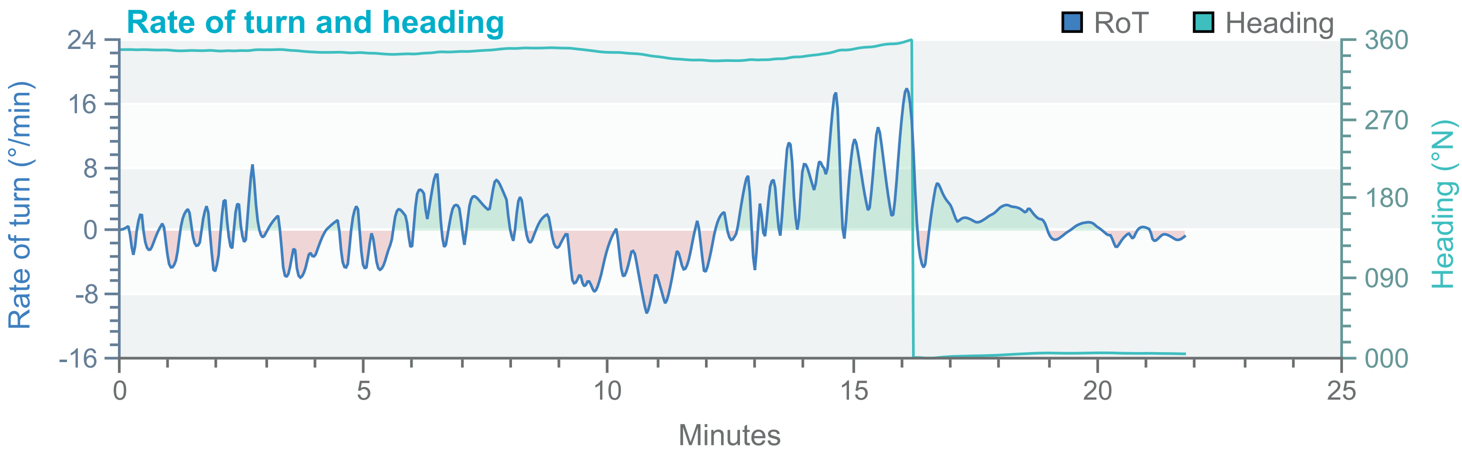
Ships plotted every 1 mins, highlight every 10 mins

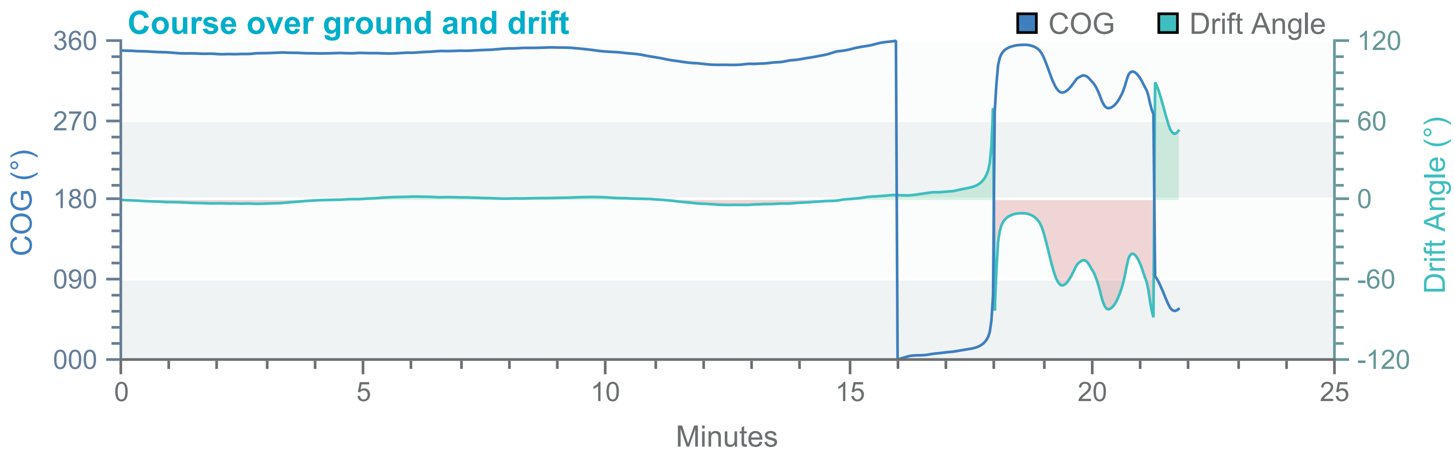

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
1.3
1.0
0.7
0.4
0.1
360
270
180
090
000
0
5
10
15
20
25

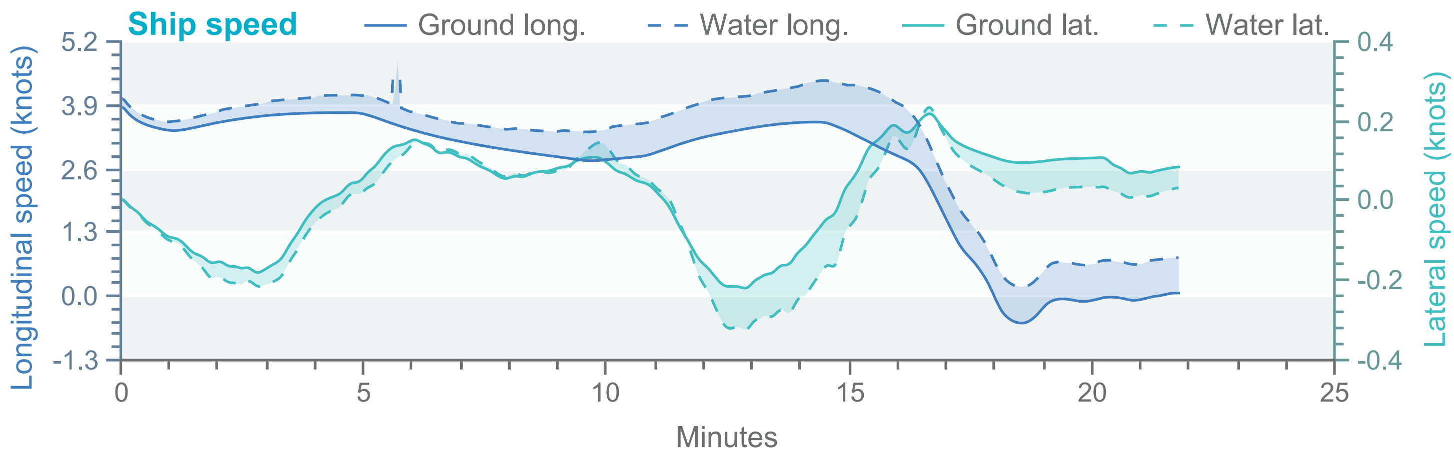

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
25

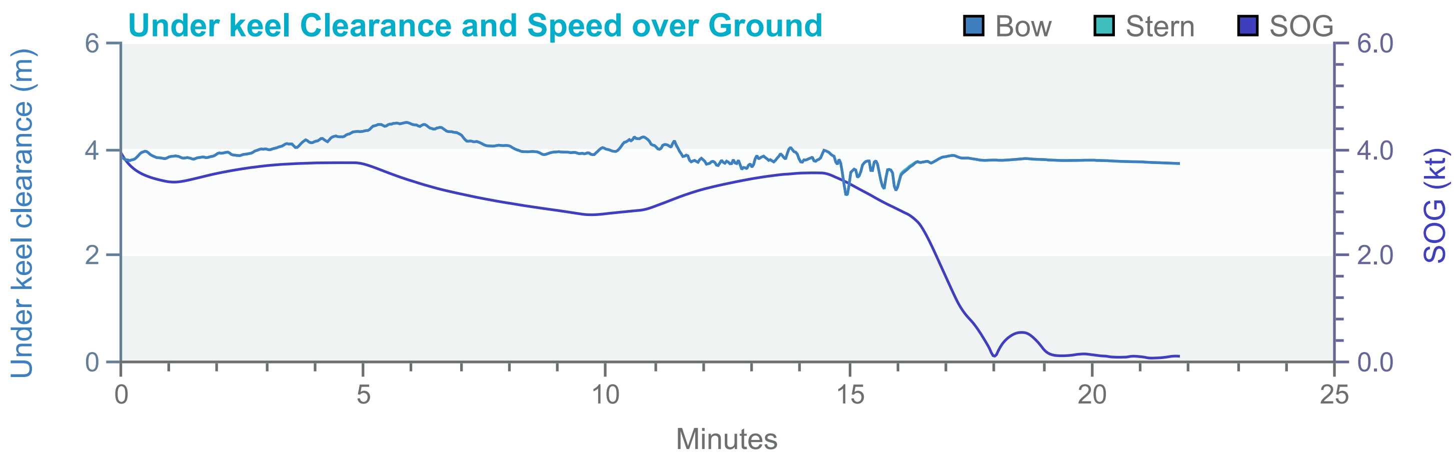

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
25


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
3min
6min
9min
12min
15min
18min
21min
24min

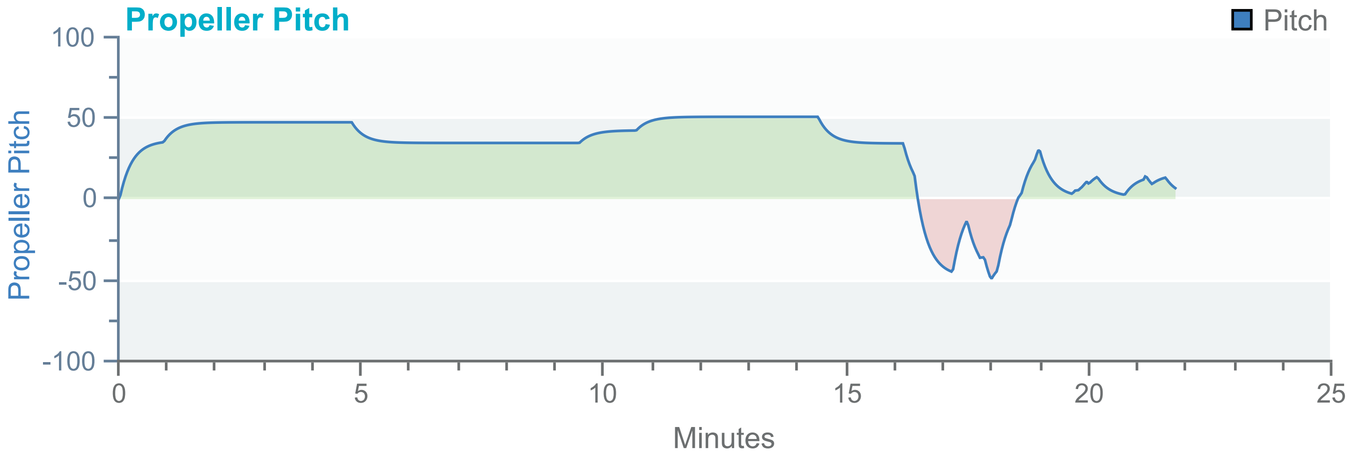

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
24
16
8
0
-8
-16
360
270
180
090
000
0
5
10
15
20
25
Minutes


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
25
Minutes

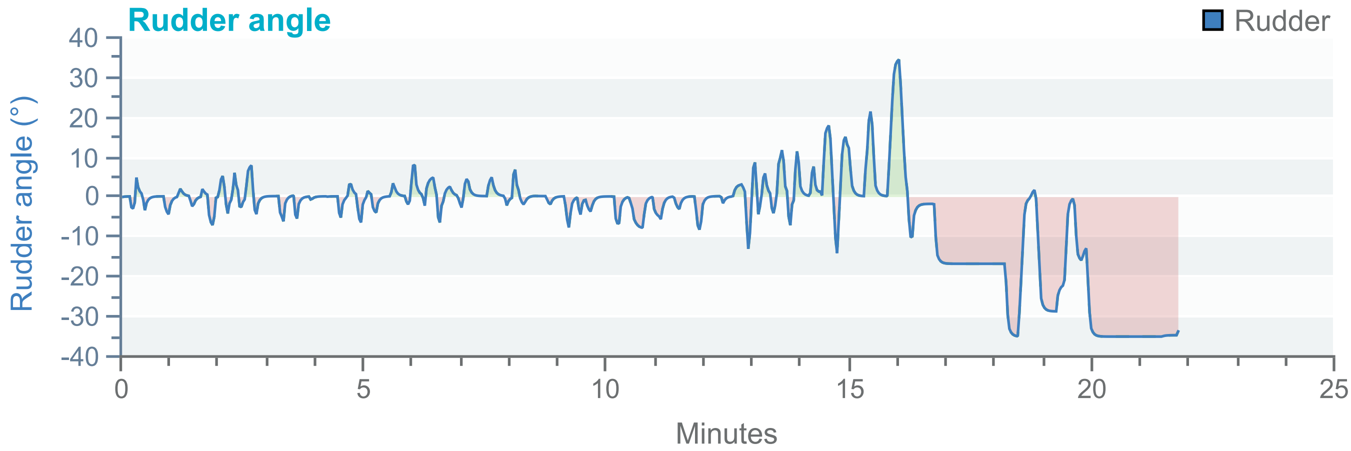

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.2
3.9
2.6
1.3
0.0
-1.3
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
25
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
6
4
2
0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
Minutes

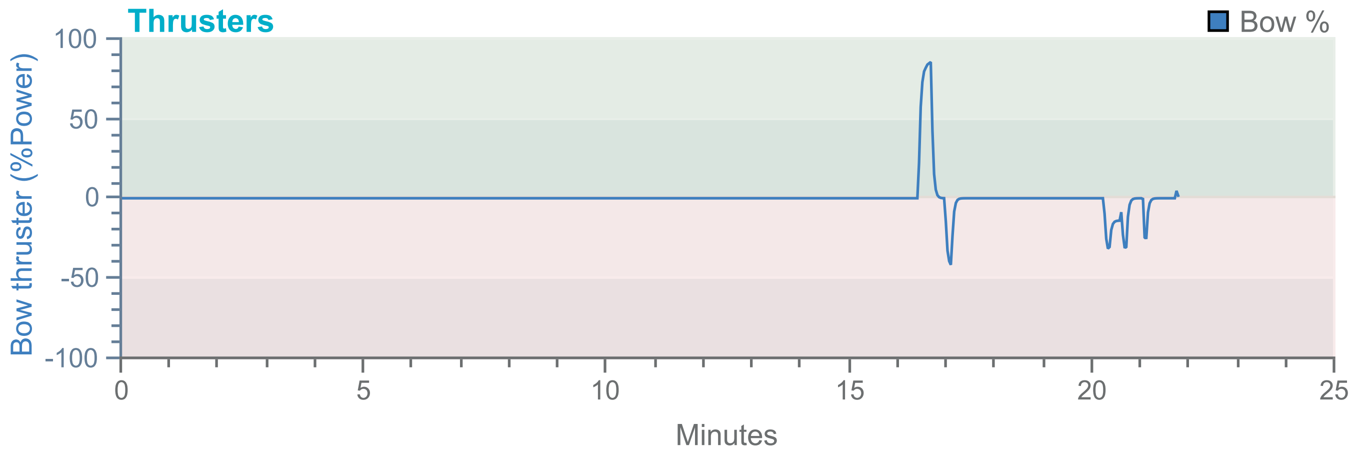
Propeller Pitch



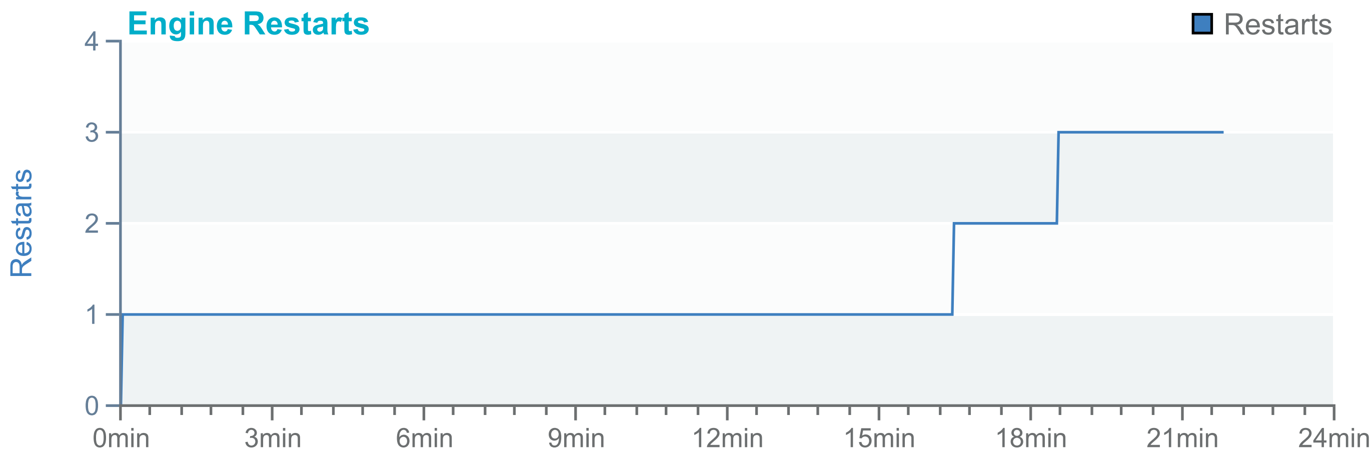
Rudder angle



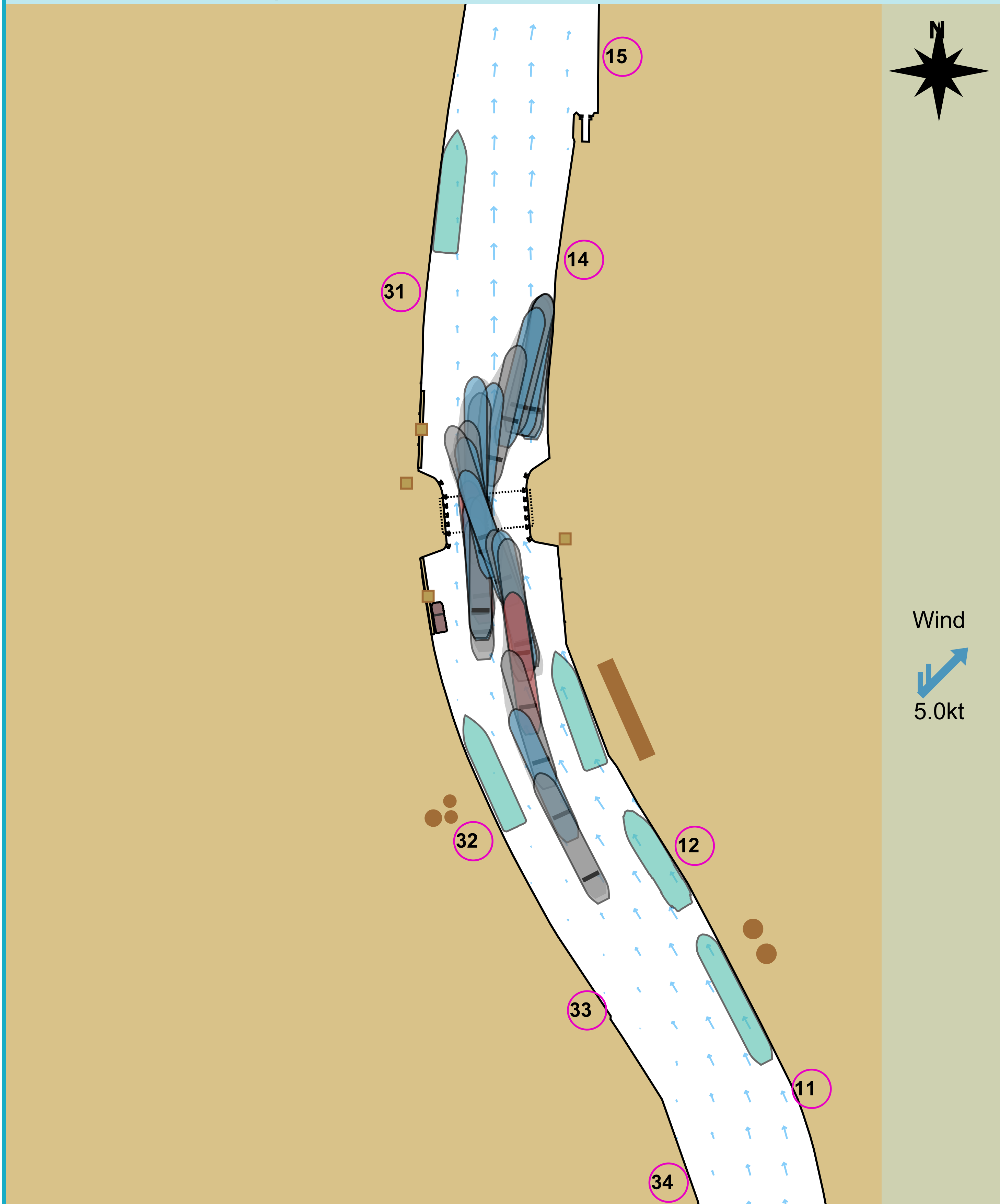
Thrusters



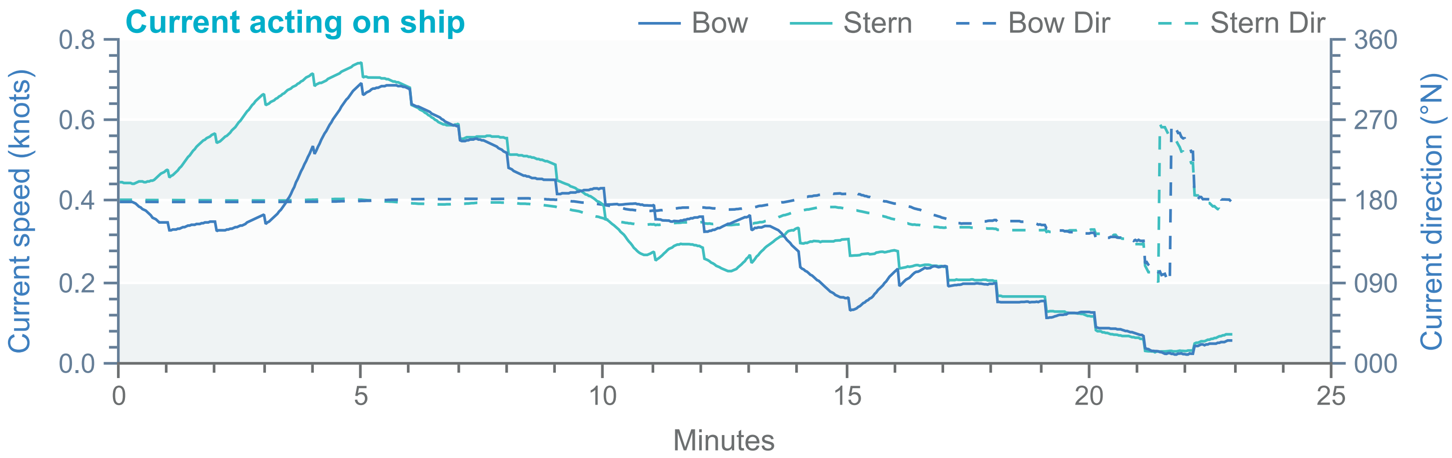
Engine Restarts

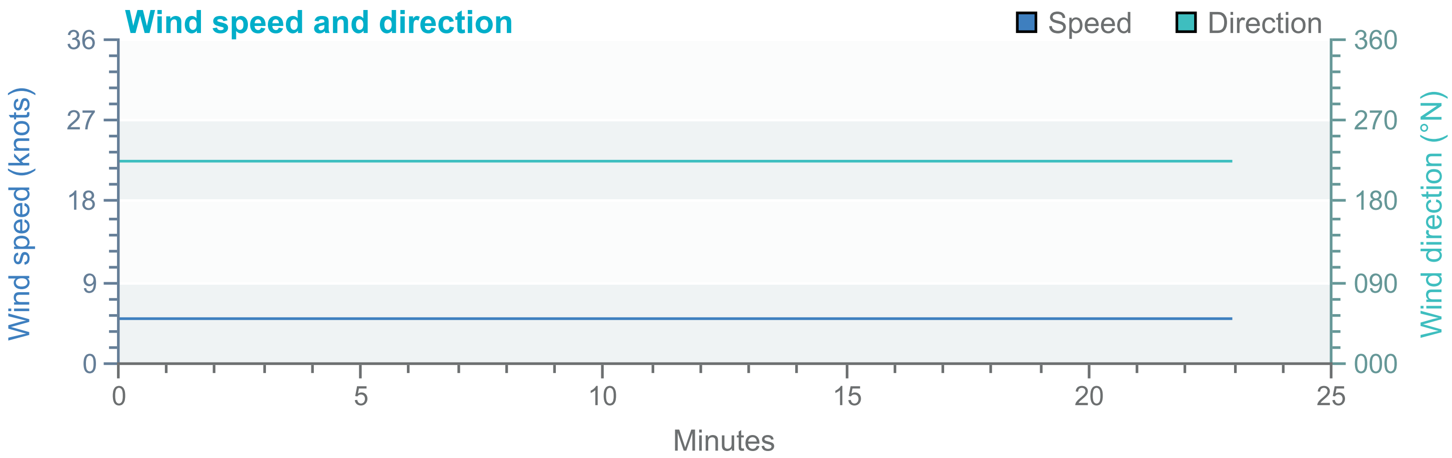


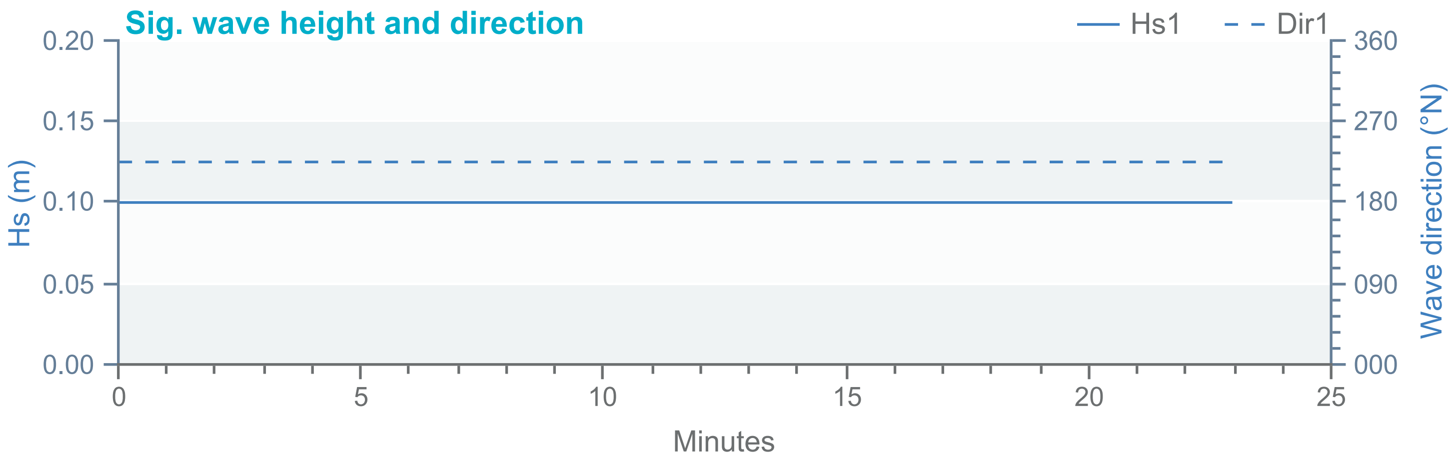
Manoeuvre track plot

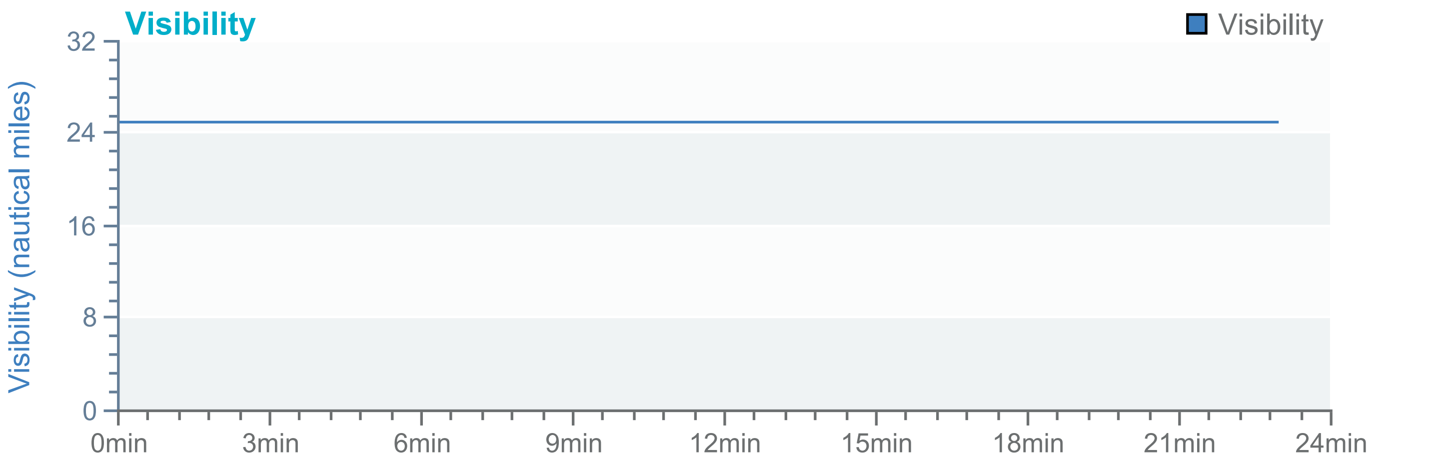


Ships plotted every 1 mins, highlight every 10 mins

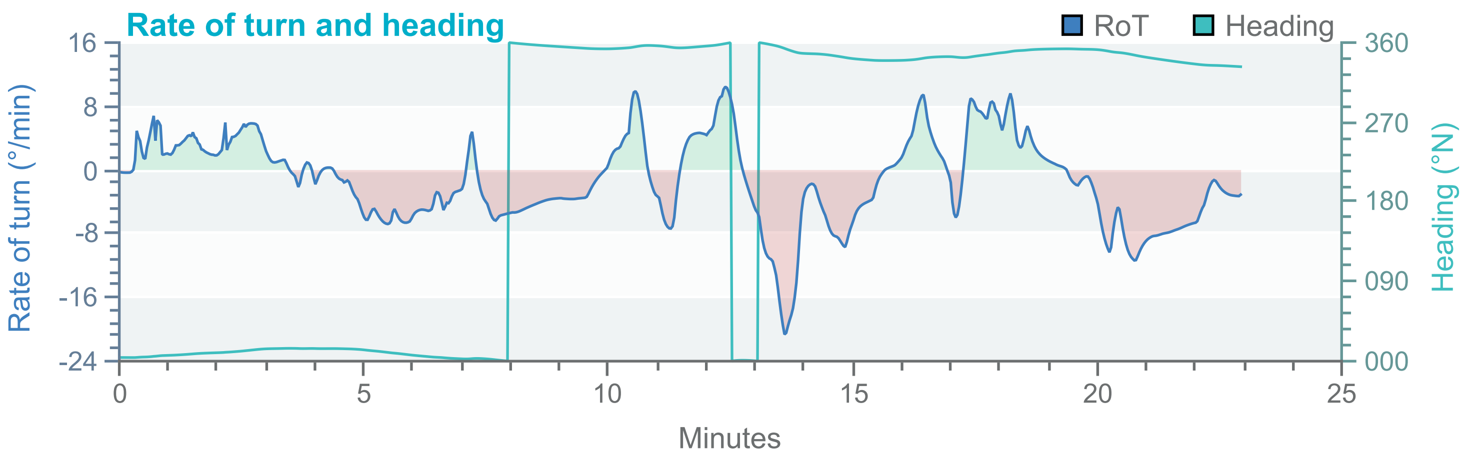

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
0.0
0.2
0.4
0.6
0.8
000
090
180
270
360
0
5
10
15
20
25

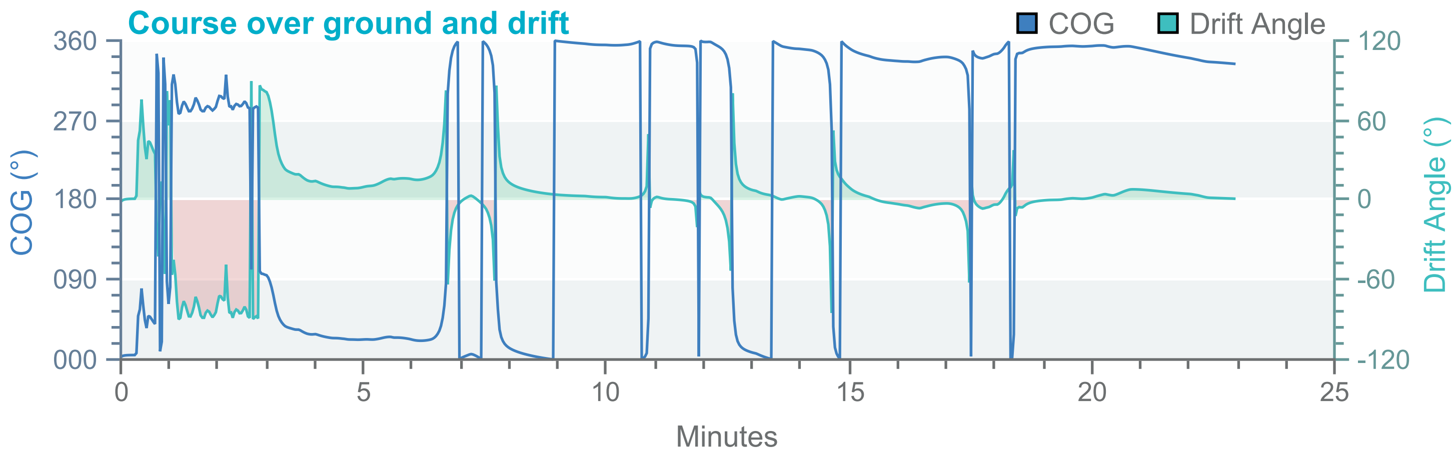

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
0
9
18
27
36
000
090
180
270
360
0
5
10
15
20
25

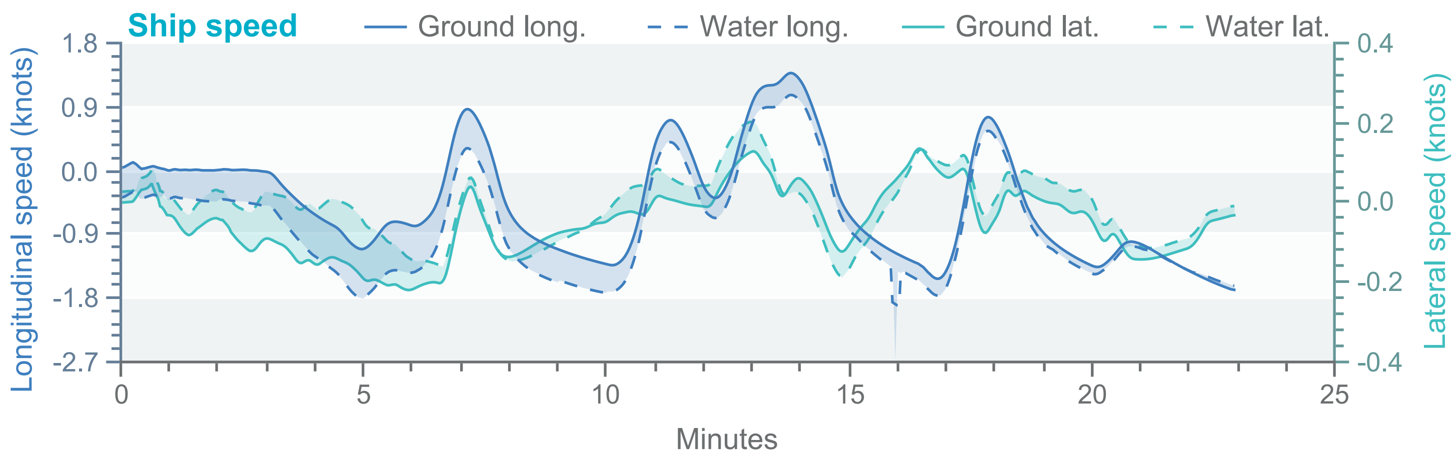

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.00
0.05
0.10
0.15
0.20
000
090
180
270
360
0
5
10
15
20
25

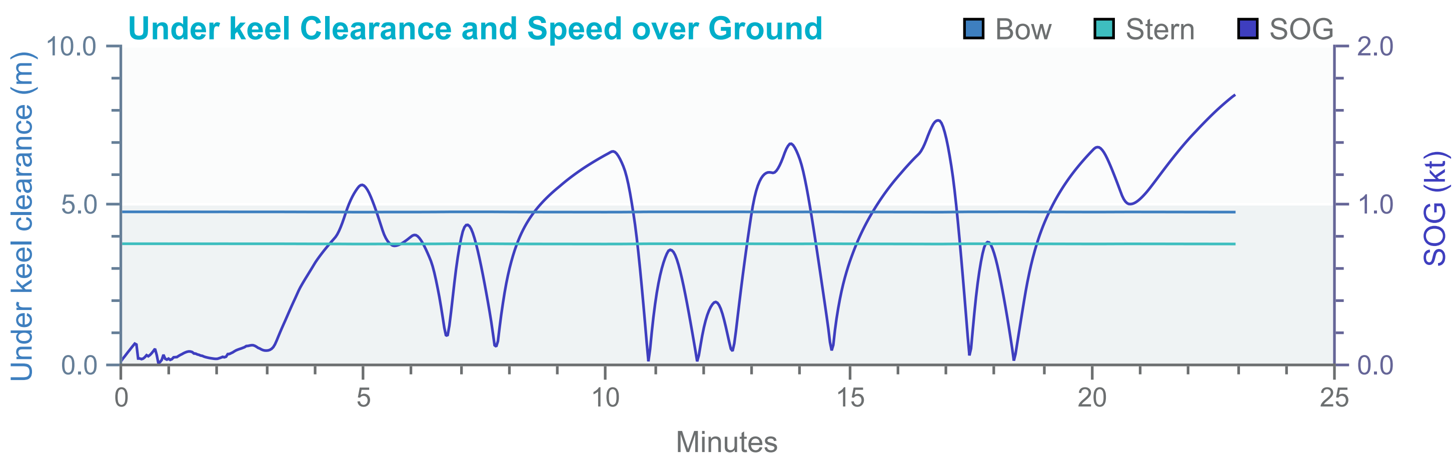

Visibility
Visibility
Visibility (nautical miles)
0
8
16
24
32
0min
3min
6min
9min
12min
15min
18min
21min
24min

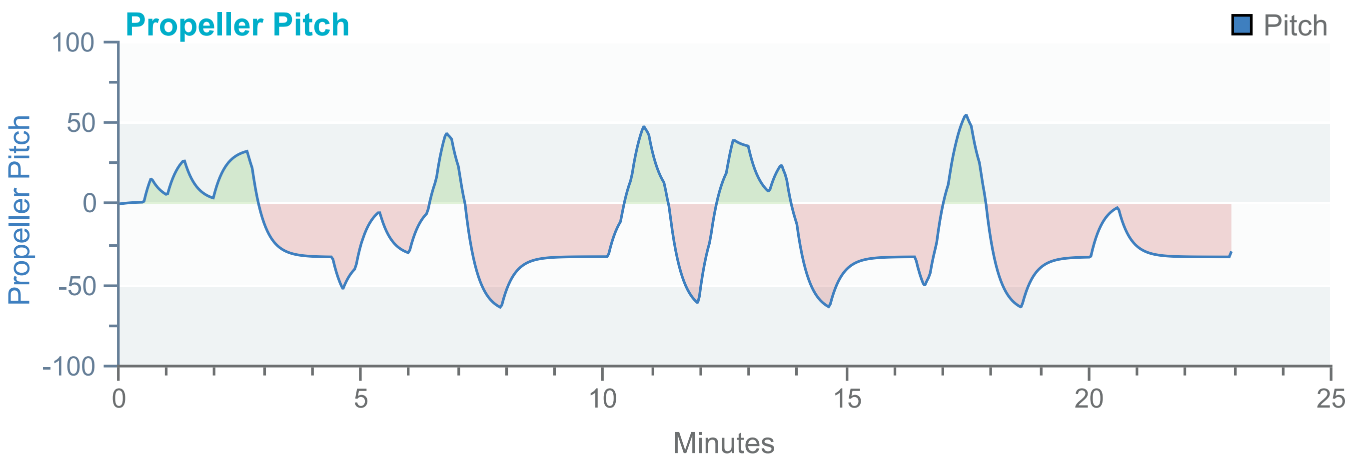
Tracks | Environment | Loya Ballast

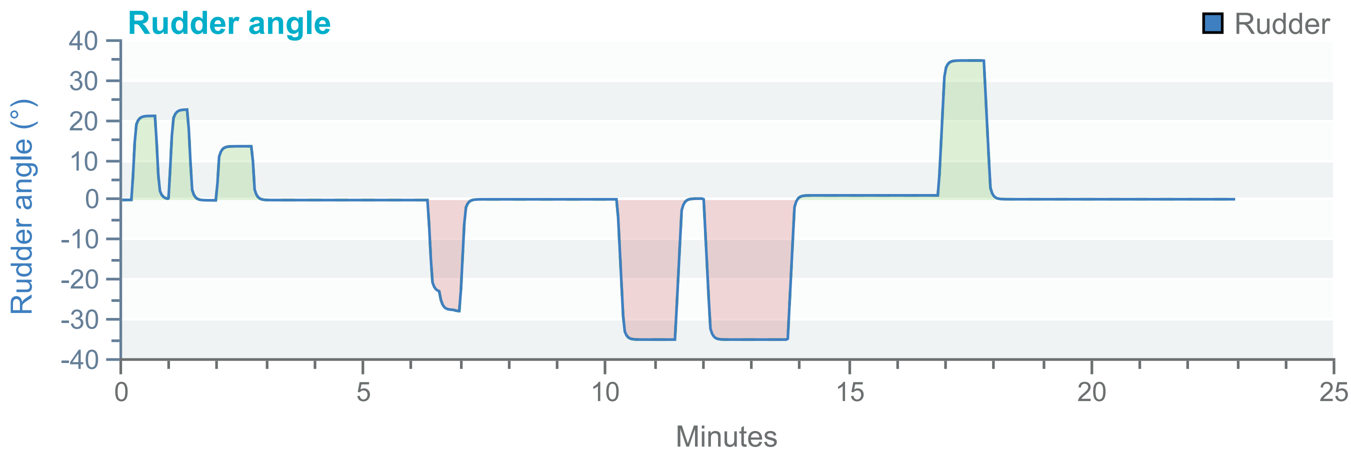


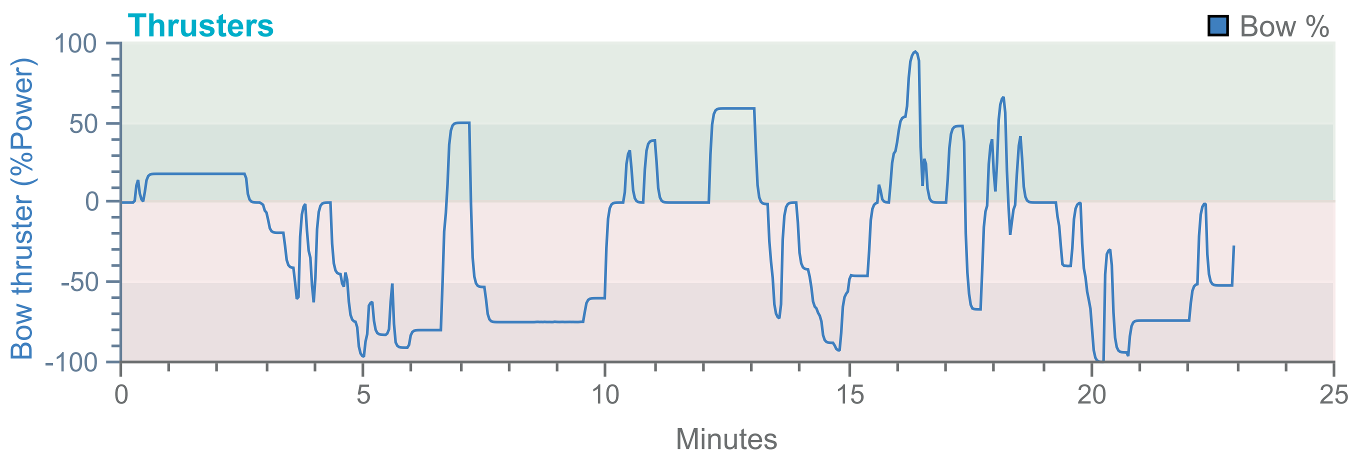


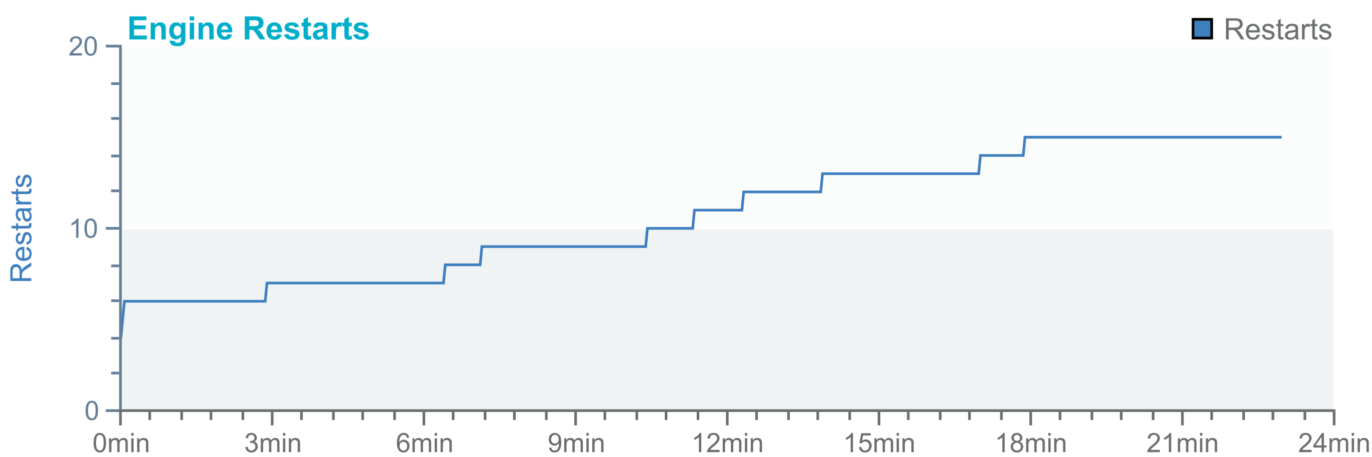




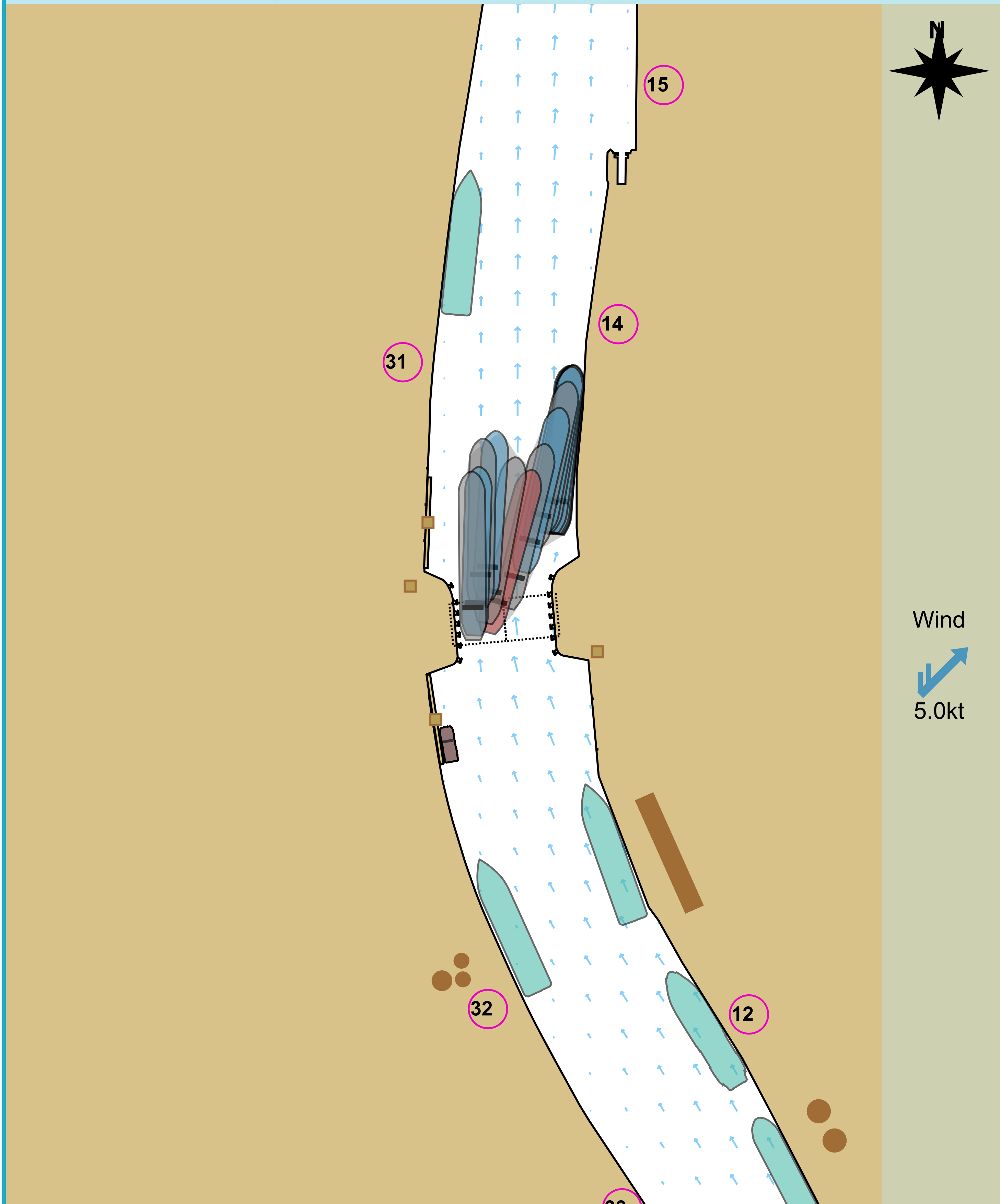

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
20
25
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
20
25
Minutes

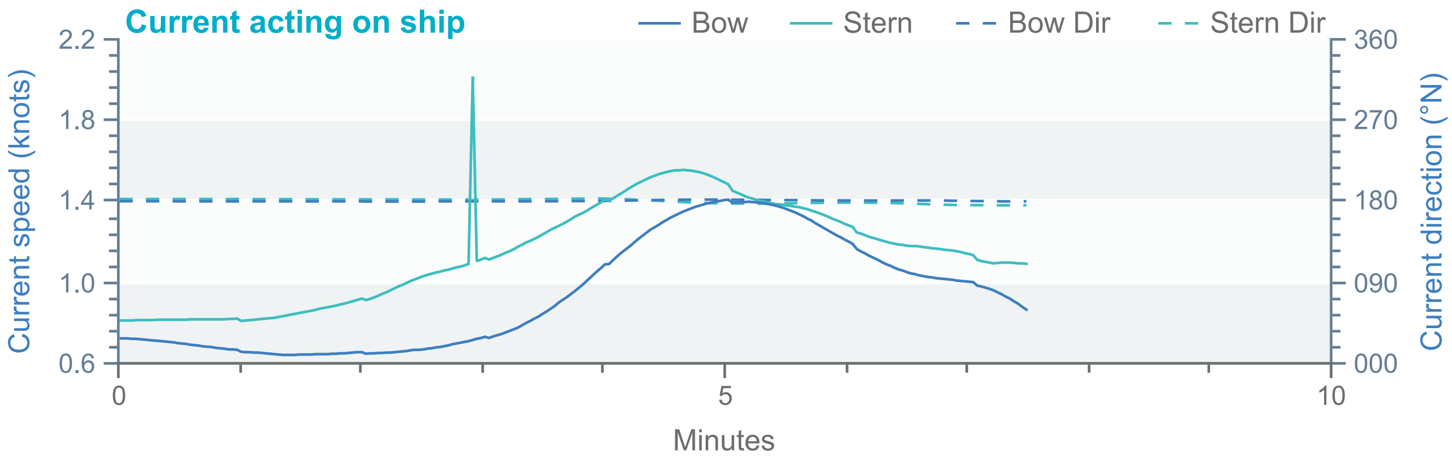

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
25
Minutes

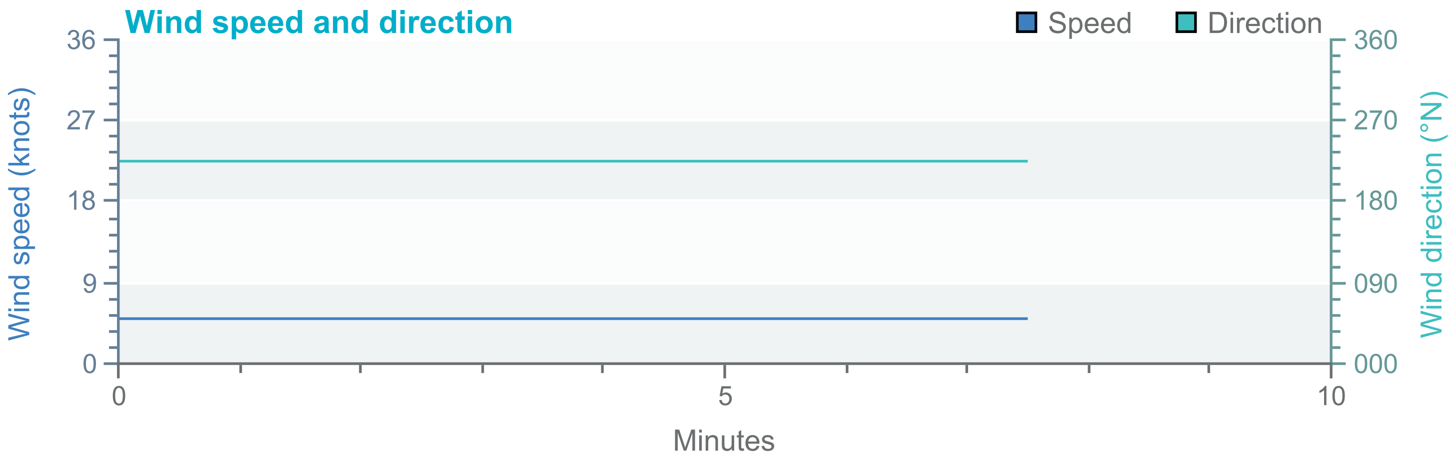

Engine Restarts
Restarts
Restarts
20
10
0
0min
3min
6min
9min
12min
15min
18min
21min
24min

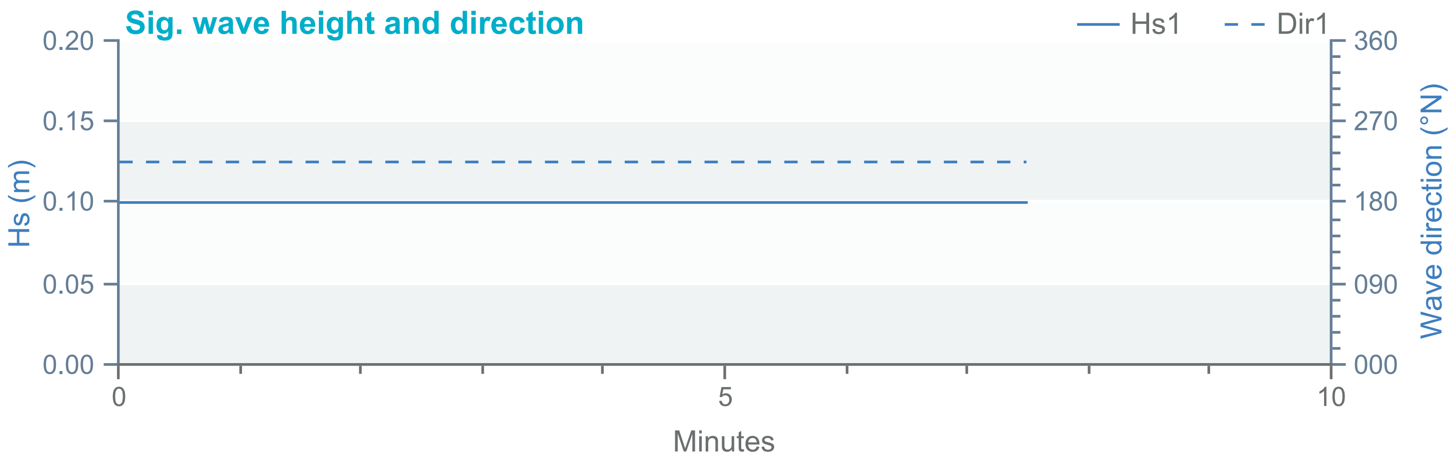
Manoeuvre track plot

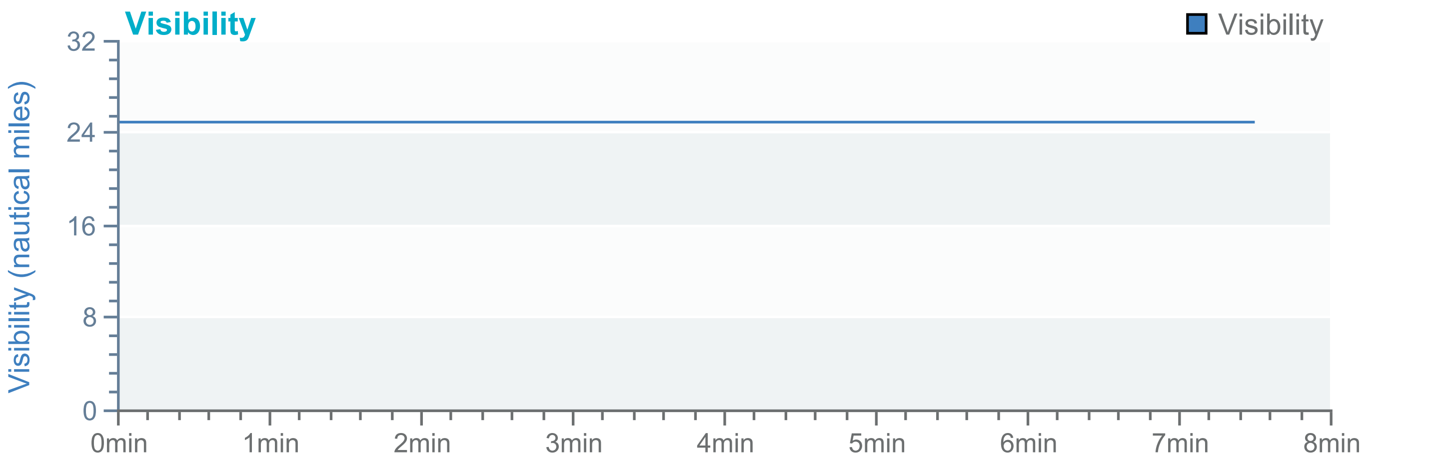


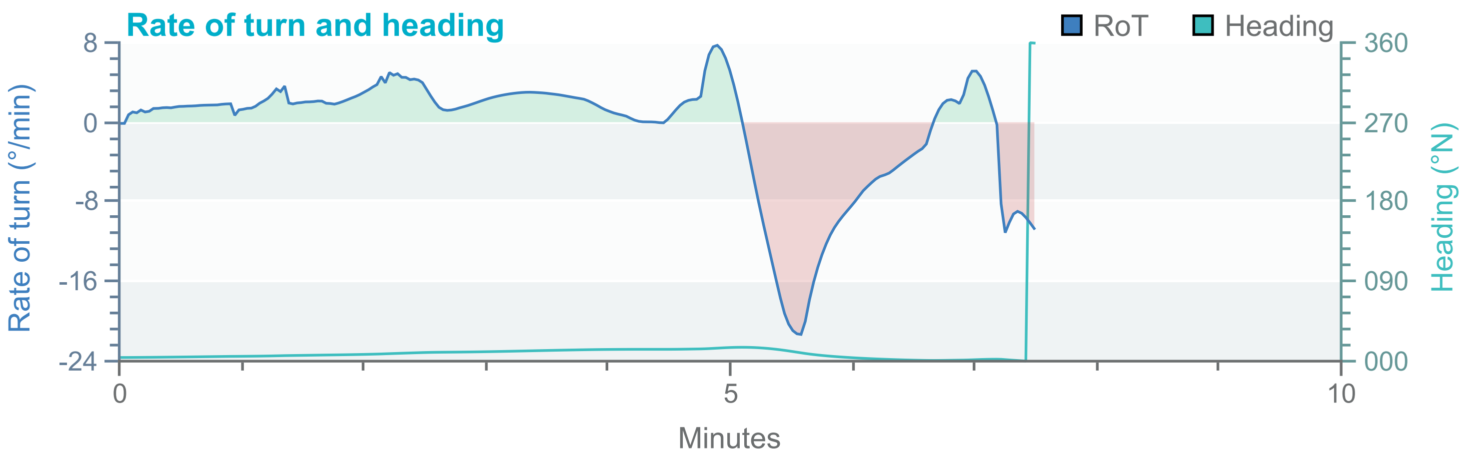
Ships plotted every 0 mins, highlight every 5 mins

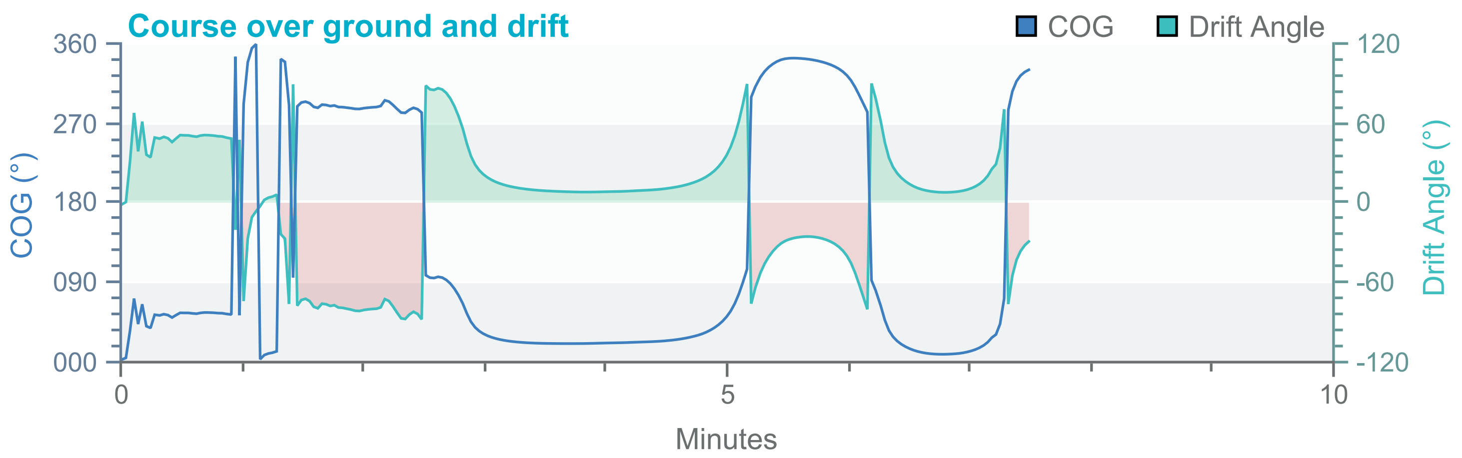

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
2.2
1.8
1.4
1.0
0.6
360
270
180
090
000
0
5
10
Minutes

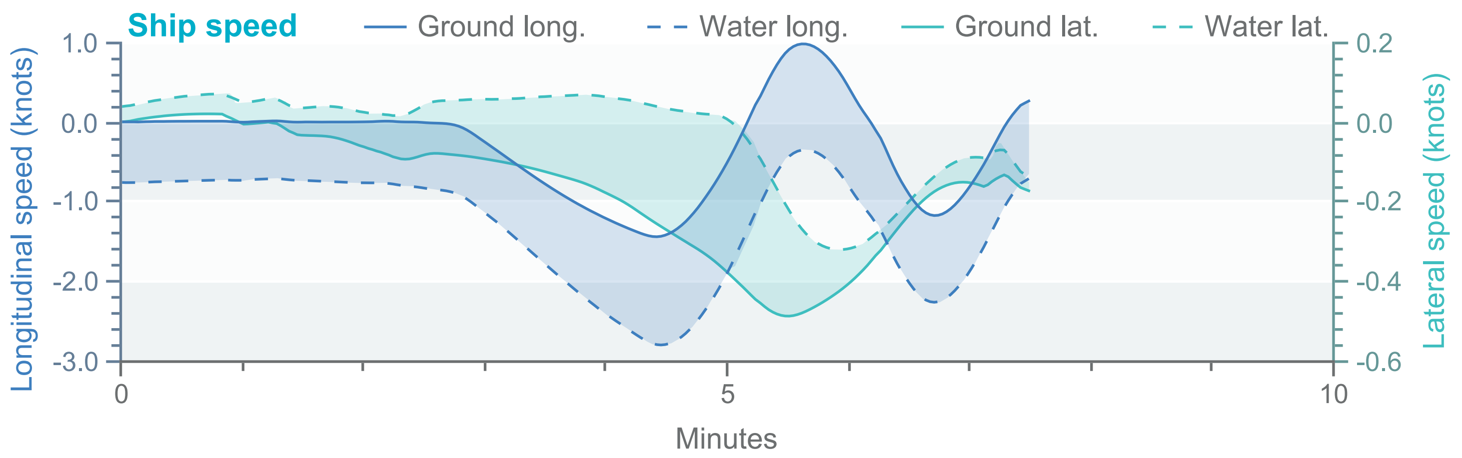

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
Minutes

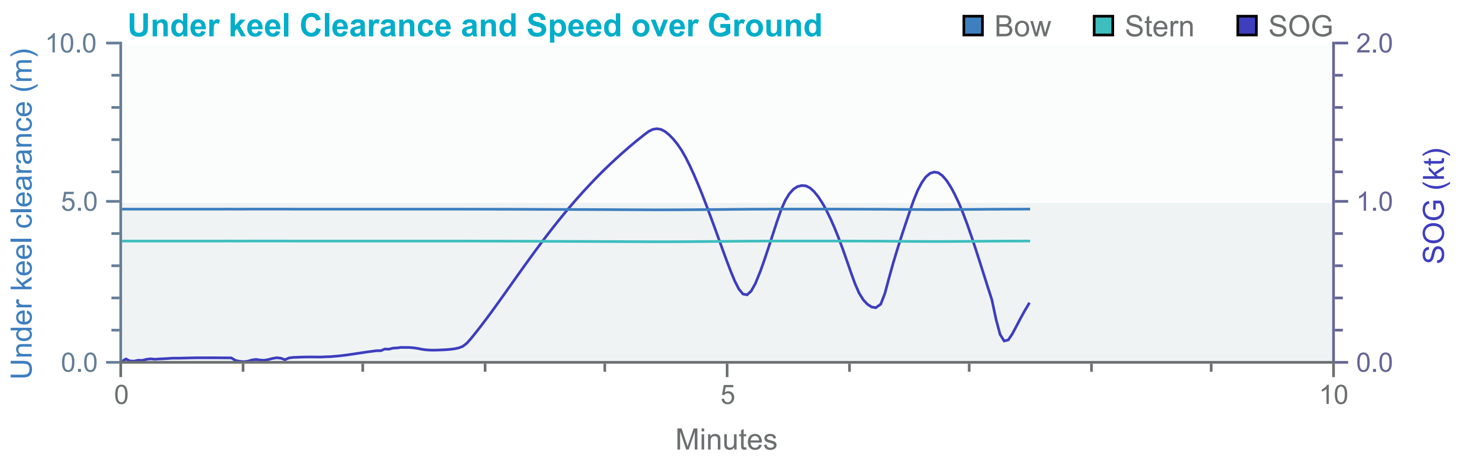

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
Minutes

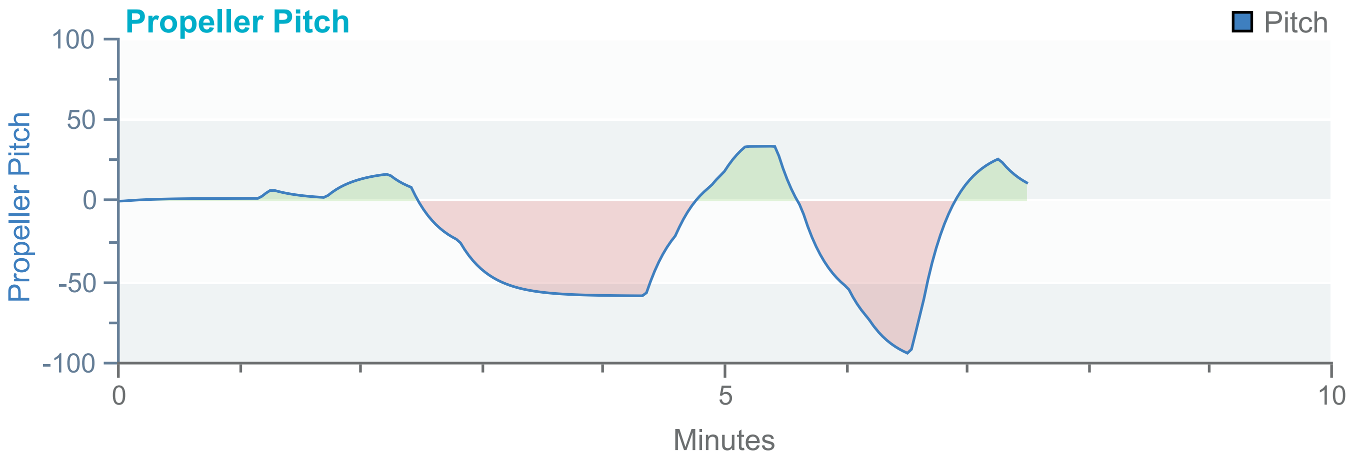

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
1min
2min
3min
4min
5min
6min
7min
8min

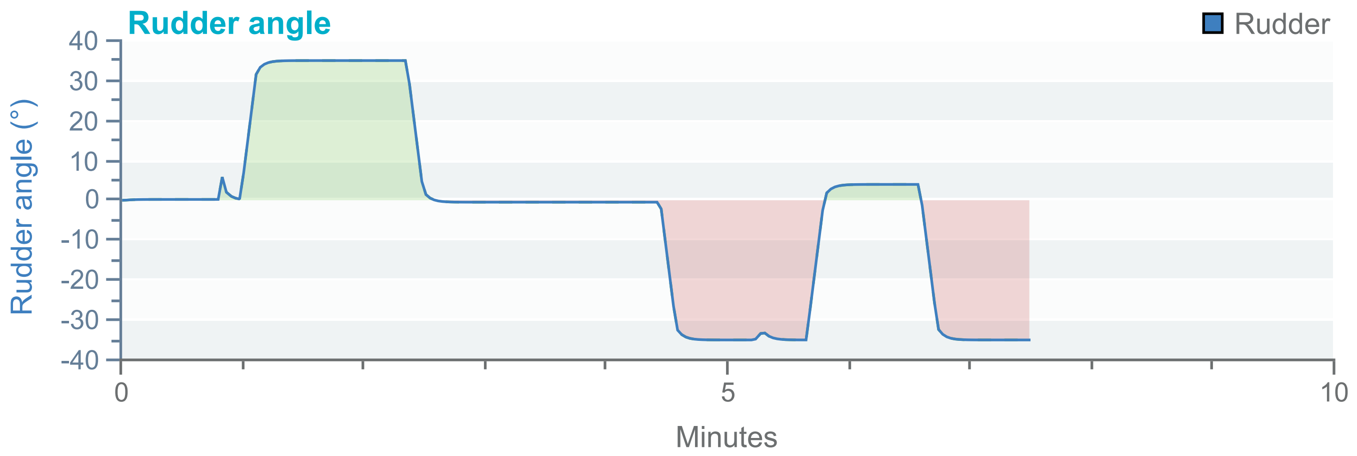

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
8
0
-8
-16
-24
360
270
180
090
000
0
5
10
Minutes

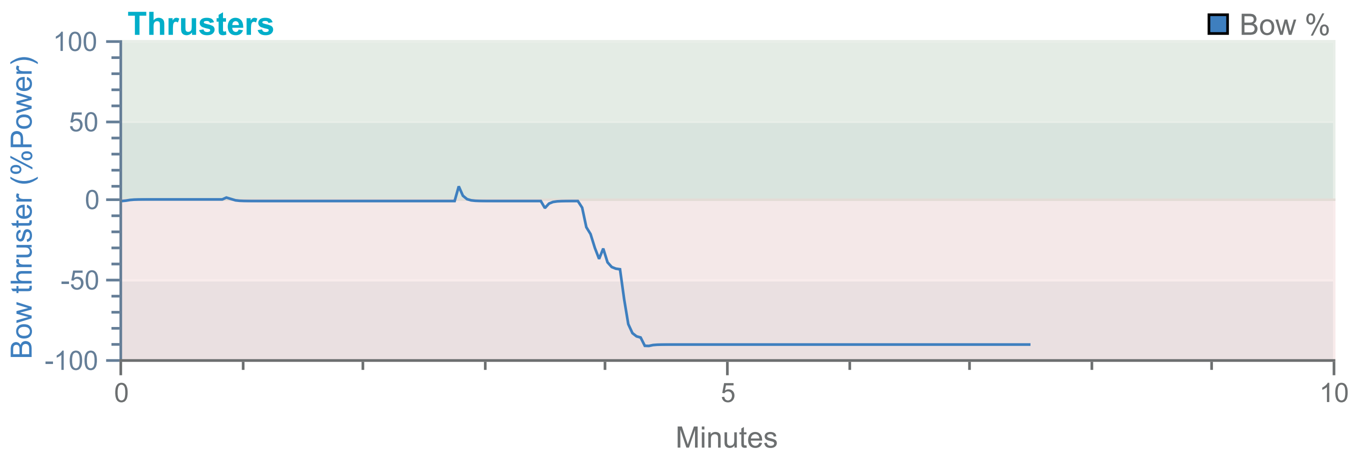

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
Minutes

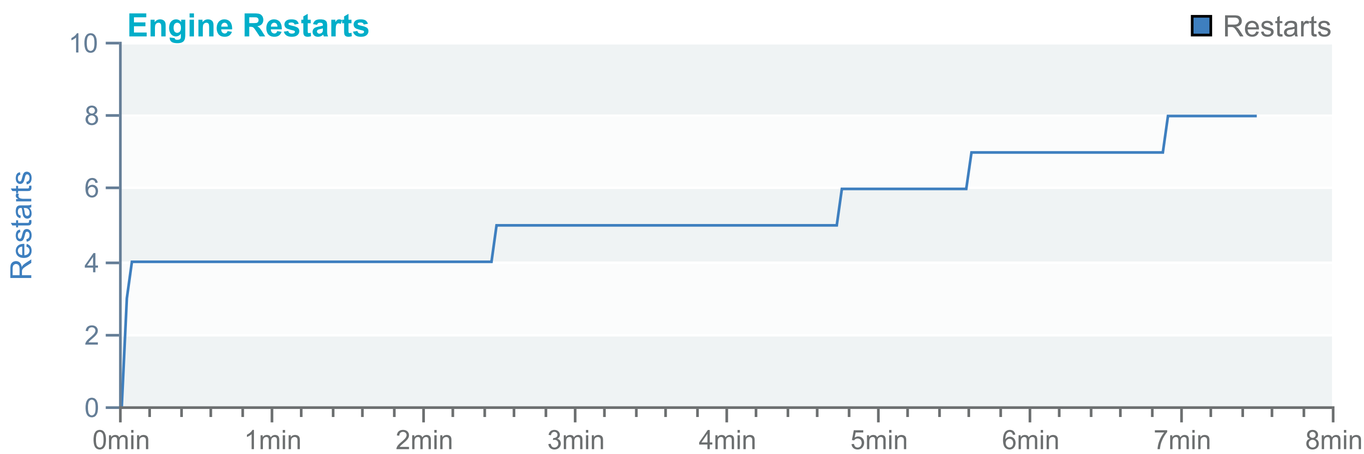

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
1.0
0.0
-1.0
-2.0
-3.0
0.2
0.0
-0.2
-0.4
-0.6
0
5
10
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
2.0
1.0
0.0
0
5
10
Minutes

