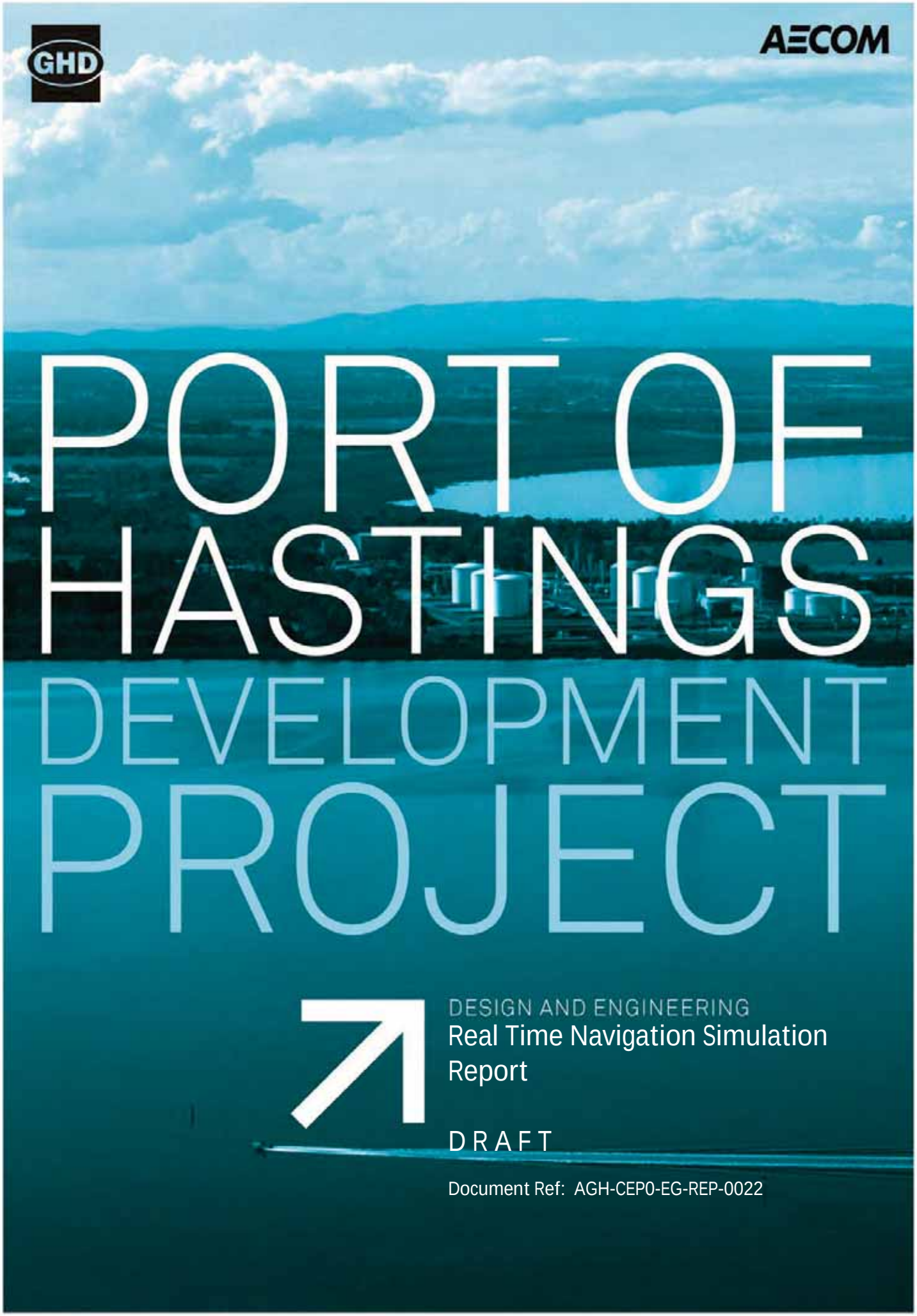

DESIGN AND ENGINEERING

Real Time Navigation Simulation Report

DRAFT

Document Ref: AGH-CEP0-EG-REP-0022

In May 2016 the Special Minister of State asked Infrastructure Victoria to provide advice on the future capacity of Victoria's commercial ports. Specifically, the Minister has asked for advice on when the need for a second container port is likely to arise and which variables may alter this timeline. The Minister has also asked for advice on where a second container port would ideally be located and under what conditions, including the suitability of, and barriers to investing in, sites at the Port of Hastings and the Bay West location.

In undertaking this task, Infrastructure Victoria reviewed work that was completed as part of the Port of Hastings development project before it was cancelled in 2014. This document forms part of the initial work undertaken for the proposed port development at Hastings. Infrastructure Victoria considers that much of the previous Hastings work, although preliminary in nature, is relevant and suitable for informing a strategic assessment. Therefore, Infrastructure Victoria has made the reports previously commissioned for the development project part of the evidence base on which Infrastructure Victoria will use in providing the Minister with advice.

The opinions, conclusions and any recommendations in this document are based on conditions encountered and information reviewed at the date of preparation of the document and for the purposes of the Port of Hastings Development Project.

Infrastructure Victoria and its consultants have used the information contained in these reports as an input but have not wholly relied on all the information presented in these reports.

DRAFT

Port of Hastings Development Project – Design and Engineering

Real Time Navigation Simulation Report

DRAFT

Client: Port of Hastings Development Authority

ABN: 33 737 350 749

Prepared by the AECOM + GHD Joint Venture

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HR Wallingford
Working with water

Port of Hastings

Navigation Simulation Study - Phase 1

DJZ5415-RT001-R03-00 May 2015

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Summary

The Port of Hastings is located in the North Arm of Western Port Bay in southern Victoria, Australia.

The Port of Hastings Development Authority is preparing a business case for the development of a container port, which is to have a minimum ultimate annual throughout of 9 million TEUs. The AECOM + GHD Joint Venture has been appointed to undertake the port planning and engineering works for this project. As part of this work ship navigation simulation studies are required to assess the feasibility of a number of port layouts and refine the dimensions of the approach channels and manoeuvring basins.

The simulation work was proposed in two stages as follows:

- A first phase to provide an initial assessment of the navigation requirements for concept project stages and layouts, and to assist with refining the initial channel design
- A second phase to refine the preferred layout and seek input from the Port Phillip Sea Pilots.

This report describes the first of these studies, with the real time navigation simulation session conducted at HR Wallingford's Australia Ship Simulation Centre in Fremantle, Western Australia, from 16th to 20th March 2015.

The study considered the feasibility of navigating a range of vessels through the proposed access channels and manoeuvres of these vessels within the proposed port area layout options.

A total of 21 real time navigation simulation runs were conducted to assess the navigational aspects of the proposed layouts (see Figure 4.1 to Figure 4.6) as follows:

- Stage 1 south: 7 arrival manoeuvres and 2 departures in varying environmental conditions
- Along the shore: 1 arrival and 1 departure in off berth environmental conditions
- Basin short: 4 arrival manoeuvres and 5 departures in varying environmental conditions
- Basin long: 1 arrival manoeuvre.

The main conclusions arising from the simulation session are described as follows:

Access Channel

From seaward the study concluded that:

- The Western Channel was found to be navigable for all the considered vessels for the environmental conditions investigated. Strong currents at McHaffie Point were found to be a significant feature for the transit of the channel, which should be considered in the navigation plan.
- The bend east of Sandy Point was found to have adequate dimensions for the transit of all the considered vessels in all environmental conditions. However, the entrance to the section of channel commencing at Buoys 19/20 is of particular concern. Consideration should be given to widening the channel at the entrance to the North Arm by approximately one ship's beam, for the design ship with the largest beam.
- Consideration should be given to providing additional width in the proposed channel between Buoys 19/20 and Buoys 23/24. Any additional widening should take place on the western side of the access channel by approximately one ship's beam, for the design ship with the largest beam.
- The deflection of the channel at Buoy 24 is a significant navigational feature. Consideration should be given to widening the channel and/or easing the bend in this area in line with the recommendation above.

- Navigation of the channel north of Buoy 24 is feasible, although consideration should be given to increasing the number of lateral navigation marks in this section. The width of the entrance to the manoeuvring area between Buoys 31/32 is insufficient. Consideration should be given to the removal of Buoy 32 to allow the vessel to use all the available water depth understood to exist west of the proposed buoy location.

Manoeuvring area – 'Stage 1 south'

- The manoeuvring area north of Buoys 31 to 35 is of adequate dimensions both laterally and longitudinally. There is scope to consider reducing the dredged area in this location, particularly east of the access channel.
- The manoeuvring space north of Buoy 37 is of sufficient dimensions to allow vessels to manoeuvre stern-first into the area.

Manoeuvring area – 'Along the shore'

- The manoeuvring area south of Buoy 37 is of adequate dimensions to allow for the swinging of 400m vessels at any of the adjacent berths.
- The berth access area north east of Buoy 37 is of adequate dimension to allow the stern-first navigation of vessels within the area.

Manoeuvring area – 'Basin short'

- The layout of the basin and the influence of the training wall produces a reduction in the current flows in the area north west of Buoy 39. This enables safe vessel manoeuvring into the basin entrance.
- The area south of Buoys 37/39 immediately south east of the basin entrance provides sufficient space to swing vessels of 400m length overall.
- The dimensions of the basin are sufficient to allow for the entrance/exit of vessels stern-first into the basin.
- Consideration can be given to reducing the dredged area south east of the basin entrance, in particular, east of proposed Buoys 33 to 37 (see Figure 6.1).

Manoeuvring area – 'Basin long'

- The presence of the training wall provides significant current shadow for vessels manoeuvring into the basin north west of Buoy 39.
- The deflection of the ebb current caused by this long training wall does not adversely impact on manoeuvres at the southern berthing area.

Aids to navigation

Aids to navigation play an important role for the safe navigation of the channel. This section describes the conclusions and recommendations arising from the study in this regard. The following was concluded:

- Existing aids to navigation along the Western Channel were found to be appropriate for the safe transit of the channel.
- Aids to navigation between Buoys 19/20 and Buoys 23/24 in the proposed channel were found satisfactory for the safe navigation of the channel.
- Provision of an additional pair of buoys equidistant between Buoys 25/26 and 27/28 and Buoys 27/28 and 29/30 would assist in visually determining the vessels lateral position in this section of the channel (see Figure 6.2).

- Buoy 32 should be removed to provide additional space for the entrance into the Stage 1 manoeuvring area.
- Buoys may be offset to improve their visibility from the 400m long vessel conning position (Figure 6.2).
- The training wall represents a hazard, especially for tugs, when berthing at the basin. It is recommended to add visual marks on the training wall to indicate the existence of a submerged structure.

Manoeuvres at Long Island Point

- Both the proposed dredged area and the new terminal were found to have no impact on existing manoeuvres at Long Island Point.

Towage

- A minimum of 3 tugs should be provided to assist in the vessel manoeuvres. Tugs provided should be of such a design that they can assist with the speed management of the vessels.
- The tugs should be of 80t BP for the assistance of the 400m long container vessel.
- 115,000 DWT bulk carrier manoeuvres can continue with the existing tug deployment and capacities that are being used at Port of Hastings.

Contents

Figures

Tables

1. Introduction

This report describes a real time navigation simulation study which involved a 5 day long simulation session conducted at HR Wallingford's Australia Ship Simulation Centre in Fremantle, Western Australia, from 16th to 20th March 2015.

1.1. Background

The Port of Hastings Development Authority is preparing a business case for the development of a container port, which is to have a minimum ultimate annual throughout of 9 million TEUs. The AECOM + GHD Joint Venture has been appointed to undertake the port planning and engineering works for this project. As part of this work a navigation simulation study was required to assess the feasibility of a number of port layouts and refine the dimensions of the approach channels and manoeuvring basins.

It was proposed that the simulation work was undertaken in two stages as follows:

- A first phase to provide an initial assessment of the navigation requirements for concept project stages and layouts, and to assist with refining the initial channel design;
- A second phase to refine the preferred layout and seek input from the Port Phillip Sea Pilots.

This report describes the first of these studies.

1.2. Study objectives

The scope of work of this navigation simulation study was focused on providing an initial assessment of the navigation requirements for concept project stages and layouts, and to assist with refining the initial channel design.

The work was undertaken in accordance with the guidelines outlined by PIANC (2014) to assess key navigation criteria relevant to the concept designs. This included the following specific objectives:

- To establish the operational feasibility of port layouts including the swing basins;
- To determine the adequacy of swing basin dimensions and geometry;
- To determine the adequacy of channel width and alignment;
- To identify likely Aids To Navigation that would be required;
- To verify accessibility in extreme environmental conditions.

In particular, the key areas of interest to be assessed during the study were:

- The bend at McHaffie Reef on an ebb tide;
- Width of the North Arm;
- Length and width of the swing basin(s) at peak currents and/or operational wind conditions;
- Manoeuvring astern over a long distance from a swing basin at the port entrance;
- Existing berthing and departure operations at Long Island Point are not impacted adversely by the port development.

2. The Port of Hastings

The Port of Hastings is located on the North Arm of Western Port Bay in southern Victoria.

The main access channel and the port area the Port of Hastings are covered by Chart AUS151.

The main port facilities are named as Stony Point Jetty, Crib Point Jetty and Long Island Point Jetty. They are located along the North Arm of Western Port Bay.

For the navigation of the main access channel, McHaffie Point, Sandy Point, Crib Point and Long Island Point represent the major references as shown in Figure 2.1. The maintained depth in the channel is 14.2m beyond Buoys 13/14 up to Long Island Point.

The proposed development is located north of Long Island Point.

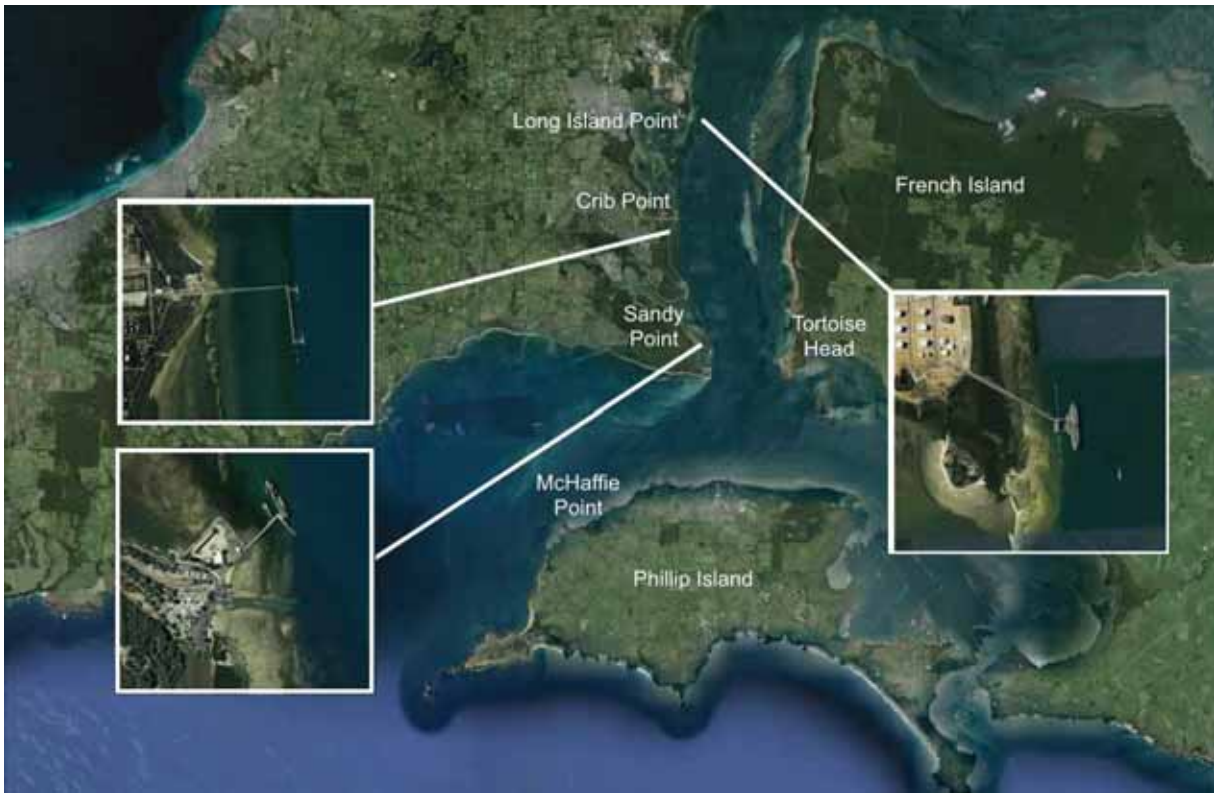


Figure 2.1: Port of Hastings location

3. Ship Simulation Centre

HR Wallingford's Australia Ship Simulation Centre in Fremantle is a sophisticated, flexible ship simulation facility, running HR Wallingford's advance Ship Navigation Simulation System which is suitable for port design, as well as operational assessments and marine facility familiarisation exercises.

Further information is presented in Appendix A and in this case one of the simulators was used to represent the ships that were considered.

4. Simulator configuration

4.1. Overview

The Ship and Tug Simulators at HR Wallingford are specifically designed for port design and ship operations applications. They have been used in a wide range of port design studies worldwide and have proved to be a reliable, flexible and cost-effective design and evaluation tool. Uses include optimising port and harbour layouts, establishing operational strategies and training in safe manoeuvring procedures.

The aim of the simulators is to present to Pilots and, where applicable Tug Masters, 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 and (where applicable) tug manoeuvring models that are representative of the manoeuvring characteristics of the design vessels are produced. The vessels can then be operated in a realistic manner.

At this stage in the Port of Hastings development, a relatively simplified simulator configuration was used to provide an initial examination of the modified approach channel and port area layout options under study. These simplifications included the inclusion of a basic visual scene only, such that it was still adequate for effective ship navigation and 2D hydrodynamic flow data. Nevertheless, overall the simulator databases were sufficiently representative to meet the objectives of the work.

At this stage the work also did not assess the 3D aspects of the design, so the under keel clearance requirements of the ships was not examined.

More details of the specific simulator configuration for this project are given in the following sections.

4.2. Layouts

The port area layout options available to use during the navigation simulation session were provided by the client and included:

- Stage 1 development and modified approach channel:
  - South: swing basin adjacent to the southern-most berths;
  - All: swing basin extending further north;
  - Extension: extended stage 1 with swing basin at southern berths;
- ‘Along the shore’ alignment and modified approach channel;
- ‘Basin Short’ alignment and modified approach channel. The ‘Basin Short’ layout includes a vertical wall along the north side of the basin that extends out to about the 0mCD contour. Beyond this point the bed level slopes back from the toe-line at a slope of 1 in 5 up to the existing bed level;
- ‘Basin Long’ alignment and modified approach channel. The ‘Basin Long’ layout corresponds to a vertical "training" wall along the north side of the basin that extends out to Buoy 37. Beyond this point the bed level slopes back from the toe-line at a slope of 1 in 5 up to the existing bed level.

The port area layout options are shown in Figures 4.1 to 4.6.