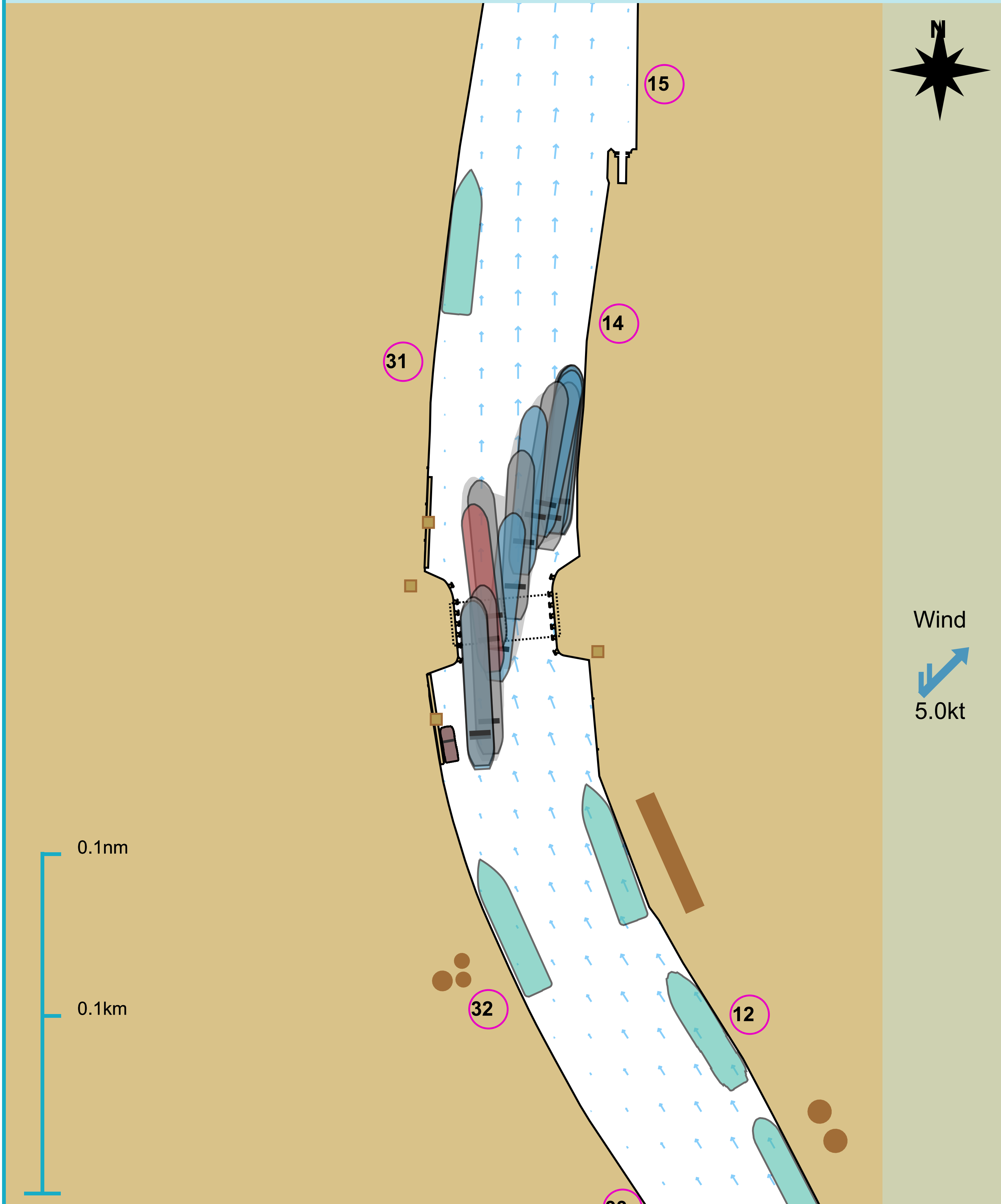

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
Minutes

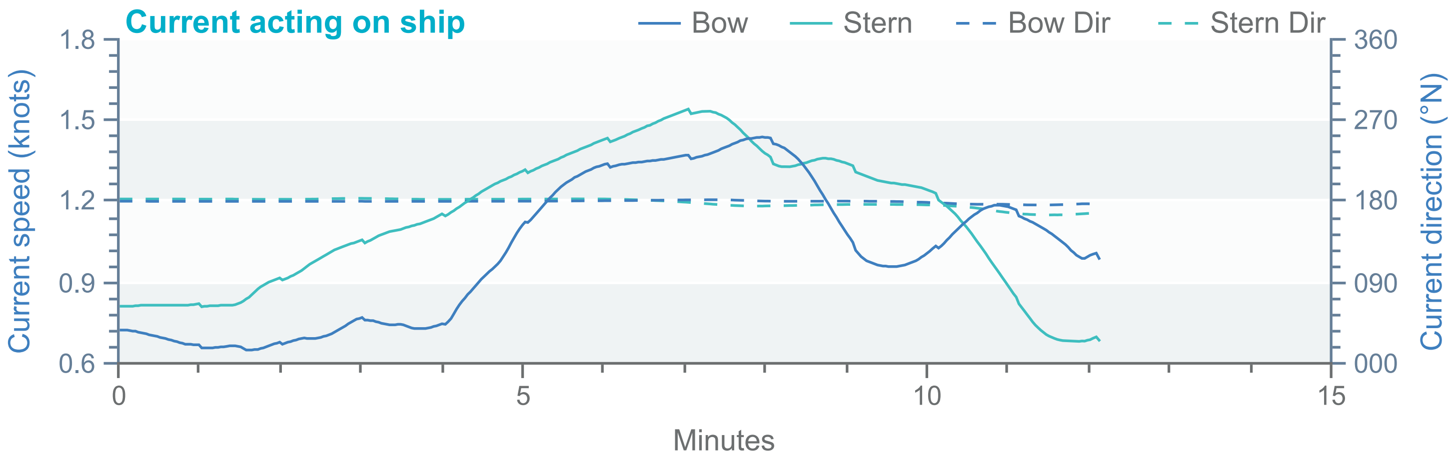

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
Minutes

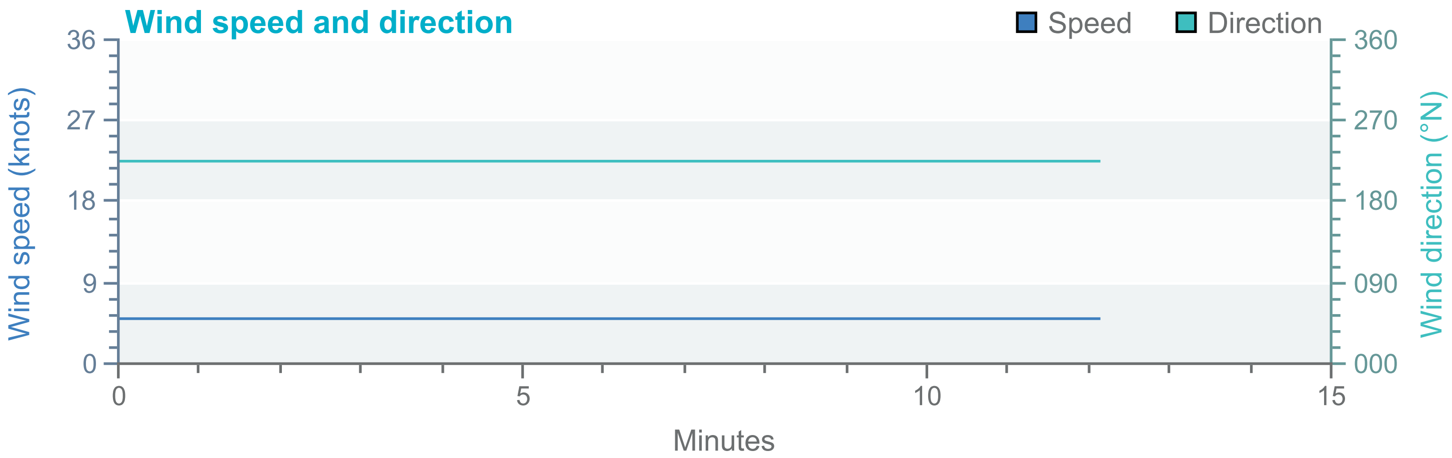

Engine Restarts
Restarts
Restarts
10
8
6
4
2
0
0min
1min
2min
3min
4min
5min
6min
7min
8min

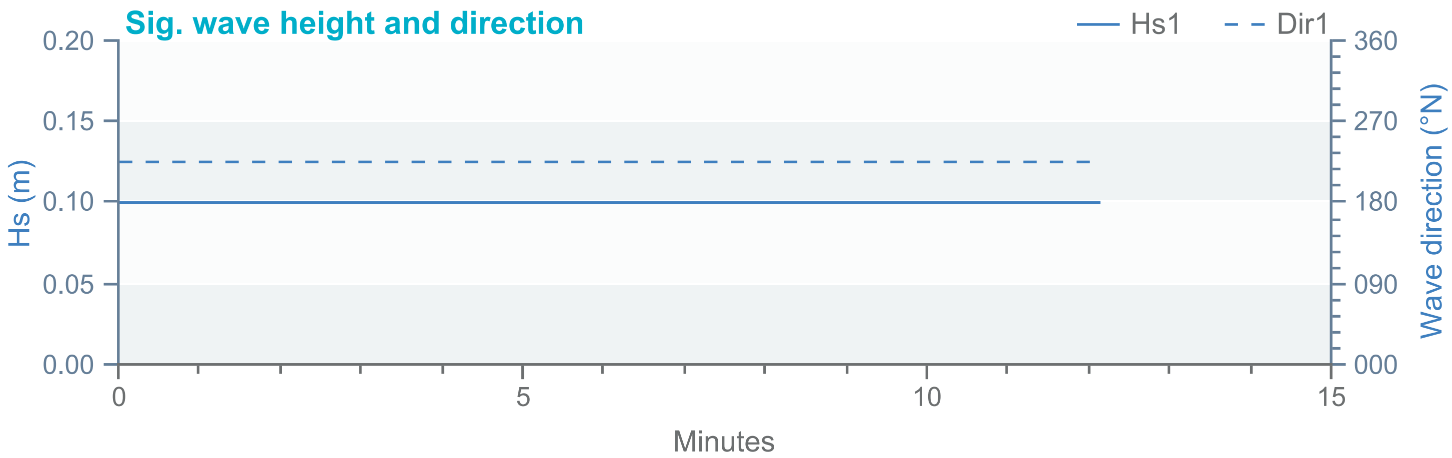
Manoeuvre track plot

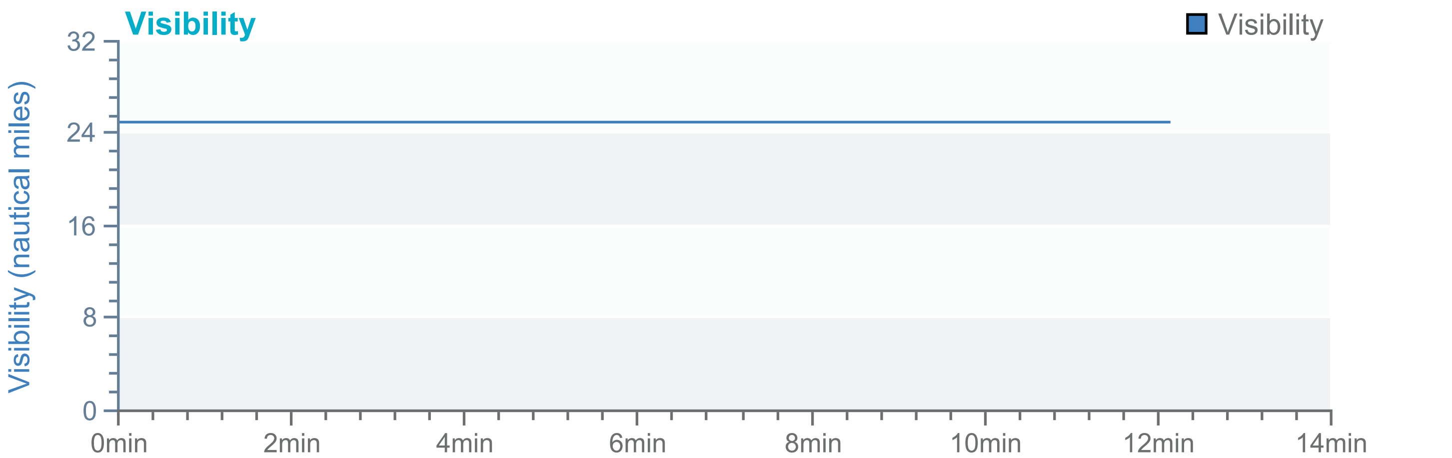


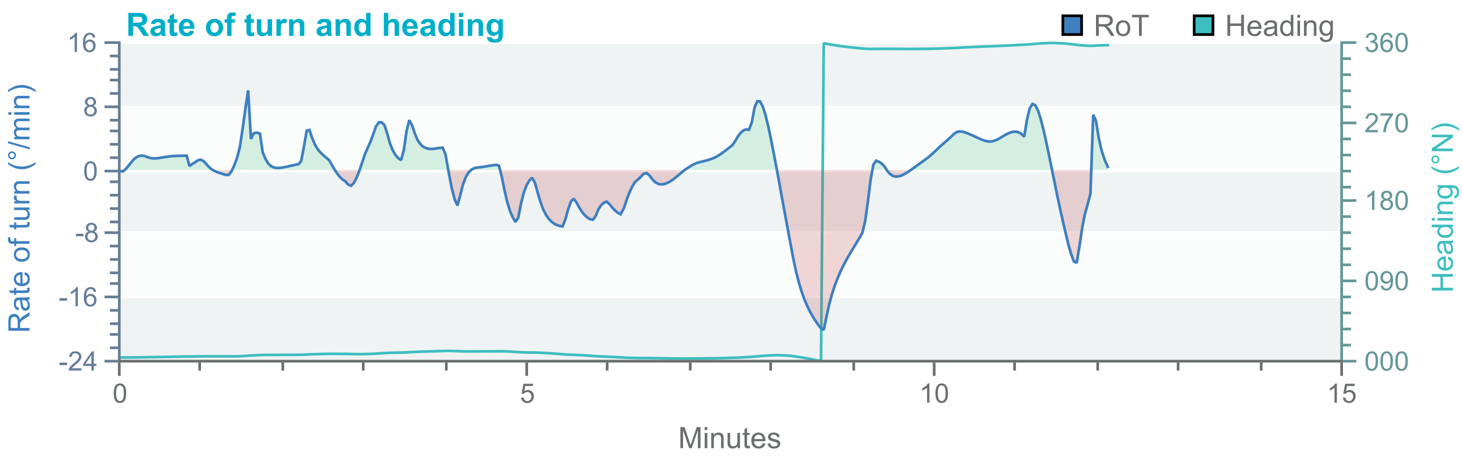
Ships plotted every 1 mins, highlight every 10 mins

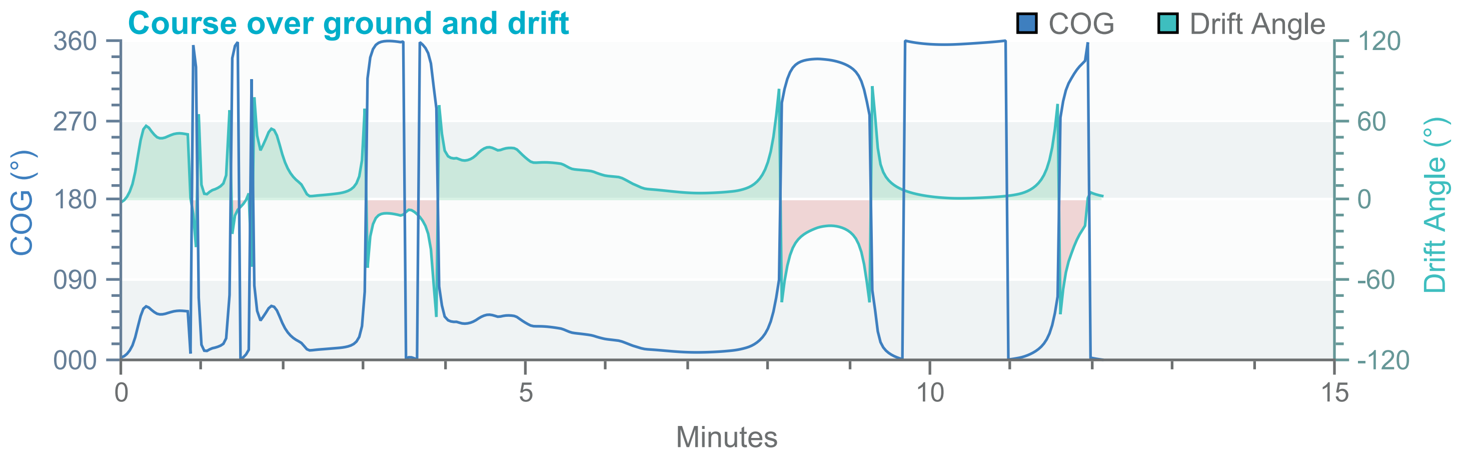

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes

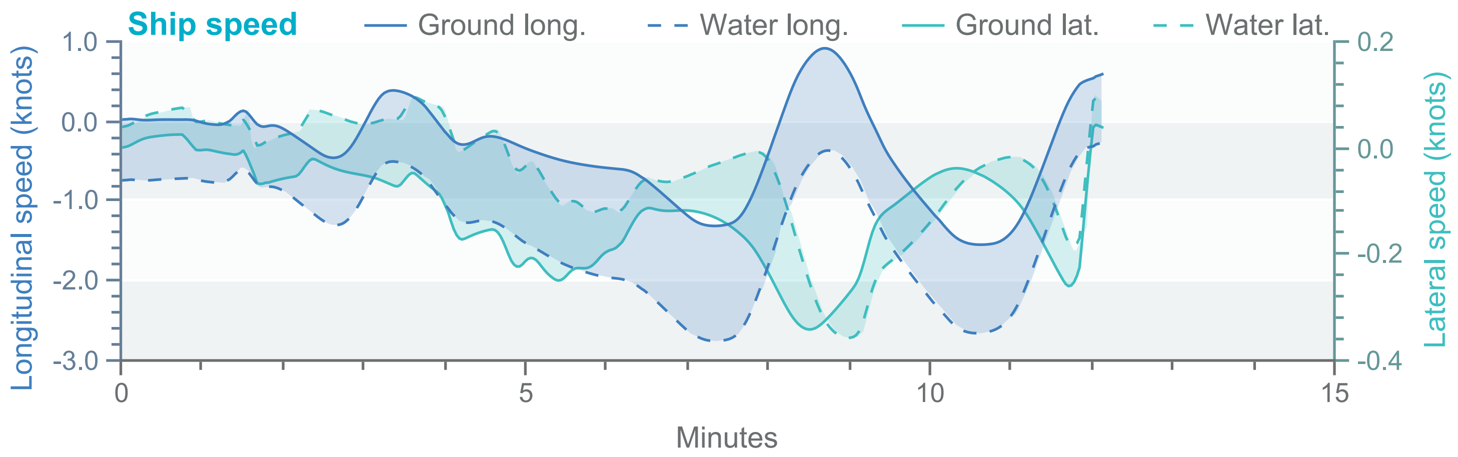

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes

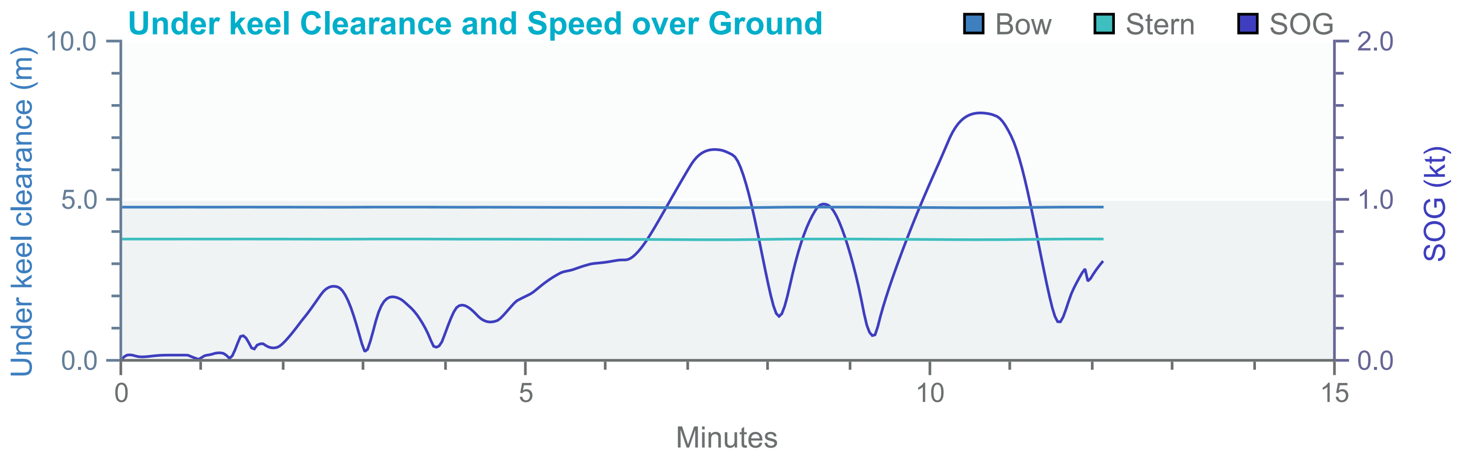

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes

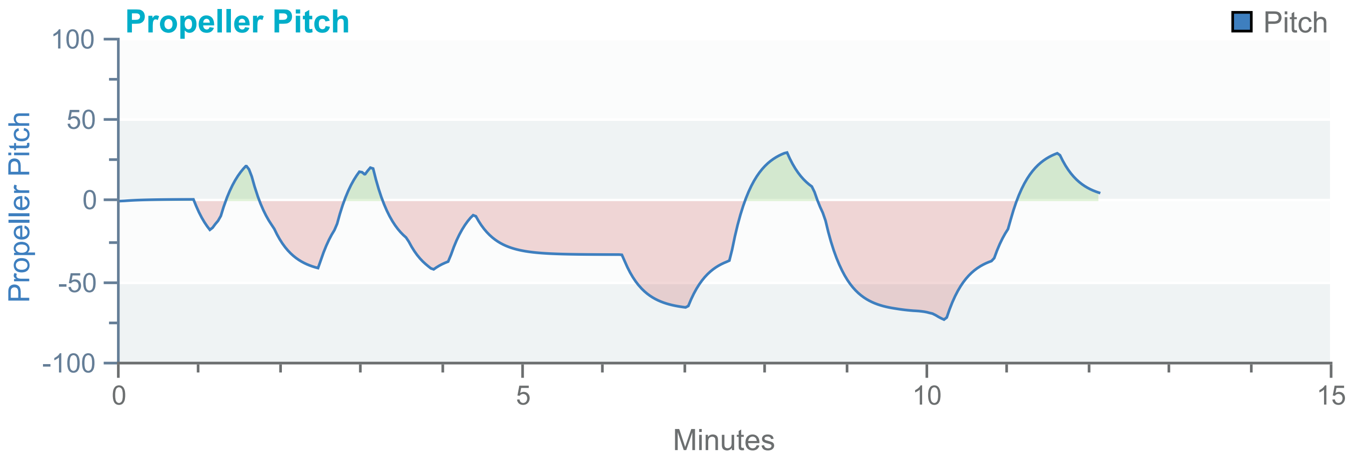

Visibility
Visibility
Visibility (nautical miles)
0min
2min
4min
6min
8min
10min
12min
14min

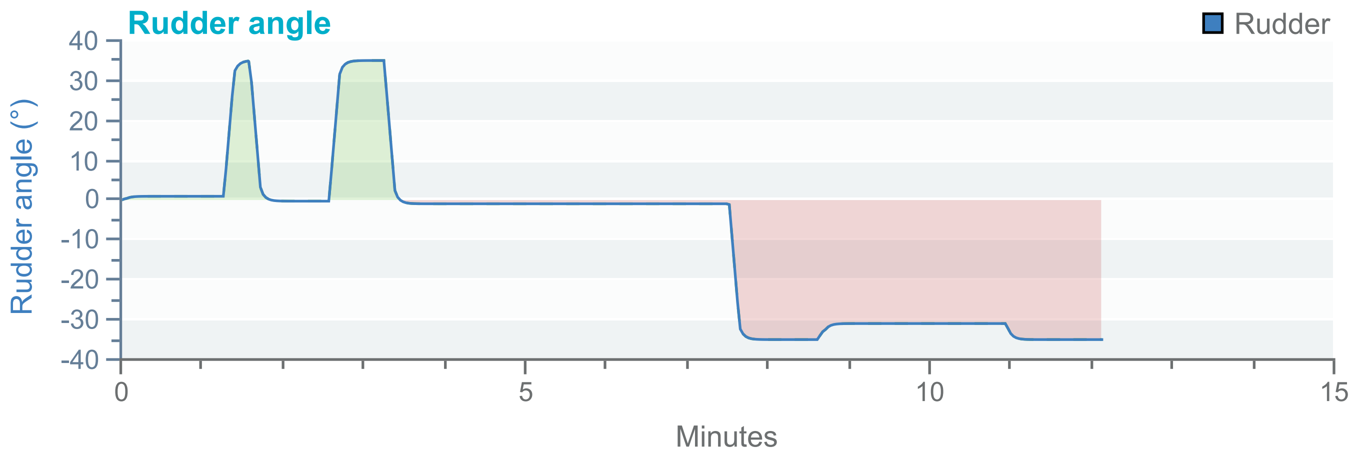

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
16
8
0
-8
-16
-24
360
270
180
090
000
0
5
10
15
Minutes

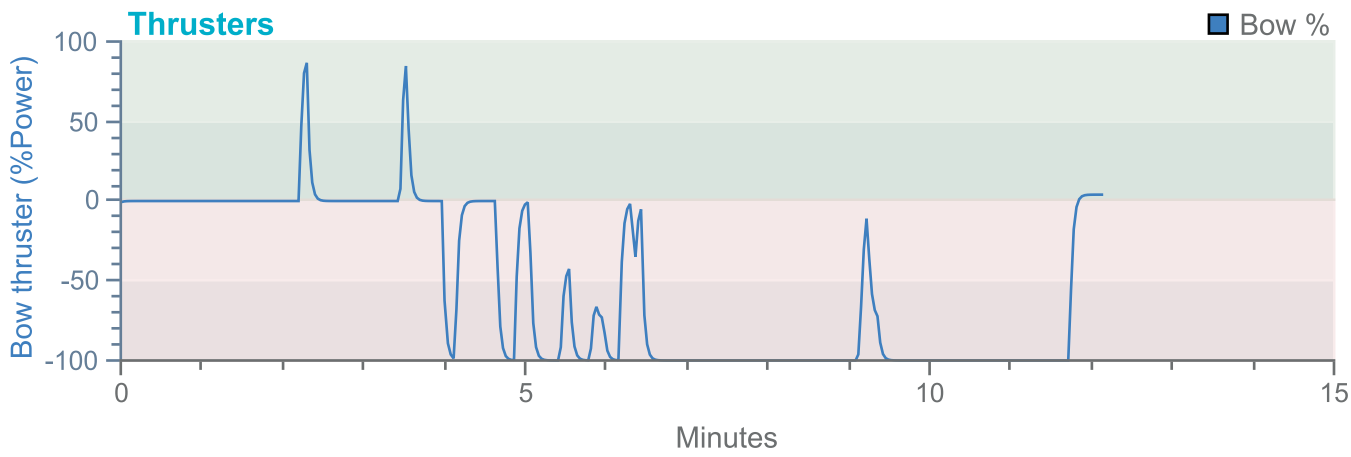

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
Minutes

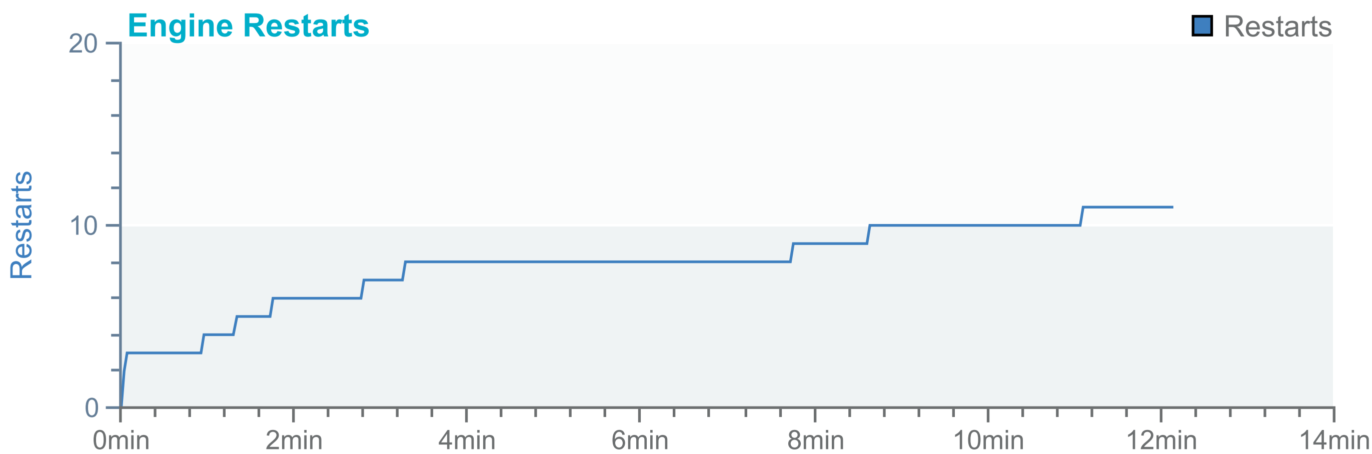

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
1.0
0.0
-1.0
-2.0
-3.0
0.2
0.0
-0.2
-0.4
0
5
10
15
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
2.0
1.0
0.0
0
5
10
15
Minutes


Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
Minutes


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

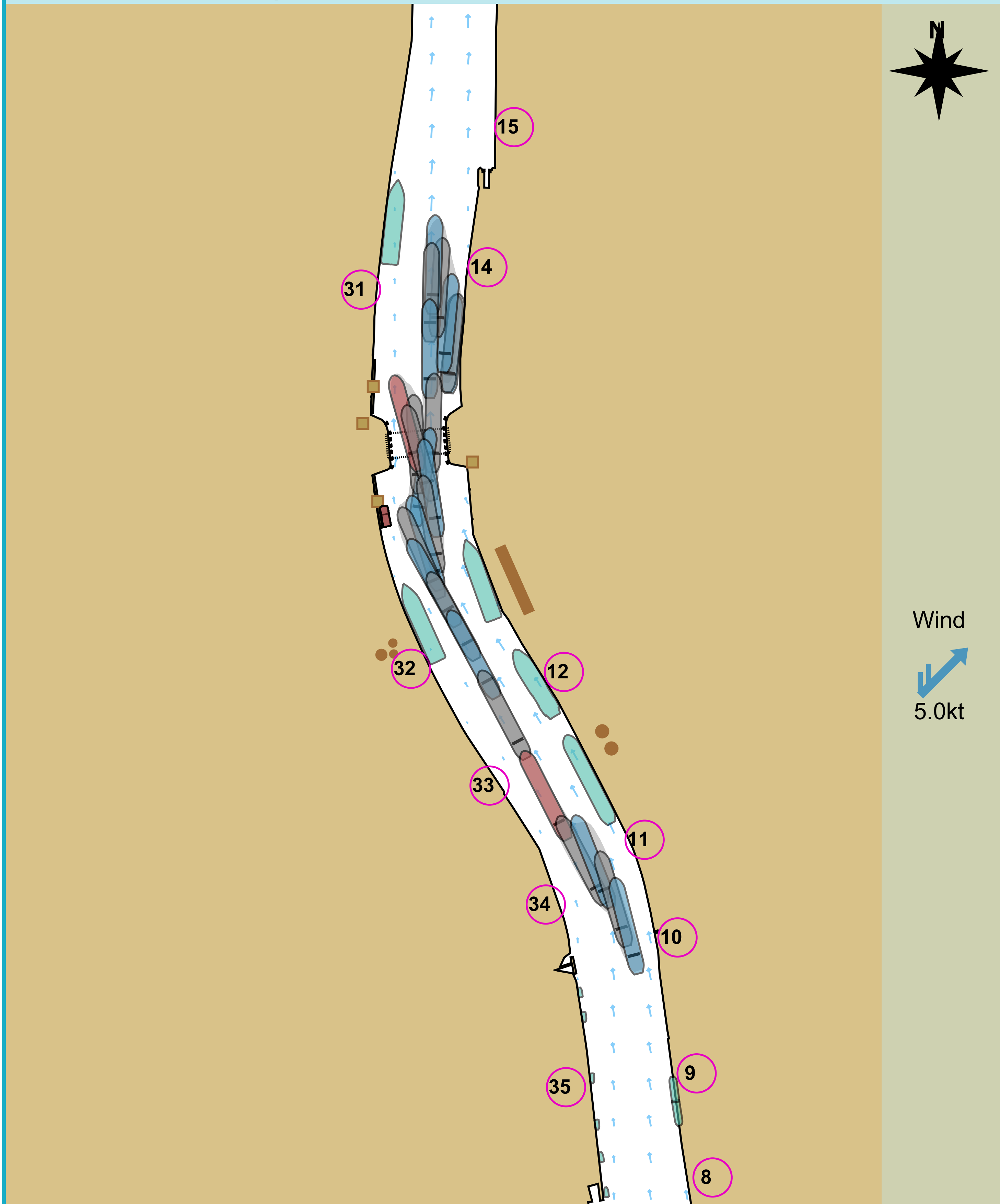

Engine Restarts
Restarts
Restarts
20
10
0
0min
2min
4min
6min
8min
10min
12min
14min

HR Wallingford
Working with water

Project: Great Yarmouth
Session: 3rd Crossing 2019
Configuration: September 2019
Run: 18

Tracks	Environment	Loya Ballast

Manoeuvre track plot



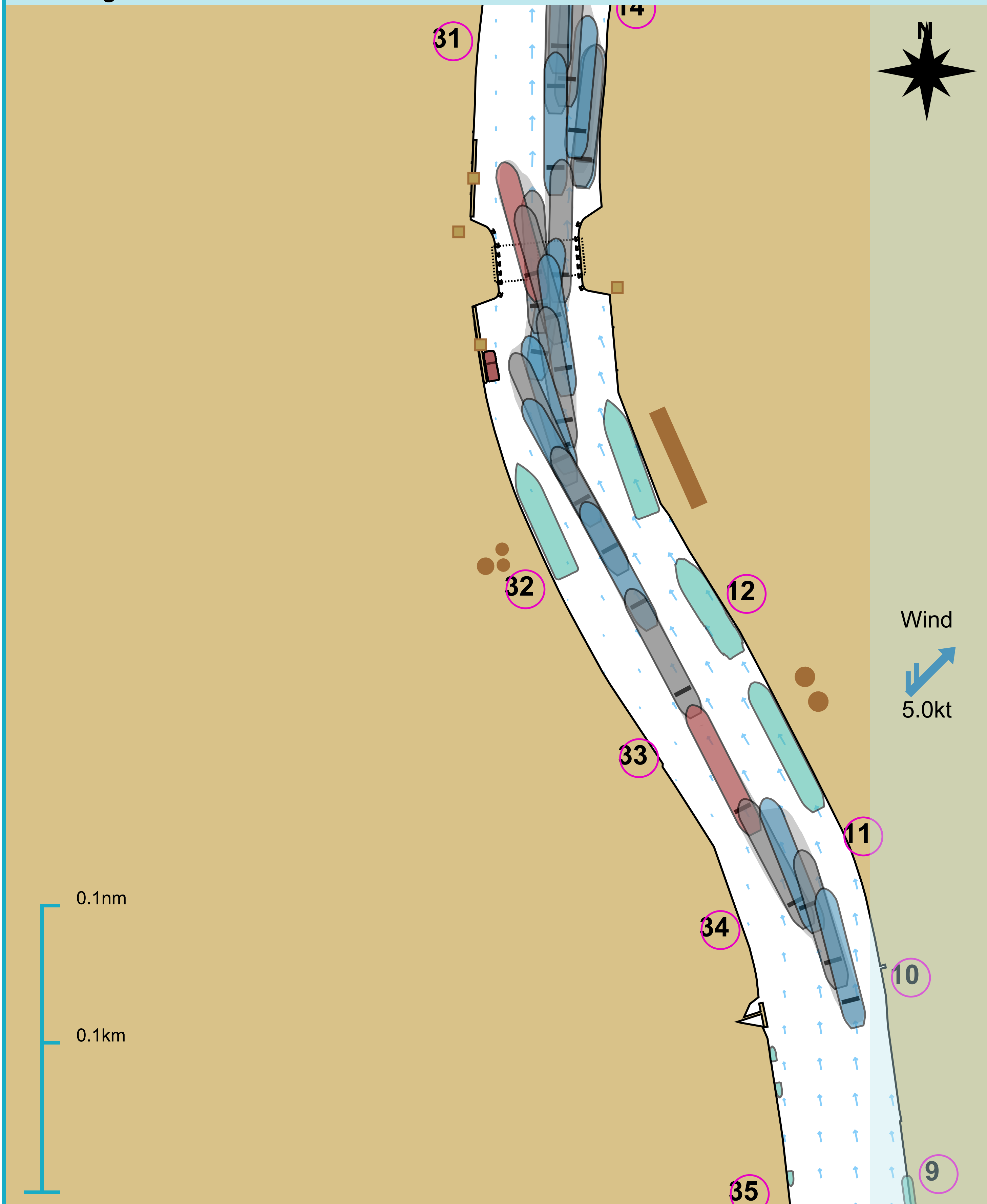
Ships plotted every 1 mins, highlight every 10 mins

Pilot: DM
Manoeuvre: Departure

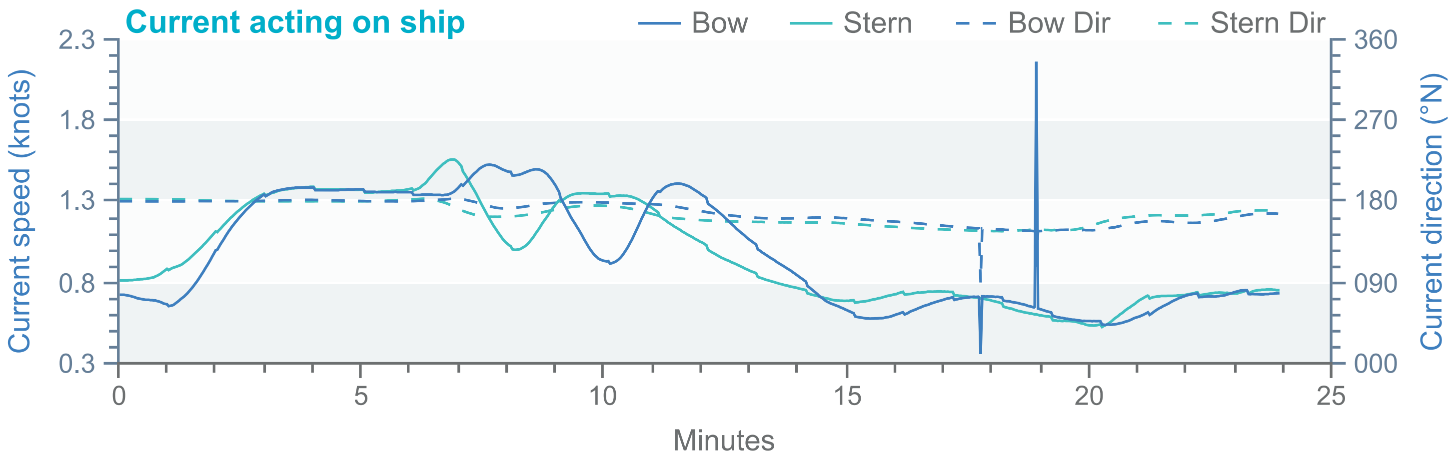
Project: Great Yarmouth
Session: 3rd Crossing 2019
Configuration: September 2019
Run: 18

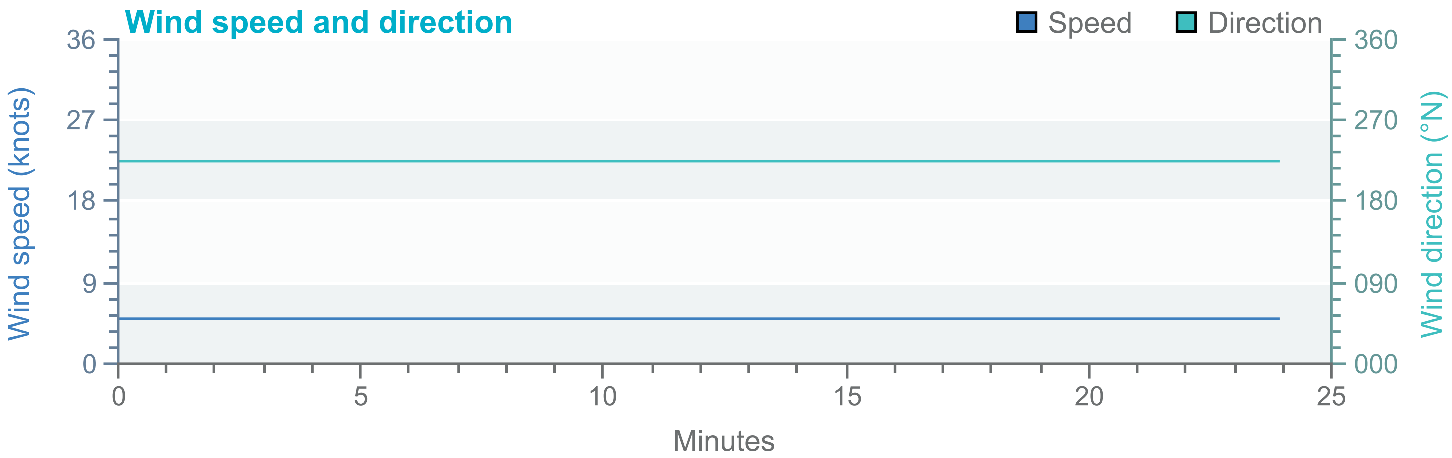
Tracks	Environment	Loya Ballast

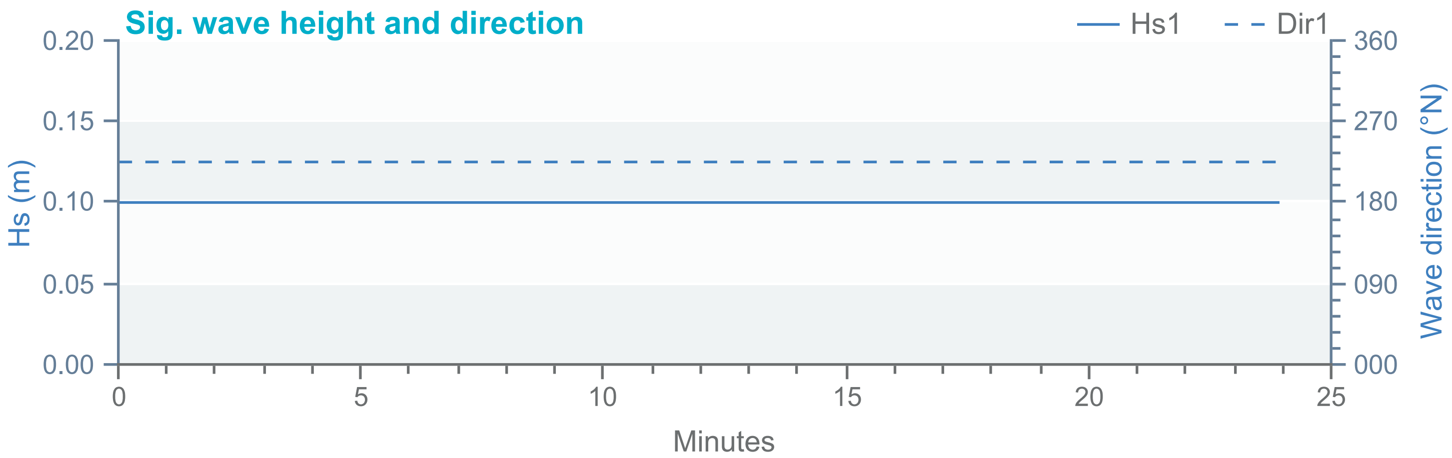
Berthing

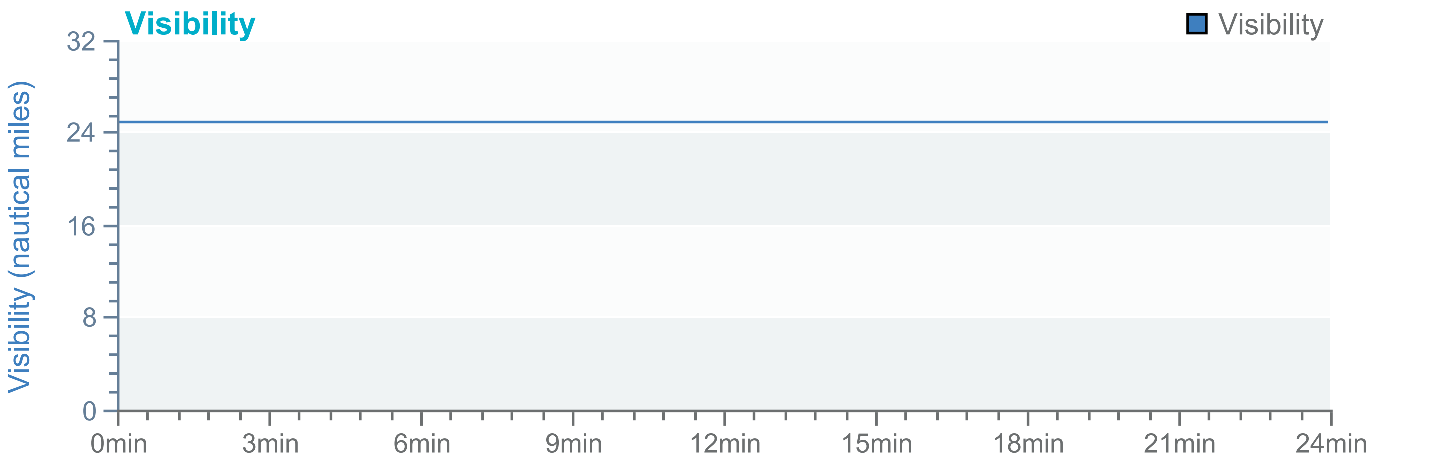


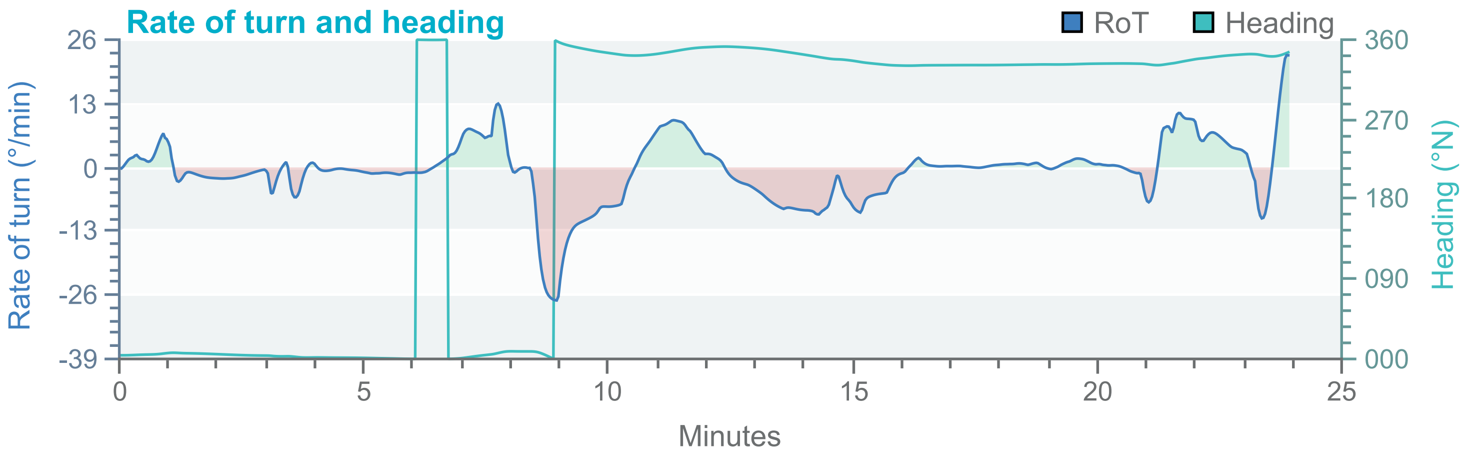
Ships plotted every 1 mins, highlight every 10 mins

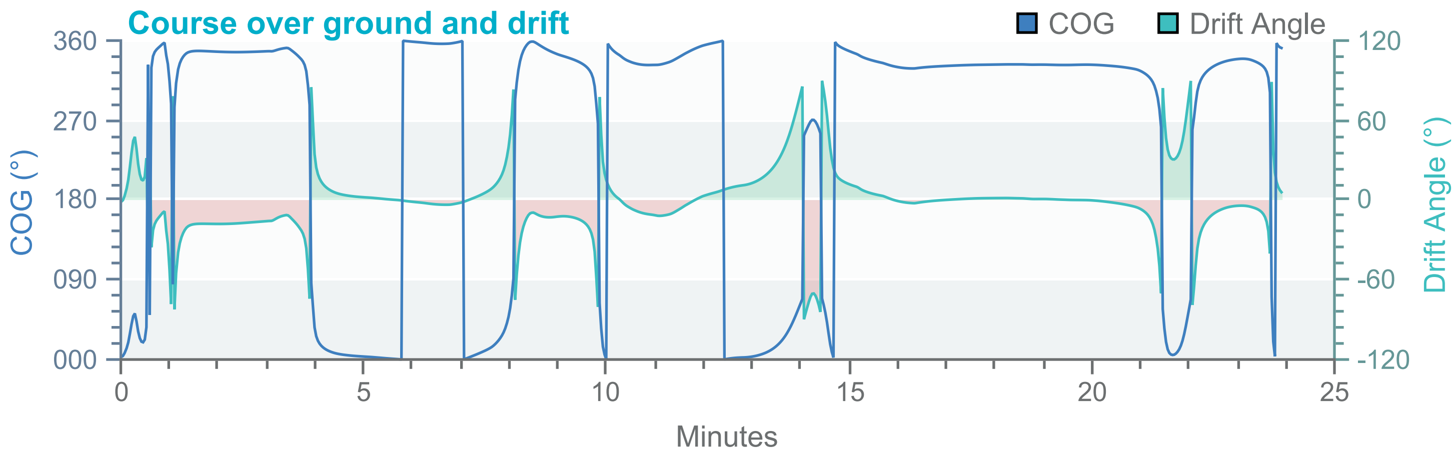

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
2.3
1.8
1.3
0.8
0.3
360
270
180
090
000
0
5
10
15
20
25
Minutes

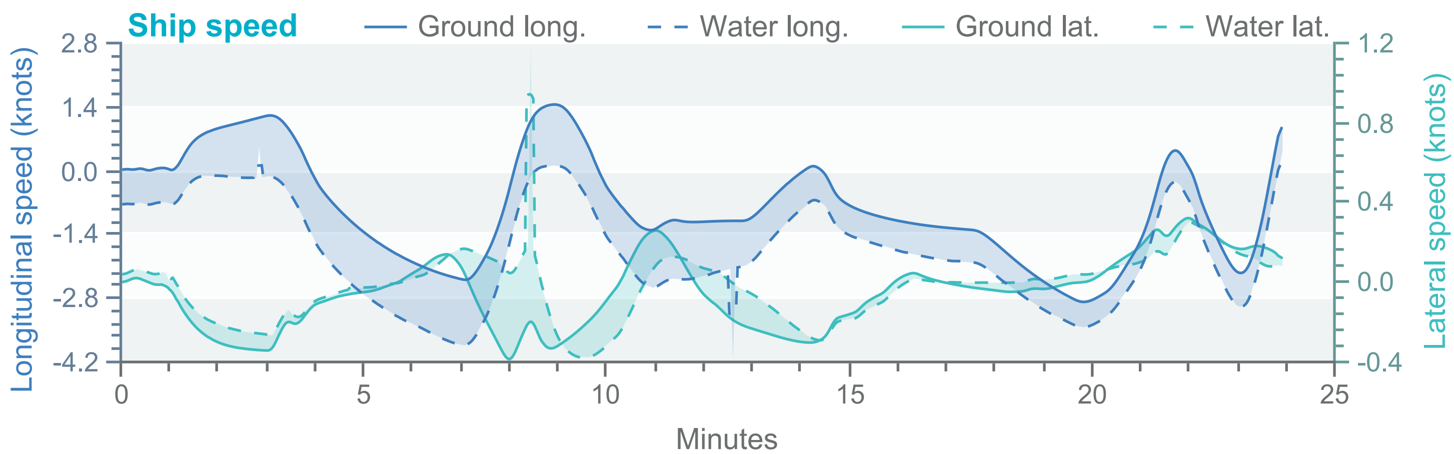

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
25
Minutes

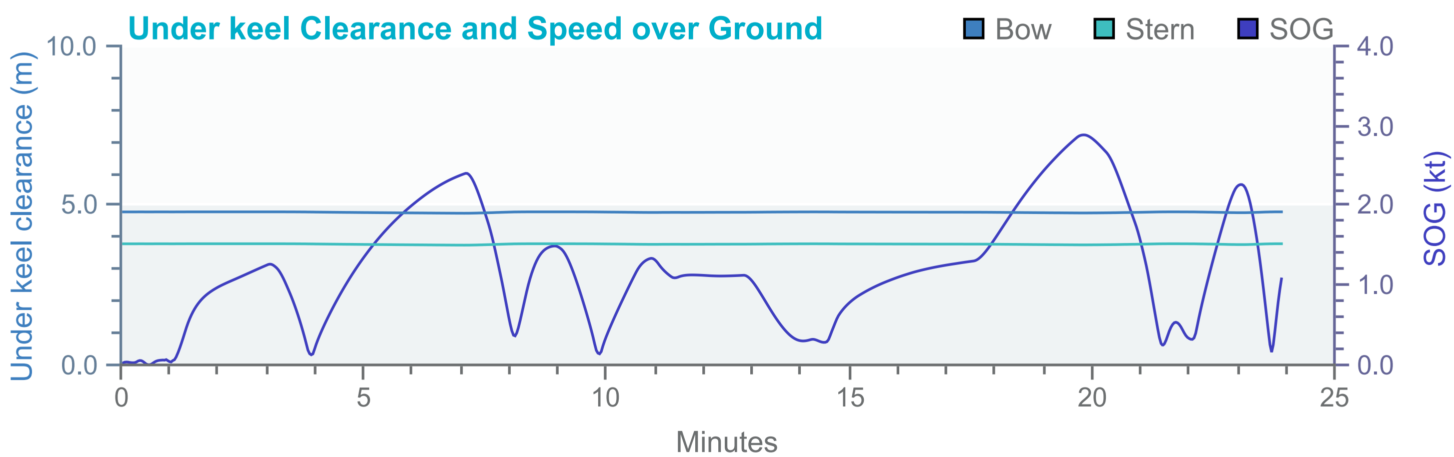

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
25
Minutes

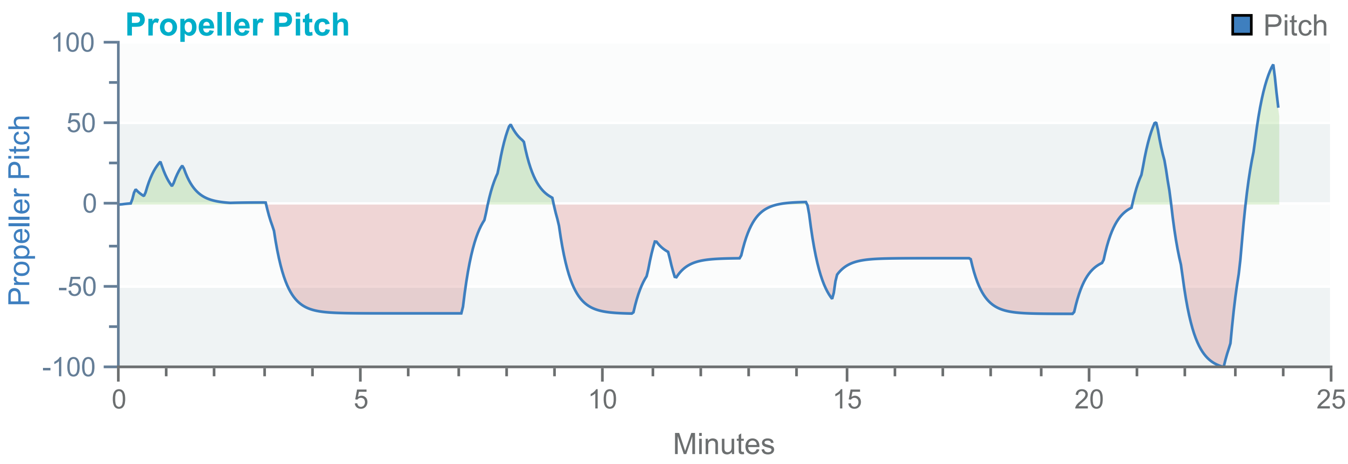

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
3min
6min
9min
12min
15min
18min
21min
24min

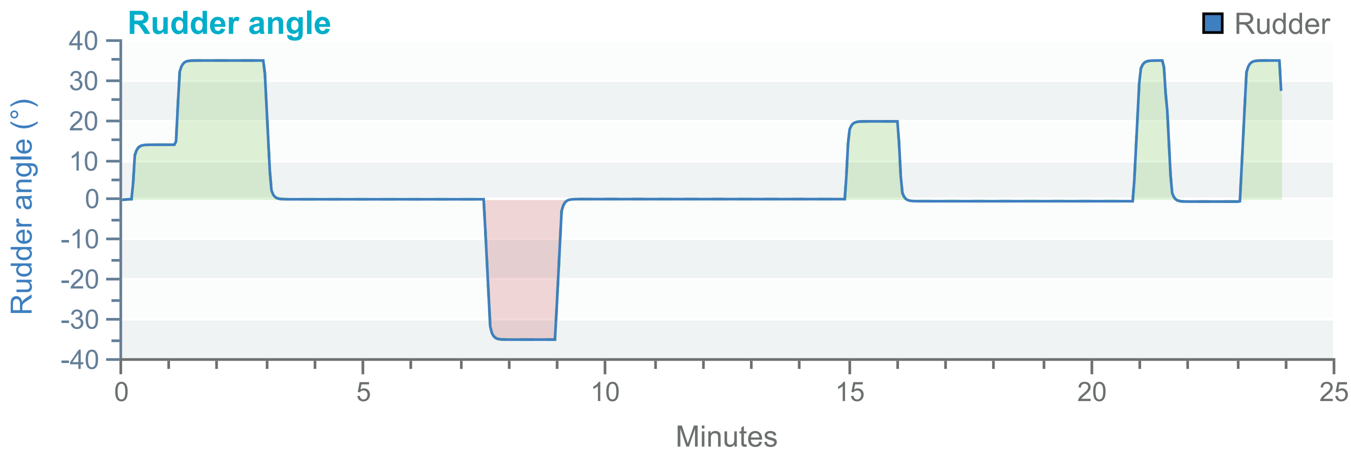

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
26
13
0
-13
-26
-39
360
270
180
090
000
0
5
10
15
20
25
Minutes

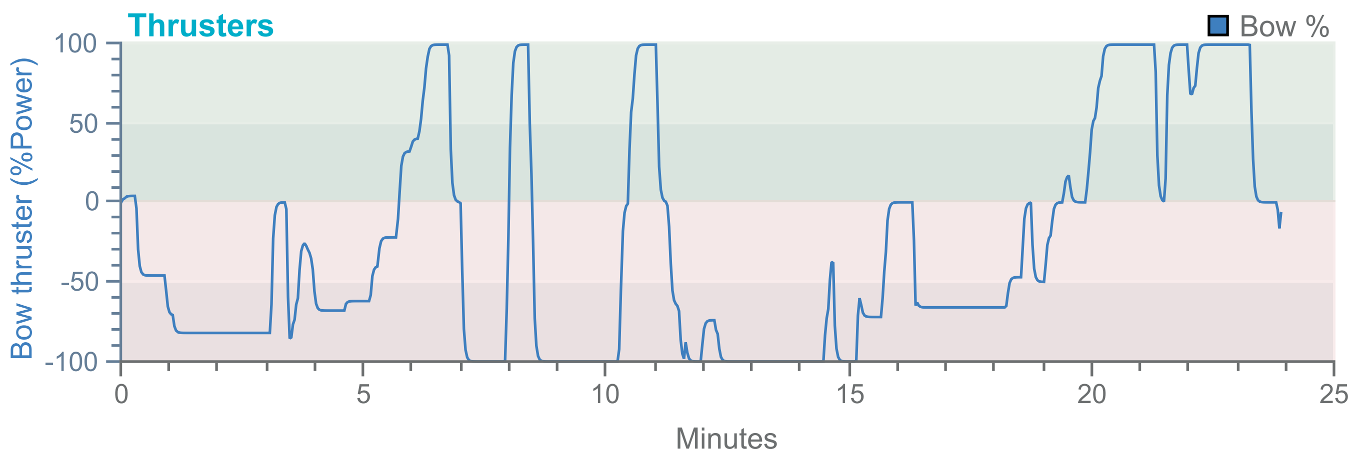

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
25
Minutes

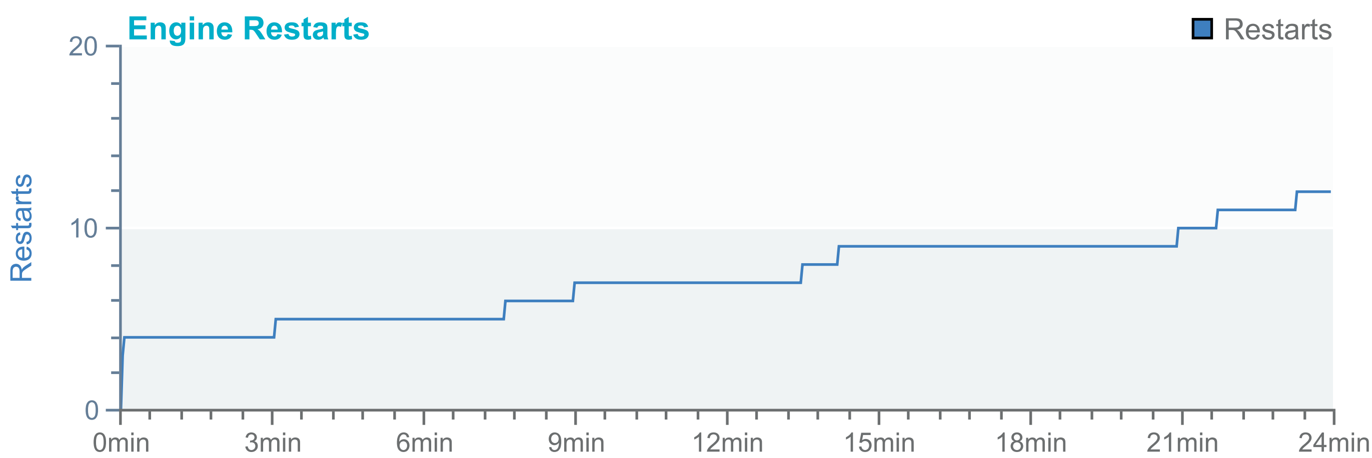

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
2.8
1.4
0.0
-1.4
-2.8
-4.2
1.2
0.8
0.4
0.0
-0.4
0
5
10
15
20
25
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
Minutes

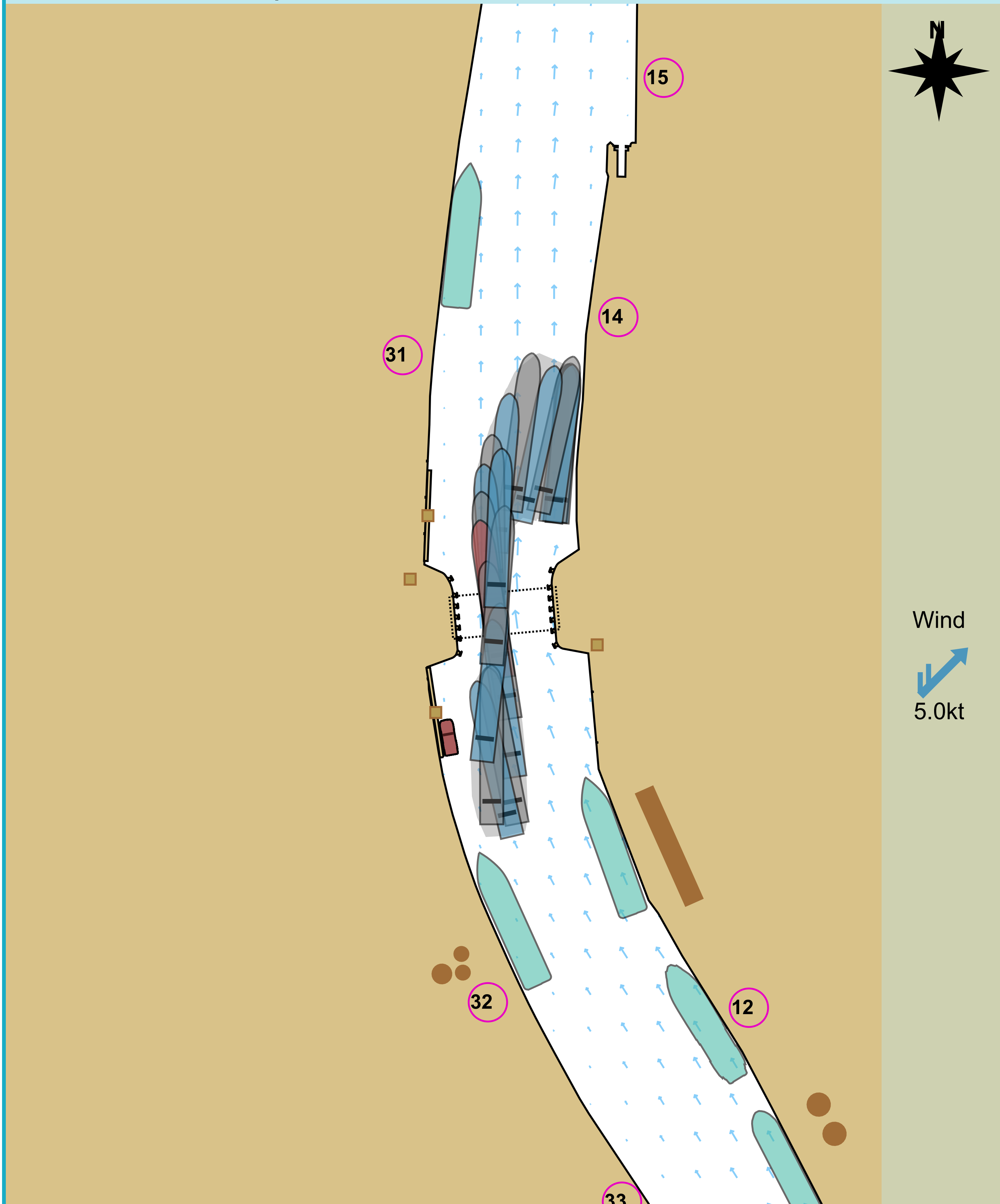

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
20
25
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
20
25
Minutes

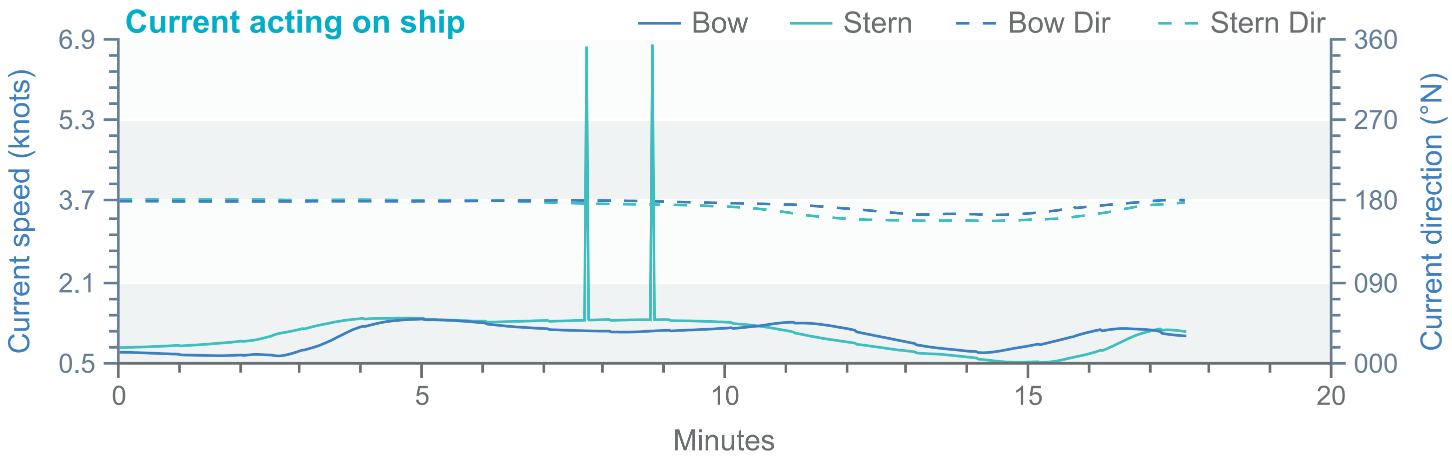

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
25
Minutes

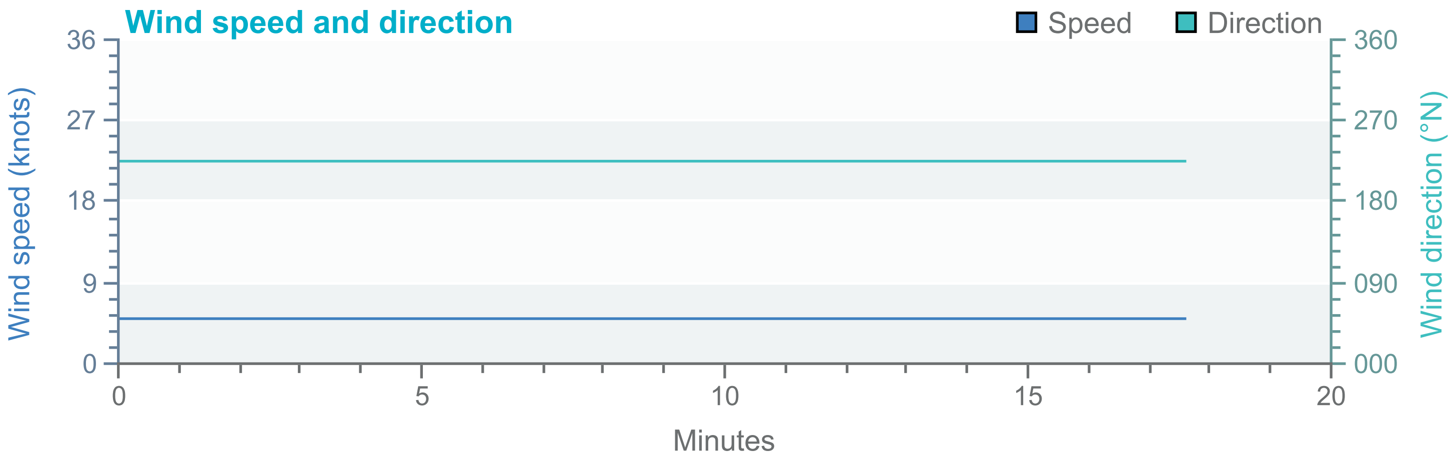

Engine Restarts
Restarts
Restarts
20
10
0
0min
3min
6min
9min
12min
15min
18min
21min
24min