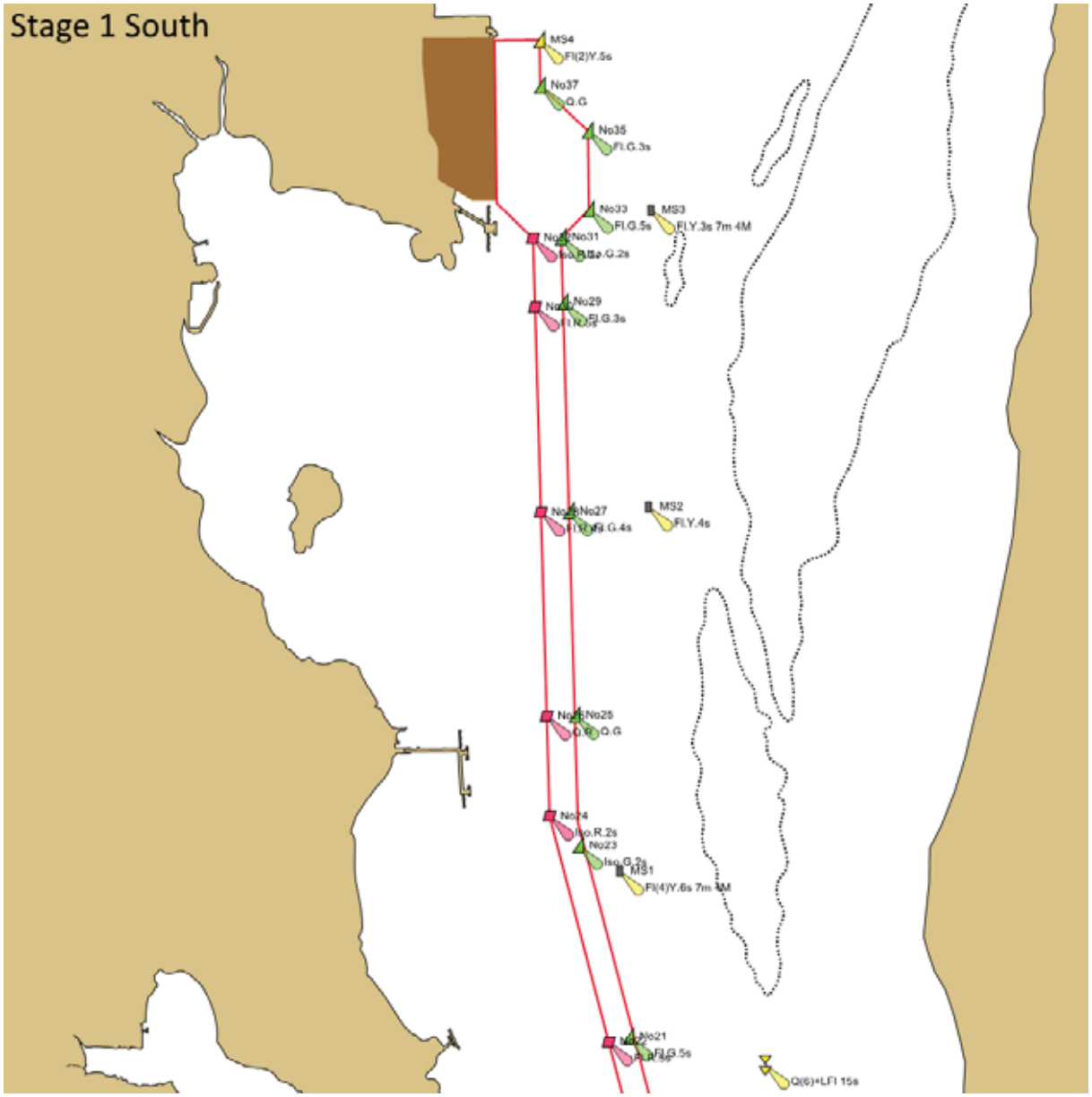


Figure 4.1: Stage 1 south layout

Source: HR Wallingford Ship Simulator

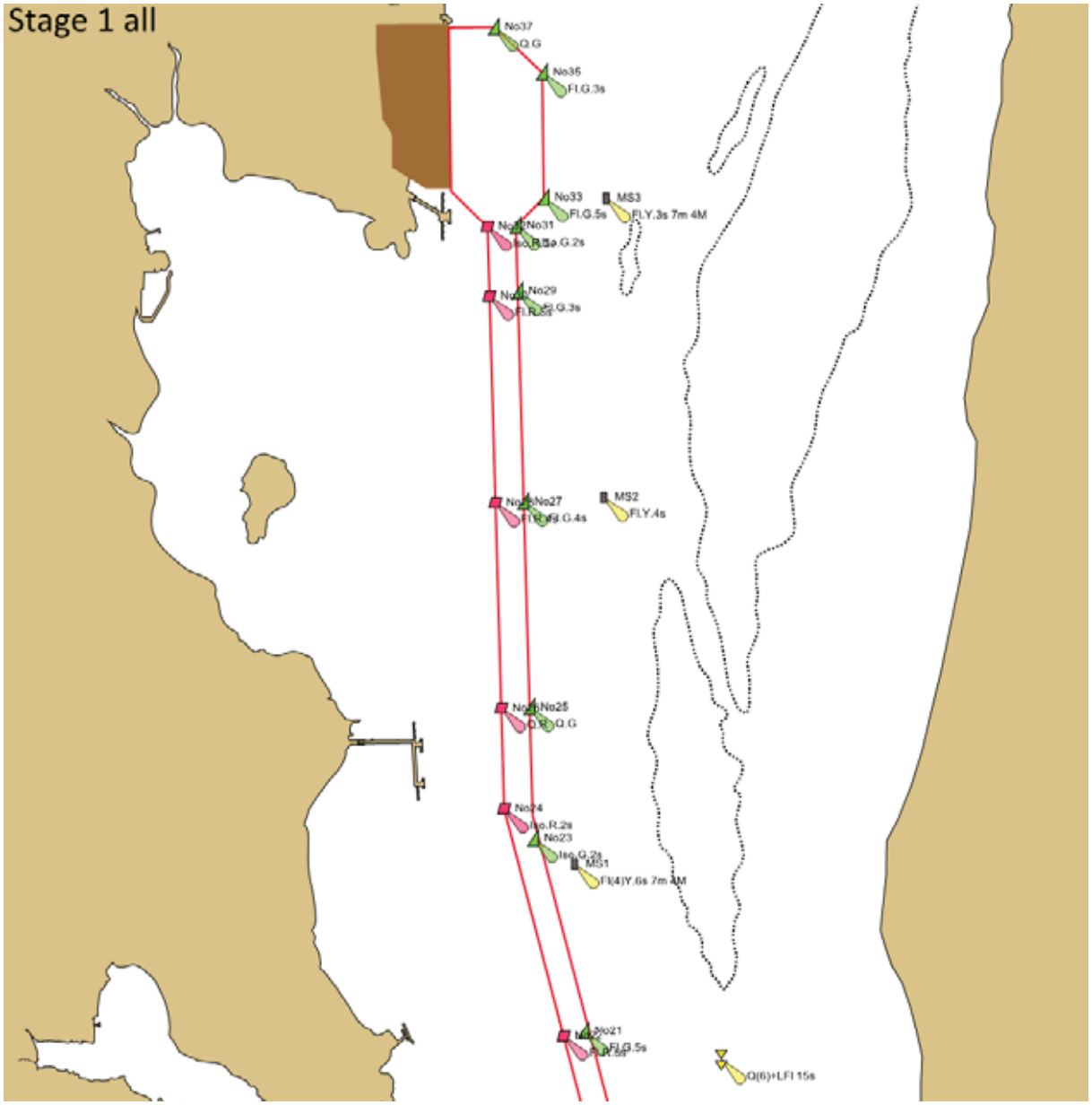


Figure 4.2: Stage 1 all layout

Source: HR Wallingford Ship Simulator

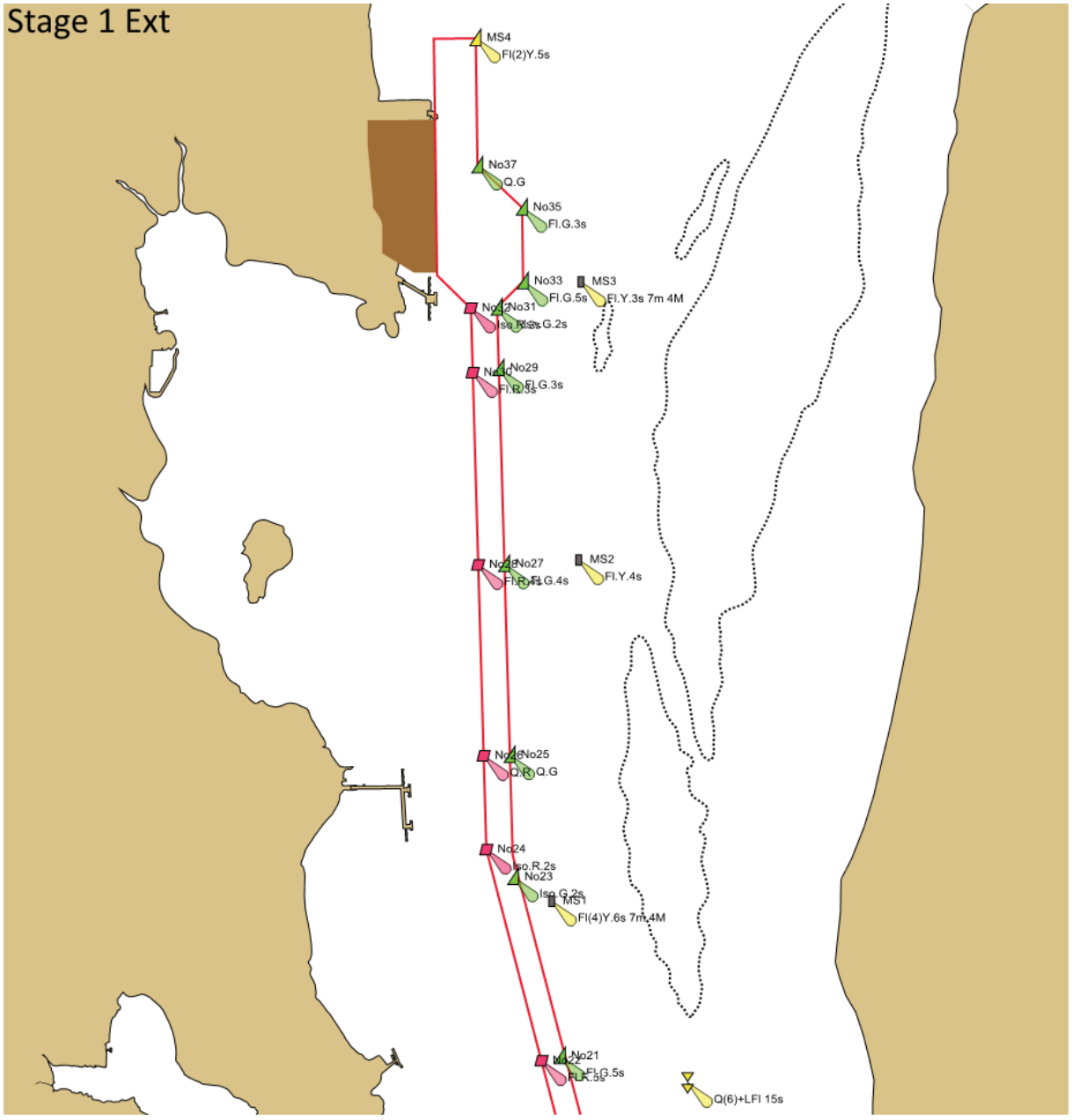


Figure 4.3: Stage 1 extension layout

Source: HR Wallingford Ship Simulator

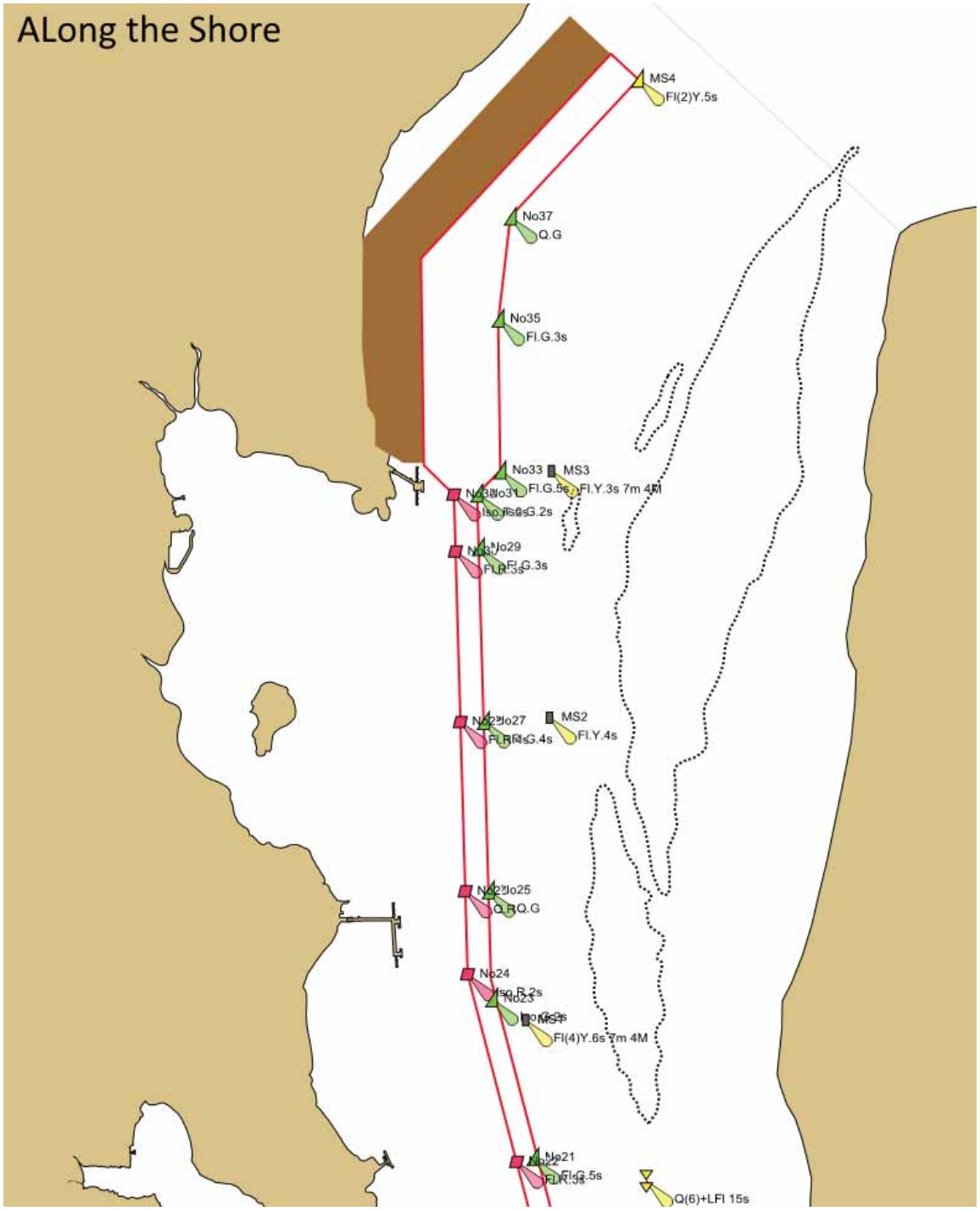


Figure 4.4: Along the shore layout

Source: HR Wallingford Ship Simulator

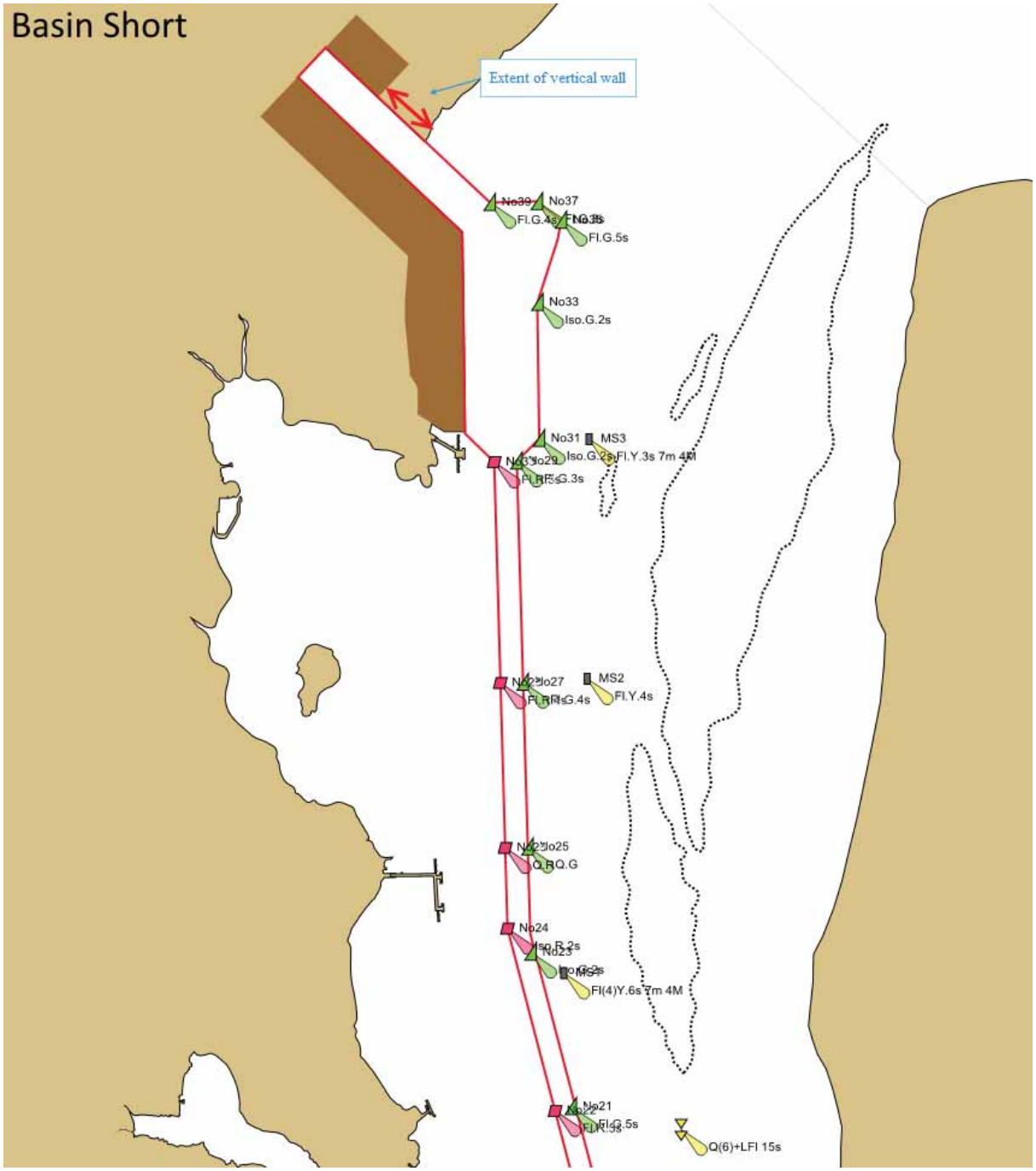


Figure 4.5: Basin short layout

Source: HR Wallingford Ship Simulator

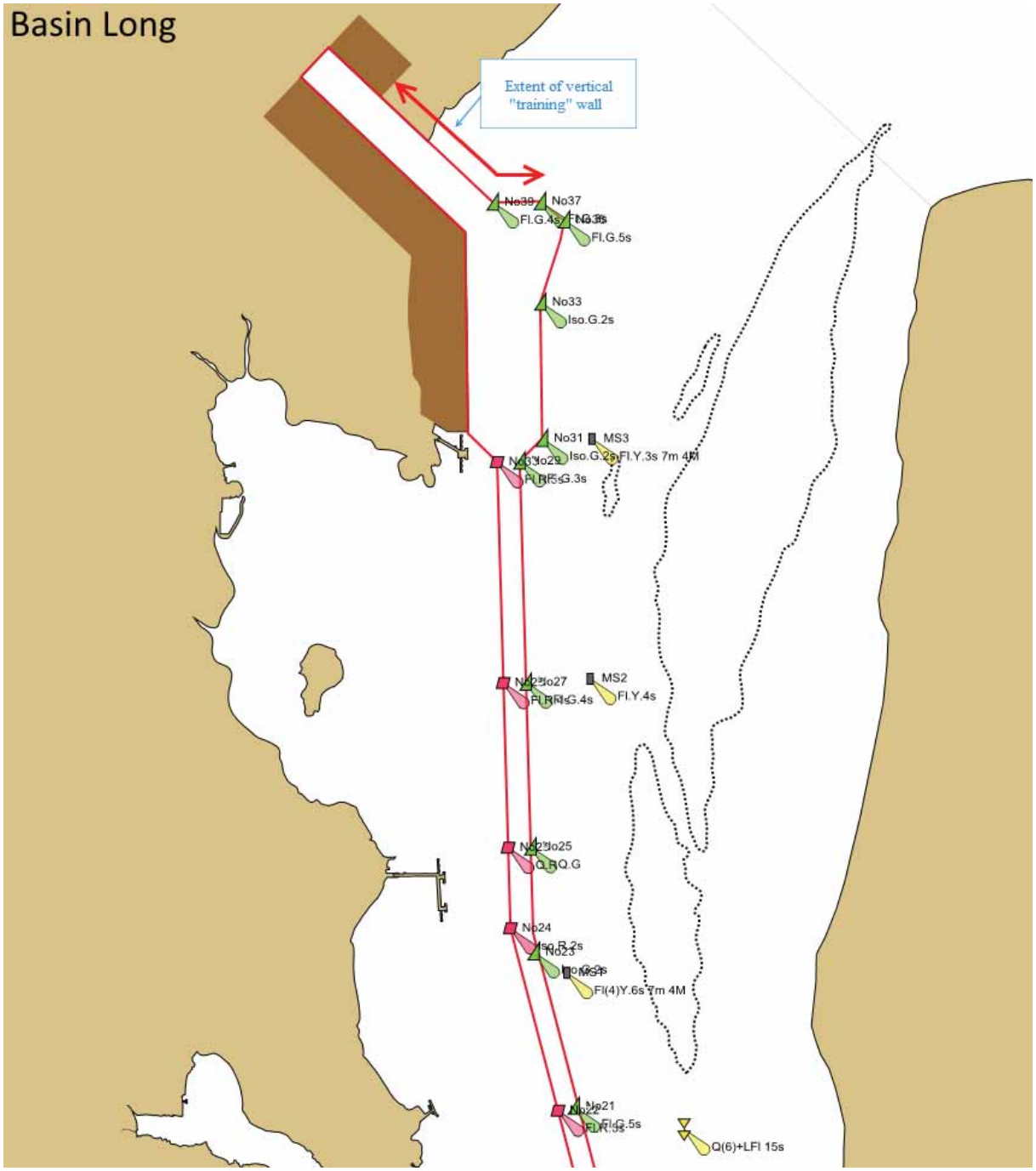


Figure 4.6: Basin long layout

Source: HR Wallingford Ship Simulator

4.3. Visual scene

The visual scene for the simulation work described in this document was created using photographs provided by the client along with satellite imagery. The visual scene created provided the pilot with sufficient visual cues to conduct the manoeuvres as necessary.

Sample views of the visual scene are shown in Figure 4.7 to Figure 4.10.

Figure 4.7: Stage 1 south swing basin

Source: HR Wallingford Ship Simulator

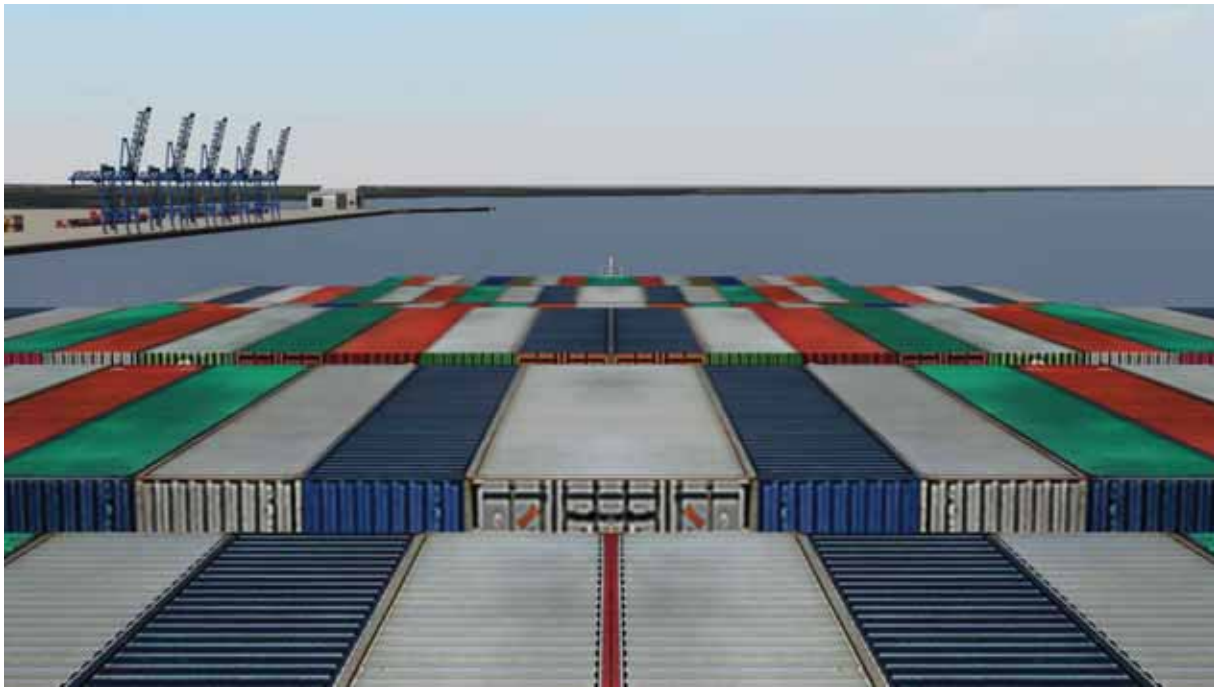


Figure 4.8: Visual of proposed terminal Stage 1 south from the bridge of the vessel

Source: HR Wallingford Ship Simulator

Figure 4.9: Full development – Basin short layout

Source: HR Wallingford Ship Simulator

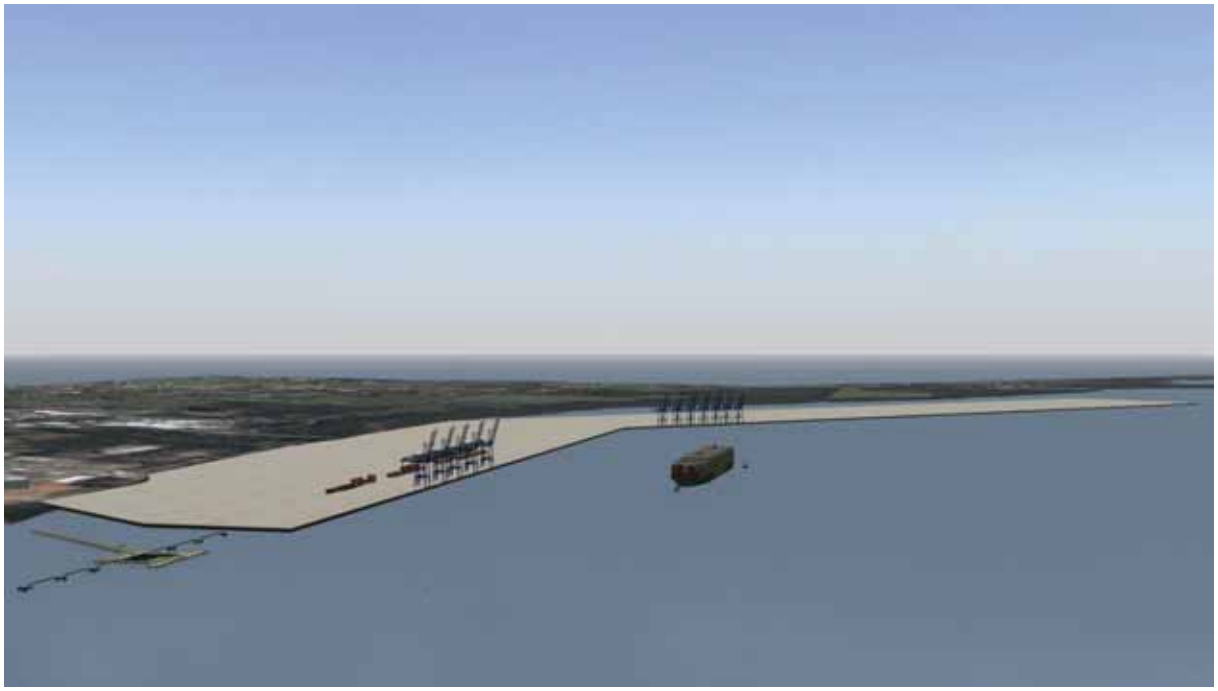


Figure 4.10: Full development – Along the shore layout

Source: HR Wallingford Ship Simulator

4.4. Environmental conditions

4.4.1. Bathymetry and tidal condition

The bathymetry and current flows were represented on a 20m fine grid in the area of navigation interest. The data was based on the hydrodynamic study provided by the client for the navigation simulation work. The tidal information presented was based on a 2D depth average spring tidal range.

4.4.2. Water depth

All simulations were conducted with a water depth corresponding to the state of the tide selected for each run. This ensured that the manoeuvres were undertaken with representative minimum under keel clearances within the port. Height of tide is with reference to the height above 0mCD.

4.4.3. Wind

The wind conditions were discussed before each run. The maximum wind speed conditions chosen were those that represent the maximum permitted wind speeds for operations at a range of similar developments worldwide.

Westerly and easterly wind directions were identified as the most critical conditions for the proposed channel configuration due to the drift angles required to keep the vessel within the channel. Within the port area a range of particularly adverse wind directions were tested to assess the suitability of the extents of the turning

basin and berth pocket. In deriving these conditions reference was made to site wind rose data provided by the Client Representative.

Information from various locations worldwide, where similar vessels are operating, suggests that 30 knots is considered to be an upper limit for safe operations. As a comparison the Port of Melbourne has a limit of 30 knot wind speed (35 knot gust) for berthing and unberthing activities. This wind speed was therefore used throughout as representing the most challenging conditions in which the container vessel would be expected to operate.

4.4.4. Waves

Wave conditions were related to the wind speed and direction. The details of the wave conditions applied during each run were discussed before the start of the run.

The proposed area under study is sheltered by Phillip Island so swell was not considered to be significant at the location except in the outer reaches of the Western Channel. Swell was not therefore included for the majority of runs. Sea waves with periods around 4s were simulated in the runs as representative of the most common sea state in the area under study on the advice of the client representative.

4.5. Ship models

The following ship manoeuvring models were used to represent a range of vessels expected to or currently operating at Port of Hastings (see Table 4.1). More details are presented in Table 4.2.

Table 4.1: Ship models

Vessel type	LOA [m] [1]	Beam [m]
Container Ship	400.0	58.6
Products Tanker	250.0	44.0
Bulk Carrier	255.0	43.0

Note: [1] LOA is the length overall

4.6. Bridge instruments and displays

Key ship manoeuvring data is relayed to the Pilot on the bridge via a comprehensive array of bridge instruments and displays including:

- Radar
- Situation display (ECDIS)
- Ship speed indicators (longitudinal and transverse ground speeds)
- Ship heading indicator
- Rate of turn indicator
- Helm indicator
- Engine display
- Relative wind indicator
- Under keel clearance.

Table 4.2: Ship models – vessel particulars summary

Characteristic	Unit	Value								
Ship Name		400m Container Ship			250m Products Tanker			115K Bulker		
Deadweight	dwt	183,800			112,000			115,000		
Model name		400m Container vessel			250mx44m_Products_Tanker			115kdwt_bulker		
Length overall	m	400			250			255		
Length between perpendiculars	m	383.0			239.0			244.0		
Beam overall	m	58.6			44.0			43.0		
Design laden draught	m	14.5			14.5			14.5		
Block coefficient		0.652			0.838			0.820		
Distance bridge to stern	m	238.4			42.2			35.9		
Modelled conditions			**Ballast**	**Laden**		**Ballast**	**Laden**		**Ballast**	**Laden**
Draught forward	m		-	14.5		8.0	14.5		7.0	14.5
Draught aft	m		-	14.5		8.0	14.5		8.0	14.5
Displacement	t		-	218,000		72,262	130,974		65,000	128,000
Propulsion										
Main engine type		Hyundai-BW 12K98ME7			Slow speed diesel			Slow speed diesel		
Engine power (total)	kW	56,800			13,560			11,500		
No. of propellers, type		1 x fixed pitch			1 x fixed pitch			1 x fixed pitch		
Bow thrusters	t	76			N1			N1		
Stern thrusters	t	N1			N1			N1		
Rudder type		Spade			Standard			Standard		
Max rudder angle	°	35			35			35		
Manoeuvring engine order		**RPM**	**Speed (knots)**		**RPM**	**Speed (knots)**		**RPM**	**Speed (knots)**	
Full Ahead		60	-	16.6	90	16.0	15.0	98	13.0	12.0
Half Ahead		52	-	14.4	60	10.6	10.0	74	9.8	9.0
Slow Ahead		38	-	10.5	40	7.1	6.7	52	6.9	6.4
Dead Slow Ahead		30	-	8.3	22	3.9	3.7	32	4.2	3.9
STOP		0	-	0	0	0	0	0	0	0
Dead Slow Astern		-30	-	-3.2	-22	-3.4	-3.1	-32	-3.9	-3.5
Slow Astern		-38	-	-4.0	-35	-5.4	-5.0	-48	-5.8	-5.2
Half Astern		-52	-	-5.5	-55	-8.5	-7.8	-60	-7.3	-6.5
Full Astern		-60	-	-6.3	-70	-10.8	-10.0	-74	-9.0	-8.0
Windage										
Windage lateral	m²		-	15,510		3,879	2,274		4,077	2,317
Windage frontal	m²		-	2,771		1,082	796		1,359	1,080
Wind Speed (knots)			**Beam wind force (t)**			**Beam wind force (t)**			**Beam wind force (t)**	
15			-	57		14	8		15	8
20			-	100		25	15		26	15
25			-	157		39	23		41	23
30			-	226		57	33		59	34
35			-	308		77	45		81	46
40			-	402		100	59		106	60
45			-	509		127	75		134	76

4.7. Tugs

The tugs in the simulation were selected from HR Wallingford's extensive tug model library, which includes a wide range of tugs. The tug models used during the simulation session were as follows:

- 45tBP ASD tug "centrally-controlled" tug model
- 80tBP ASD tug "centrally-controlled" tug model.

Note:

[1] The 80tBP ASD tug used was a 75tBP ASD tug model, which had its bollard pull increased to 80 tonnes.

All of the tugs used during the simulation session were centrally controlled by the Simulator Operator, following the Pilots' commands, and were subject to realistic delays (as outlined in Table 4.3) when assisting the vessel.

The maximum force delivered by the tugs ranges with the assist mode (push, direct pull, powered indirect, indirect pull and transverse arrest). The effectiveness of these tugs was also subject to degradation due to both wave action and their speed through the water, as shown in Figure 4.11 and Figure 4.12.

Table 4.3: Simulated tug response delay times

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

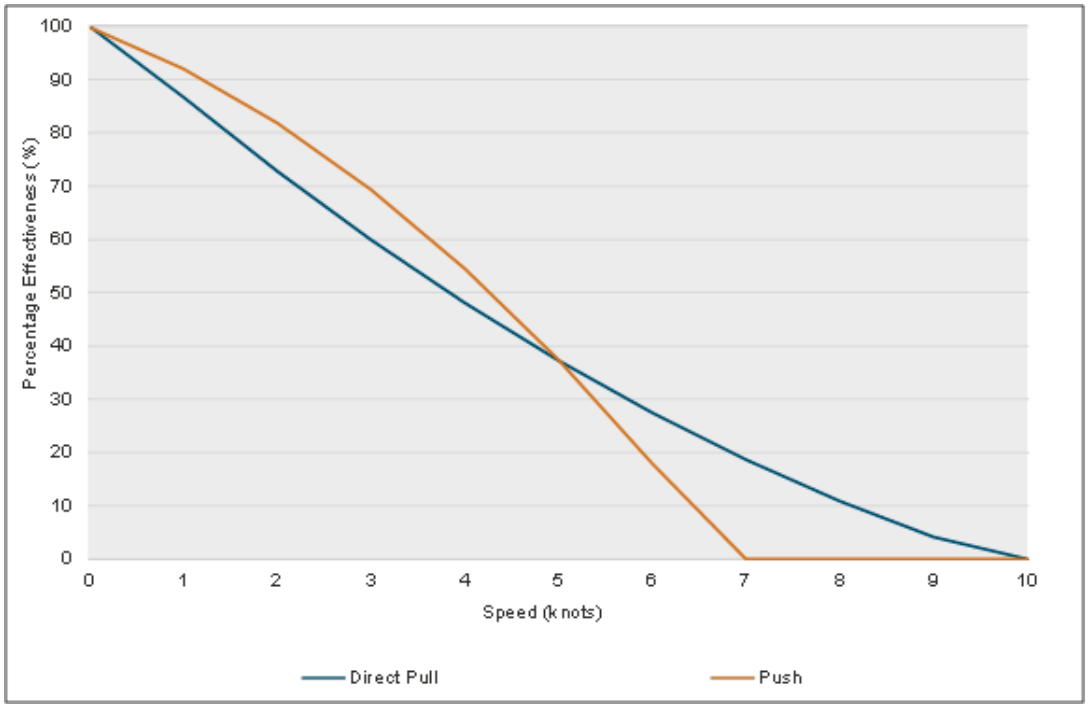


Figure 4.11: Loss of tug effectiveness with speed

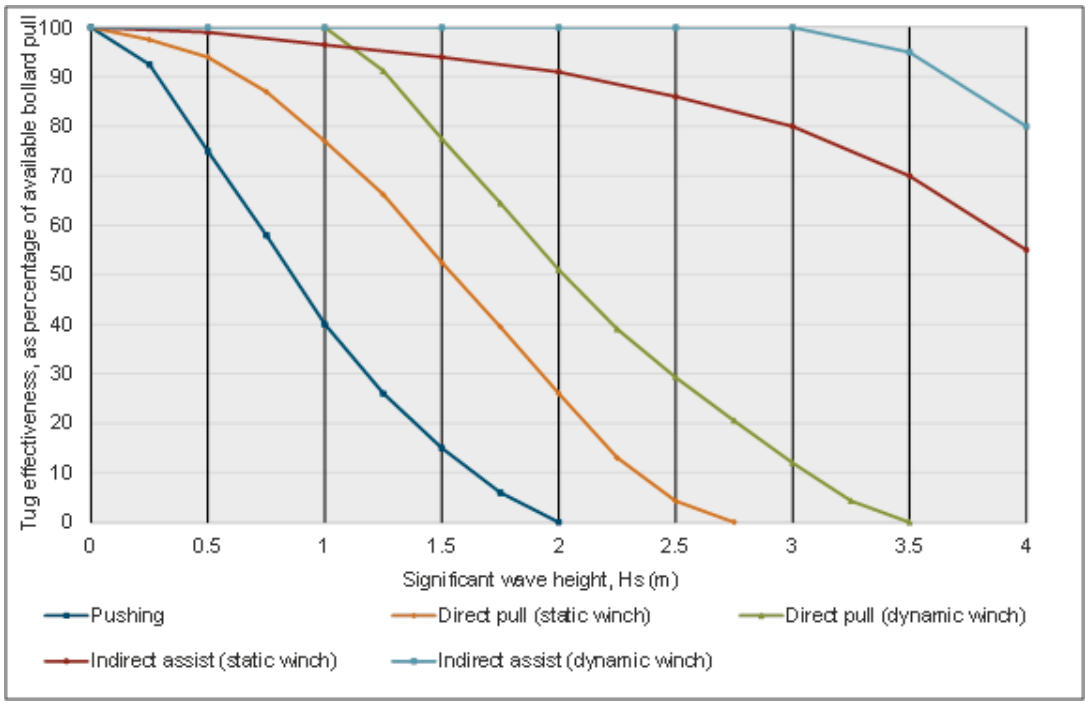


Figure 4.12: Loss of tug effectiveness in waves

4.8. Verification of the simulator configuration

The ship manoeuvring models were tested using standard trials such as turning circle and emergency stop tests. The results of these tests were considered to be consistent with the known and assumed behaviour of similar vessels. The HR Wallingford Pilot also verified the performance of each of the modelled ships 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 vessels;
- Wind force on vessel;
- 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 vessel footprint and location with the simulation visual scene and situation display.

5. Simulation session

5.1. Attendance

The navigation simulation session took place over 5 days, from Monday 16th to Friday 20th March 2015 at HR Wallingford's Australia Ship Simulation Centre in Fremantle, Western Australia.

The simulation session participants were as follows:

AECOM + GHD Joint Venture:	Ben Gray Richard Clarke
Port of Hastings:	Matthew Primmer Lal Edirisinghe
HR Wallingford:	Capt Ian Simpson Juan Pedro Maria Sanchez

5.2. Presentation of the results

The data and results from each simulation run are presented here in a range of formats, which are described in the following sections.

5.2.1. Simulation run summary

Following each run, a summary table entry was completed. This is shown in Appendix B and captures the set-up of the exercise including the vessel used, the manoeuvre conducted, the tug configuration and the environmental conditions used.

5.2.2. Grading of runs

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

Successful — Arrival / departure manoeuvres:

- The vessel remains under full control at all times retaining a margin of unused controllability (e.g. full rudder not used in conjunction with high engine setting) and without resorting to aggressive manoeuvring techniques (e.g. engine not used at more than half astern during manoeuvres);
- The vessel and any assisting tugs maintain an acceptable clearance from all port structures, and other vessels berthed at the port, where an acceptable clearance is considered to be when sufficient horizontal separation between the manoeuvring ship and adjacent structures exists to the satisfaction of the pilot;
- The vessel's water and ground speed is appropriate for the nature of the fairway/channel e.g. to avoid adverse interactions with other moored vessels, to allow for safe tug assistance;
- Tugs are operating safely and within sustainable limits;
- For berthing manoeuvres, the vessel ends the run alongside, or in such a position that lines would be ashore without appreciable difficulty, at zero speed, with an acceptable sway velocity and no appreciable yaw rate;
- For departure manoeuvres the vessel exits smoothly, without risk of being blown or set onto port structures or other vessels.

Marginal — Arrival / departure manoeuvres:

- The Pilot considers the vessel is at the limit of control during the manoeuvres;
- The vessel stays within the fairway, but with unacceptable clearances, or inappropriate ship speed;
- The vessel clears all port structures, and other vessels berthed at the port, but with unacceptable clearances;
- Tugs are operating safely, but approaching their sustainable operating limits;
- For approach manoeuvres, the vessel ends up alongside, but may have a high approach velocity. The manoeuvre can be concluded, but with the potential for minor damage to occur;
- On departure, the vessel may get off the berth only with some difficulty. The manoeuvre is completed with the potential for minor damage only.

Fail — Arrival / departure manoeuvres:

- The Pilot loses control of the vessel;
- The vessel strays outside the fairway and/or grounds;
- The vessel either contacts, or has a near-miss, with port structures, and/or other vessels berthed at the port;
- Tugs are required to operate too close to adjacent structures, or tug power demanded cannot be sustained for the time required. For approach manoeuvres, the vessel cannot get alongside at all, or it has struck the berth with sufficient force that severe damage may have occurred;

- On departure, the vessel either cannot lift off the berth at all, or encounters significant difficulty in manoeuvring, such that severe damage may have occurred.

The grade for each run is included in the run summary presented in Appendix C.

5.2.3. 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 C.

The vessel data and track plots show:

- The position of the vessel at one minute intervals is indicated by a succession of black and blue vessel outlines. Red vessel outlines indicate the vessel's position every 10 minutes from the start of the run;
- The positions of port structures and aids to navigation;
- The current flow field of the particular run;
- 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 °N;
- 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, 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;
- Significant wave height (meters) and peak period (seconds);
- Tug forces acting on the ship;
- Tug position and tug force delivered for each of the tugs used. The tug position is referenced to a numbering sequence which ascends around the vessel hull in anti-clockwise manner so that position 1 relates to a forward centre lead position, position 8 is a centre lead aft position and the highest number on the graph, position 14, relates to a starboard shoulder position (see Figure 5.1).

Where there are no plots for a particular parameter, for example for bow thruster power, this indicates that the particular parameter was not relevant for the particular run or no bow thruster was available.

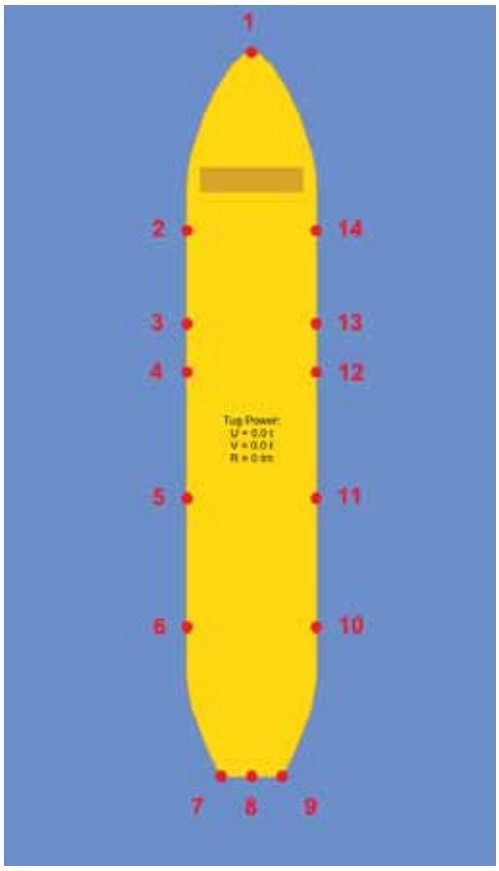


Figure 5.1: Tug positions

Source: HR Wallingford Ship Simulator

5.2.4. Pilot debrief

Immediately after each simulation run, there was a debrief at which relevant comments on various aspects of the run were recorded. Relevant comments captured in these debriefs are included within the “Remarks” column of the run summary table in Appendix B.

5.3. Discussion of results

5.3.1. Overview

A total of 21 real time navigation simulation runs were conducted, as detailed in the run summary contained in Appendix B. Runs were conducted in day time with a good visibility to assess the navigational aspects of the proposed layouts as follows:

- Stage 1 south: 7 arrival manoeuvres and 2 departures in varying environmental conditions
- Along the shore: 1 arrival and 1 departure in off berth environmental conditions
- Basin short: 4 arrival manoeuvres and 5 departures in varying environmental conditions
- Basin long: 1 arrival manoeuvre.

Layouts ‘Stage 1 all’ and ‘Stage 1 extension’ were not examined during the simulation session as it was demonstrated that the manoeuvring area at ‘Stage 1 south’ can be considered adequate for the manoeuvres under study.

Detailed track and data plots for each of the runs performed can be found in Appendix C. The scenarios selected for the runs were mainly conducted in the most adverse environmental conditions, in order to provide the most stringent test of the designs presented. Simulation runs were carried out by an HR Wallingford Pilot who has experience of manoeuvring the vessels of the types simulated.

At the start of each run, the vessel’s position, heading, forward and transverse speeds were estimated by the Pilot and Simulator Operator. These were chosen to give the most realistic starting point based on the type of manoeuvre to be simulated and the wind and current conditions used for each run.

It can take a few minutes for the simulation system to settle as the motion of the vessel becomes adjusted based on the selected environmental conditions. This is a normal feature of all vessel navigation simulation systems and is not judged to have affected the outcome of the runs. To minimise this effect, care was taken to select an appropriate starting position for the vessel.

Use of tugs

On arrival tugs waited for the vessel at a position indicated by the Pilot. The tug deployment was discussed in advance before each run depending on the type of vessel, the tugs were then secured as instructed by the Pilot. The tugs then assisted the vessel as directed by the Pilot to achieve the objective of the run. For the 400m long container ship, 2 x 80tBP ASD tugs were used to assist the vessel in wind speeds up to 25 knots. The first tug to attach to the vessel was on the stern centre-lead after passing Buoys 27 and 28. This tug was used initially to control the vessel’s speed using transverse arrest (where the tugs thrusters are both directed outward at 90° to the direction of travel, which creates a strong slowing effect) and direct pull modes. Once the vessel was inside the turning basin, the forward tug was made fast onto the centre-lead forward position to assist the vessel during the swing manoeuvre. Further tugs were then deployed as necessary.

In winds in excess of 25 knots a third tug was required to assist the vessel when berthing or manoeuvring within each of the presented design layouts. This tug was deployed variously as required. For the 115,000 DWT bulk carrier and the 250m long products tanker, the existing tug deployment was used. It is understood this consists of 2 x 45tBP ASD tugs, with the forward tug made fast on the shoulder and the aft tug on the quarter.

Initial assessment

The initial run (Run 01) of the simulation session was designed to simulate an arrival manoeuvre in benign wind conditions for the ‘Stage 1 south’ layout. The objective of this first run was to identify those areas of the channel likely to prove most challenging conditions and identify any issues arising from the dimensions of the associated manoeuvring area for the largest design vessel. This was the 400m container vessel which is expected to be the largest vessel to operate in at the Port of Hastings.

This initial run suggested that the navigation of the existing Western Channel between Buoys 1/ 2 and Buoy 15, as defined in Chart AUS151 (see Figure 5.2) was not a challenging feature of the passage. The area of this channel in the region of McHaffie Reef (see Figure 2.1) was noted, however, to pose particular challenges due to the existence of strong currents. This issue was identified during this run and it is discussed further in Section 5.3.2. The speed of the design vessel was used as a means of controlling lateral drift in this area and the channel is of adequate width for the passage of this vessel. The Western

Channel is designated as a two way channel, however, two way transits of the Western Channel were not a focus of this study.

The channel bend east of Sandy Point did not give rise to any navigational concern. As a result of findings from this initial run, both the geometry and alignment were considered to be of adequate dimensions.

Subsequently therefore, the simulation session runs were focused on the proposed channel and the manoeuvring areas north of Buoy 15.

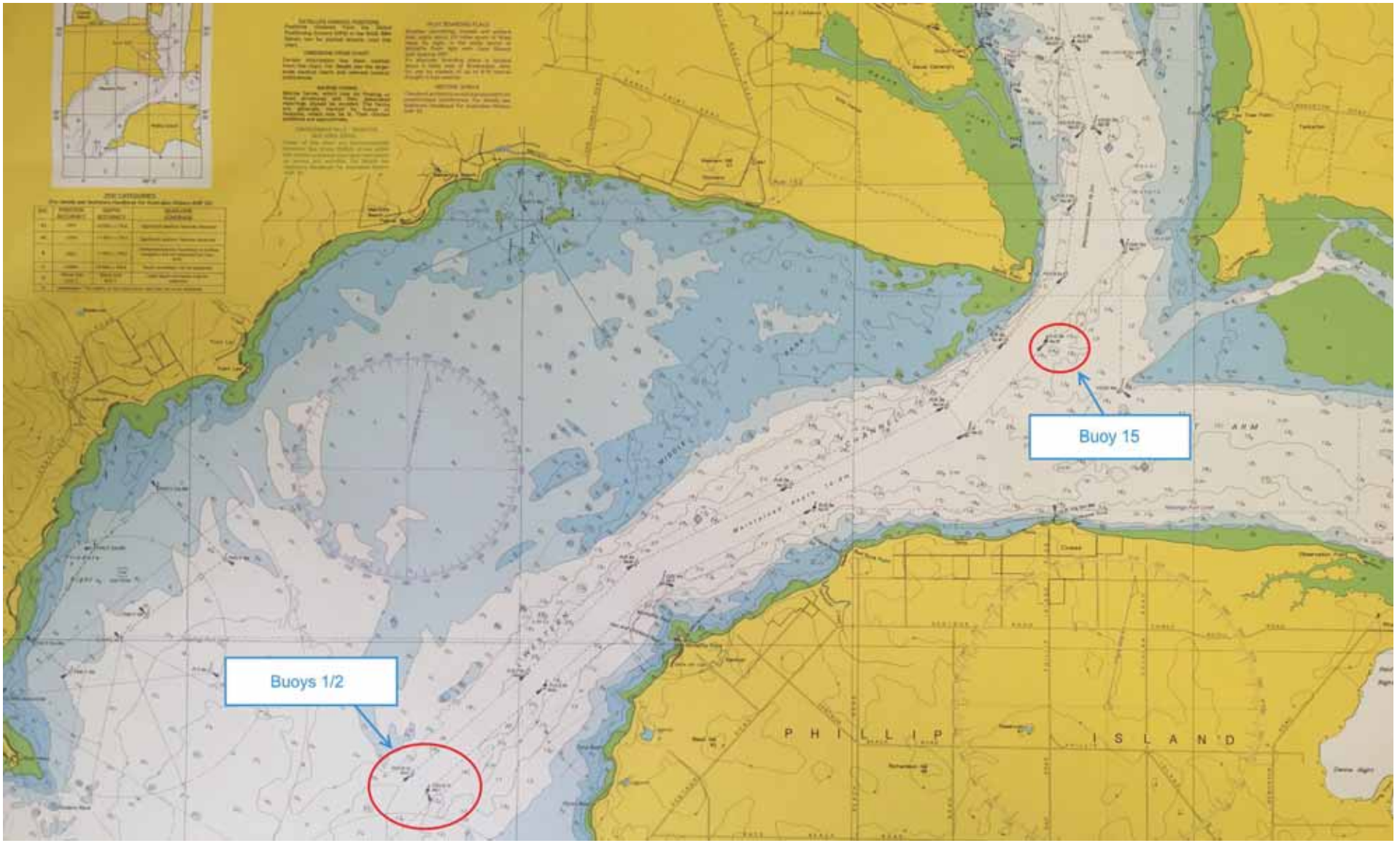


Figure 5.2: Western channel defined in Nautical Chart Aus151

5.3.2. Stage 1 south

The navigation simulation session continued with the study of 'Stage 1 south' layout. A total of 9 runs were performed to assess the navigational aspects of the proposed channel and manoeuvring area.

Arrival manoeuvres

Runs 01 to 06 examined arrivals with a 400m long container ship to the proposed manoeuvring area. The conditions were selected to investigate both arrival and swing manoeuvres in adverse environments for the proposed layout.

Following the preliminary conclusions obtained after Run 01, the arrival Runs 02 to 05 commenced with the vessel in a starting position at Buoy 15. Westerly and easterly 30 knots winds were used in combination with flood and ebb tides.

For all arrivals, the bend east of Sandy Point was found to have adequate dimensions in all environmental conditions. Sufficient space exists to conduct the turn making minimal use of helm and reducing speed as necessary to achieve a well-controlled transit of this area.

Runs 02 and 03 simulated arrivals in westerly winds. In these runs the vessel came close to Buoy 20 when transiting the channel to control the vessel set towards the east side of the channel. The vessel required constant heading corrections and high drift angles between Buoys 19/20 and Buoys 23/24 to maintain the vessel within the channel in this environment. After passing Buoy 22, the Pilot set the vessel towards the west side of the channel in anticipation of the turn at Buoy 24. Clearances between the western toe line of the dredged channel and the vessel were of concern in these runs.

After completing the bend at Buoy 24, the ebb tide (see Run 02) required a large drift angle to counteract the effect of the environment on the vessel. This resulted in the ships head apparently being out of the channel at a point at which visual references are not visible from the conning position and suggests more visible navigational aids will assist the passage. This is of less concern on a flood tide, though the vessel is again close to the western edge of the channel.

Runs 04 and 05 examined easterly winds. Once again the vessel was set towards the west side of the channel between Buoys 19/20 and Buoys 23/24. As before the Pilot experienced difficulty in keeping the vessel within the channel limits whilst allowing for the environmental conditions. After conducting the turn to starboard at Buoy 24, the vessel was kept inside the channel maintaining safe clearances within the buoys. However, for a flood tide (see Run 04) the Pilot lost sight of the channel lateral marks once north of Buoy 25 due to the large drift angle set to control the vessel.

Tugs were necessary from Buoy 27 to assist in reducing speed on approach to the manoeuvring space. In Runs 03 and 04, as the vessel speed decreased, the effect of the flood tide on the vessel induced a significant set towards Buoy 32, demonstrating that the width of the channel is of concern in this region as the vessel's headway is reduced.

Run 06 simulated a south westerly wind combined with a flood tide and was designed to test the longitudinal dimensions of the manoeuvring area. The speed of the approach was controlled using the tug on the stern centre-lead. Once in the turning basin, the vessel headway was reduced and the swing manoeuvre was initiated. However, the south westerly wind combined with the flood tide set the vessel towards the north east area of the basin. Despite this the vessel remained within the basin limits, which was therefore considered to be of adequate horizontal dimensions.

The basin dimensions were considered to be generous for a variety of swing manoeuvre strategies that were conducted, as shown in Figure 5.3.

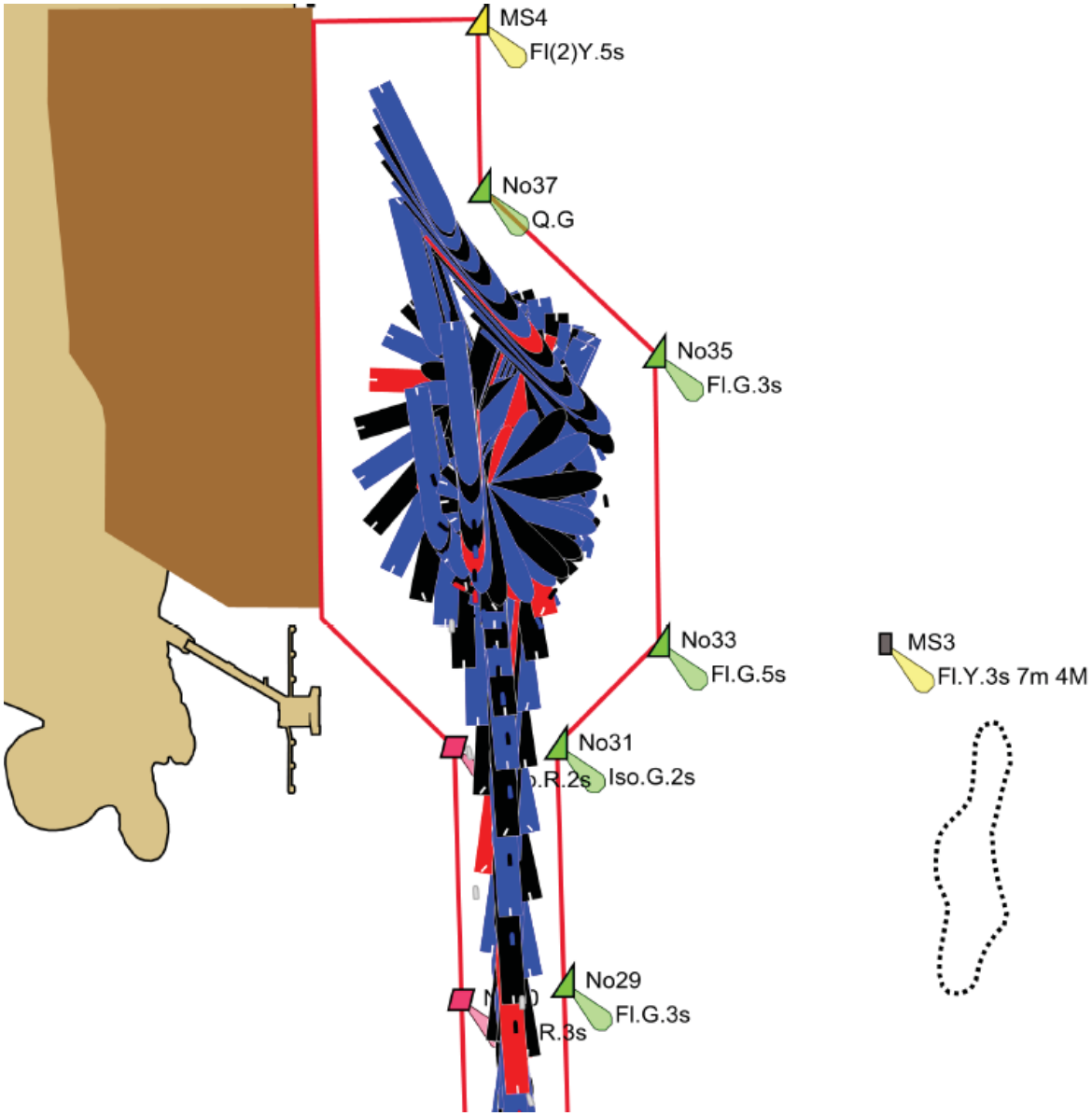


Figure 5.3: Combined track plot of all arrival manoeuvres for Stage 1 south swing basin

Source: HR Wallingford Ship Simulator

Departure manoeuvre

Run 07 examined an outbound manoeuvre of a 400m long container ship from the northern quay of the manoeuvring area to a position clear of the Western Channel. The run simulated the departure manoeuvre and the complete passage of the main access channel. The environmental conditions were chosen as the most adverse for the transit of the channel with a 400m long container ship.

Wind roses provided by the client showed that easterly wind components are not common in the area under study. For this reason, the run was undertaken using a westerly 30 knots wind and an ebb tide.

The run indicated the difficulty of transiting the channel from Buoys 24 to 20 for the selected conditions. The channel width appears narrow as a result of the drift angle required to balance the effect of the environmental conditions on the vessel. Although, the dimensions of the manoeuvring area were found to be adequate to unberth the vessel, the manoeuvre to orientate it adequately to enter the channel at Buoys 32/31 and initiate the transit of the channel proved challenging.

McHaffie Point passage

Runs 01 and 07 examined the transit of the channel at McHaffie Point for a 400m long container ship. Both arrival and departure were simulated for an ebb tide to investigate whether the effect of the currents on the vessel would prove a challenge to maintaining the vessel within the channel limits.

Client information indicated that local port pilots have reported that controlling the vessel is more difficult at this point due to the existence of strong currents at McHaffie Point, particularly on the ebb tides. These currents were identified during the runs conducted in the simulation session.

Currents at McHaffie Reef were in excess of 3 knots with a noticeable effect on the vessel. However, with no necessity to control the vessel at slow speeds, and a naturally wide channel, sufficient means were available to counteract the effect of the currents on the vessel.

Manoeuvres to and from Long Island Point

Runs 24 and 25 simulated an arrival and a departure manoeuvre to and from Long Island Point of a 250m long products tanker to assess the effect on the vessel operations of the proposed development north of Long Island Point.

The conditions were selected to investigate both arrival and departure within the existing operational limits. Tug capacities and deployment were those that are employed at present. So 2 x 45t BP ASD tugs were used in the existing configuration and Buoy 32 was considered to be absent from the proposed station.

Berthing at Long Island Point berth was found to be unaffected by the existence of the proposed development. The presence of the proposed new terminal was not considered to represent a navigational hazard to existing manoeuvres for the departure operations.

5.3.3. Along the shore

Runs 08 and 26 investigated the suitability of the basin dimensions for the ‘Along the shore’ layout. They examined the 400m long container ship to assess the dimensions of the manoeuvring area when berthing and departing from the basin (see Figure 5.4). Environmental conditions were selected to be the most adverse, which were considered to be in an off-berth direction. In 30 knots wind speed, 3 x 80tBP tugs were required to maintain control of the vessel.

Run 08 showed that there was sufficient space to swing a 400m long container ship at the north-south alignment for the selected conditions. Manoeuvring the vessel astern to the northern quays of the basin was found to be feasible in all of the conditions simulated.

Run 26 examined a departure manoeuvre from the northern quays of the basin. The environmental conditions were selected to be the most adverse combination of wind and currents with off-berth components.

This run showed a clear failure to control the vessel which impacted Buoy 37 having failed to remain in the dredged area. This indicates more tugs may be necessary to control the vessel in such circumstances.

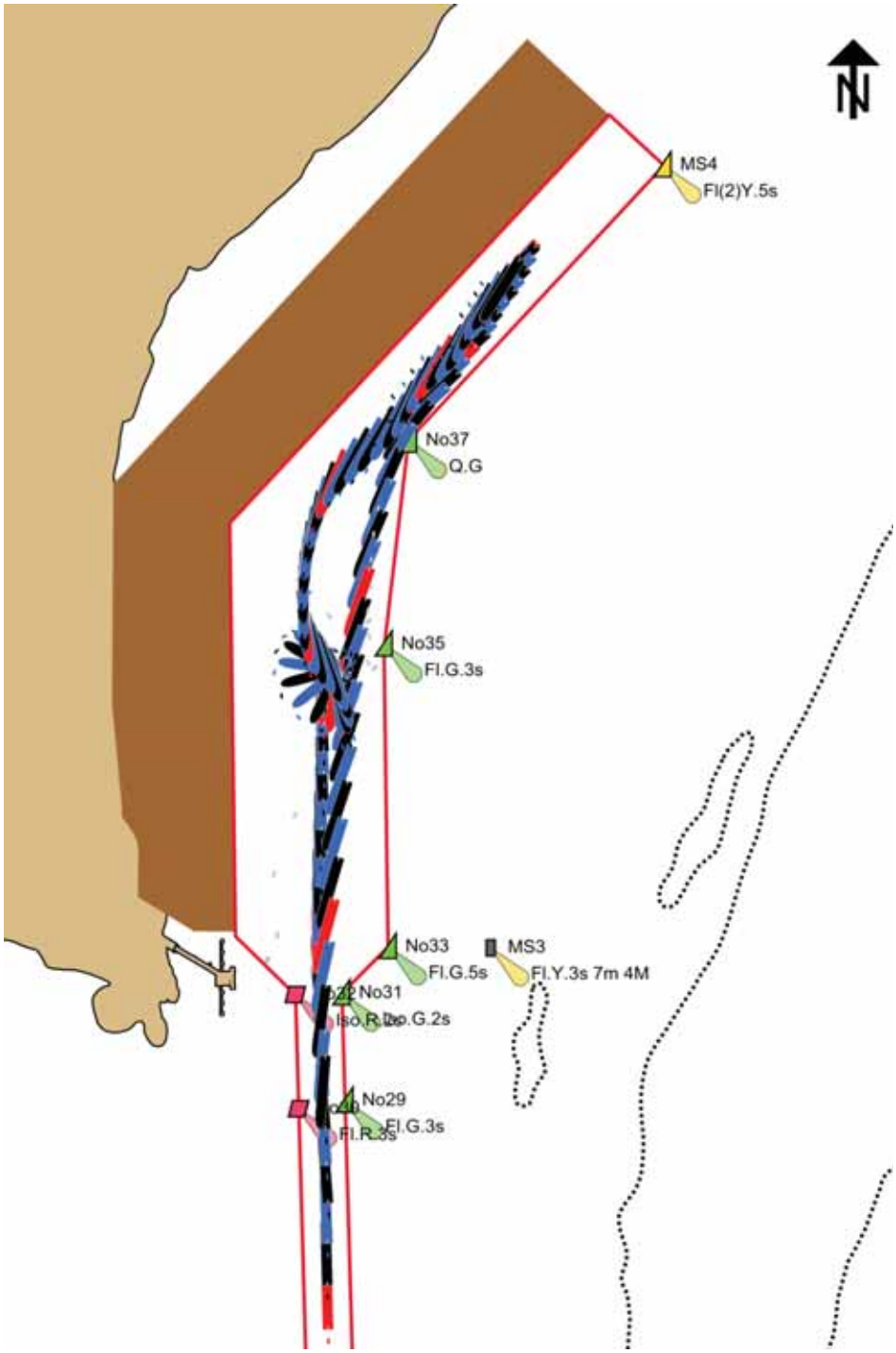


Figure 5.4: Combined track plot of all manoeuvres for 'Along the shore' layout option

Source: HR Wallingford Ship Simulator

5.3.4. Basin short

For the 'Basin short' layout, a total of 9 runs were simulated examining both arrival and departure manoeuvres to and from the basin. All runs were simulated with 30 knots wind speed except Run 09, which simulated a 10 knot wind speed.

Arrival manoeuvres

Runs 09, 10 and 13 examined the arrival manoeuvres to the northern quays of the basin of a 400m long container ship. Environmental conditions were selected to provide a combination of wind and currents setting in the same direction. All the runs started at the turning basin with the tugs secured on the vessel.

Run 09 assessed whether in these conditions the vessel could safely manoeuvre into the proposed design stern-first whilst remaining clear of port infrastructure and potential moored vessels. The manoeuvre was considered feasible and the design was found to be appropriate in providing sufficient space to allow the vessel to access the terminal.

Runs 10 and 13 investigated this conclusion allowing for the maximum combined effect of wind and currents on the vessel in the proposed layout. Berthing was found to be possible for both off and on-berth conditions with 3 tugs, but additional care must be taken regarding maintaining safe clearances to port infrastructure and potential mooring vessels when completing the swing and astern manoeuvre for northerly wind and ebb tide conditions. Sufficient space exists within the basin to hold the vessel with 3 tugs, as previously noted.

Departure manoeuvres

Departures were conducted in Runs 11, 12, 14 and 23 for a 400m long container ship. These used 3 x 80tBP ASD tugs, deployed as required. At the start of each run, the tugs were made fast to the vessel. All runs commenced from the basin with the vessel speed at rest and 200m off the berth, with all mooring lines released.

Runs 11, 12 and 23 simulated the departure of a vessel from starboard side to the berth for a combined effect of wind and currents. Sufficient space was available to allow unberthing in all environmental conditions. Enough space was found to exist to allow a managed exit from the basin into the manoeuvring area adjacent to the north-south aligned berths.

Run 14 examined the departure manoeuvre when the vessel needed to be manoeuvred stern-first out of the basin and swung for departure. The run demonstrated that space is sufficient and unberthing in the simulated conditions was possible. Careful management of the swing position is necessary if the vessel is to be maintained in the dredged area, which was found to be of adequate dimensions.

All runs demonstrated that particular care is required when the vessel transits the north-south alignment to prevent the vessel developing excessive speed that may then cause interaction with ships berthed at the southern quays. However, the design allows sufficient space for navigation of the vessel.

115,000 DWT bulk carrier manoeuvres

Runs 16 and 17 investigated the feasibility of manoeuvring a bulk carrier in the proposed manoeuvring area using 2 x 45tBP ASD tugs in the existing configuration. These runs simulated a peak flood tide. Both arrival and departure manoeuvres were found to be feasible for all environmental conditions. Also, adequate space was available for the swing manoeuvre.

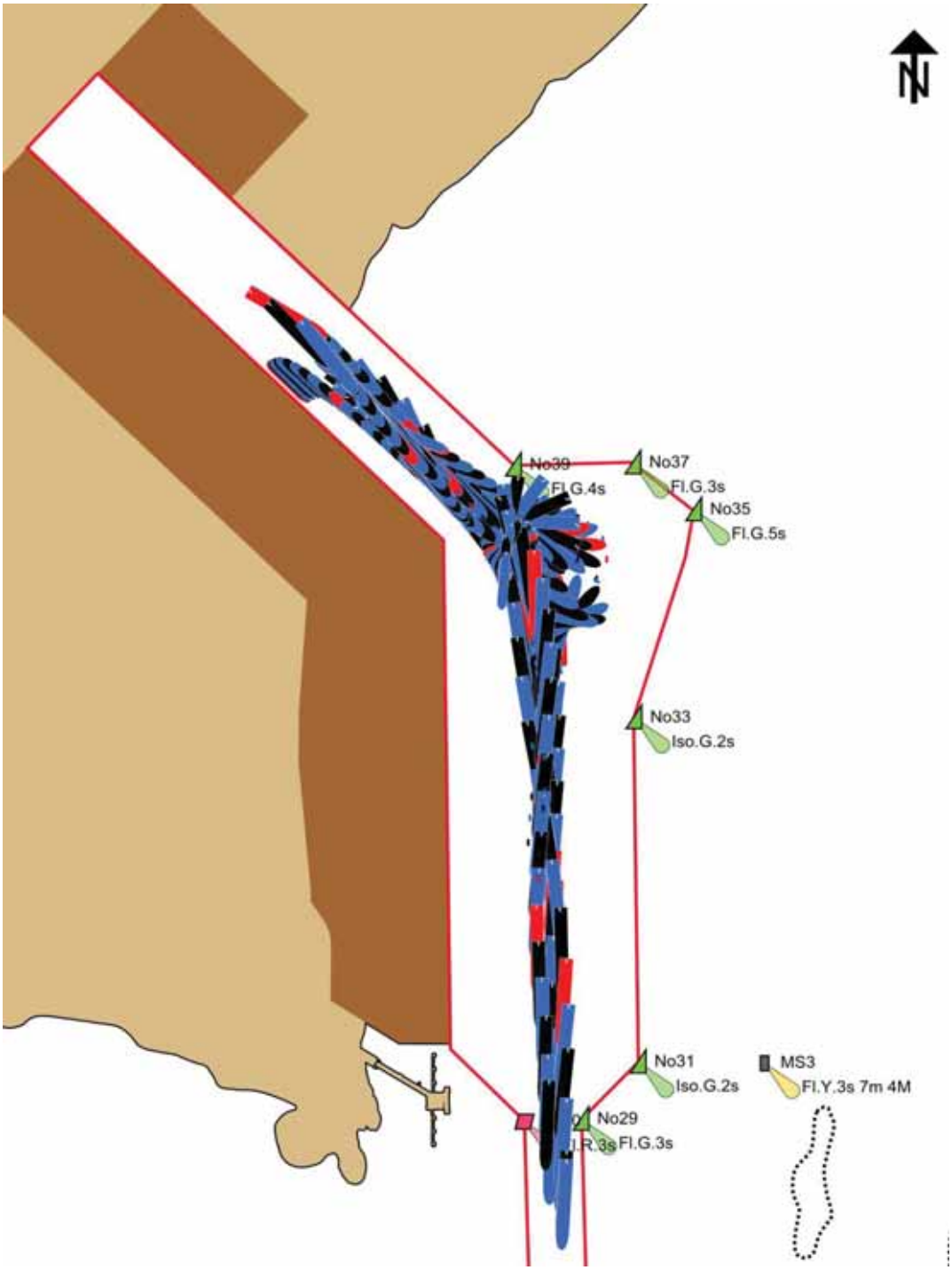


Figure 5.5: Combined track plot of all manoeuvres for 'Basin short' layout option

Source: HR Wallingford Ship Simulator

5.3.5. Basin long

The 'Basin long' layout contains a long training wall placed on the north side of the basin to prevent possible sediment deposition. This training wall interacts with the tidal flow changing its pattern particularly on the ebb tide. This has the effect of deflecting the ebb tide current flow at the northern end of the basin, providing a sheltering effect in the area adjacent to the basin entrance. This then impacts onto the manoeuvring area at the southern end of the north-south alignment as shown in Figure 5.6.

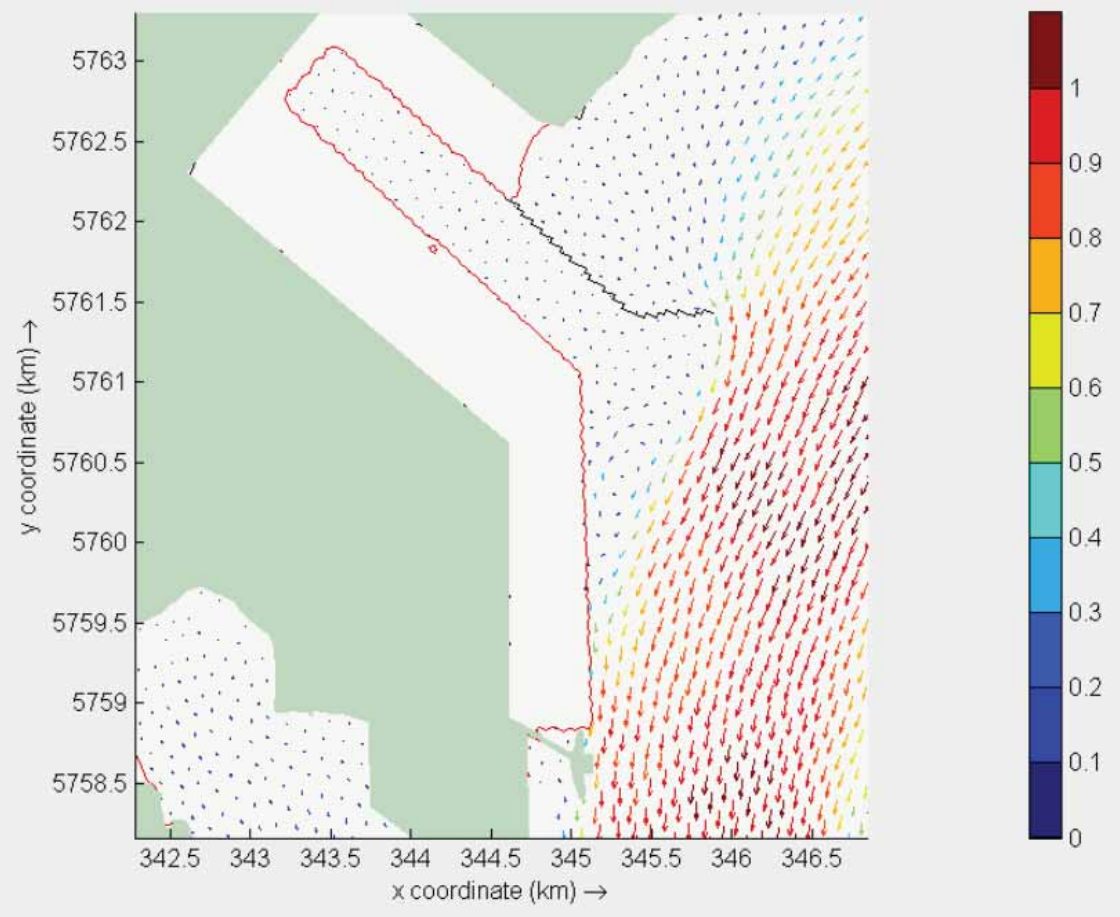


Figure 5.6: Current pattern for an ebb tide at HW+3.75 hours at Basin long layout

Source: Royal Haskoning DHV

Run 15 examined the effect of this on a vessel manoeuvring to the southern berths. This run demonstrated that this effect of the current is unlikely to cause any significant manoeuvring issues in that area and is therefore not navigationally significant.

6. Conclusions

This study considered the feasibility of manoeuvring vessels in the proposed channel and port area layout options at the Port of Hastings.

The main conclusions arising from the simulation session are described in the following sections.

6.1. Access Channel

From seaward the study concluded that:

- The Western Channel was found to be navigable for all the considered vessels for the environmental conditions investigated. Strong currents at McHaffie Point were found to be a significant feature for the transit of the channel, which should be considered in the navigation plan.
- The bend east of Sandy Point was found to have adequate dimensions for the transit of all the considered vessels in all environmental conditions. However, the entrance to the section of channel commencing at Buoys 19/20 is of particular concern. Consideration should be given to widening the channel at the entrance to the North Arm by approximately one ship's beam, for the design ship with the largest beam.
- Consideration should be given to providing additional width in the proposed channel between Buoys 19/20 and Buoys 23/24. Any additional widening should take place on the western side of the access channel by approximately one ship's beam, for the design ship with the largest beam.
- The deflection of the channel at Buoy 24 is a significant navigational feature. Consideration should be given to widening the channel and/or easing the bend in this area in line with the recommendation above.
- Navigation of the channel north of Buoy 24 is feasible, although consideration should be given to increasing the number of lateral navigation marks in this section. The width of the entrance to the manoeuvring area between Buoys 31/32 is insufficient. Consideration should be given to the removal of Buoy 32 to allow the vessel to use all the available water depth understood to exist west of the proposed buoy location.

6.2. Manoeuvring areas

6.2.1. Stage 1 south

- The manoeuvring area north of Buoys 31 to 35 is of adequate dimensions both laterally and longitudinally. There is scope to consider reducing the dredged area in this location, particularly east of the access channel.
- The manoeuvring space north of Buoy 37 is of sufficient dimensions to allow vessels to manoeuvre stern-first into the area.

6.2.2. Along the shore

- The manoeuvring area south of Buoy 37 is of adequate dimensions to allow for the swinging of 400m vessels at any of the adjacent berths.
- The berth access area north east of Buoy 37 is of adequate dimension to allow the stern-first navigation of vessels within the area.

6.2.3. Basin short

- The layout of the basin and the influence of the training wall produces a reduction in the current flows in the area north west of Buoy 39. This enables safe vessel manoeuvring into the basin entrance.
- The area south of Buoys 37/39 immediately south east of the basin entrance provides sufficient space to swing vessels of 400m length overall.
- The dimensions of the basin are sufficient to allow for the entrance/exit of vessels stern-first into the basin.
- Consideration can be given to reducing the dredged area south east of the basin entrance, in particular, east of proposed Buoys 33 to 37 (see Figure 6.1).

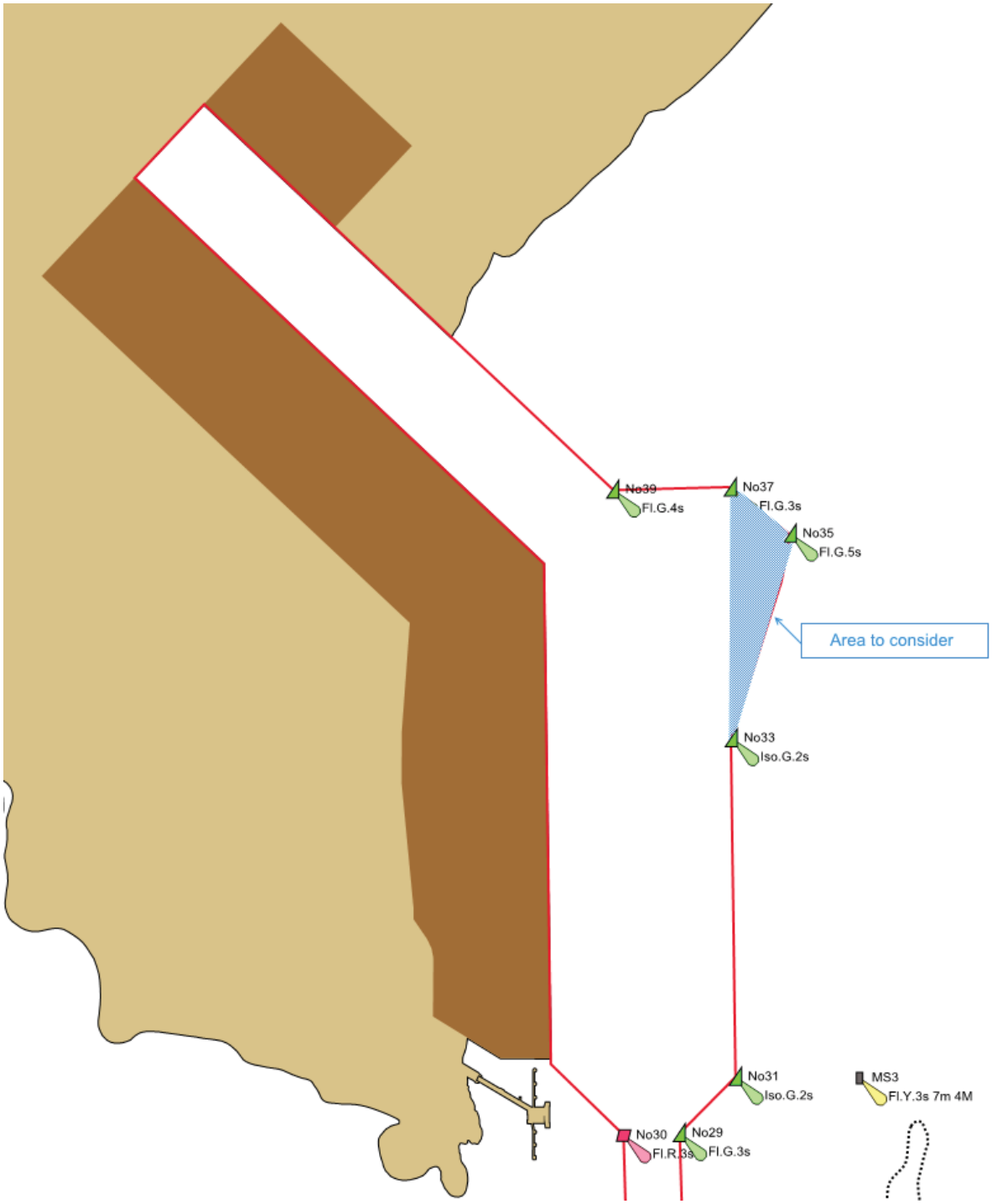


Figure 6.1: Dredged area for consideration for reducing the manoeuvring area

Source: HR Wallingford Ship Simulator

6.2.4. Basin long

- The presence of the training wall provides significant current shadow for vessels manoeuvring into the basin north west of Buoy 39.
- The deflection of the ebb current caused by this long training wall does not adversely impact on manoeuvres at the southern berthing area.

6.3. Aids to navigation

Aids to navigation play an important role for the safe navigation of the channel. This section describes the conclusions and recommendations arising from the study in this regard. The following was concluded:

- Existing aids to navigation along the Western Channel were found to be appropriate for the safe transit of the channel.
- Aids to navigation between Buoys 19/20 and Buoys 23/24 in the proposed channel were found satisfactory for the safe navigation of the channel.
- Provision of an additional pair of buoys equidistant between Buoys 25/26 and 27/28 and Buoys 27/28 and 29/30 would assist in visually determining the vessels lateral position in this section of the channel (see Figure 6.2).
- Buoy 32 should be removed to provide additional space for the entrance into the Stage 1 manoeuvring area.
- Buoys may be offset to improve their visibility from the 400m long vessel conning position (Figure 6.2).
- The training wall represents a hazard, especially for tugs, when berthing at the basin. It is recommended to add visual marks on the training wall to indicate the existence of a submerged structure.

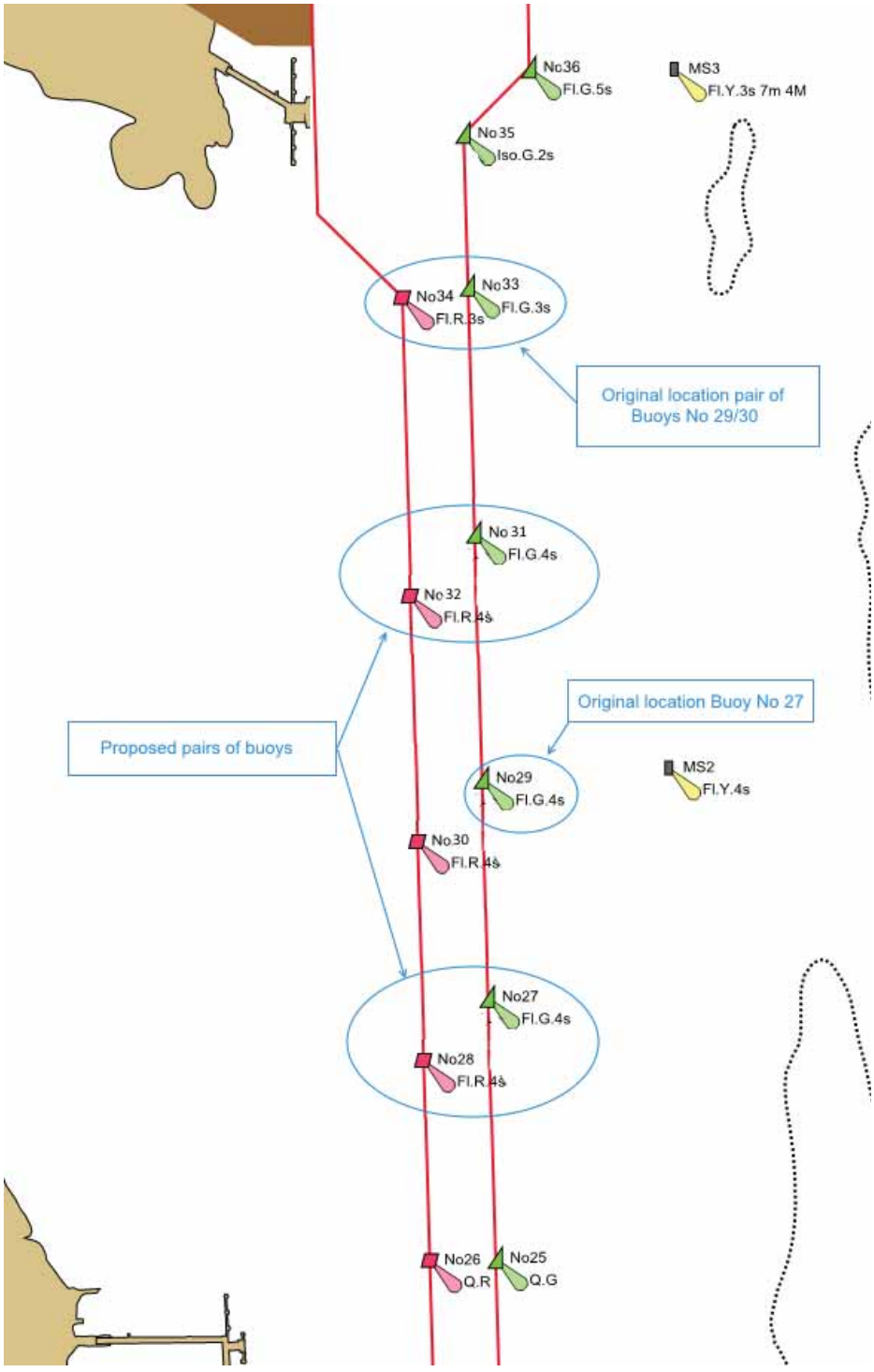


Figure 6.2: Proposed aids to navigation layout of the modified approach channel

Source: HR Wallingford Ship Simulator

6.4. Manoeuvres at Long Island Point

- Both the proposed dredged area and the new terminal were found to have no impact on existing manoeuvres at Long Island Point.

6.5. Towage

- A minimum of 3 tugs should be provided to assist in the vessel manoeuvres. Tugs provided should be of such a design that they can assist with the speed management of the vessels.
- The tugs should be of 80t BP for the assistance of the 400m long container vessel.
- 115,000 DWT bulk carrier manoeuvres can continue with the existing tug deployment and capacities that are being used at Port of Hastings.