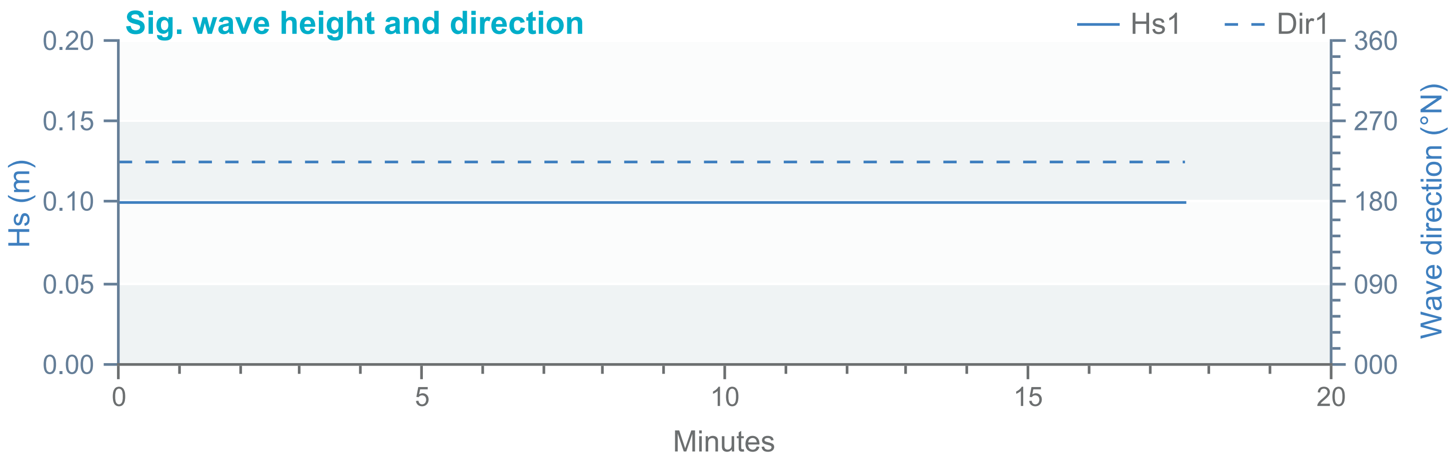
Manoeuvre track plot

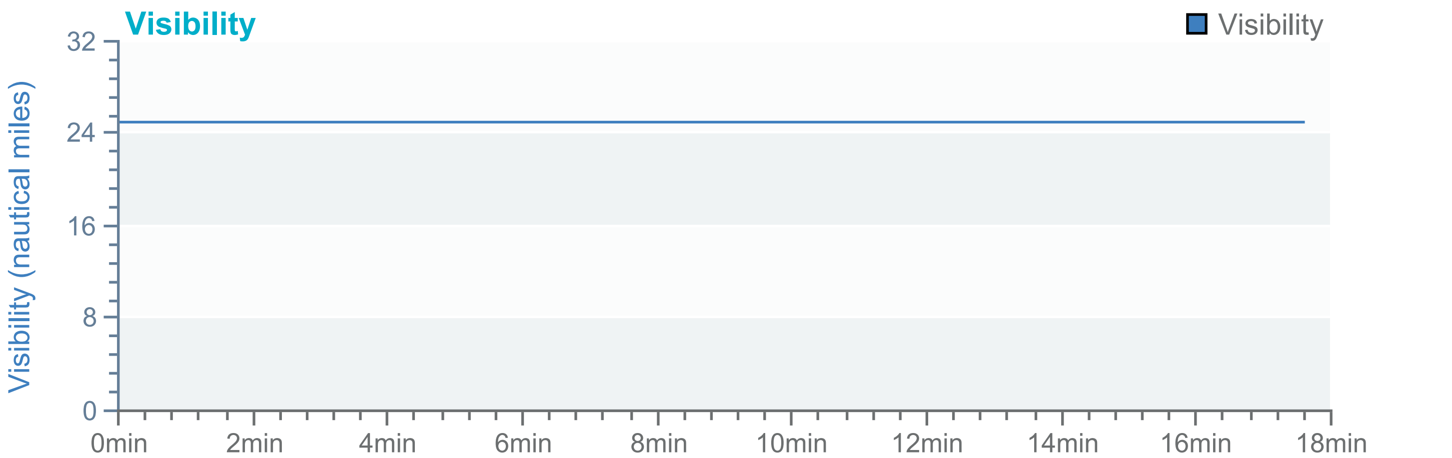


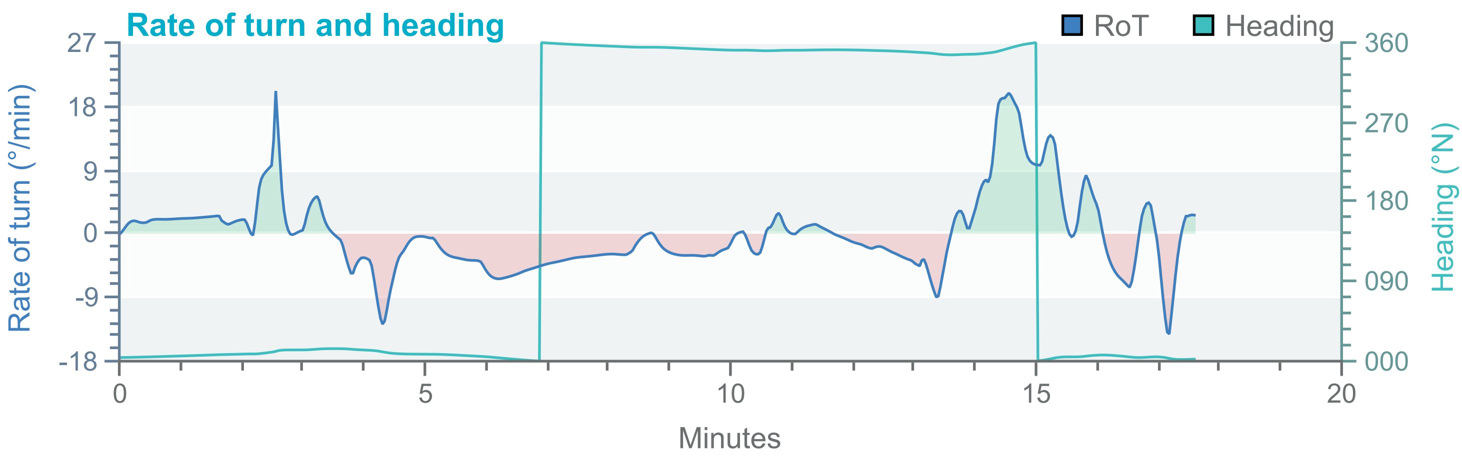
Ships plotted every 1 mins, highlight every 10 mins

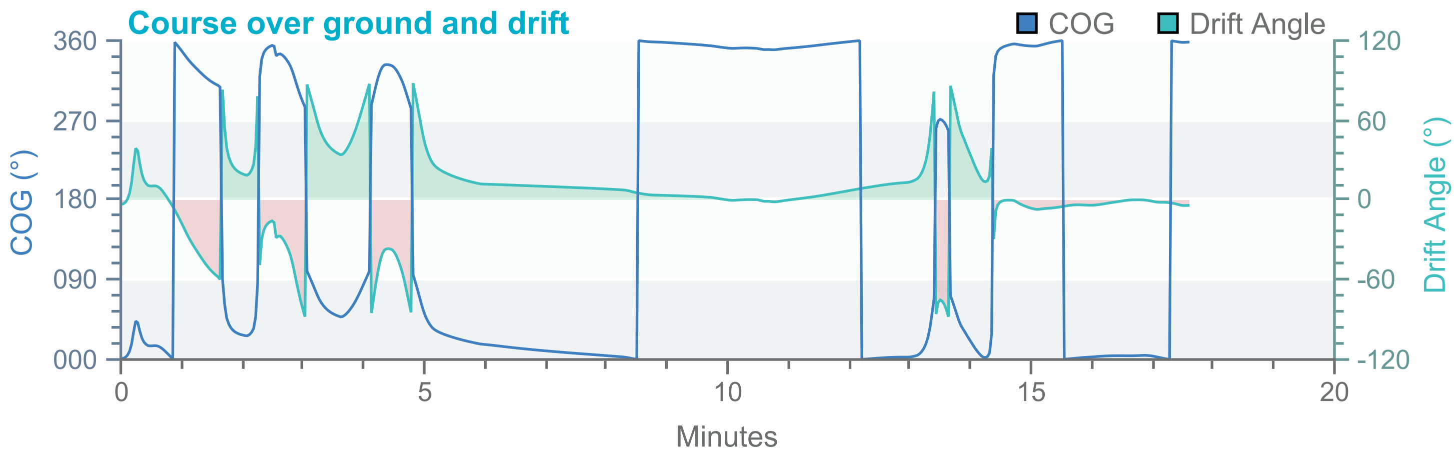

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
6.9
5.3
3.7
2.1
0.5
360
270
180
090
000
0
5
10
15
20

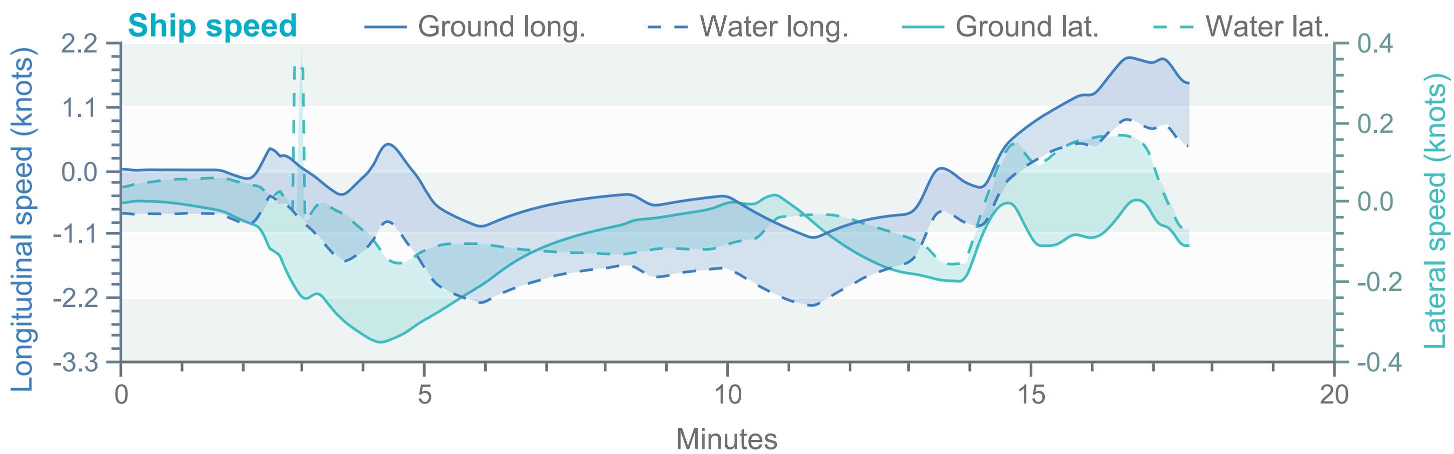

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20

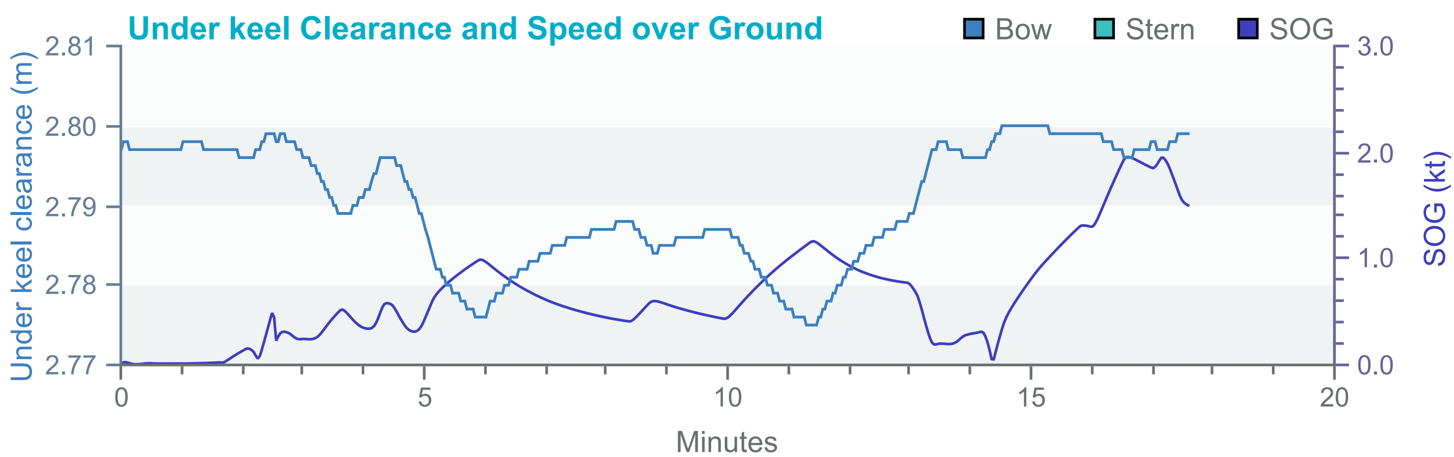

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min


Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
Minutes

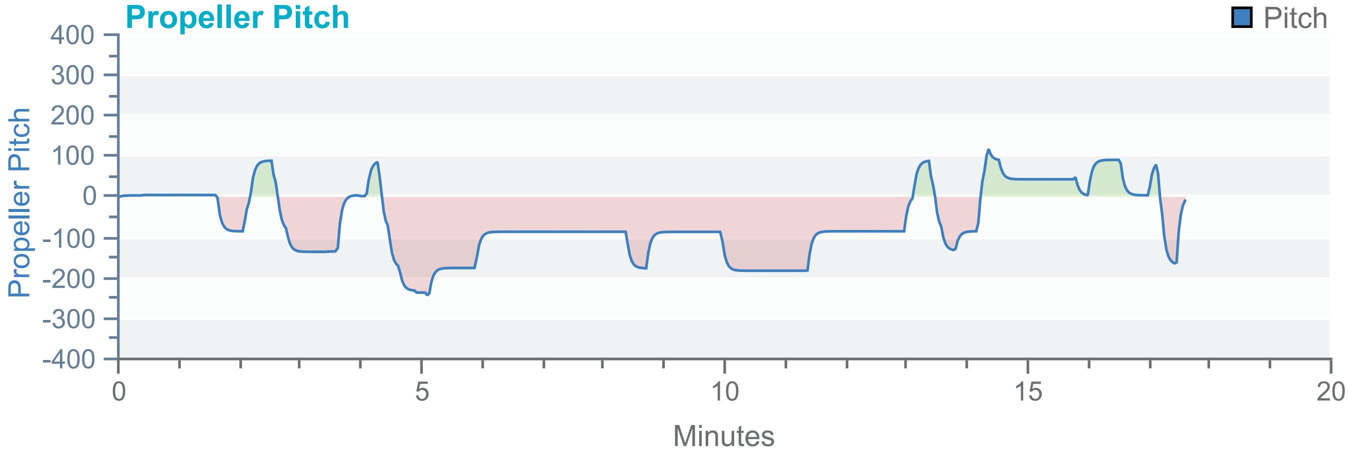

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Minutes


Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
Minutes

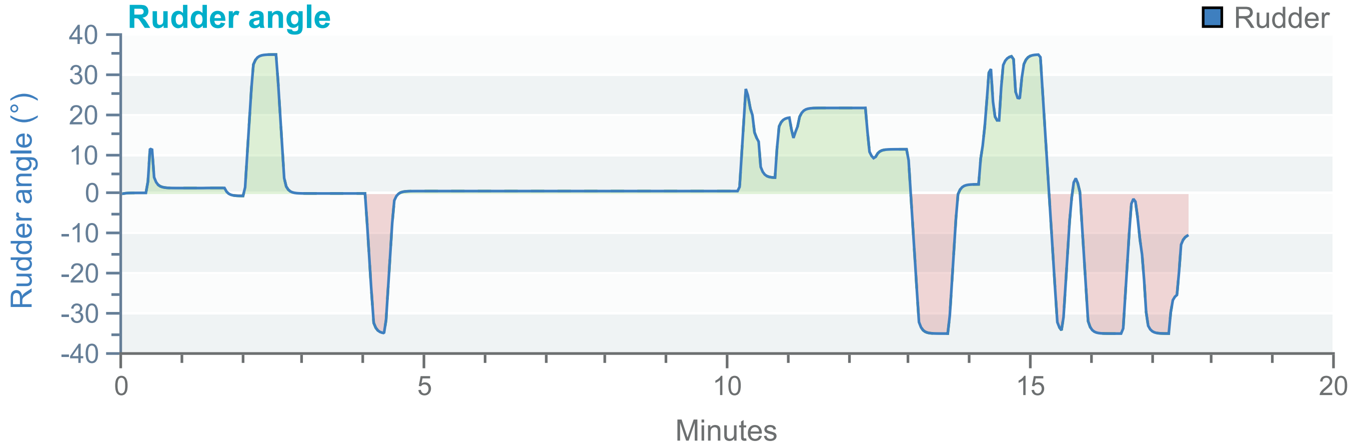

Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
Minutes

Tracks | Environment | Fischland Laden

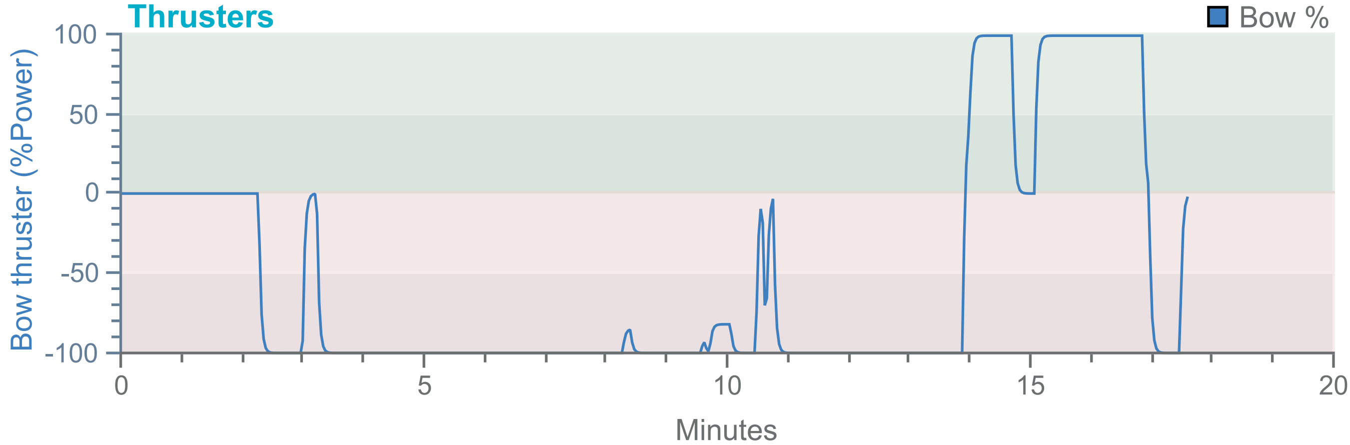
Propeller Pitch



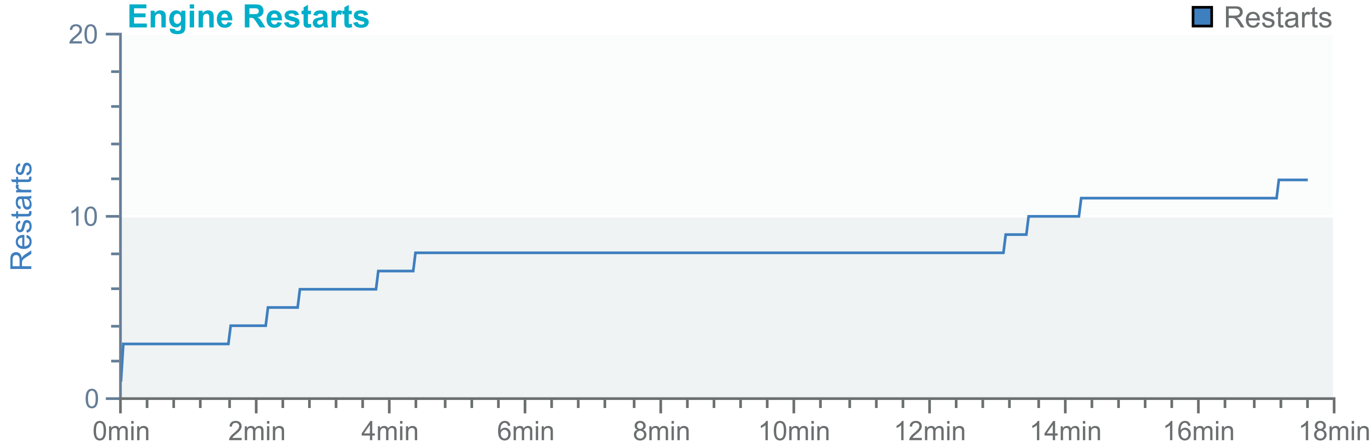
Rudder angle



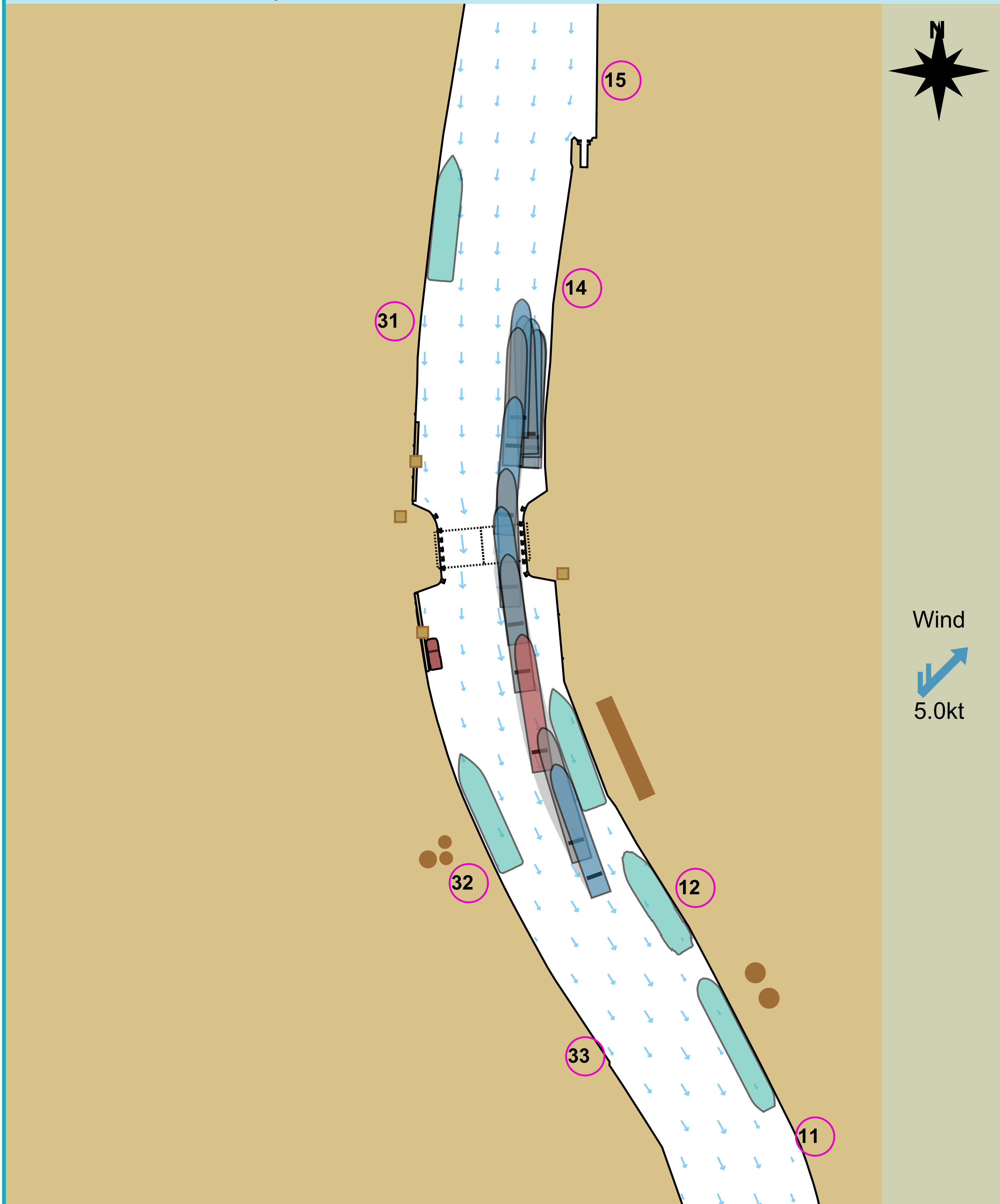
Thrusters



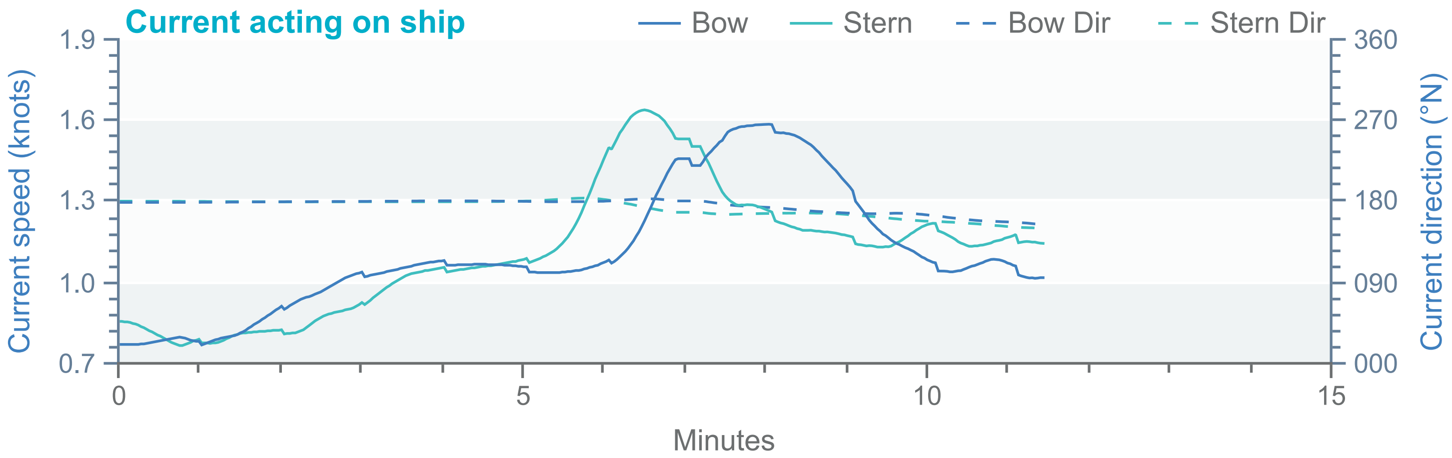
Engine Restarts

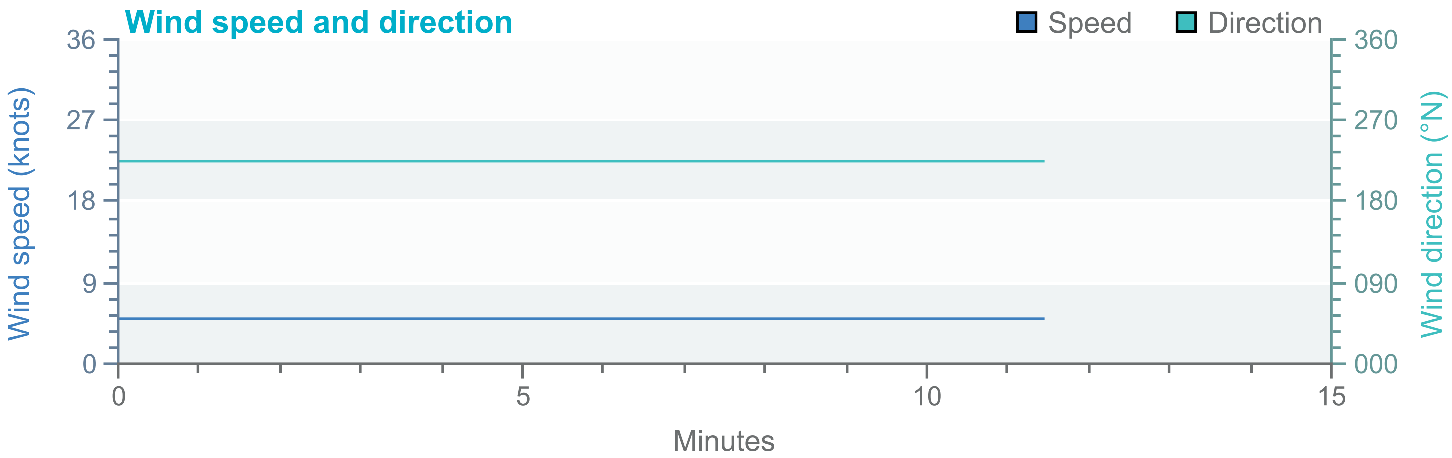


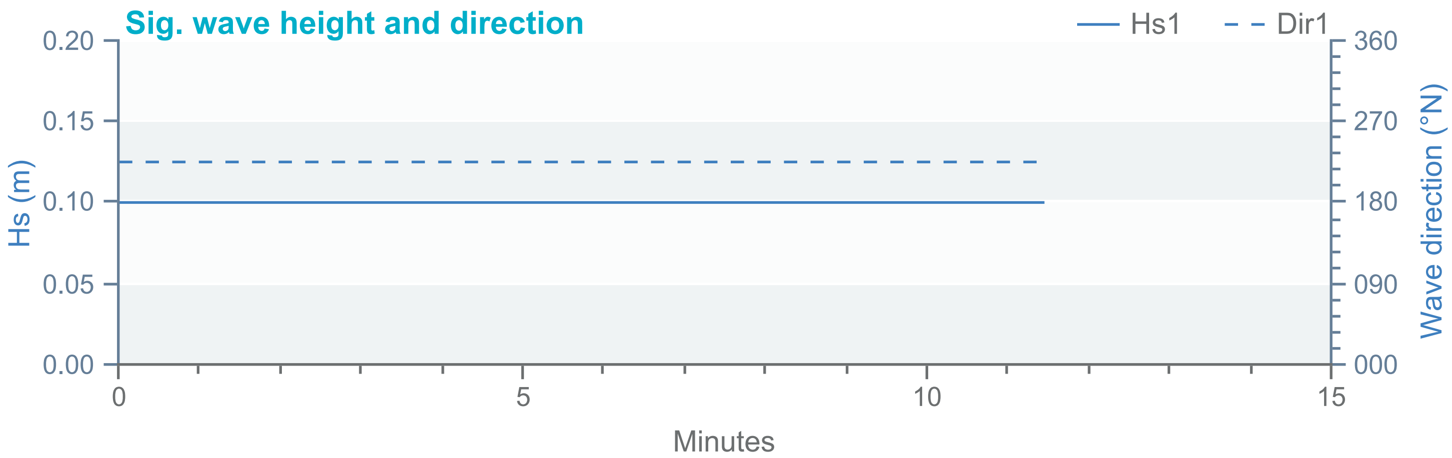
Manoeuvre track plot

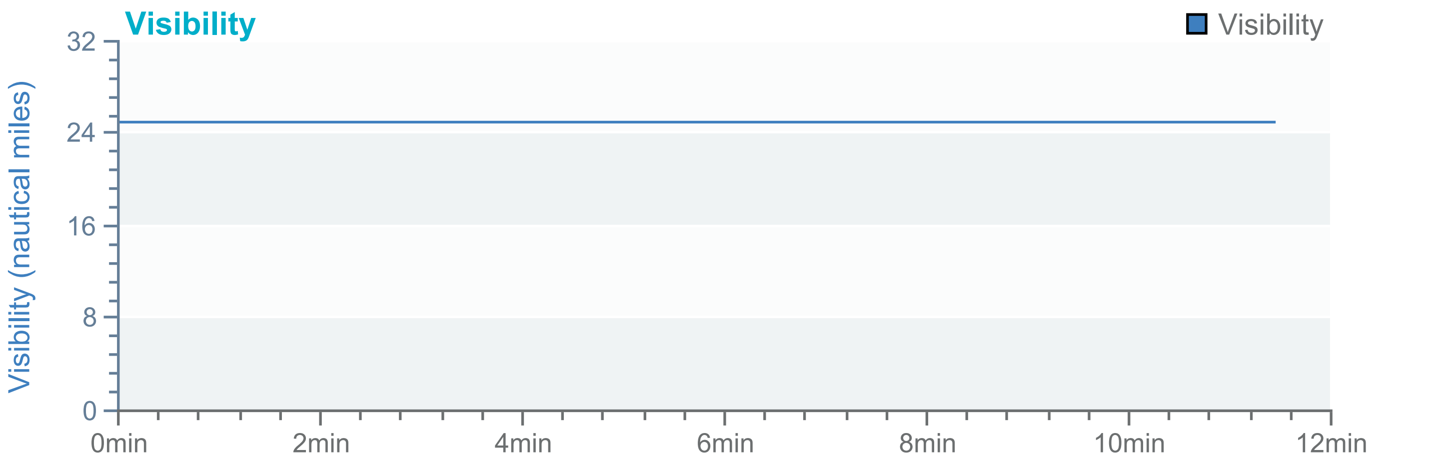


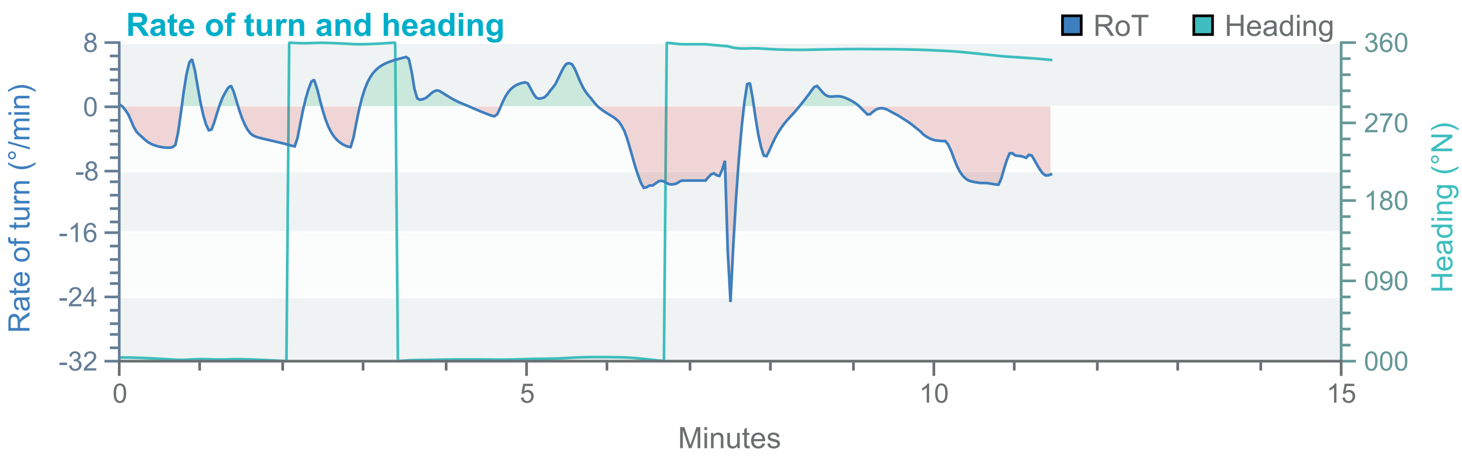
Ships plotted every 1 mins, highlight every 10 mins

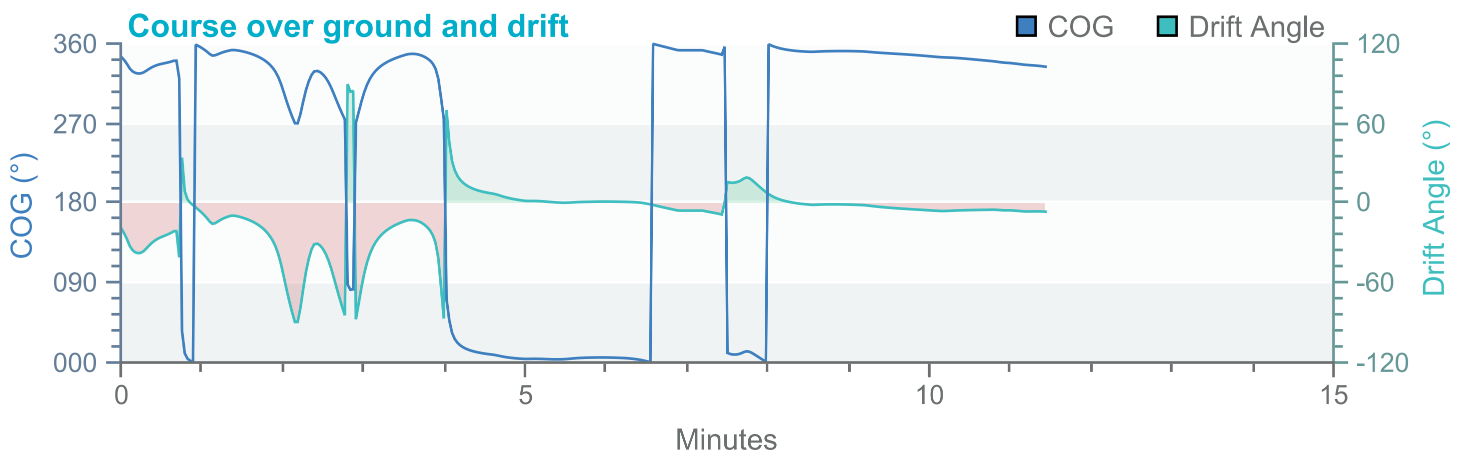

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes

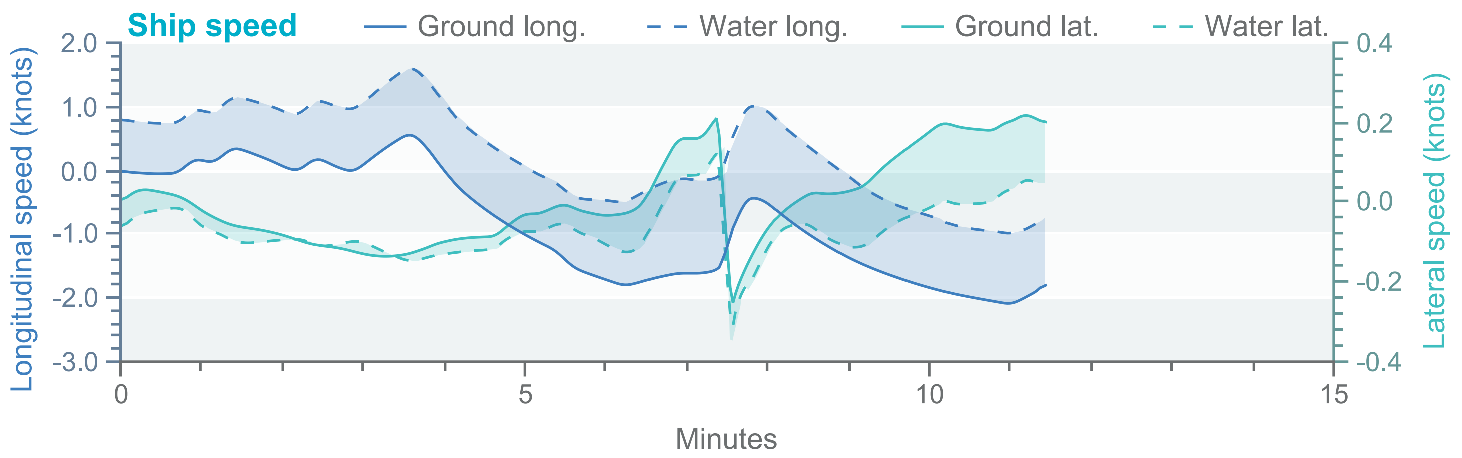

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes

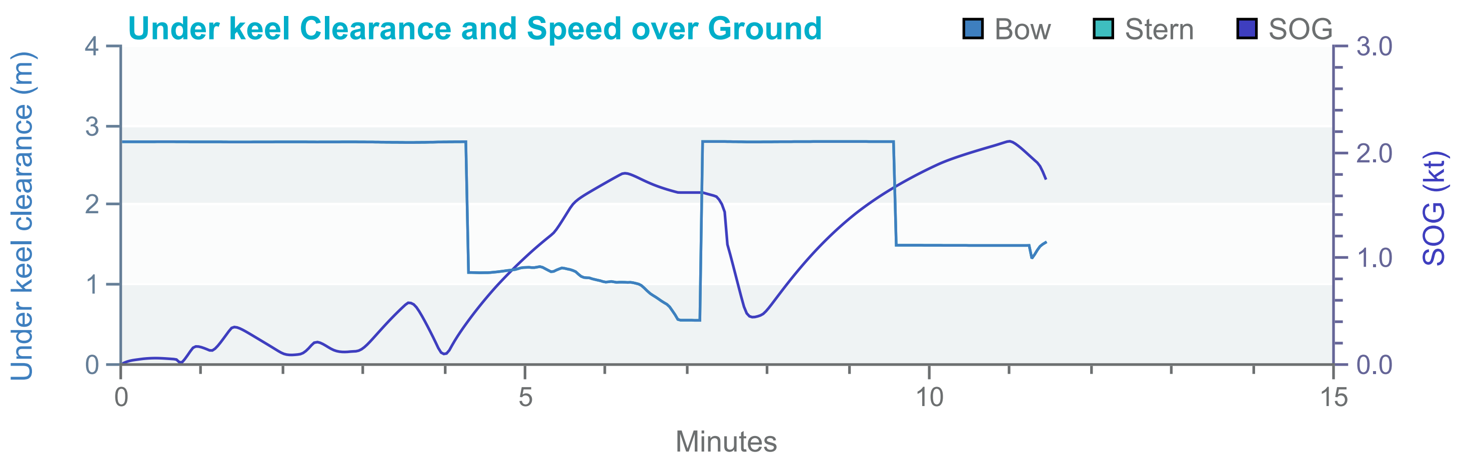

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes

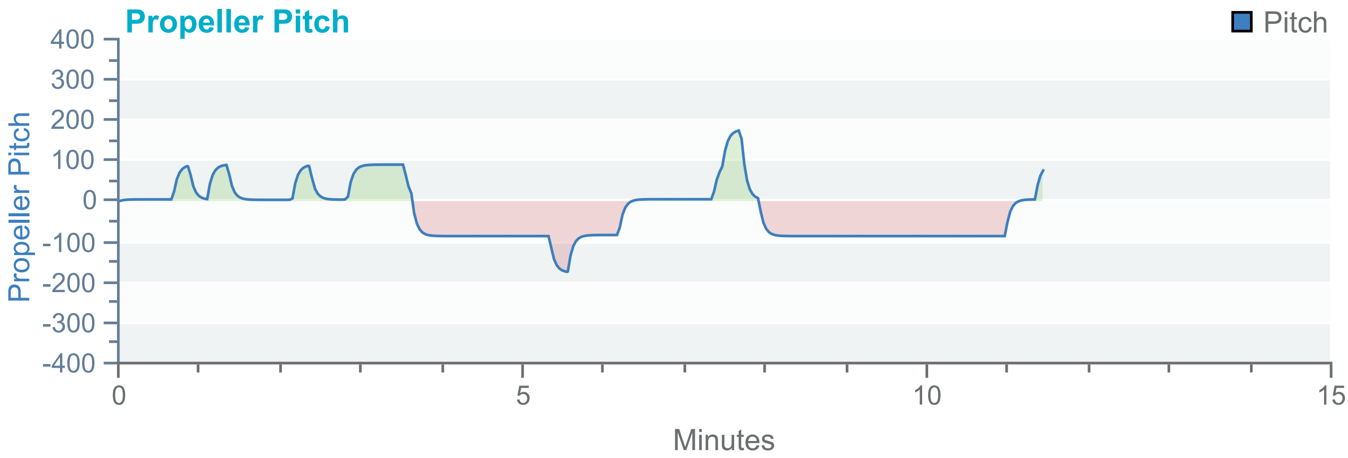

Visibility
Visibility
Visibility (nautical miles)

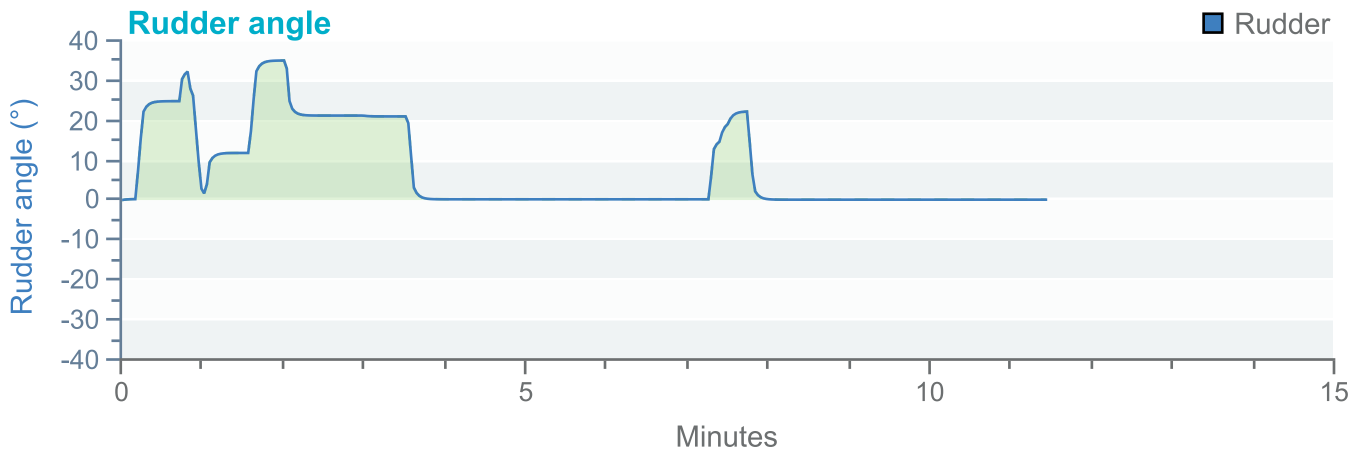

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
8
0
-8
-16
-24
-32
360
270
180
090
000
0
5
10
15
Minutes

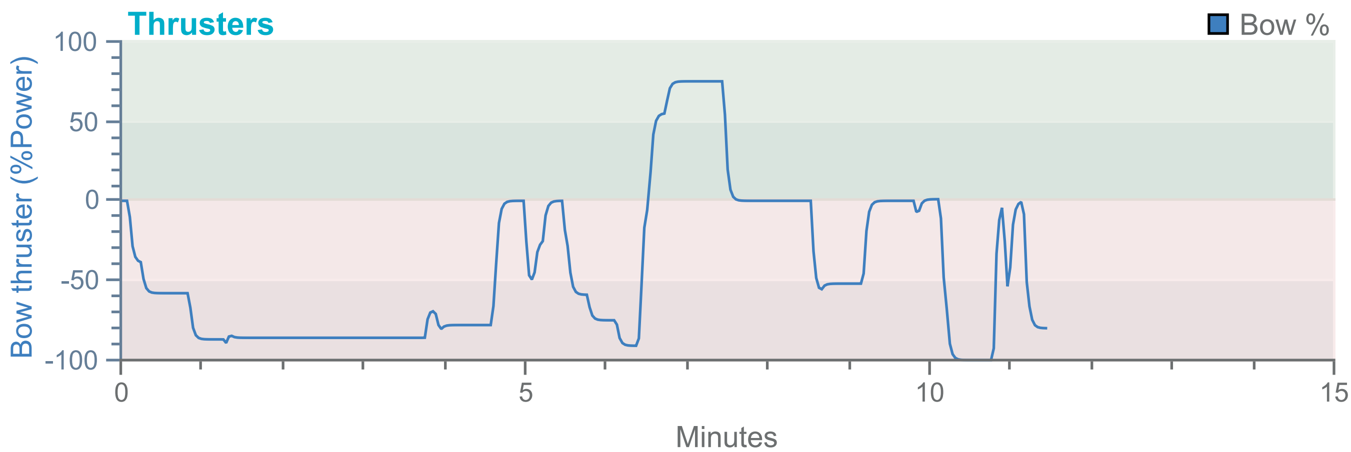

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
Minutes

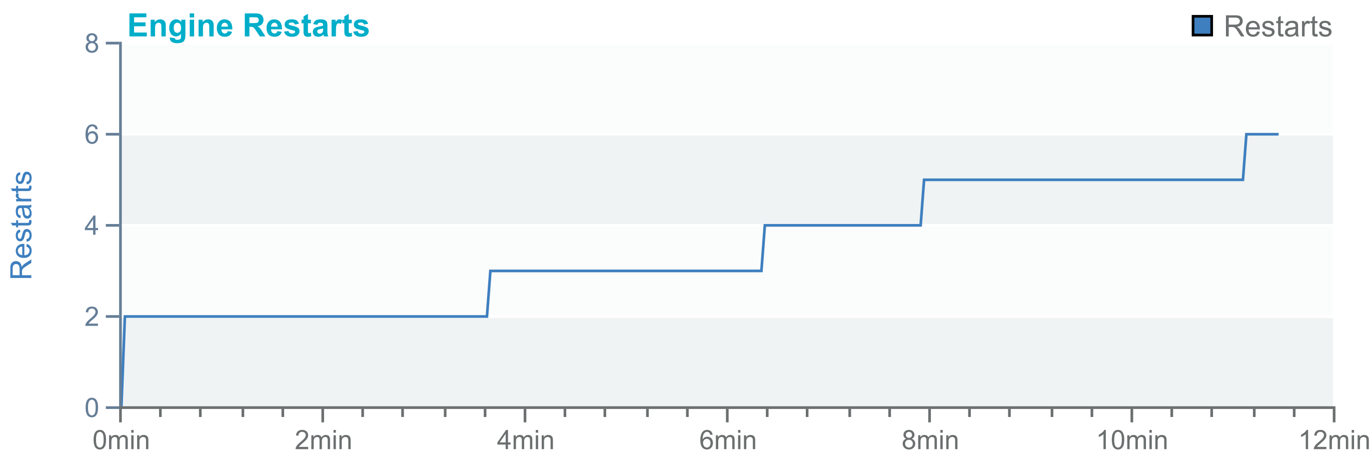

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
2.0
1.0
0.0
-1.0
-2.0
-3.0
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
4
3
2
1
0
3.0
2.0
1.0
0.0
0
5
10
15
Minutes

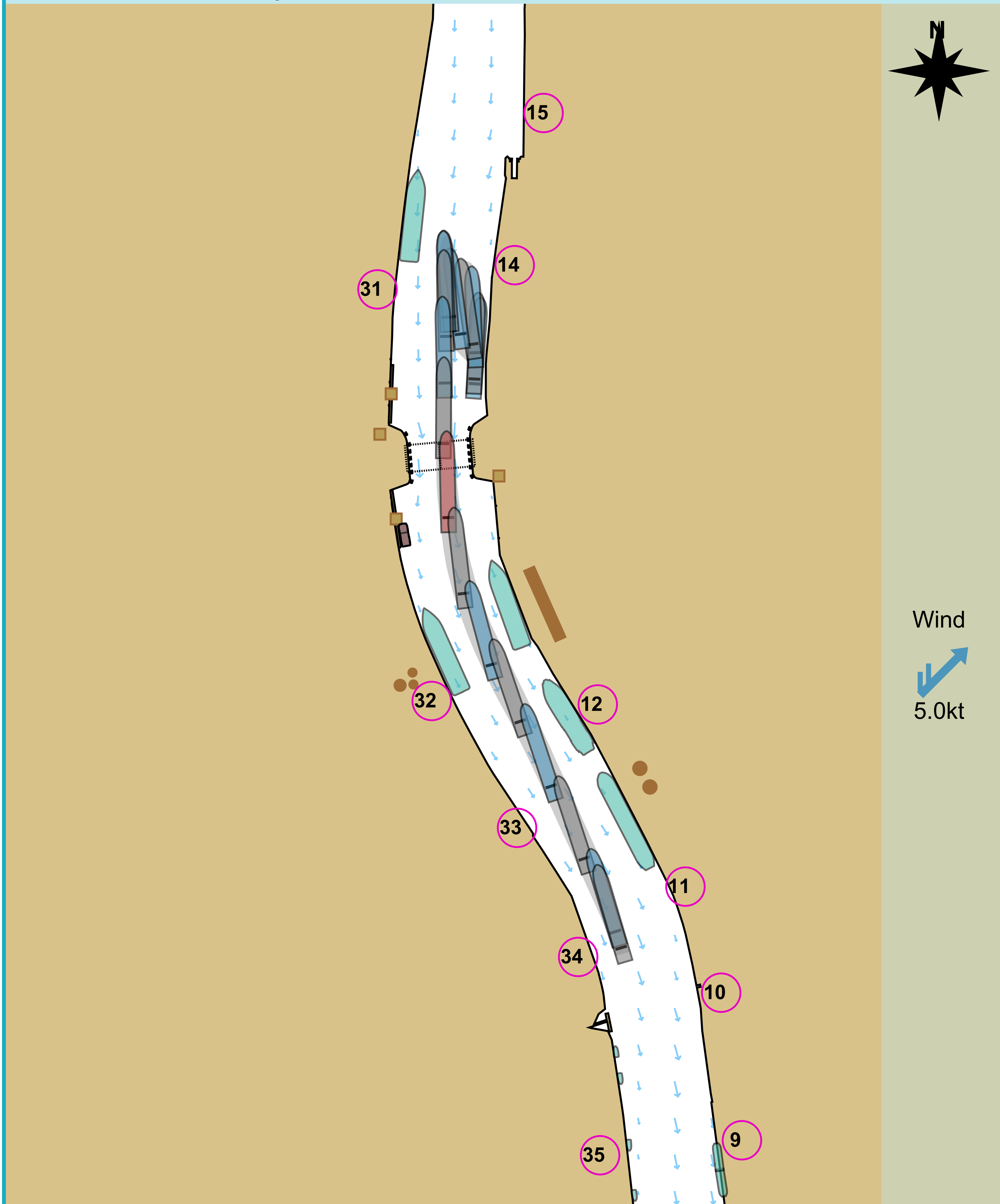

Propeller Pitch
Pitch
400
300
200
100
0
-100
-200
-300
-400
Propeller Pitch
0
5
10
15
Minutes


Rudder angle
Rudder
40
30
20
10
0
-10
-20
-30
-40
Rudder angle (°)
0
5
10
15
Minutes

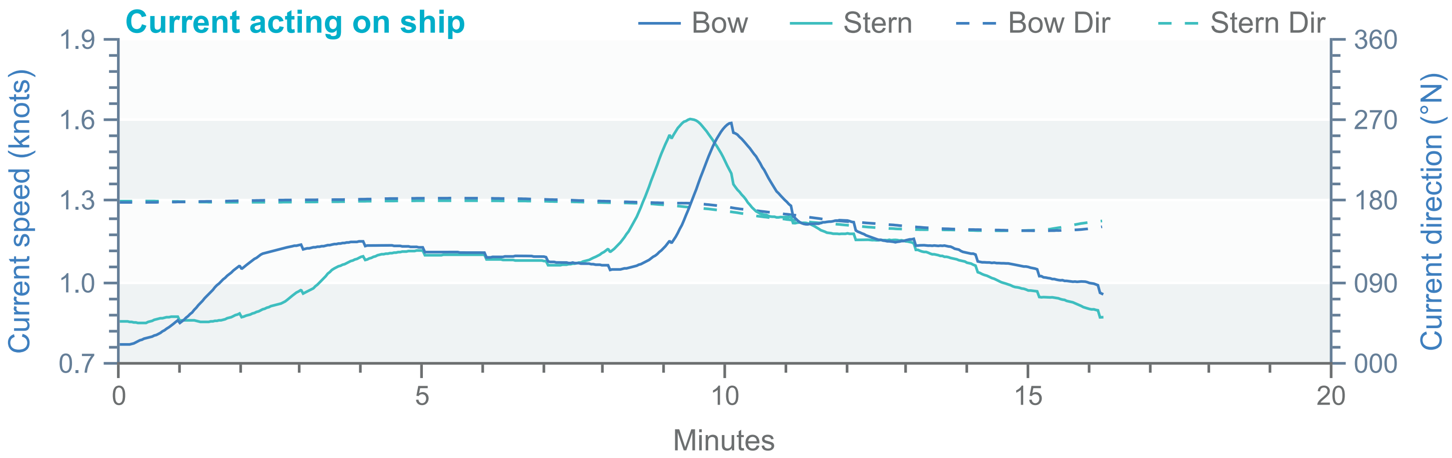

Thrusters
Bow %
100
50
0
-50
-100
Bow thruster (%Power)
0
5
10
15
Minutes

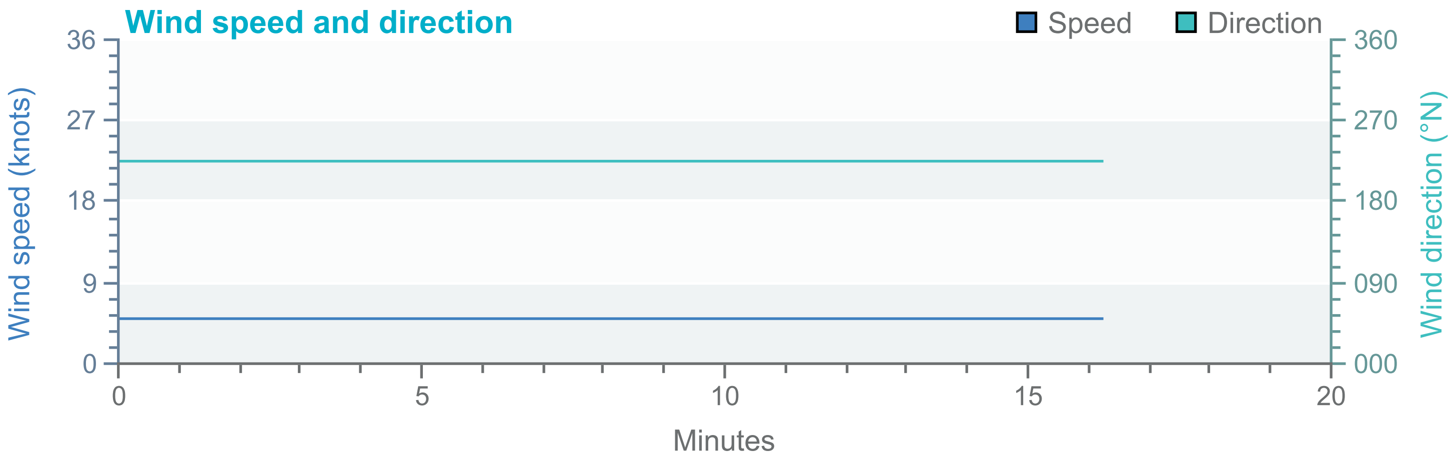

Engine Restarts
Restarts
8
6
4
2
0
Restarts
0min
2min
4min
6min
8min
10min
12min

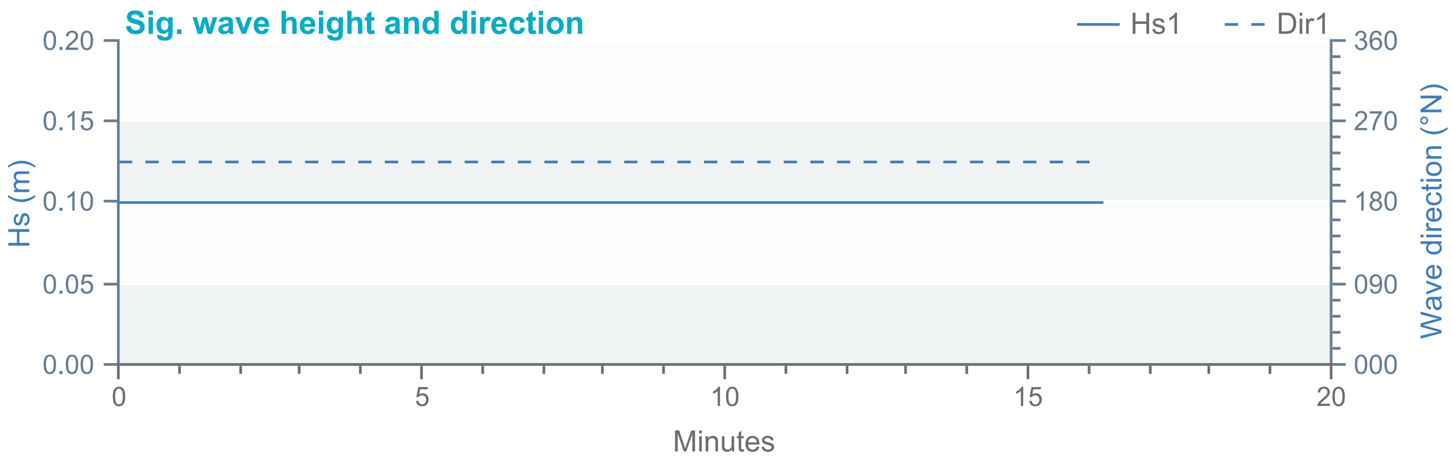
Manoeuvre track plot

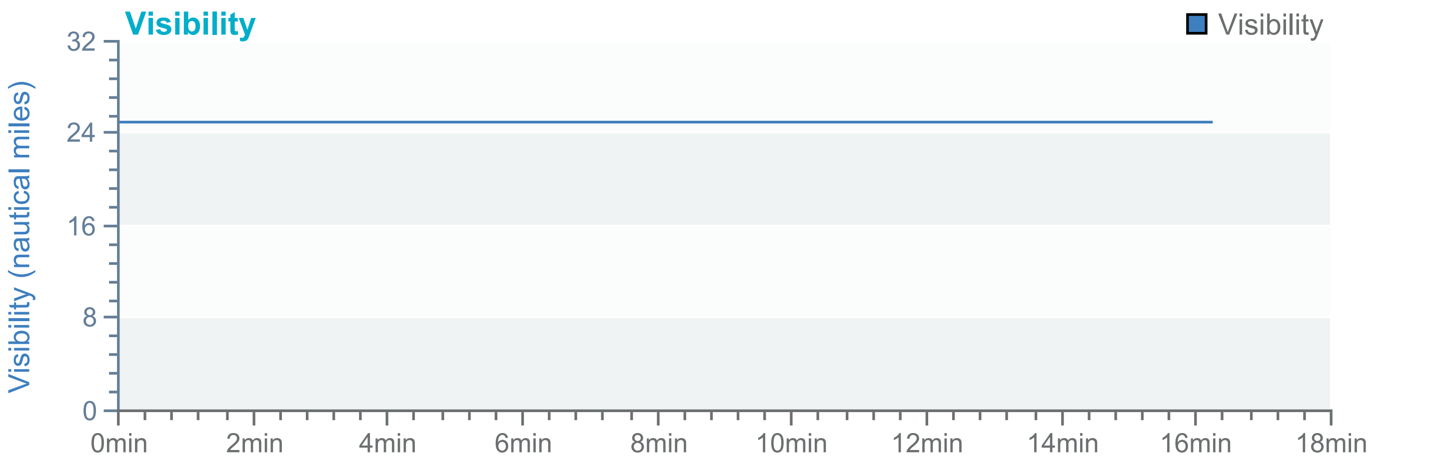


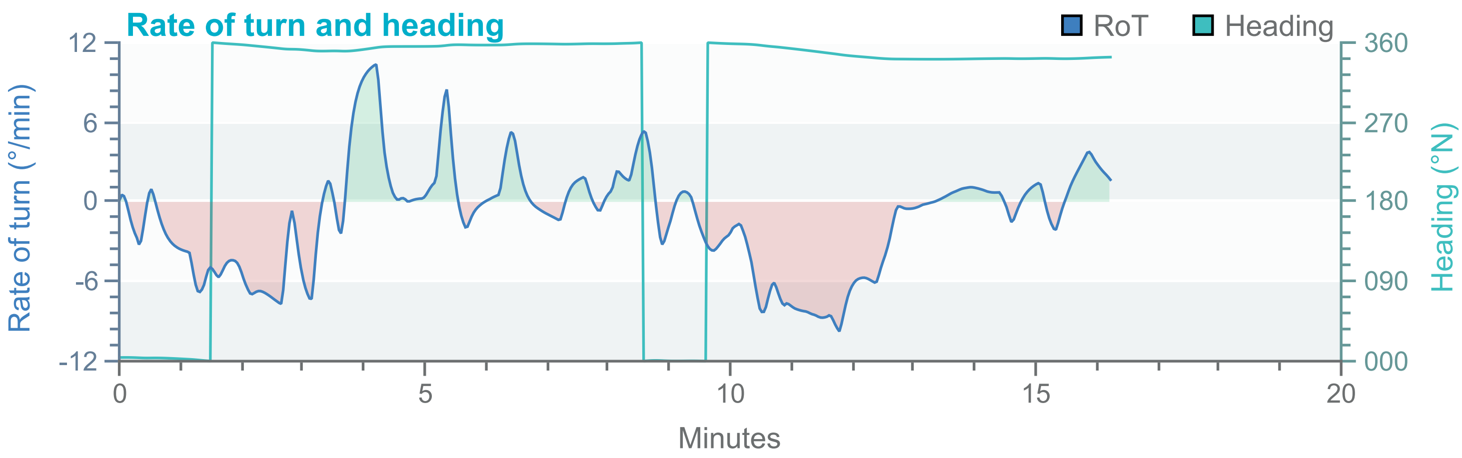
Ships plotted every 1 mins, highlight every 10 mins

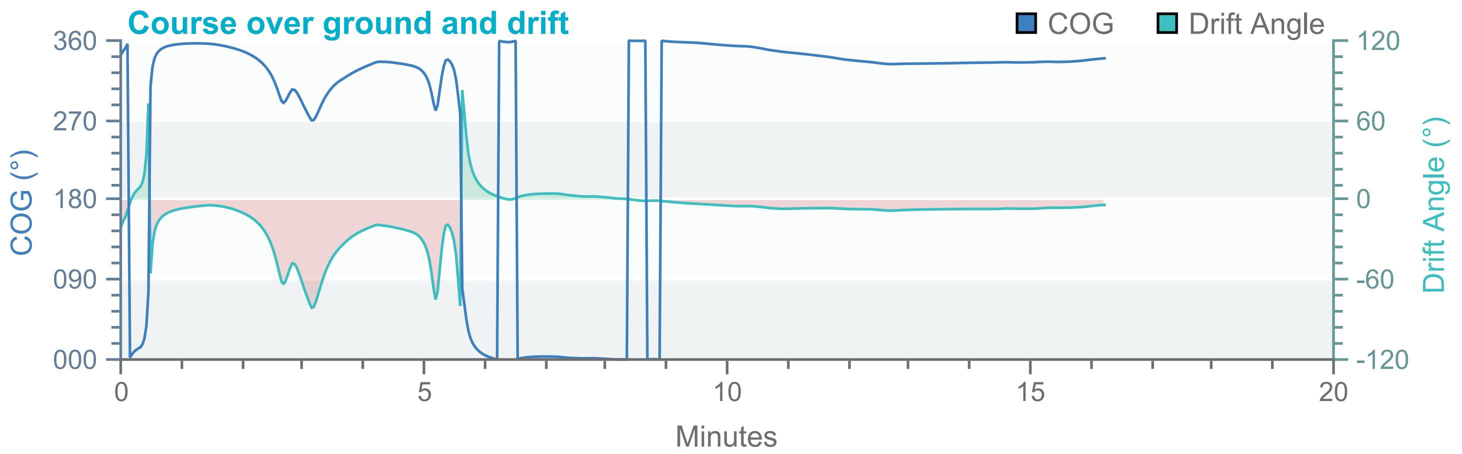

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
1.9
1.6
1.3
1.0
0.7
360
270
180
090
000
0
5
10
15
20
Minutes

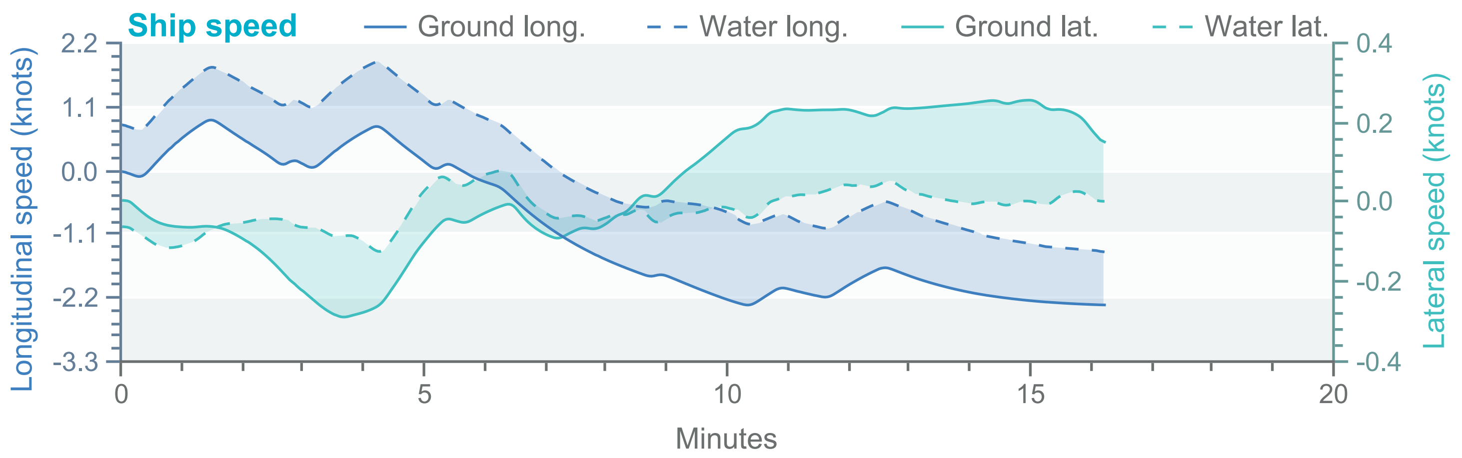

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
Minutes


Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
Minutes


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min

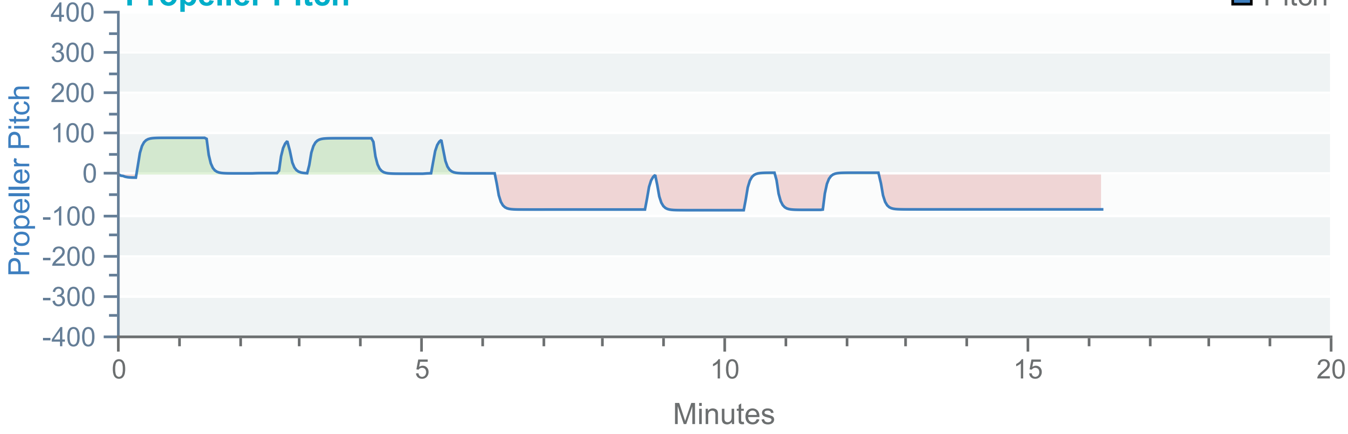

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
12
6
0
-6
-12
360
270
180
090
000
0
5
10
15
20
Minutes


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
Minutes

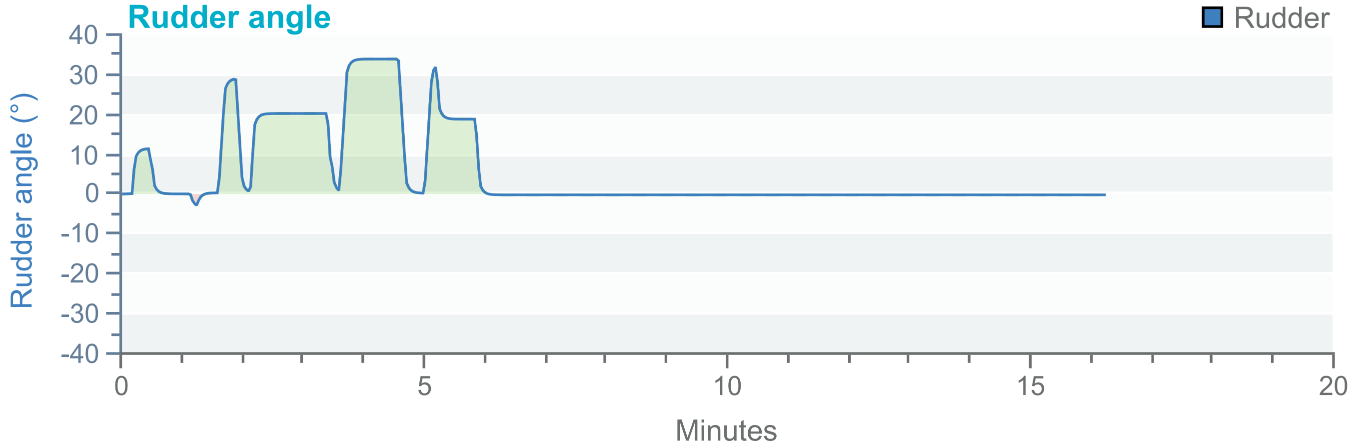

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
2.2
1.1
0.0
-1.1
-2.2
-3.3
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
4
3
2
1
0
3.0
2.0
1.0
0.0
0
5
10
15
20
Minutes