7. Further work

Further ship navigation simulation work will be required to assist in finalising the design of the channel and manoeuvring areas once a decision has been made on the preferred port layout. This work is anticipated to include:

- Development of the existing simulation configuration into a more detailed simulation and updating to take account of the proposed port configuration to be examined. Allowance should be made to examine up to 3 scenarios to allow some flexibility in the design.
- Due to the complexity of the current flows in the area, the simulation should include data from a more detailed flow model than that already available. It is understood that this will be based on a 3D flow model that Royal HaskoningDHV are developing at present.
- The study should be more extensive than that already undertaken so that it can be used to finalise the design of the channel widths and manoeuvring area sizes, define the limiting environmental conditions for safe operations, finalise the tug requirements and the aids to navigation.
- The work should also include an assessment of the likely passing ship effects as ships transit the channel past moored vessels. This should be assessed initially as a desk based study, to compare likely passing ship speeds, separation distances and other relevant data against internationally accepted guidance on the risk of moored vessel disturbance from passing ships. If this indicates that there is likely to be an issue, a more detailed numerical modelling assessment should be carried out.
- Under keel clearance study that should be used to examine the channel and manoeuvring area depth requirements for safe navigation of the design ships, particularly in the areas that are exposed to wave action.

8. References

1. Port of Hastings Operating Handbook and Harbour Master's Directions, December 2013 Edition.
2. Hydrodynamic input for 2D Vessel Simulations - Draft (HY-WP-27). Technical Note, 3rd February 2015.

Appendices

A. Australia Ship Simulation Centre

HR Wallingford
Working with water

Australia Ship Simulation Centre

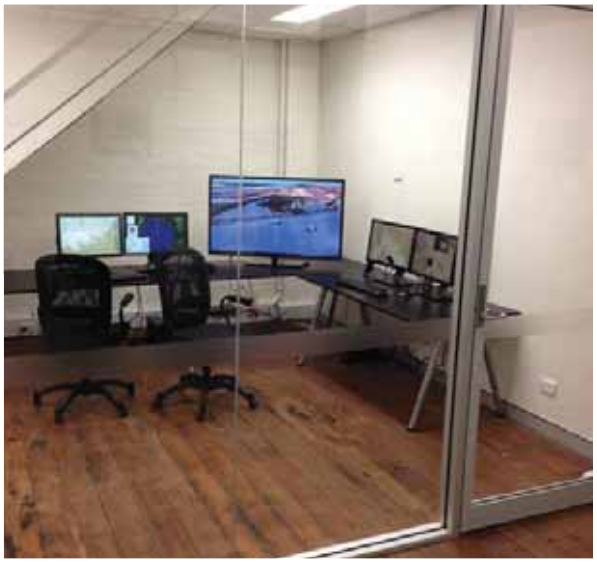
HR Wallingford is a world leader in simulating vessel navigation, and operates Ship Simulation Centres in the UK and Australia.

We combine our extensive hydraulic modelling capabilities with ship manoeuvring models and our experienced, expert team of master mariners, trained pilots, naval architects and software modelling experts – all focused through our suite of real-time ship simulators.

Our Australia Ship Simulation Centre is located in Fremantle, near Perth, Western Australia. The facilities are used to support ongoing marine operations and the development of marine facilities including:

- undertaking design assessments of marine facilities;
- assessing and refining safe marine operational thresholds;
- establishing the nature of tug requirements to support all marine operations;
- developing, optimising and communicating marine operating procedures;
- delivering site familiarisation training for pilots, tug crews and masters of visiting vessels;
- delivering emergency and failure scenario training for pilots, VTS personnel and tug crews;
- incident investigations;
- professional development training and development for individual pilots, tug masters, VTS personnel and other mariners.

Australia Ship Simulation Centre



Our facilities

- Three real time ship simulation bridges.
- VTS simulator.
- All simulators can be operated separately, or simultaneously allowing independent, interactive control between vessels within the same simulated environment.
- Dedicated simulator control rooms.
- Dedicated observation, briefing and meeting areas.
- High quality simulation environment using the HR Wallingford Ship Simulation System.
- Realistic hydrodynamic ship and tug models with 6 degree of freedom motions.
- Staff experienced in the use of simulators for port design and operational training.

State of the art ship simulation

Our full bridge, real time manoeuvring simulators are specifically designed for port design and ship operations, but can also be used for training and familiarisation purposes.

The simulators can be run individually or simultaneously, allowing multiple independent interactive control between vessels (ships and tugs or ship to ship) within the same simulated environment.

Our off-bridge facilities include observation, briefing and debriefing rooms, interactive display boards,

interactive visual scene tool, work stations and conference facilities to ensure that all participants are fully informed and involved at all stages of the simulation.

The simulation system uses sophisticated techniques to represent the spatial and temporal behaviour of a ship. Hydrodynamic modelling includes full six degree-of-freedom ship response to waves, wind and currents, allowing for both lift and drag effects and close quarter effects such as shallow water, bank effects, bow and stern thrusters, ship interaction and collisions.

HR Wallingford at FMSC

HR Wallingford
Working with water

FMSC

'HR Wallingford at FMSC' is an alliance between HR Wallingford and Fremantle Maritime simulation Centre (FMSC) to deliver world-class ship simulation in Western Australia. The alliance facilities include three simulator bridges as well as observation, briefing and meeting areas.

Combined ship simulation facilities

The HR Wallingford and FMSC simulation facilities are complimentary and share one building. The combined facilities can be linked to total seven simulators - two ship bridge simulators, four tug simulators and a VTS simulator.

How to find us

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There is easy access to the Facility from Fremantle Railway Station, and parking available for those travelling by car.

Fremantle is approximately 40 minutes by car from Perth Domestic and International Airports.

> All day metered parking available at Victoria Quay car park.

> Short term (up to 2 hours) metered parking available in Pakenham St, Short St and Leake St.

B. Simulation run summary

Table B.1: Run summary

Exercise ID	Pilot [1]	Layout	Vessel\ Condition	Manoeuvre	Tugs [2] (initial positions)	Tide [3]	Wind	Incident waves (initial)	Scenario\ Purpose of run	Outcome	Run Commentary and Remarks
Day 1 01	IS	Stage 1 South	400m long Containership Laden	Arrival from South West Buoys 1/2.	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by between Buoy 27 and 29.	Ebb HW+2.5 hours	E 15 knots	Nil	To conduct initial run through the access channels with the maximum size design vessel To identify any points of concern with proposed access channel design and manoeuvring areas in standard transit conditions. Identify issues for further assessment runs.	Successful	Adjacent to McHaffie Point the vessel was experiencing strong currents as reported. To remain under control within channel margins vessel maintained at full manoeuvring speed (15 knots). At this point there is not speed limitation and the channel is sufficiently wide for this not to cause concern. The existing Western Channel - from Buoy 1 to Buoy 20 appears of adequate width to be safely navigated by this vessel. The channel bend at Sandy Point is of adequate dimensions to allow for the navigation of this type of vessel. The channel entrance at Buoy 20 and the transit to Buoy 26 are areas of concern. The channel appears uncomfortably narrow -the vessel requires drift angle occupying almost the entire channel width due to the lateral set caused by current and wind. The bend at Buoy 24 becomes a critical point. Following this run it is concluded that westerly and easterly winds are the most critical conditions for this channel configuration. These wind directions will therefore be used to examine channel configuration in subsequent runs. Following the channel transit the swing manoeuvre of the vessel was safely conducted within the proposed manoeuvring area. There are no concerns regarding the dimensions of this area at this point.
02	IS	Stage 1 South	400m long Containership Laden	Arrival from Buoy 15	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by between Buoy 27 and 29.	Ebb HW+2.5 hours	W 30 knots	W 0.5m 4s	To assess the dimensions of the proposed channel and manoeuvring area for a combination of strong westerly wind and ebb tide.	Channel transit: Marginal Proximity to Buoy 20. Vessel set towards the west side of the channel. Visual reference lost at Buoy 26 Swing and stern-first berthing approach: Successful	The vessel experienced the same concerns for the transit of the channel as in run 01. Vessel passed close to Buoy 20 –difficulty experienced in achieving entry between Buoys 19/20 safely whilst allowing for a combination of constricted manoeuvring width and whilst counteracting the lateral set induced by the combined effect of the wind and the currents. The turn to starboard at Buoy 24 within the channel was effected without undue concern-vessel setting towards centreline of channel throughout. When passing Buoy 26 pilot commented there was no visual reference (navigation aid) when transiting the channel making it difficult to establish the vessels lateral position within the proposed channel as at this stage pilot had lost the reference of Buoy 26 and to maintain position within the channel the drift angle required meant the vessel's heading was apparently steering the vessel out of the channel. This gives rise to concern both over the available width and the marking of this section of the channel. Tugs required North of Buoy 28 and Buoy 30 to control vessel's speed. Drift angle increases as the vessel's ground speed decreased while entering the manoeuvring area. Once the vessel is clear of Buoy 30 adequate room exists in the proposed manoeuvring area both to conduct the swing and manoeuvre the vessel stern-first to the northern most berths with appropriate tug assistance. Vessel manoeuvres with appropriate margin of safety from area margins and the port structures.

Exercise ID	Pilot [1]	Layout	Vessel\ Condition	Manoeuvre	Tugs [2] (initial positions)	Tide [3]	Wind	Incident waves (initial)	Scenario\ Purpose of run	Outcome	Run Commentary and Remarks
03	IS	Stage 1 South	400m long Containership Laden	Arrival from Buoy 15	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by between Buoy 27 and 29.	Flood HW-3.5 hours	W 30 knots	W 0.5m 4s	To assess the proposed channel and manoeuvring area for a combination of strong westerly wind and flood tide.	Channel transit: Marginal Proximity to Buoy 20. Proximity to west side of the channel between Buoys 19 and 23. Swing manoeuvre: Successful	Vessel uncomfortably close to Buoy 20 as vessels enters narrower area of channel, difficulty experienced regaining the centreline between Buoys 20 and 24 resulting from lateral position at Buoy 20. Insufficient room at the stern to allow for necessary drift angle to be established. More difficulty reducing vessel's ground speed when entering the manoeuvring area due to the flood tide, however the vessel was under control. Once the vessel is clear of Buoy 30 adequate room exists in the proposed manoeuvring area to conduct the swing maintaining adequate margin of safety from area margins and the port structures. Berthing the vessel in these wind conditions requires three tugs. Manoeuvring area dimensions are generous
Day 2 04	IS	Stage 1 South	400m long Containership Laden	Arrival from Buoy 15	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by between Buoy 27 and 29.	Flood HW-3.5 hours	E 30 knots	E 0.5m 4s	To assess the proposed channel and manoeuvring area for a combination of strong easterly wind and flood tide.	Channel transit: Marginal Proximity to west side of the channel. Visual reference lost at Buoy 26 Swing manoeuvre: Marginal Proximity to the port infrastructure	During the inbound transit, between Buoys 20 and 26, the vessel was set towards the west edge of the main access channel due to the combined effect of the easterly wind and flood tide. Vessel maintained within the channel limits with difficulty. When the vessel was passes Buoy 26, visual references marking channel boundary not visible from vessel conning position. At this stage the vessel was apparently heading out of the channel due to the drift angle required to maintain lateral position under the combined effect of current and wind. Entering the manoeuvring area vessel sets toward Buoy 32 requiring aggressive manoeuvring to clear the Buoy 32 resulting in difficulty reducing speed within the manoeuvring area. Unable to maintain satisfactory clearance from port infrastructure during swing. Necessity to employ aggressive strategy in proximity to Buoy 32 results in vessel being unable to reach optimum position for swing. More space in proximity to Buoy 32 and on western side of approach channel would allow for a more controlled channel approach and differing manoeuvring strategy. This may address the infrastructure proximity issues.
05	IS	Stage 1 South	400m long Containership Laden	Arrival from Buoy 15	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by at Buoy 27.	Ebb HW+2.5 hours	E 30 knots	E 0.5m 4s	Investigate the proposed channel and manoeuvring area under ebb tide and strong easterly wind.	Channel transit: Marginal Proximity to west side of the channel Swing manoeuvre: Successful	Repeat run 04 for an ebb tide condition. Between Buoy 20 and Buoy 22 Difficulty estimating appropriate drift angle due to opposing wind/current forces. Unable to achieve safe lateral position -vessel sets towards the west side of the channel north of Buoy 22. Vessel enters manoeuvring area under appropriate control. Swung maintaining adequate clearances from port infrastructures and area margins. In order to attempt the berthing manoeuvre three tugs required in these wind conditions.
06	IS	Stage 1 South	400m long Containership Laden	Arrival from Buoy 27	2 x 80tBP ASD tug Tug 1: standing by at turning basin. Tug 2: standing by at Buoy 27.	Flood HW-3.5 hours	SW 30 knots	SW 0.4m 4s	To test the longitudinal dimension of the manoeuvring area in most adverse environmental conditions.	Successful Adequate space exists within manoeuvring area.	Able to transit channel on centreline without large drift angle. Stern tug used from Buoy 27 to control vessel speed. At Buoy 32 the vessel's ground speed was 5.3 knots with the vessel under control. Within the manoeuvring area, planned manoeuvre was to stop the vessel and swing to starboard in the middle of the turning basin. Flood tide combined with a south westerly wind pushed the vessel towards the north edge of the turning basin wind overpowers tugs but sufficient room exists for vessel control to be re-established. Three tugs required to berth vessel. Longitudinal dimensions of the manoeuvring area appear adequate.

Exercise ID	Pilot [1]	Layout	Vessel\ Condition	Manoeuvre	Tugs [2] (initial positions)	Tide [3]	Wind	Incident waves (initial)	Scenario\ Purpose of run	Outcome	Run Commentary and Remarks
07	IS	Stage 1 South	400m long Containership Laden	Departure from northern berth	2 x 80tBP ASD tug Tug 1: port shoulder Tug 2: port quarter	Ebb HW+2.5 hours	W 30 knots	W 0.3m 4s	To test the dimensions of proposed manoeuvring area and access channels for a departure manoeuvre. To confirm towage requirement in upper limit winds To assess exit strategy in region of McHaffie Reef.	Manoeuvring area: Successful Channel transit North of Buoy 20: Marginal Proximity to Buoy 32 Vessel set towards the west side of the channel Western Channel Successful	Overestimated the wind drift whilst vessel increasing speed vessel comes close to Buoy 32. Between Buoy 32 and Buoy 24 vessel maintains middle of the channel keeping a constant drift angle to counteract the combined effect of wind and currents. S of Buoy 24 combination of lateral drift in turn, wind and current sets the vessel onto the west edge of the channel. Vessel maintained within the channel with difficulty, Channel width is a challenge. Turn at Sandy Point without major concerns as is maintaining position entering Western Channel. Adjacent to McHaffie Point vessel heavily influenced by current. However, the vessel remained within the channel limits maintaining a ground speed of 15 knots. Three tugs required in 30 knot wind.
08	IS	Along the shore	400m long Containership Laden	Arrival from Buoy 29	3 x 80tBP ASD tug Tug 1: standing by at turning basin Tug 2: standing by at Buoy 35 Tug 3: stern centre-lead	Ebb HW+2.5 hours	N 30 knots	N 0.3m 4s	To test the dimension of the turning basin. To investigate whether adequate space is available and vessel can be navigated stern-first to berths in proposed layout.	Successful	Inbound manoeuvre Vessel enters manoeuvring space in controlled manner with tugs assisting from Buoy 27. Swing can take place in desired location and navigated stern first through 45 degree bend into proposed layout adjacent to berths. Appropriate distance maintained form port infrastructure and dredged boundaries. Available space north of Buoy 33 is of generous proportions. Three tugs required to retain control in berthing phase in prevailing conditions.
Day 3 09	IS	Basin short	400m long Containership Laden	Arrival from turning basin	2 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: stern centre-lead	Ebb HW+2.5 hours	N 10 knots	N 0.1m 4s	To assess the basin layout's manoeuvring space requirement. Investigate whether vessel can navigate stern-first into basin layout in cross current flow. Assess navigation marking in this location.	Successful	Vessel maintained appropriate clearances from the port structures, vessel under control throughout the manoeuvre. Adequate space for swing manoeuvre, proposed dredged area east of Buoy 33 unused. Control of vessel bow achieved using tug centreline forward to counteract cross current. Vessel navigates stern first through the basin keeping safe distances from the berth and the training wall. Lateral position of vessel when moving stern-first is by visual reference to quay structures, additional navigation buoys not required.
10	IS	Basin short	400m long Containership Laden	Arrival from turning basin	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Ebb HW+3 hours	N 30 knots	N 0.3m 4s	To test the basin design as above in conjunction with peak wind conditions.	Marginal Vessel at the limits of control after the swing manoeuvre whilst navigating astern.	Swing effected with appropriate clearances within dredged area. Stern-first manoeuvre requires additional tug power however space available is appropriate and area east of Buoy 33 again unused. More towage assistance required in these wind conditions, alternative approach strategy-vessel approaching without swing- may be preferable in these conditions.

Exercise ID	Pilot [1]	Layout	Vessel\ Condition	Manoeuvre	Tugs [2] (initial positions)	Tide [3]	Wind	Incident waves (initial)	Scenario\ Purpose of run	Outcome	Run Commentary and Remarks
11	IS	Basin short	400m long Containership Laden	Departure from basin (200m off Quay 3)	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Ebb HW+3 hours	N 30 knots	N 0.1m 4s	To assess available space for design vessel exiting basin. Assess impact of vessel exiting on moored vessels	Basin departure: Successful	Outbound manoeuvre for the same conditions as run 10. Maintained appropriate clearances with the port infrastructures. Vessel enters channel at Buoy 30 under control but at high ground speed. Difficult to control vessel speed in these conditions, concern about the effect on the vessels berthed at the southern quays and existing oil jetty. At Buoy 30 the vessel's ground speed was 9.6 knots.
12	IS	Basin short	400m long Containership Laden	Departure from basin (200m off Quay 3)	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead Note: Tug 2 was not used	Peak Flood HW-3.5 hours	SW 30 knots	SW 0.1m 4s	To test the basin design as above in north setting conditions. To assess speed management while transiting north-south alignment.	Successful	Set the vessel with a drift angle to leave the basin and initiate the turn to starboard at the knuckle. The turn was conducted without major concerns maintaining safe clearances from the quay knuckle, port structures and training wall. Sufficient space exists for vessel to achieve uninterrupted exit into N/S alignment. Stern tug used to aid the speed control of the vessel while navigating past the southern berths. At Buoy 30 vessel enters channel under control navigating with 6.5 knots ground speed.
13	IS	Basin short	400m long Containership Laden	Arrival from turning basin	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Flood HW-3.5 hours	SW 30 knots	SW 0.2m 4s	To test the design dimensions of the manoeuvring and basin area	Successful	Swung with tug assistance S of basin entrance. Adequate space exists, area north of Buoy 33 again unused stern-first manoeuvre conducted without incident. During the approach safe clearances maintained with the quay and the training wall.
14	IS	Basin short	400m long Containership Laden	Departure from basin (200m off Quay 3)	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Flood HW-3.5 hours	SW 30 knots	SW 0.1m 4s	To test the design dimensions of the manoeuvring and basin area departing stern first Assess impact of departing vessel on existing oil berth	Astern manoeuvre: Successful Swing manoeuvre: Marginal Proximity to Buoy 39 Speed management: Successful	Tugs used to maintain vessel position as appropriate safe clearances maintained from the quay and the training wall. Once the vessel cleared the knuckle, initiated the swing manoeuvre with tug assistance. During the swing manoeuvre the combined effect of the wind and the current sets the vessel north towards limit of dredged area. The run terminated when the vessel was entering channel at Buoy 30 with 5.6 knots ground speed under control. No concern for alongside tanker. *Vessel swung too soon more effective use of available area expected to give successful outcome.*
15	IS	Basin long	400m long Containership Laden	Arrival from south Buoy 29	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead Note: Tug 2 was not used.	Ebb HW+3.75 hours	N 30 knots	N 0.3m 4s	To assess whether the deflection of ebb current by the presence of the long training wall will cause adverse effect on manoeuvring to southern berths.	Successful	For the 'Basin long' layout the expected flow pattern of the ebb tide shows current deflection from Buoy 33 to the south. Vessel swung and berthed without experiencing problems caused by ebb current.
Day 4 16	IS	Basin short	115k DWT Bulk Carrier Ballast	Arrival from turning basin	2 x 45tBP ASD tug Tug 1: port shoulder Tug 2: port quarter	Peak Flood HW-3.5 hours	SW 30 knots	SW 0.1m 4s	To investigate whether bulk vessel can safely enter basin stern first using existing towage strategy and tug deployment.	Successful	Bulk carriers are currently operating in the Port of Hastings so towage strategy is already in place. Existing upper limit wind speed for operations is 25 knots, however higher limit used for consistency. Vessel swung east of basin. Tugs effectively control vessel, stern-first manoeuvre conducted maintaining safe clearances from infrastructure and training wall. Design allows sufficient space to conduct the manoeuvres safely. Vessel does not use area east of Buoy 33.

Exercise ID	Pilot [1]	Layout	Vessel\ Condition	Manoeuvre	Tugs [2] (initial positions)	Tide [3]	Wind	Incident waves (initial)	Scenario\ Purpose of run	Outcome	Run Commentary and Remarks
17	IS	Basin short	115k DWT Bulk Carrier Laden	Departure from basin	2 x 45tBP ASD tug Tug 1: starboard shoulder Tug 2: starboard quarter	Peak Flood HW-3.5 hours	NW 30 knots	NW 0.2m 4s	To investigate whether bulk vessel can safely exit basin stern first using existing towage strategy and tug deployment	Successful	Vessel can be safely navigated within the proposed layout using existing towage assets. Adequate space in the proposed layout to conduct the manoeuvre.
Day 5 23	IS	Basin short	400m long Containership Laden	Departure from basin (200m off Quay 3)	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Ebb HW+3 hours	N 30 knots	N 0.1m 4s	Repeat run 11.To reconsider exit options from basin and investigate the speed management during an outbound passage passing southern berths.	Unberthing: Successful Speed management: Successful Transit of the channel: Marginal Proximity to Buoy 29	Alternative strategy to that of run 11.Speed reduced exiting basin with lateral control maintained by tugs. Maintained safe clearances from port infrastructure and training wall. Sufficient space for vessel and tugs to operate in this mode. Speed controlled passing berths with tug assistance When entering the channel the vessel passed 33m off Buoy 29 as a drift angle was established to conduct the transit of the channel. Set up of vessel for exit must be very precise to achieve safe exit, channel width leaves no margin for error.
24	IS	Stage 1 South	250m long Products Tanker Ballast	Arrival from North Buoy 27	2 x 45tBP ASD tug Tug 1: starboard shoulder Tug 2: starboard quarter	Ebb HW+1 hour	NW 25 knots	NW 0.1m 4s	To establish existing operations remain unaffected by proposed works close N of existing Long Island Point jetty.	Successful	Vessel approaches and is safely berthed in line with existing procedures. Presence of new construction does not affect outcome.
25	IS	Stage 1 South	250m long Products Tanker Laden	Departure from berth at Long Island Point	2 x 45tBP ASD tug Tug 1: starboard shoulder Tug 2: starboard quarter	Flood HW-1 hour	SW 25 knots	SW 0.1m 4s	To establish existing operations can continue with the proposed works close N of existing Long Island Point jetty.	Successful	Vessel departs berth is swung and able to depart in line with existing procedures. Presence of new construction does not affect outcome. Buoy 32 assumed to not be in place for this run.
26	IS	Along the shore	400m long Containership Laden	Departure from northern berths	3 x 80tBP ASD tug Tug 1: forward centre-lead Tug 2: port quarter Tug 3: stern centre-lead	Peak Ebb HW+2 hours	NW 30 knots	NW 0.1m 4s	To investigate towage requirement in upper limiting conditions. To investigate width adjacent to berths in the alongshore layout	Fail Vessel fails to remain in dredged area adjacent to Buoy 37	Tugs deployed to prevent lateral drift. Unable to hold vessel in combination of wind and off setting current (*current direction considered unusual as it does not align with solid quay face*). Vessel fails to clear Buoy 37. When clear of Buoy 37 vessel able to navigate dredged area and exit into channel at Buoy 32. Speed control requires tug aft. At Buoy 32 the vessel's ground speed was 7.4 knots with a drift angle of 10°.

Notes:

All runs were conducted using the 'March 2015' configuration, with day time and good visibility conditions.

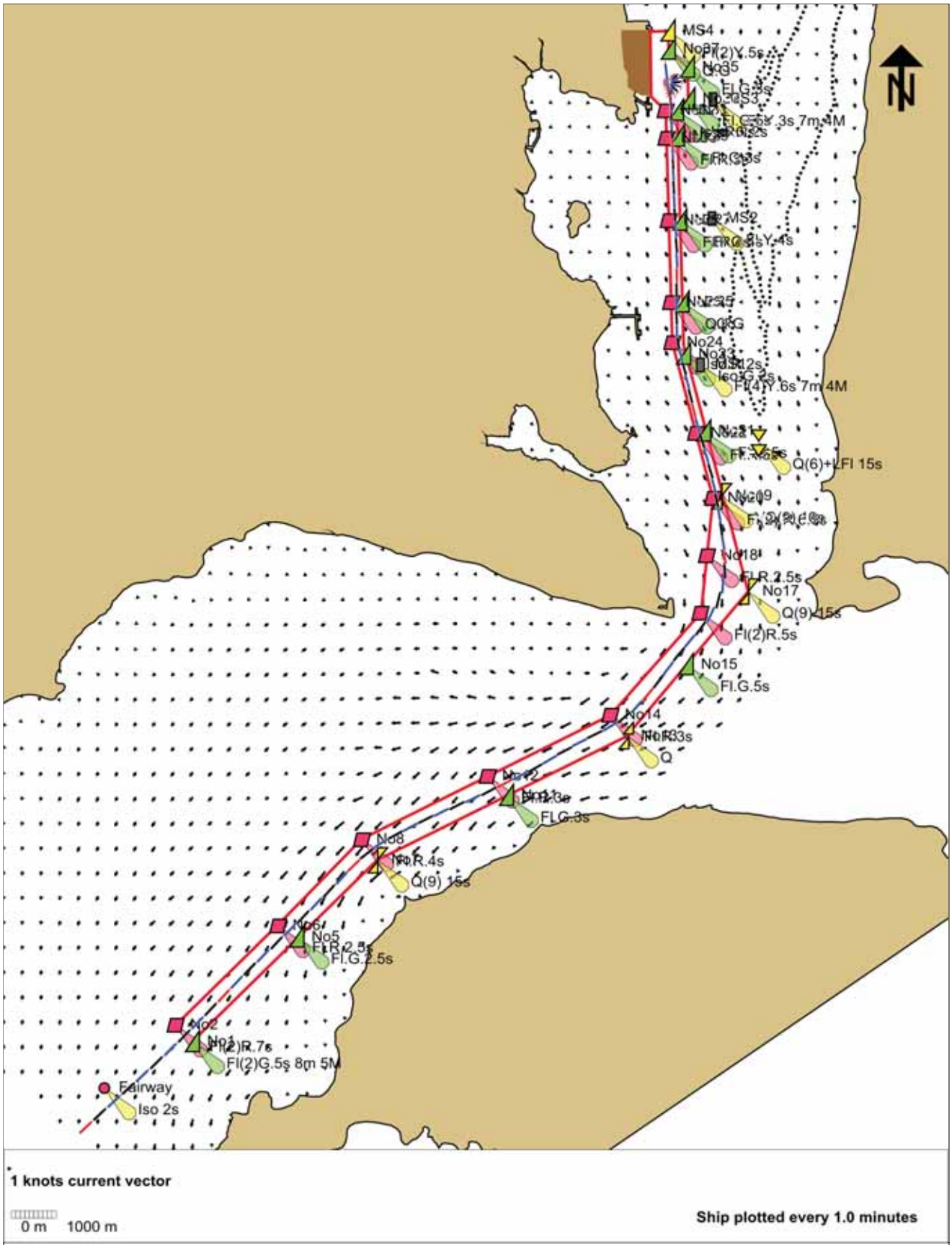
[1] Pilot: IS - Capt Ian Simpson (HR Wallingford).

[2] Tugs: All exercises using 400m long containership were conducted using centrally-controlled 80tBP ASD tugs.

All exercises using 115,000 DWT bulk carrier and 250m long products tanker were conducted using centrally-controlled 45tBP ASD tugs.

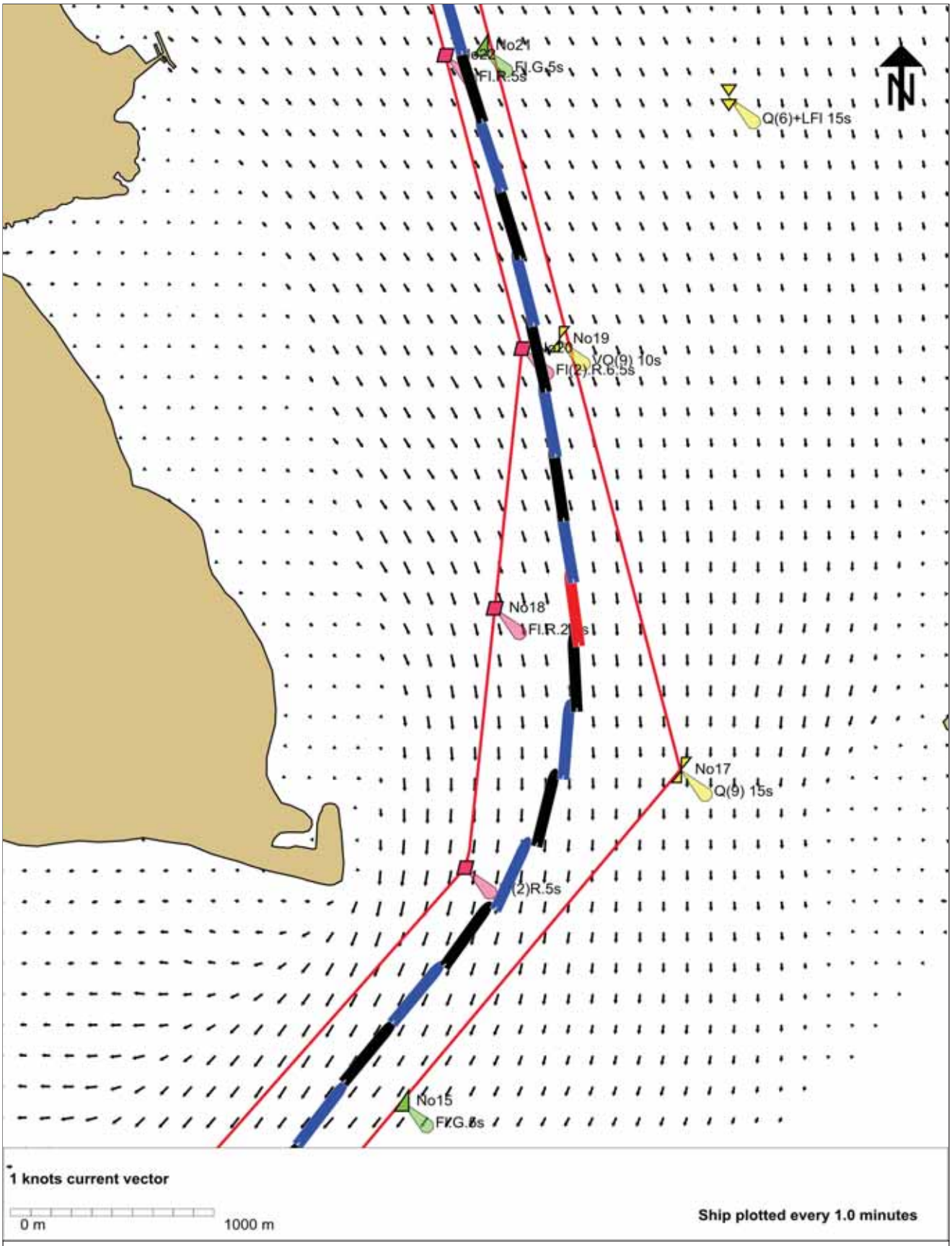
[3] Tide: The exercises were conducted with a tidal range of 2.5m.

C. Simulation run track and data plots



March 2015

Run: 01	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 15 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



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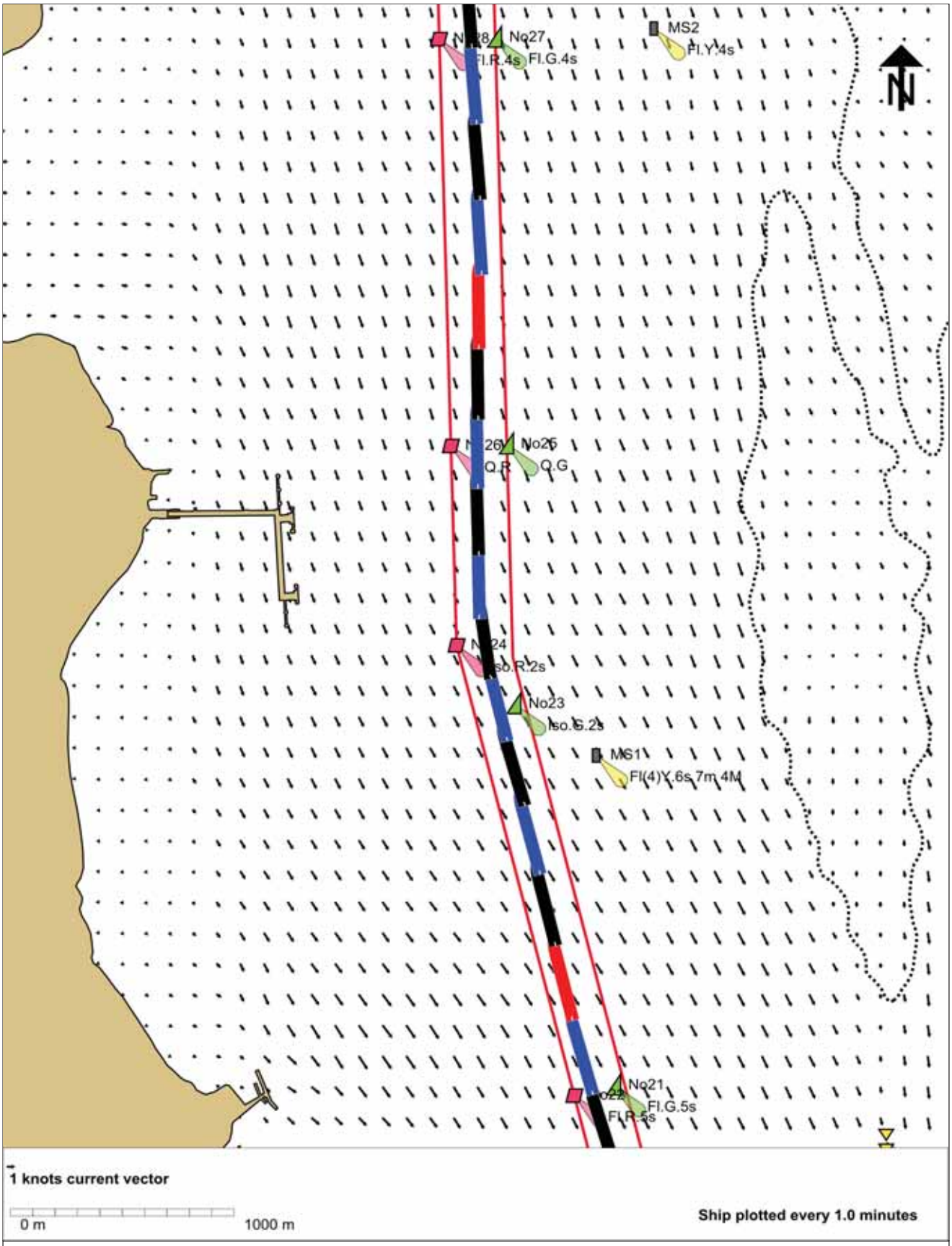

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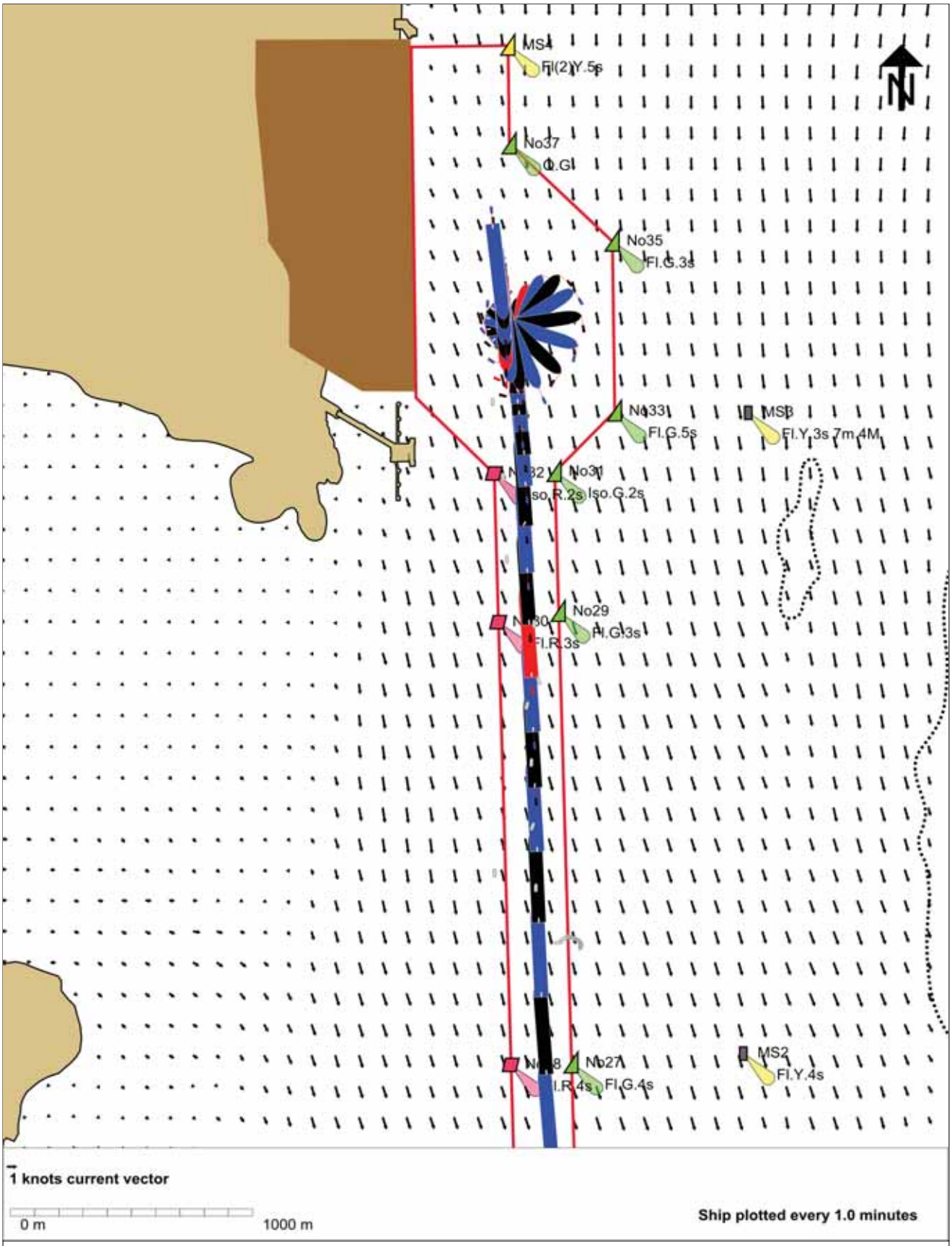

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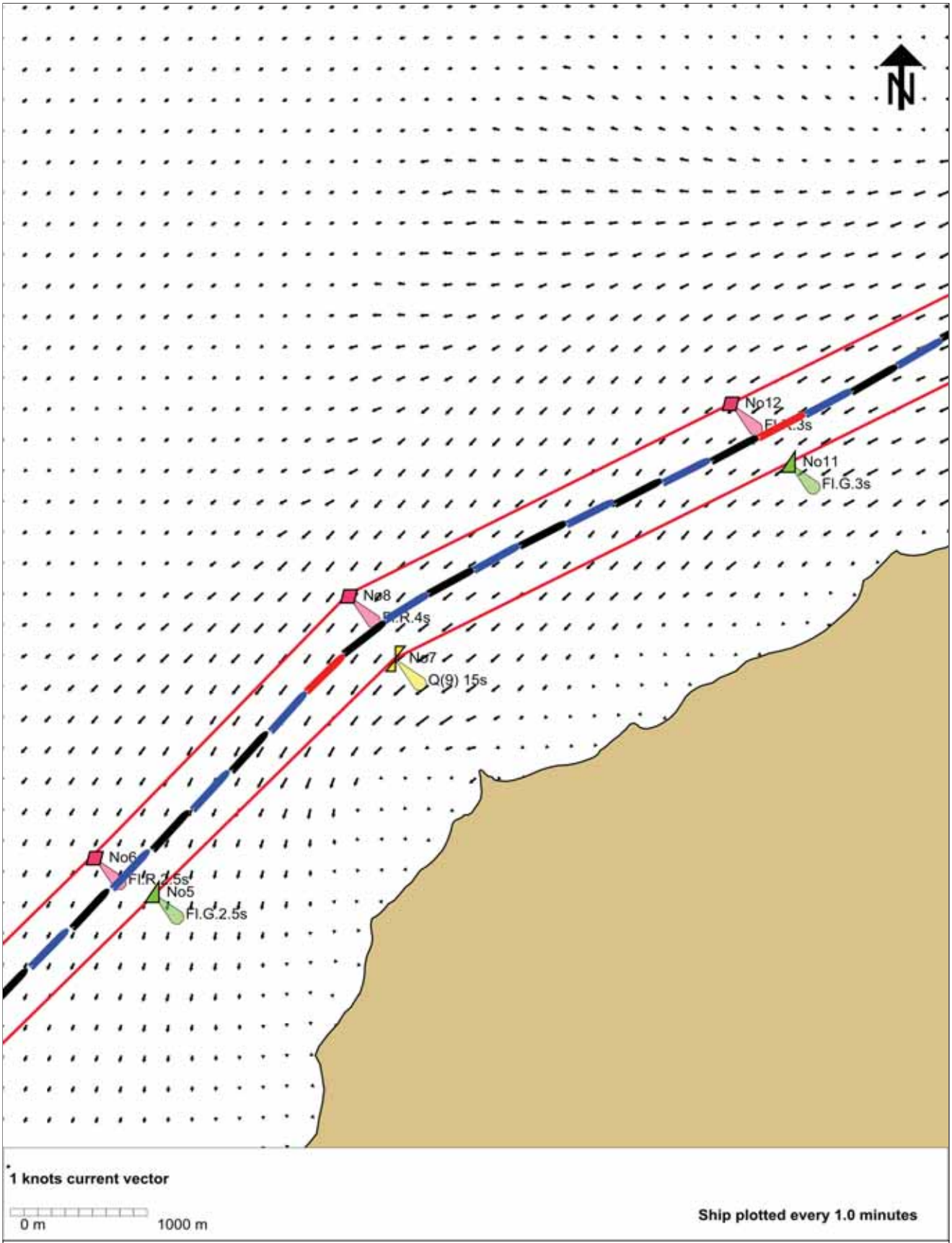

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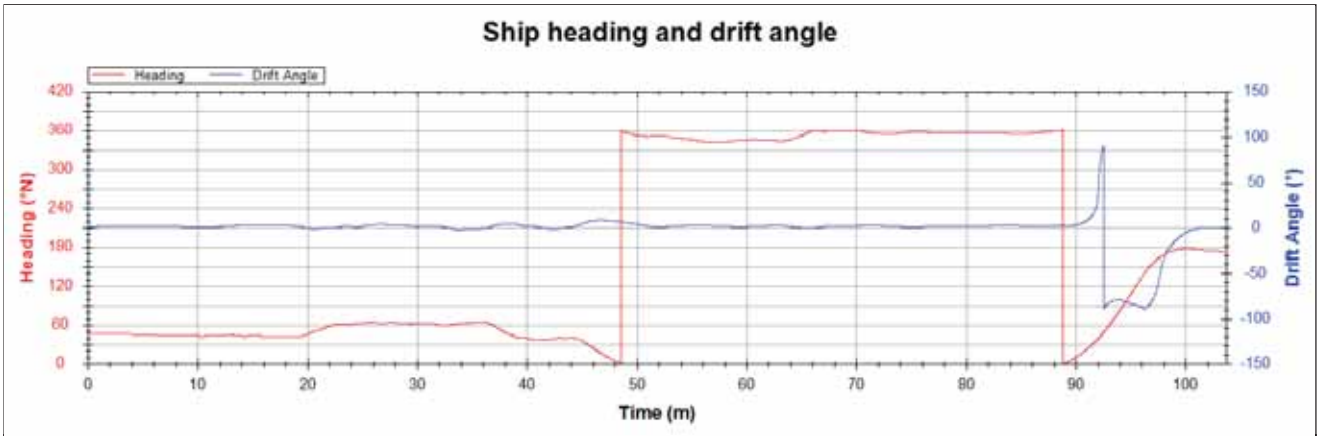

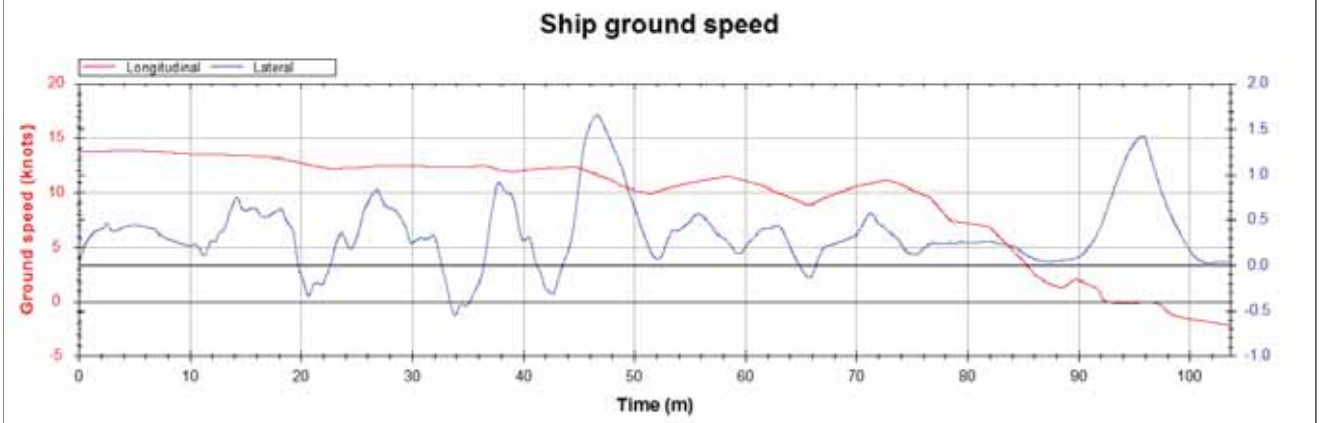

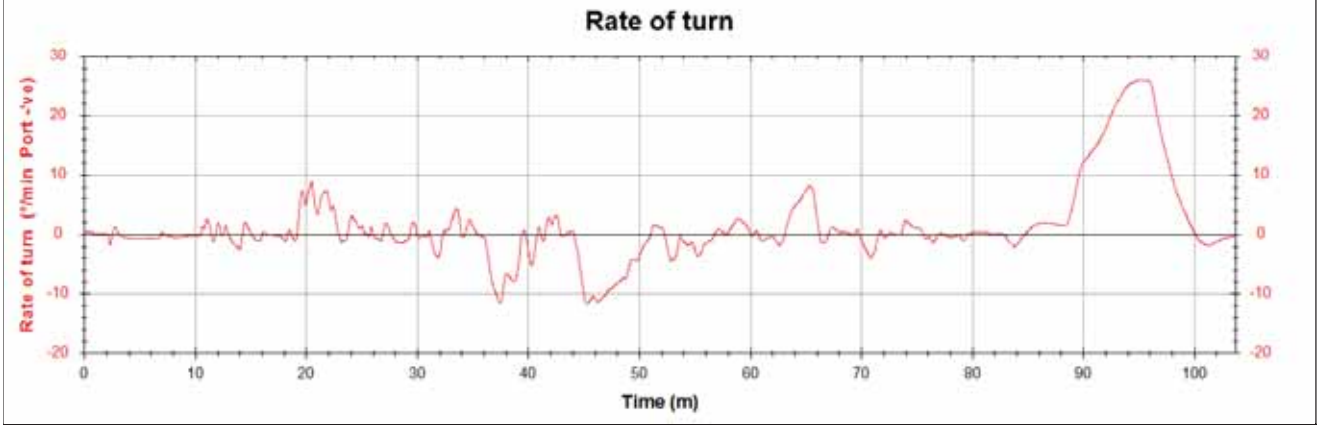

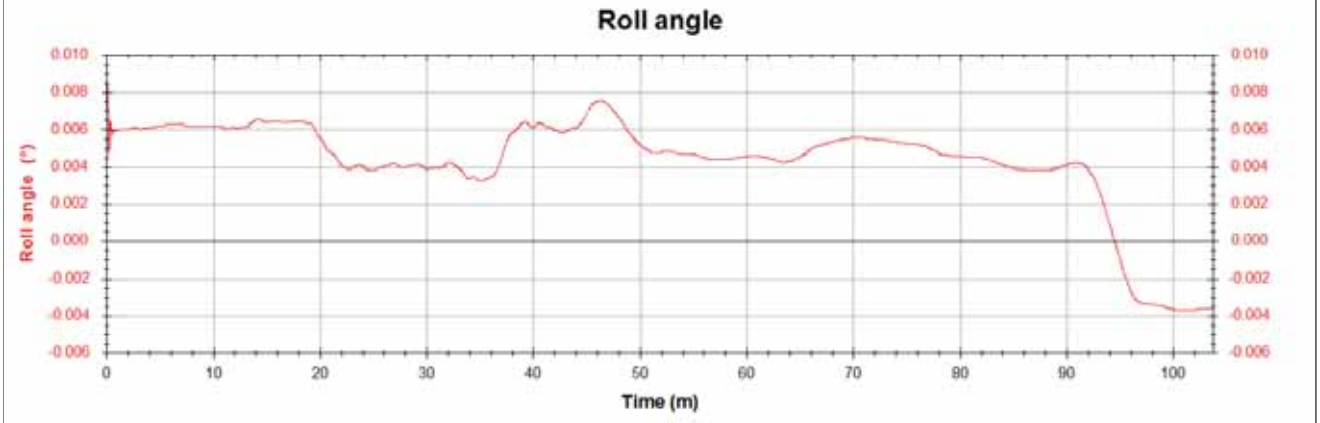

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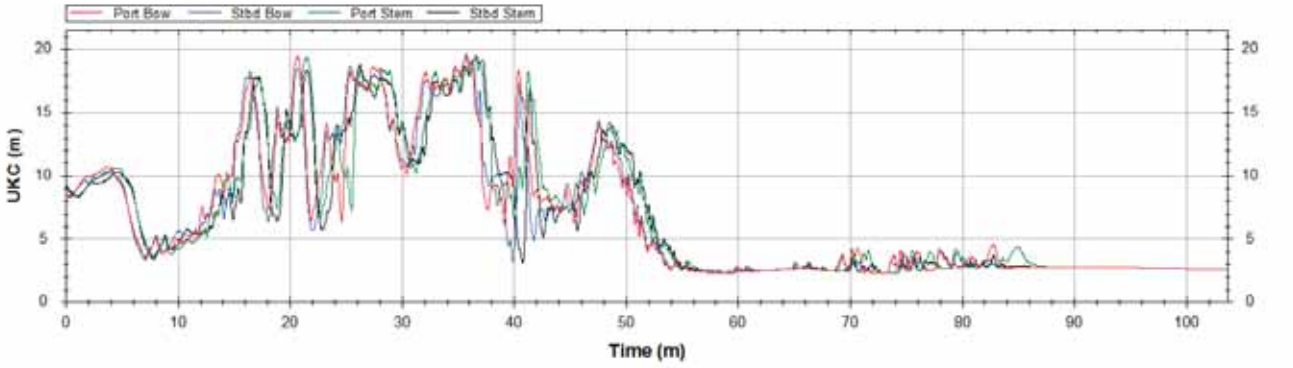

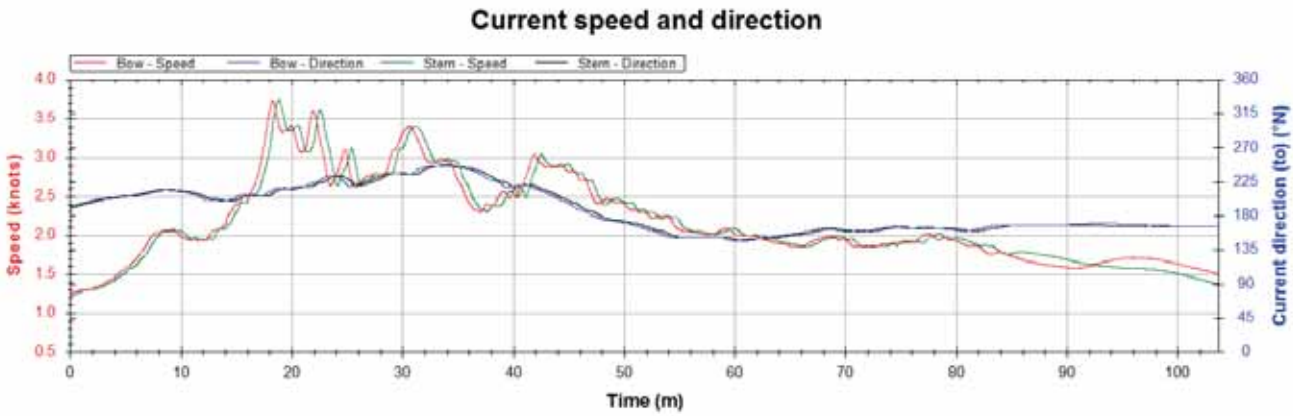

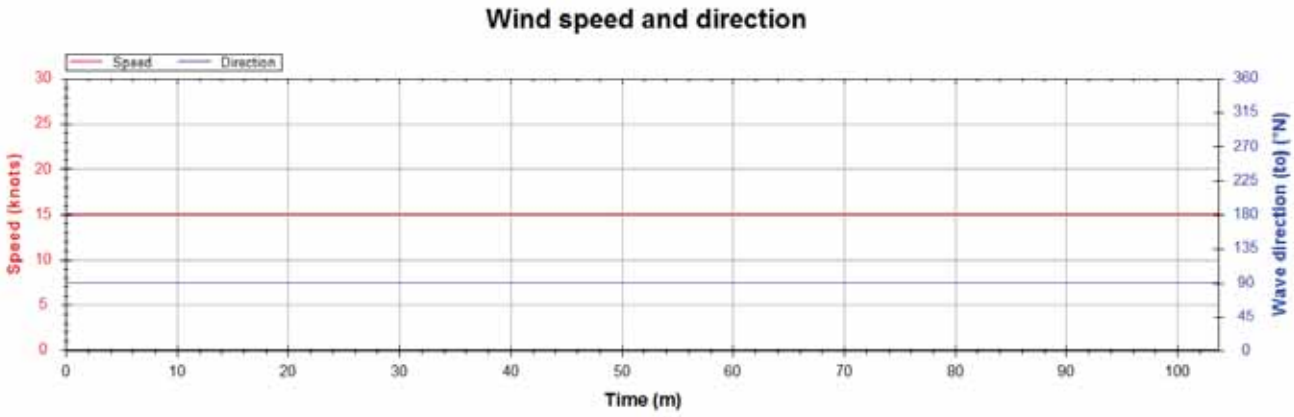

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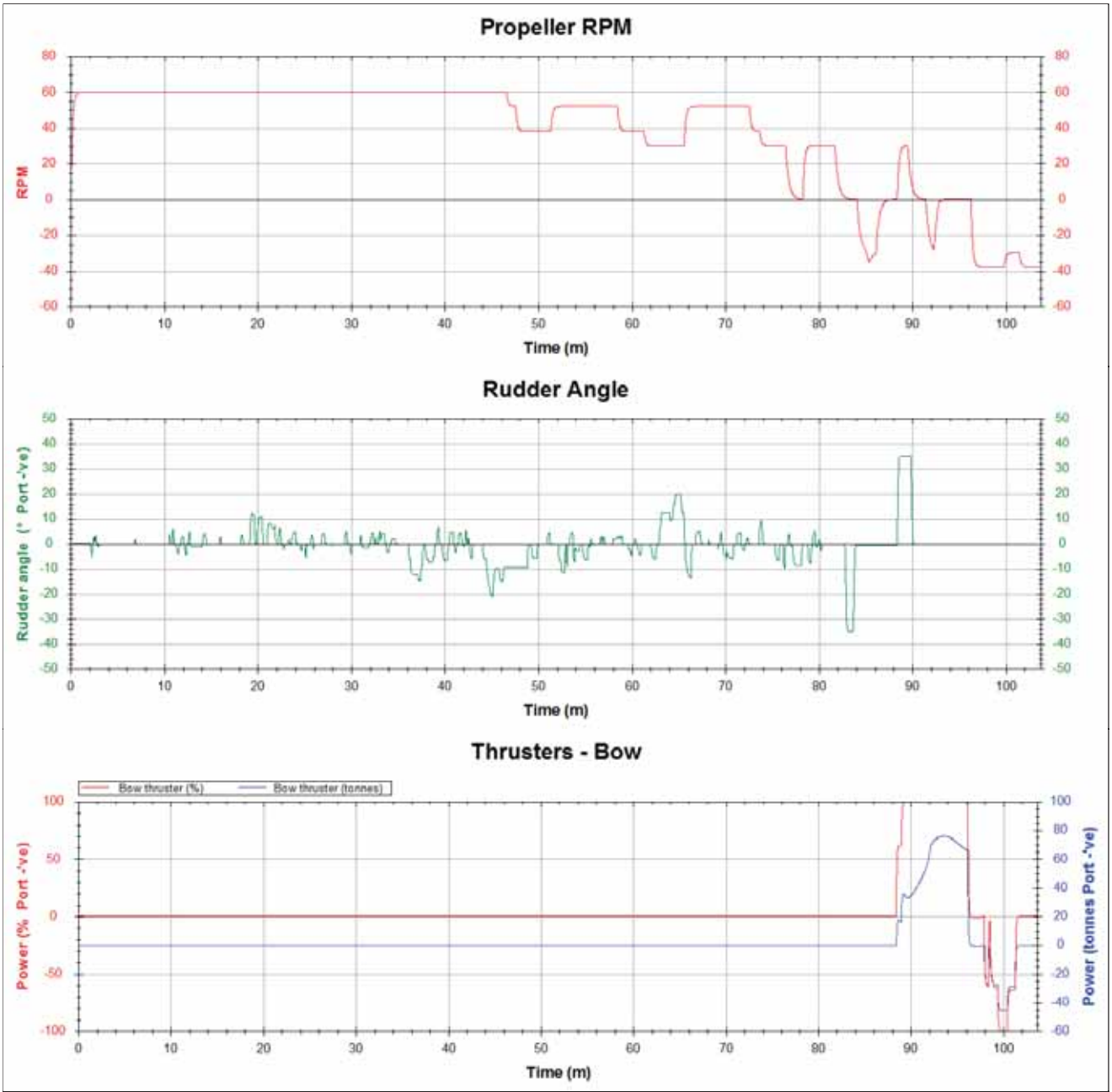

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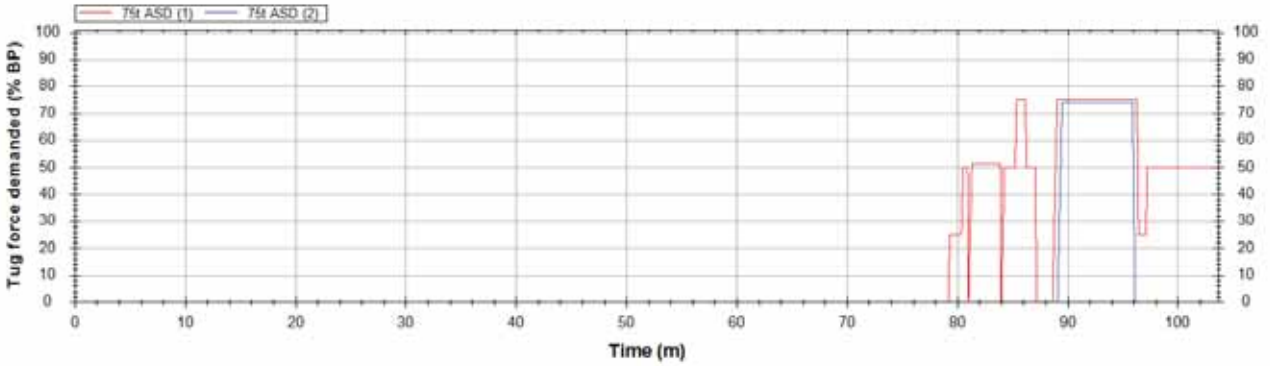
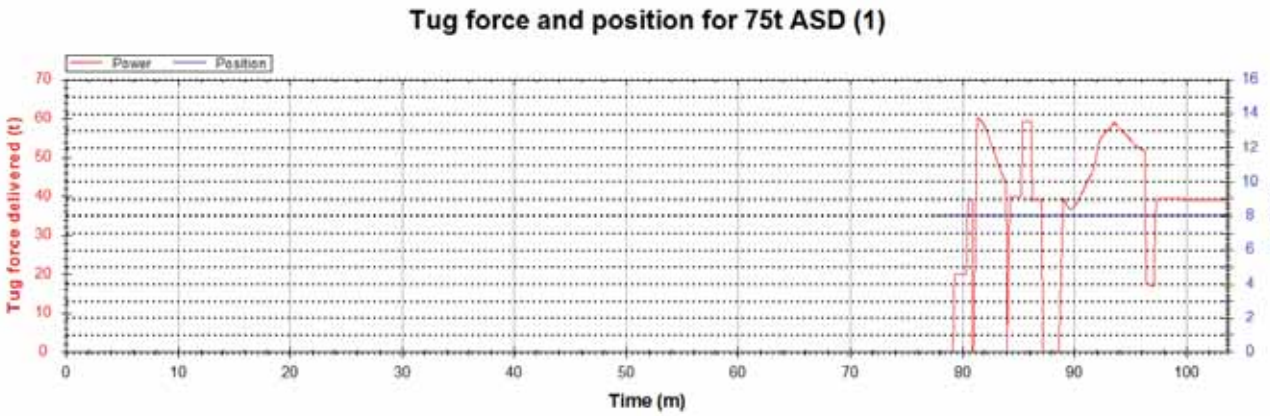
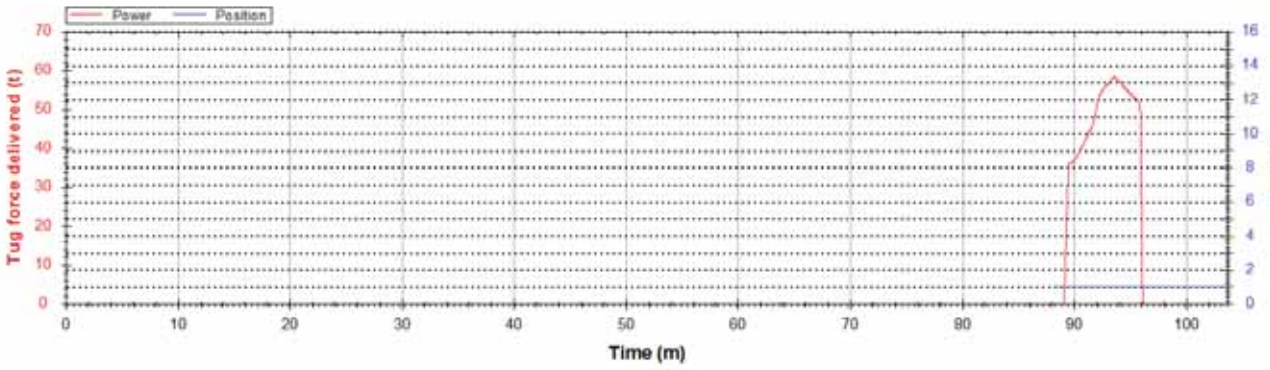
Run: 01	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 15 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

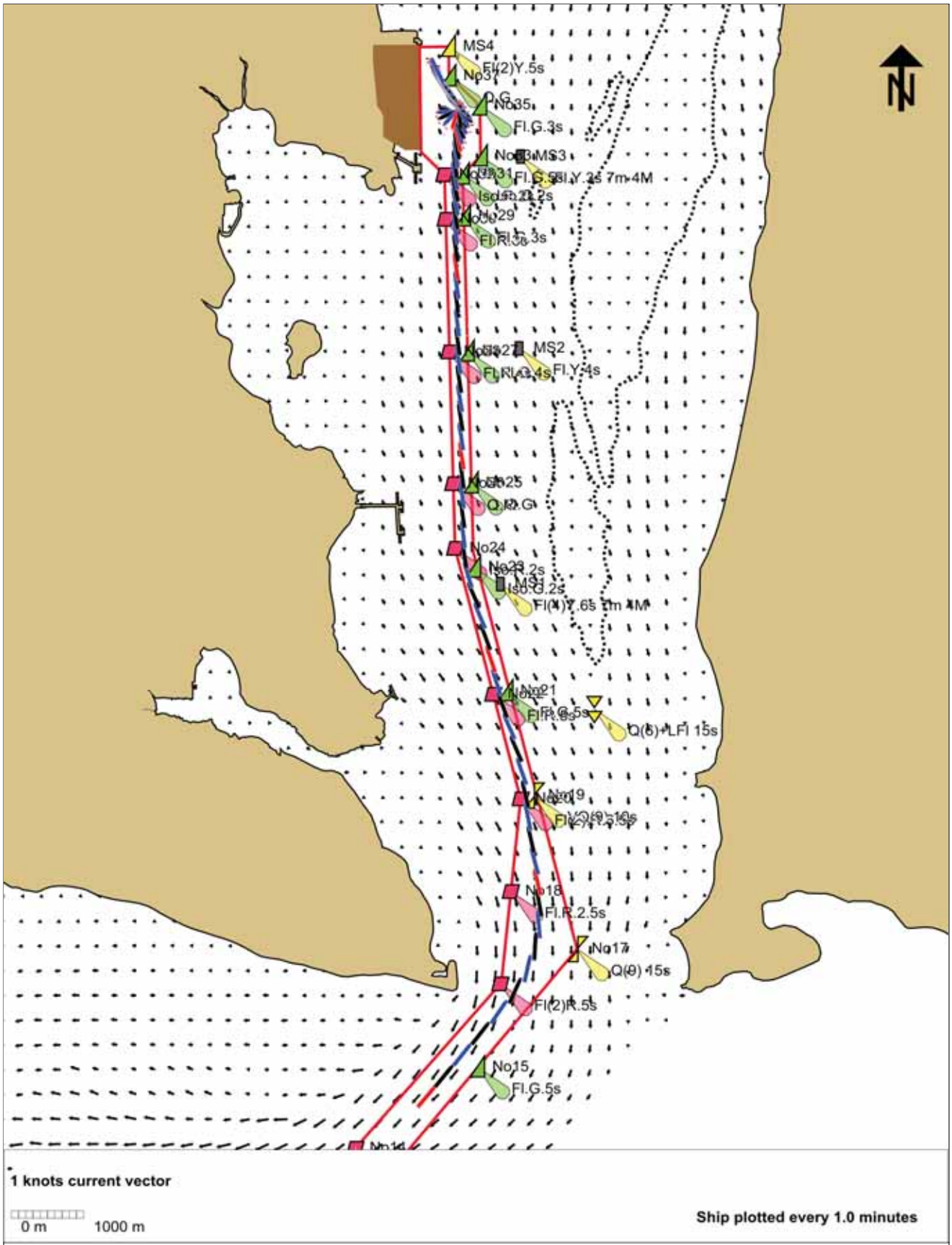






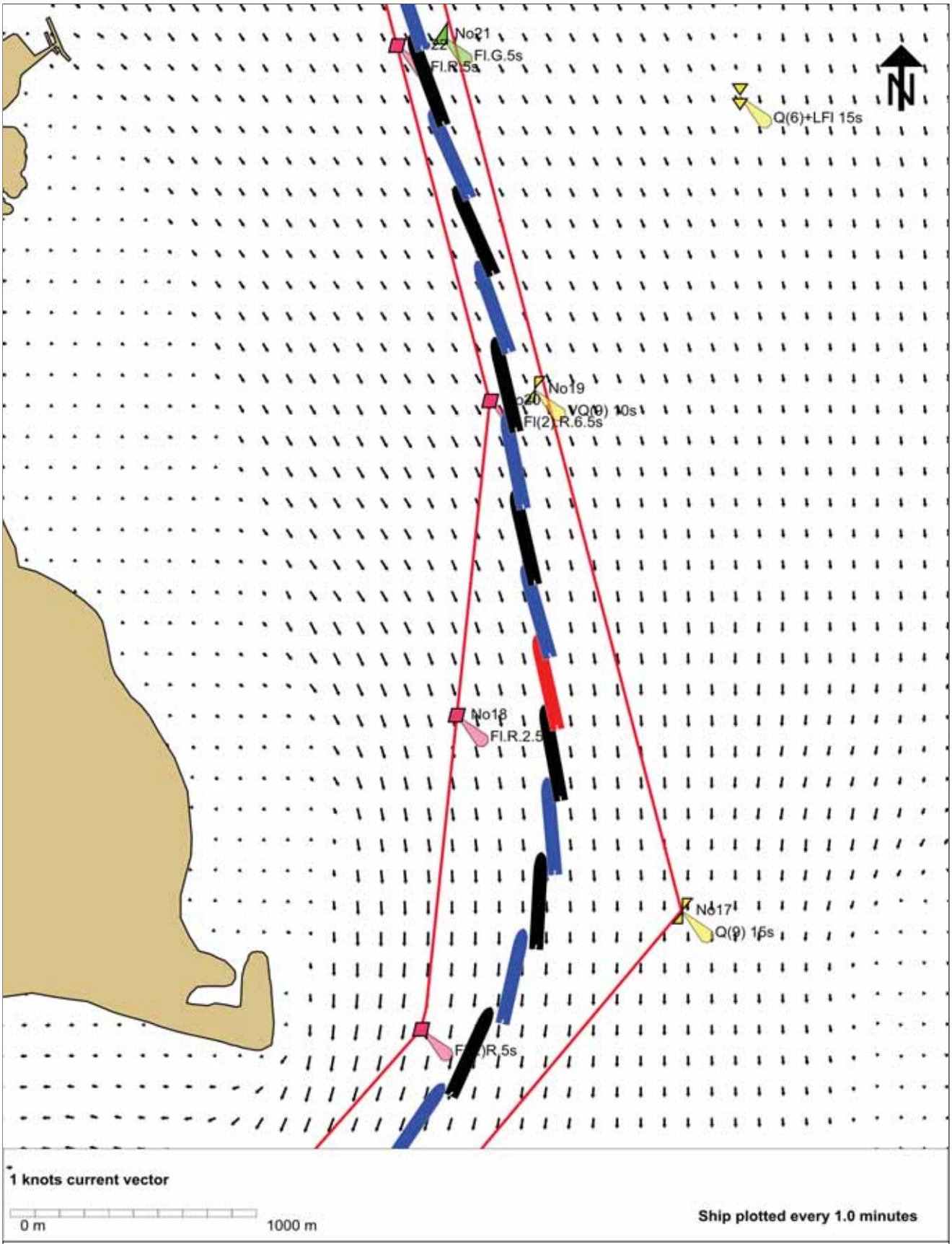
March 2015

Run: 01	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 15 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