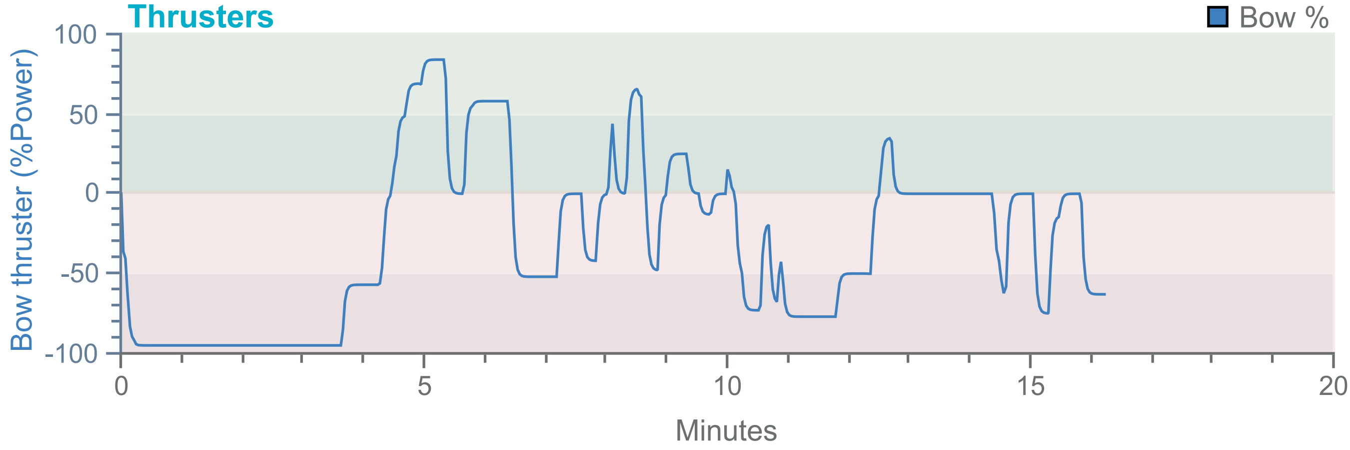
Propeller Pitch



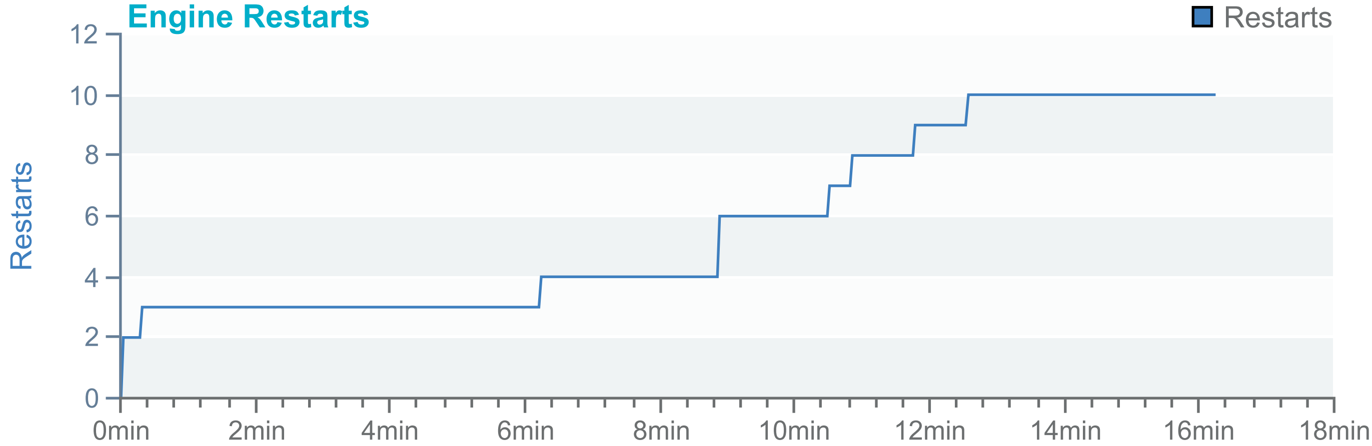
Rudder angle



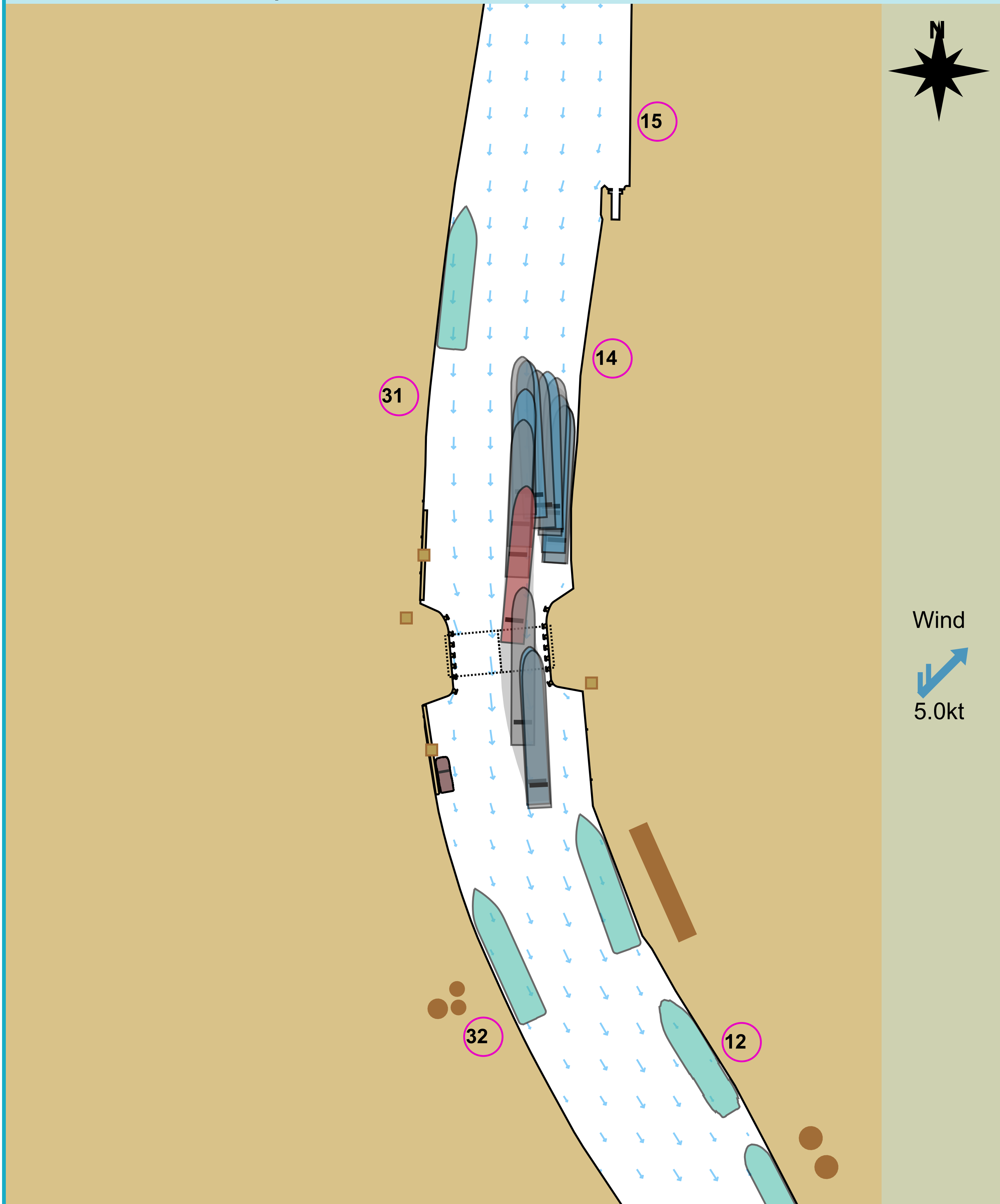
Thrusters



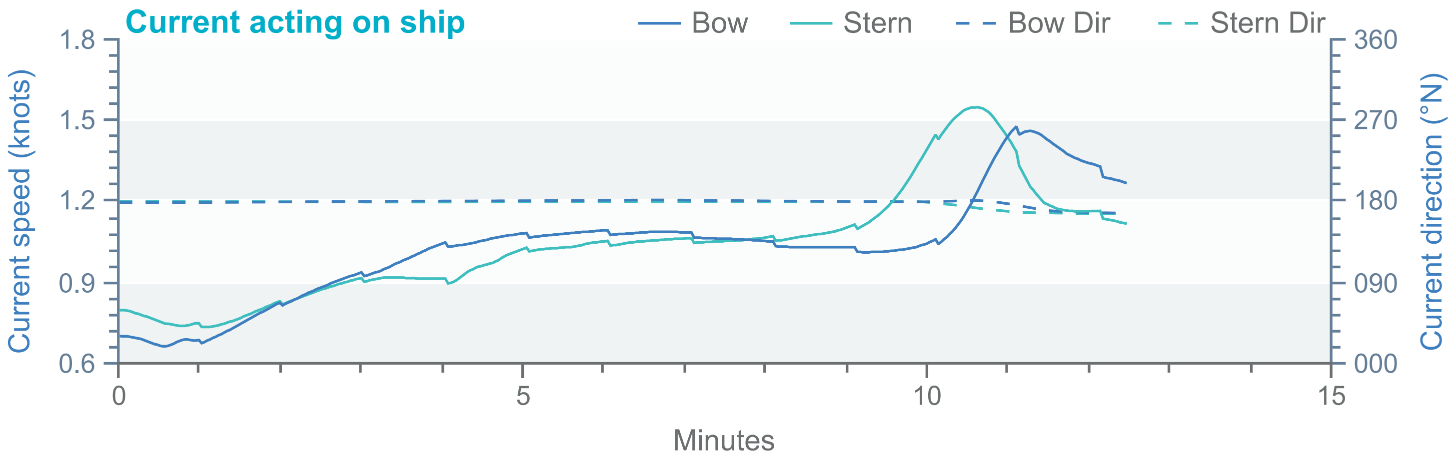
Engine Restarts

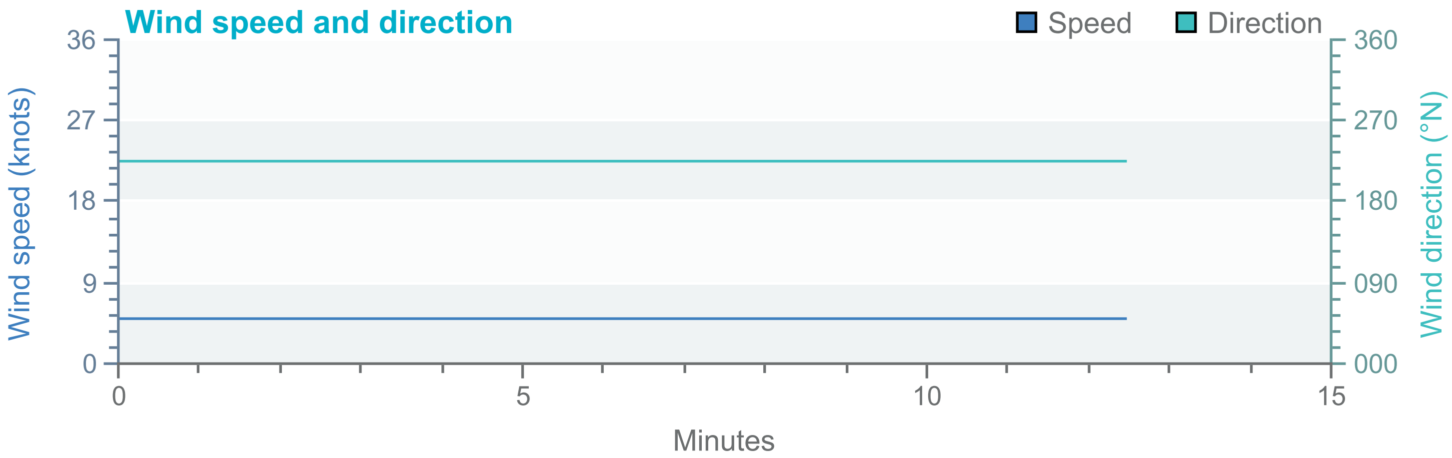


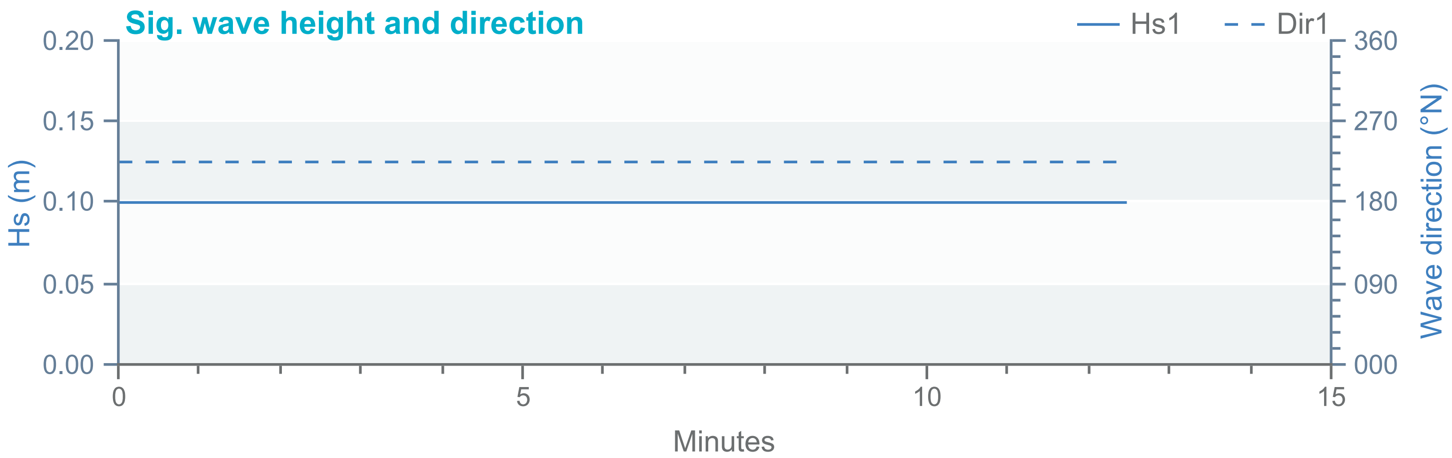
Manoeuvre track plot

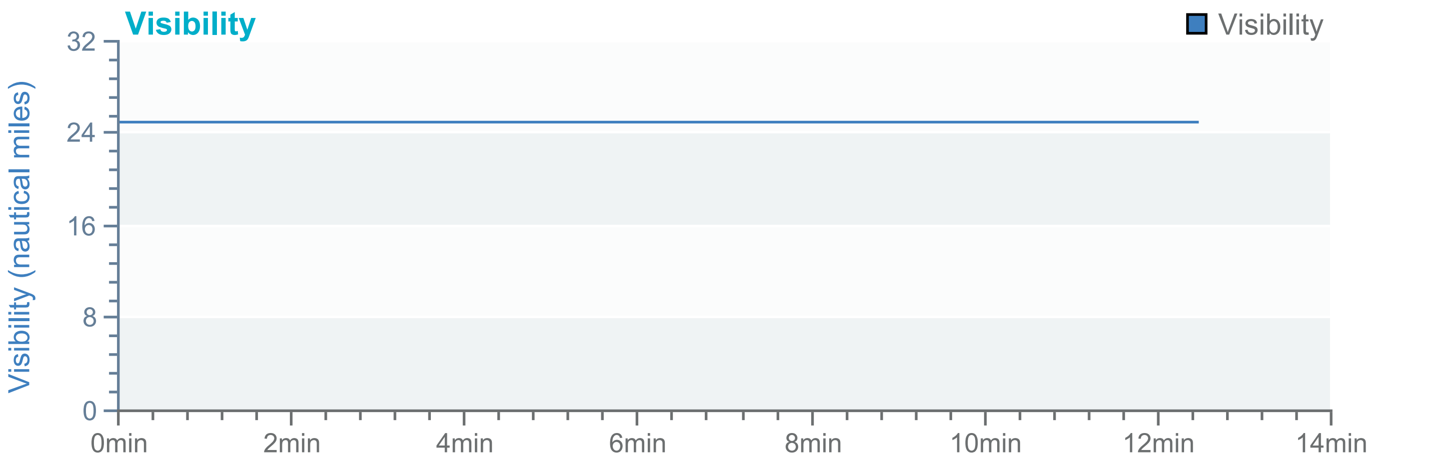


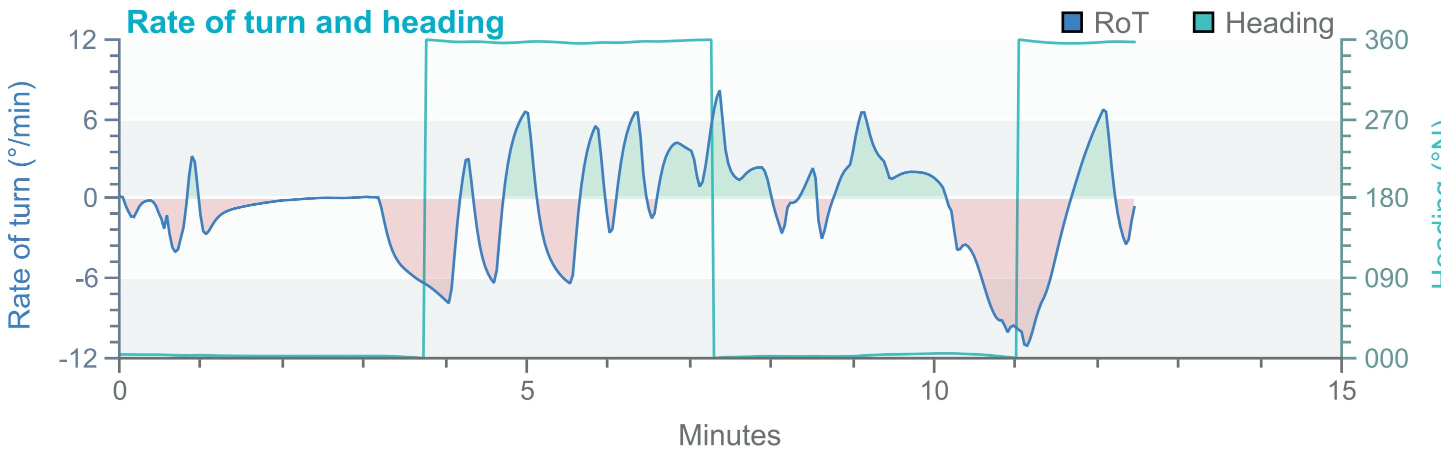
Ships plotted every 1 mins, highlight every 10 mins

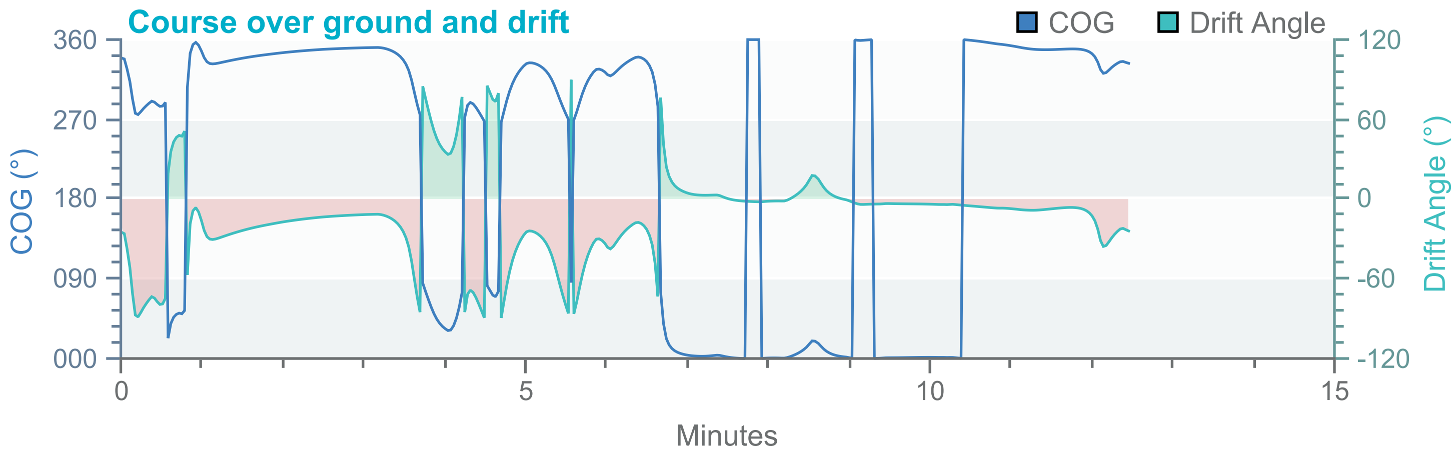

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes

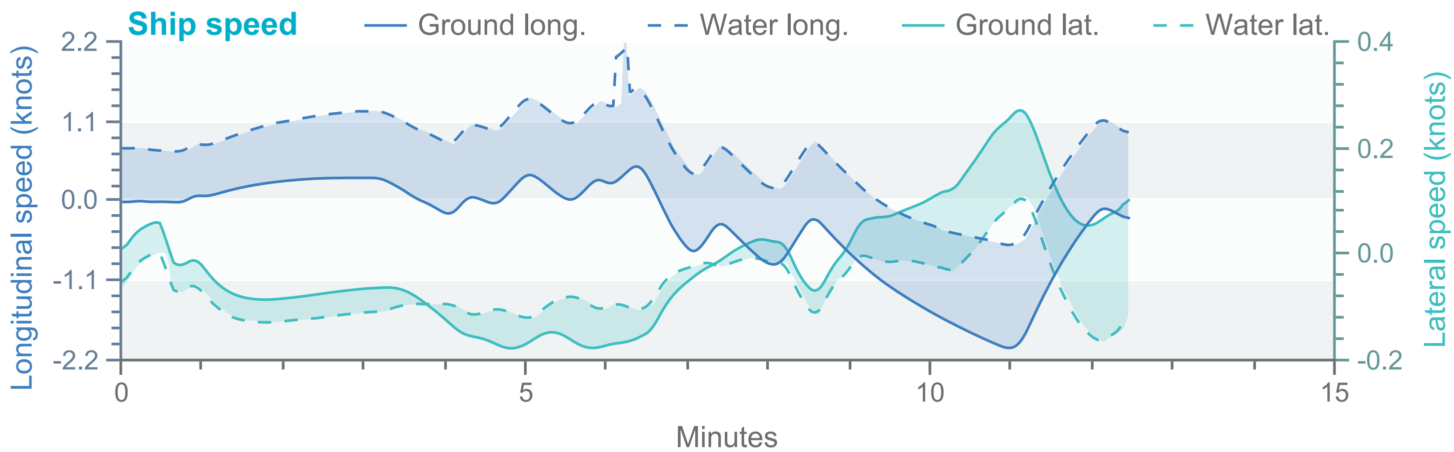

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes

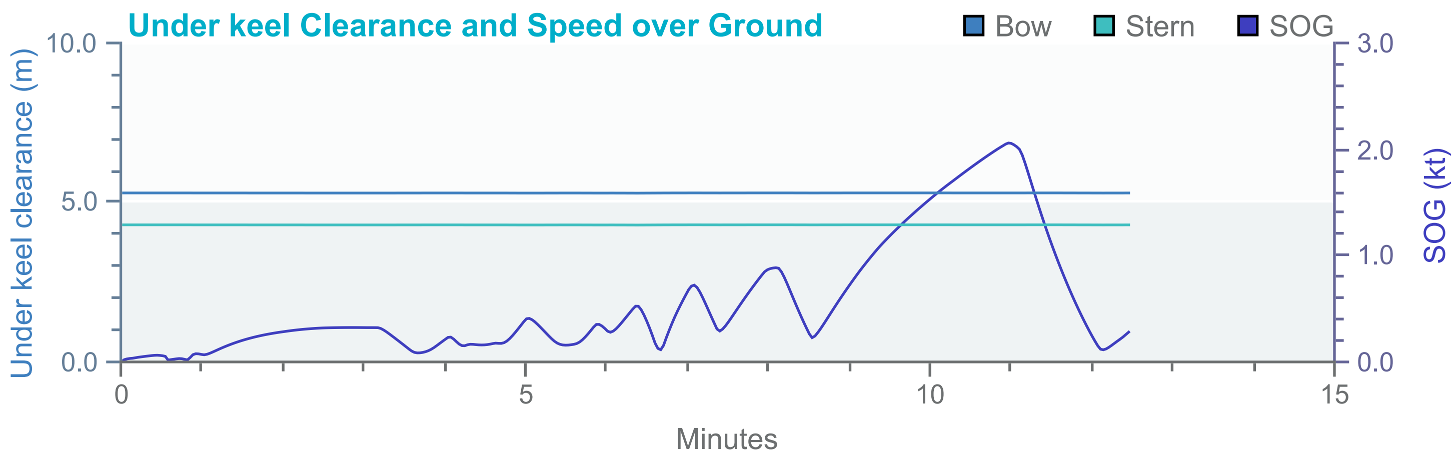

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes


Visibility
Visibility
Visibility (nautical miles)

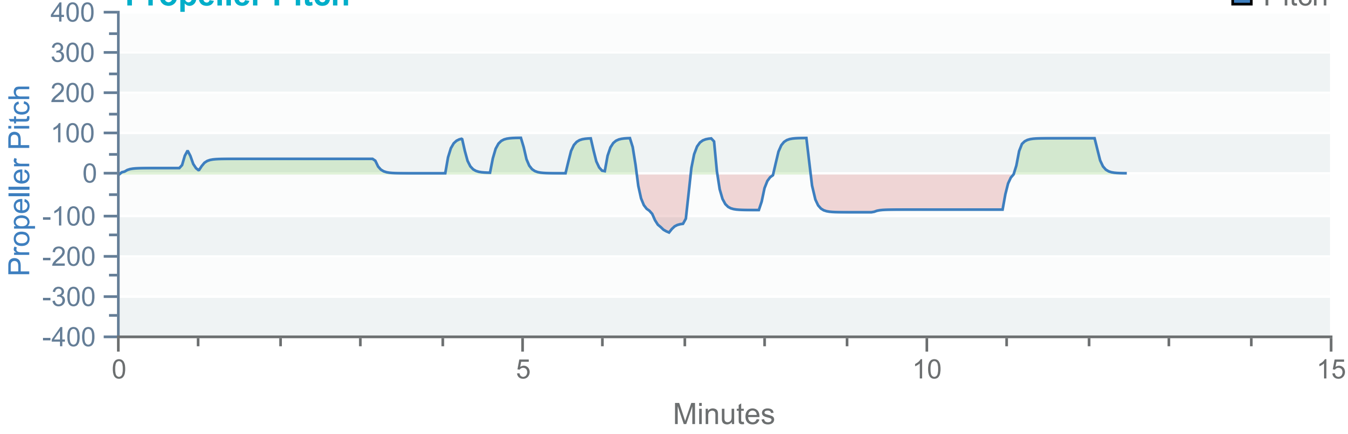

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
Minutes


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Minutes

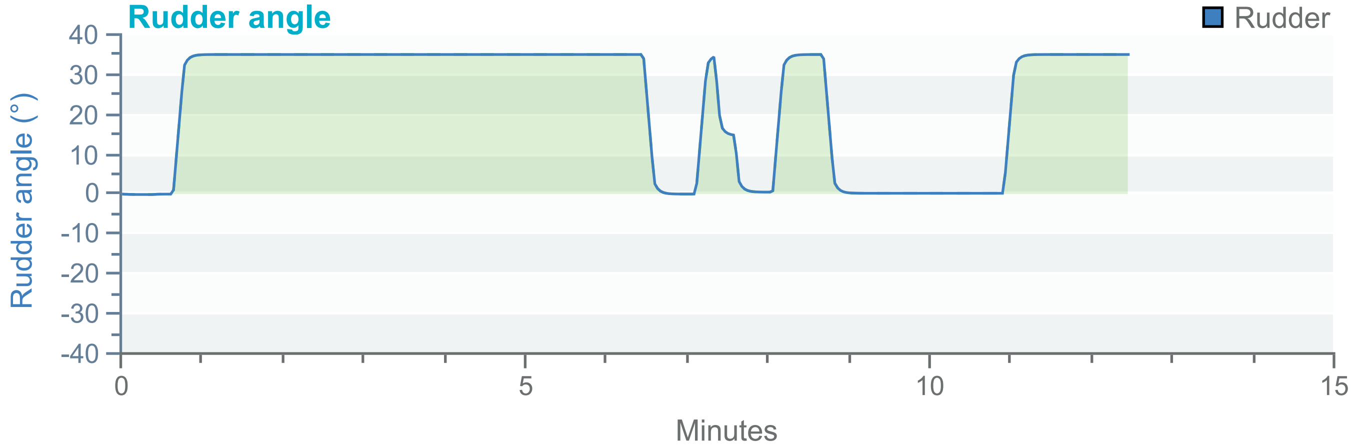

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
Minutes

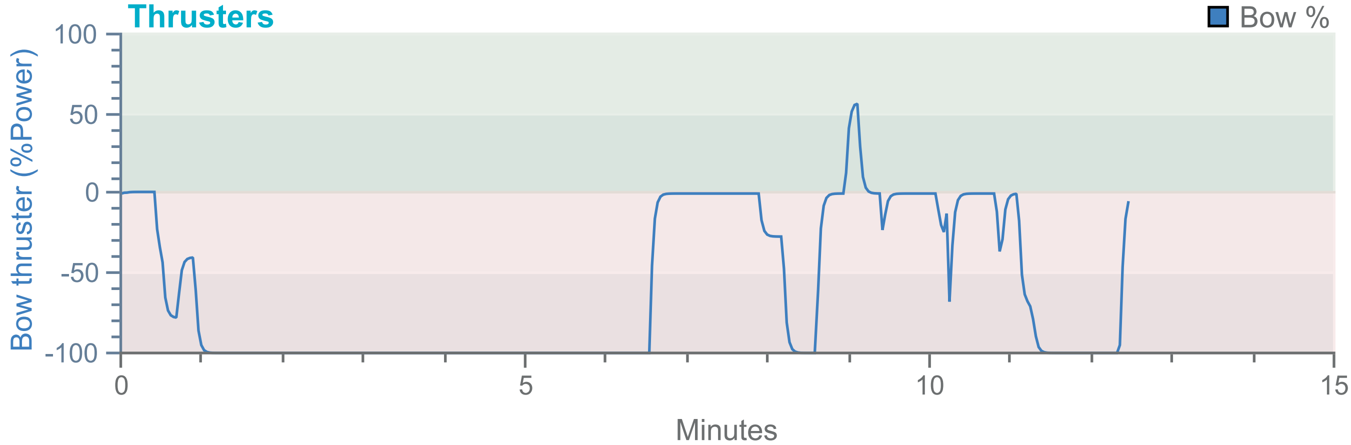
Propeller Pitch



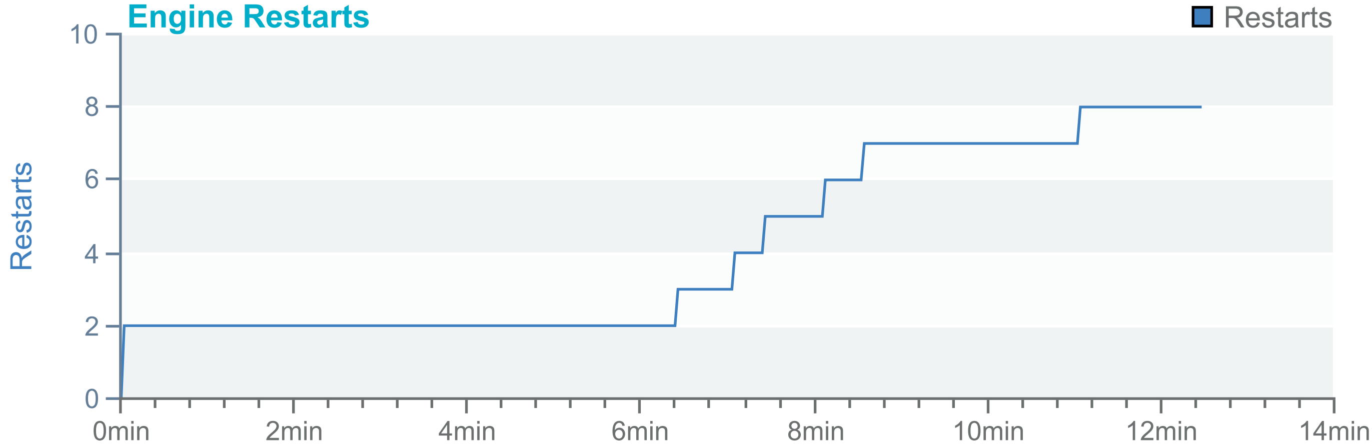
Rudder angle



Thrusters

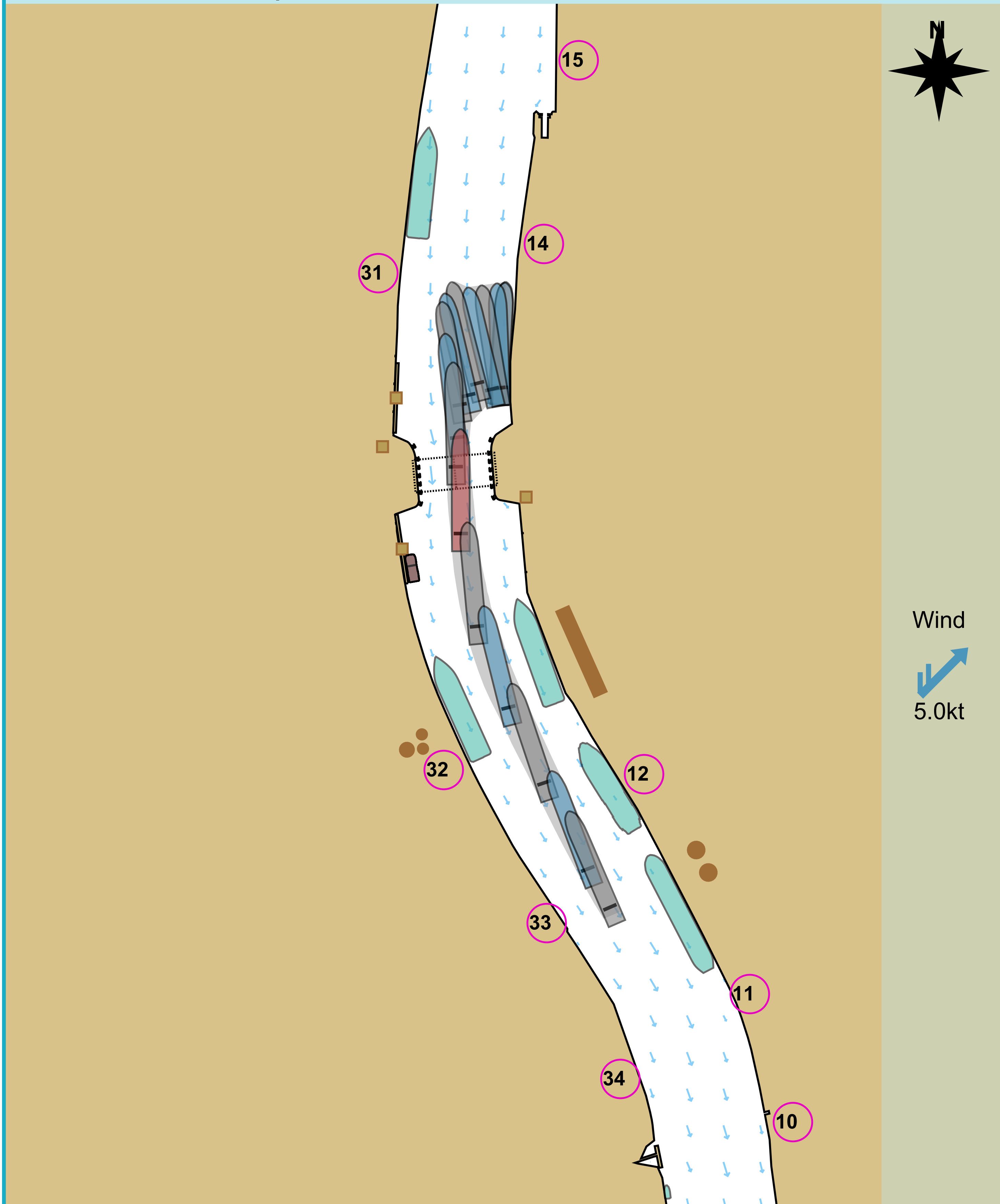


Engine Restarts

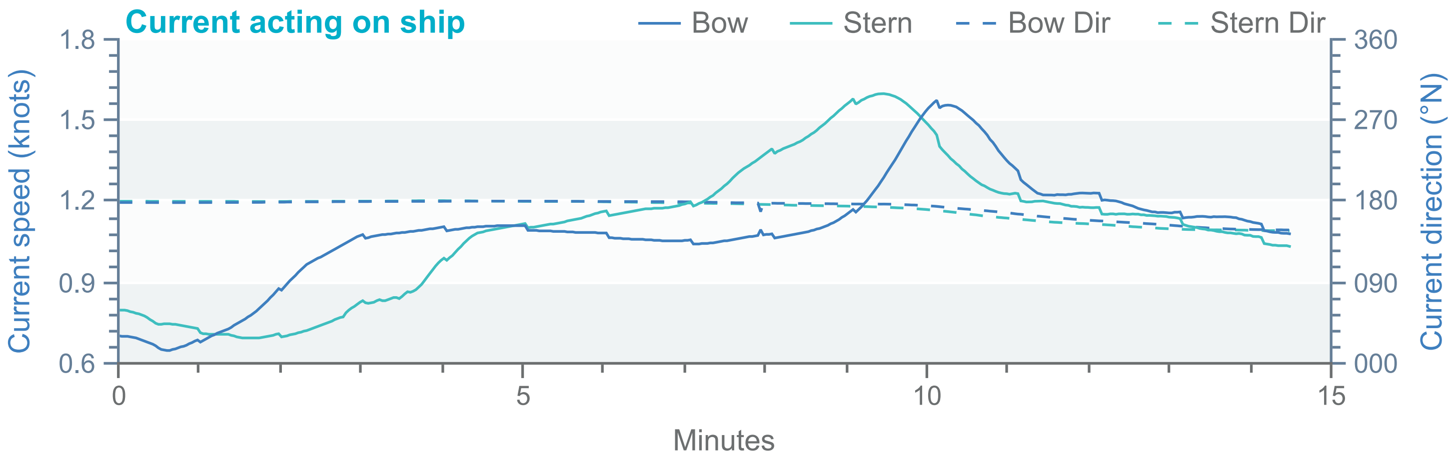


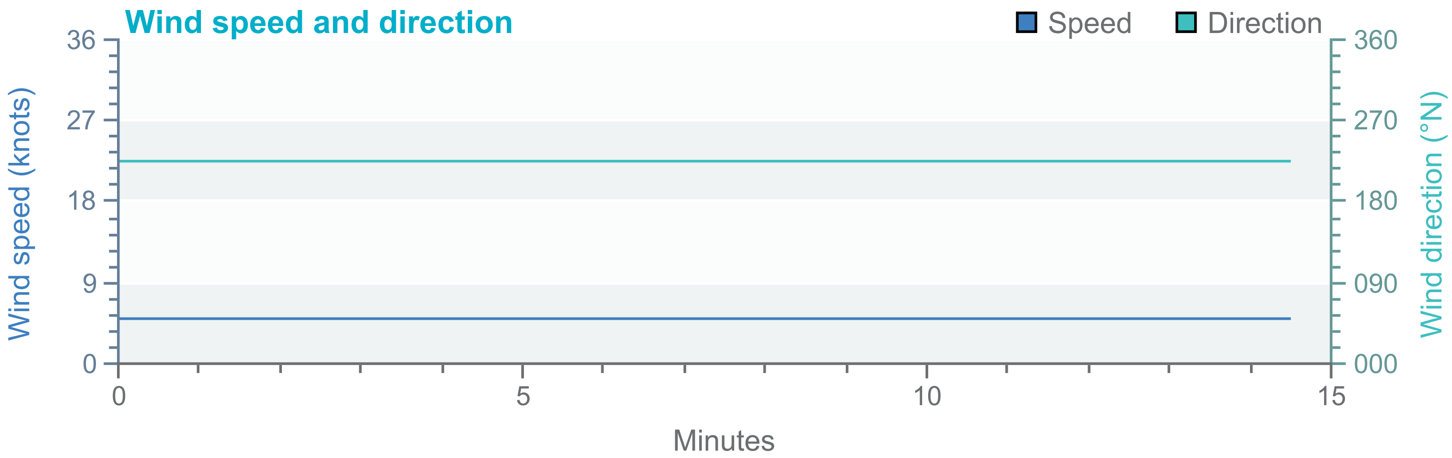
Tracks | Environment | Fischland Ballast

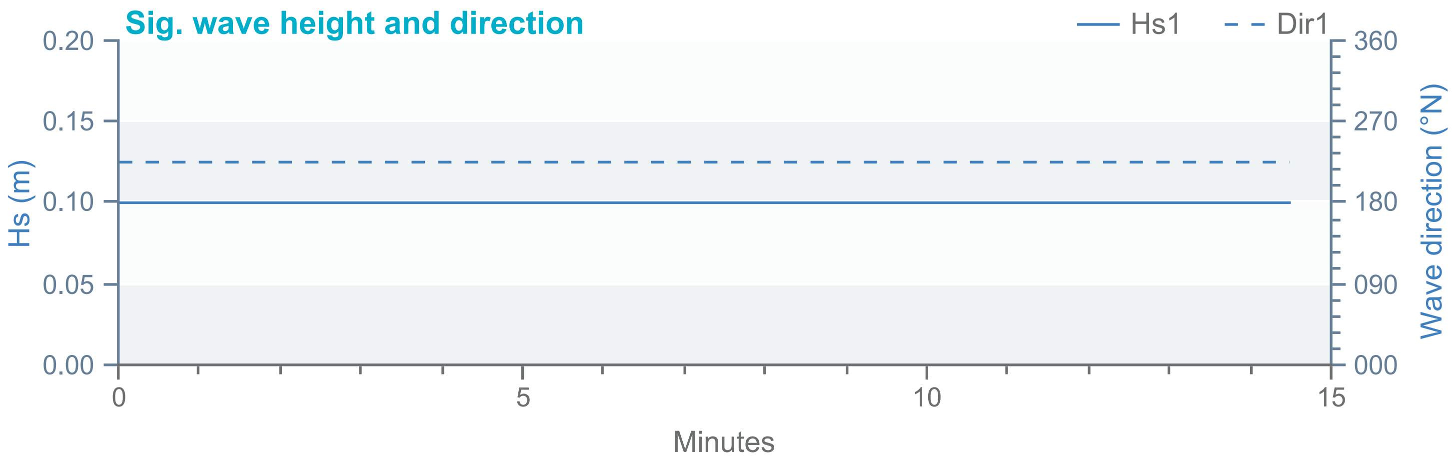
Manoeuvre track plot

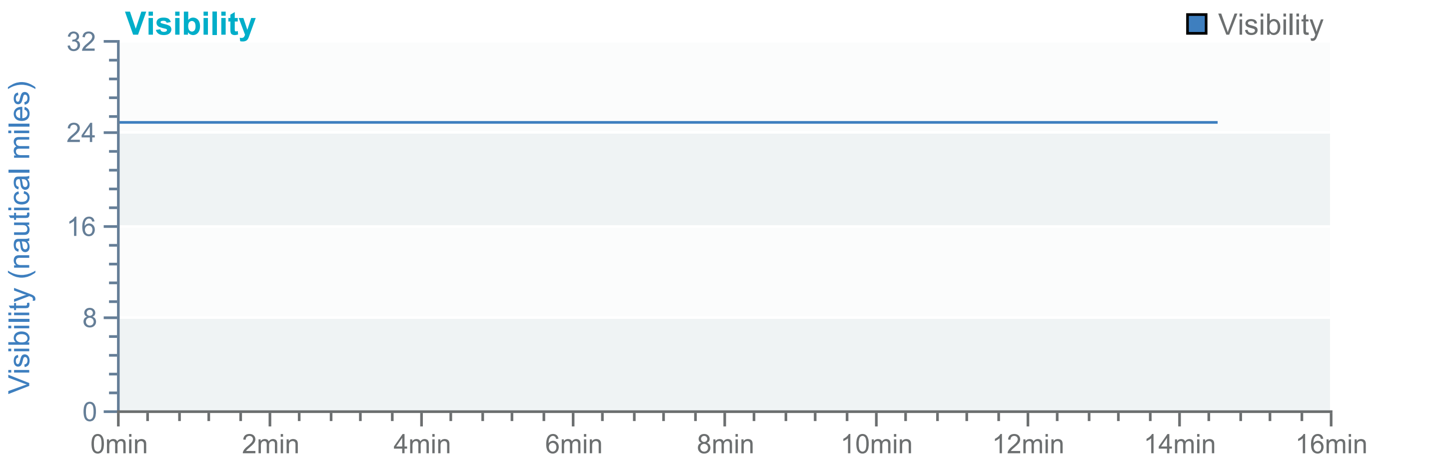


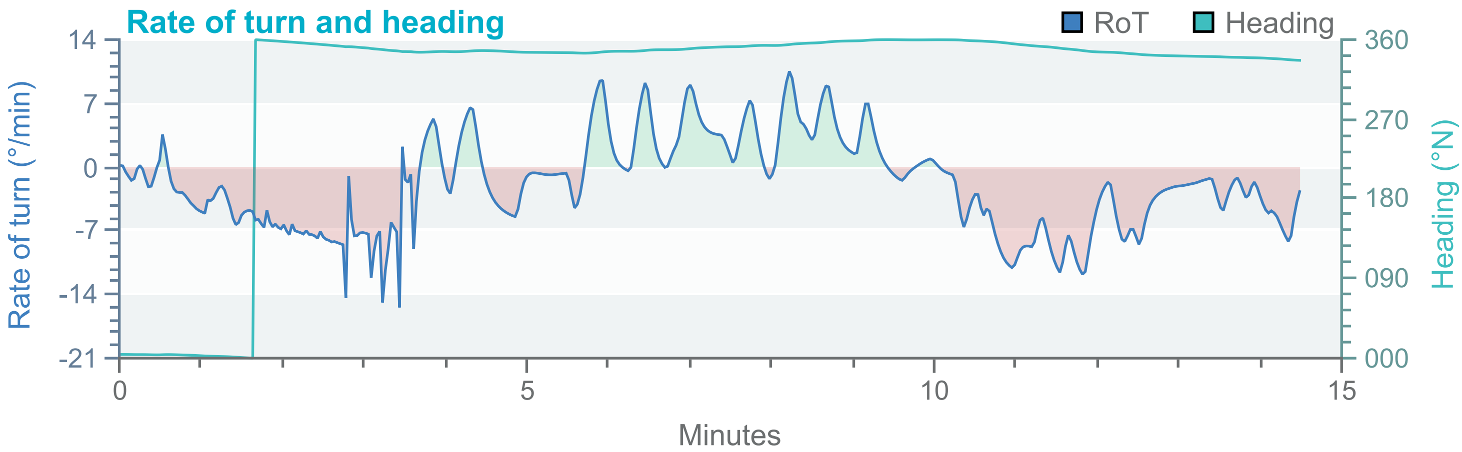
Ships plotted every 1 mins, highlight every 10 mins

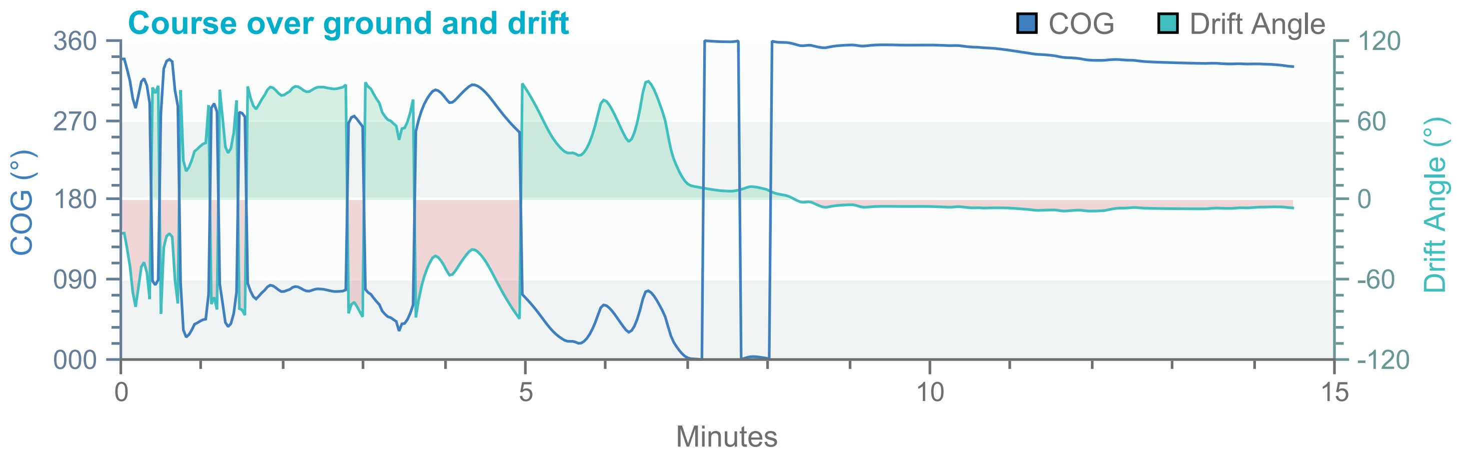

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
1.8
1.5
1.2
0.9
0.6
360
270
180
090
000
0
5
10
15

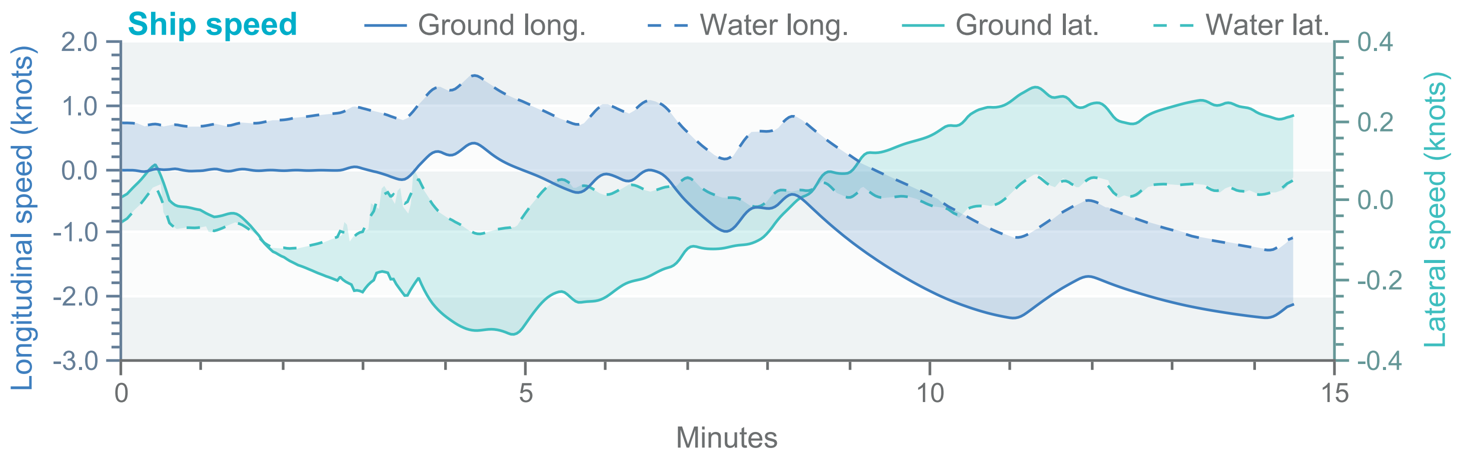

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15

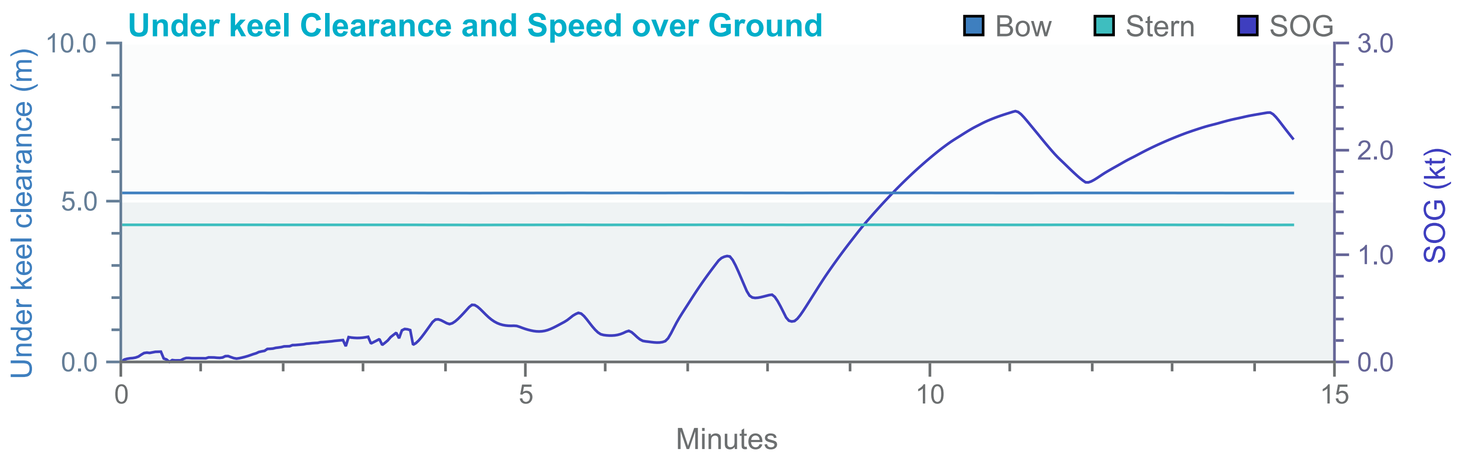

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15

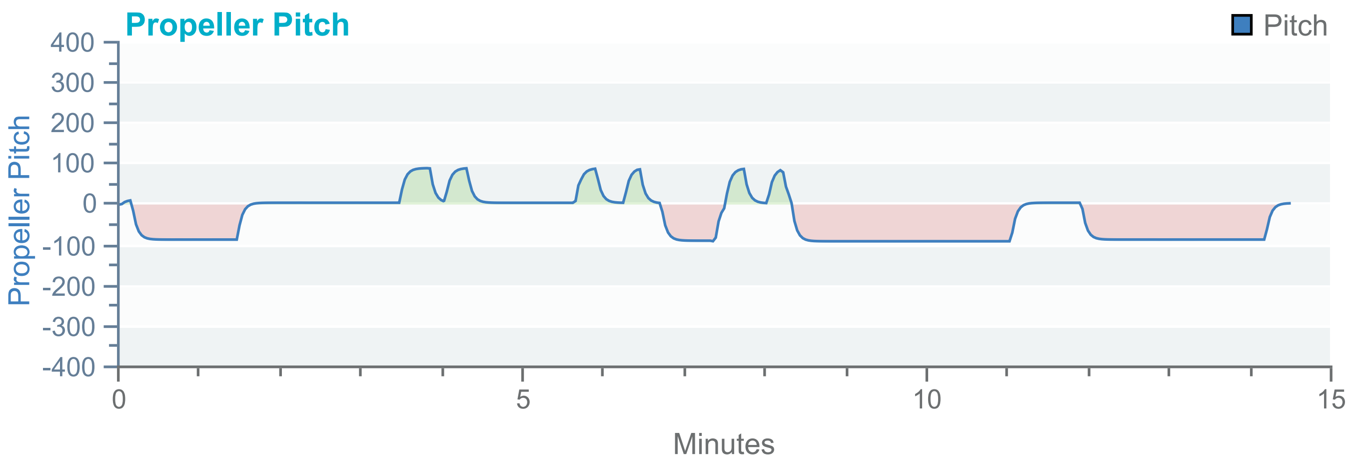

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min

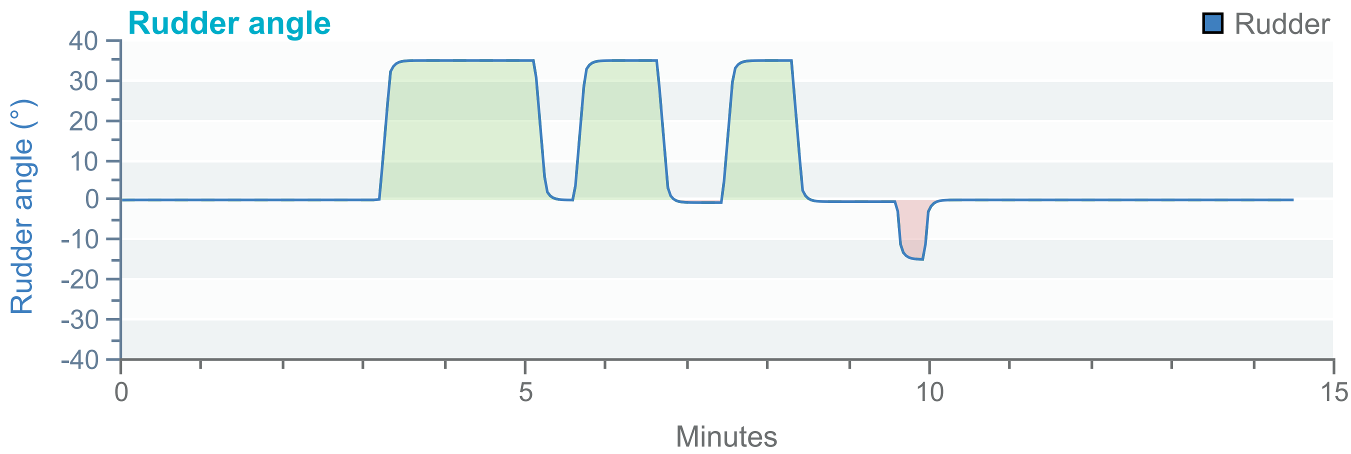

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
Minutes

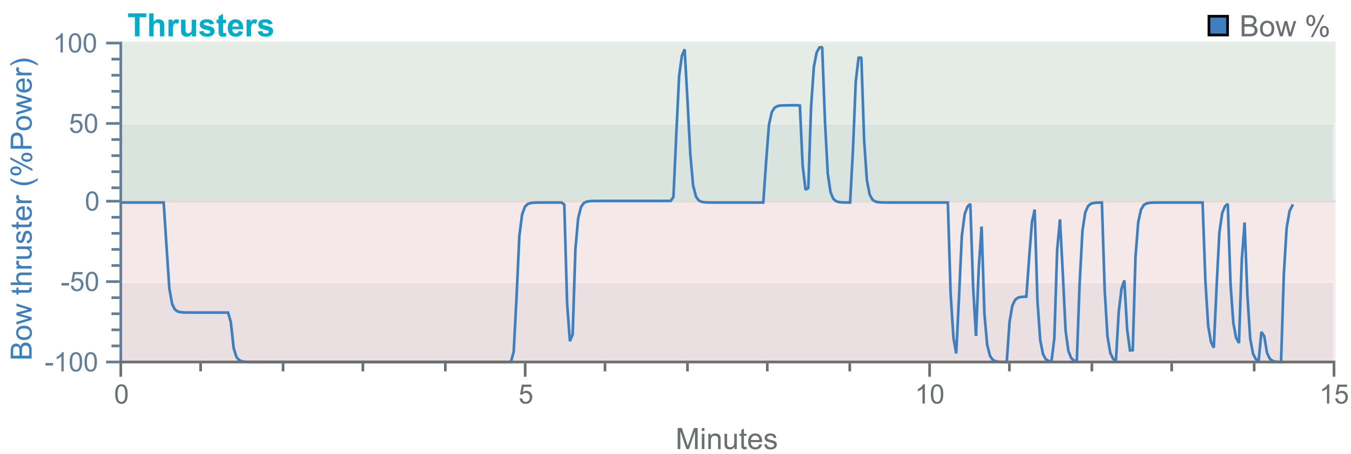

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
Minutes

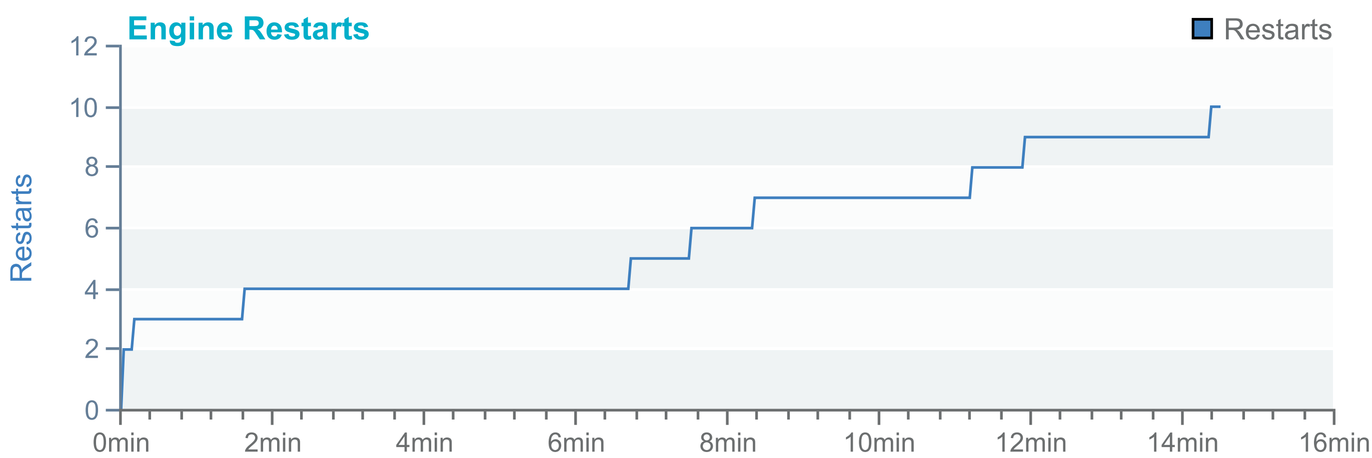

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
Minutes

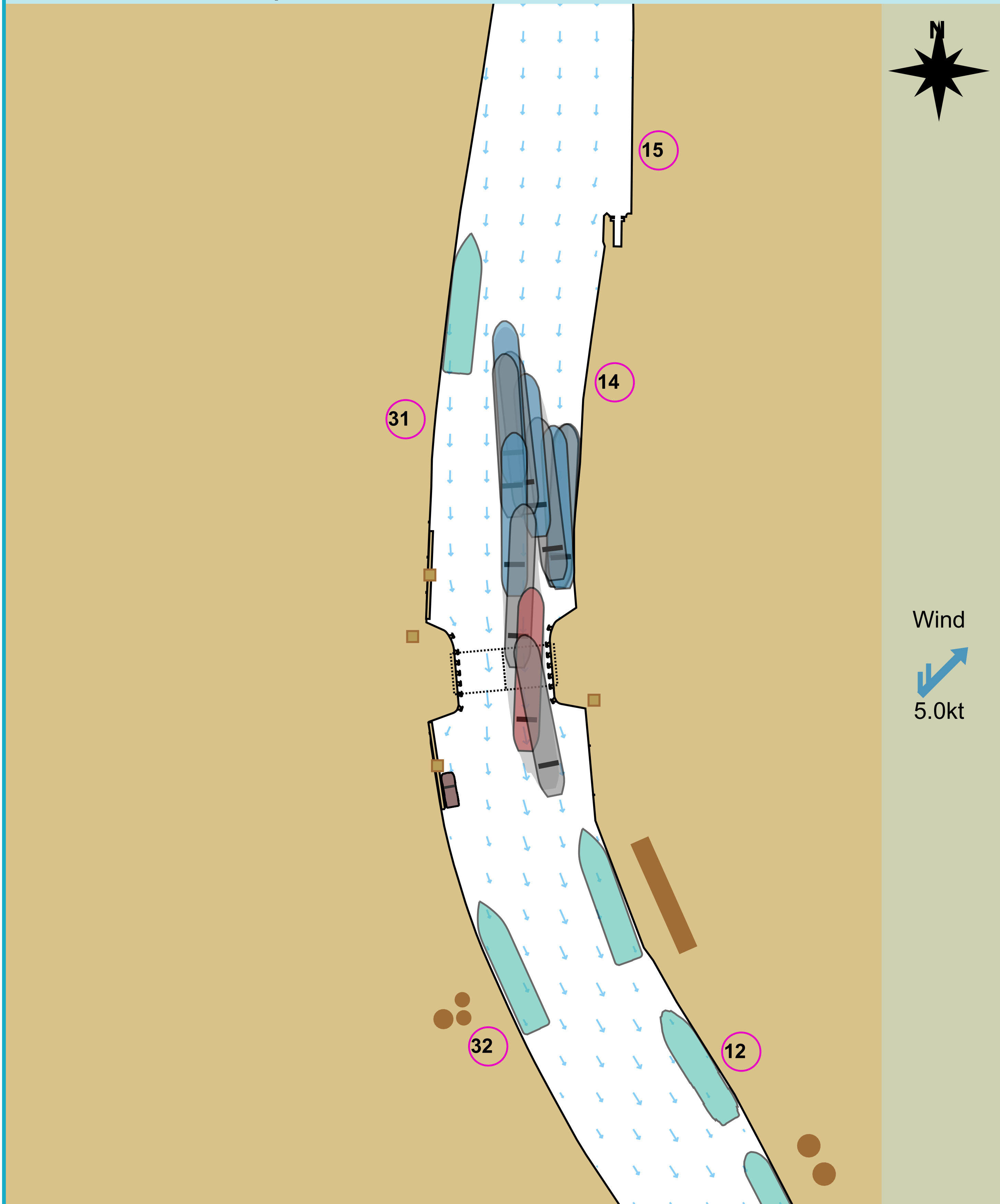

Propeller Pitch
Pitch
400
300
200
100
0
-100
-200
-300
-400
Propeller Pitch
0
5
10
15
Minutes


Rudder angle
Rudder
40
30
20
10
0
-10
-20
-30
-40
Rudder angle (°)
0
5
10
15
Minutes

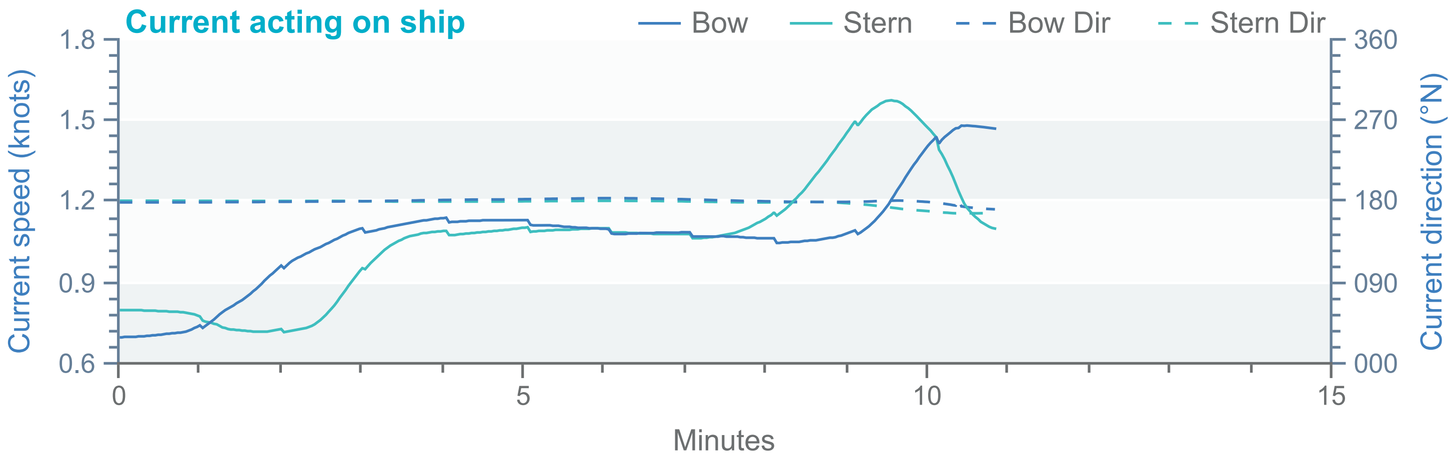

Thrusters
Bow %
100
50
0
-50
-100
Bow thruster (%Power)
0
5
10
15
Minutes

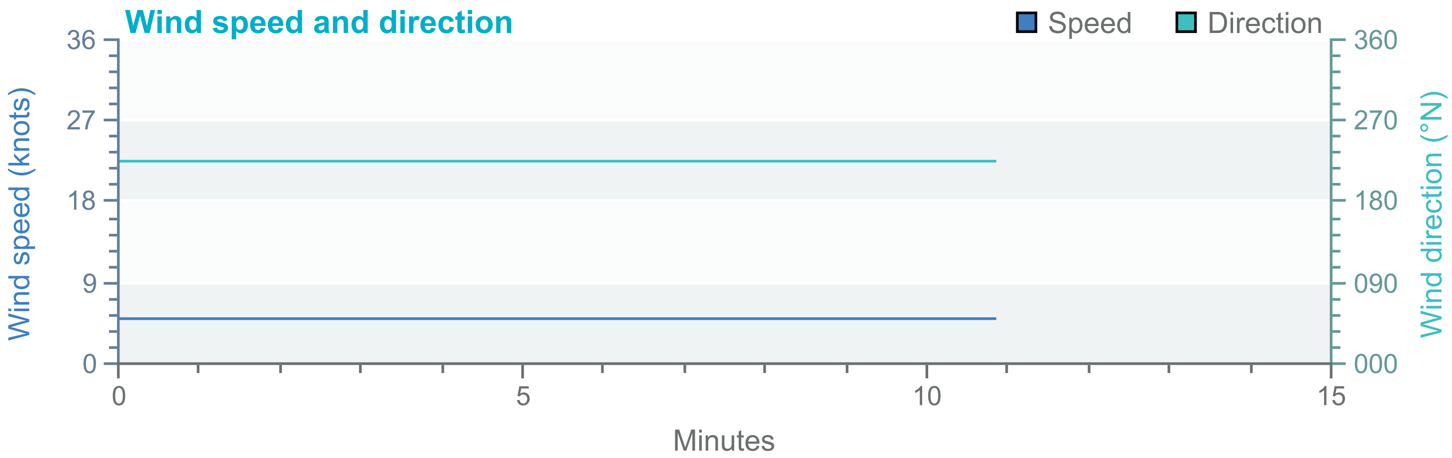

Engine Restarts
Restarts
12
10
8
6
4
2
0
Restarts
0min
2min
4min
6min
8min
10min
12min
14min
16min

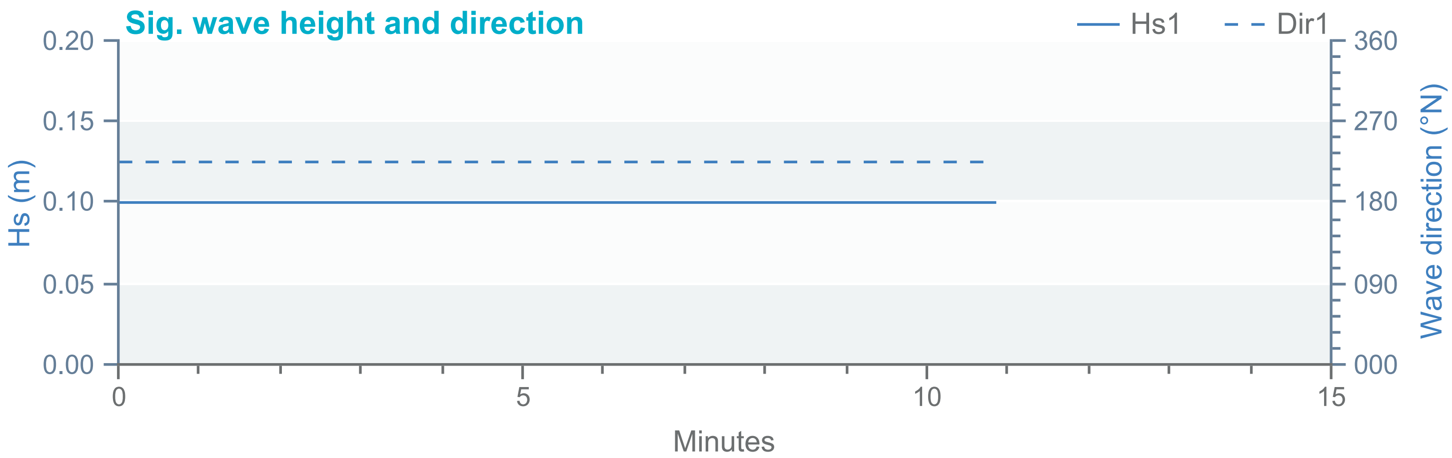
Manoeuvre track plot

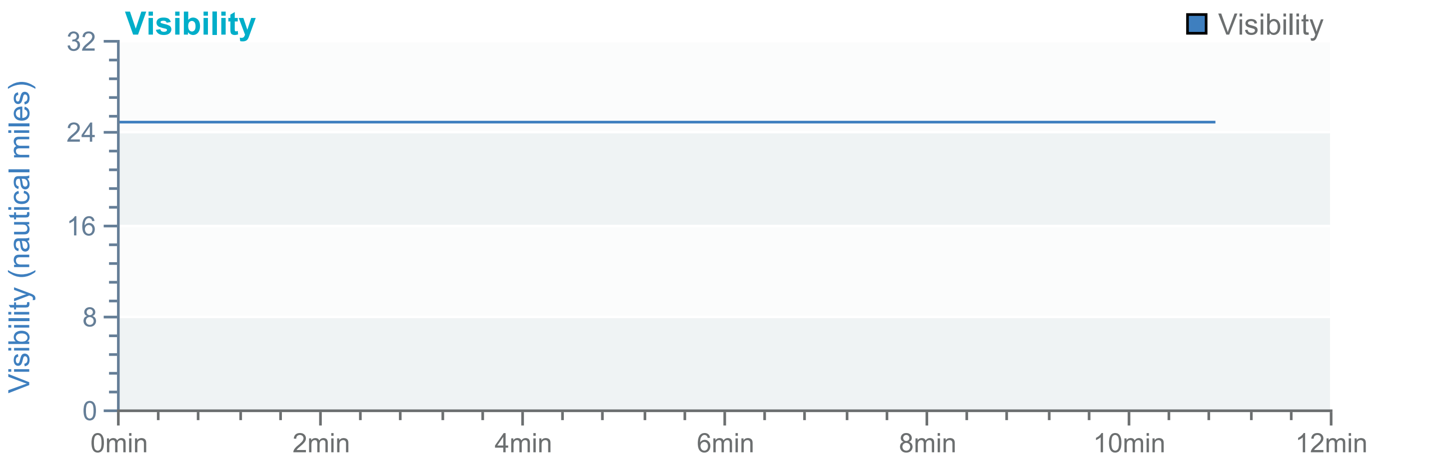


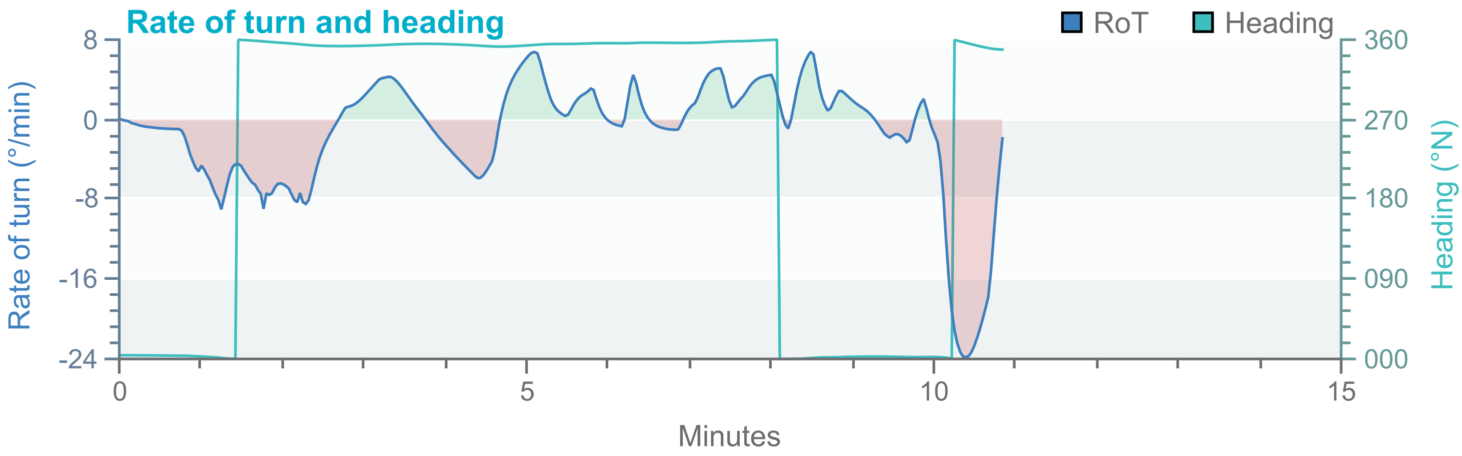
Ships plotted every 1 mins, highlight every 10 mins