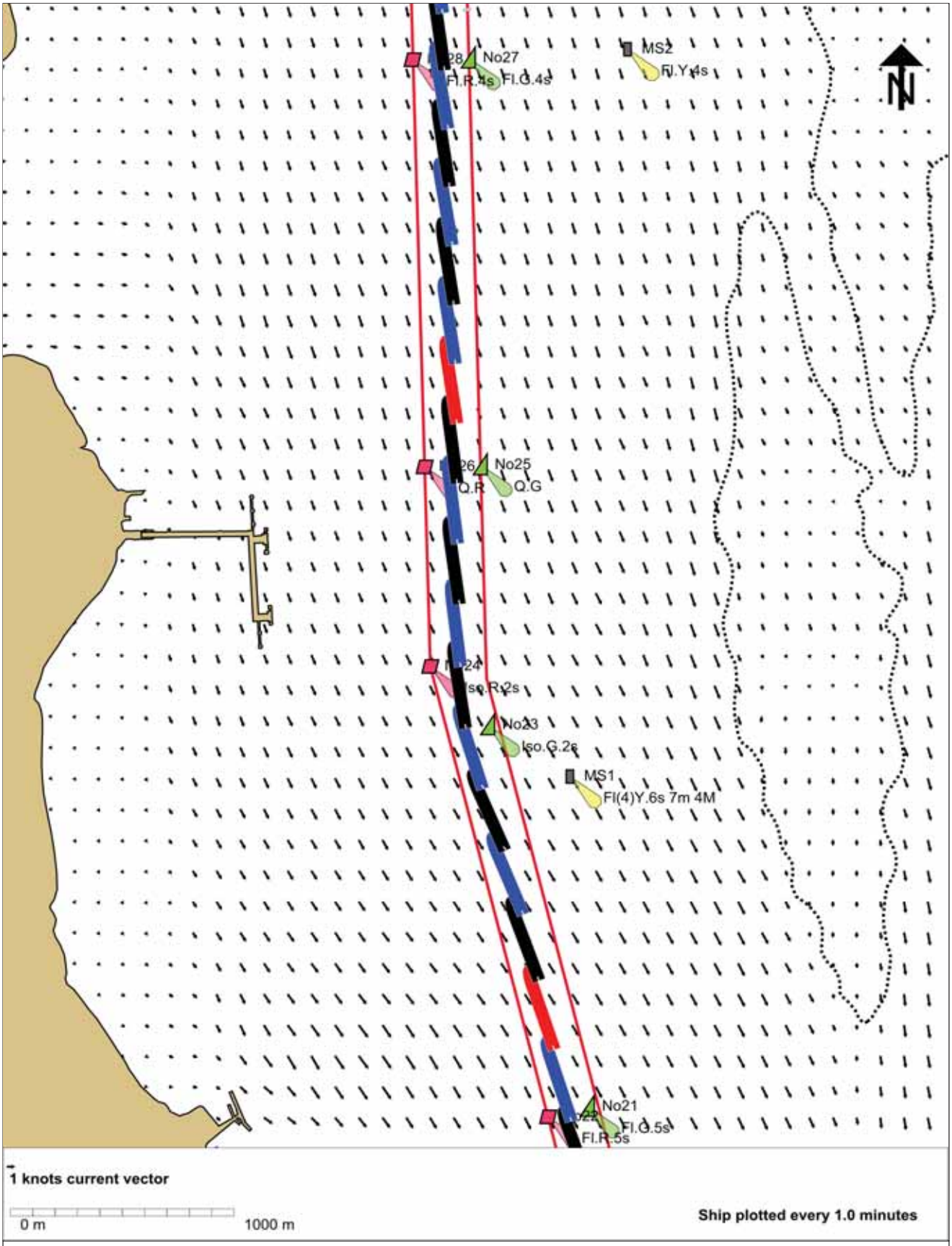
March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



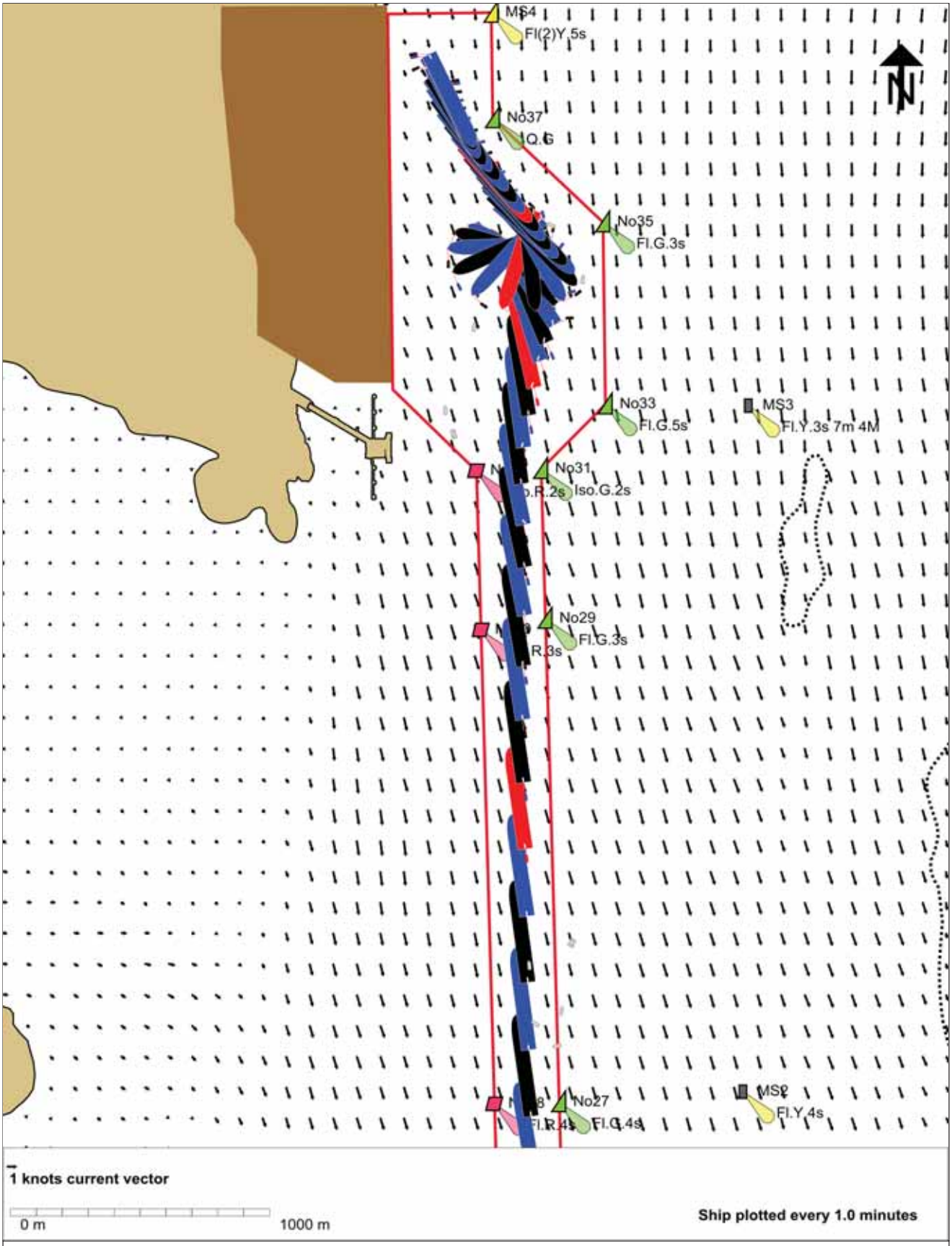
March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



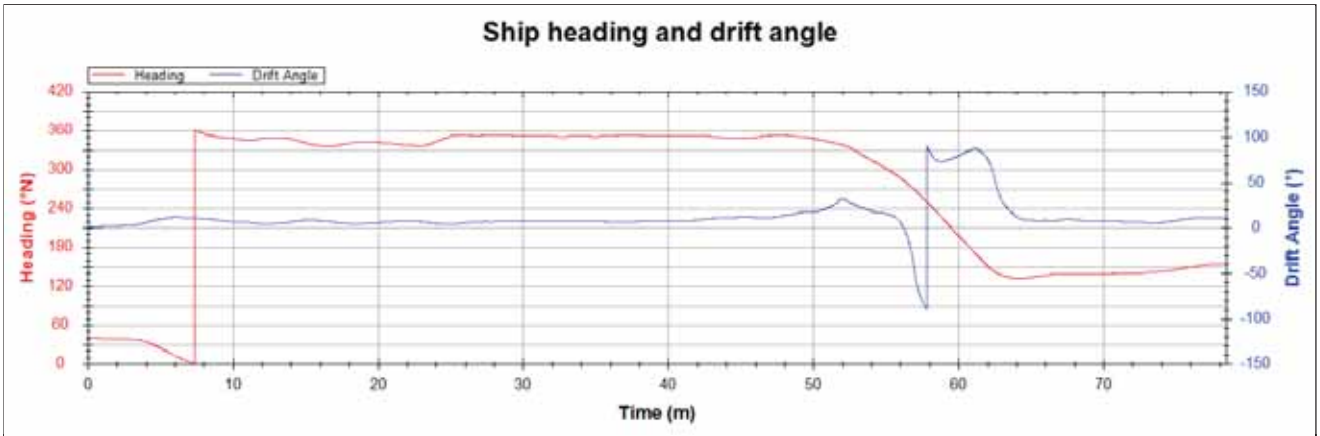
March 2015

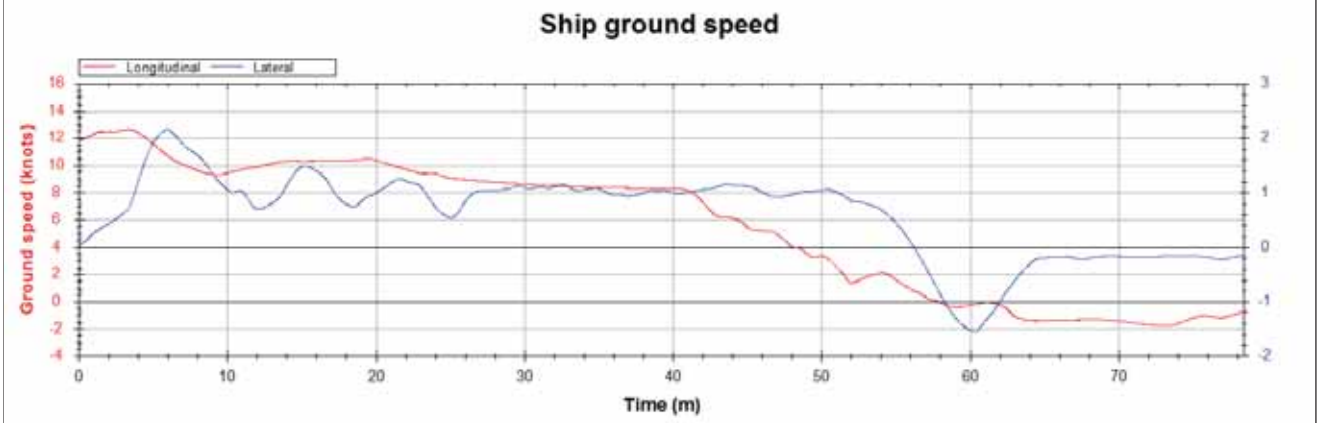
Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

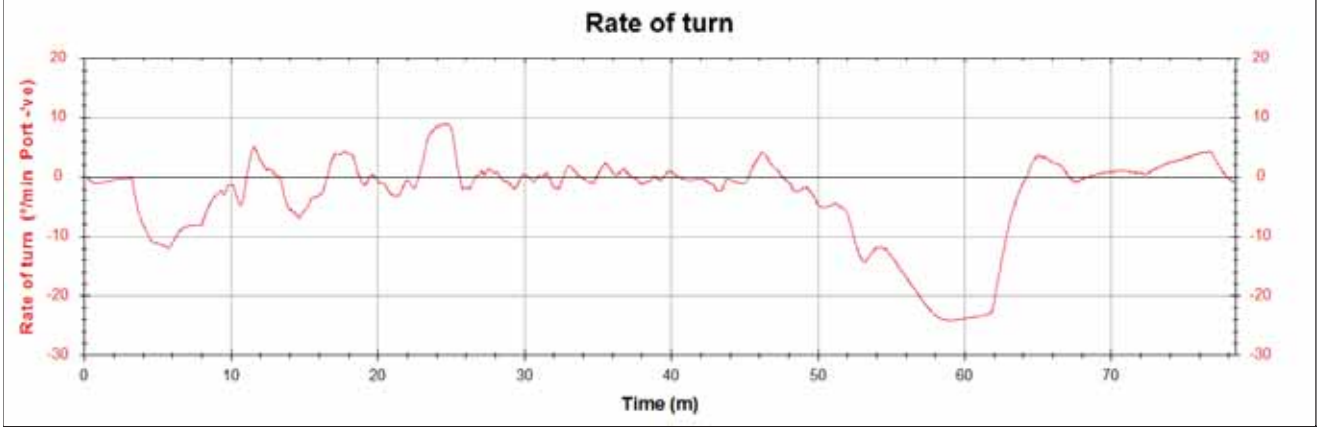


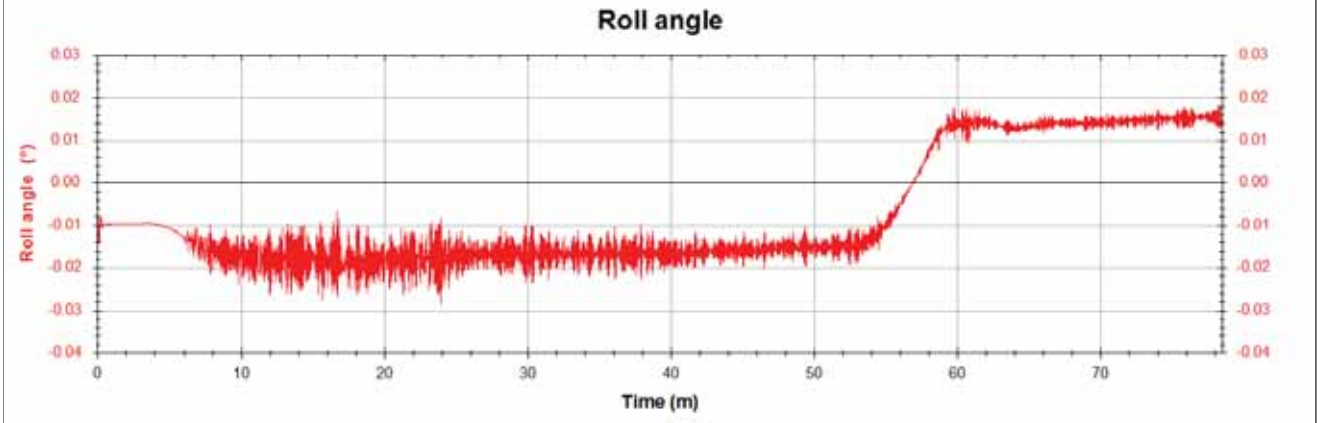
March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



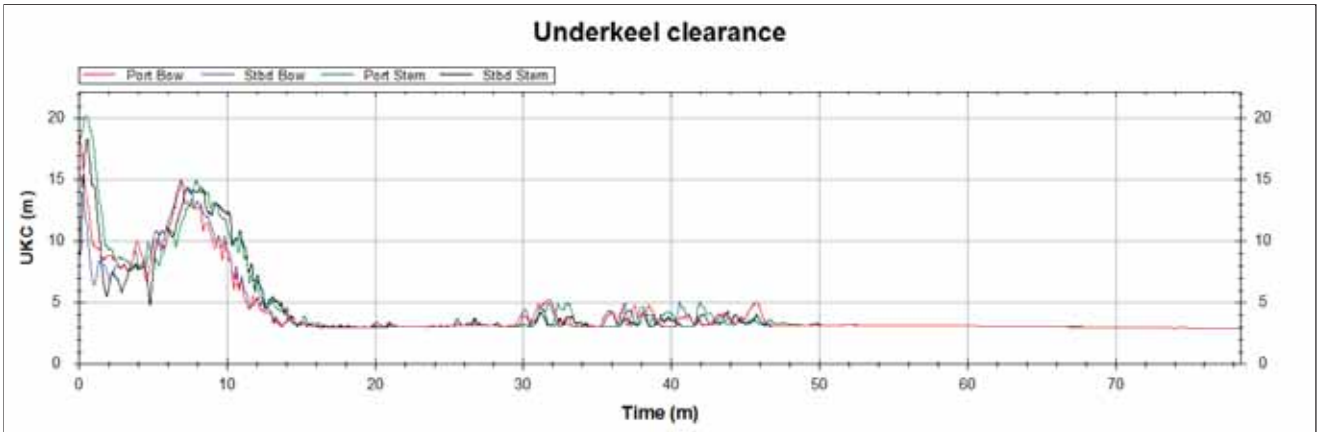


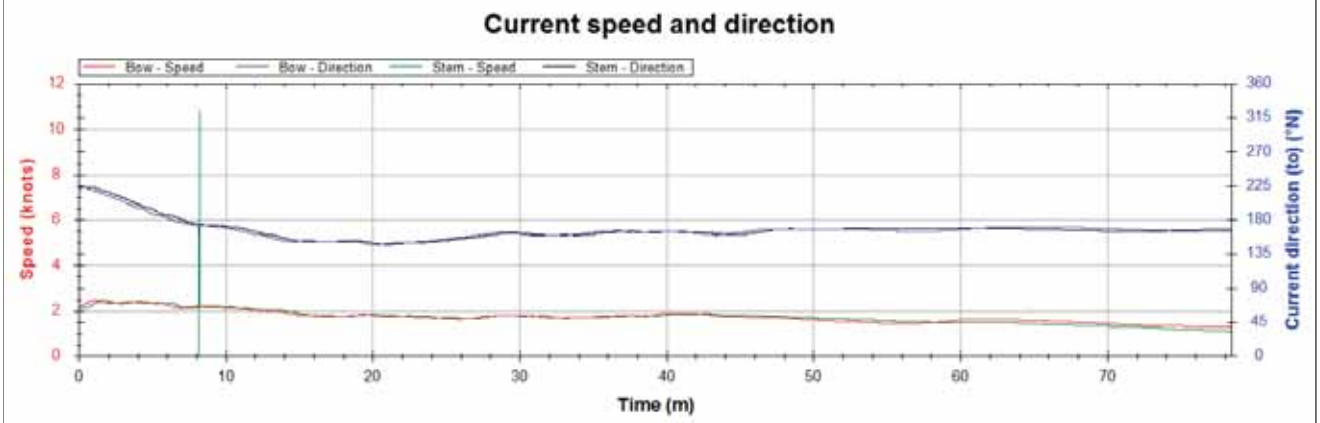


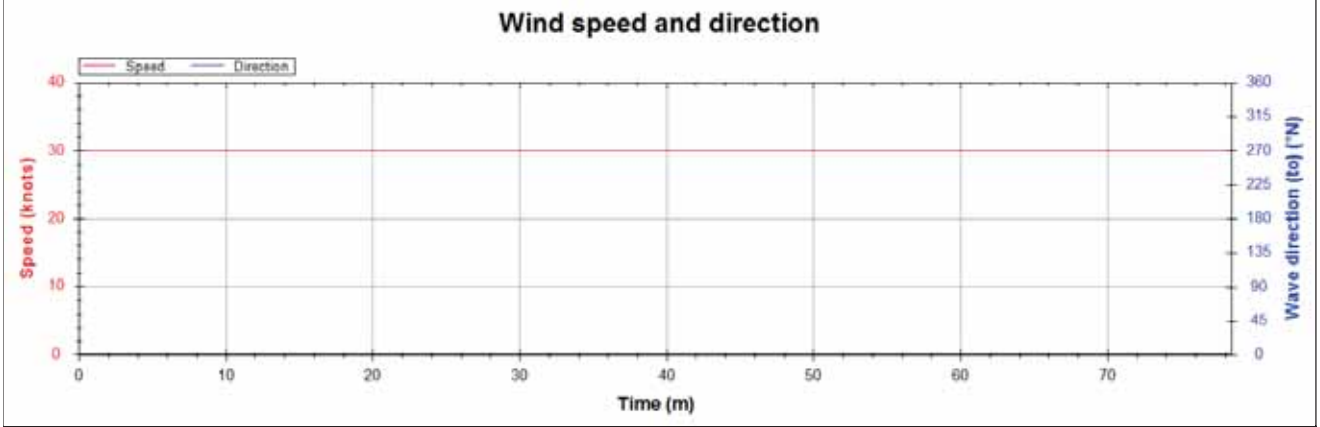


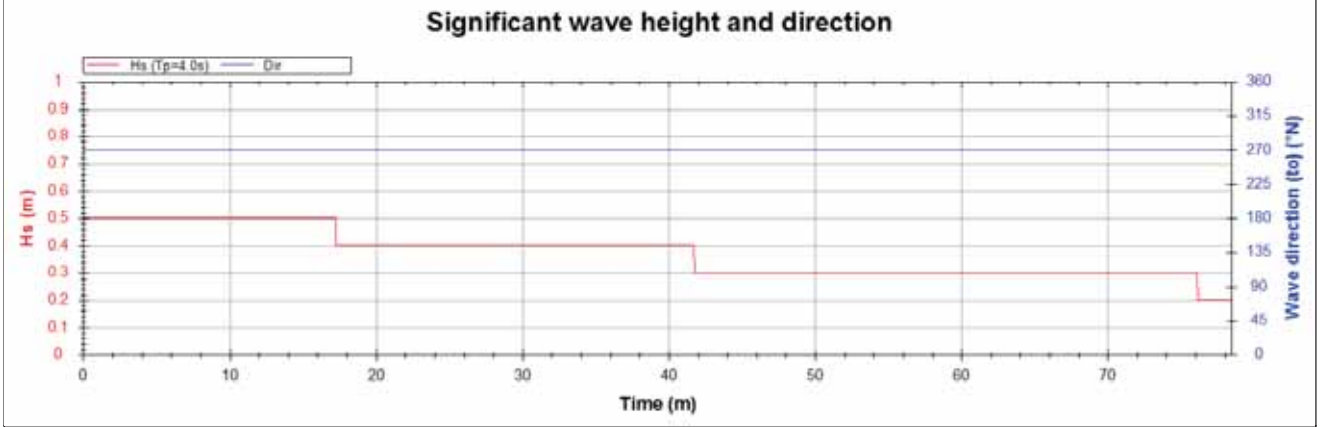
March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