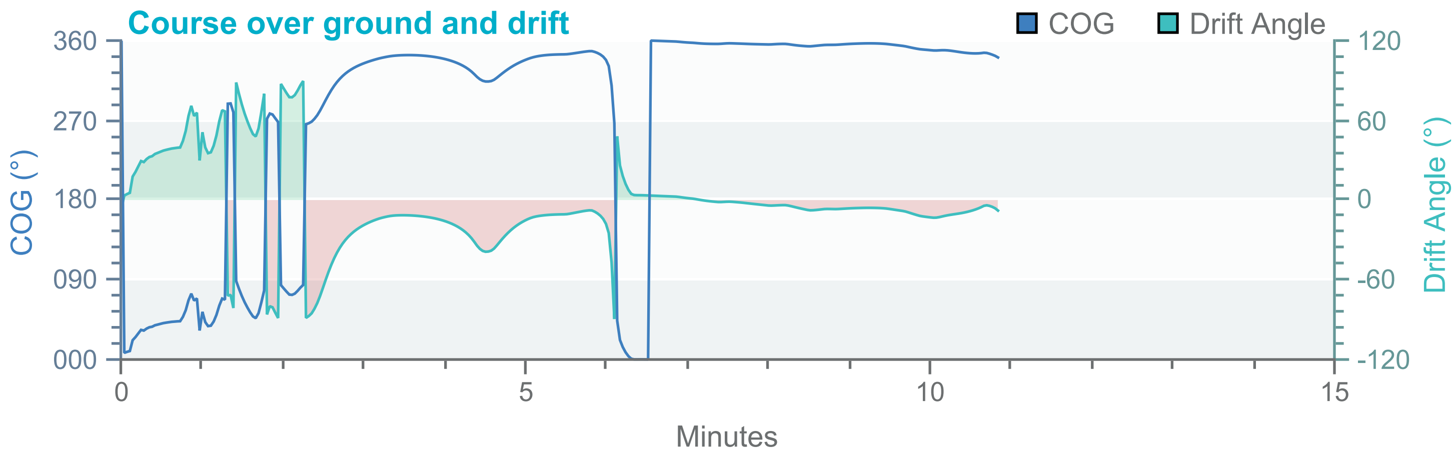

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
1.8
1.5
1.2
0.9
0.6
360
270
180
090
000
0
5
10
15
Minutes

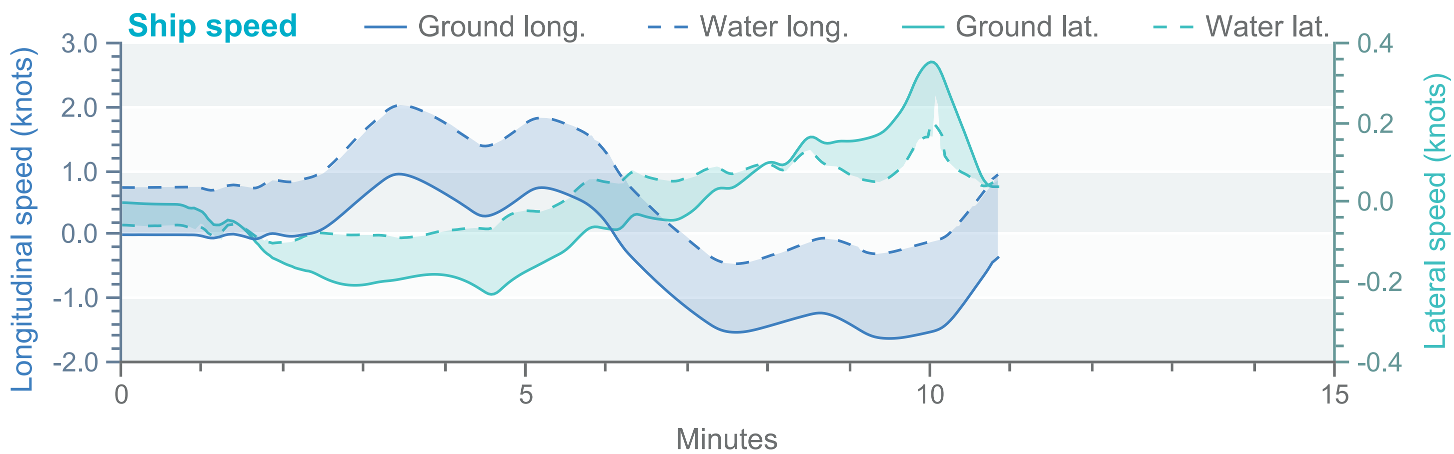

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
Minutes

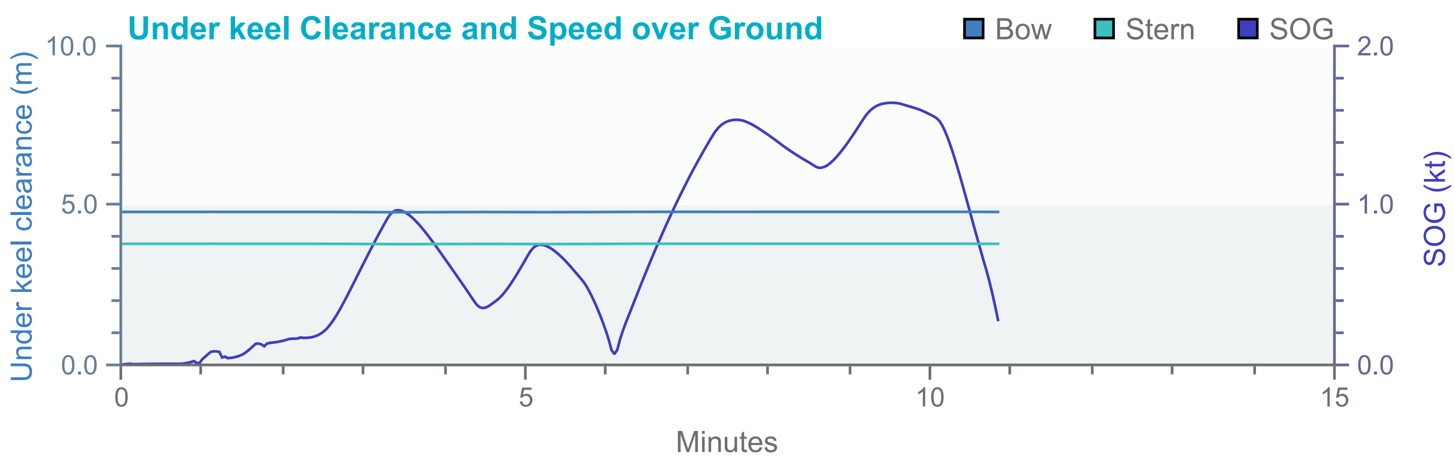

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
Minutes

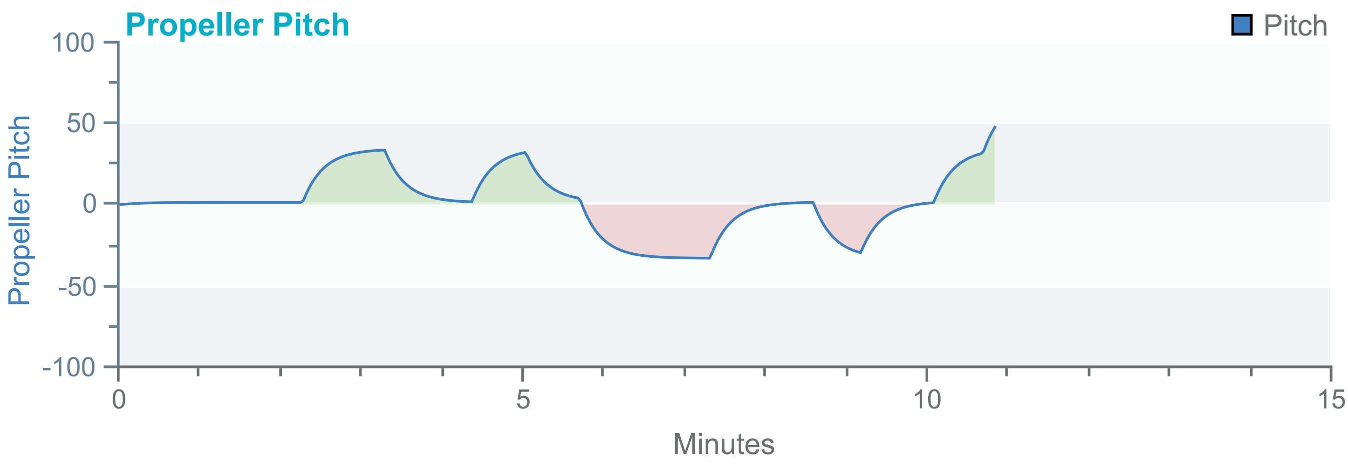

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min

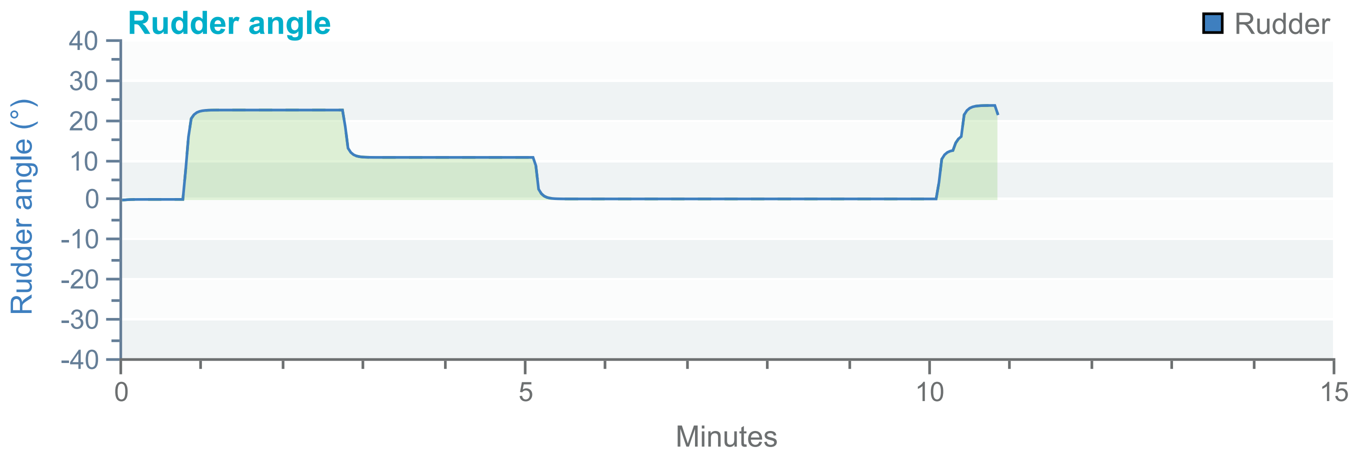

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
8
0
-8
-16
-24
Heading (°N)
360
270
180
090
000
0
5
10
15
Minutes

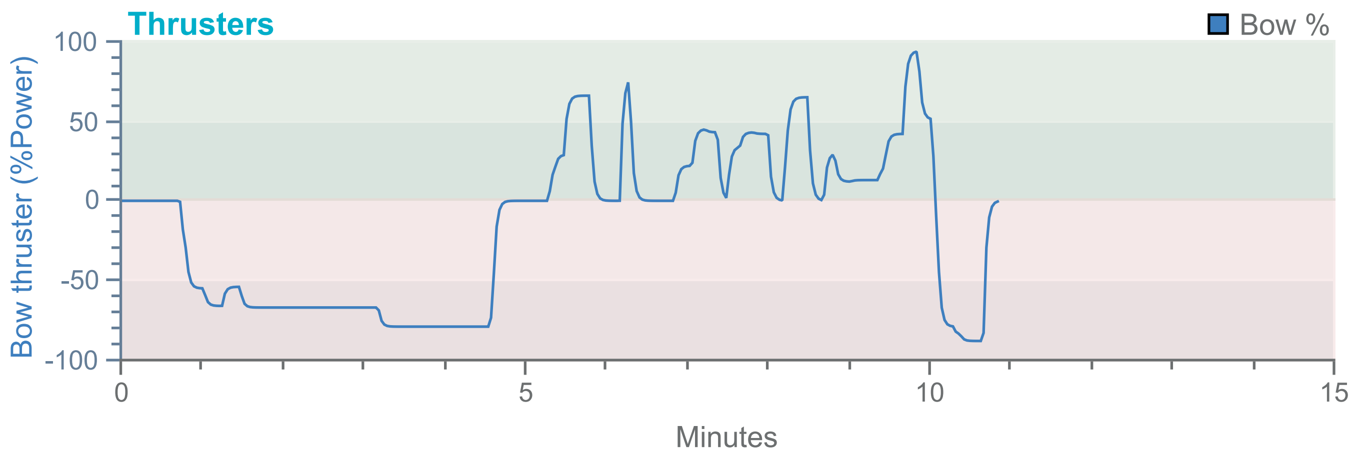

Course over ground and drift
COG
Drift Angle
COG (°)
360
270
180
090
000
Drift Angle (°)
120
60
0
-60
-120
0
5
10
15
Minutes

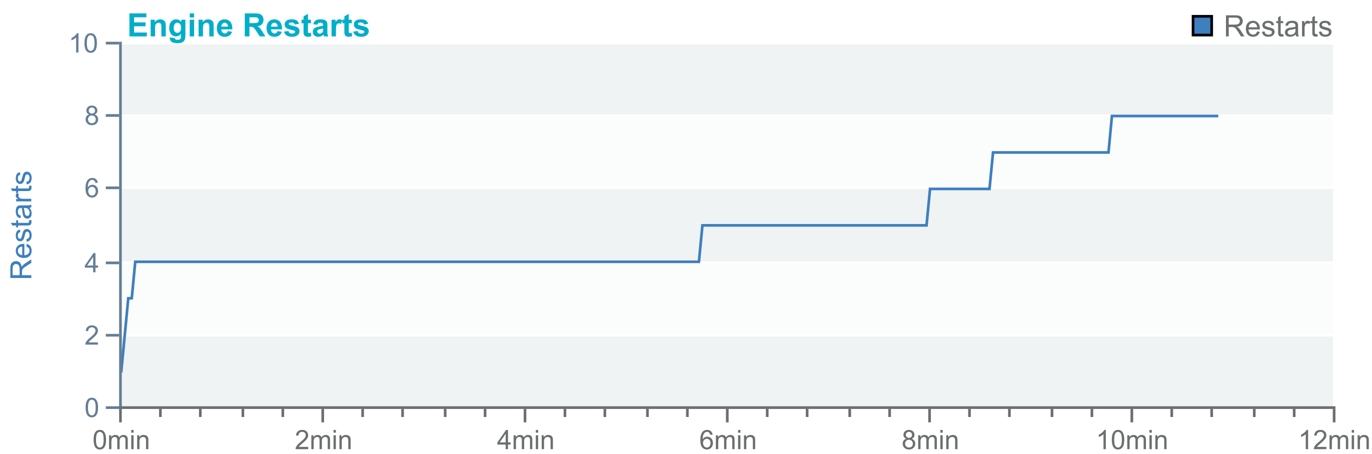

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
3.0
2.0
1.0
0.0
-1.0
-2.0
Lateral speed (knots)
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
10.0
5.0
0.0
SOG (kt)
2.0
1.0
0.0
0
5
10
15
Minutes

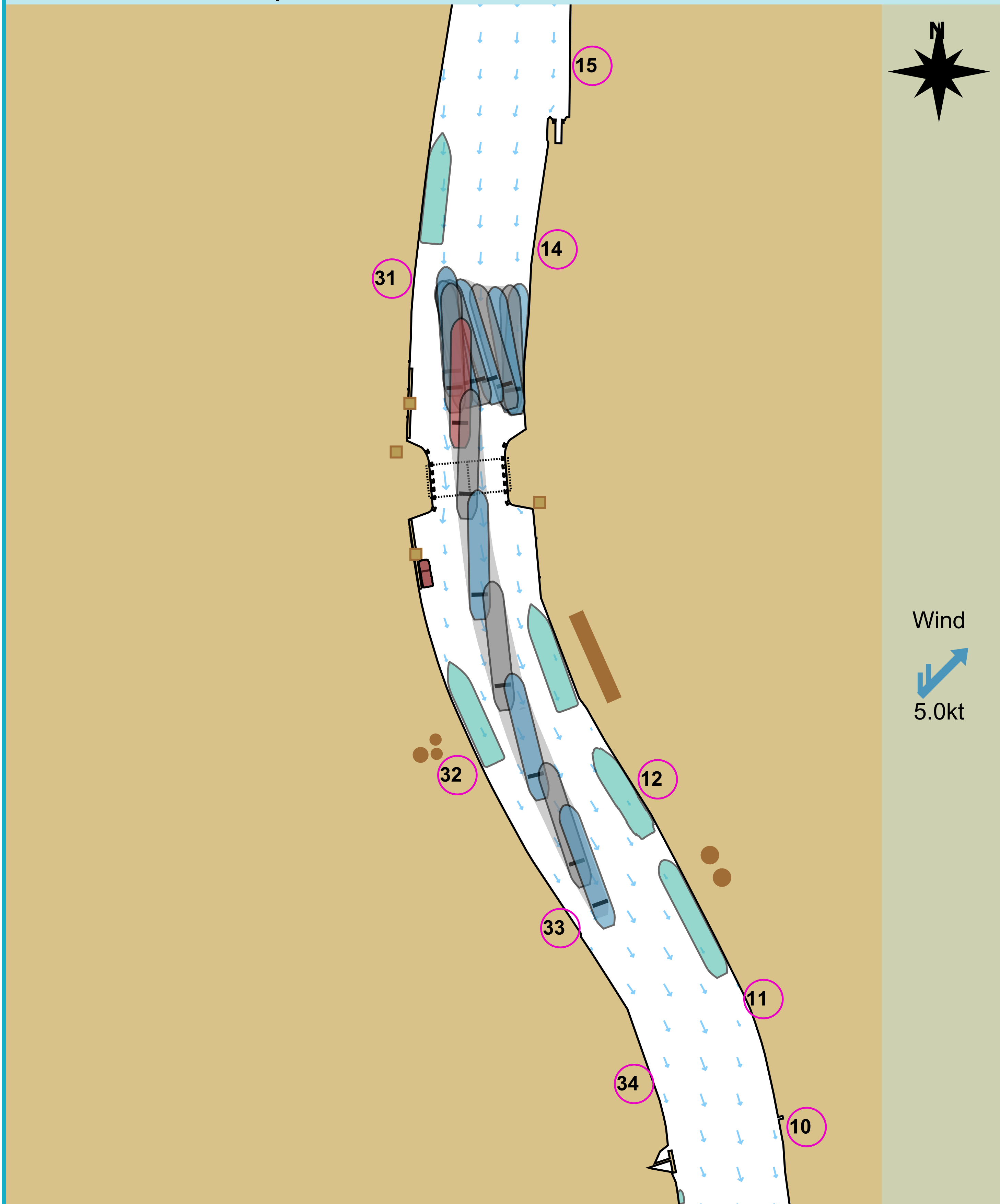

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
Minutes

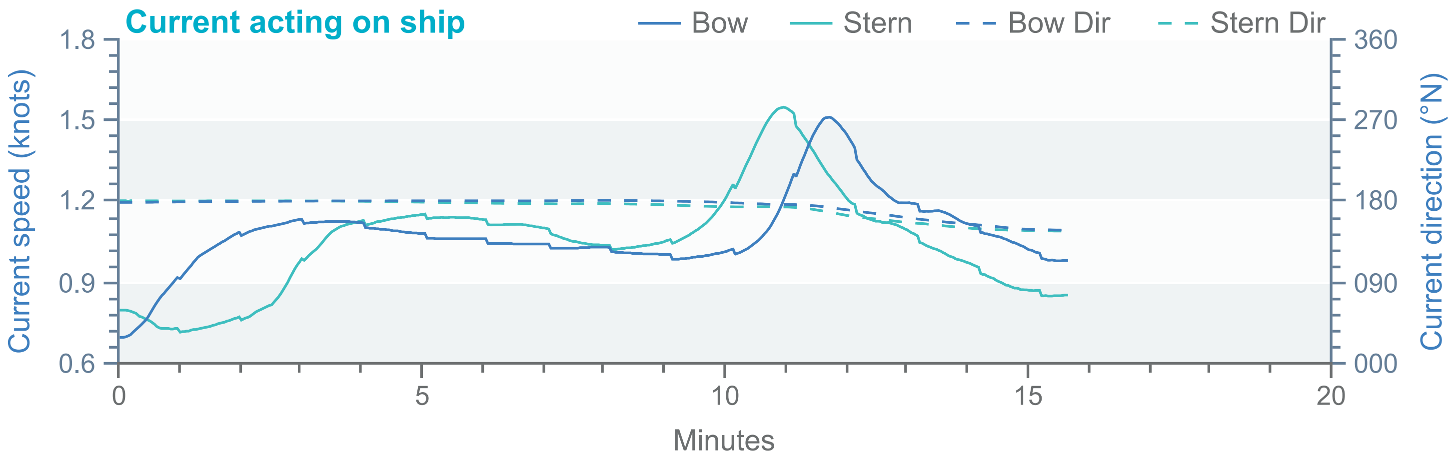

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
15
Minutes

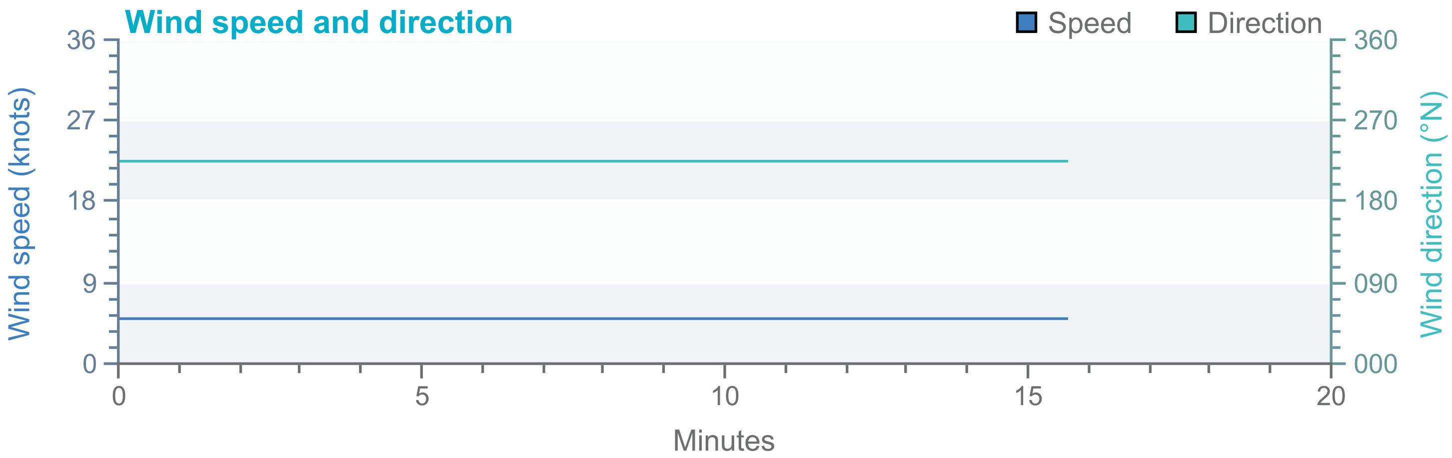

Engine Restarts
Restarts
Restarts
10
8
6
4
2
0
0min
2min
4min
6min
8min
10min
12min

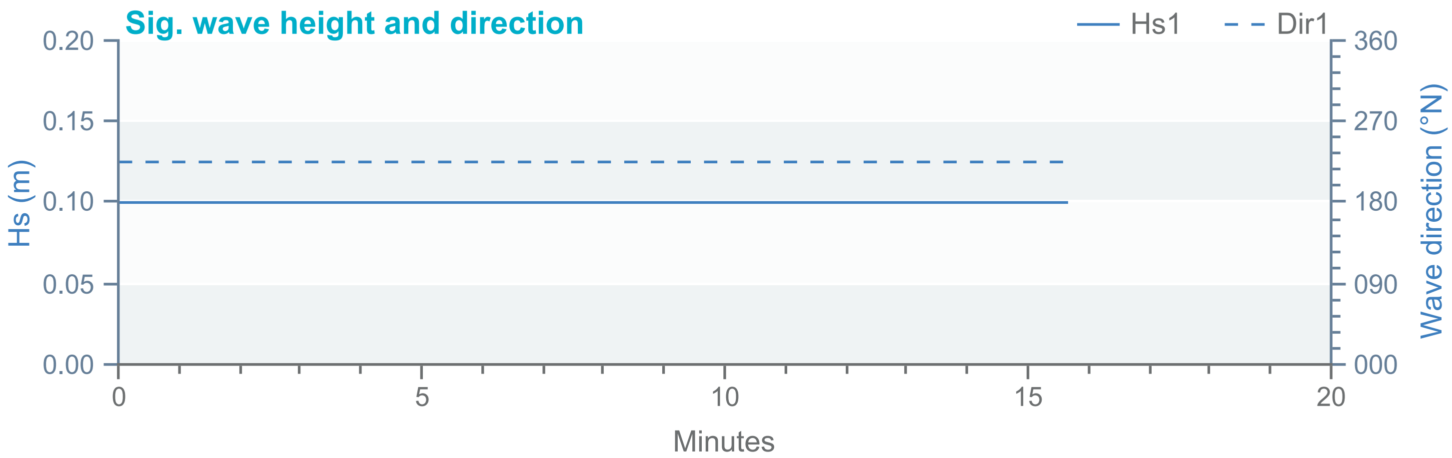
Manoeuvre track plot

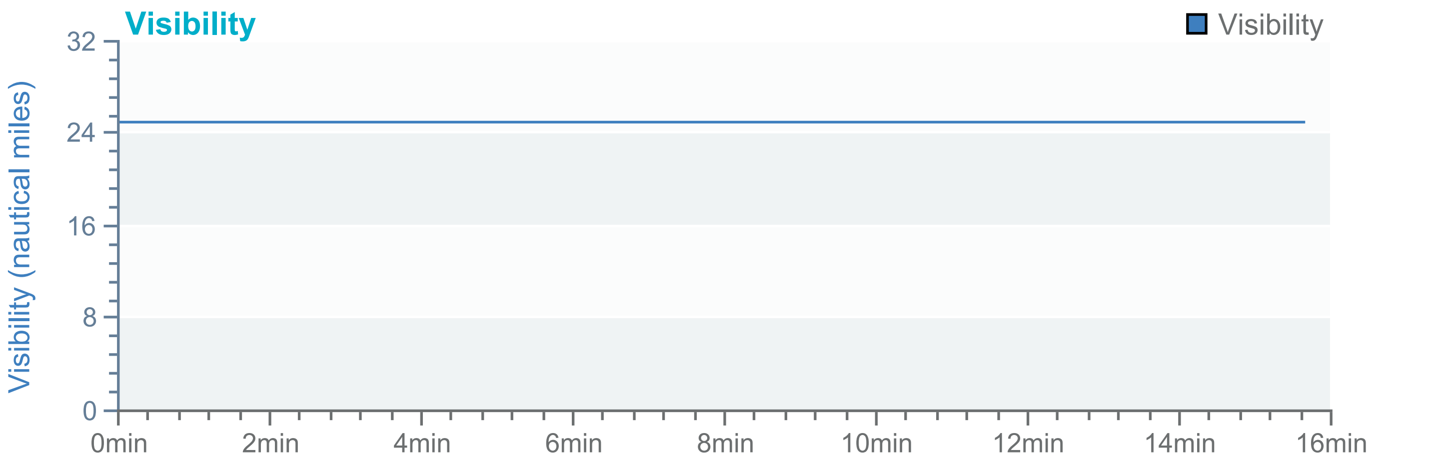


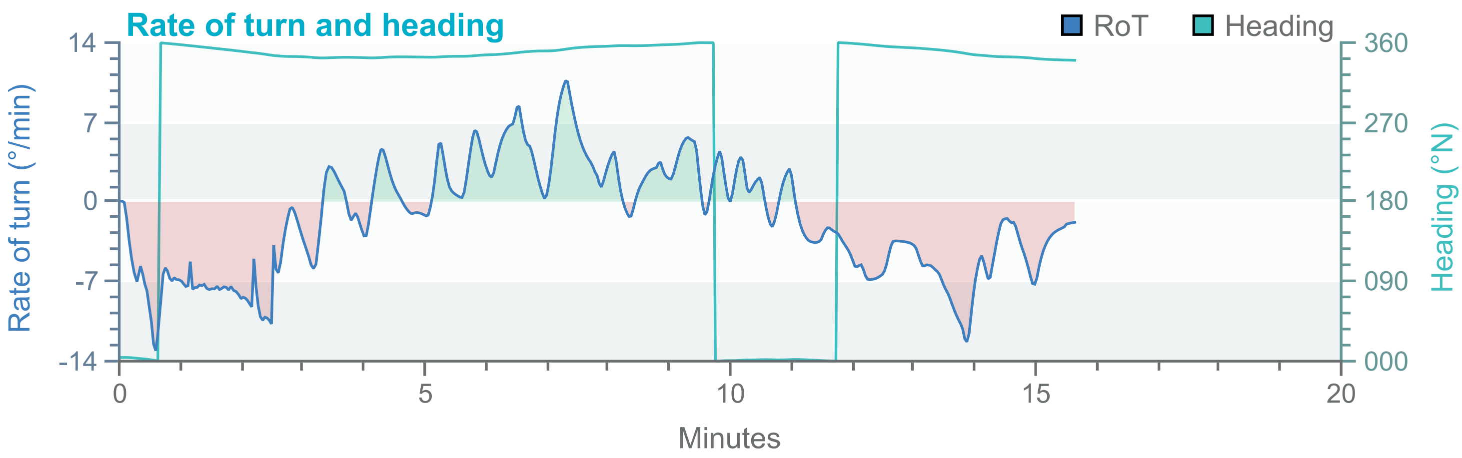
Ships plotted every 1 mins, highlight every 10 mins

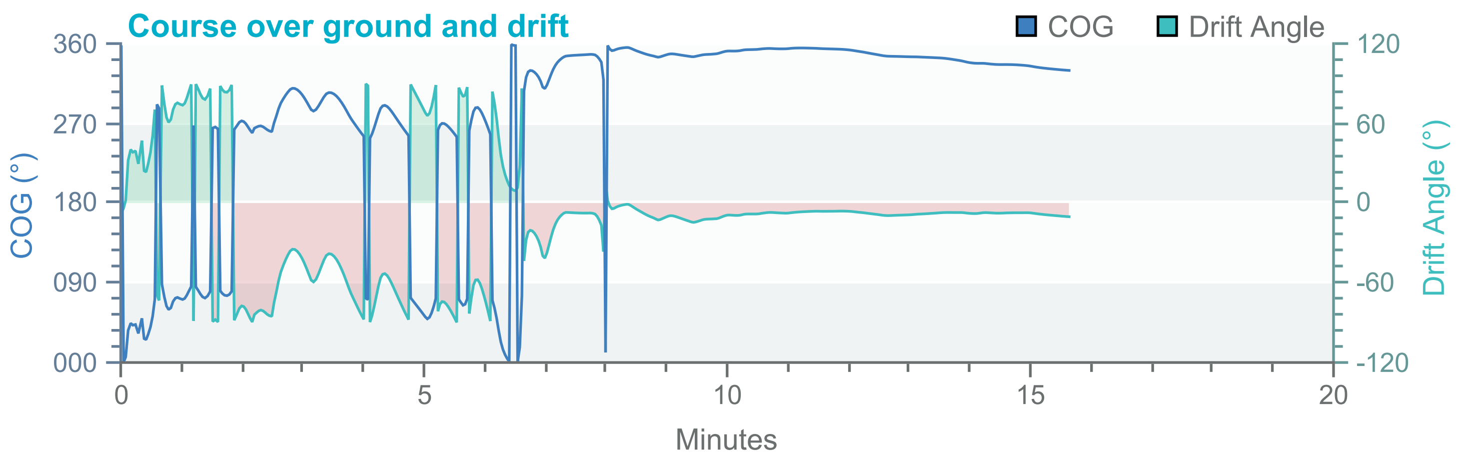

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
0.6
0.9
1.2
1.5
1.8
000
090
180
270
360
0
5
10
15
20

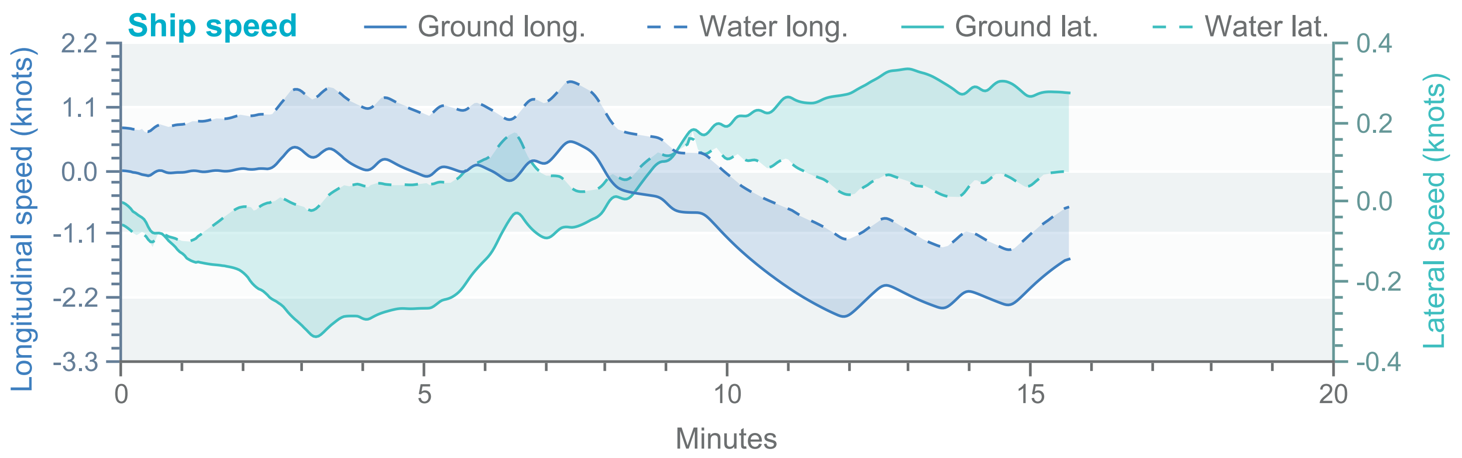

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
0
9
18
27
36
000
090
180
270
360
0
5
10
15
20

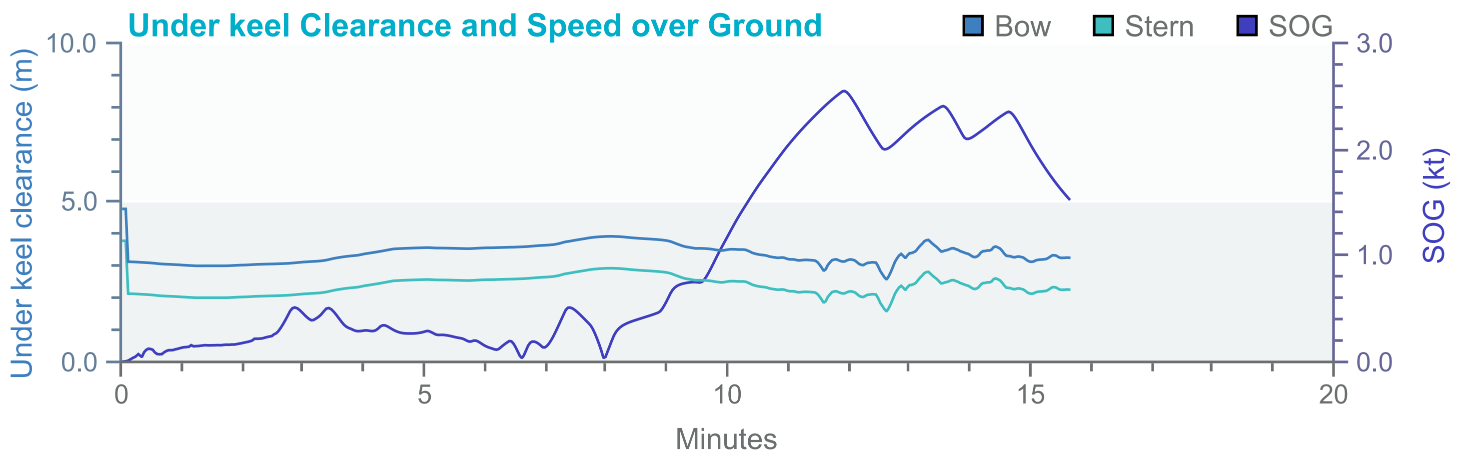

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.00
0.05
0.10
0.15
0.20
000
090
180
270
360
0
5
10
15
20

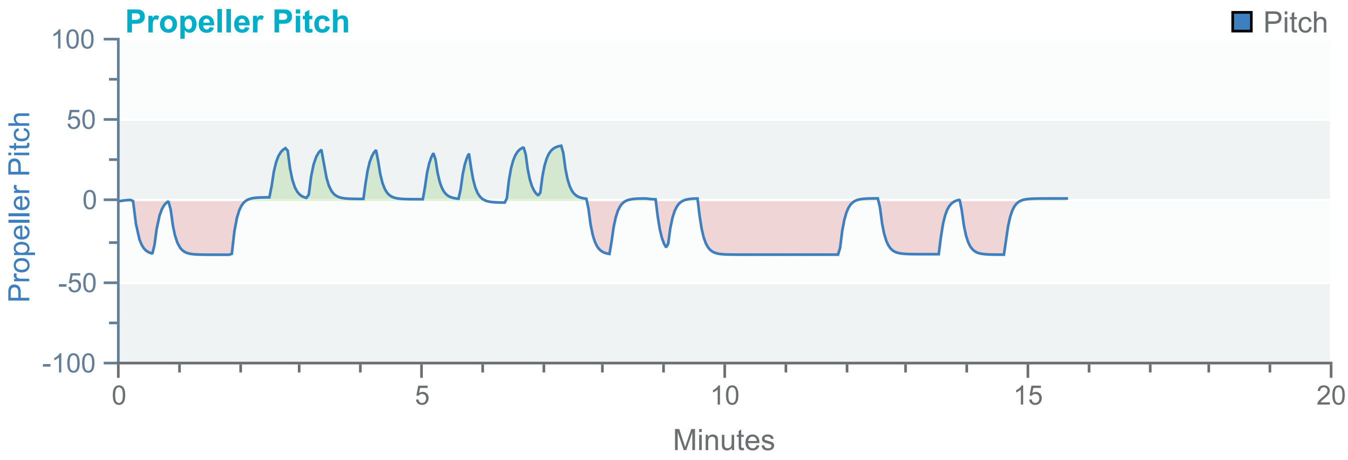

Visibility
Visibility
Visibility (nautical miles)
0
8
16
24
32
0min
2min
4min
6min
8min
10min
12min
14min
16min

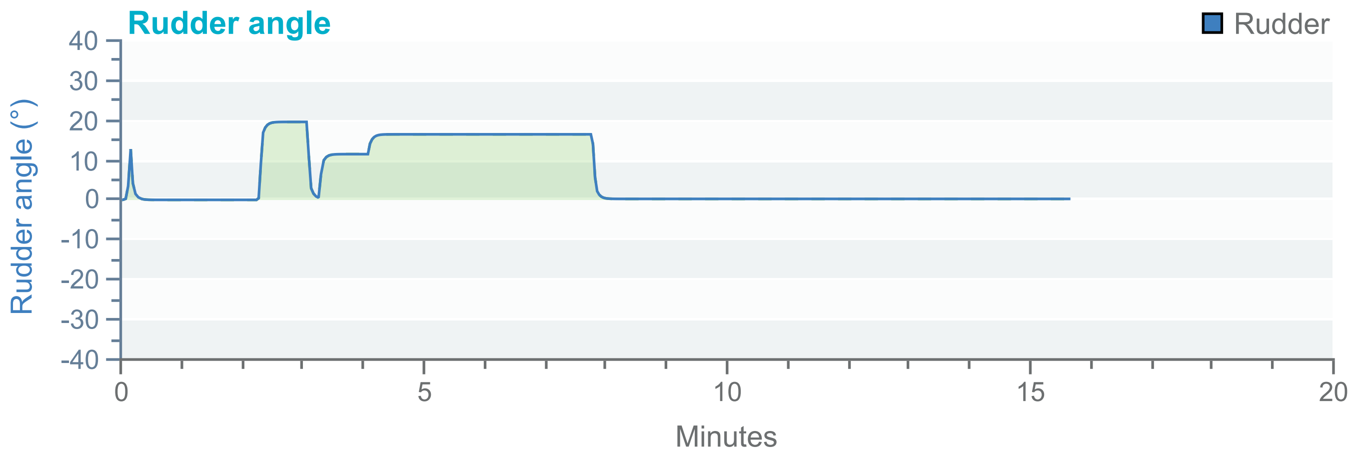

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
14
7
0
-7
-14
360
270
180
090
000
0
5
10
15
20
Minutes

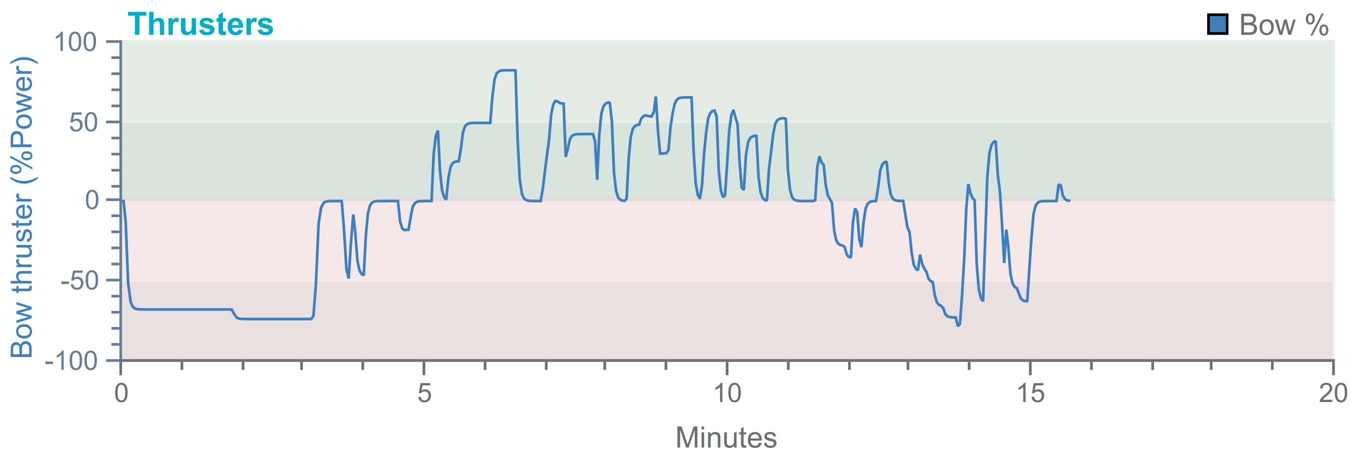

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
Minutes

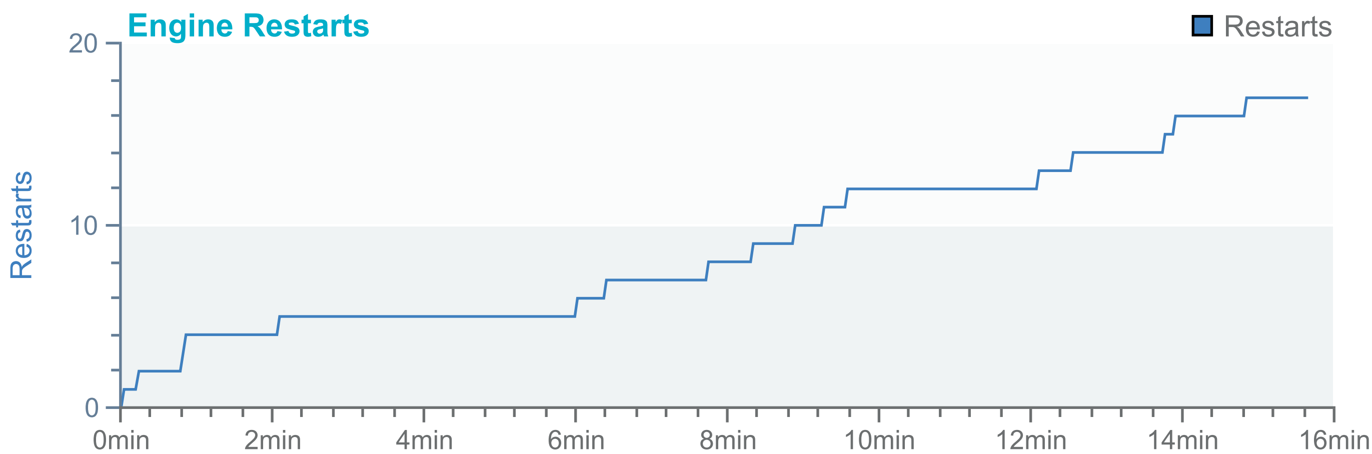

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
2.2
1.1
0.0
-1.1
-2.2
-3.3
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
3.0
2.0
1.0
0.0
0
5
10
15
20
Minutes

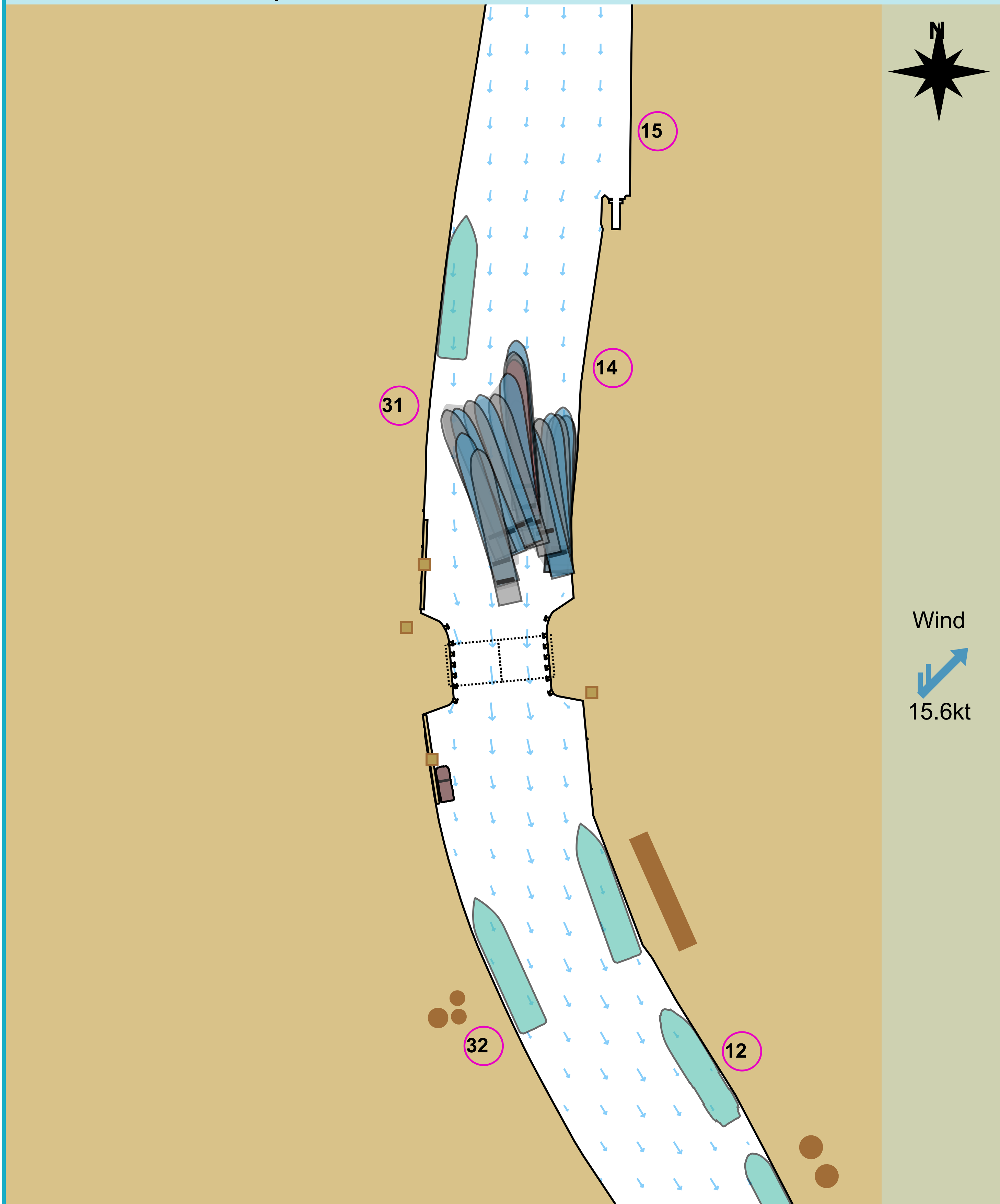

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
20
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
20
Minutes

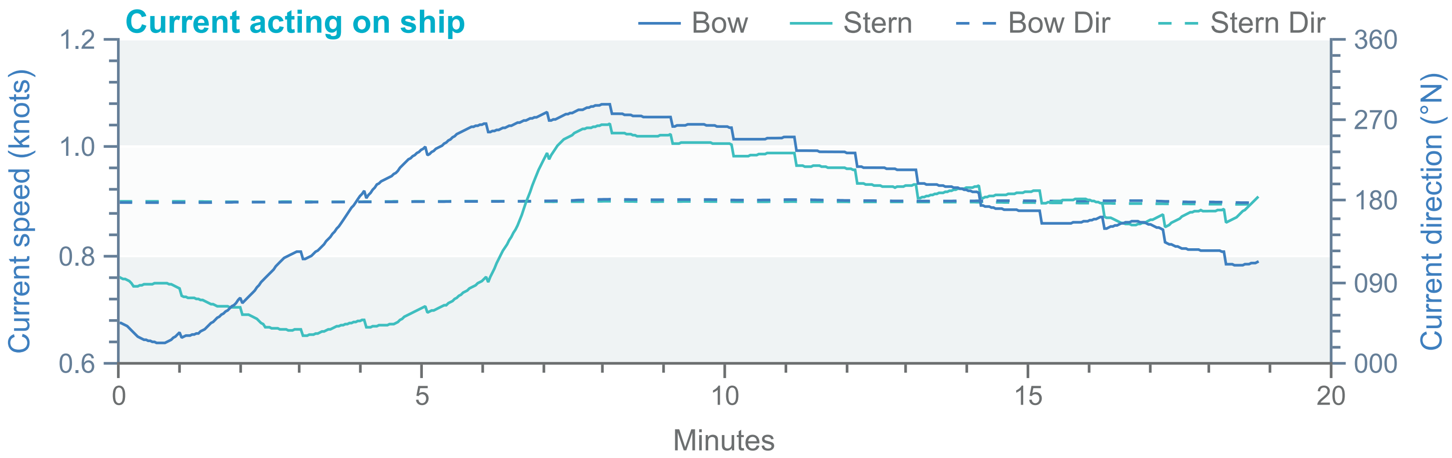

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
Minutes

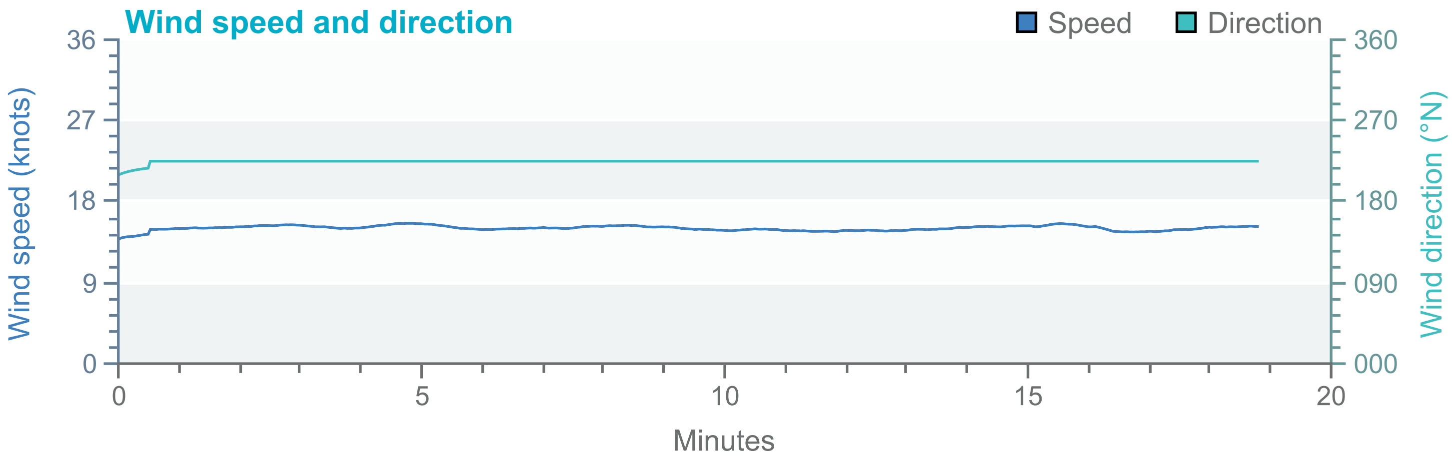

Engine Restarts
Restarts
Restarts
20
10
0
0min
2min
4min
6min
8min
10min
12min
14min
16min

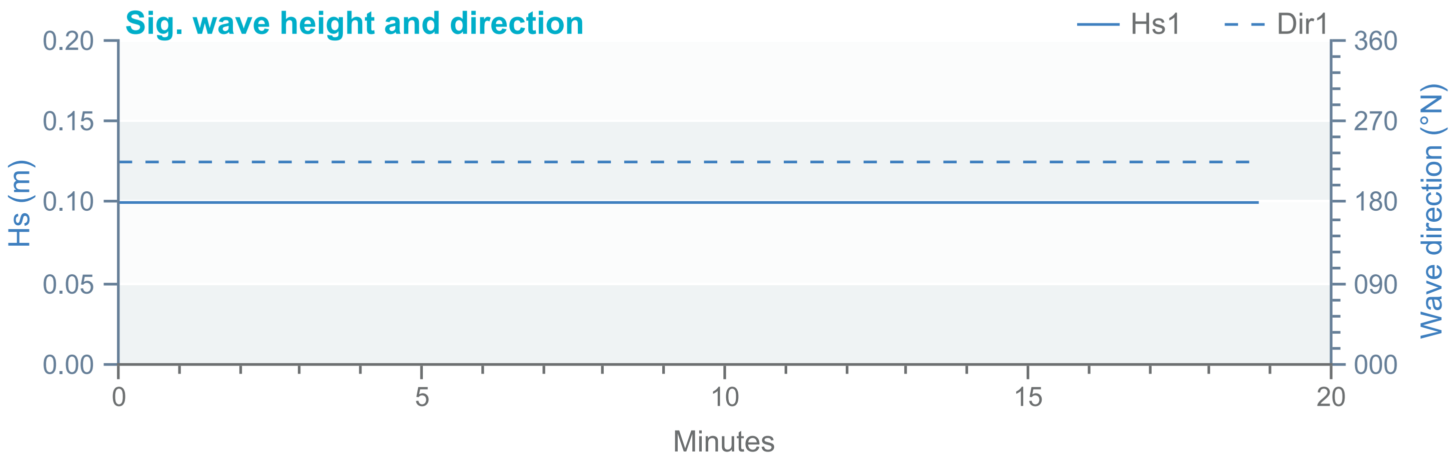
Manoeuvre track plot

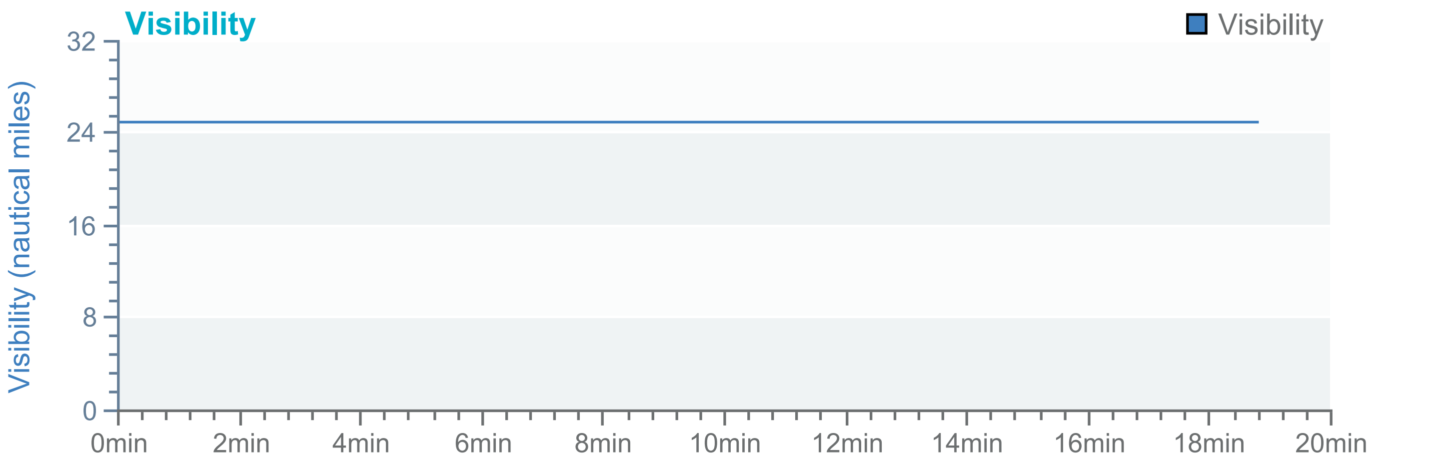


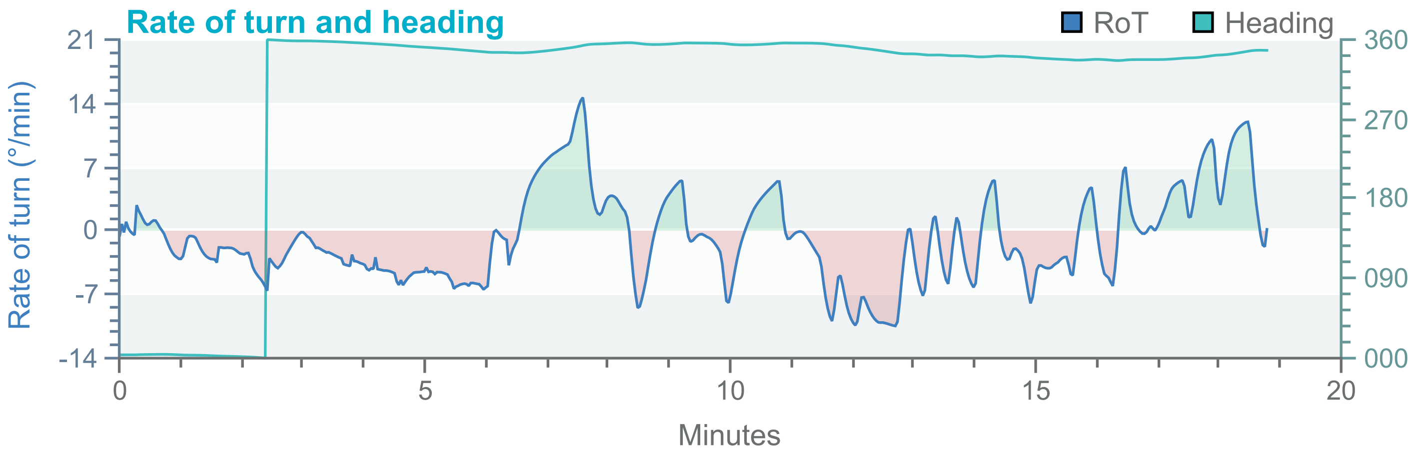
Ships plotted every 1 mins, highlight every 10 mins

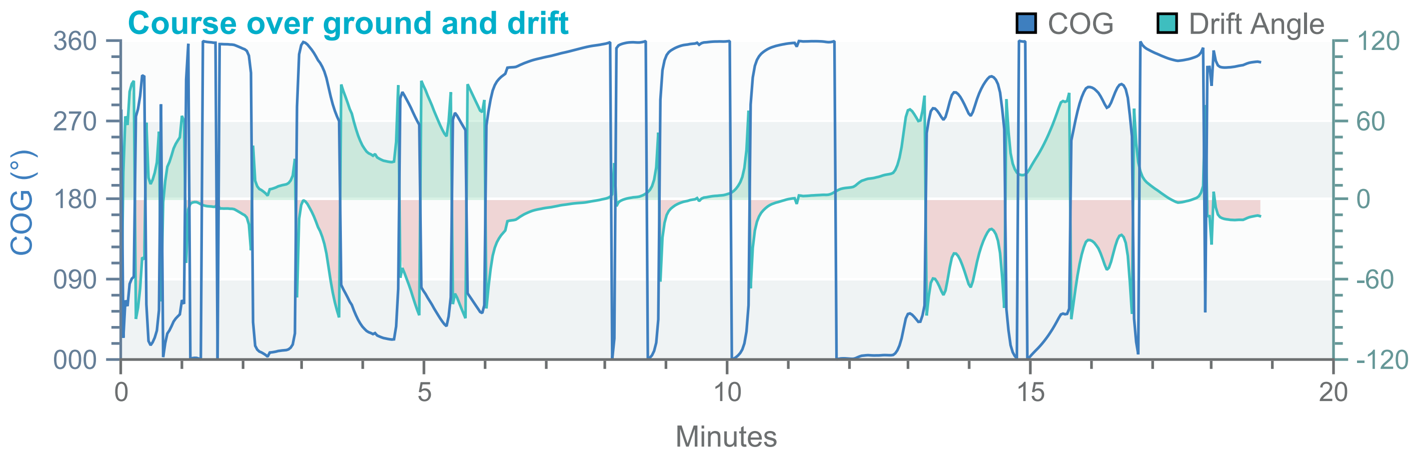

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
1.2
1.0
0.8
0.6
360
270
180
090
000
0
5
10
15
20
Minutes

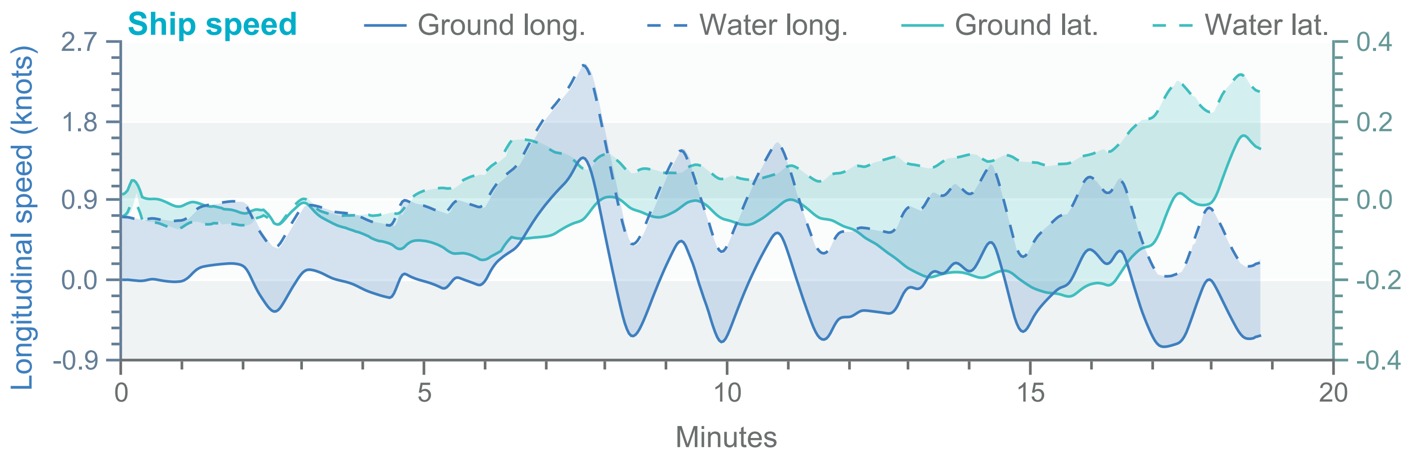

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
Minutes

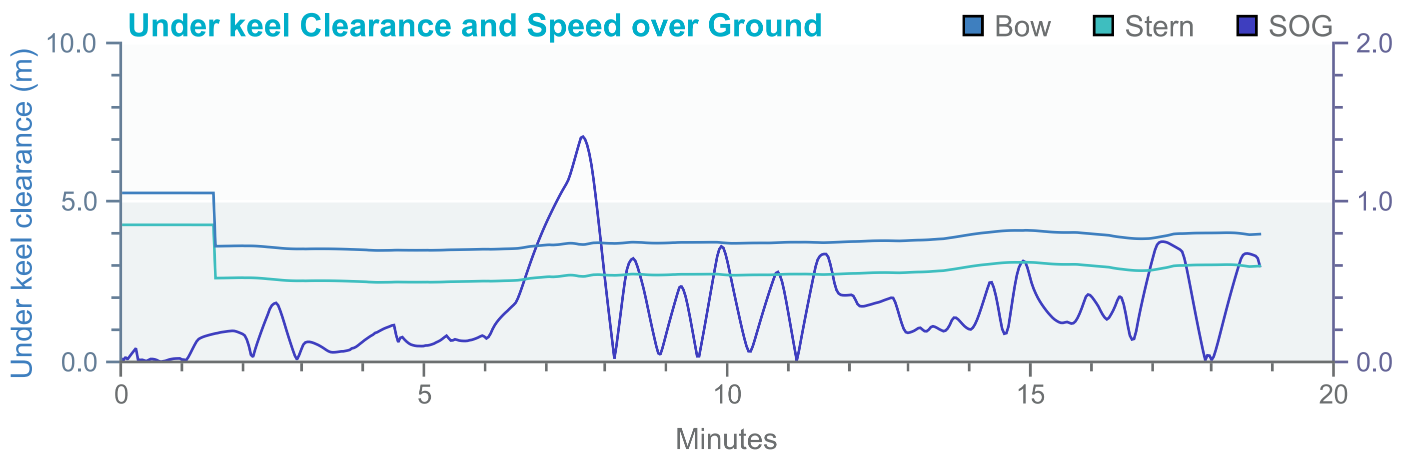

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
Minutes

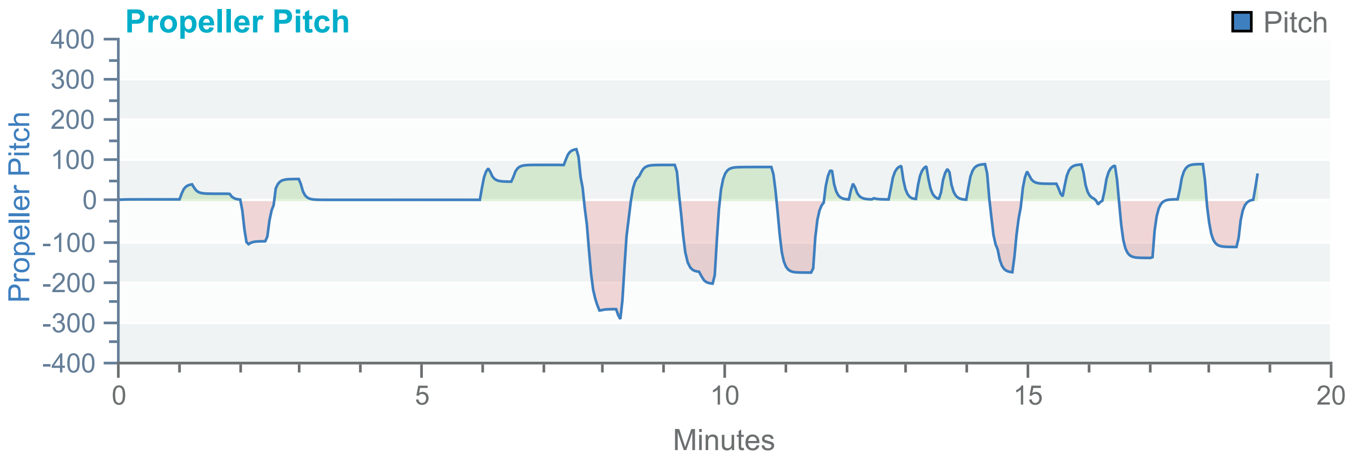

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

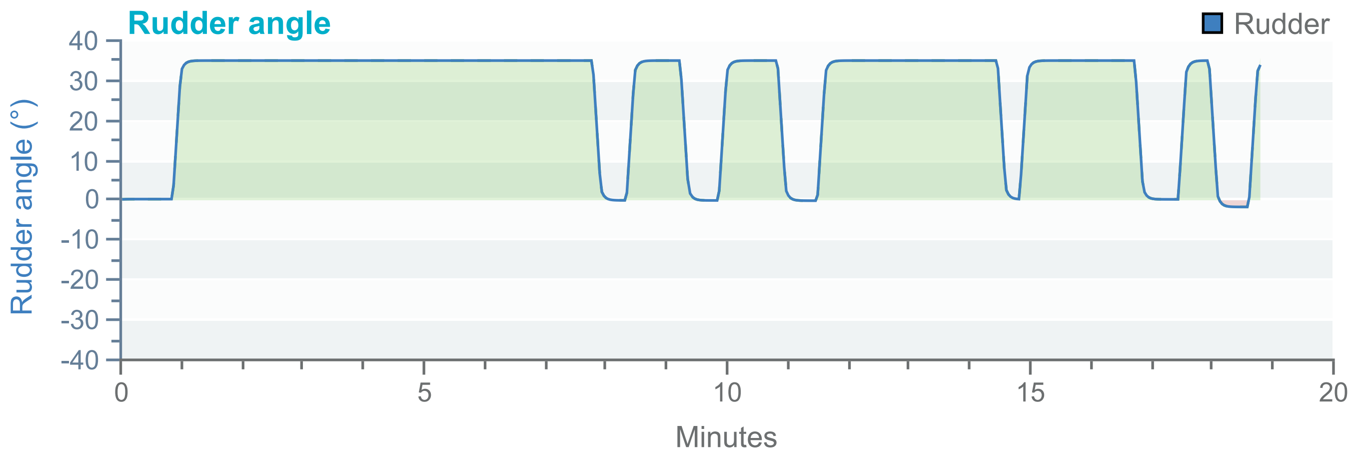

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
21
14
7
0
-7
-14
360
270
180
090
000
0
5
10
15
20
Minutes

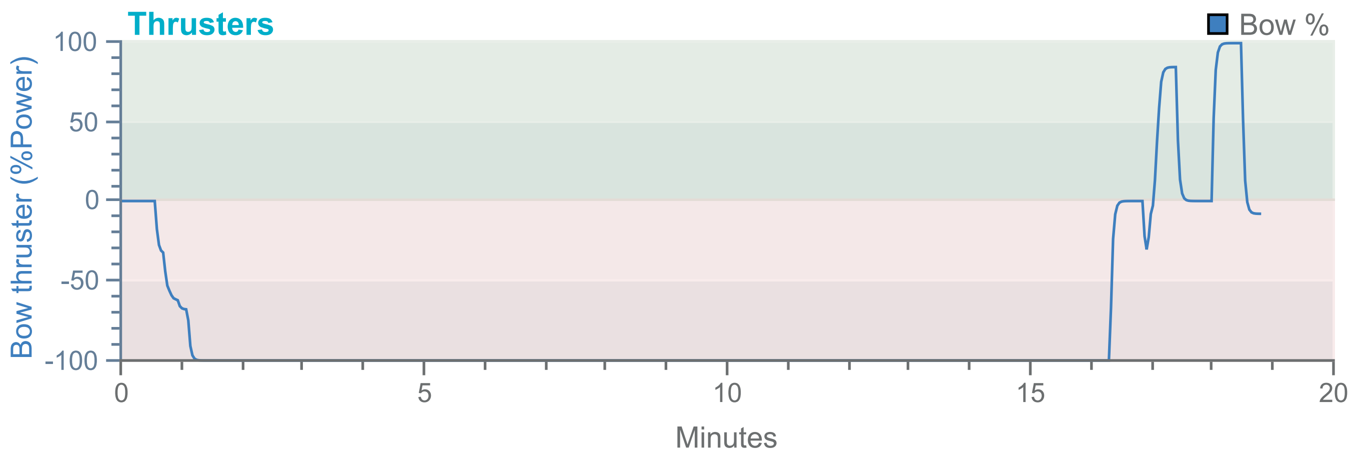

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
120
60
0
-60
-120
0
5
10
15
20
Minutes

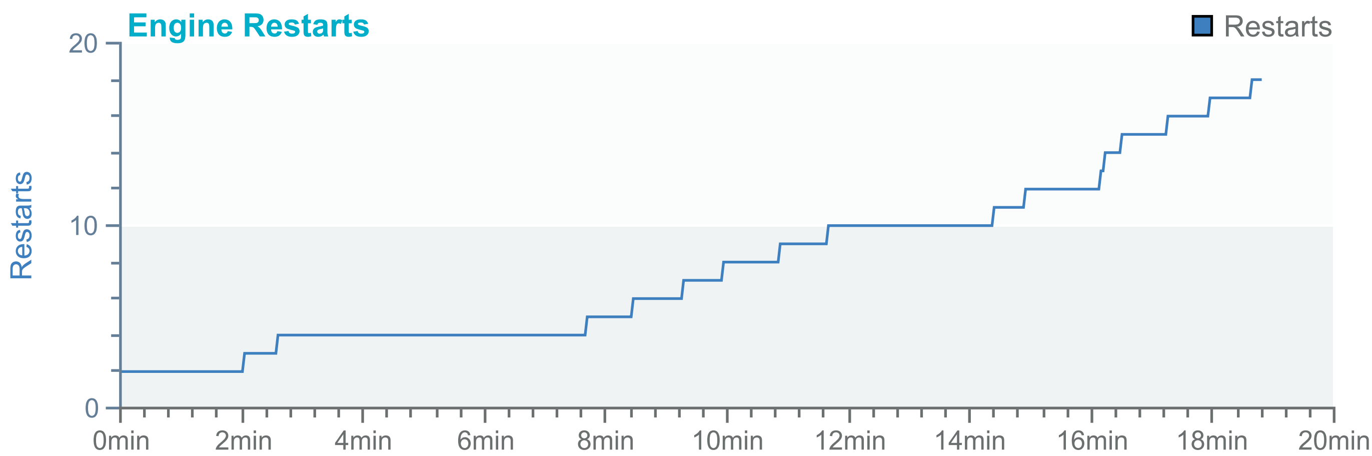

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
2.7
1.8
0.9
0.0
-0.9
0.4
0.2
0.0
-0.2
-0.4
0
5
10
15
20
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
10.0
5.0
0.0
2.0
1.0
0.0
0
5
10
15
20
Minutes


Propeller Pitch
Pitch
Propeller Pitch
400
300
200
100
0
-100
-200
-300
-400
0
5
10
15
20
Minutes

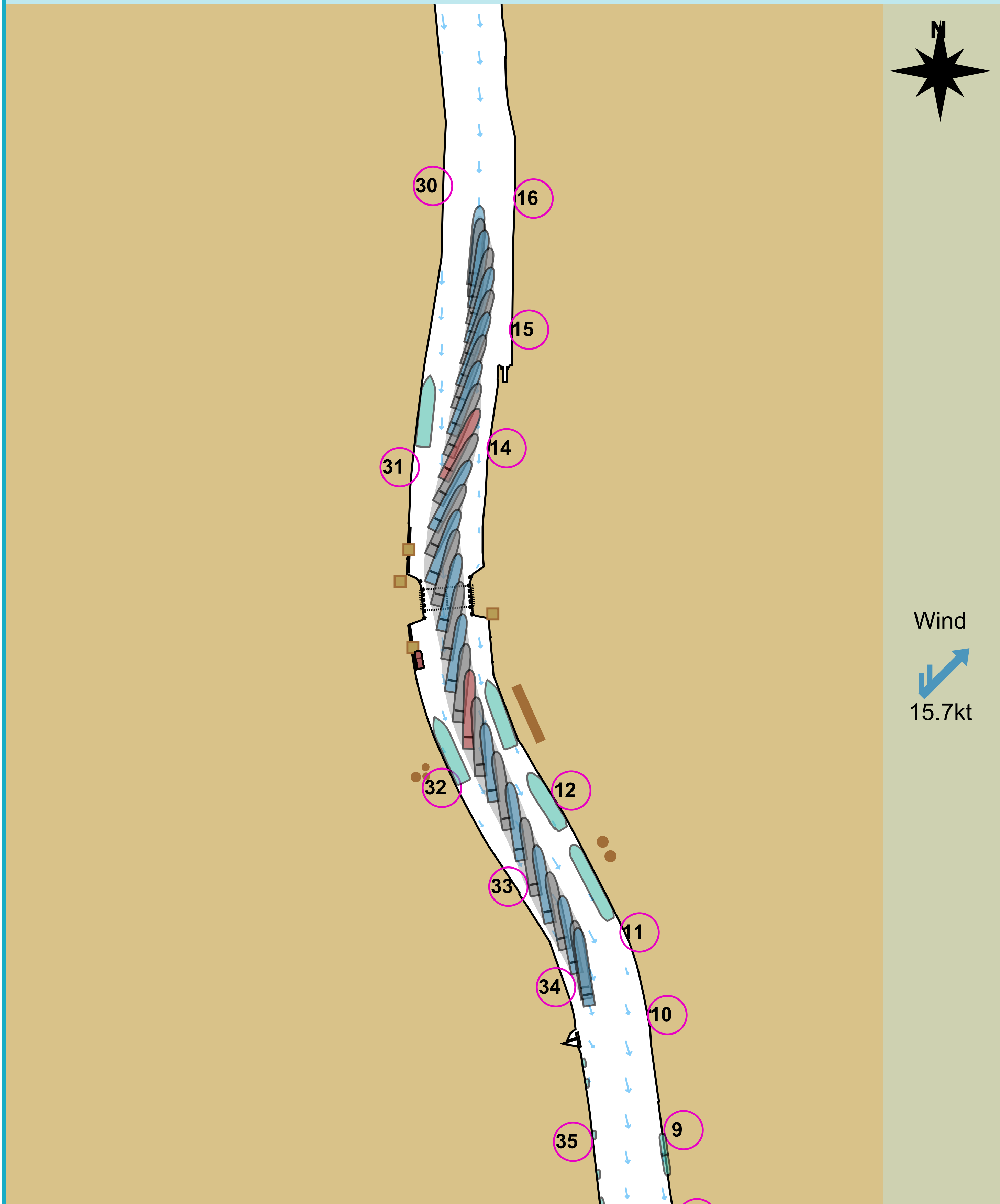

Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
20
Minutes


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


Engine Restarts
Restarts
Restarts
20
10
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

Tracks | Environment | Fischland Ballast

Manoeuvre track plot



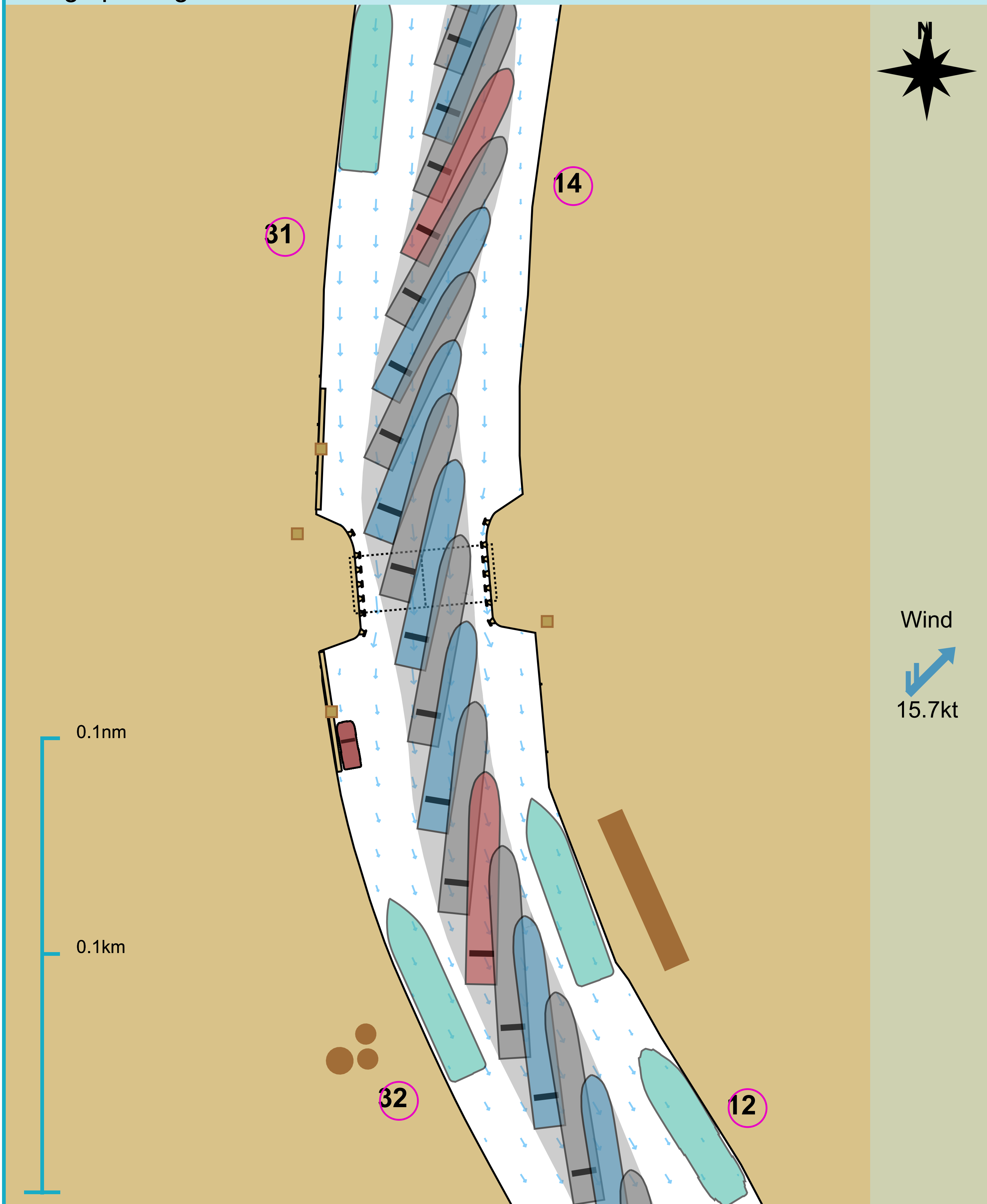
Ships plotted every 0 mins, highlight every 5 mins

HR Wallingford
Working with water

Project: Great Yarmouth
Session: 3rd Crossing 2019
Configuration: September 2019
Run: 27

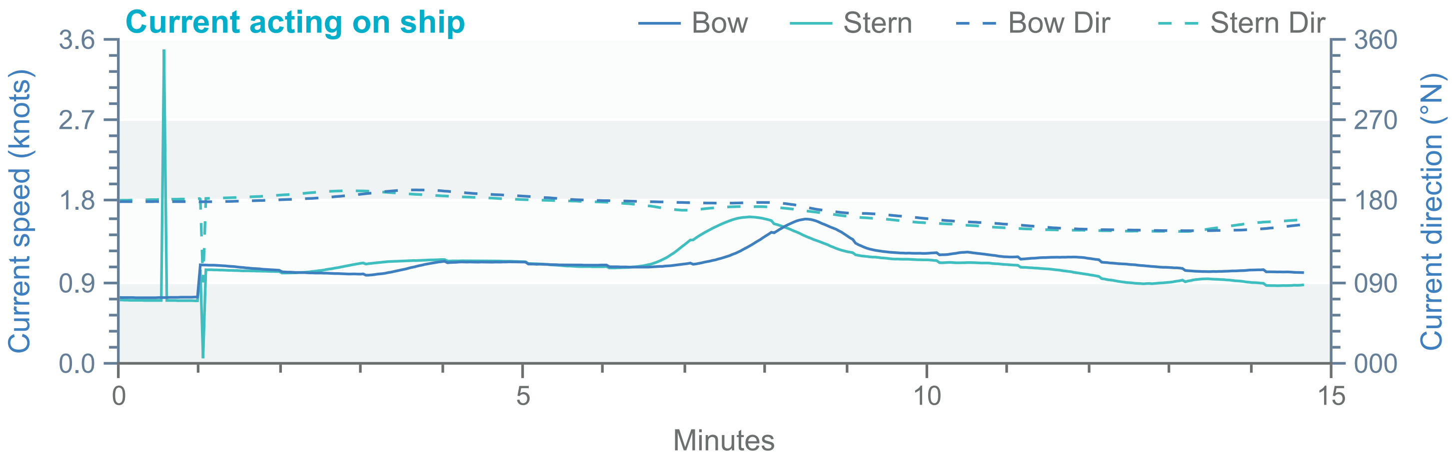
Tracks | Environment | Fischland Ballast

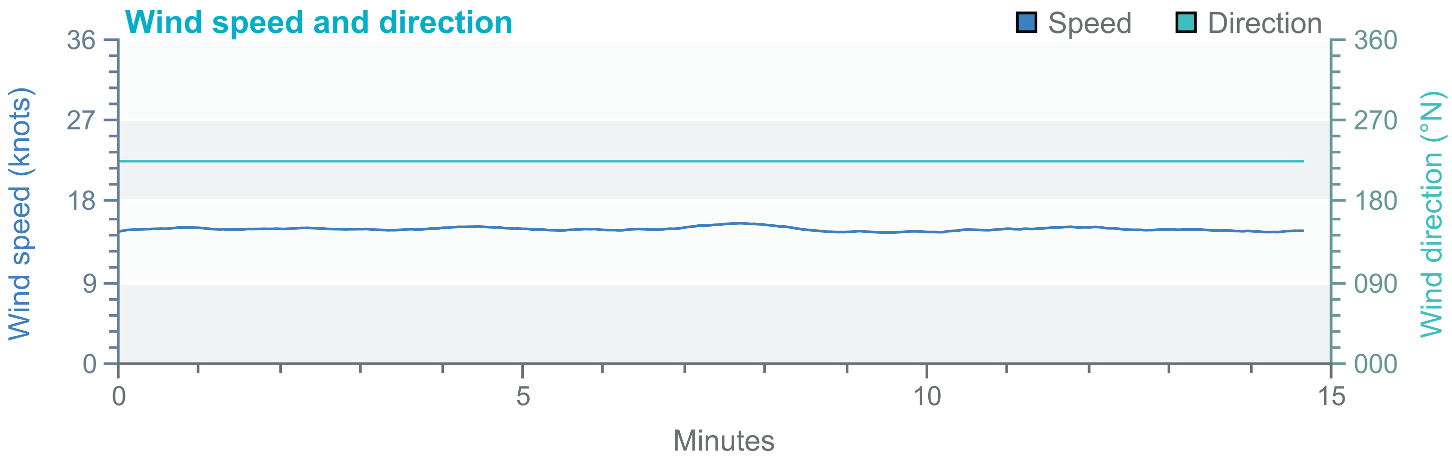
Bridge passage

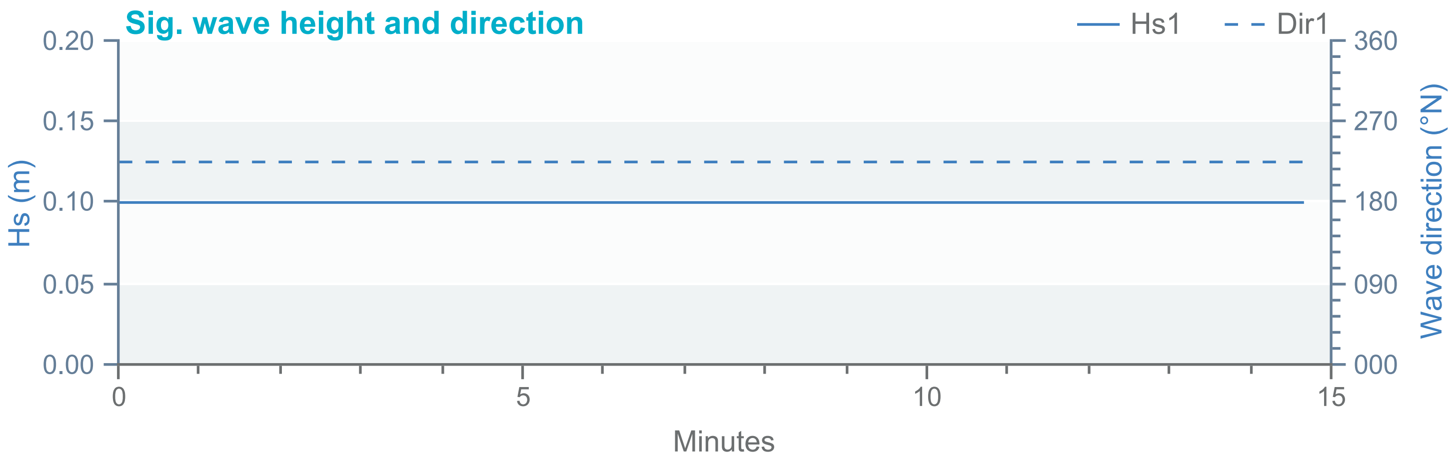


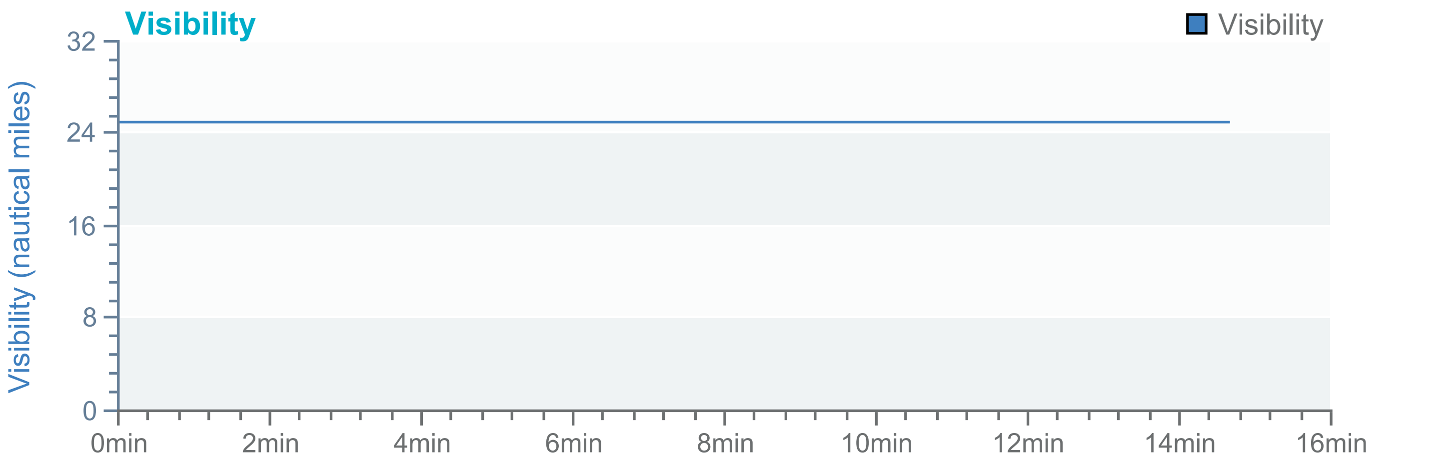
Ships plotted every 0 mins, highlight every 5 mins

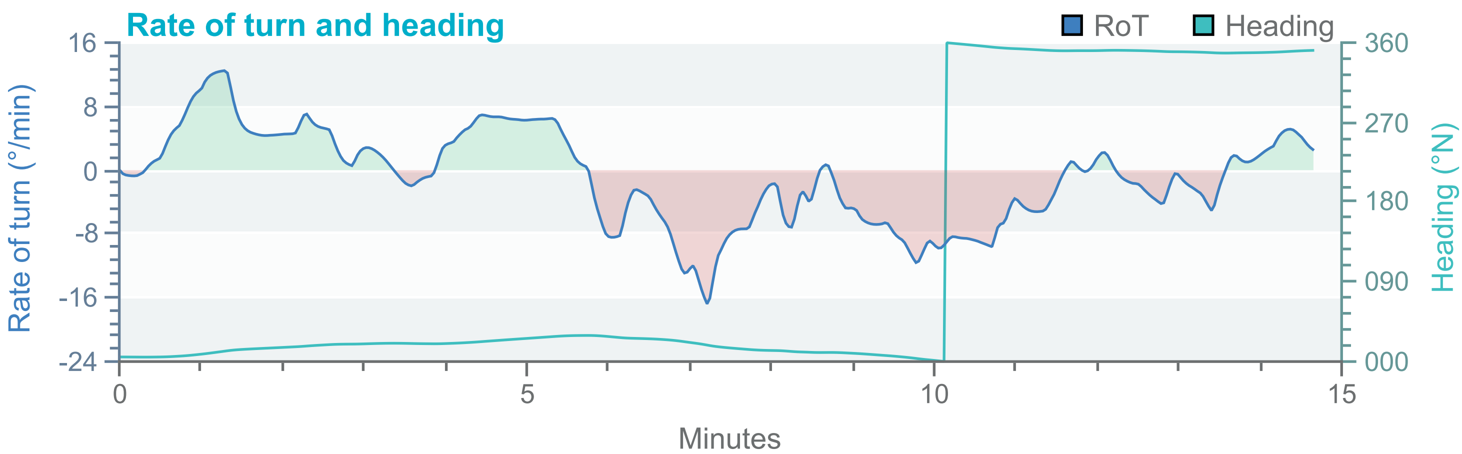
Tracks | Environment | Fischland Ballast

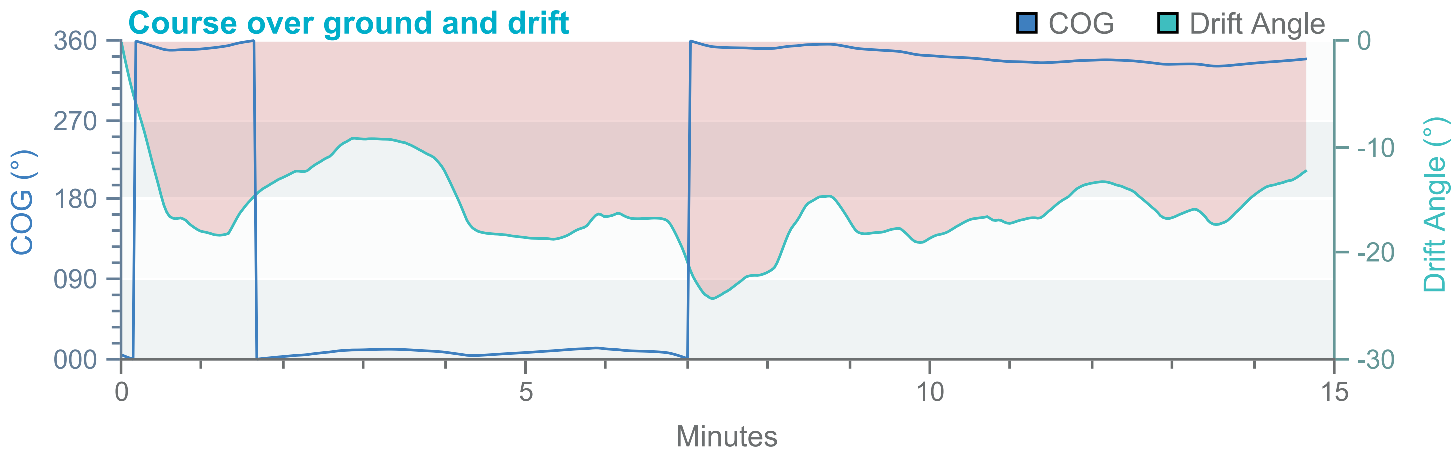


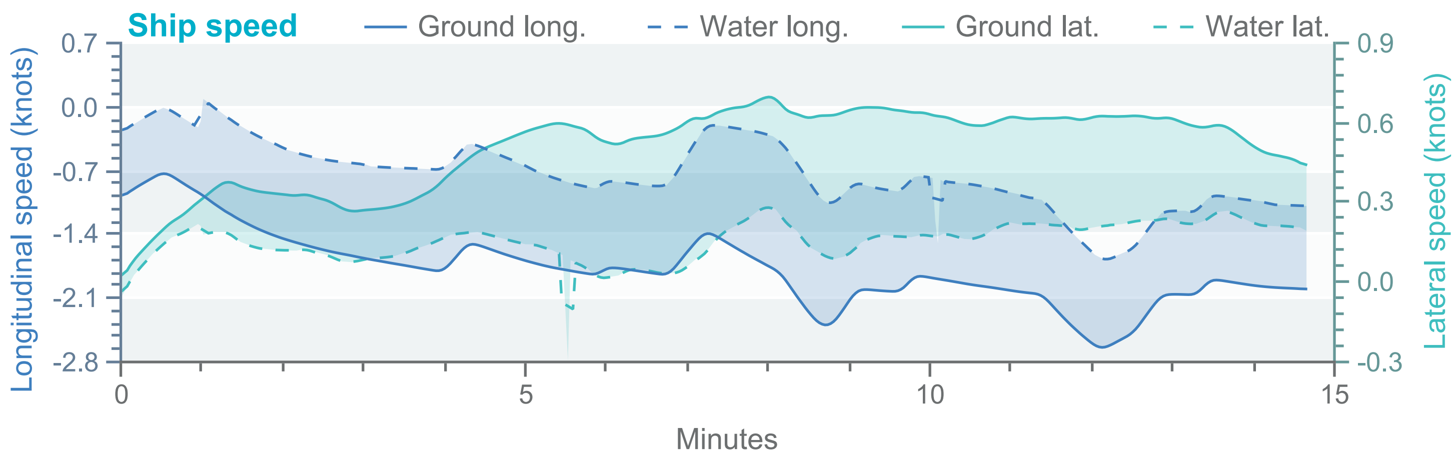


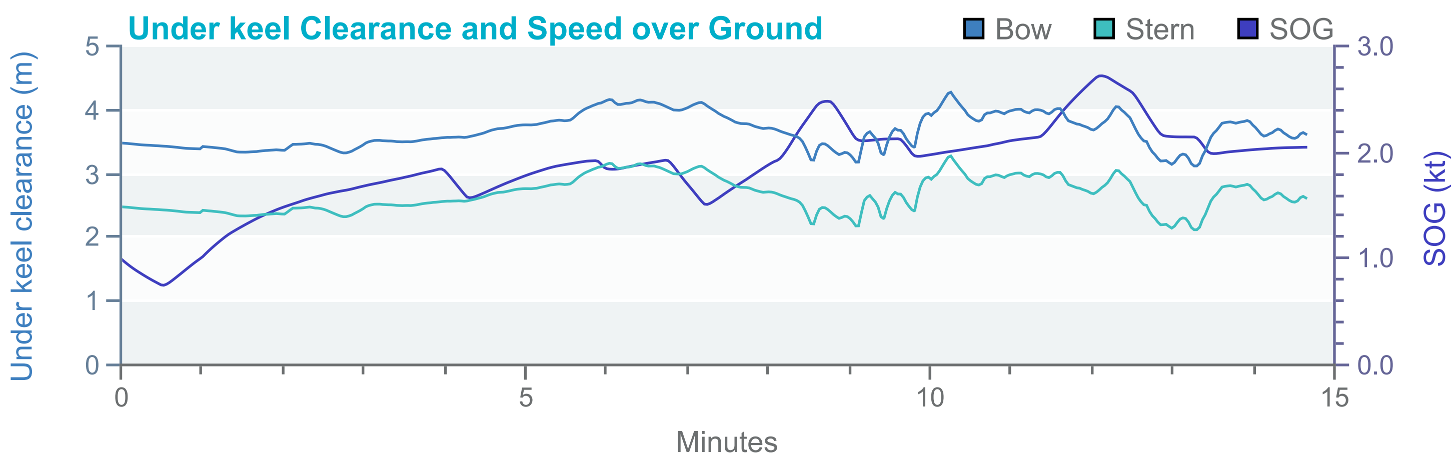


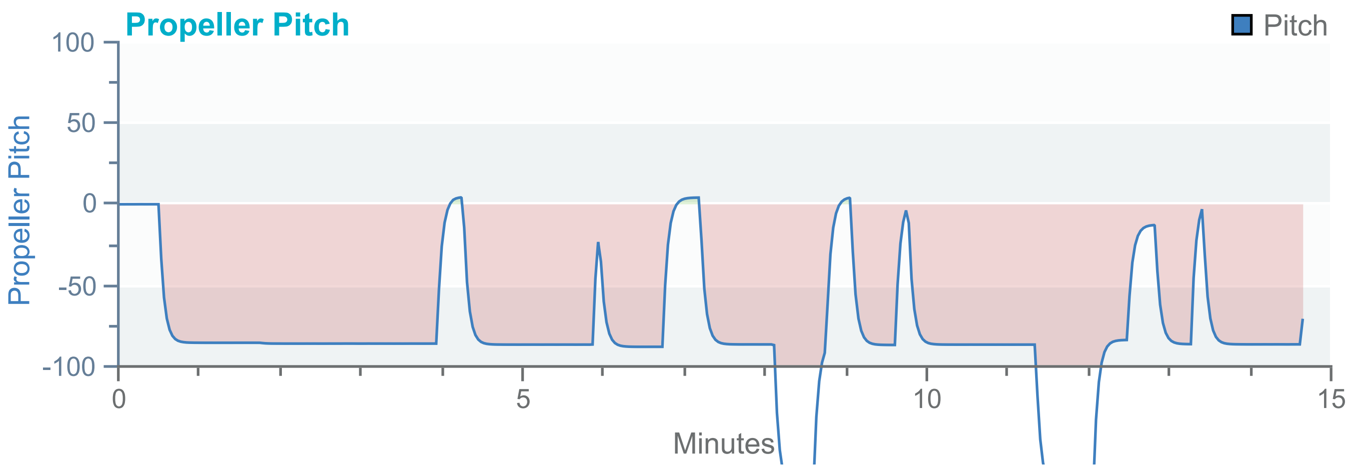


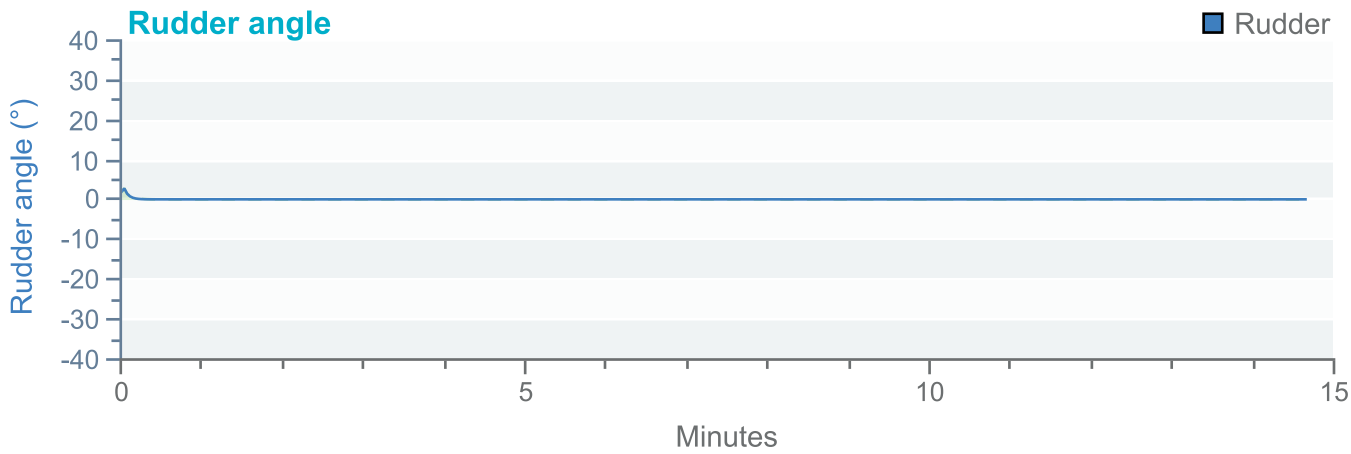

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
16
8
0
-8
-16
-24
Heading (°N)
360
270
180
090
000
0
5
10
15
Minutes

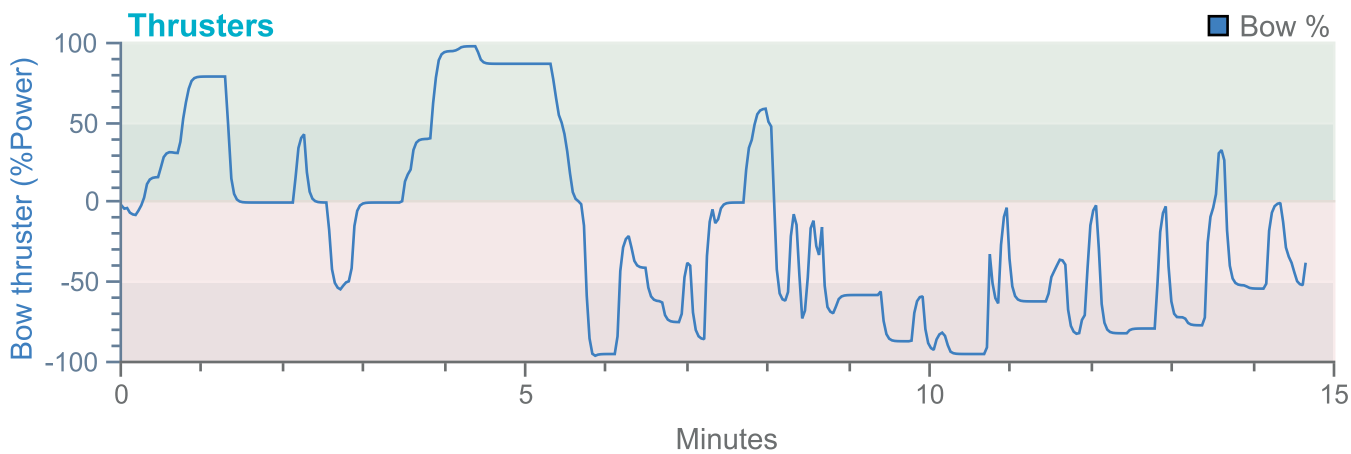

Course over ground and drift
COG
Drift Angle
COG (°)
360
270
180
090
000
Drift Angle (°)
0
-10
-20
-30
0
5
10
15
Minutes

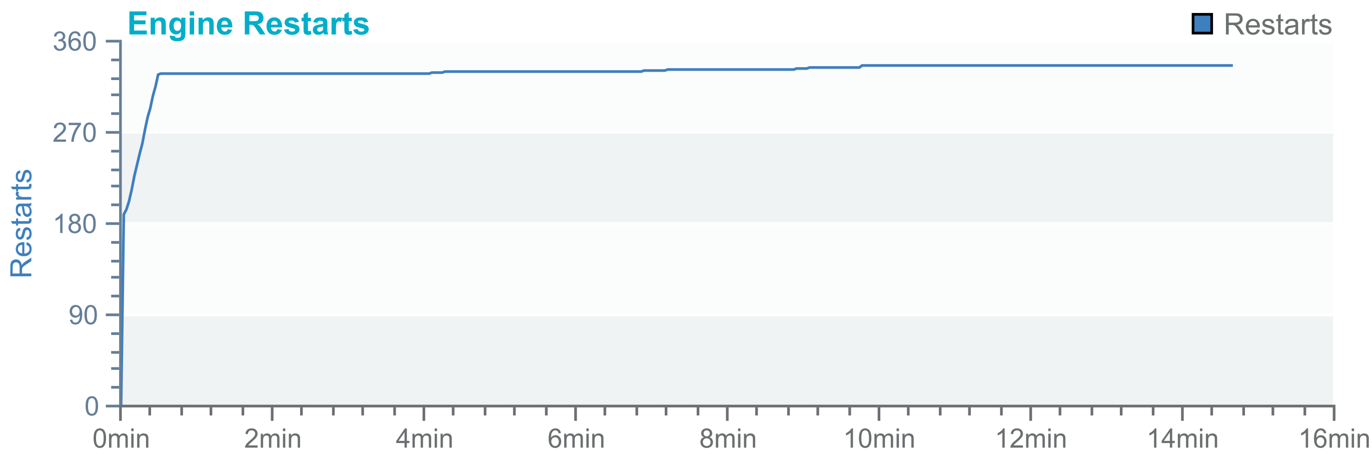

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
0.7
0.0
-0.7
-1.4
-2.1
-2.8
Lateral speed (knots)
0.9
0.6
0.3
0.0
-0.3
0
5
10
15
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
5
4
3
2
1
0
SOG (kt)
3.0
2.0
1.0
0.0
0
5
10
15
Minutes


Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
Minutes

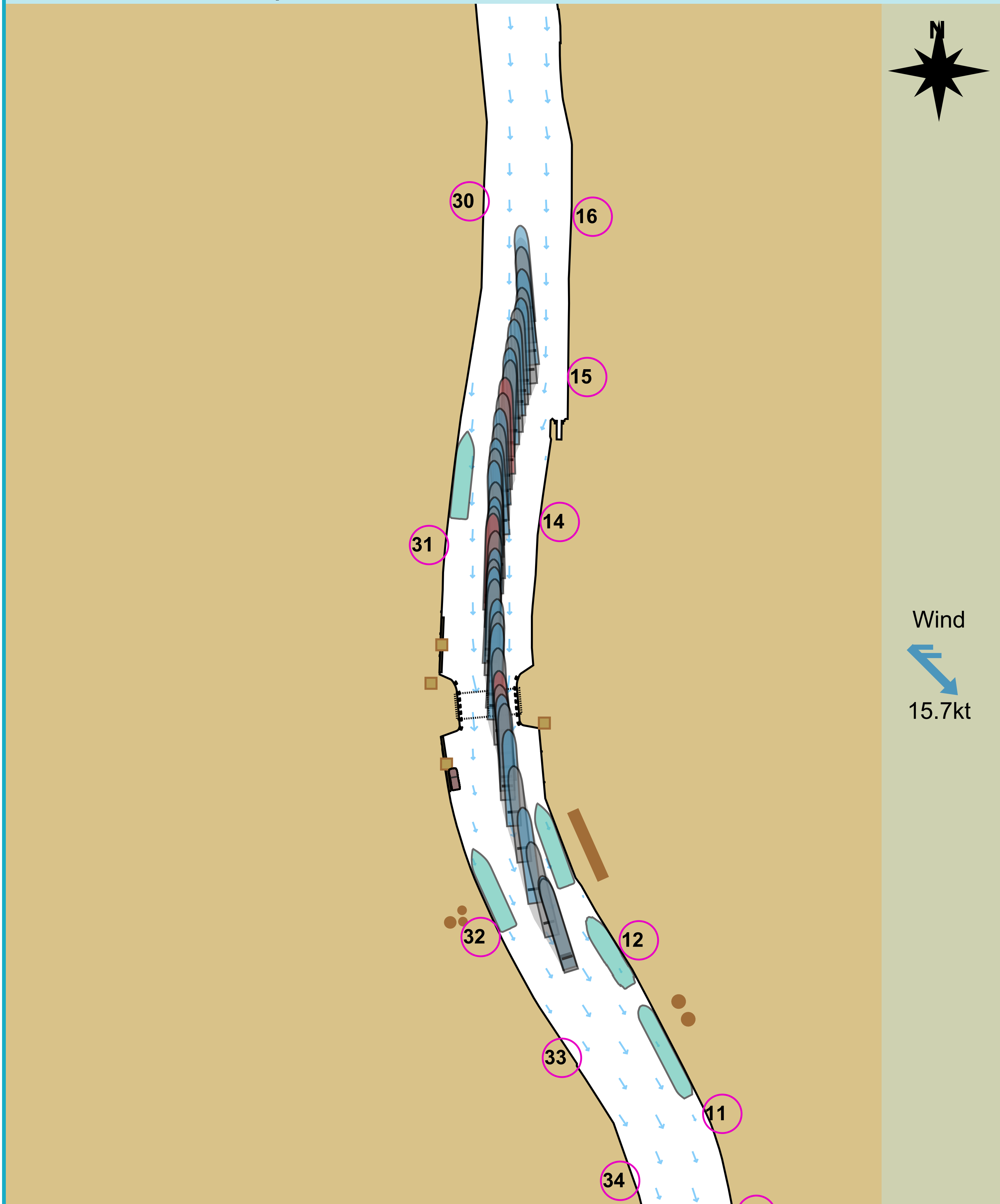

Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
Minutes


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


Engine Restarts
Restarts
Restarts
360
270
180
90
0
0min
2min
4min
6min
8min
10min
12min
14min
16min

Tracks | Environment | Fischland Ballast

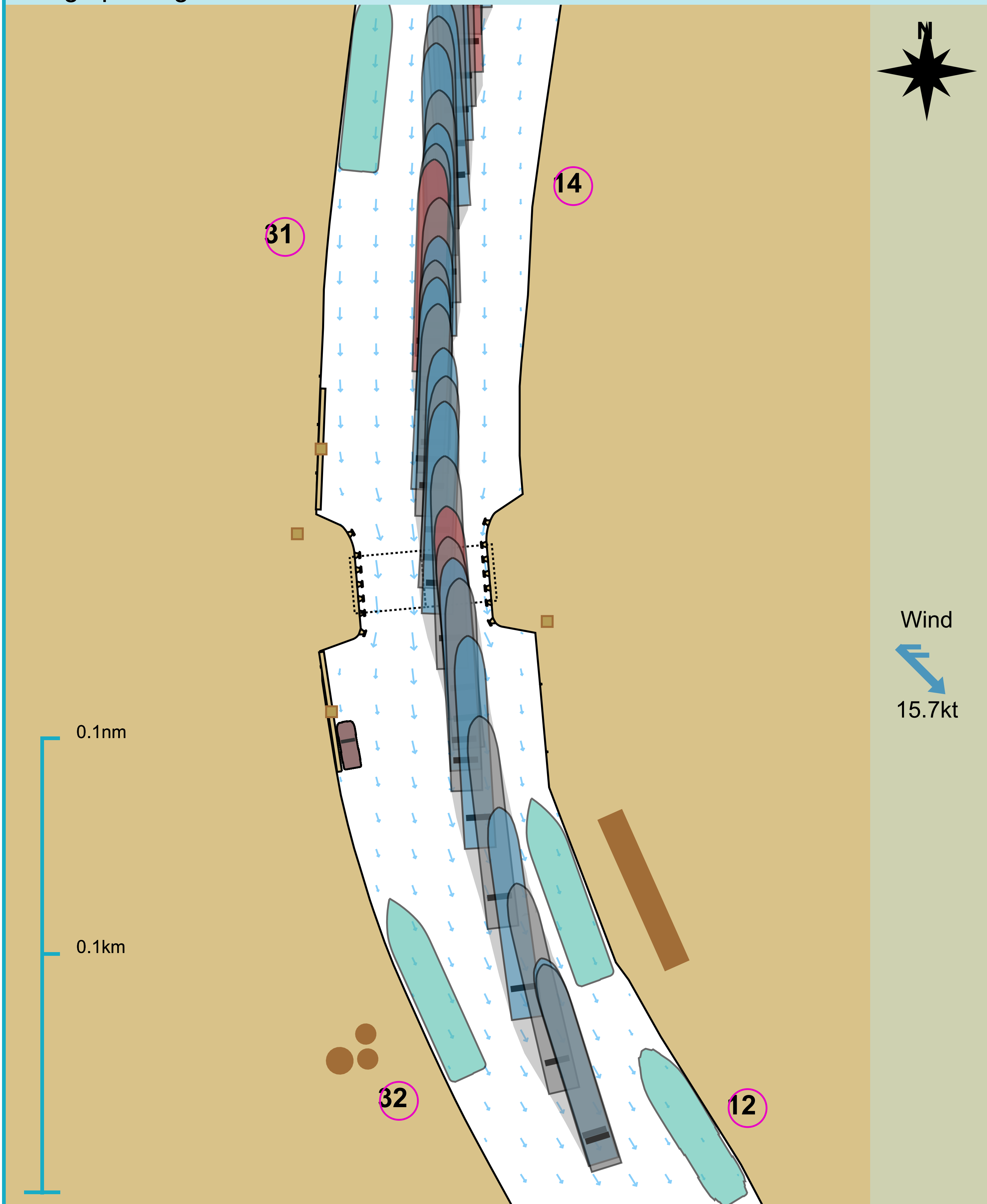
Manoeuvre track plot



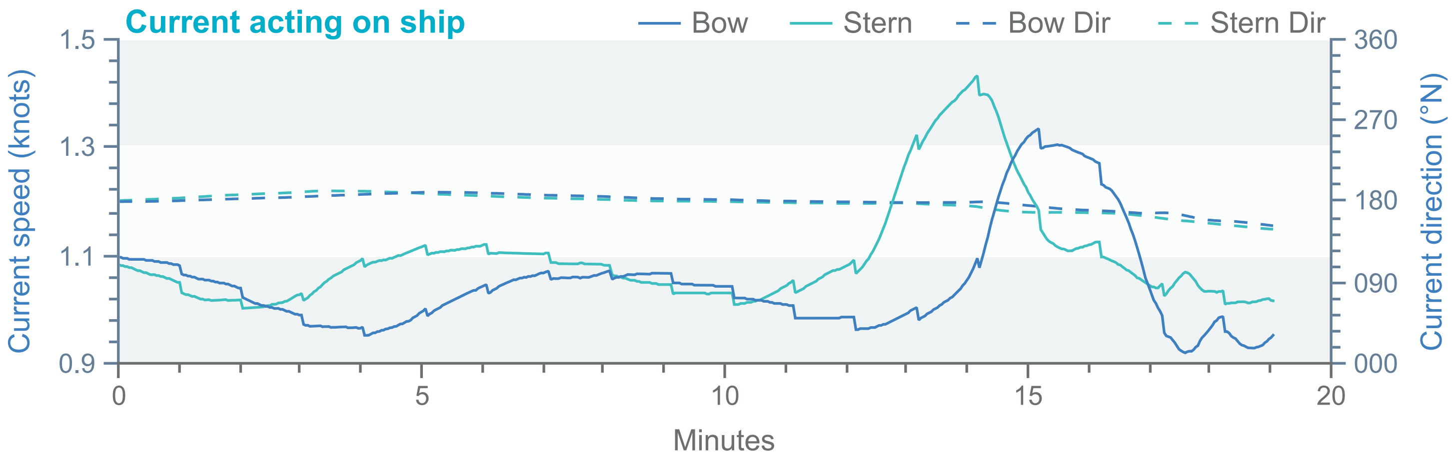
Ships plotted every 0 mins, highlight every 5 mins

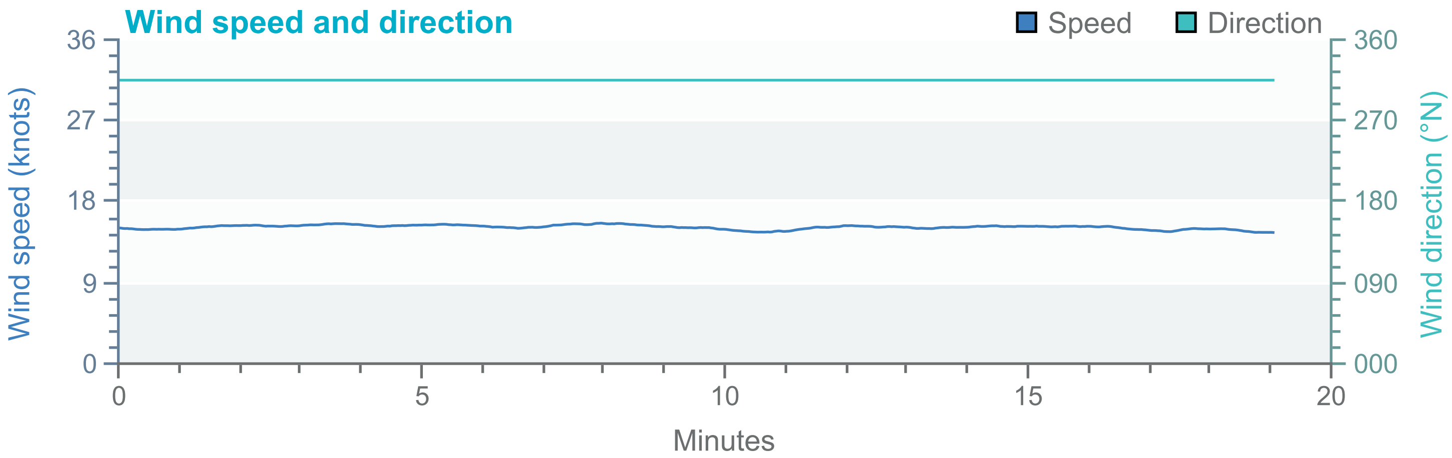
Tracks | Environment | Fischland Ballast

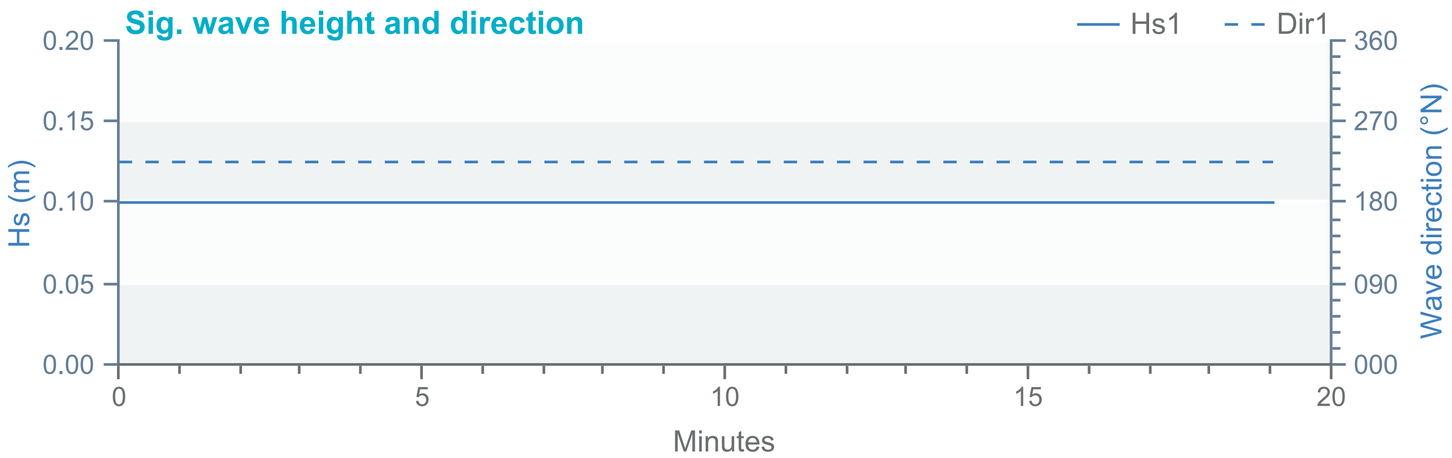
Bridge passage

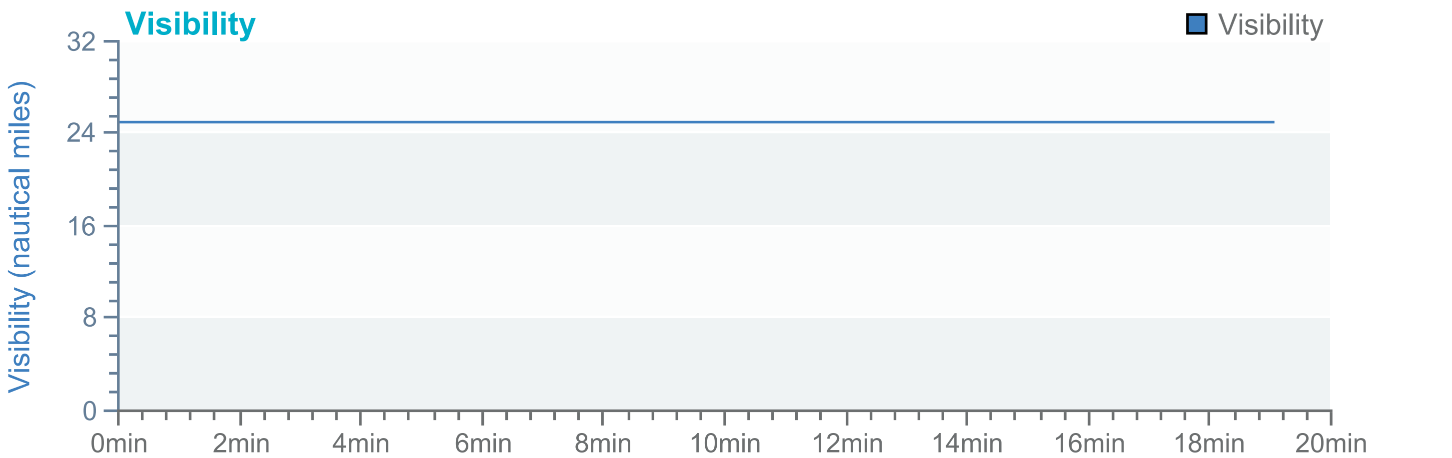


Ships plotted every 0 mins, highlight every 5 mins

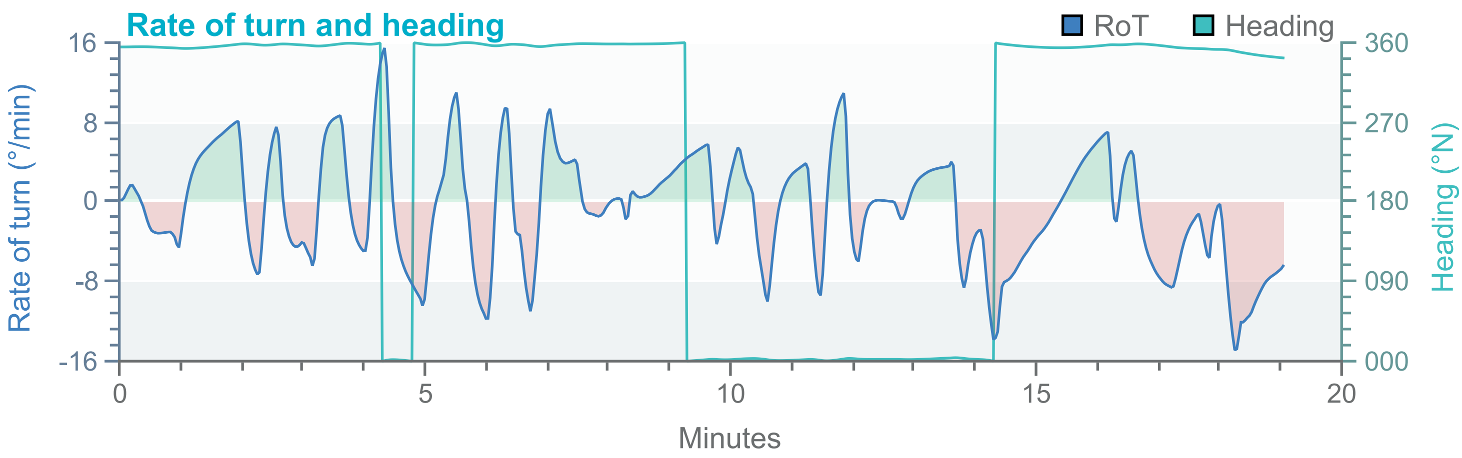

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
0.9
1.1
1.3
1.5
Current direction (°N)
000
090
180
270
360
0
5
10
15
20
Minutes

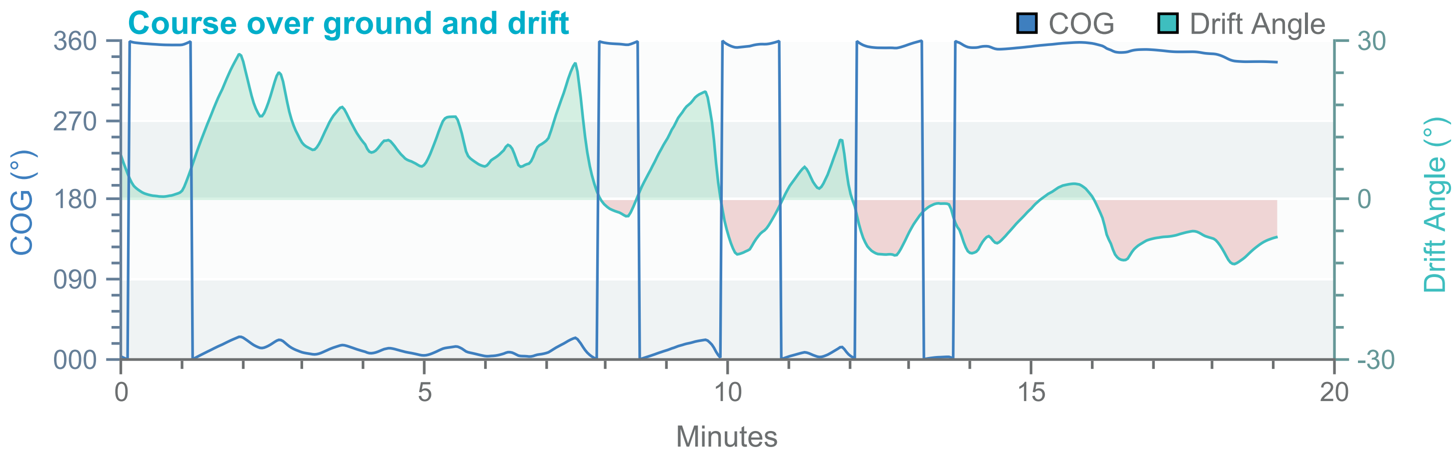

Wind speed and direction
Speed
Direction
Wind speed (knots)
0
9
18
27
36
Wind direction (°N)
000
090
180
270
360
0
5
10
15
20
Minutes

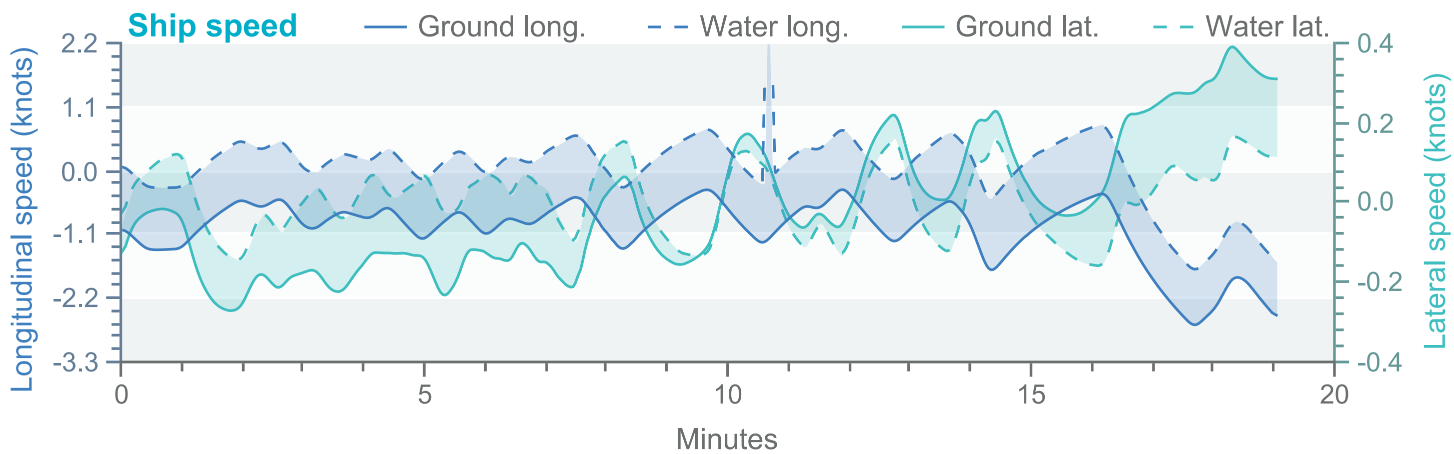

Sig. wave height and direction
Hs1
Dir1
Hs (m)
0.00
0.05
0.10
0.15
0.20
Wave direction (°N)
000
090
180
270
360
0
5
10
15
20
Minutes

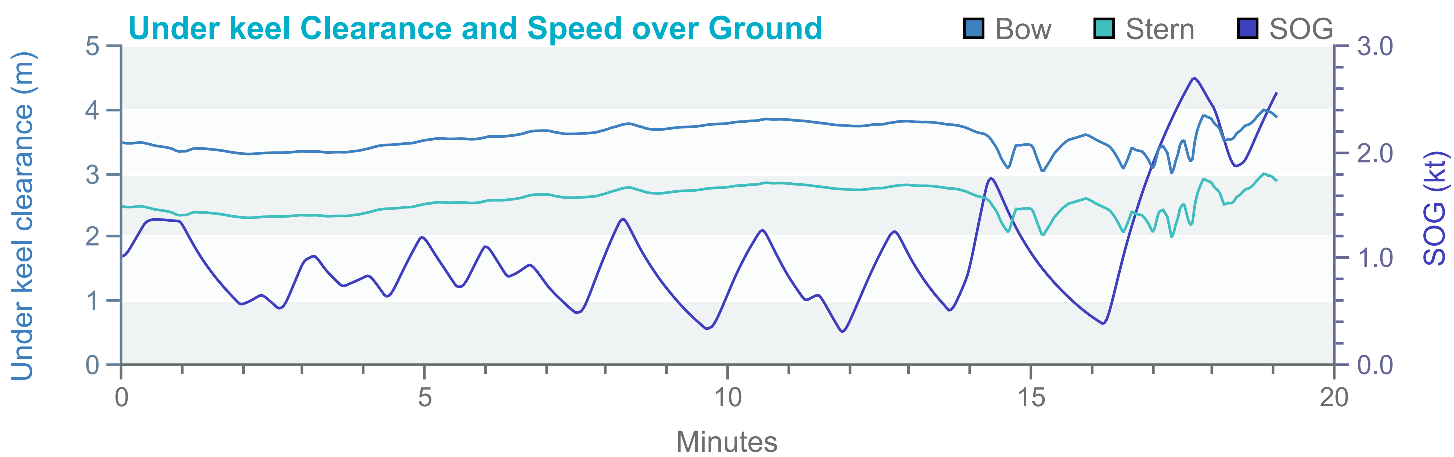

Visibility
Visibility
Visibility (nautical miles)
0
8
16
24
32
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

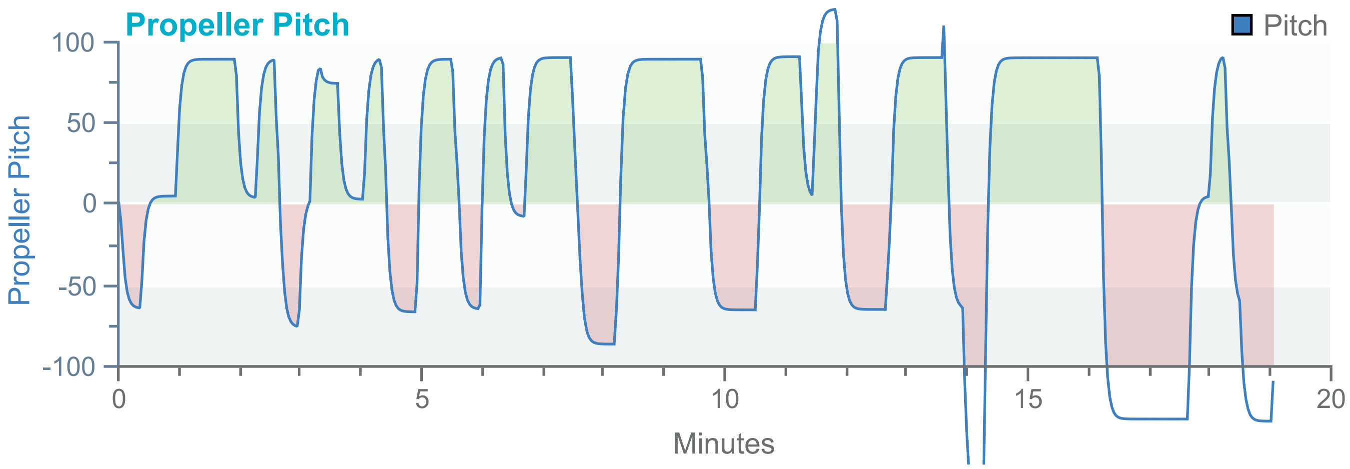
Tracks | Environment | Fischland Ballast

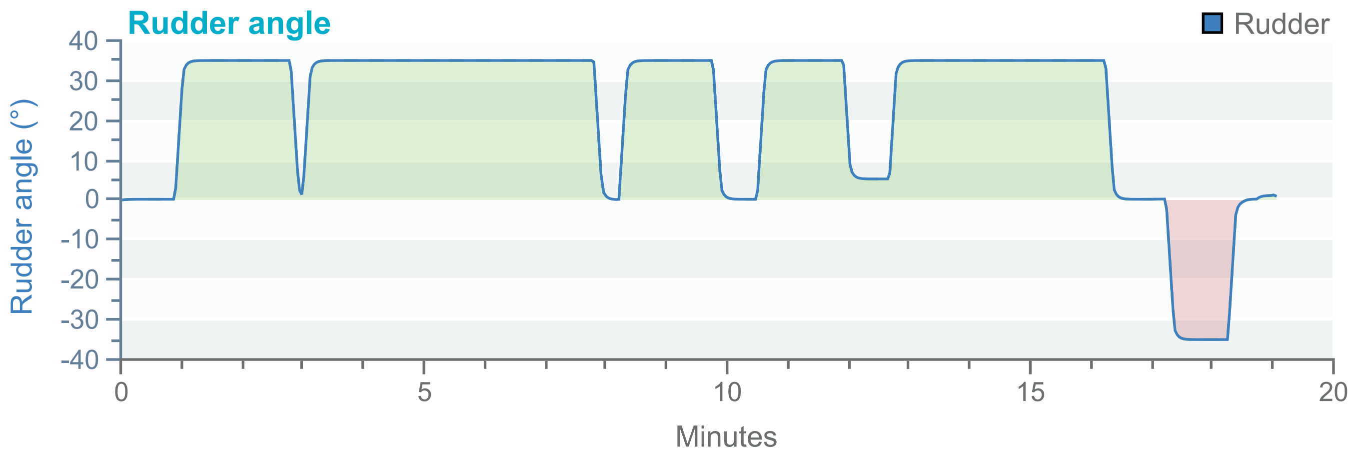


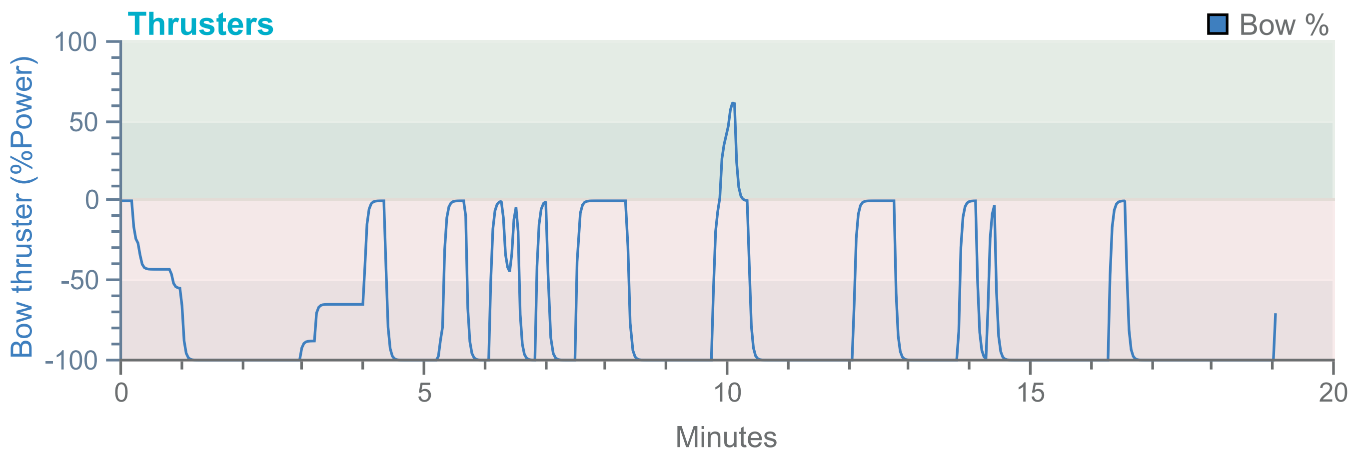


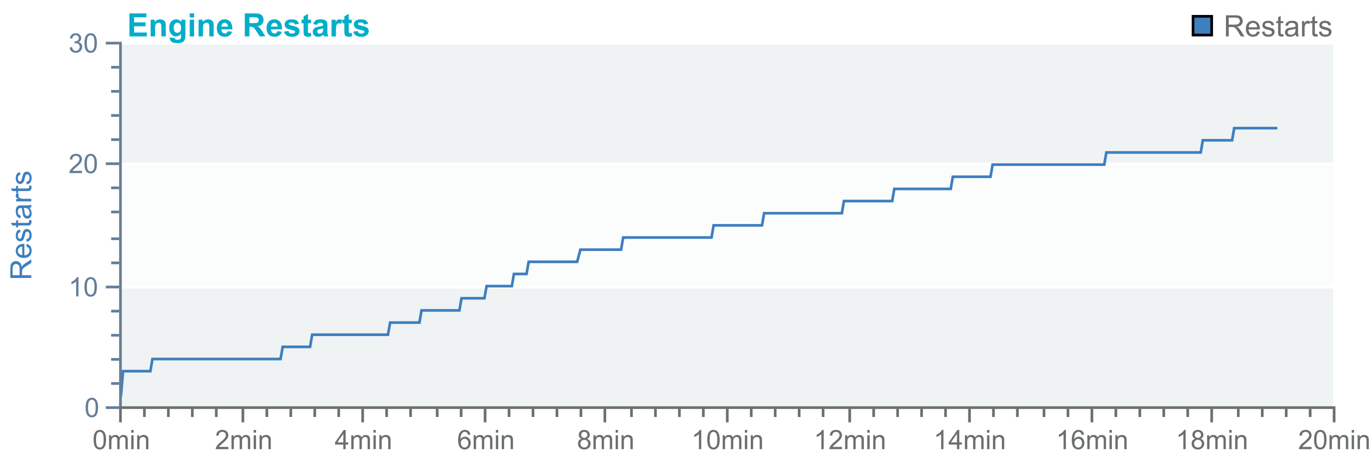




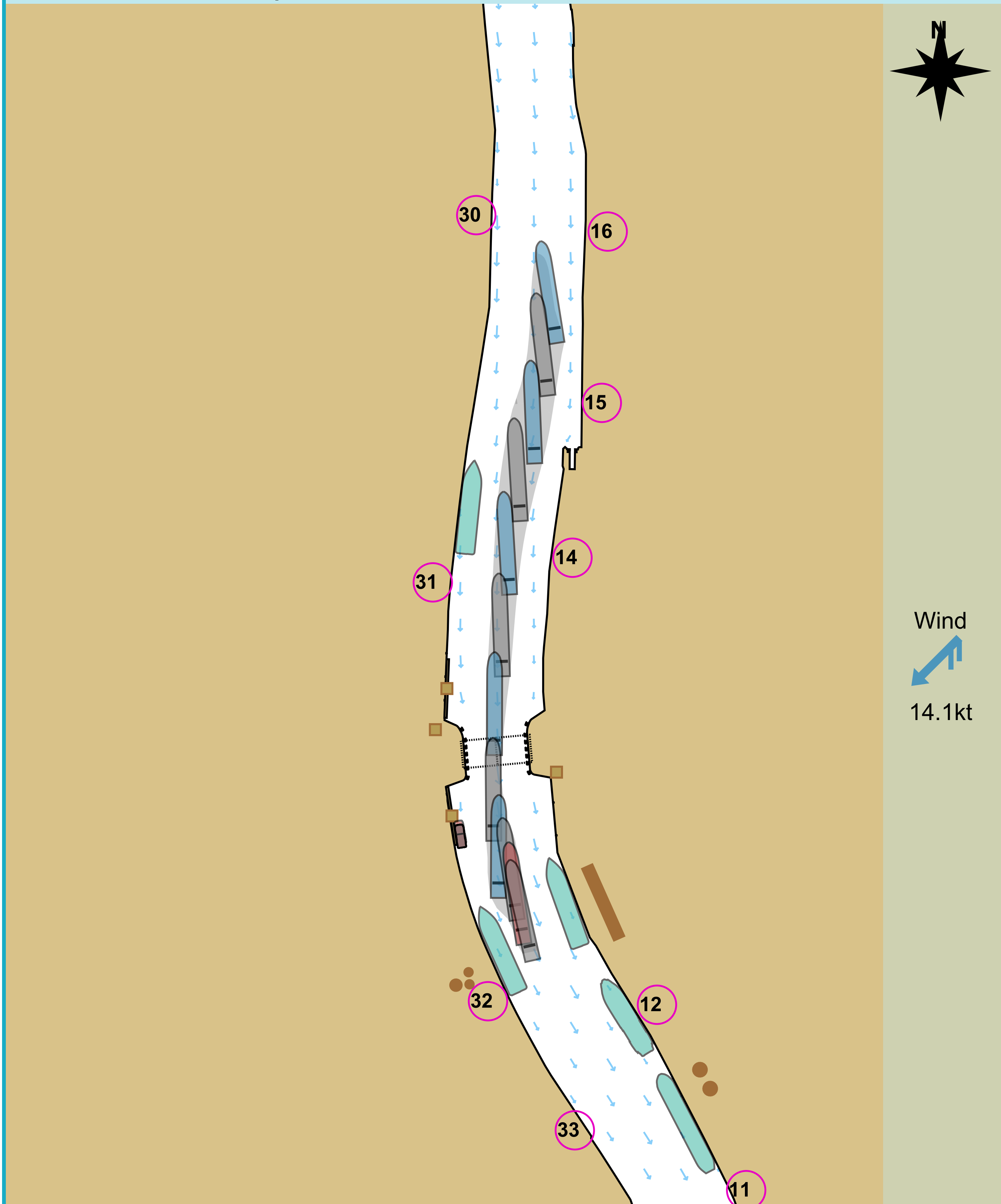

Propeller Pitch
Pitch
Propeller Pitch
100
50
0
-50
-100
0
5
10
15
20
Minutes


Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
20
Minutes

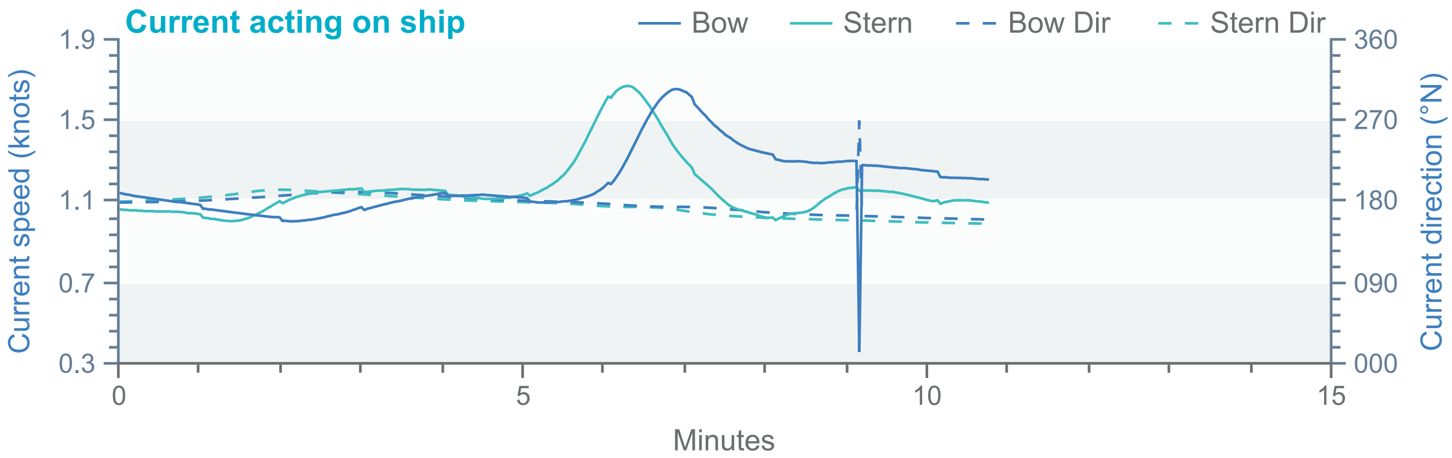

Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0
5
10
15
20
Minutes

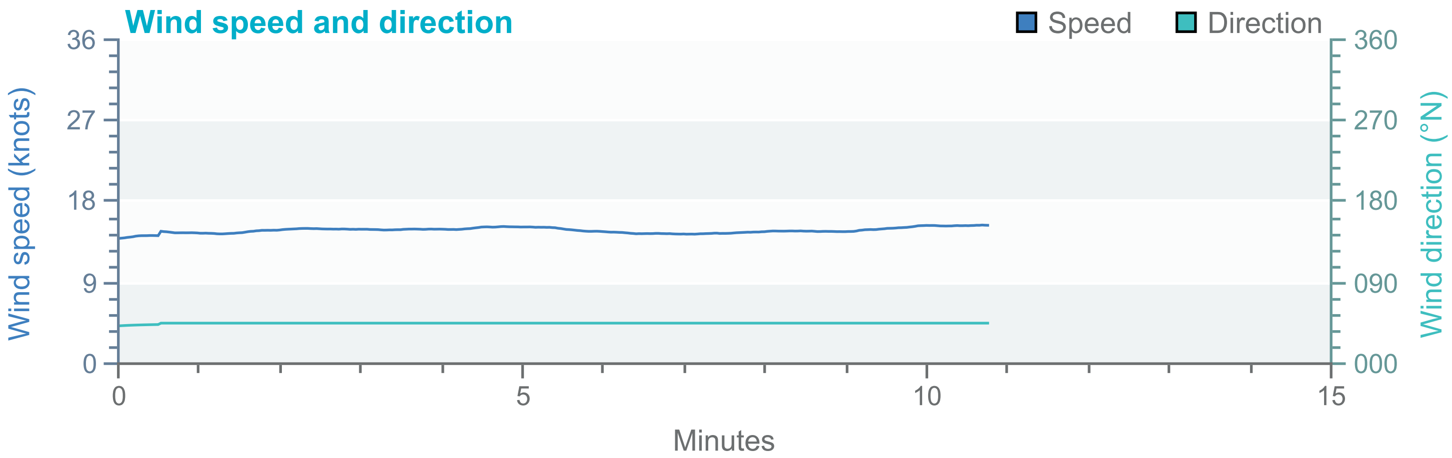

Engine Restarts
Restarts
Restarts
30
20
10
0
0min
2min
4min
6min
8min
10min
12min
14min
16min
18min
20min