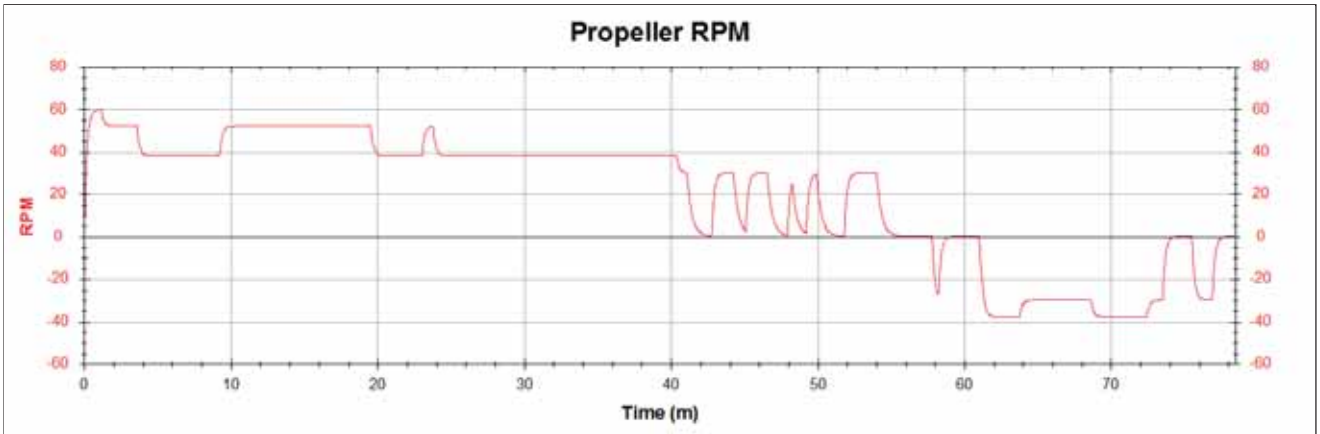


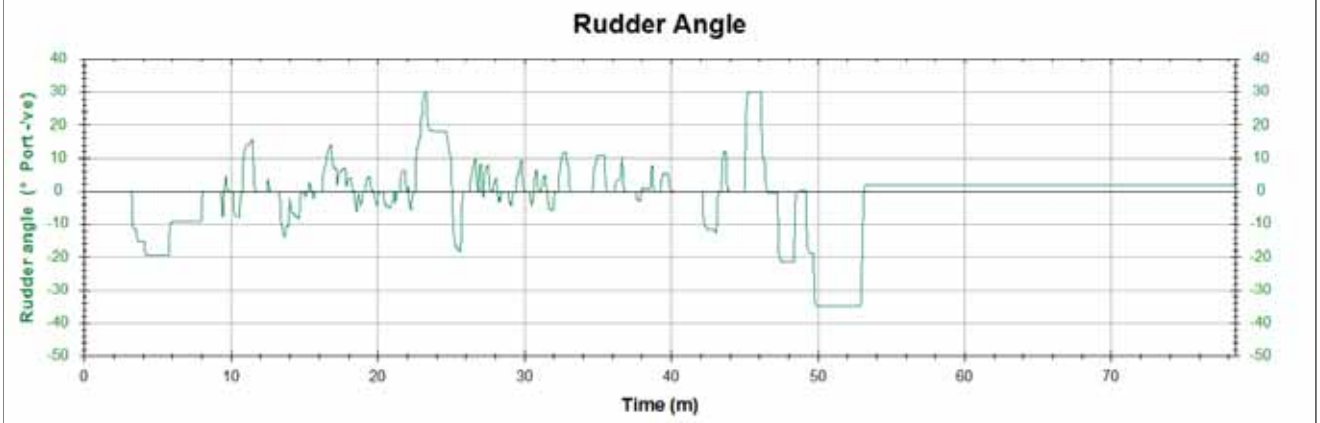


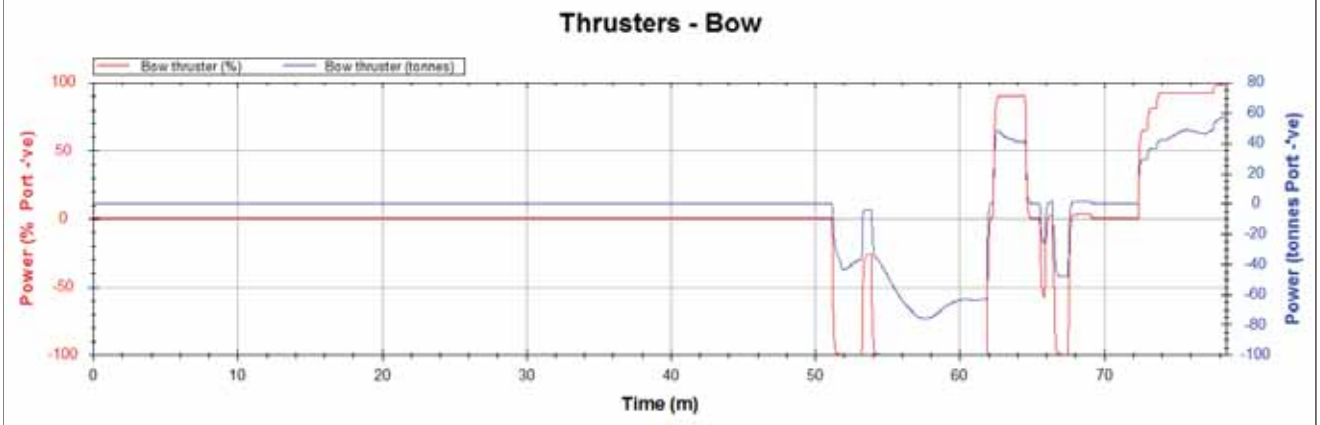


March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

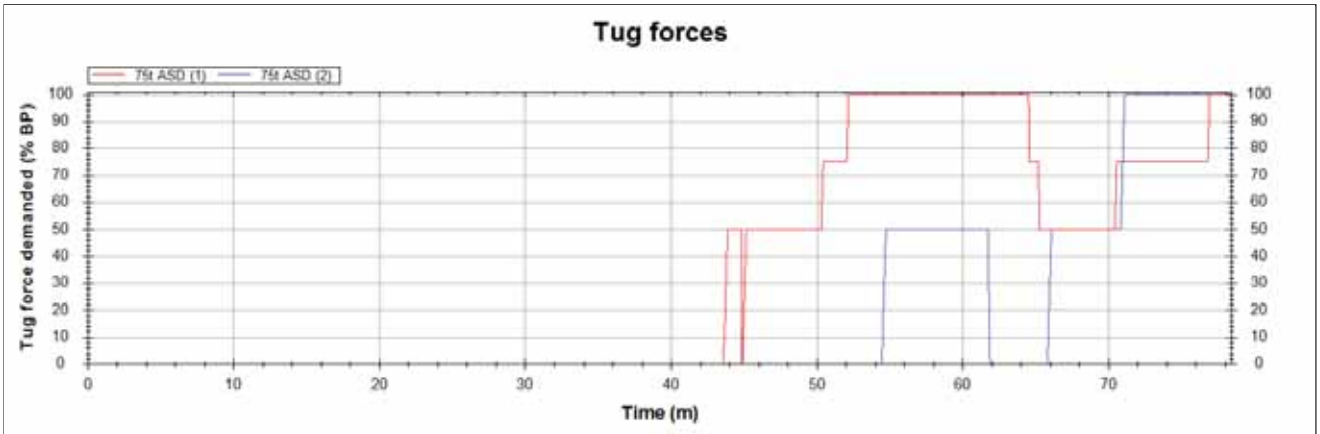


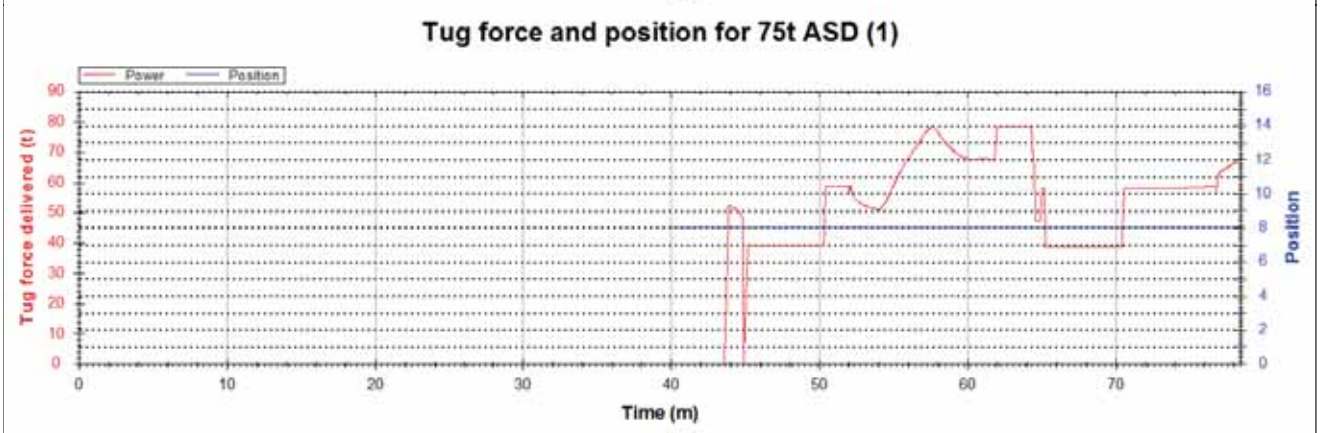


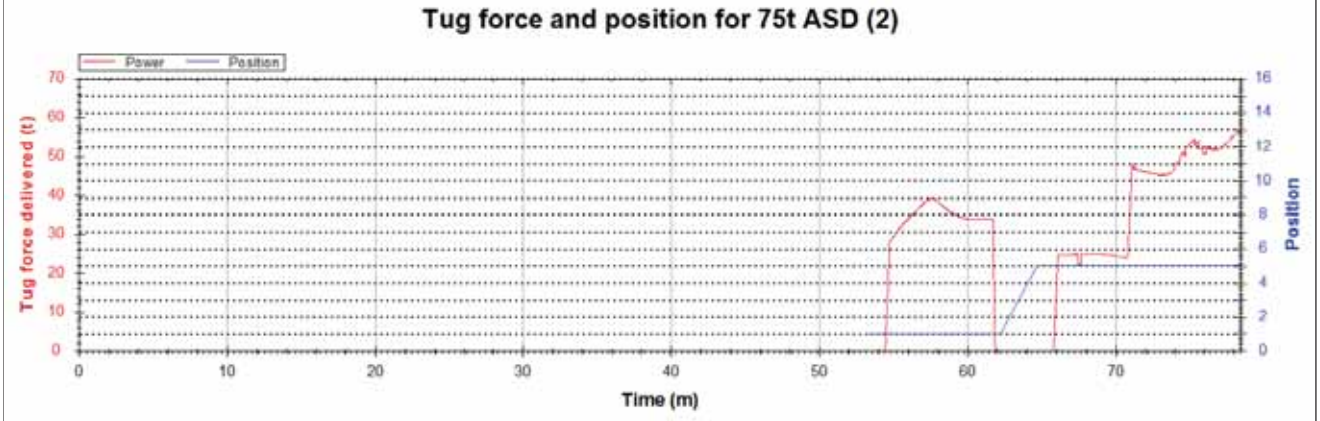


March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

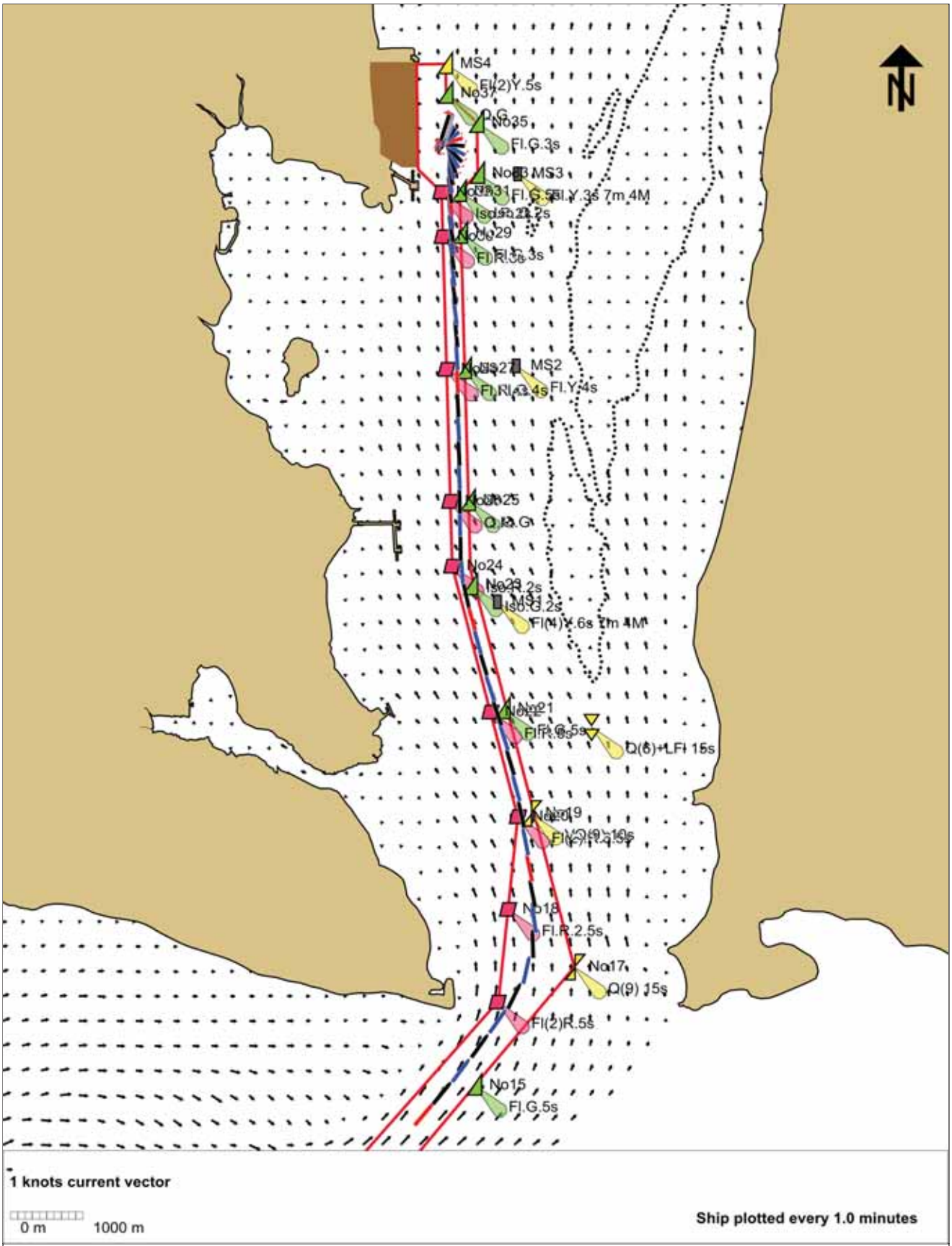






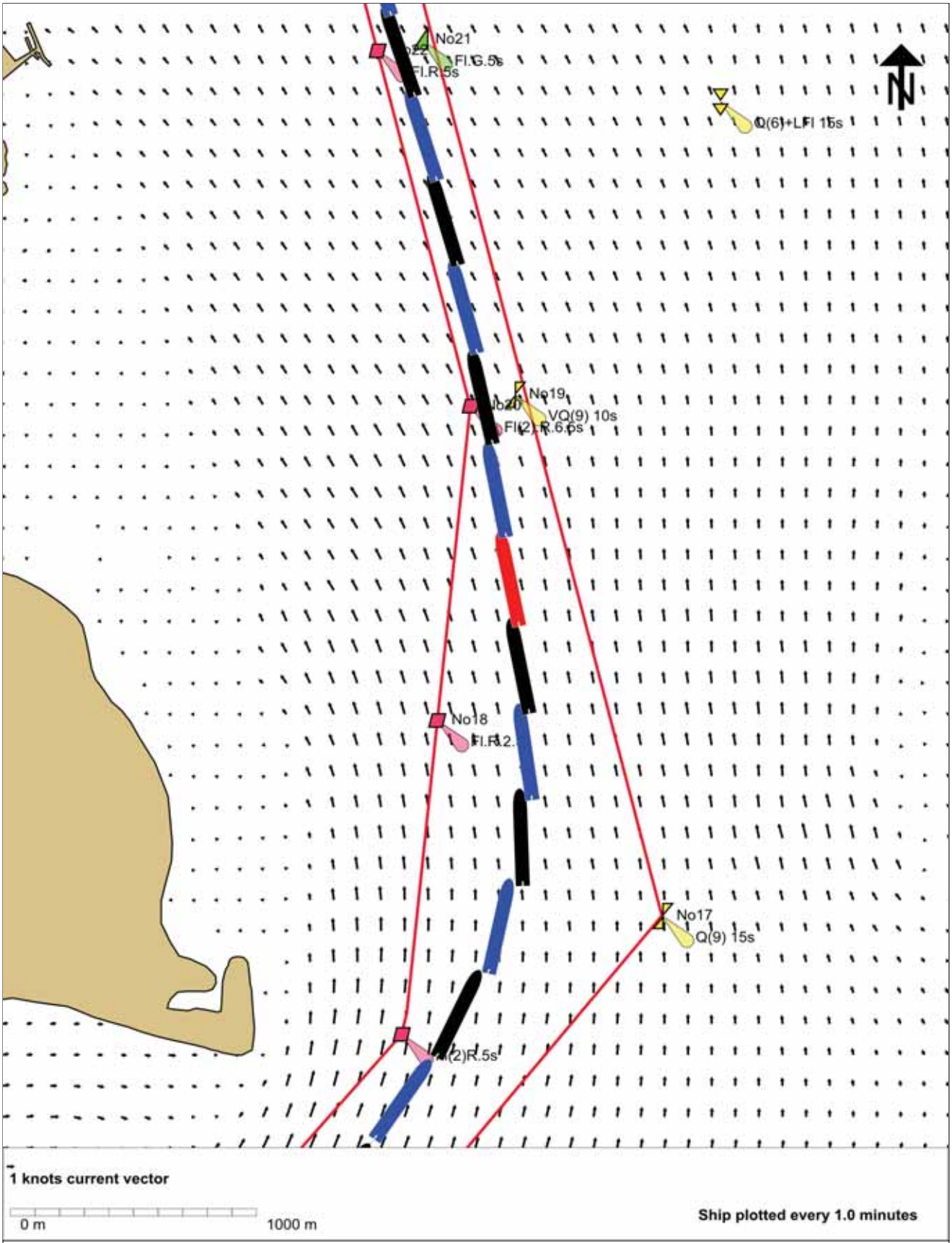
March 2015

Run: 02	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



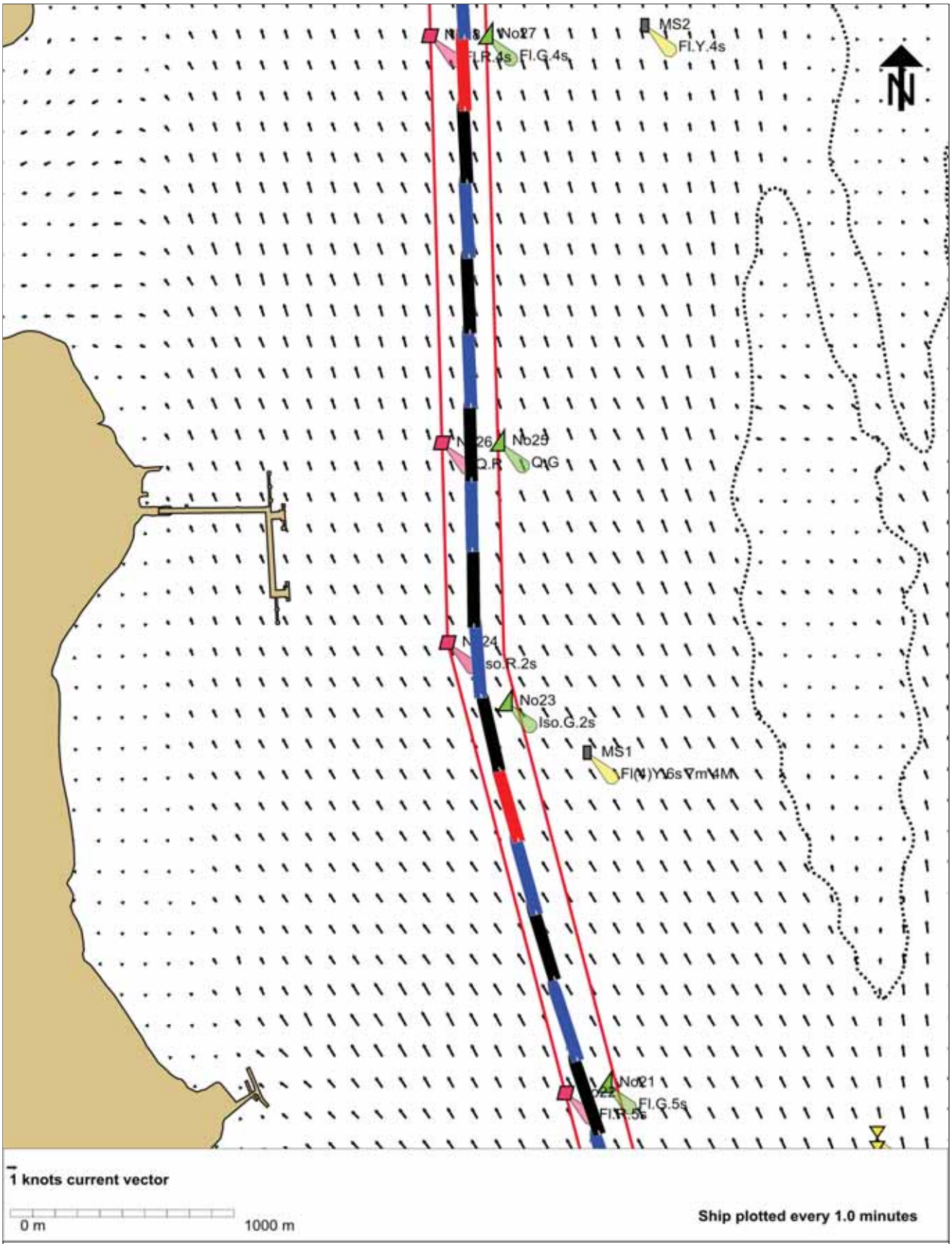
March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



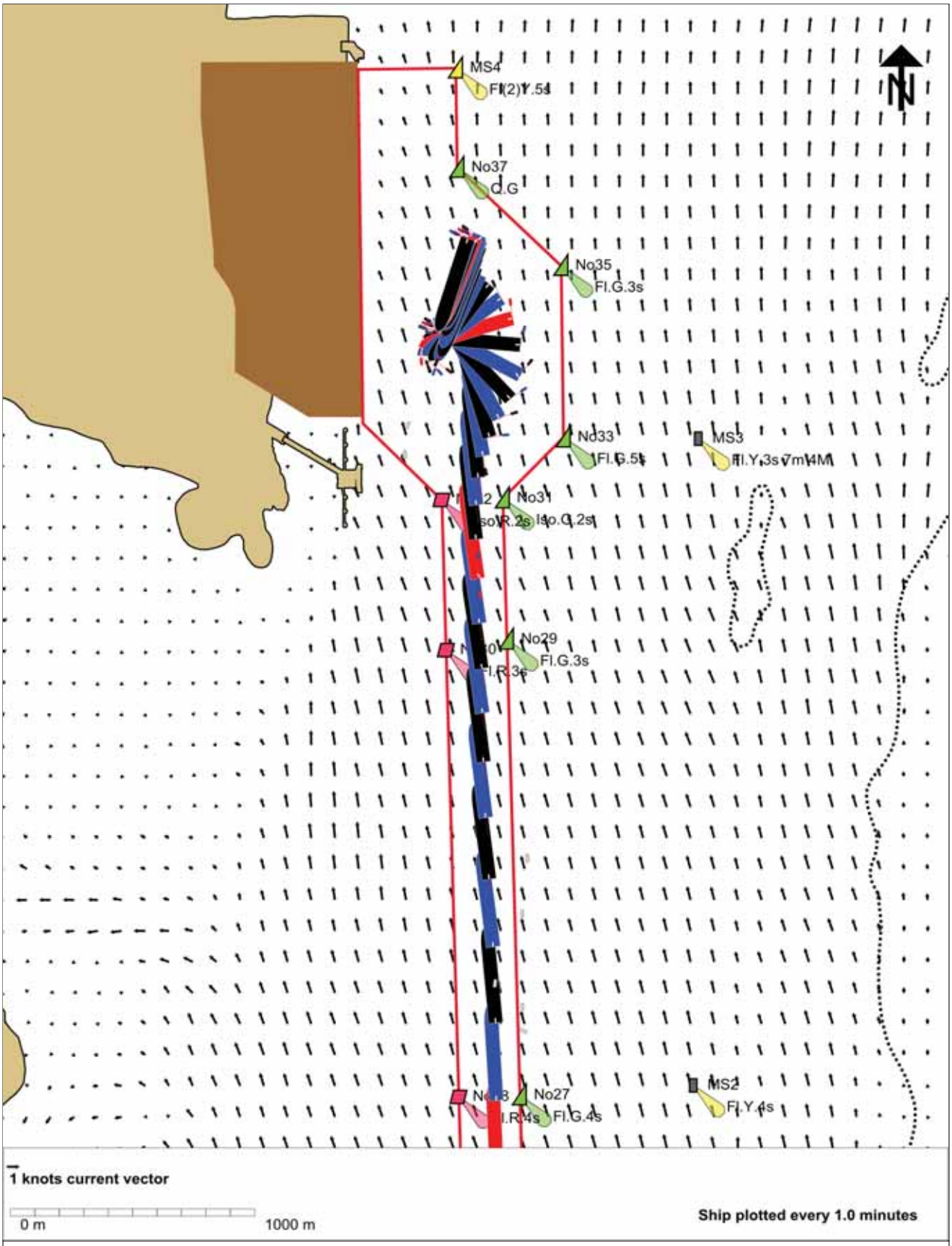
March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



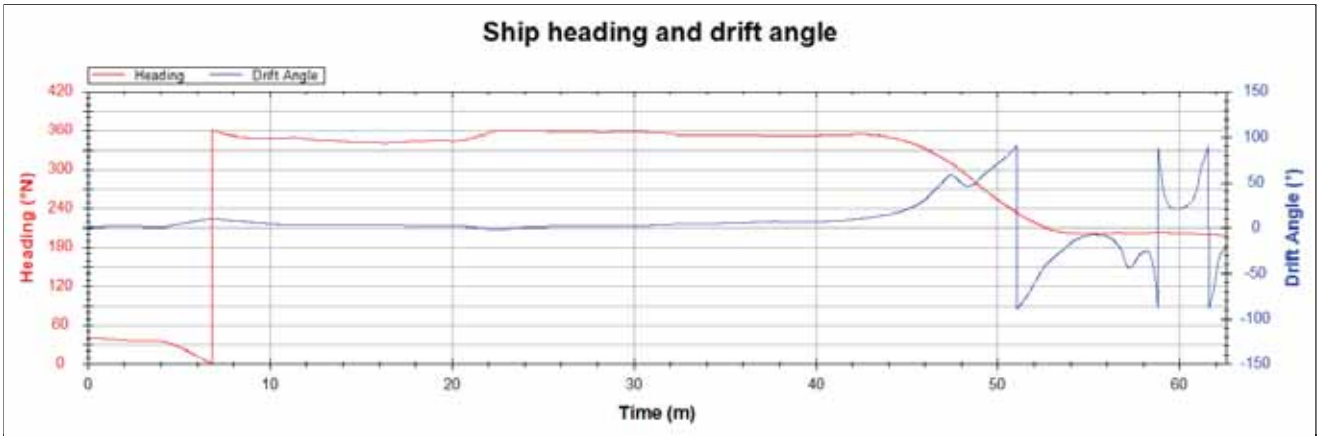
March 2015

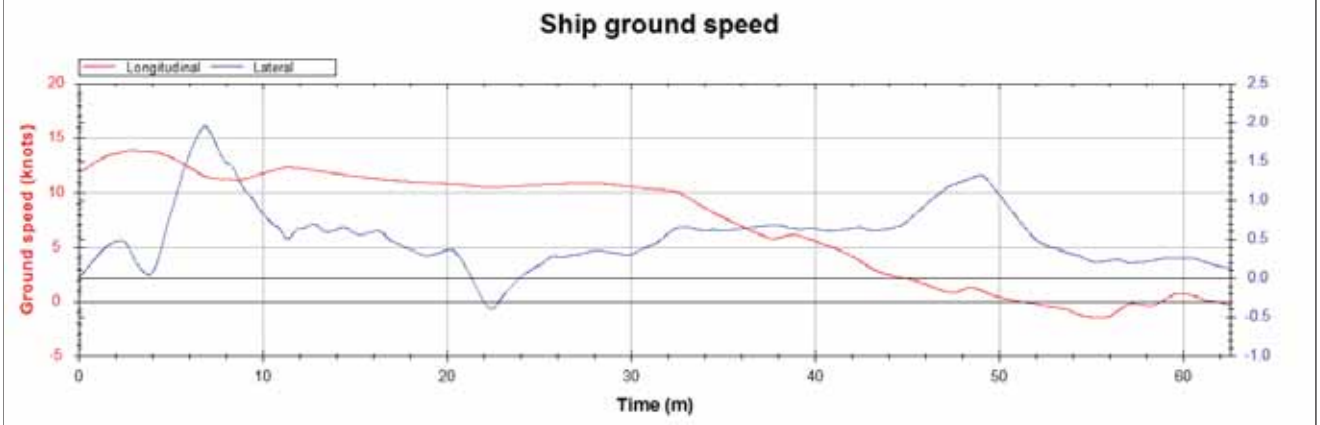
Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

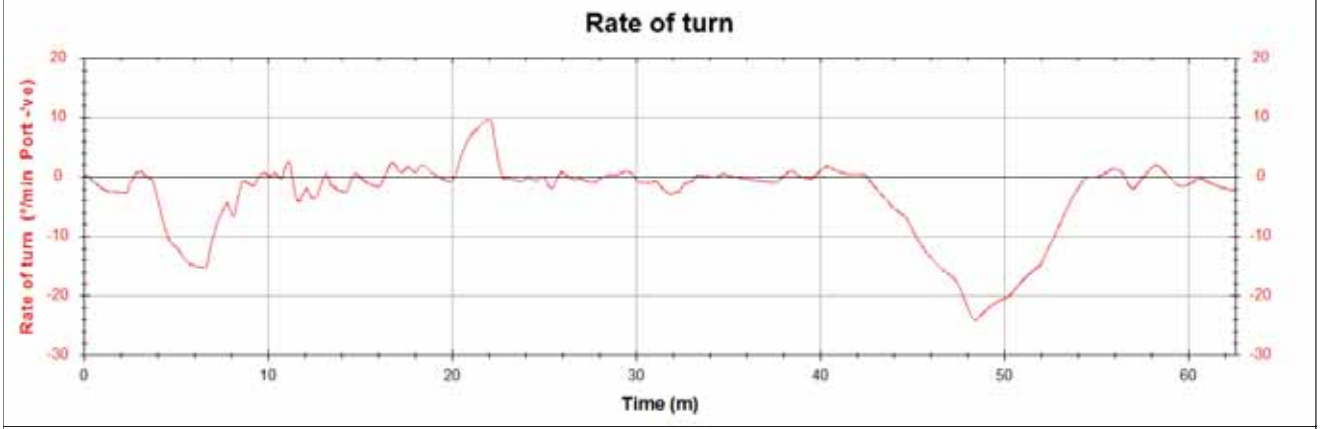


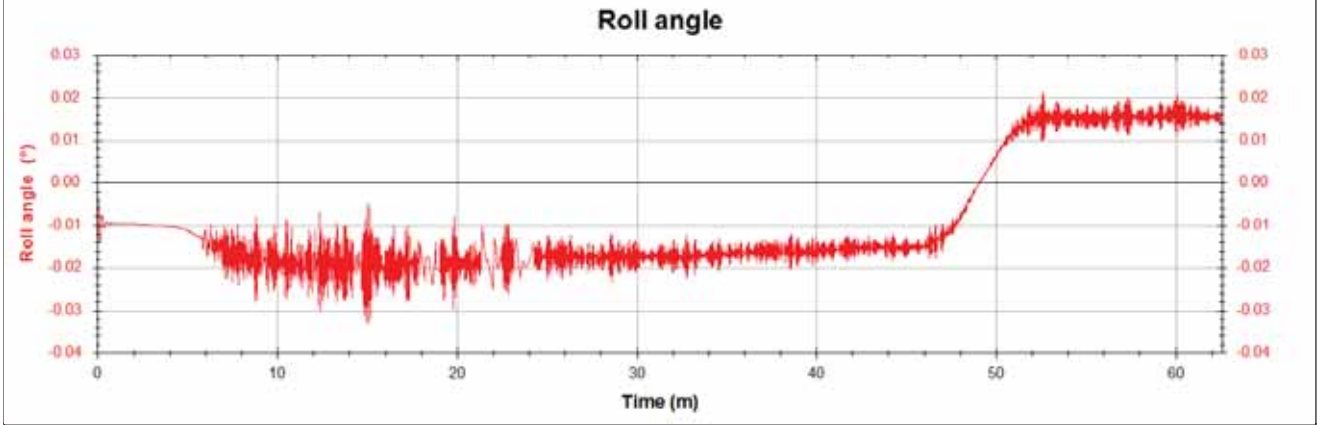
March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



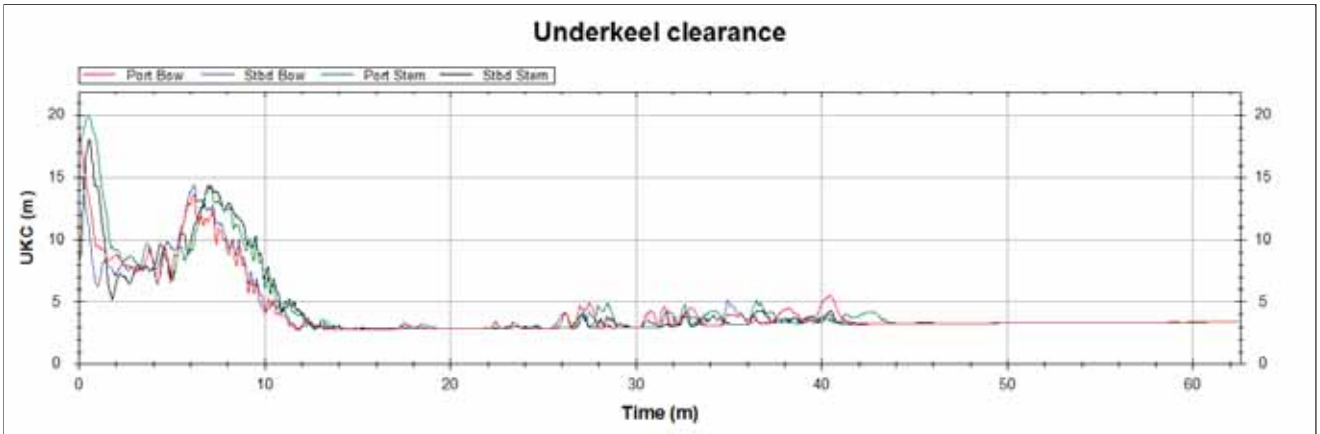


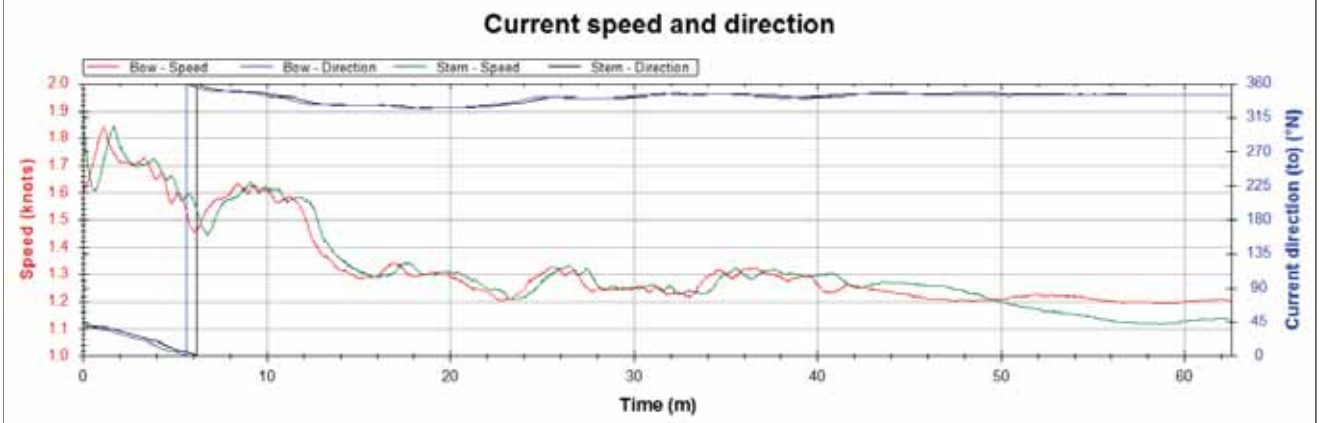


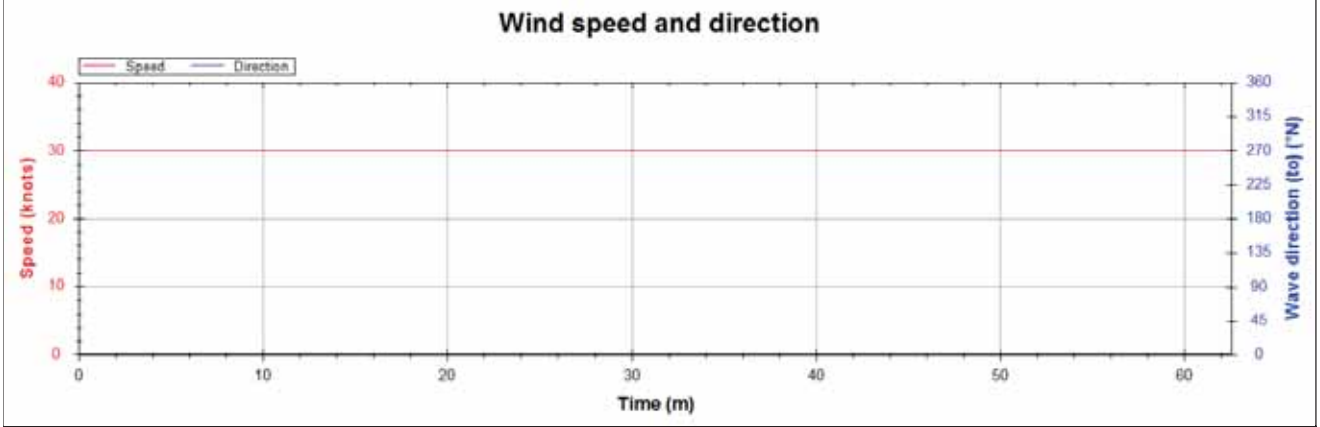


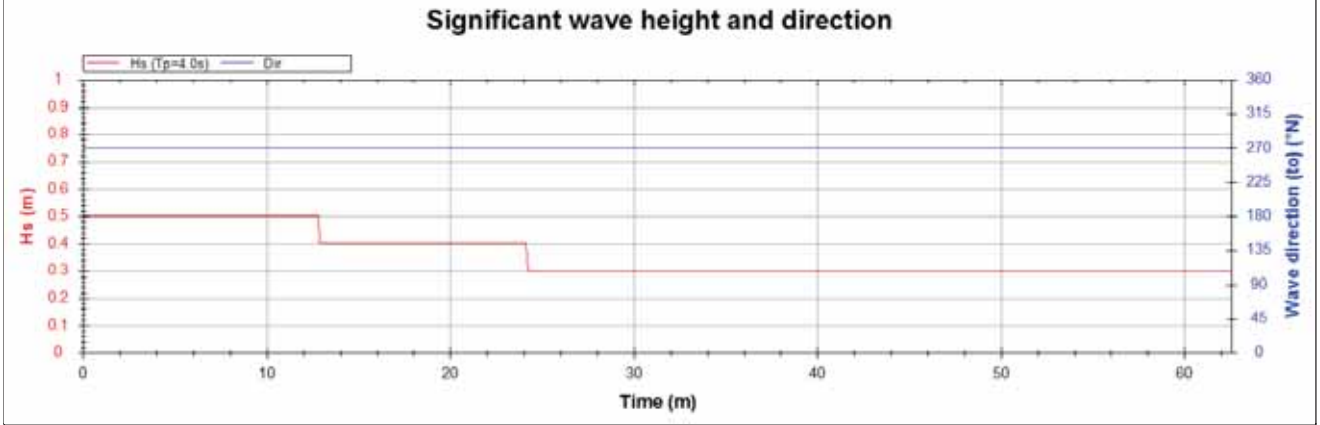
March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



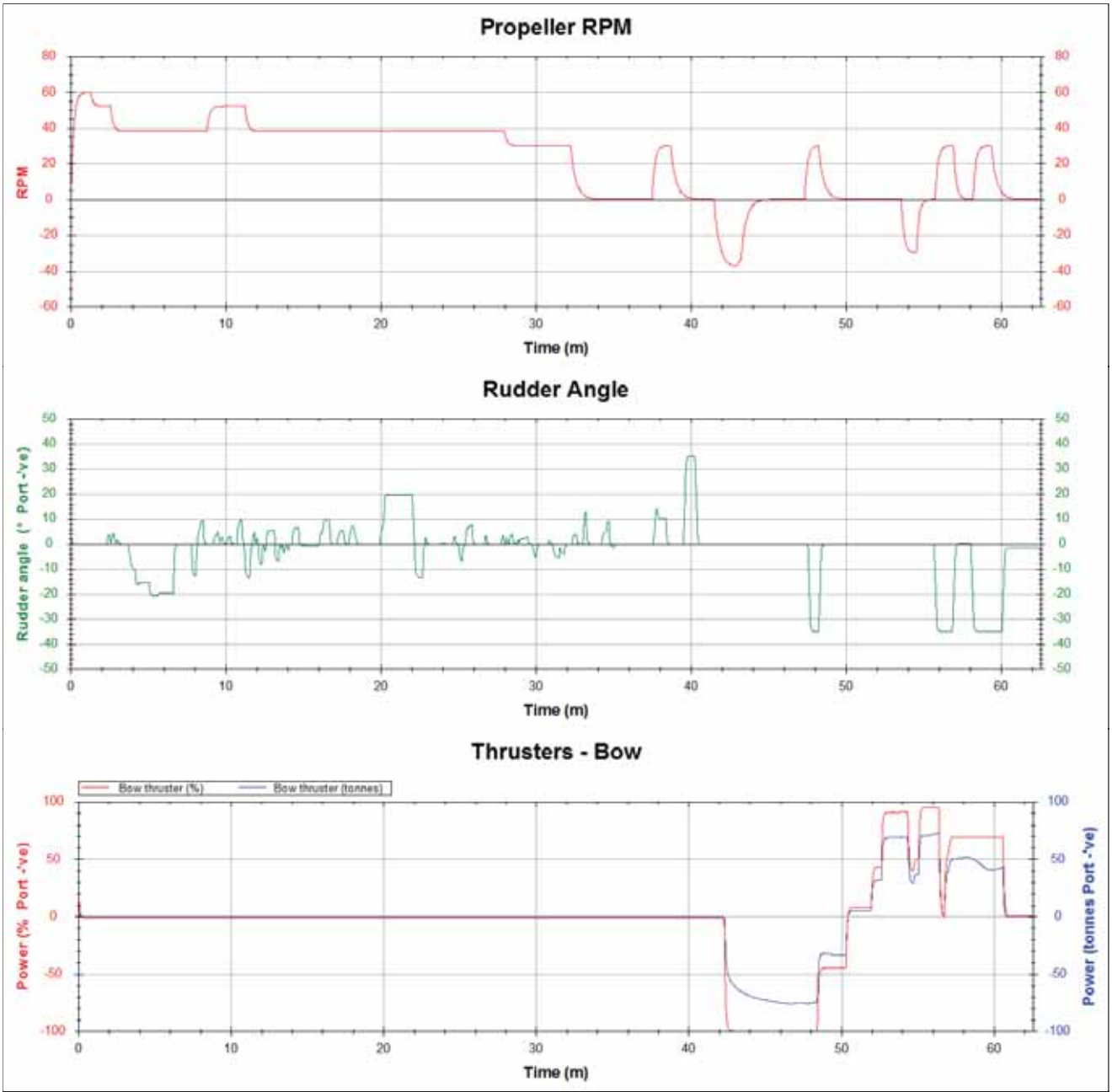






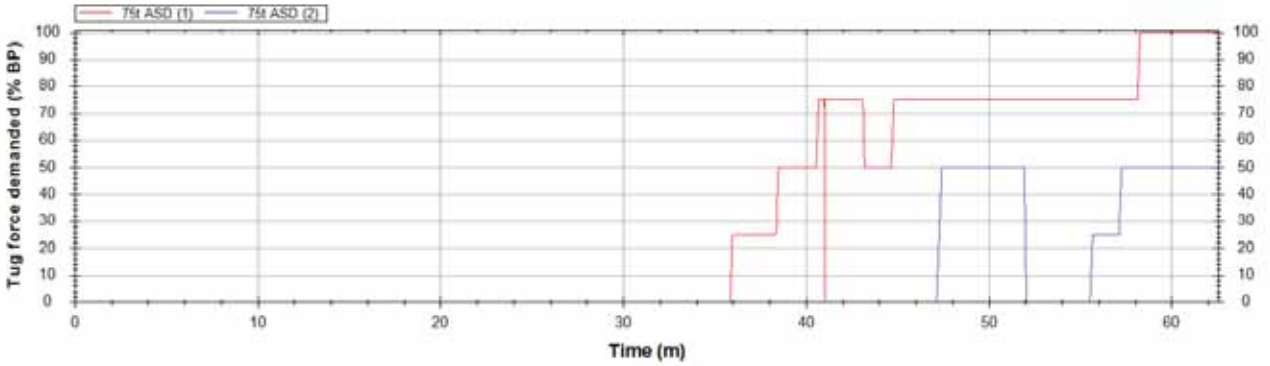
March 2015

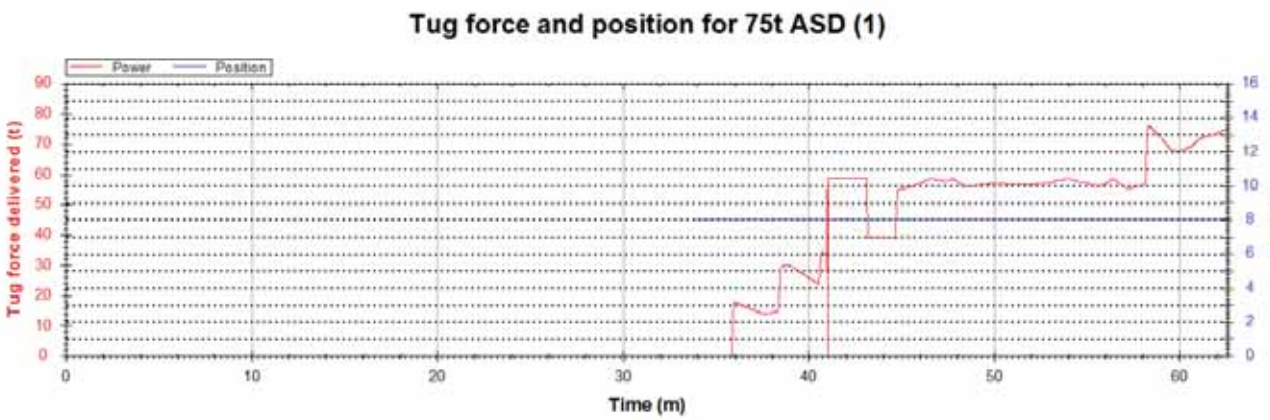
Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