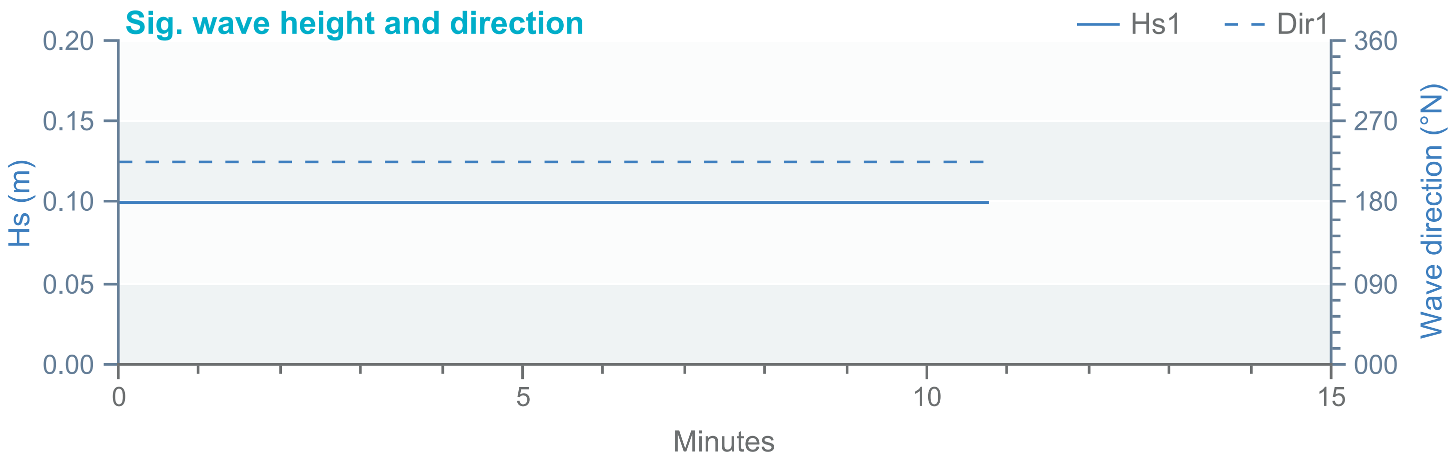
Manoeuvre track plot

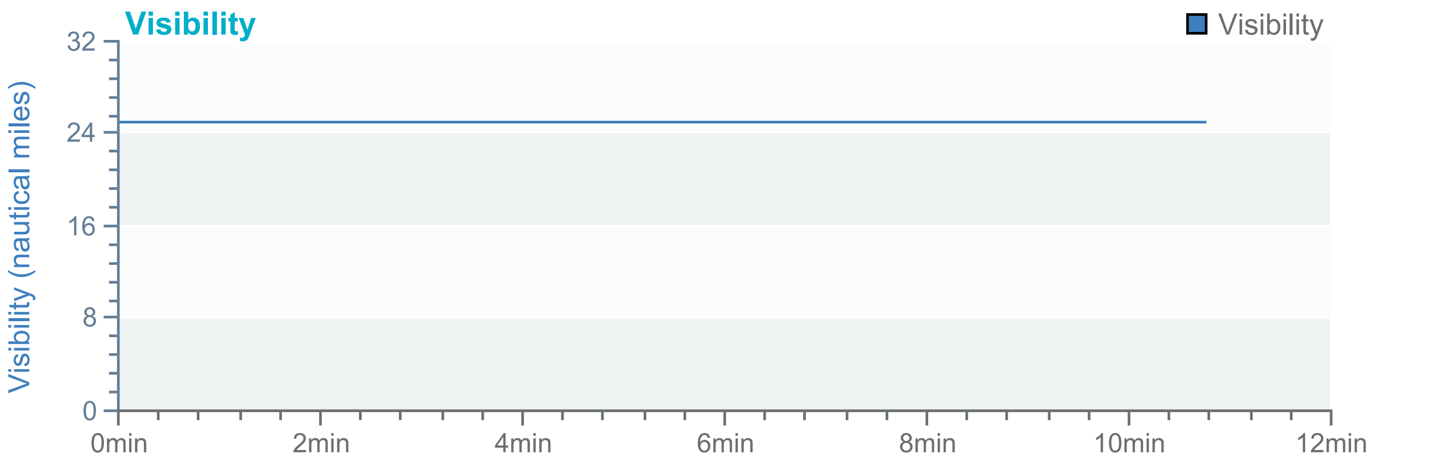


Ships plotted every 1 mins, highlight every 10 mins

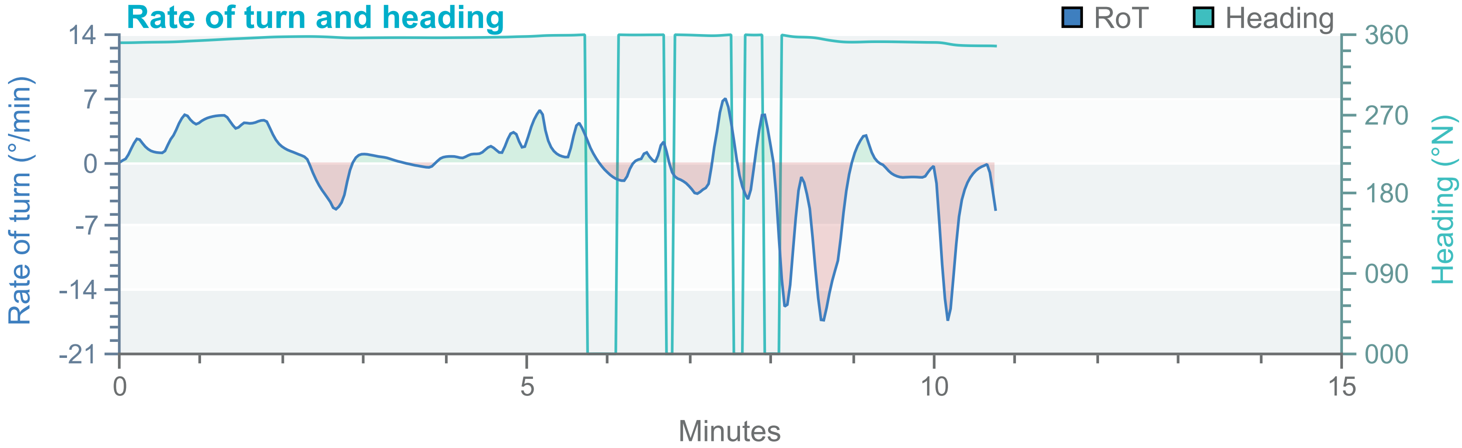

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes
1.9
1.5
1.1
0.7
0.3
360
270
180
090
000
0
5
10
15


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes
36
27
18
9
0
360
270
180
090
000
0
5
10
15

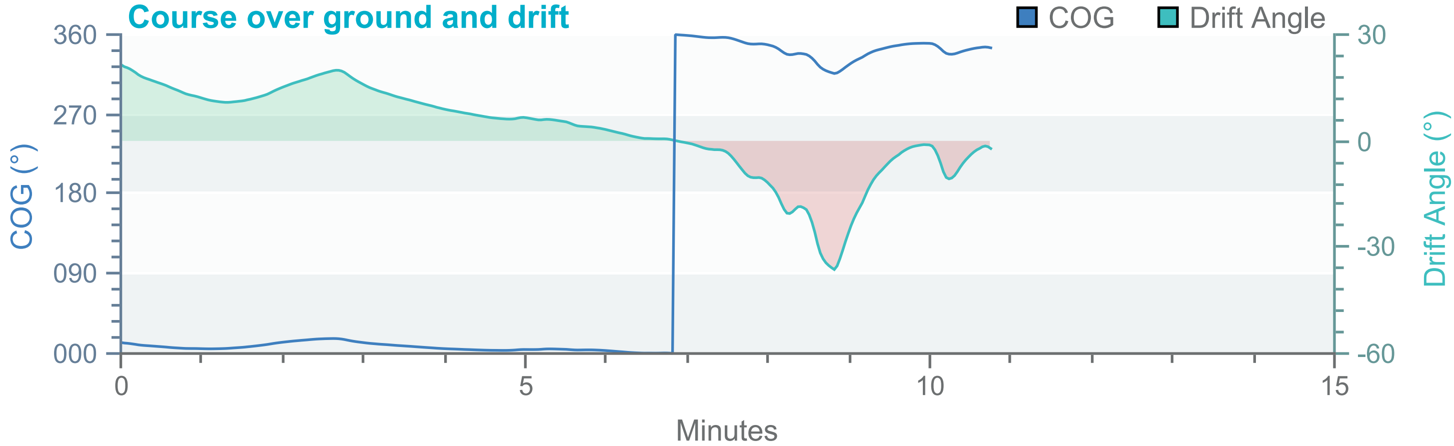

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15


Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
2min
4min
6min
8min
10min
12min

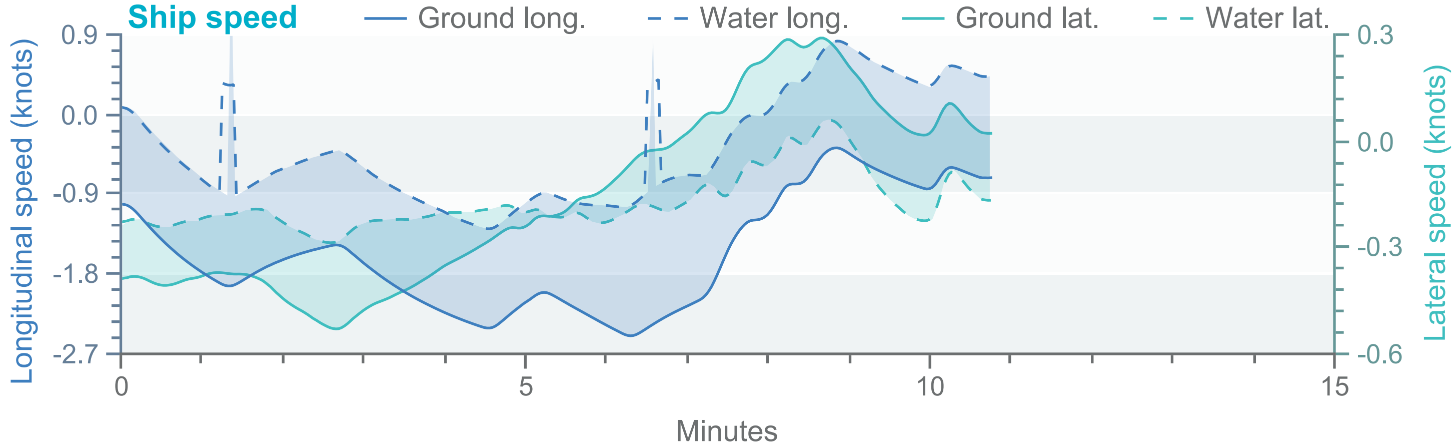
Rate of turn and heading



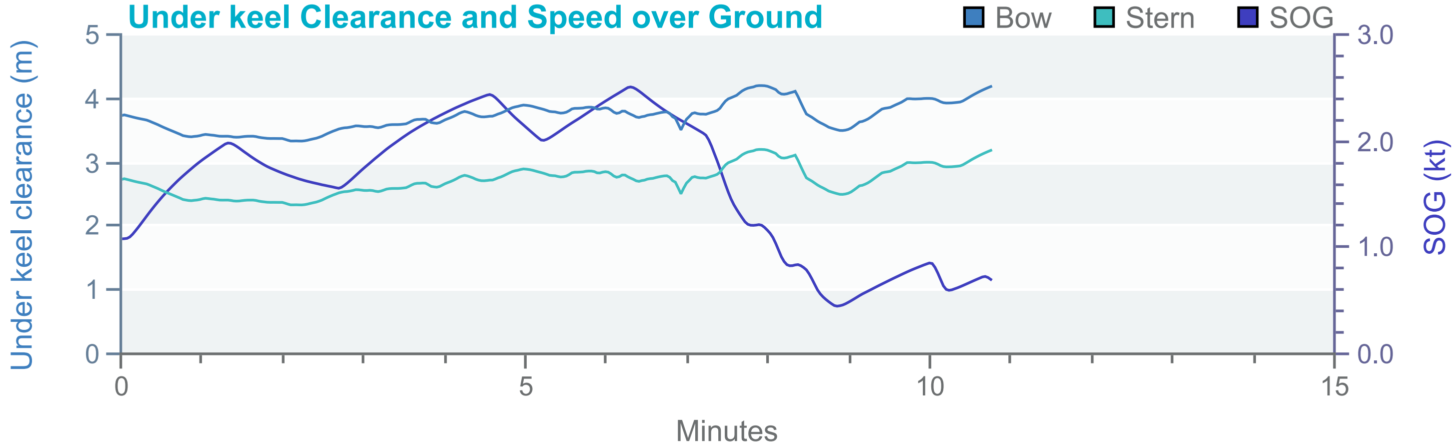
Course over ground and drift

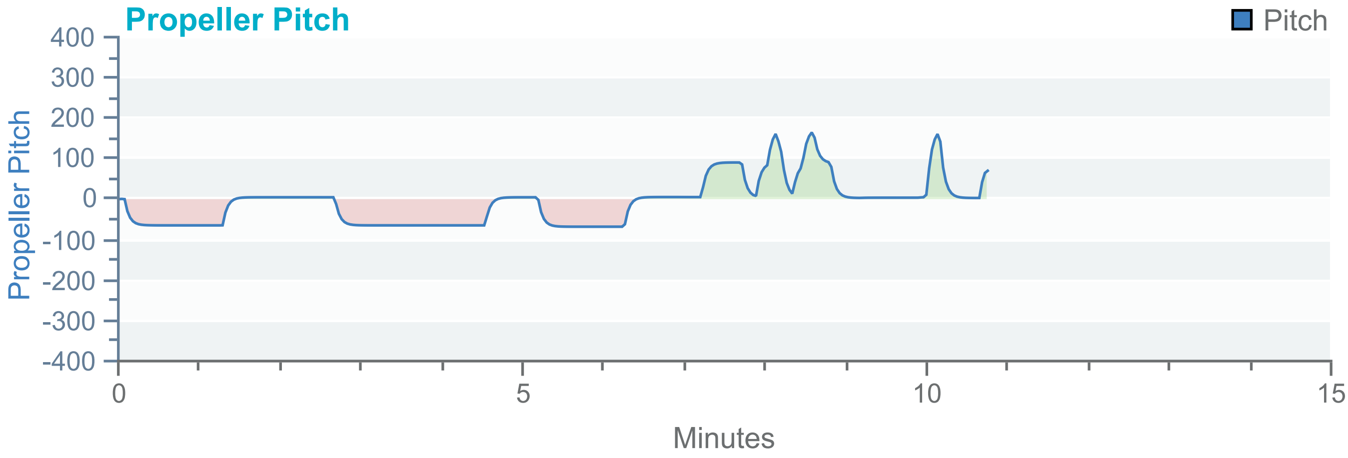


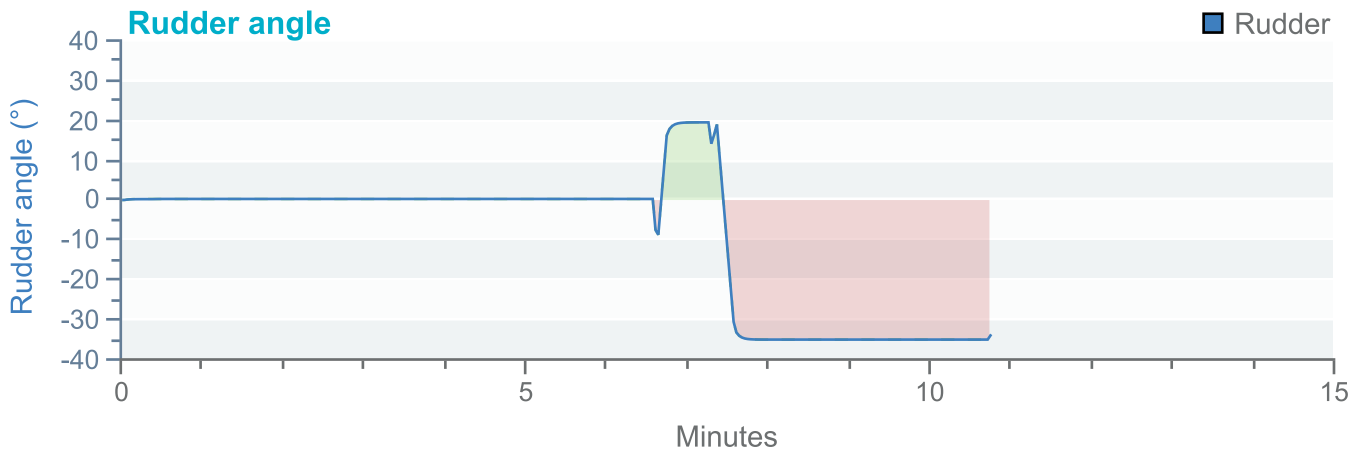
Ship speed

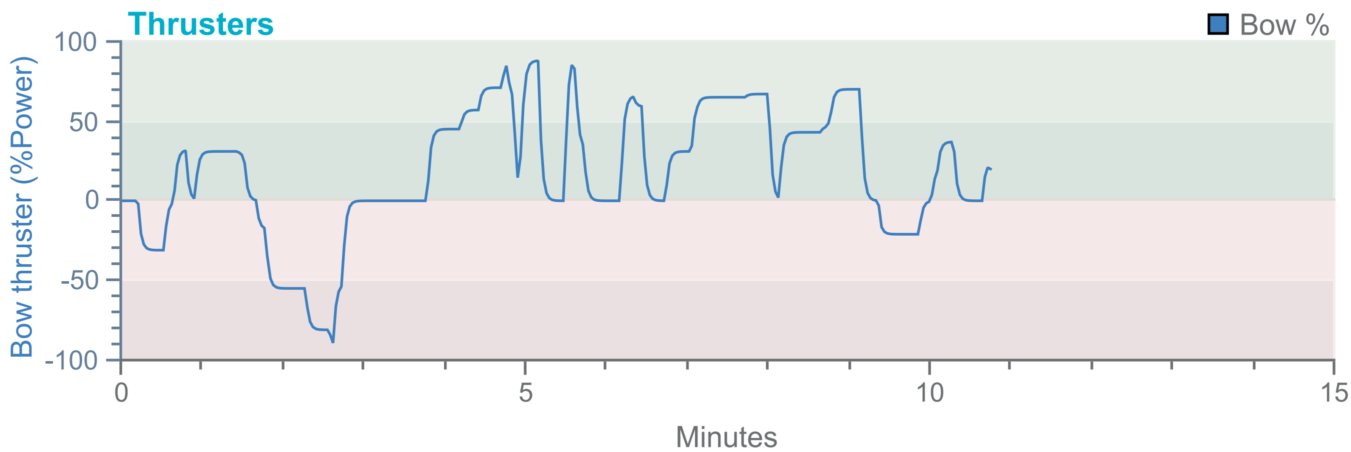


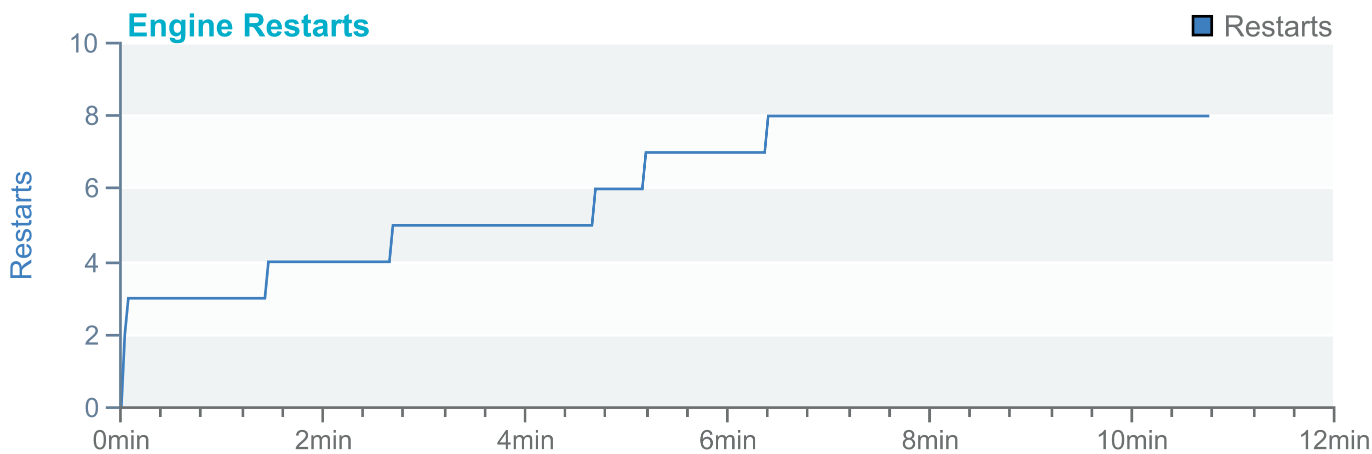
Under keel Clearance and Speed over Ground




Propeller Pitch
Pitch
Propeller Pitch
400
300
200
100
0
-100
-200
-300
-400
0
5
10
15
Minutes

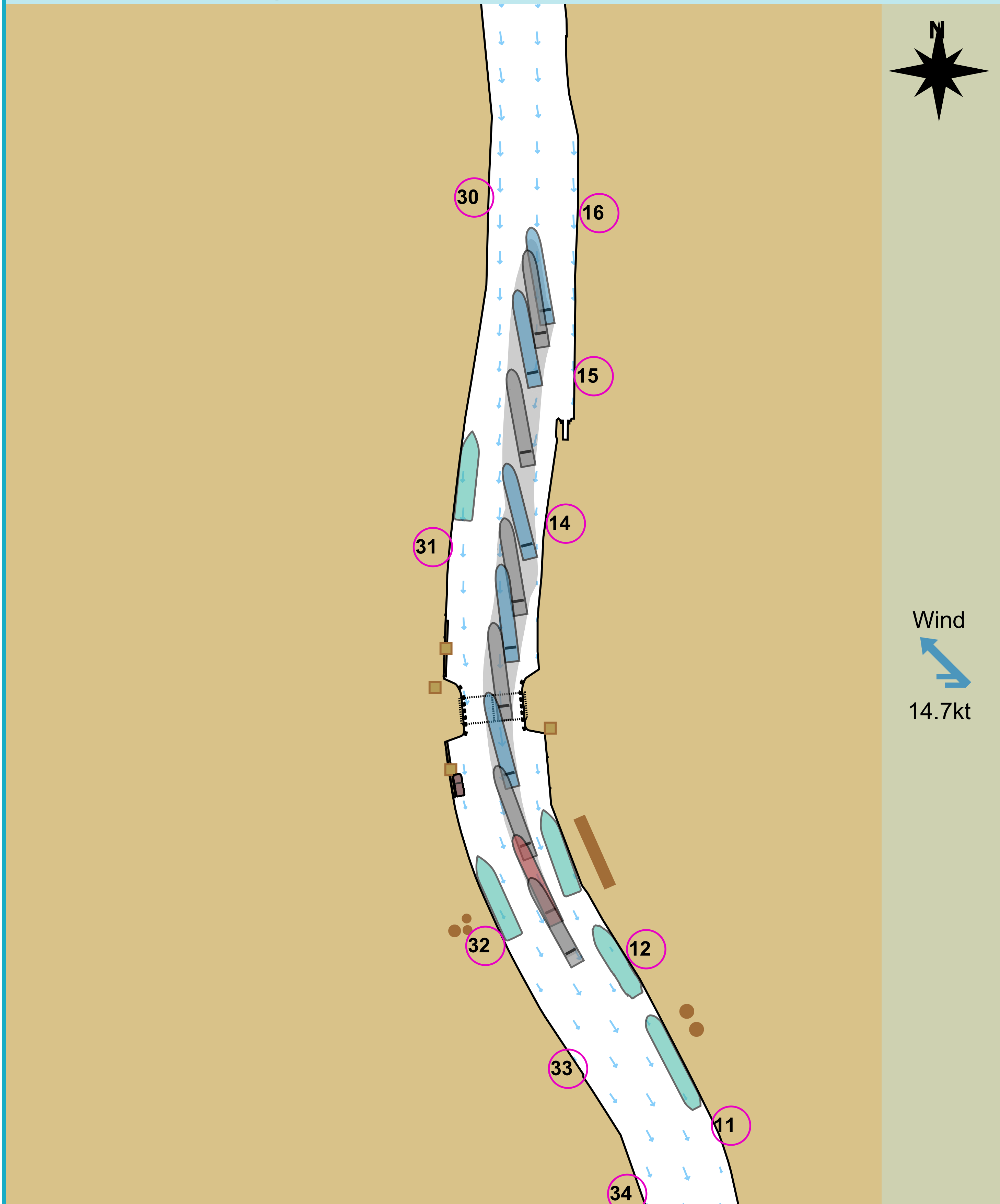

Rudder angle
Rudder
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0
5
10
15
Minutes


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

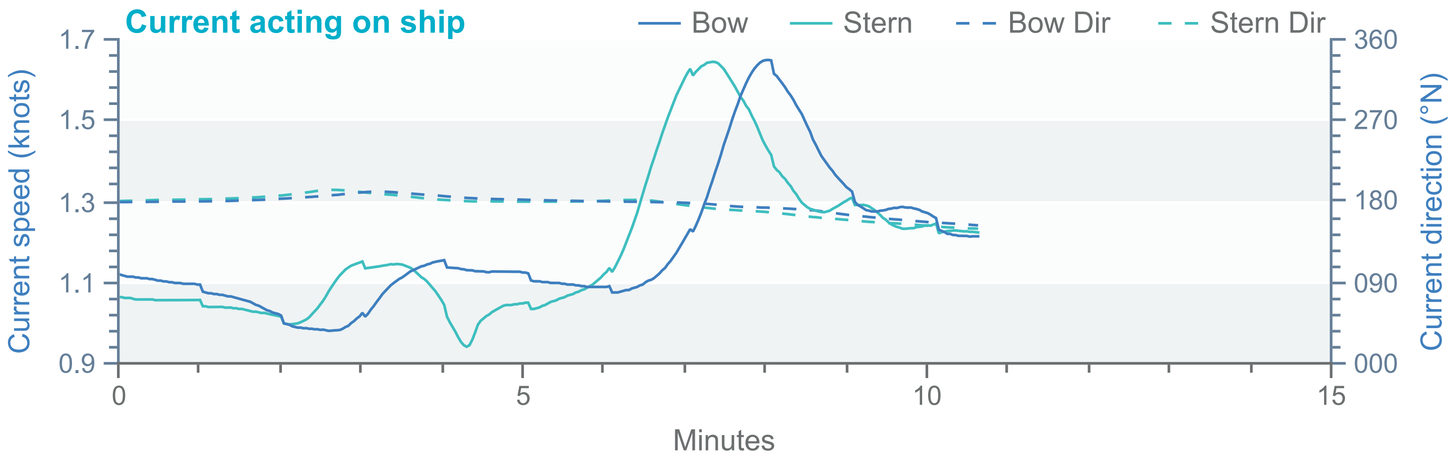

Engine Restarts
Restarts
Restarts
10
8
6
4
2
0
0min
2min
4min
6min
8min
10min
12min

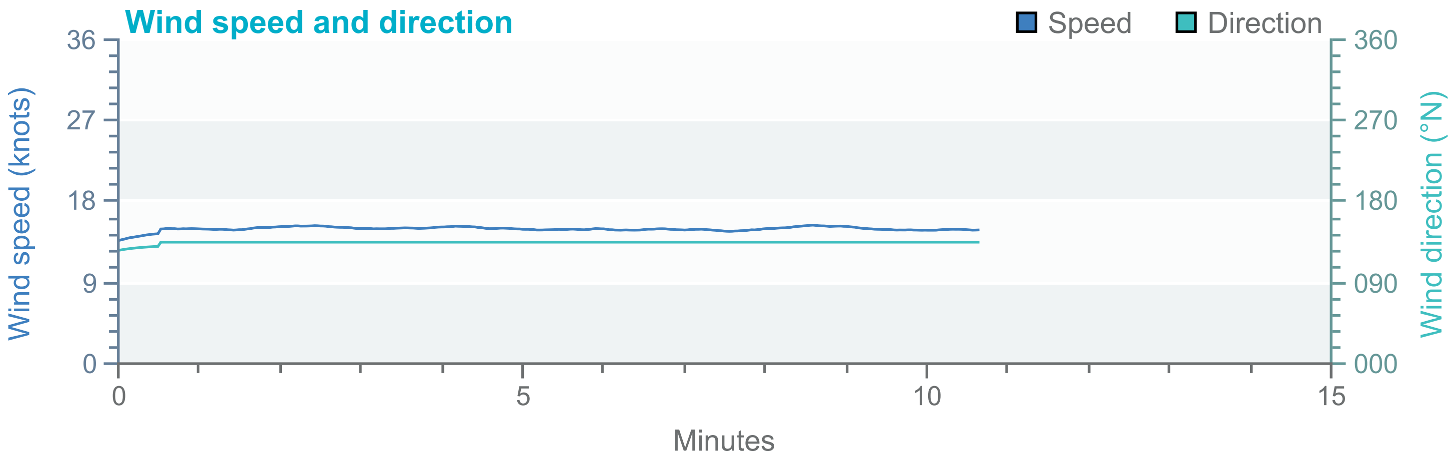
Tracks | Environment | Fischland Ballast

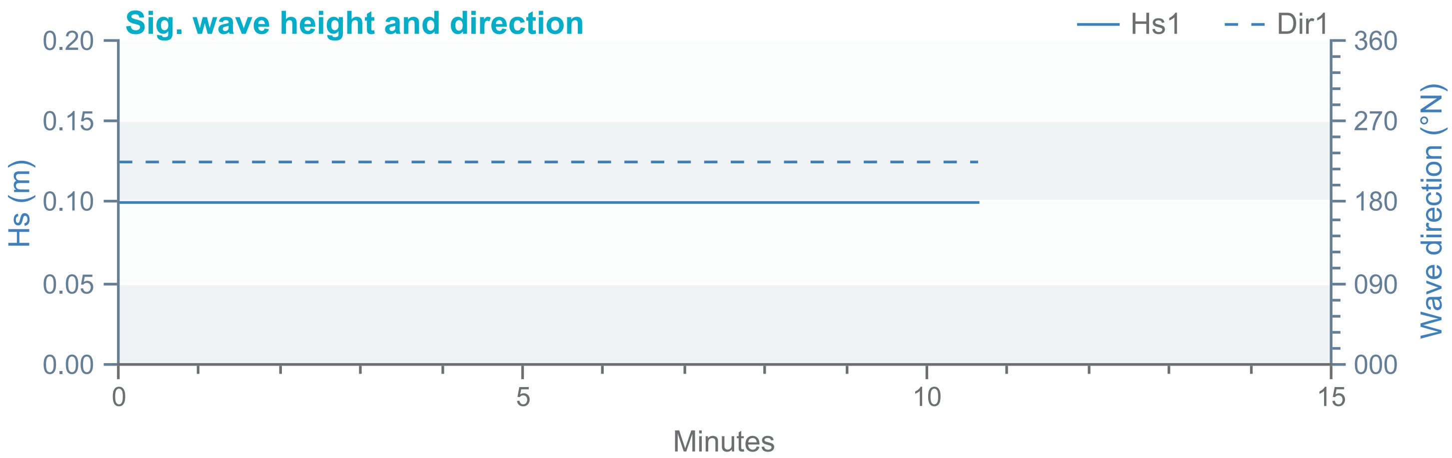
Manoeuvre track plot

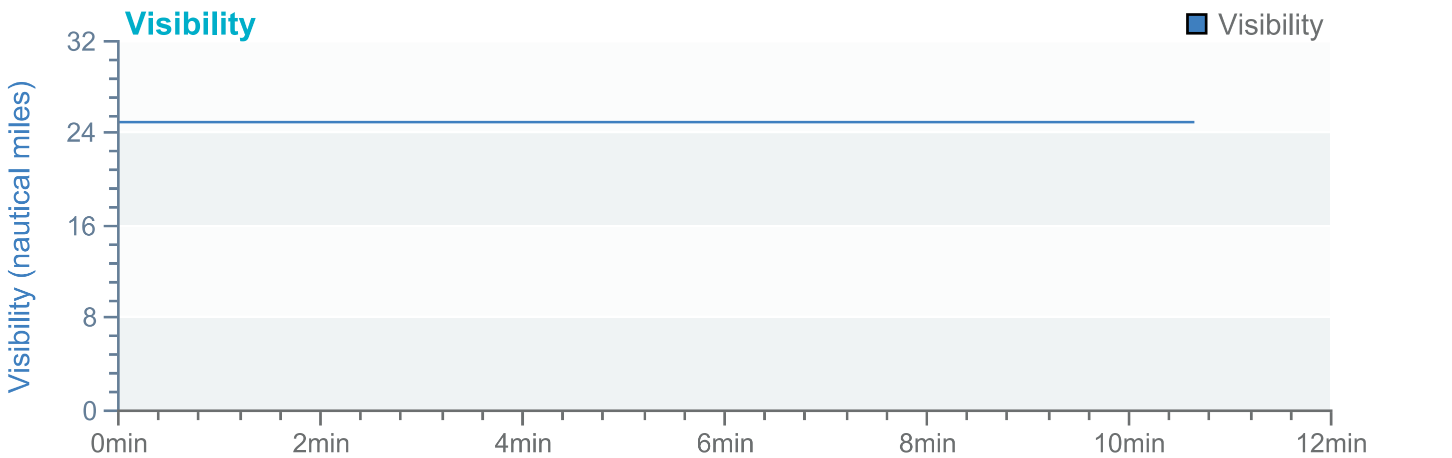


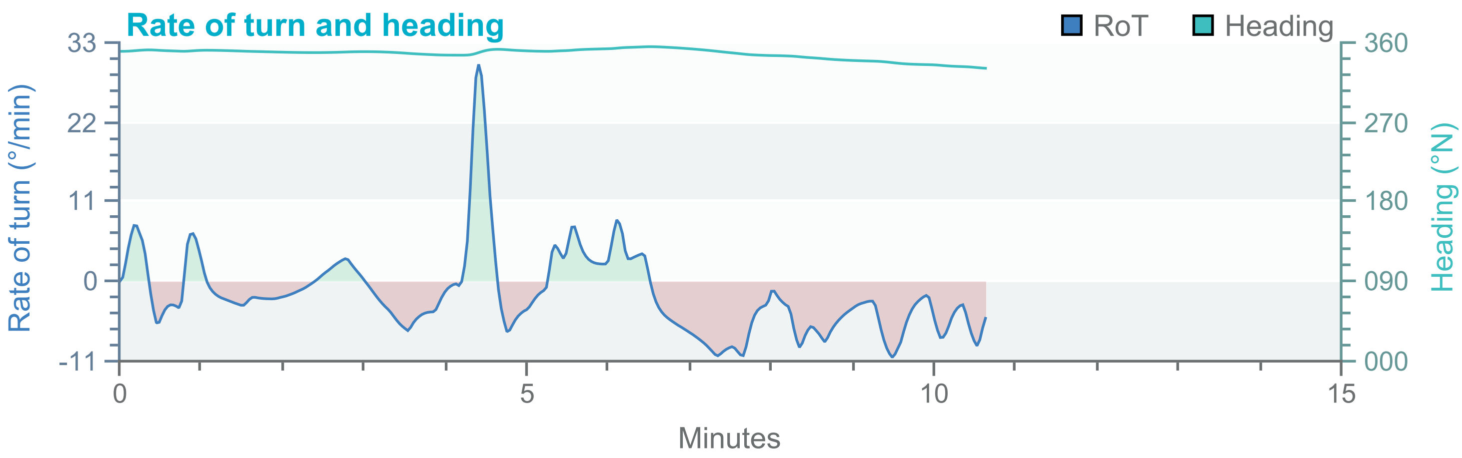
Ships plotted every 1 mins, highlight every 10 mins

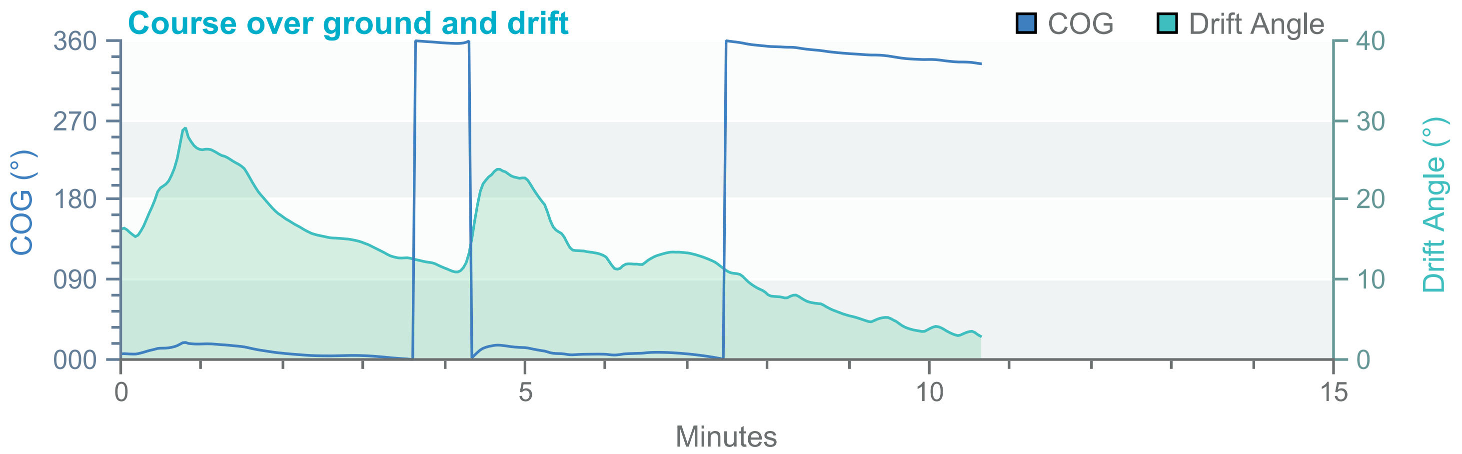

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
Minutes

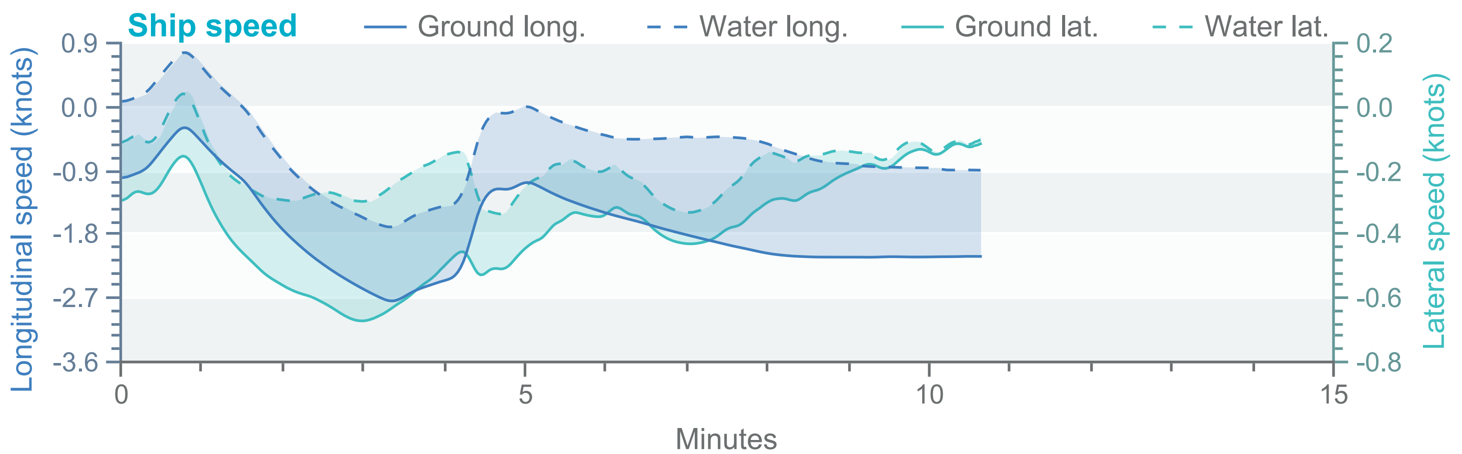

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
Minutes

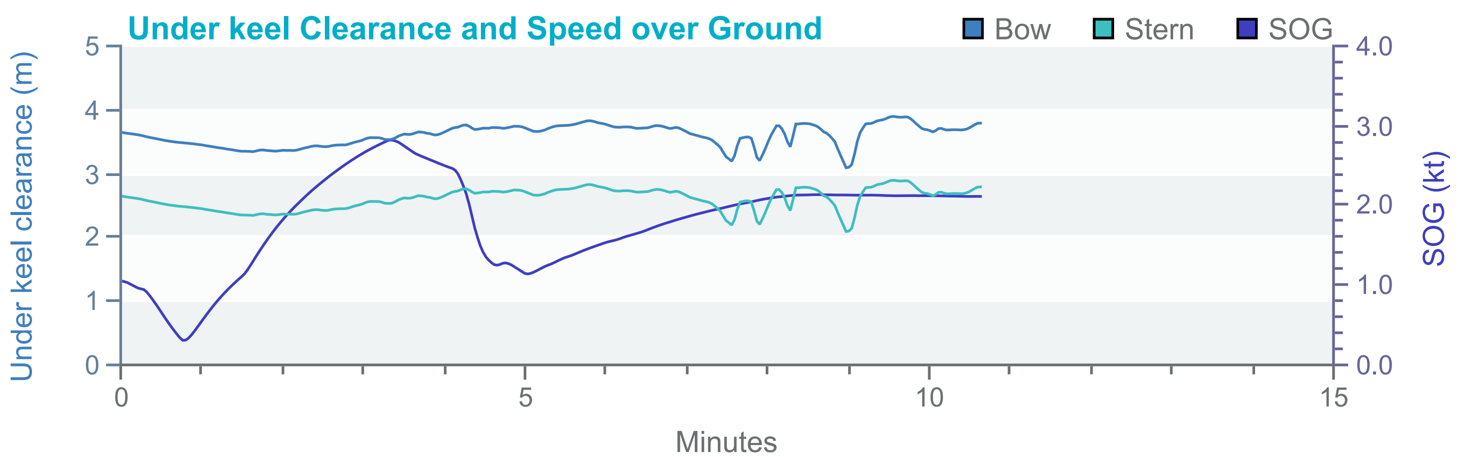

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
Minutes


Visibility
Visibility
Visibility (nautical miles)

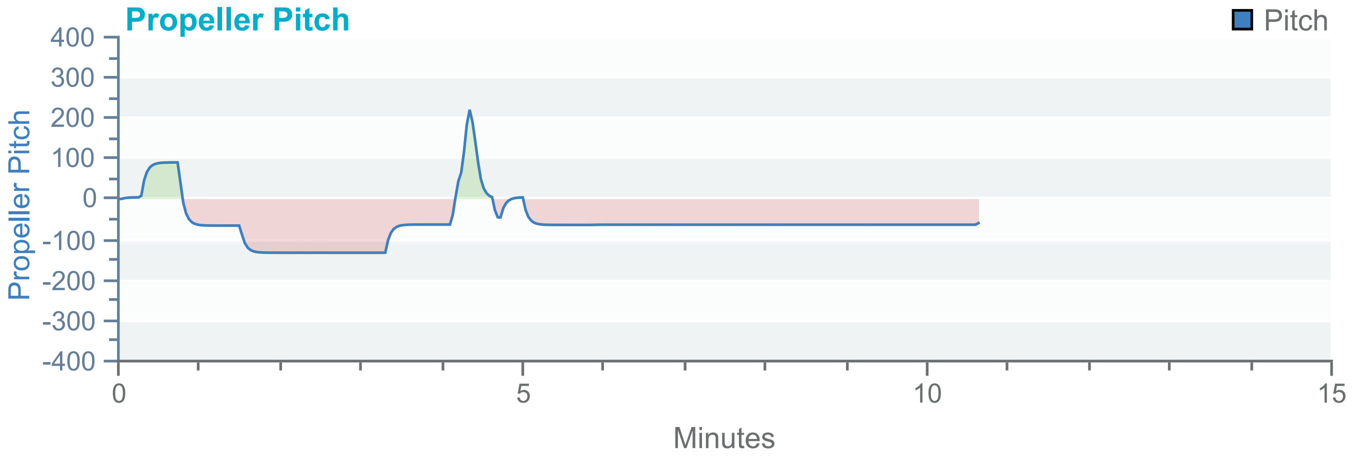

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
33
22
11
0
-11
360
270
180
090
000
0
5
10
15
Minutes


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
40
30
20
10
0
0
5
10
15
Minutes

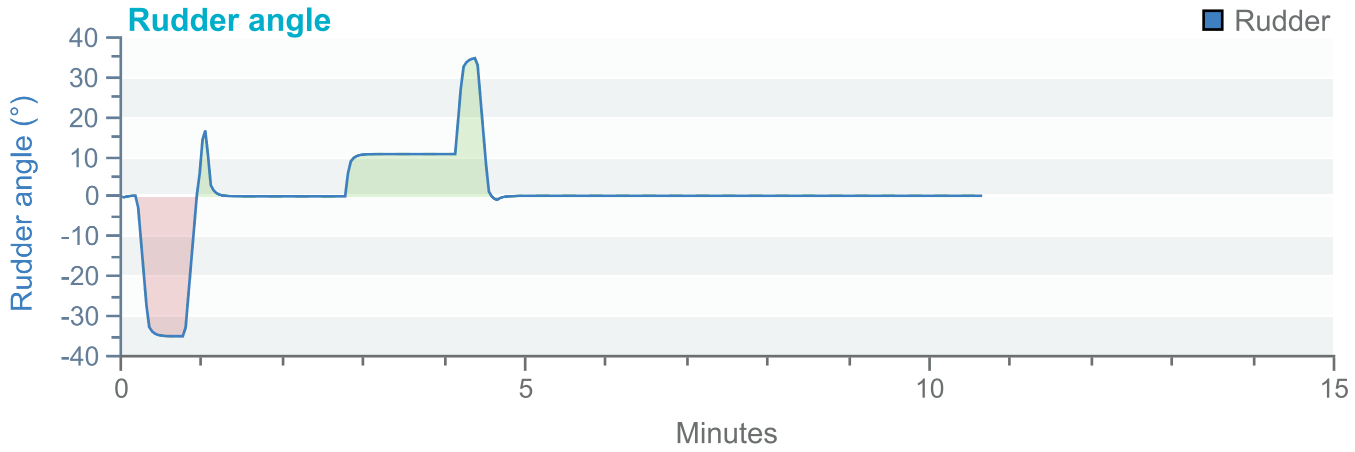

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
0.9
0.0
-0.9
-1.8
-2.7
-3.6
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
Minutes


Under keel Clearance and Speed over Ground
Bow
Stern
SOG
Under keel clearance (m)
SOG (kt)
5
4
3
2
1
0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
Minutes

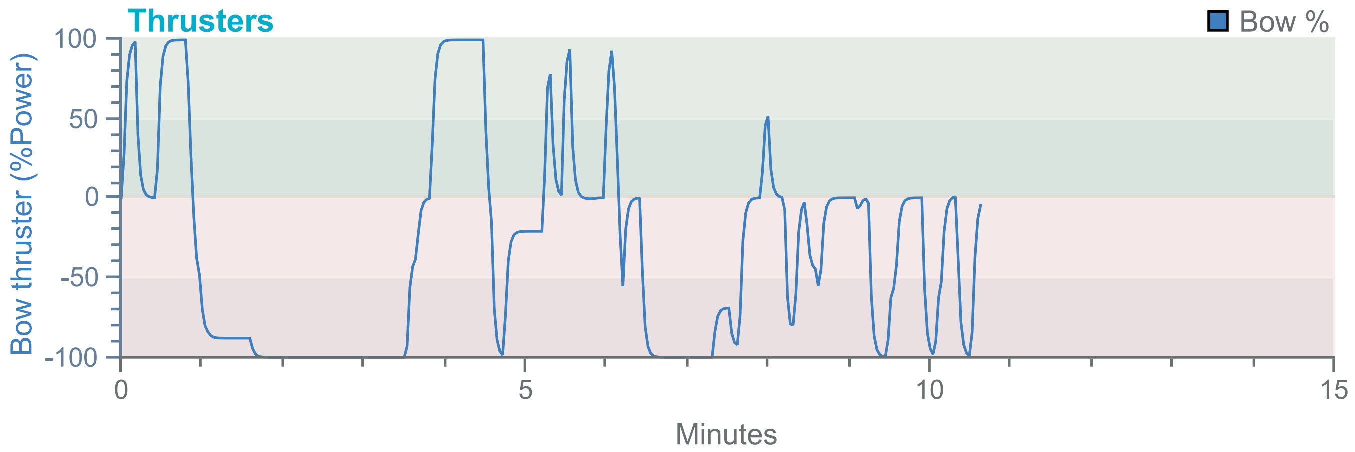
Propeller Pitch



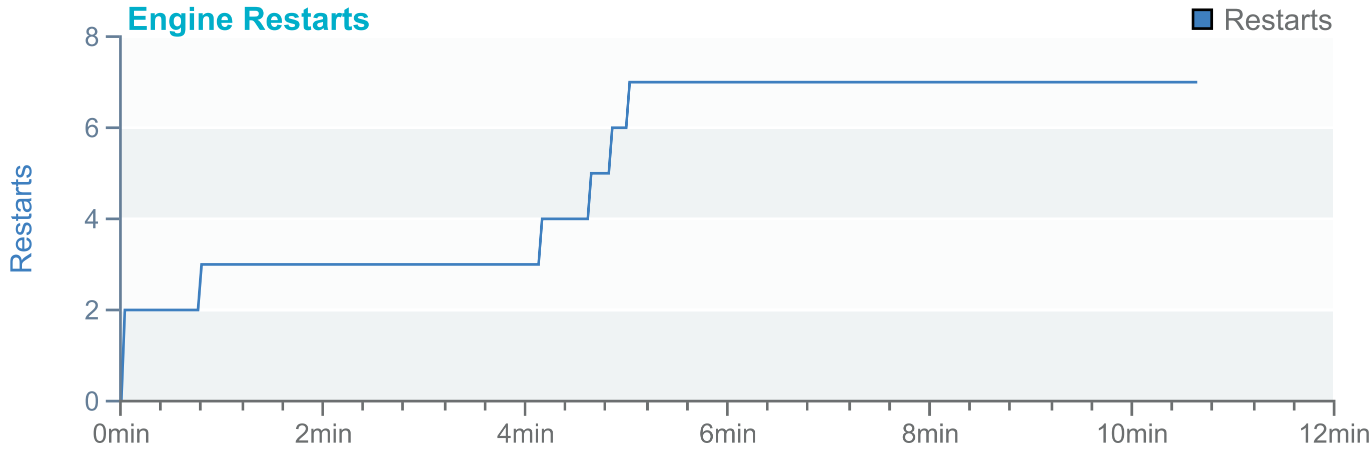
Rudder angle



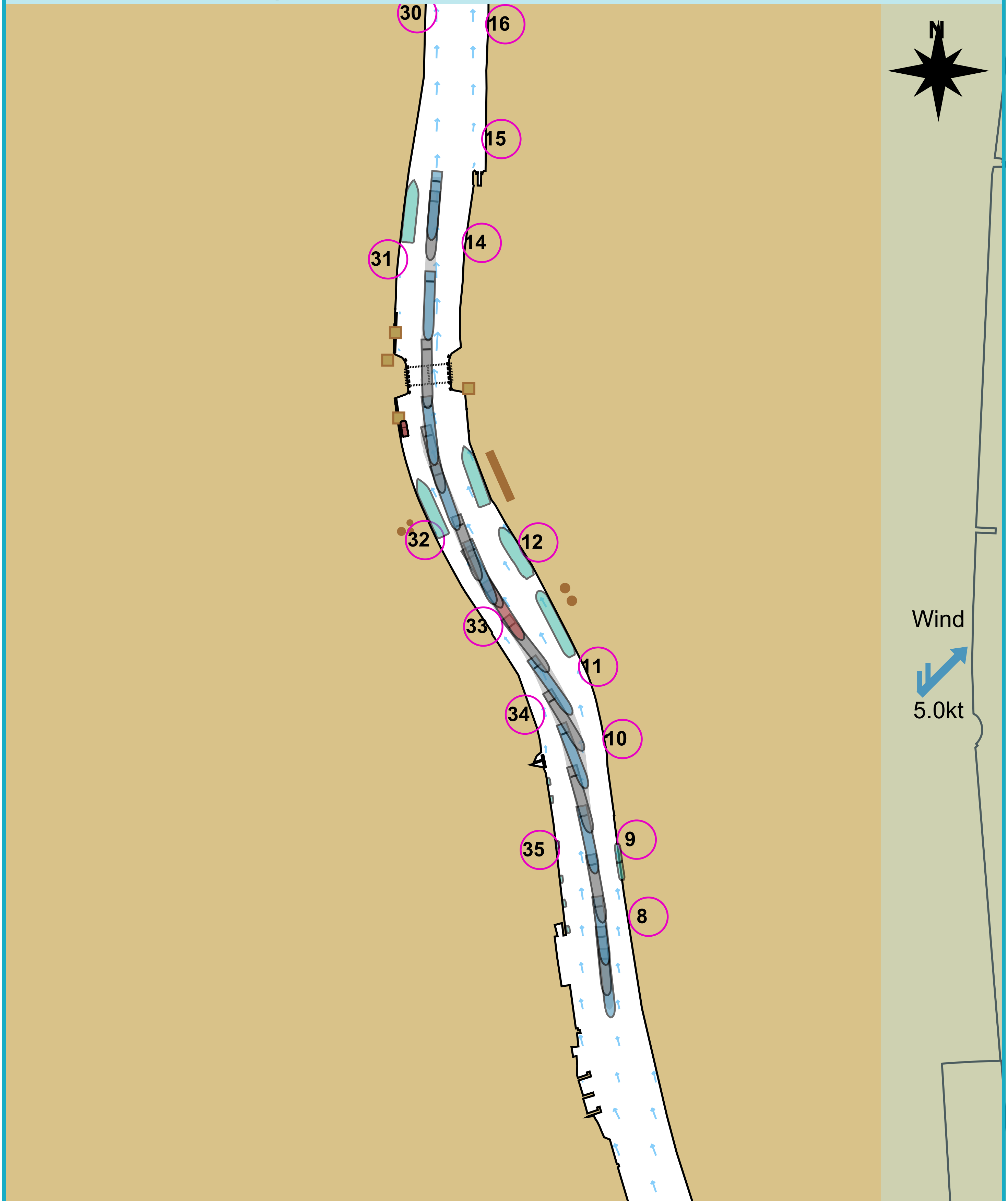
Thrusters



Engine Restarts

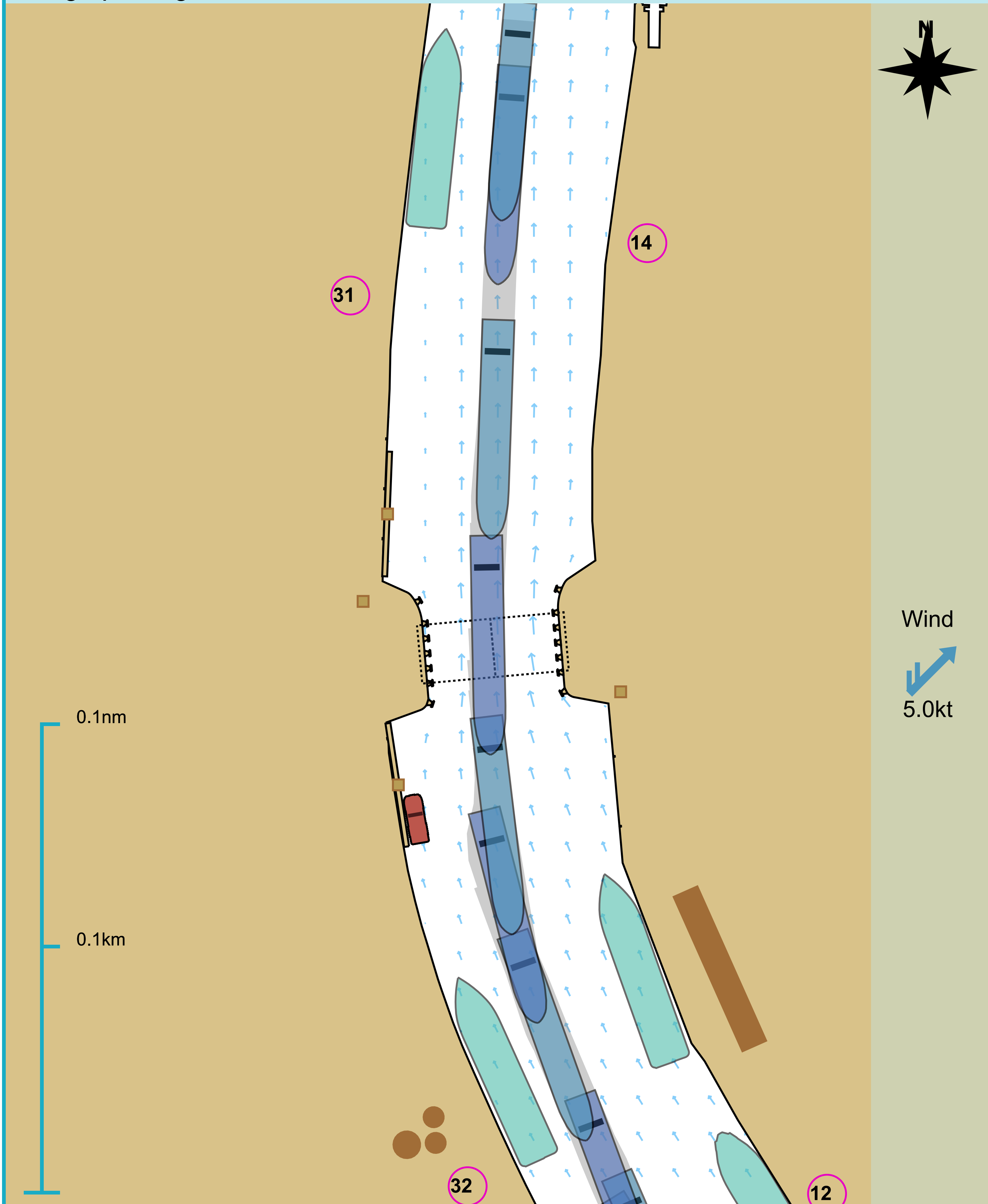


Manoeuvre track plot



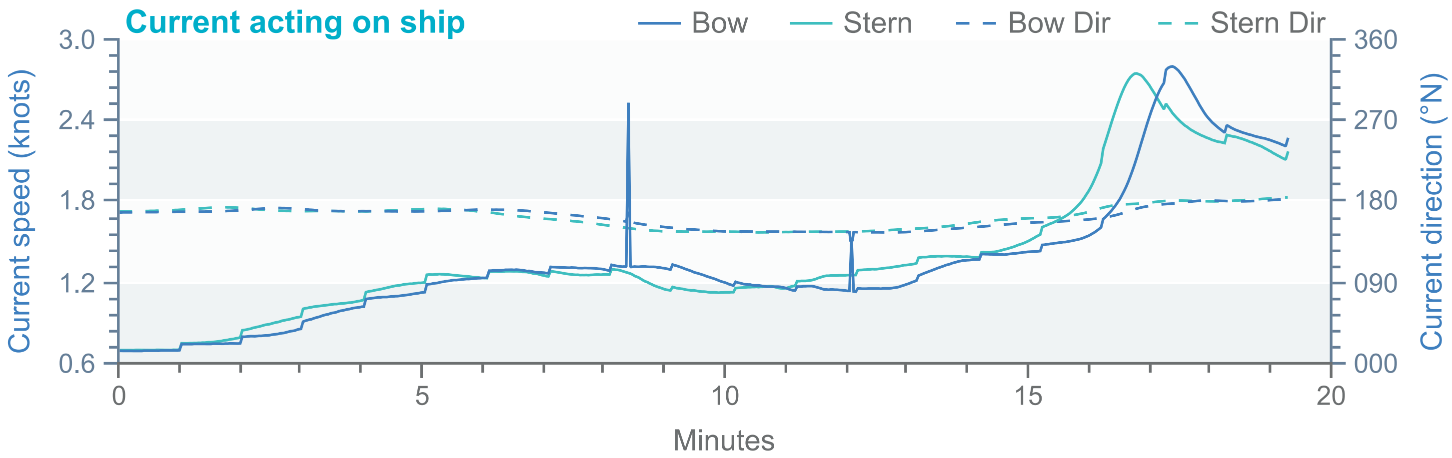
Ships plotted every 1 mins, highlight every 10 mins

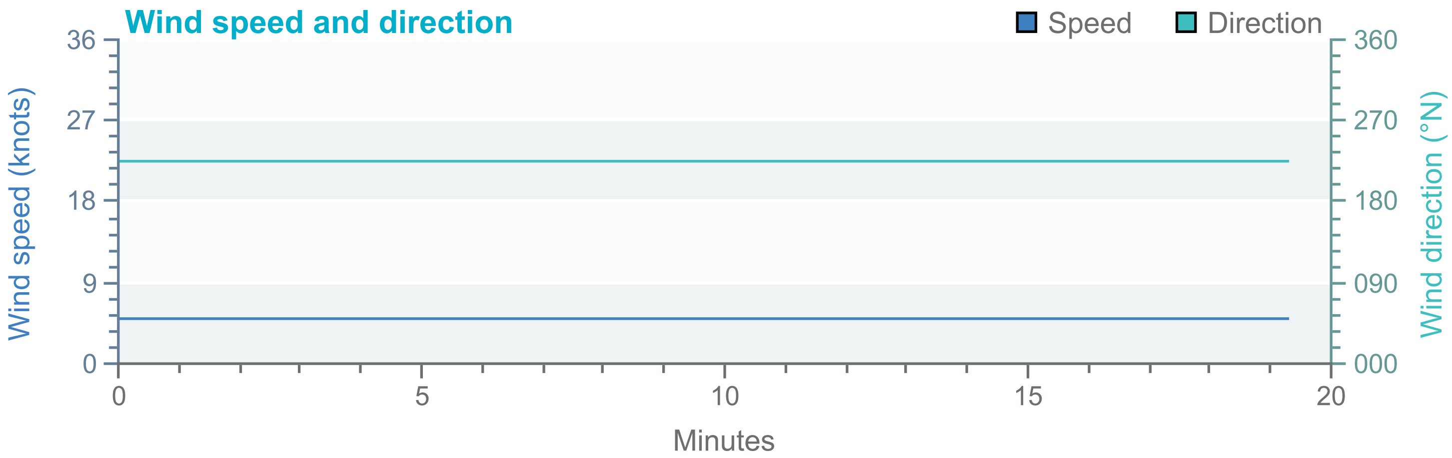
Bridge passage

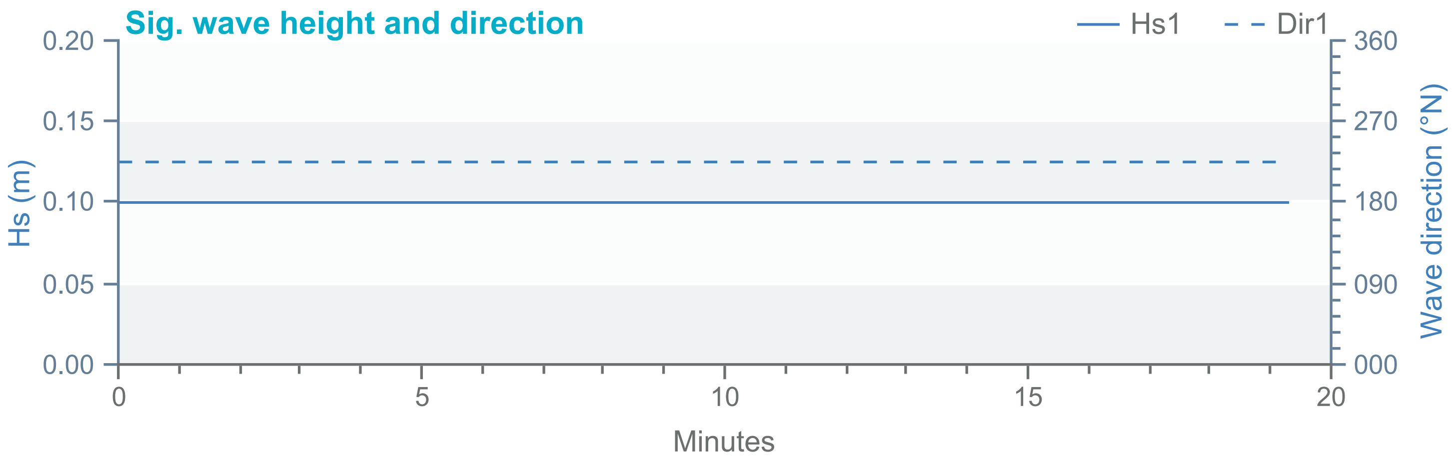


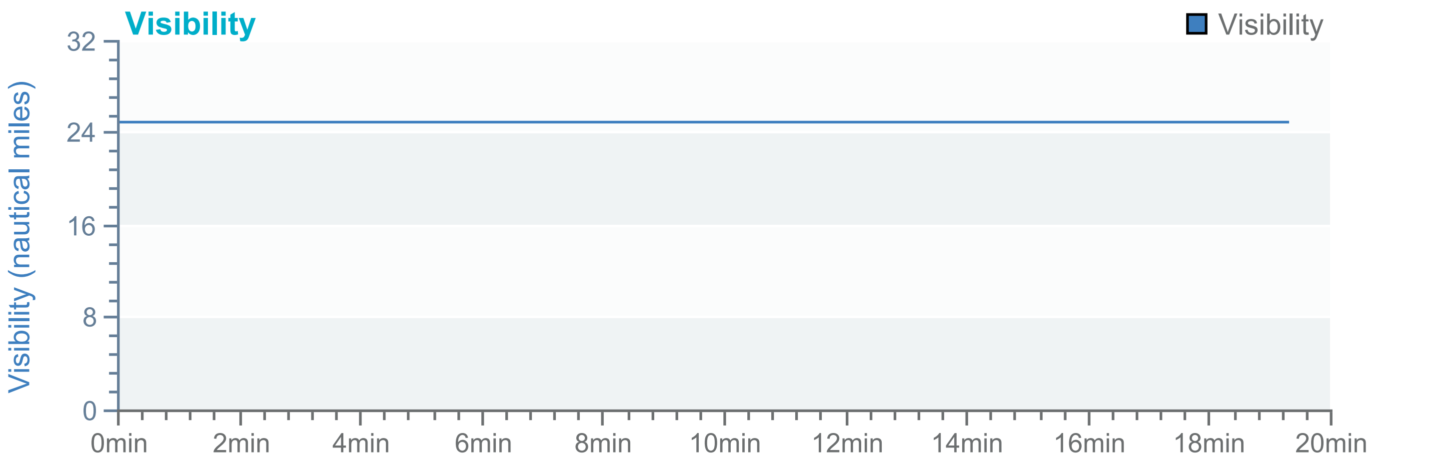
Ships plotted every 1 mins, highlight every 10 mins

Tracks | Environment | Fischland Ballast

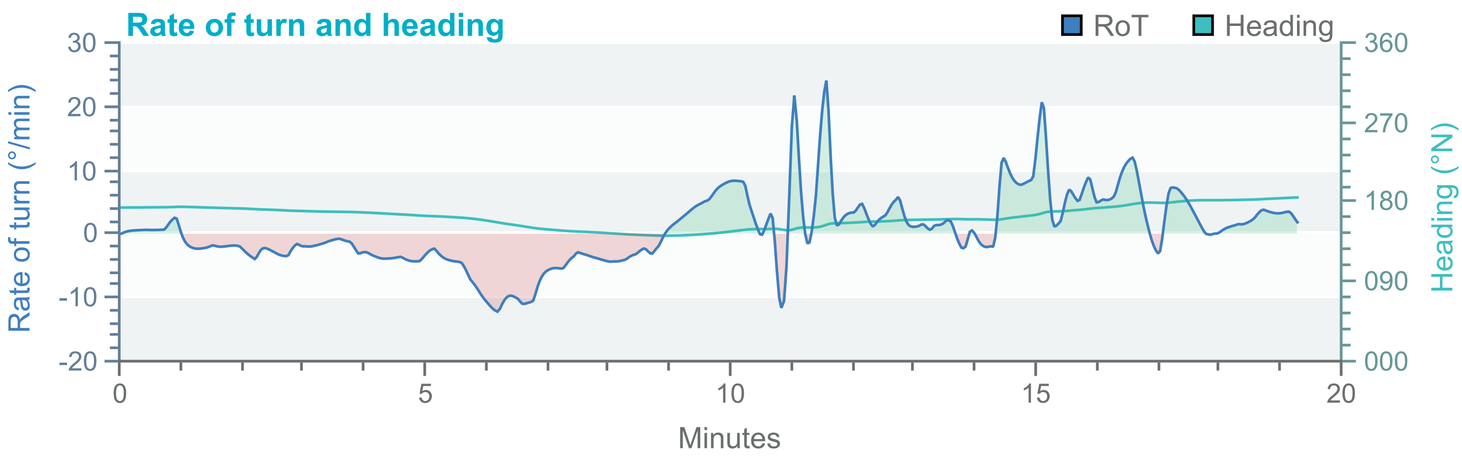


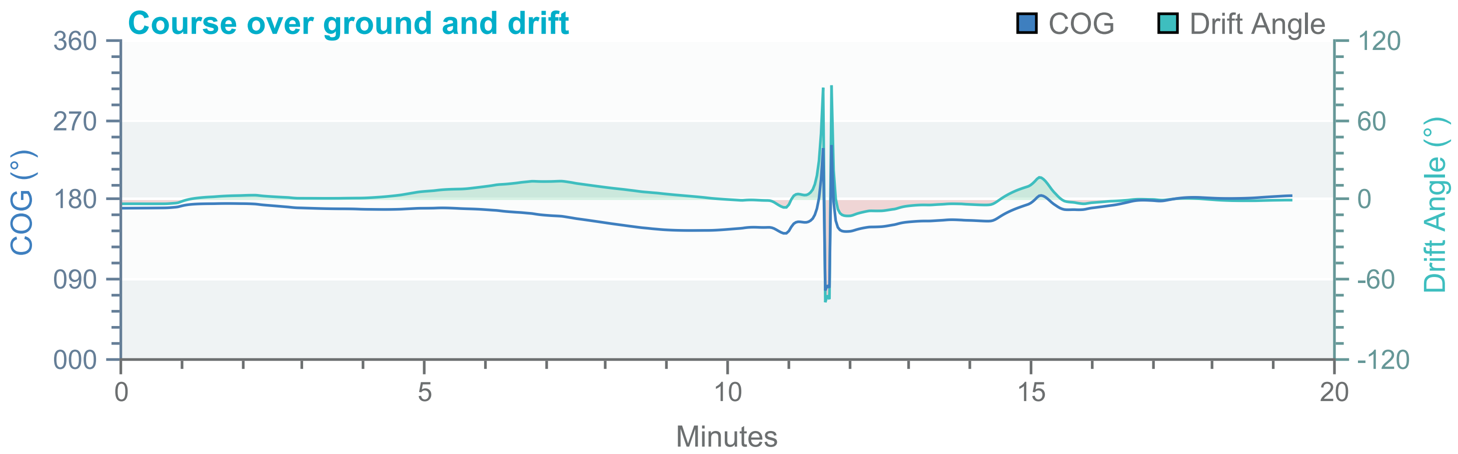


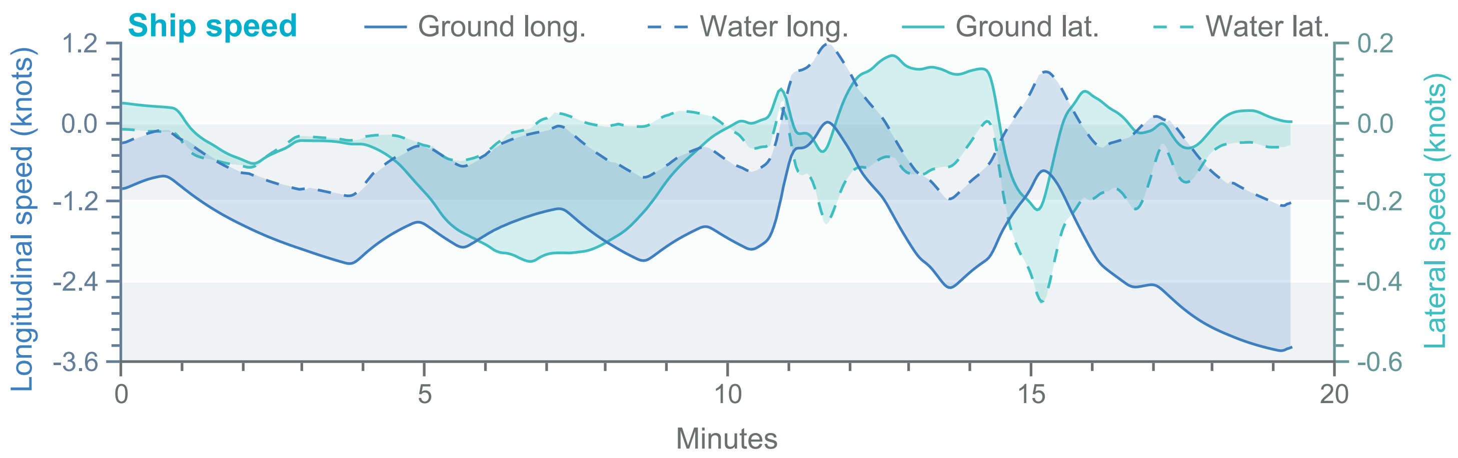


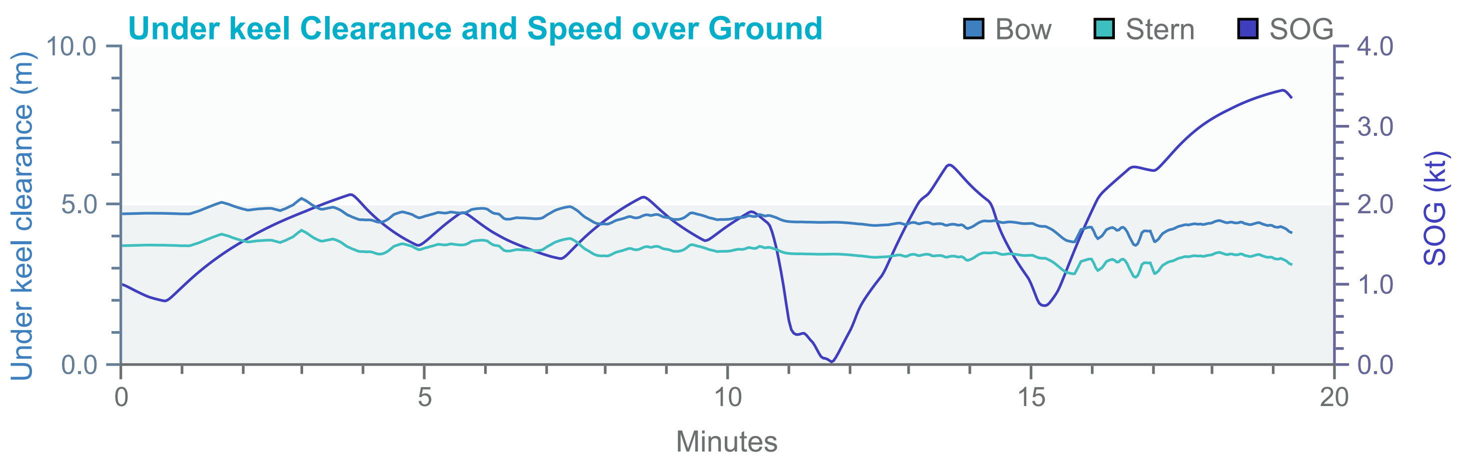


Tracks | Environment | Fischland Ballast



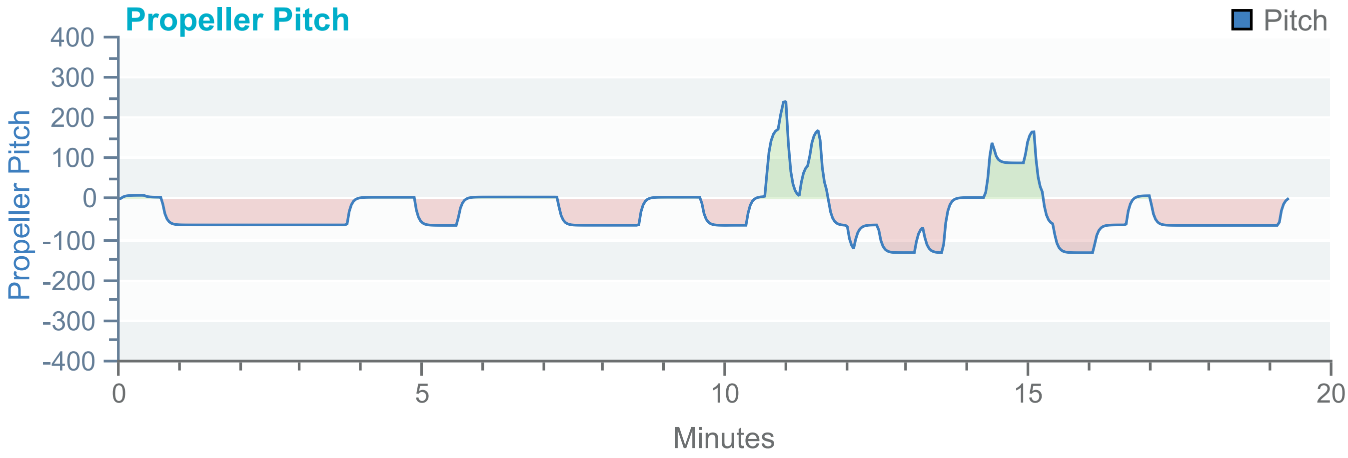




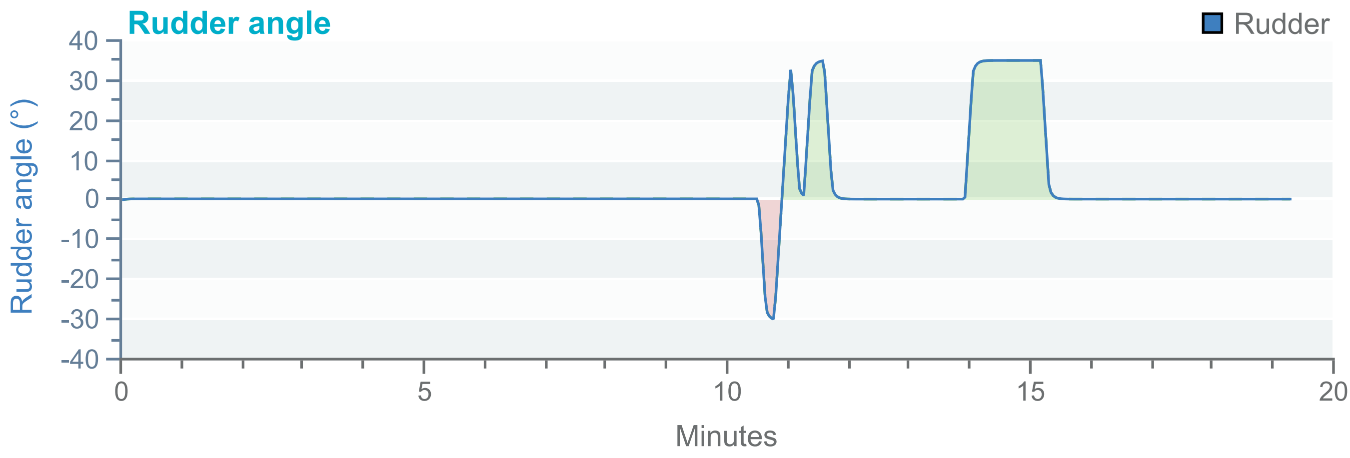


Tracks | Environment | Fischland Ballast

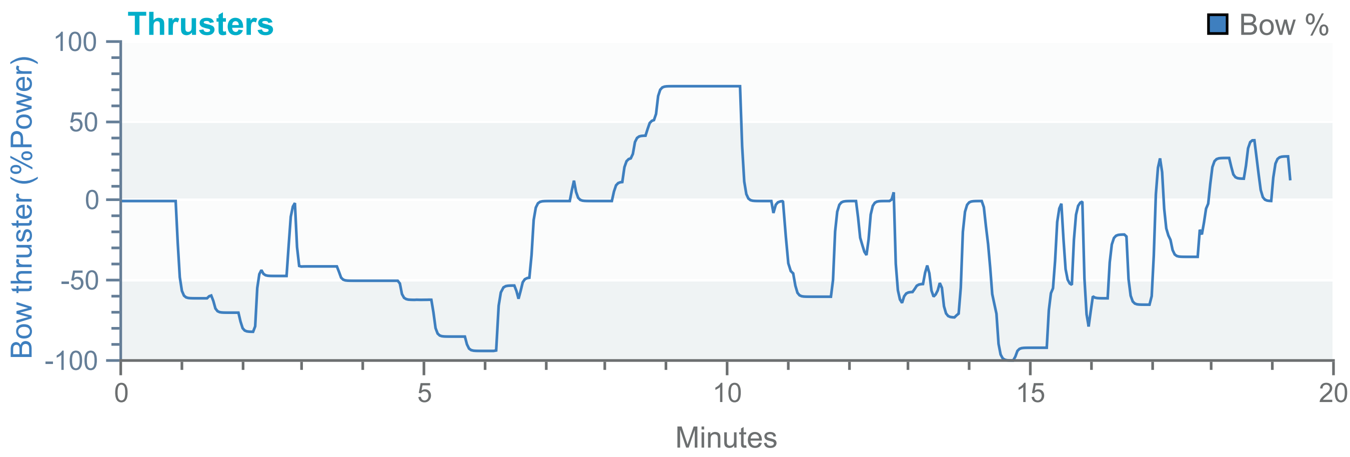
Propeller Pitch



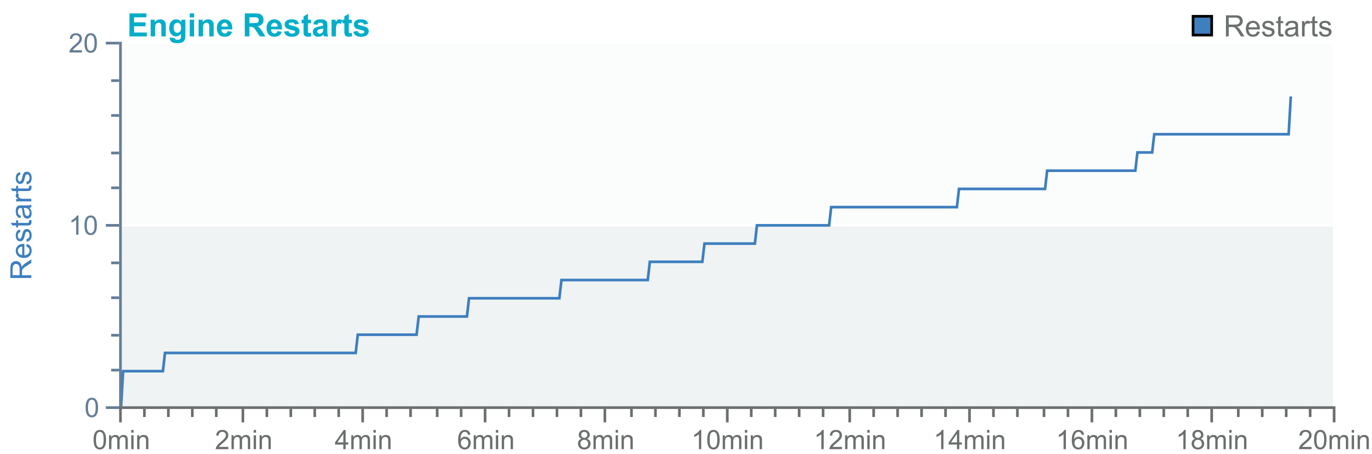
Rudder angle



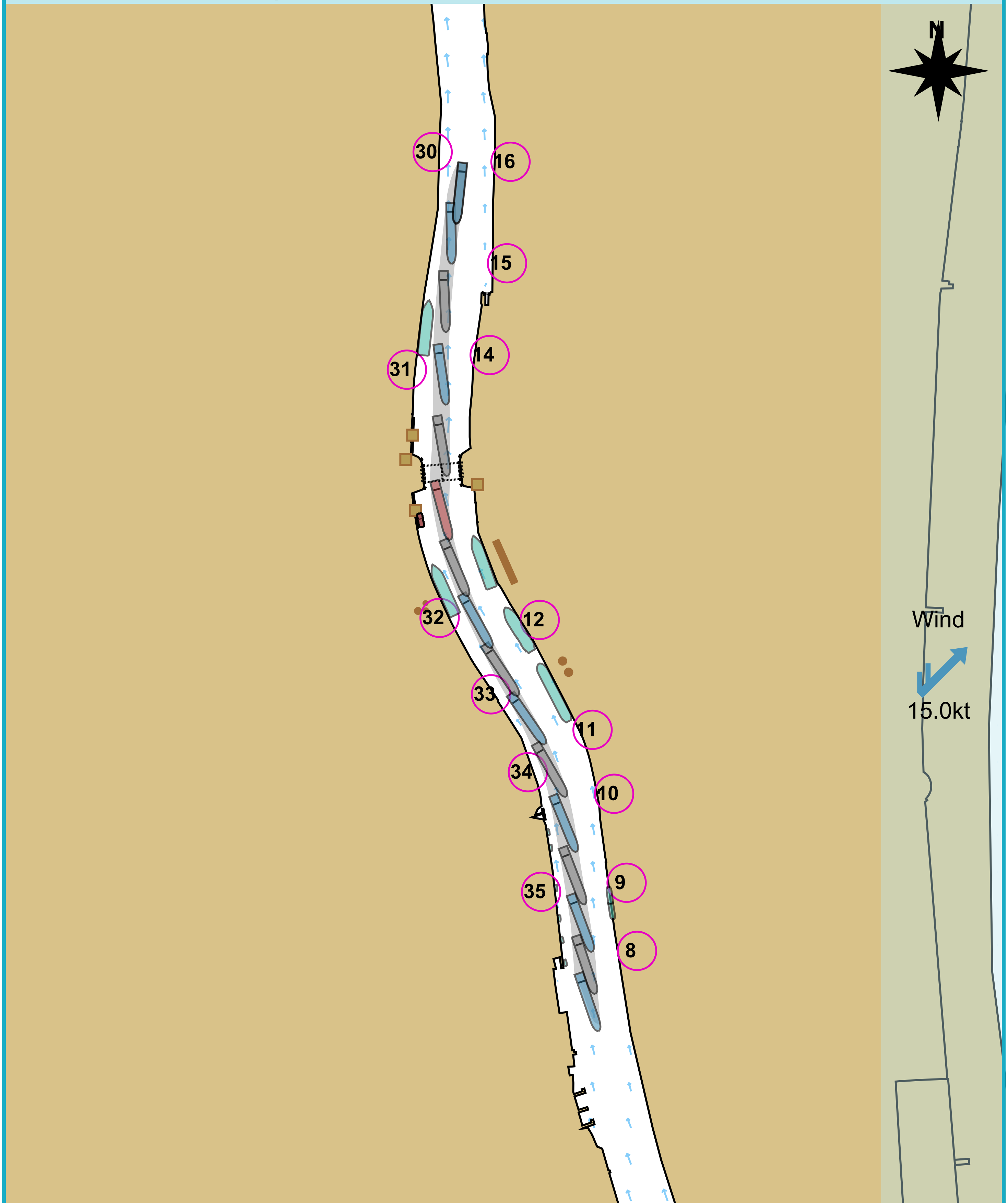
Thrusters



Engine Restarts



Manoeuvre track plot

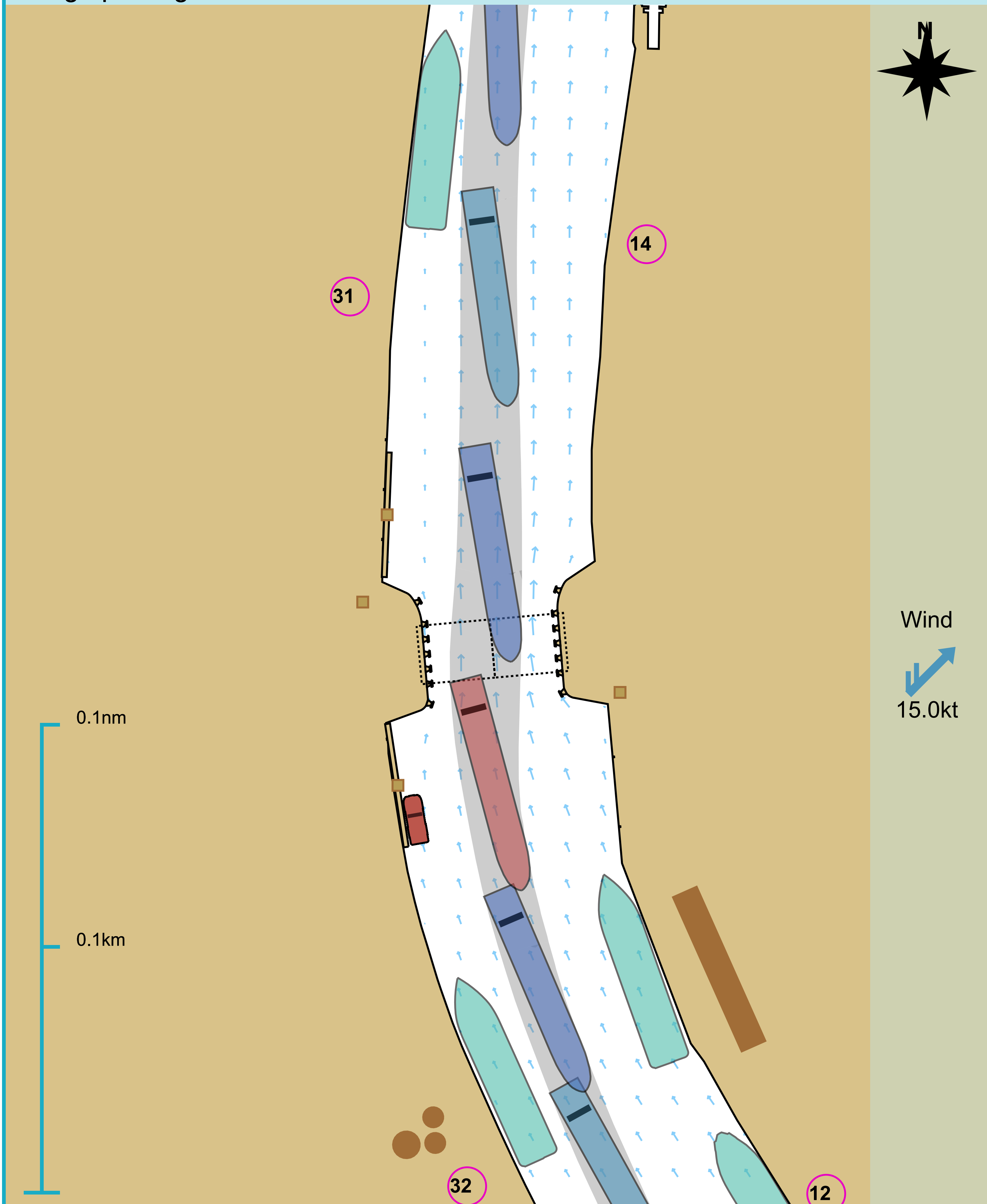


Ships plotted every 1 mins, highlight every 10 mins

Pilot: RG
Manoeuvre: Arrival

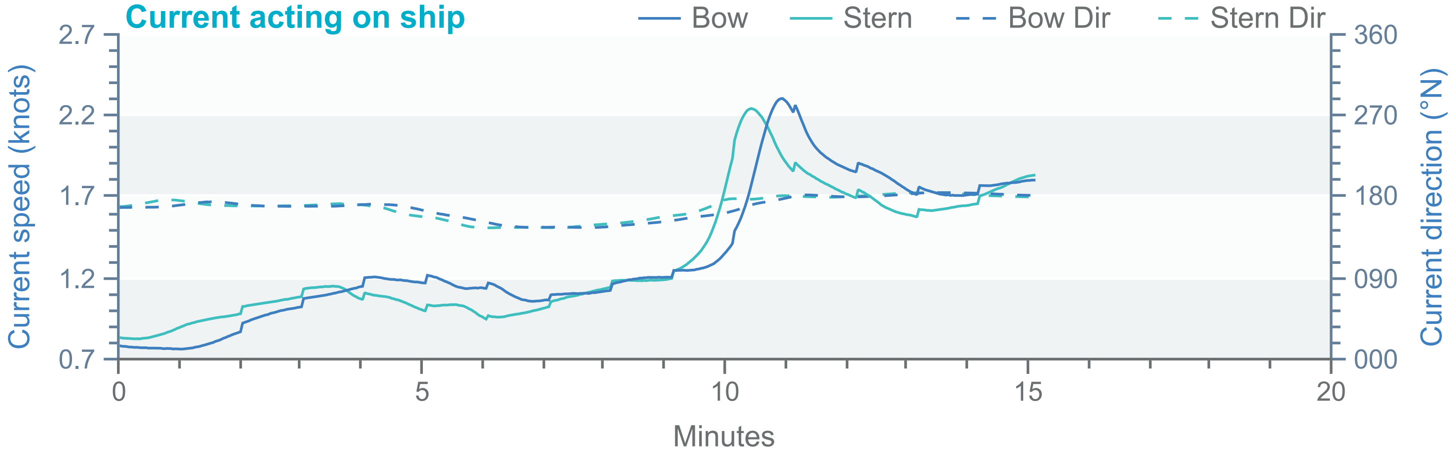
Tracks	Environment	Fischland Ballast

Bridge passage

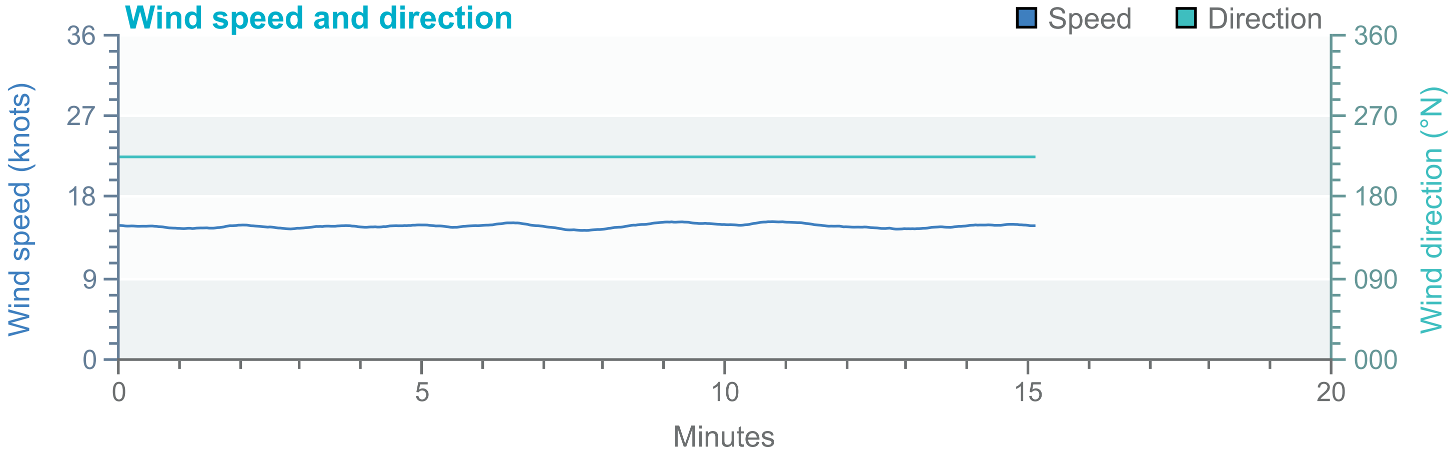


Ships plotted every 1 mins, highlight every 10 mins

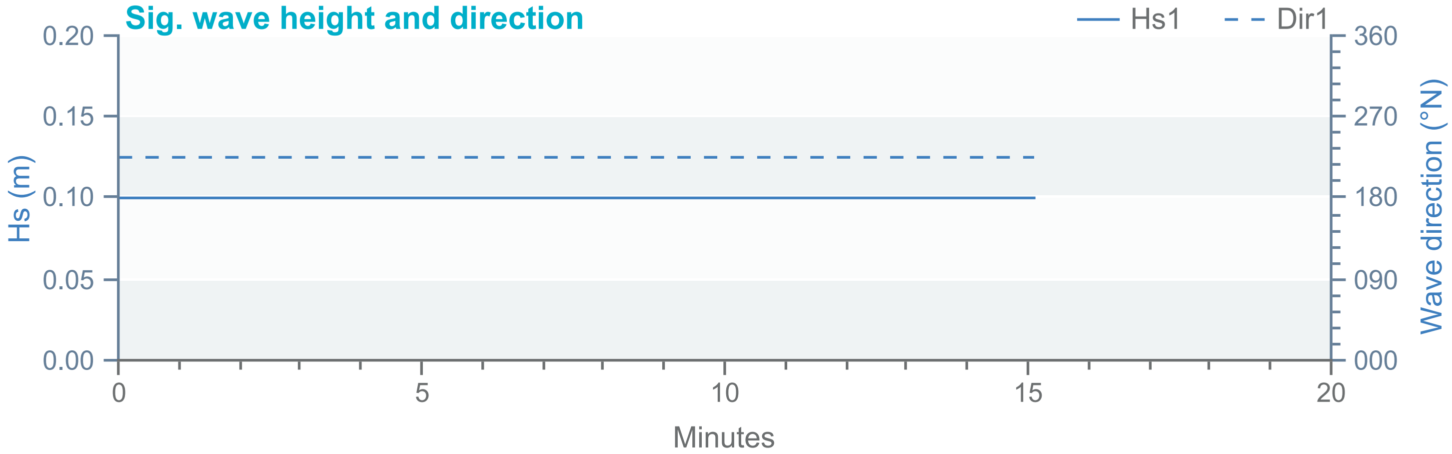
Current acting on ship



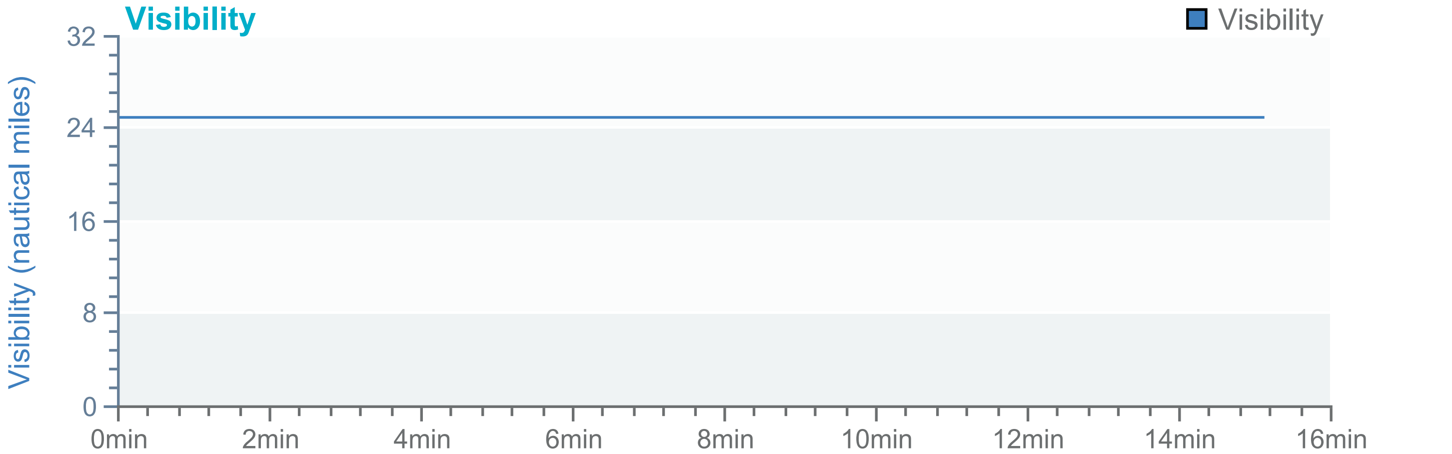
Wind speed and direction



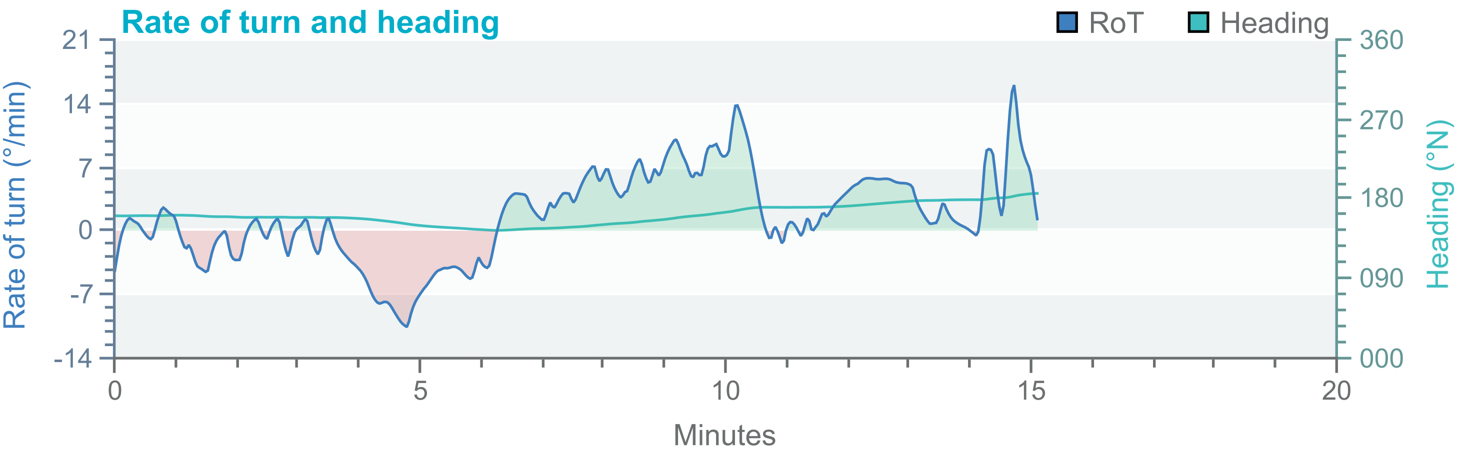
Sig. wave height and direction

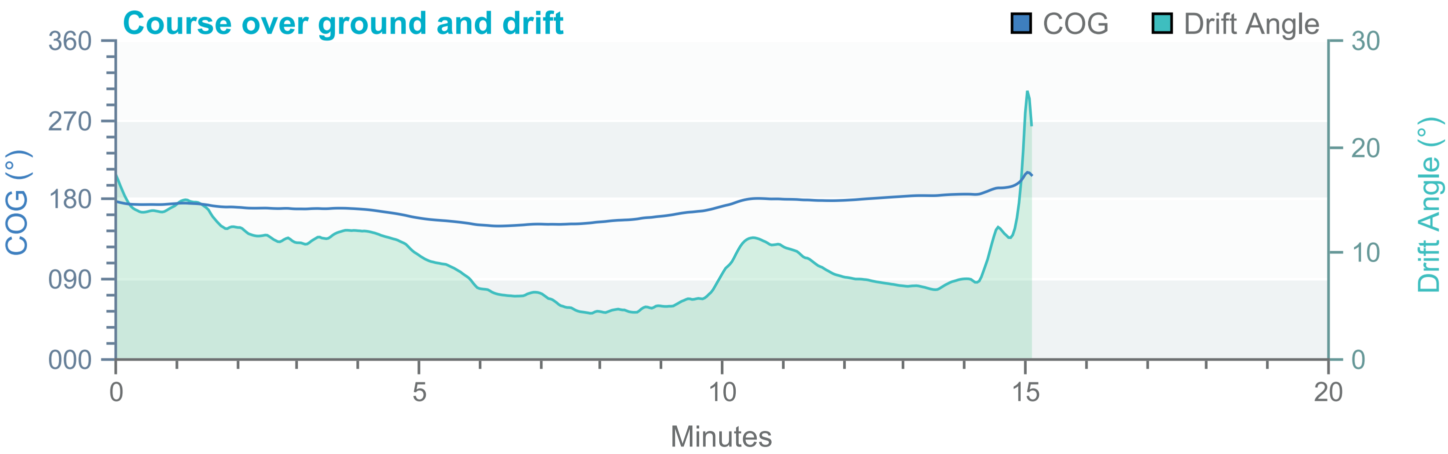


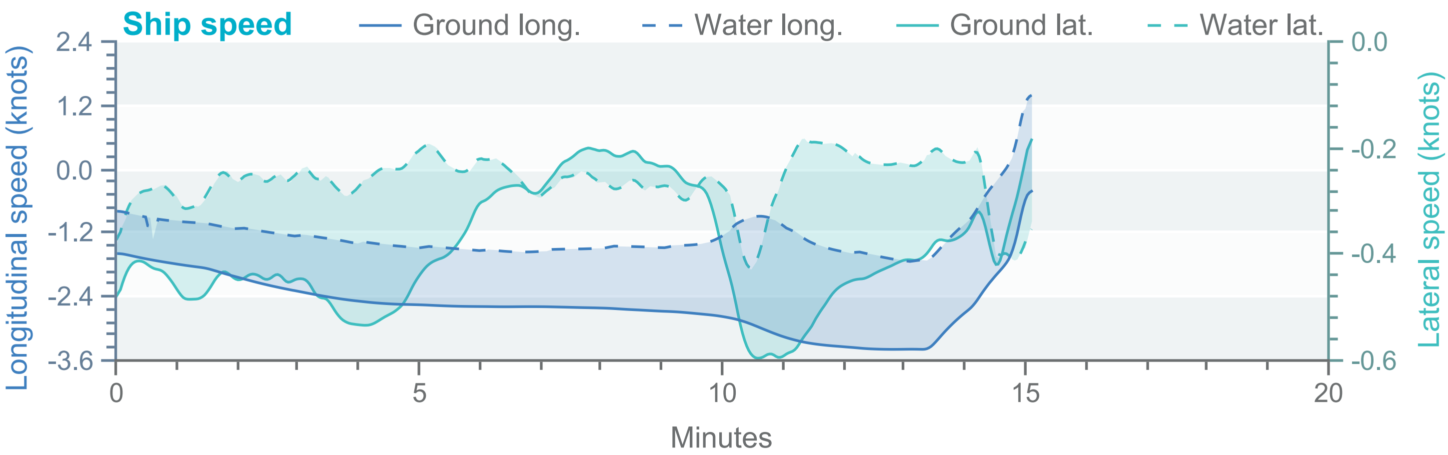
Visibility

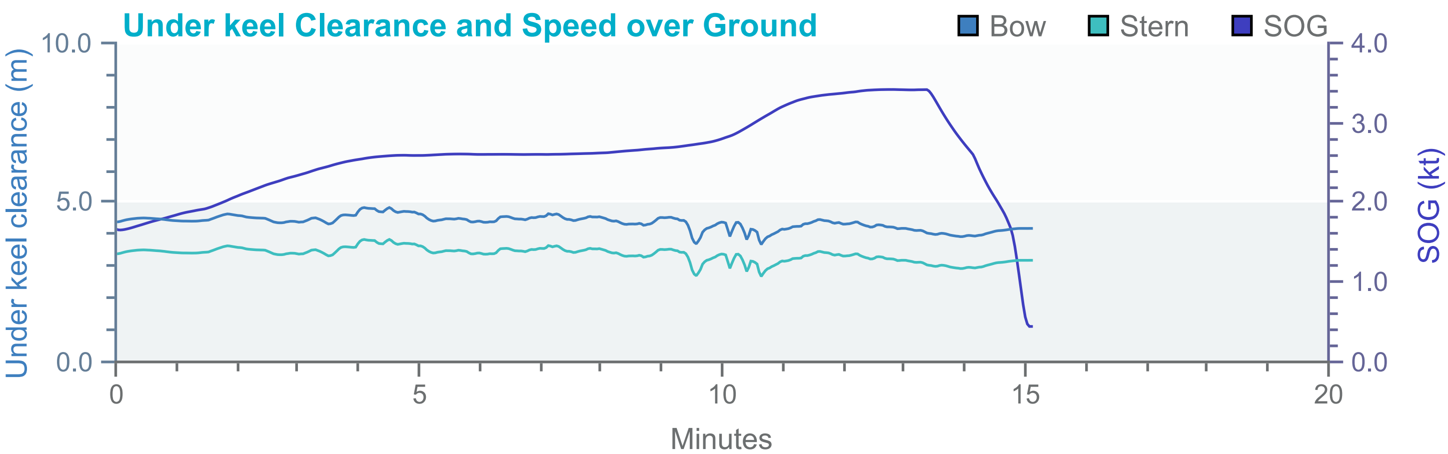


Tracks | Environment | Fischland Ballast

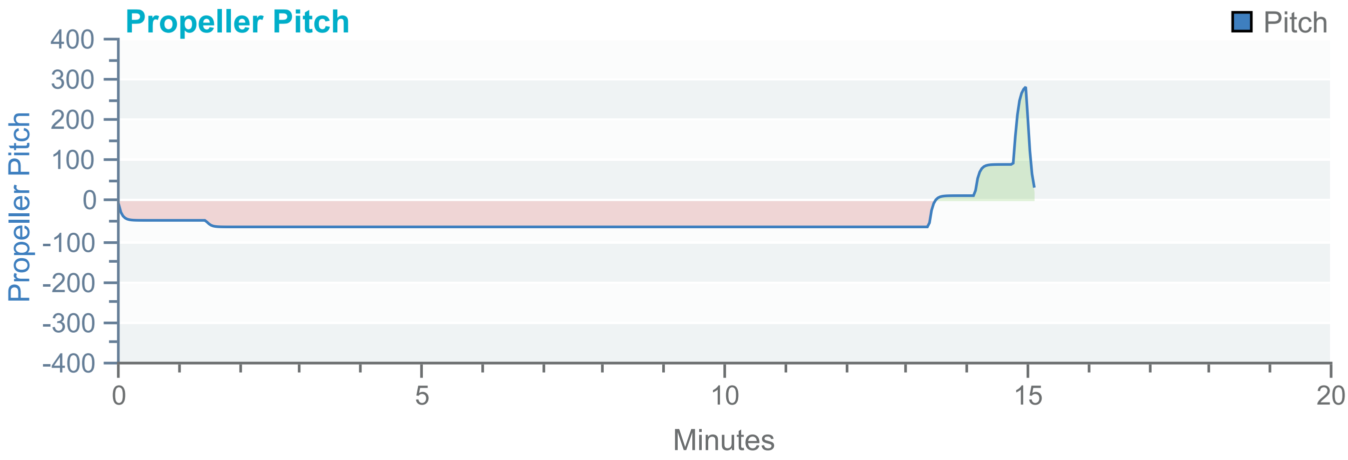


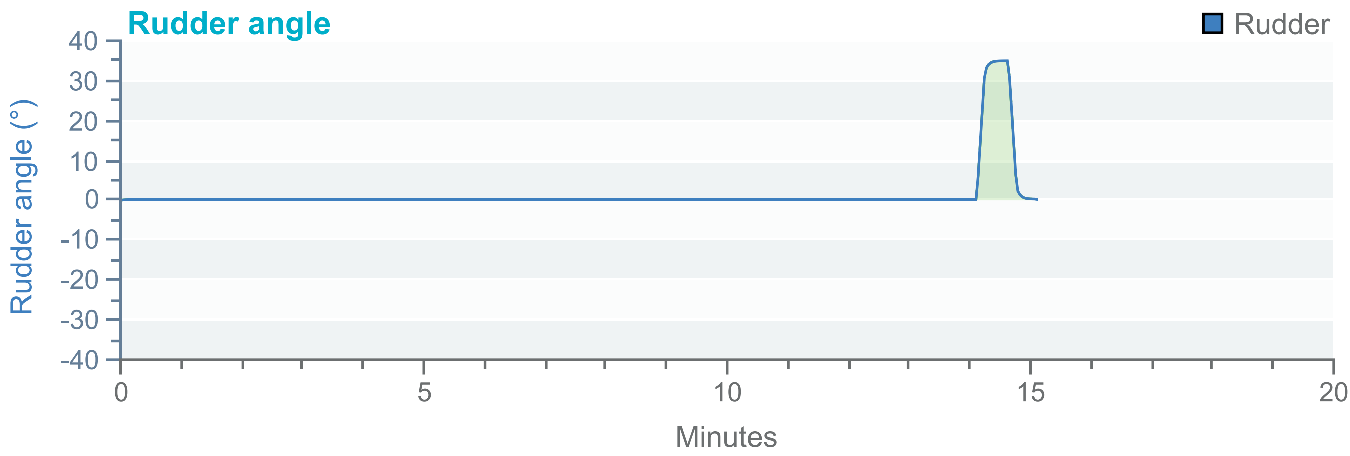


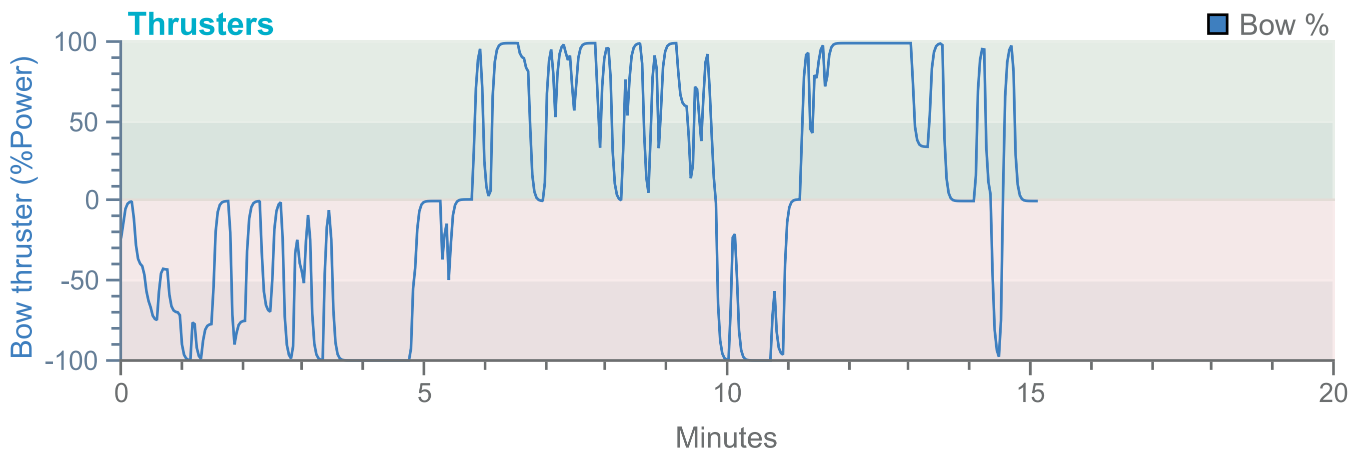


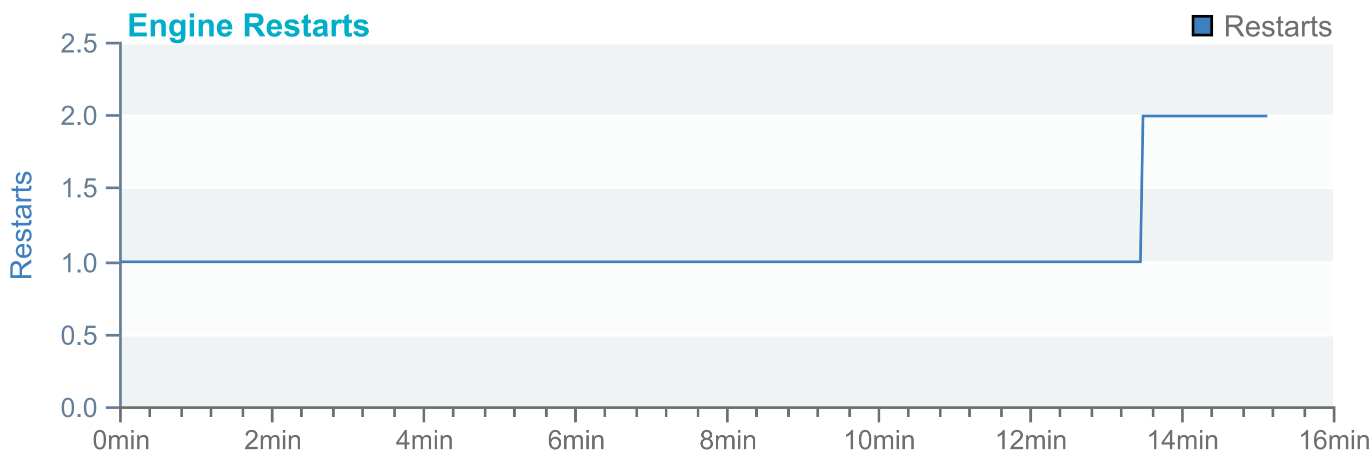


Tracks | Environment | Fischland Ballast

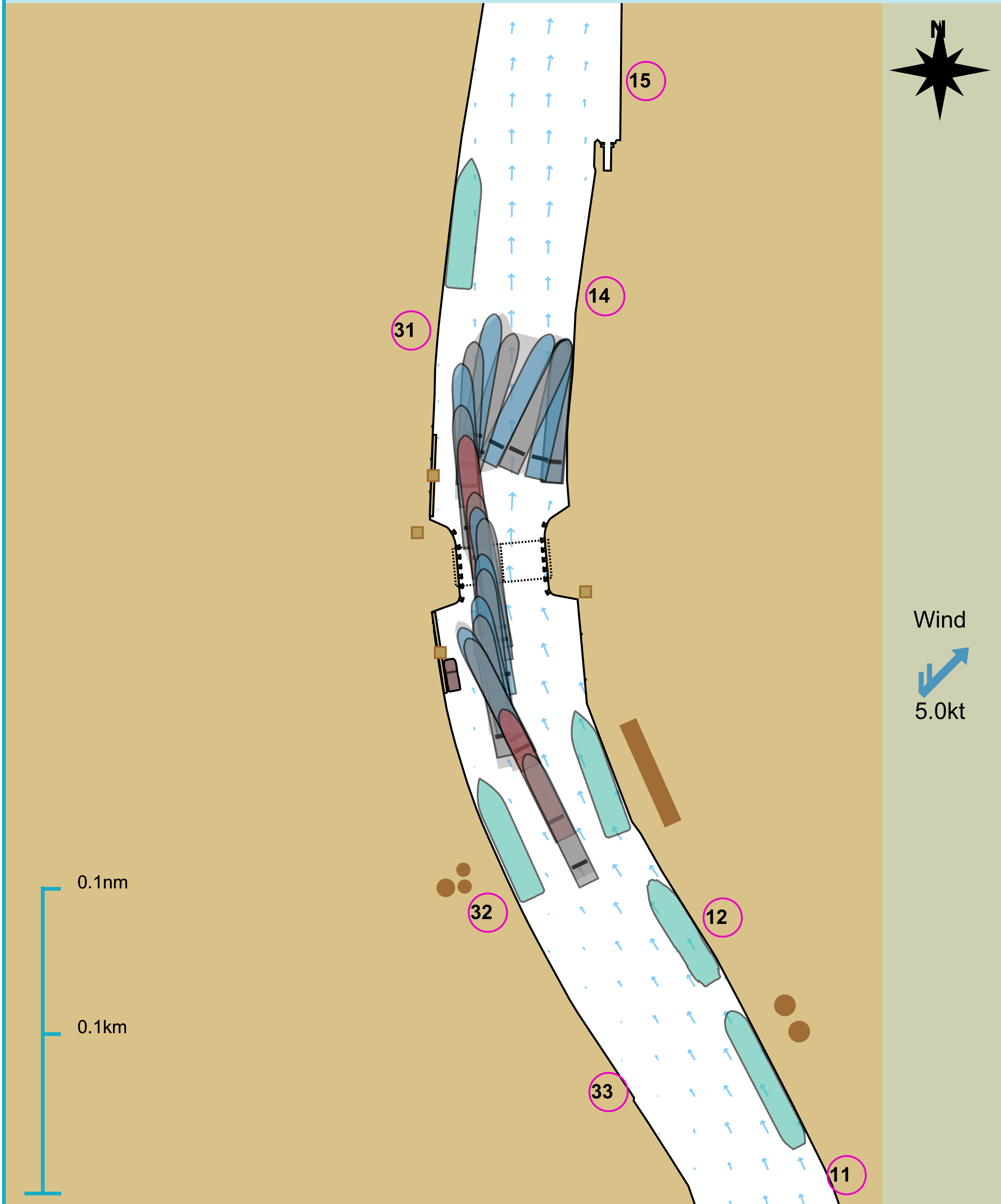






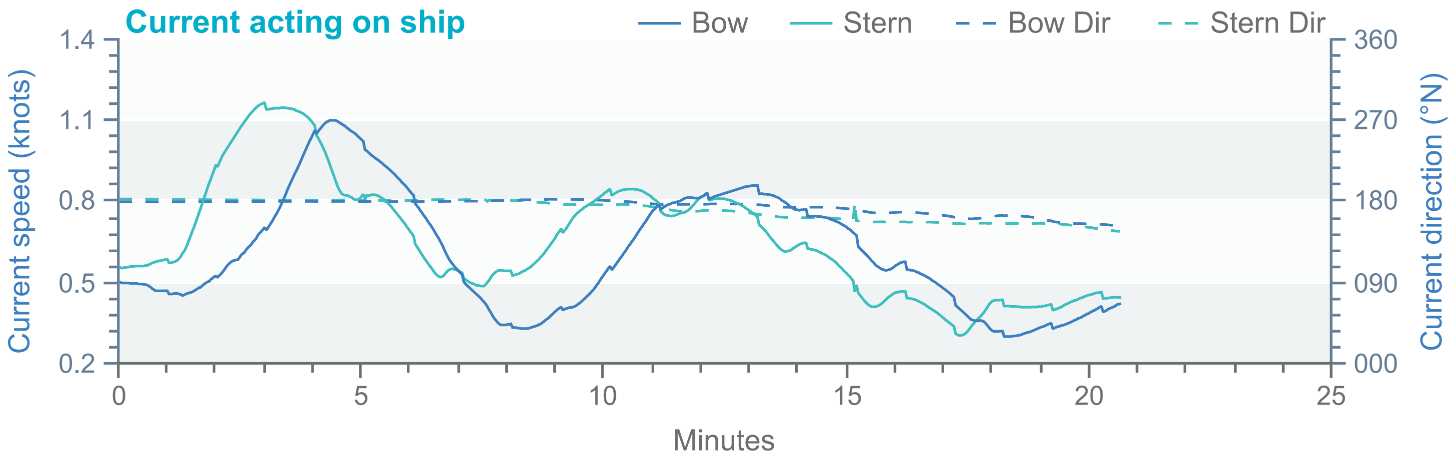


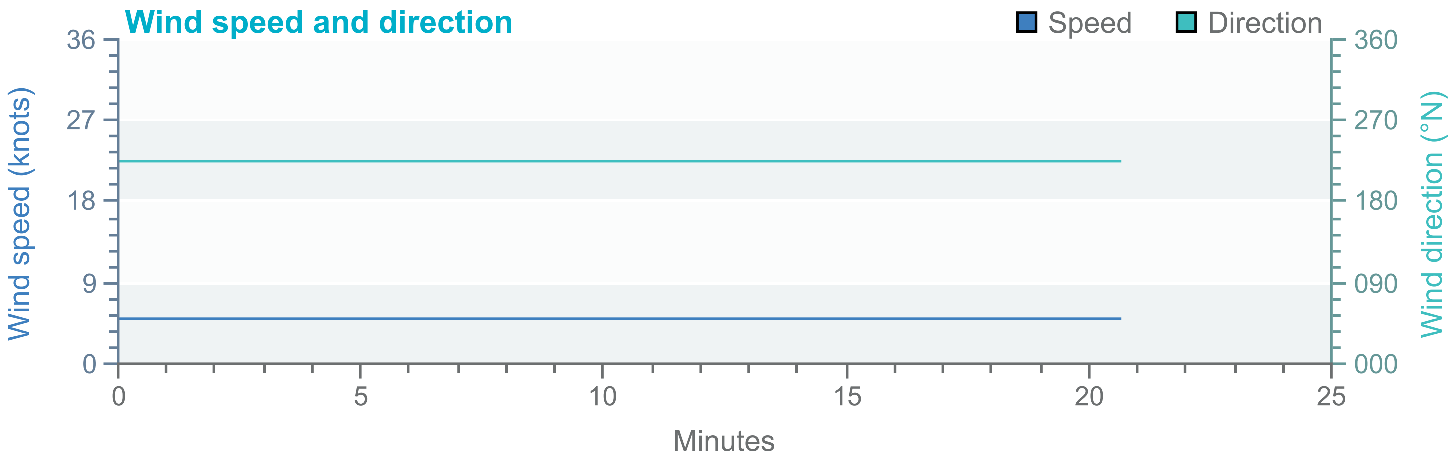
Manoeuvre track plot

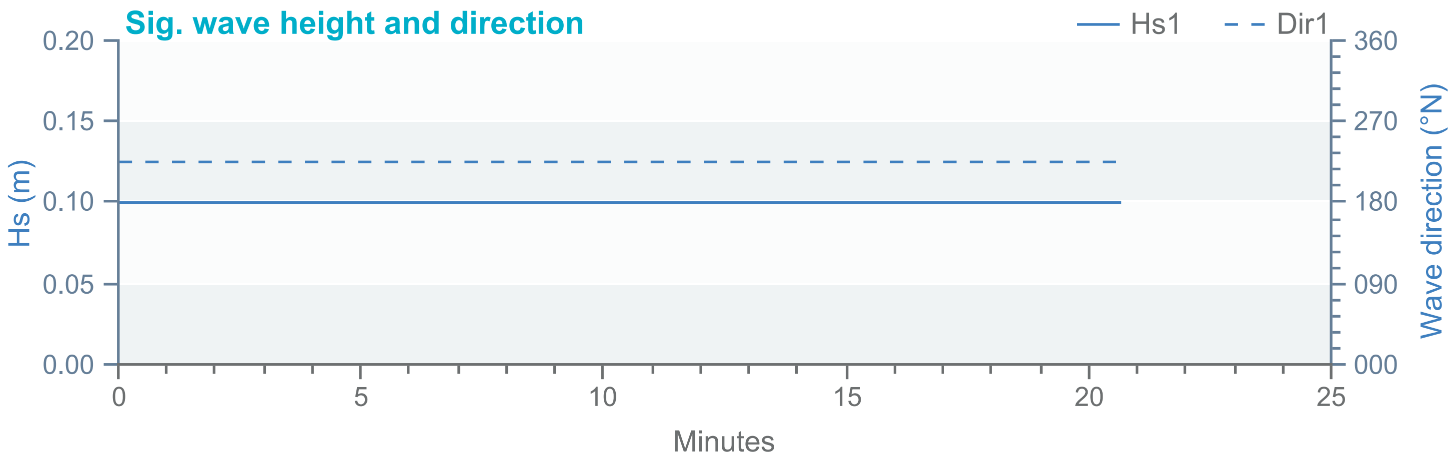


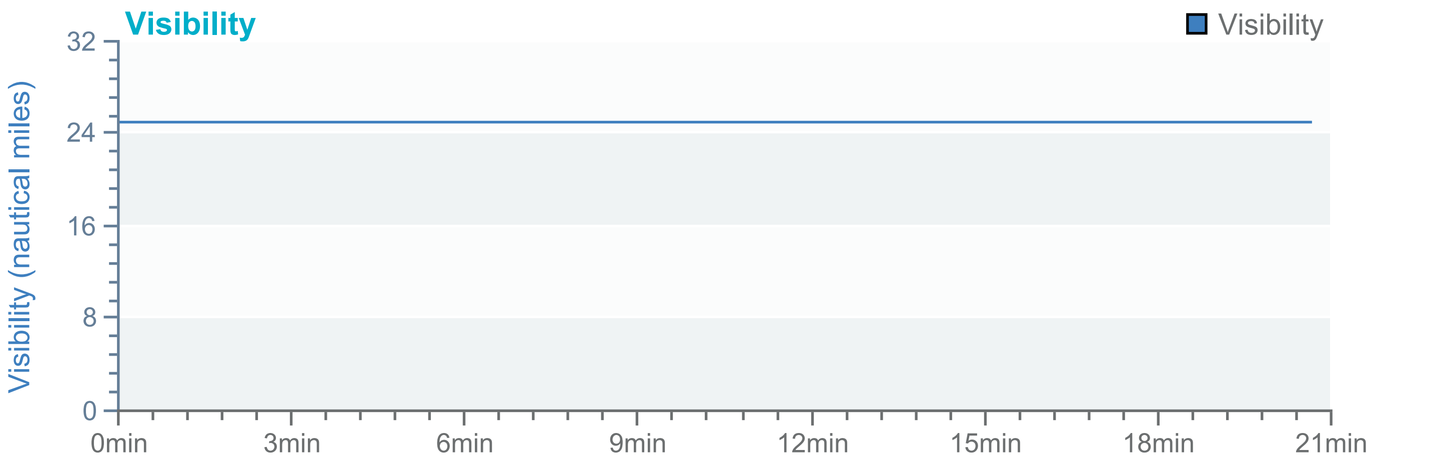
Ships plotted every 1 mins, highlight every 10 mins

Pilot: DM
Manoeuvre: Departure

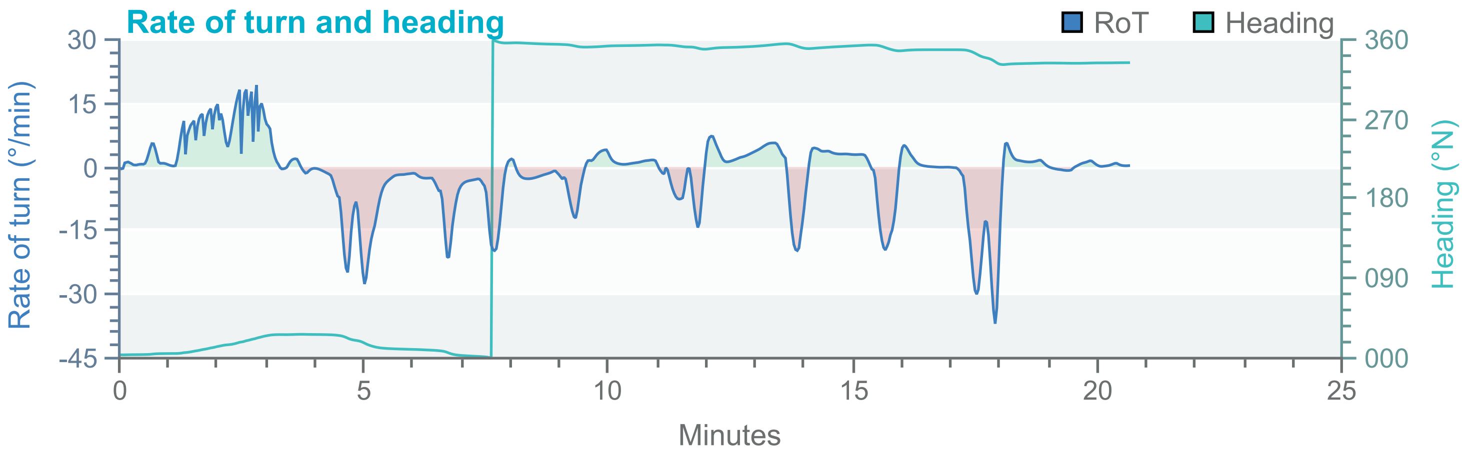

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
1.4
1.1
0.8
0.5
0.2
360
270
180
090
000
0
5
10
15
20
25
Minutes

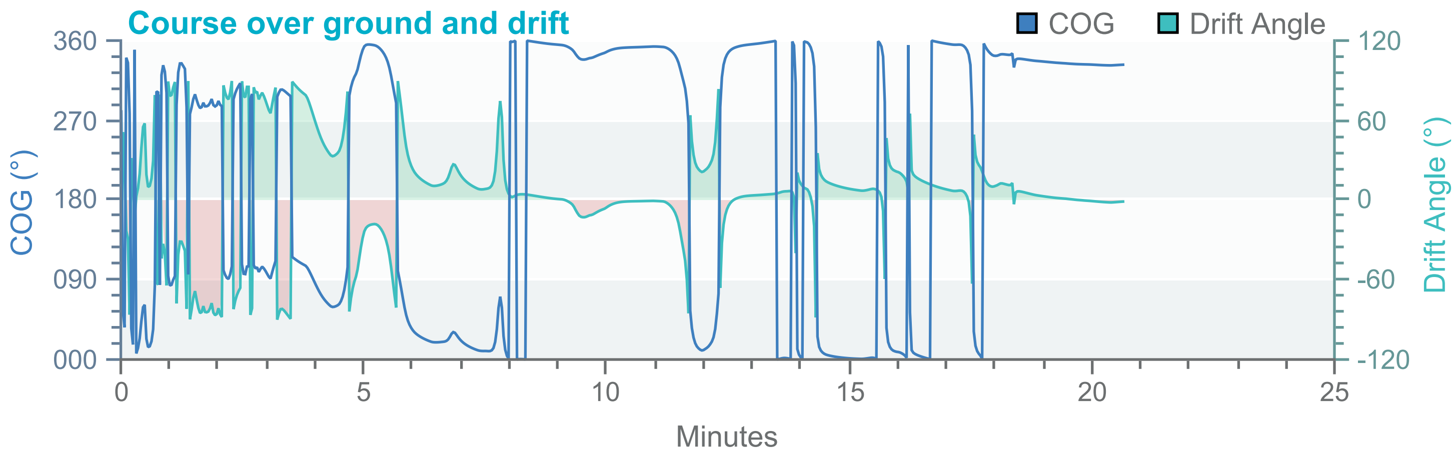

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
36
27
18
9
0
360
270
180
090
000
0
5
10
15
20
25
Minutes

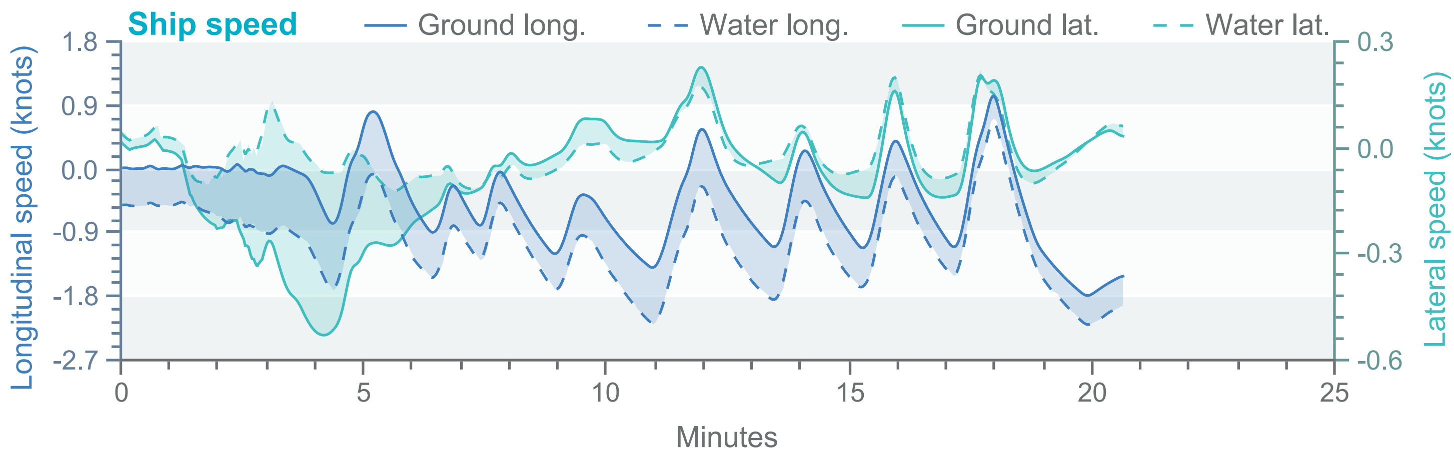

Sig. wave height and direction
Hs1
Dir1
Hs (m)
Wave direction (°N)
0.20
0.15
0.10
0.05
0.00
360
270
180
090
000
0
5
10
15
20
25
Minutes

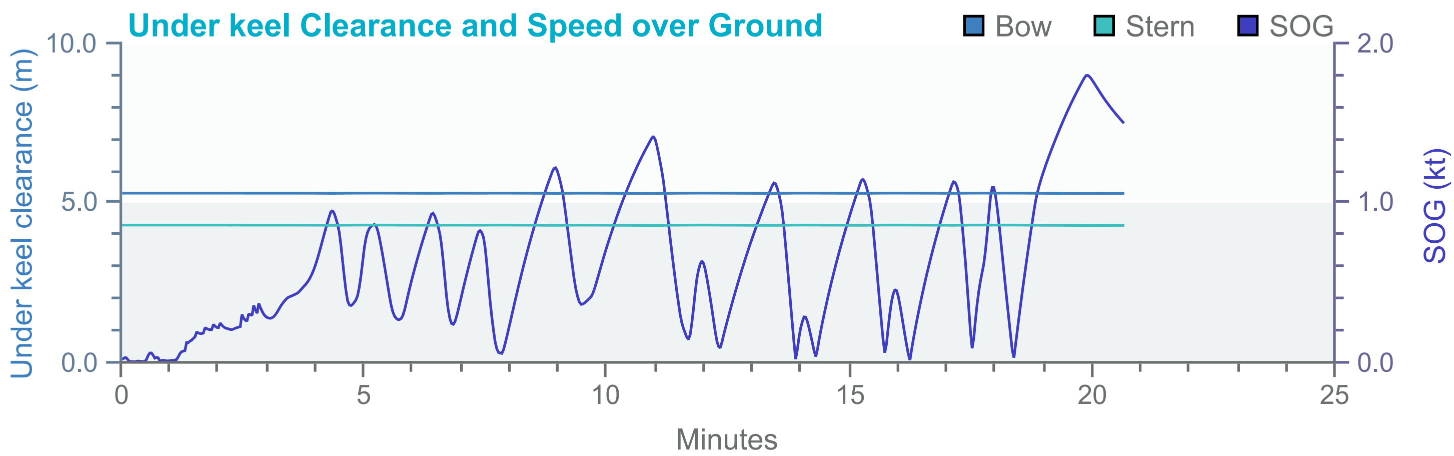

Visibility
Visibility
Visibility (nautical miles)
32
24
16
8
0
0min
3min
6min
9min
12min
15min
18min
21min

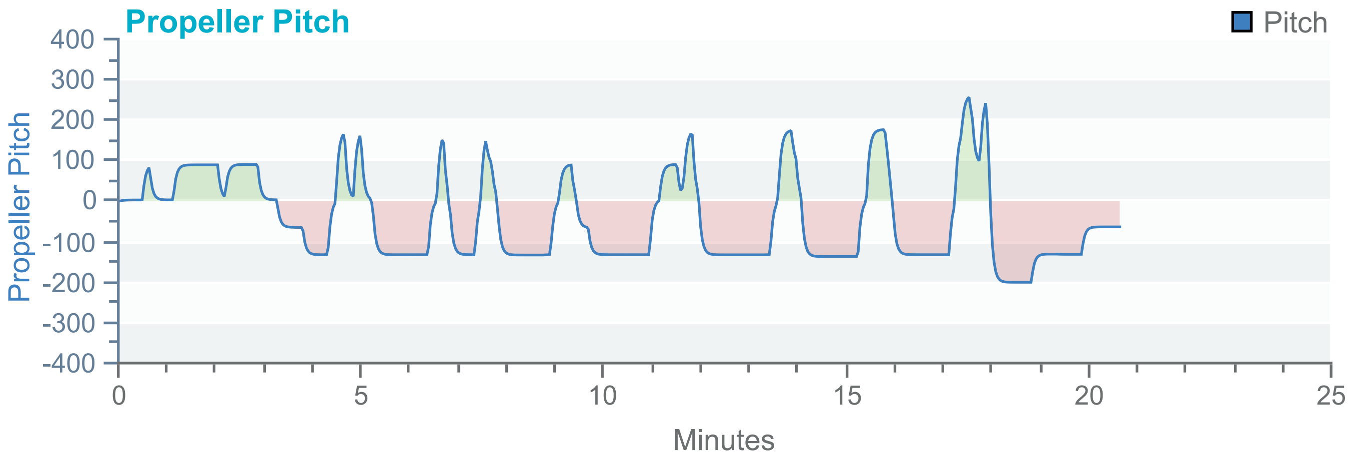
Tracks | Environment | Fischland Ballast

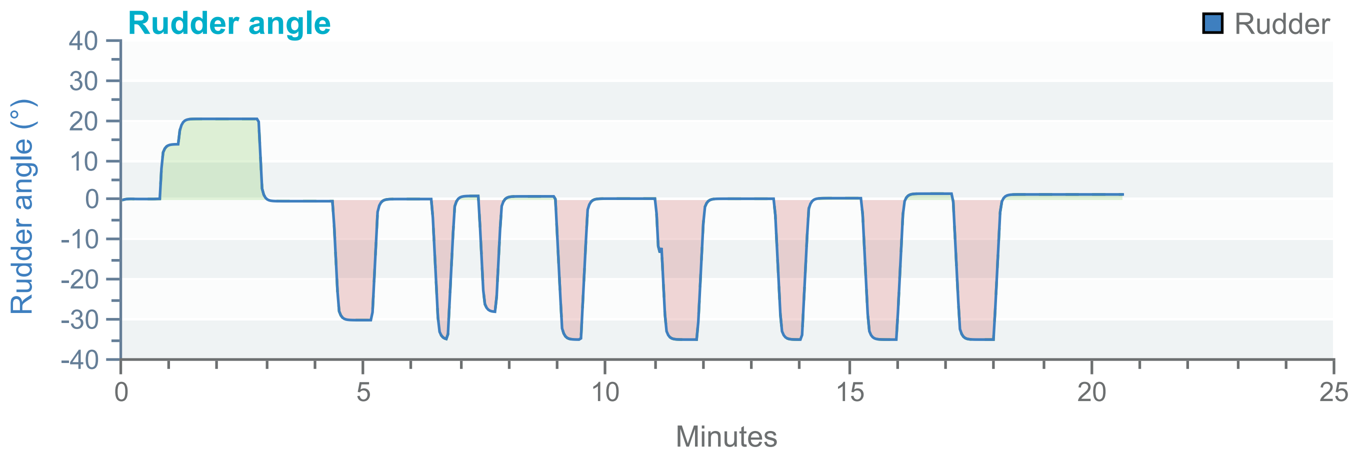


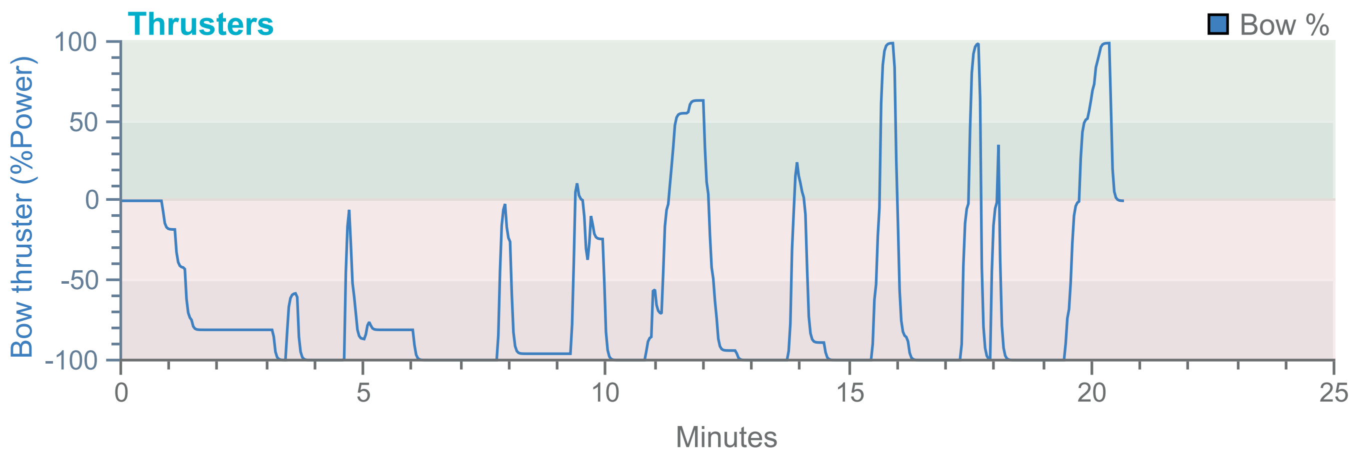


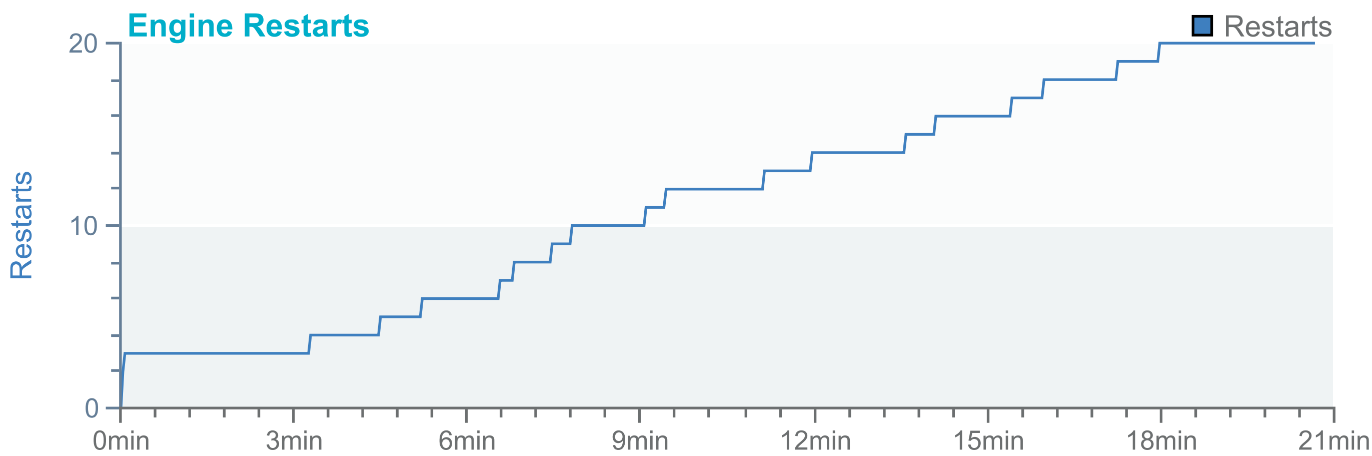





Propeller Pitch
Pitch
Propeller Pitch
Minutes


Rudder angle
Rudder
Rudder angle (°)
Minutes


Thrusters
Bow %
Bow thruster (%Power)
Minutes


Engine Restarts
Restarts
Restarts