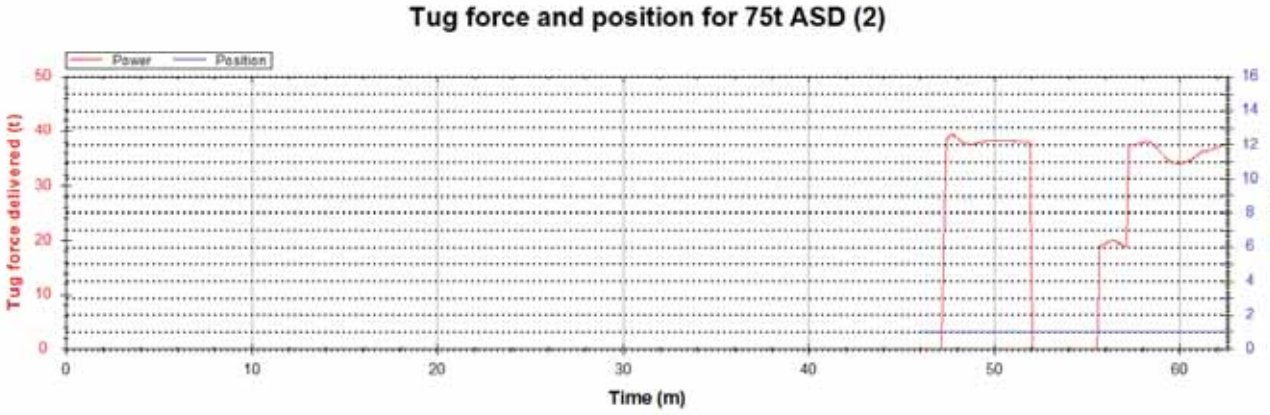


March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

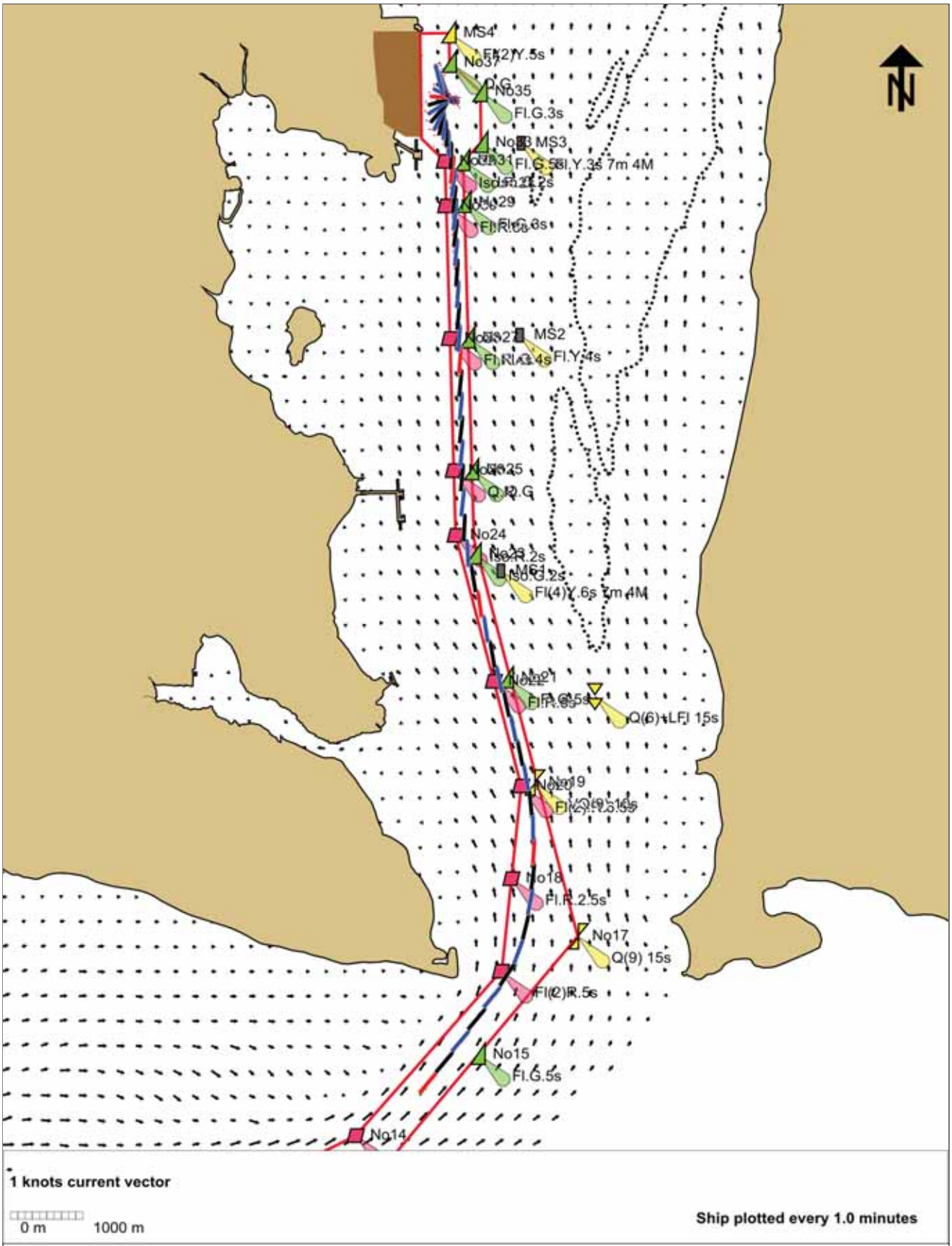






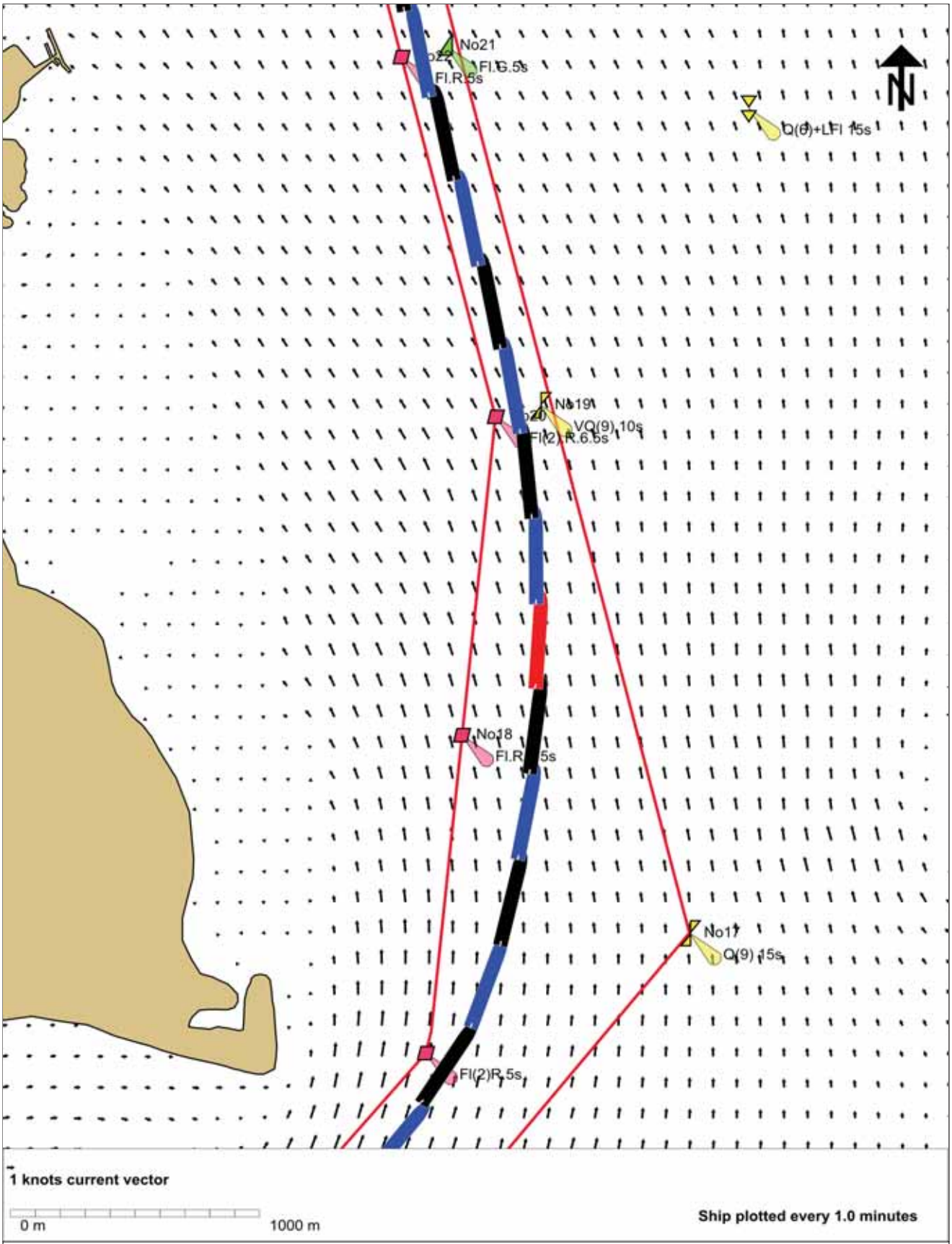
March 2015

Run: 03	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



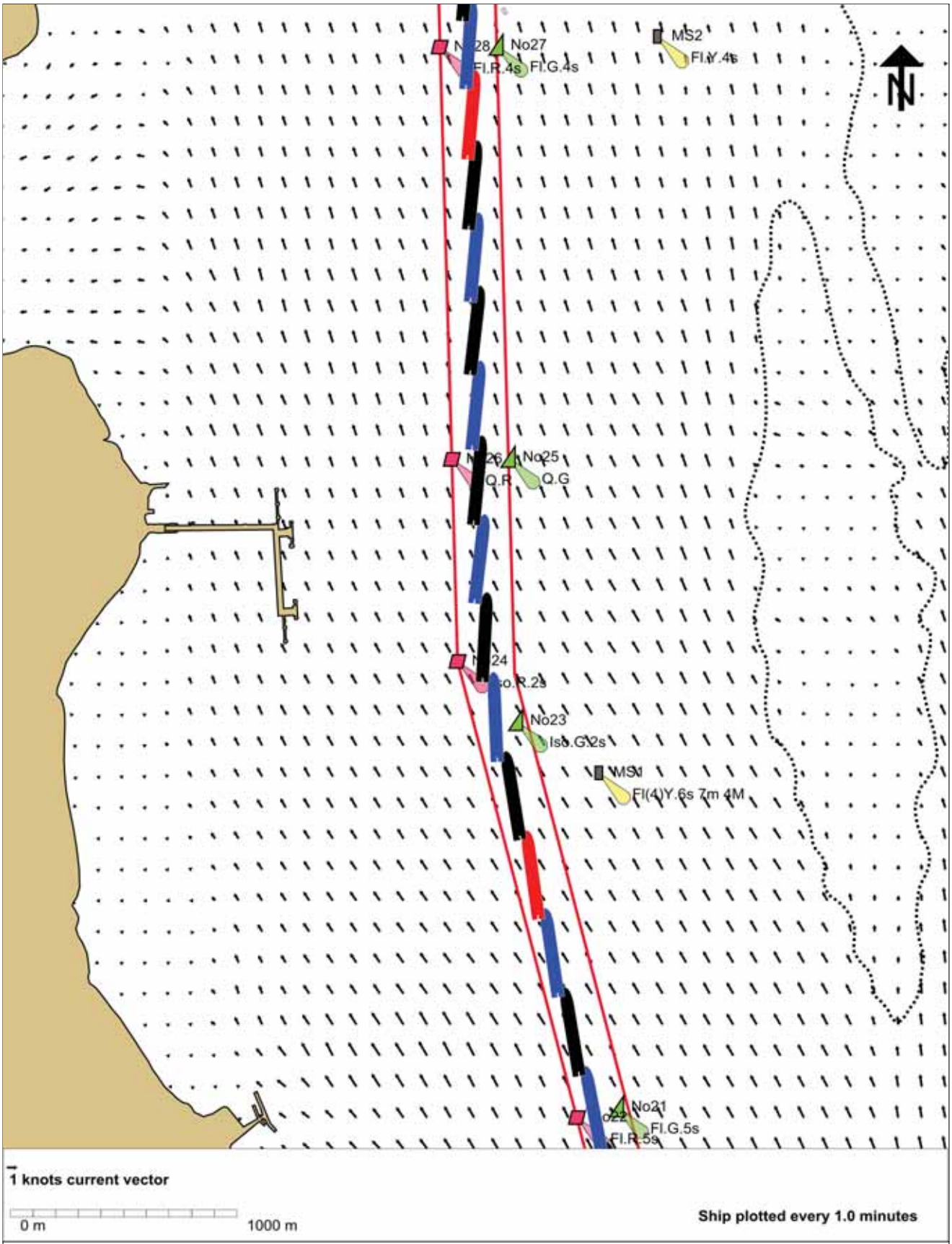
March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



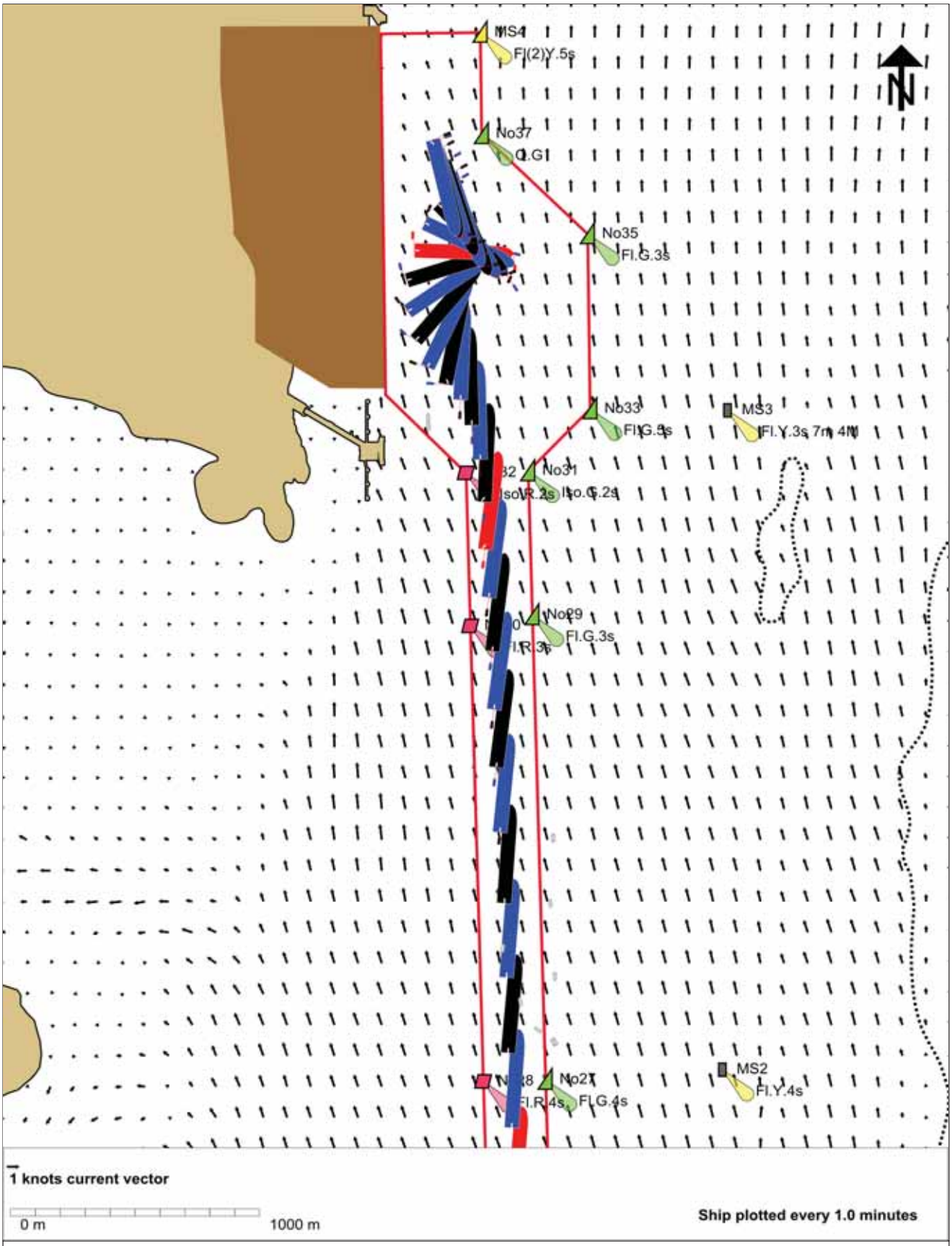
March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



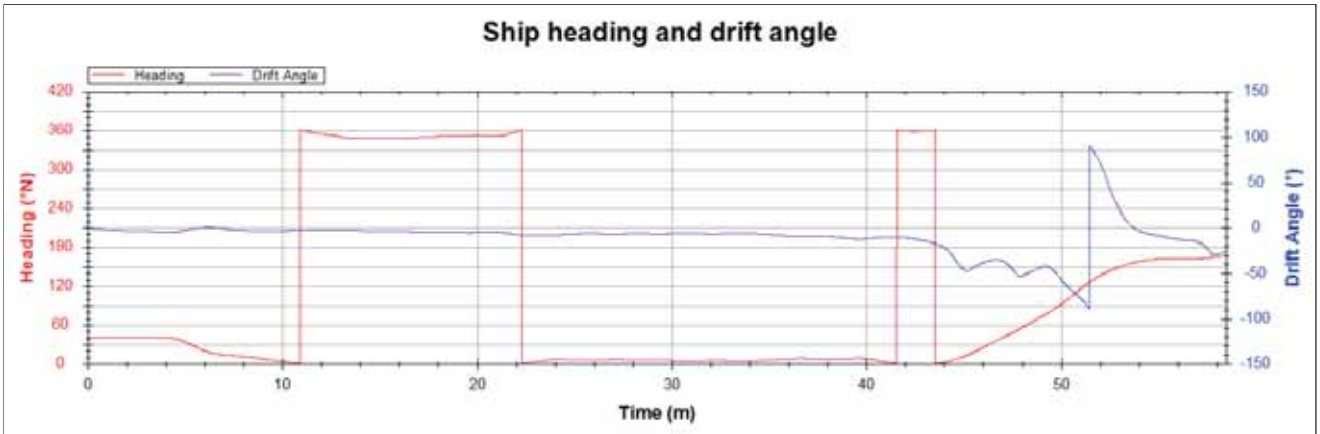
March 2015

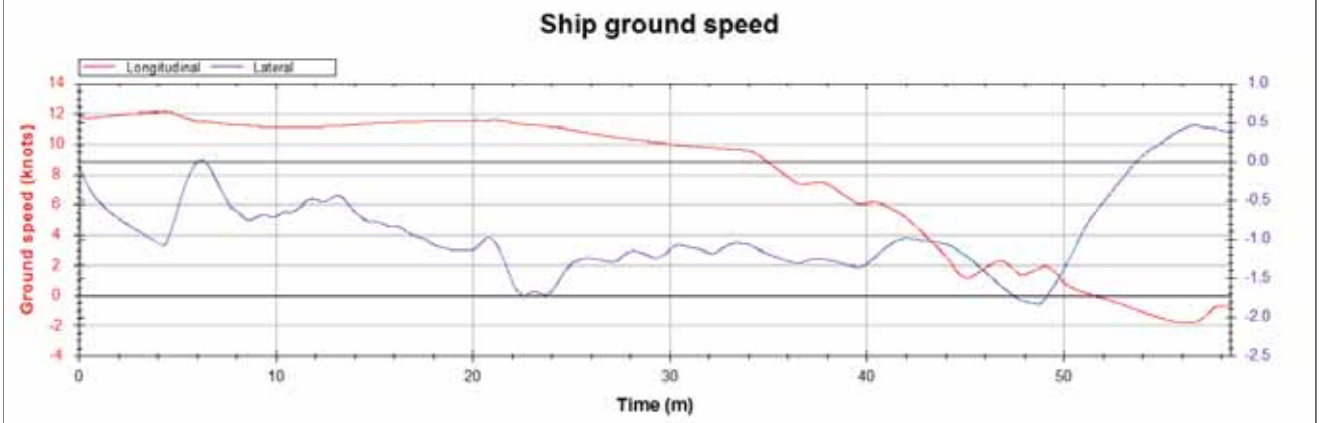
Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

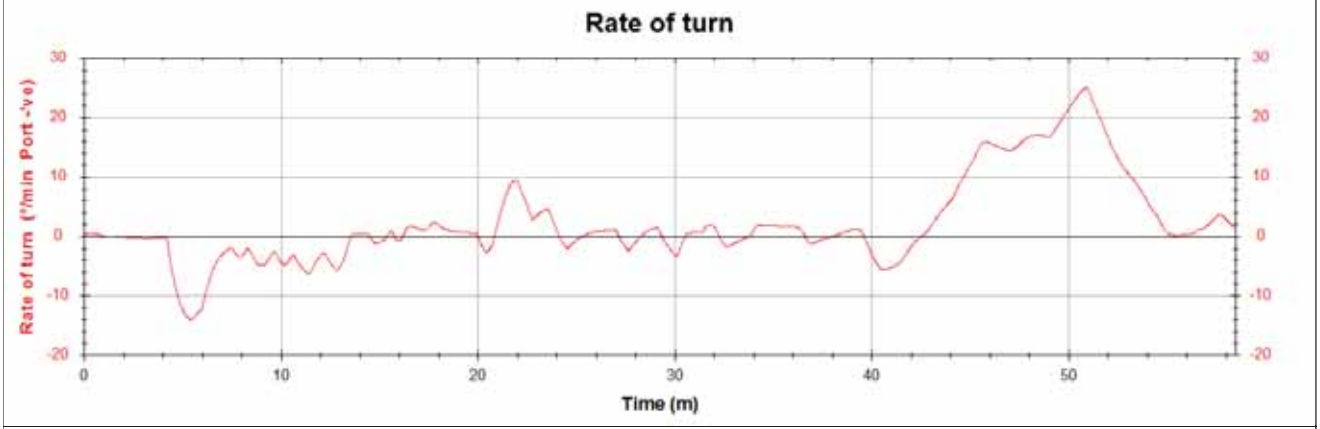


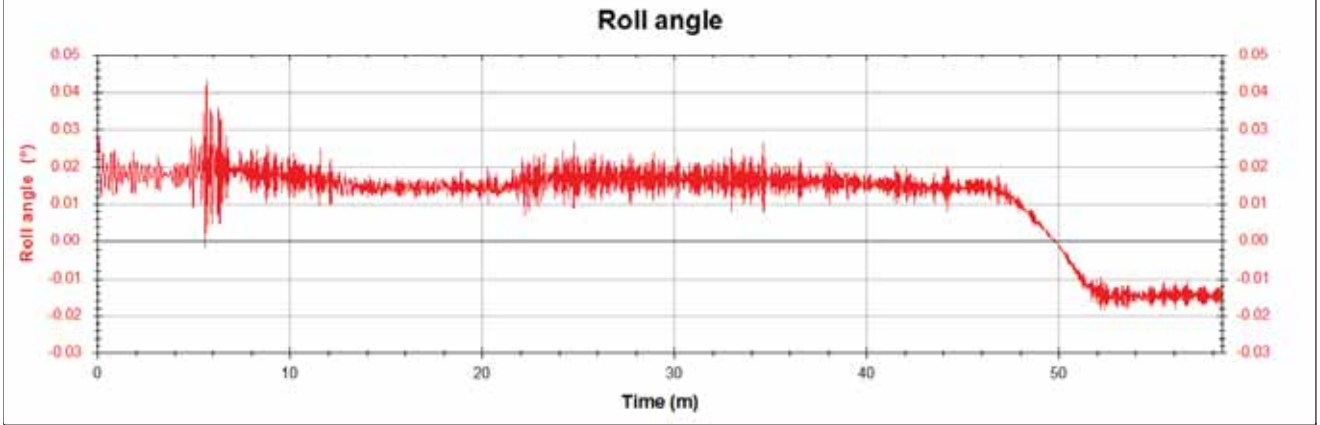
March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



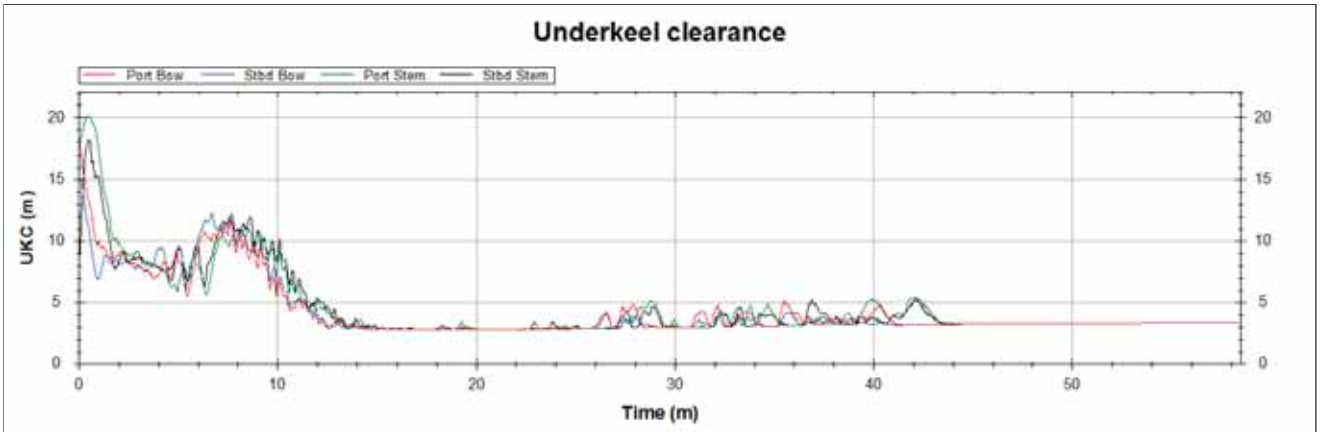


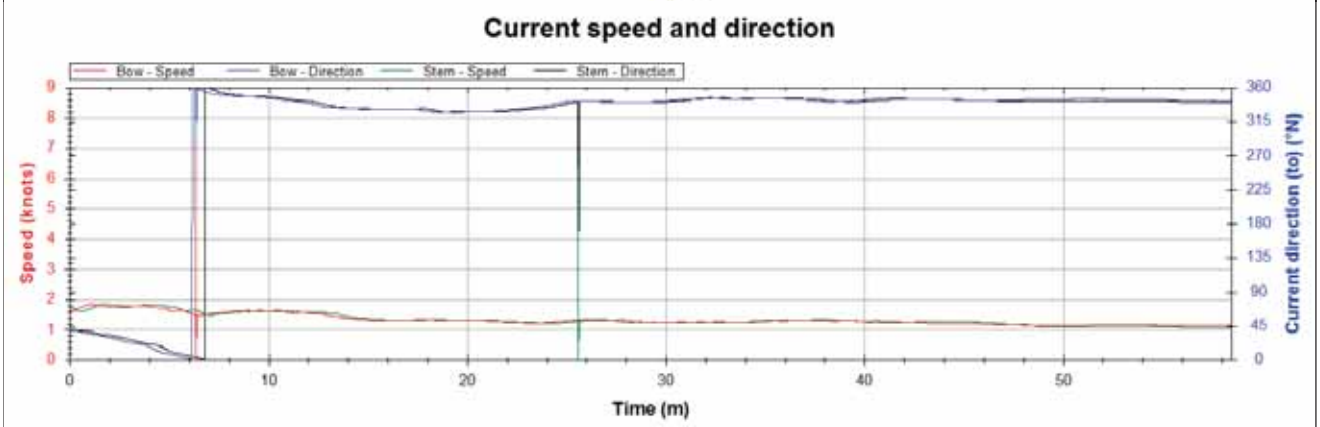


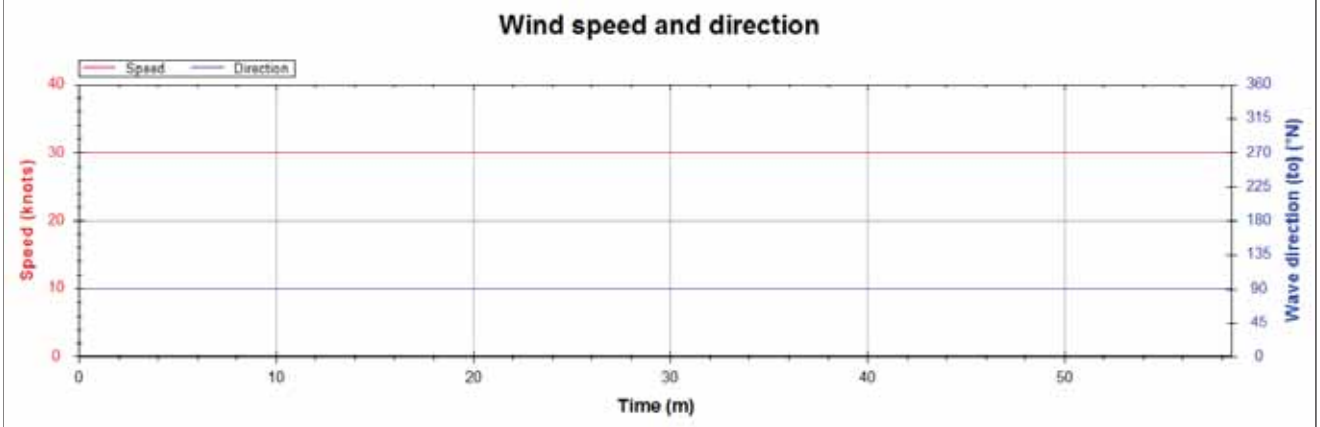


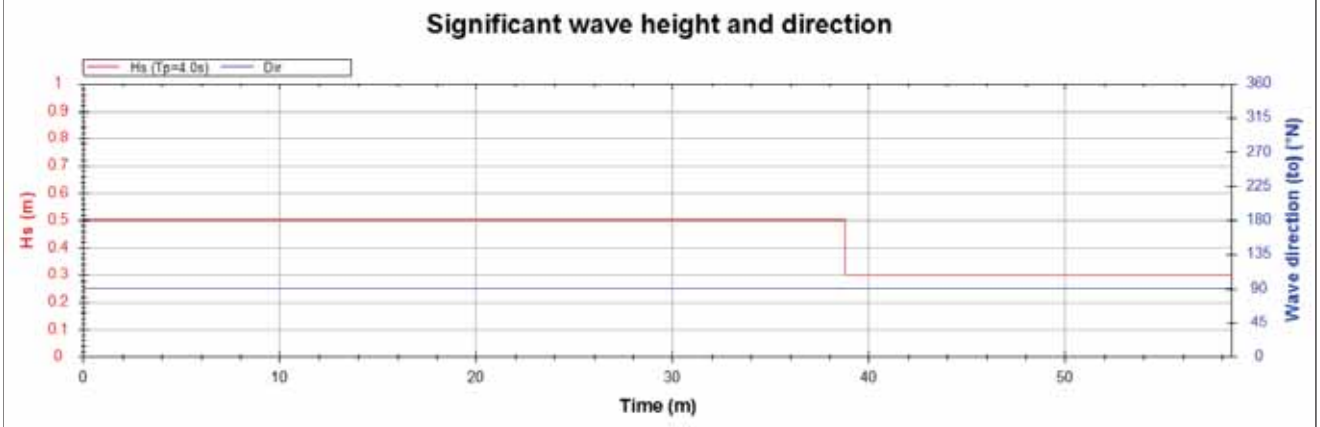
March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



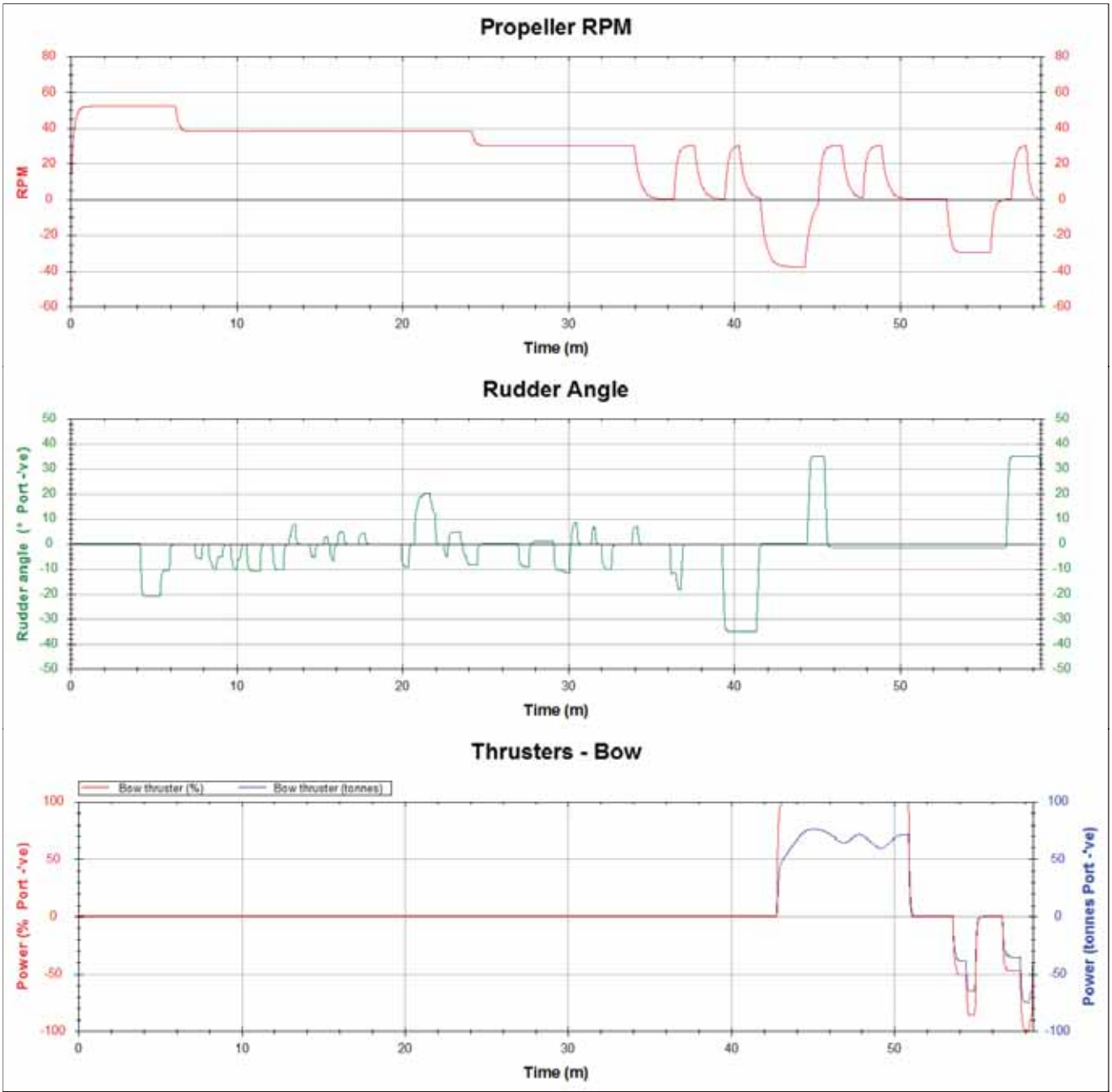






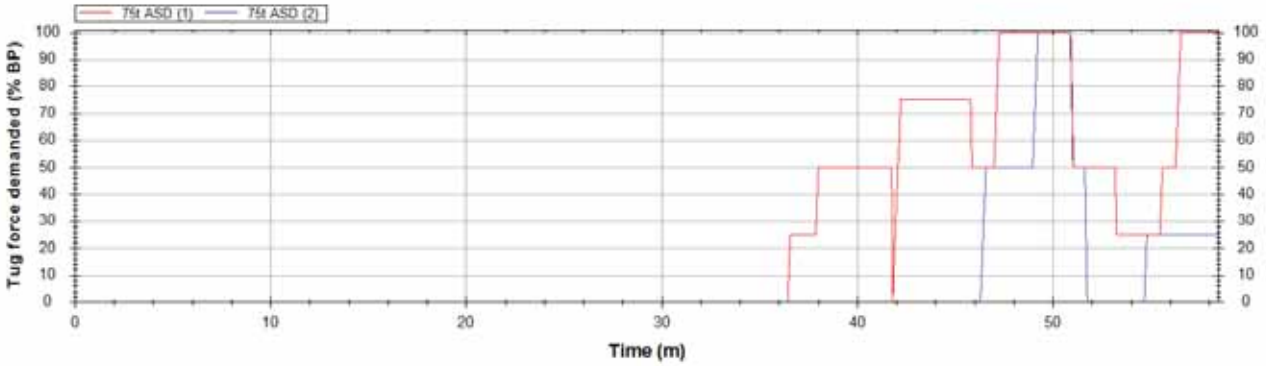
March 2015

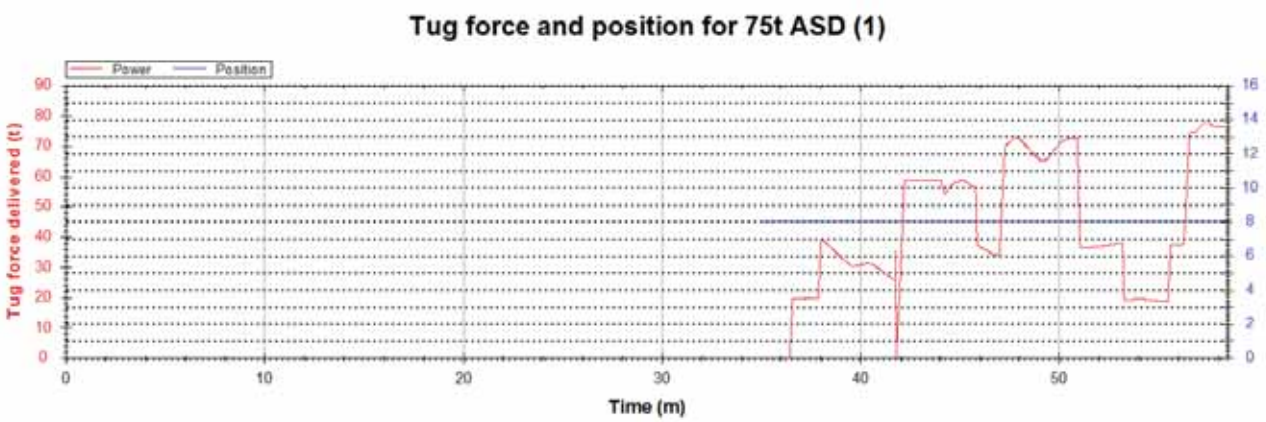
Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

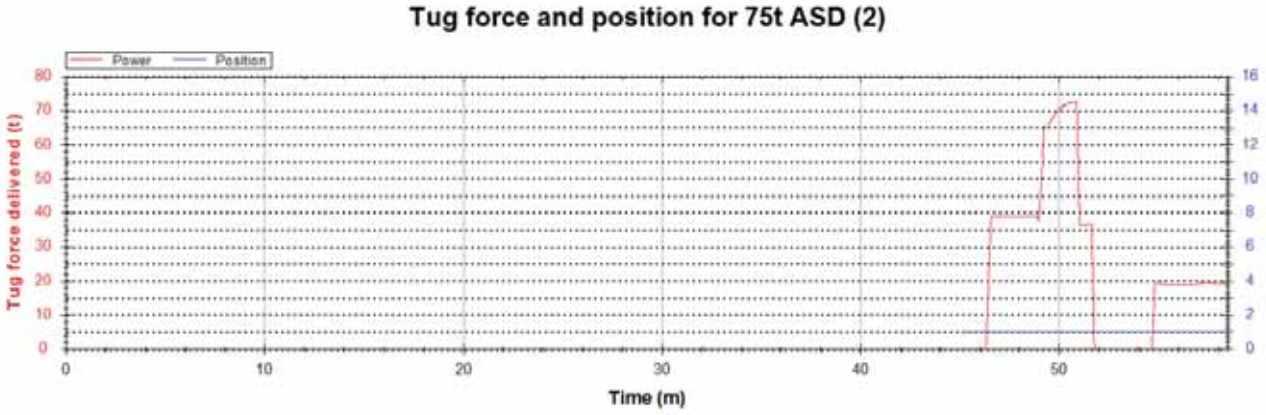


March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

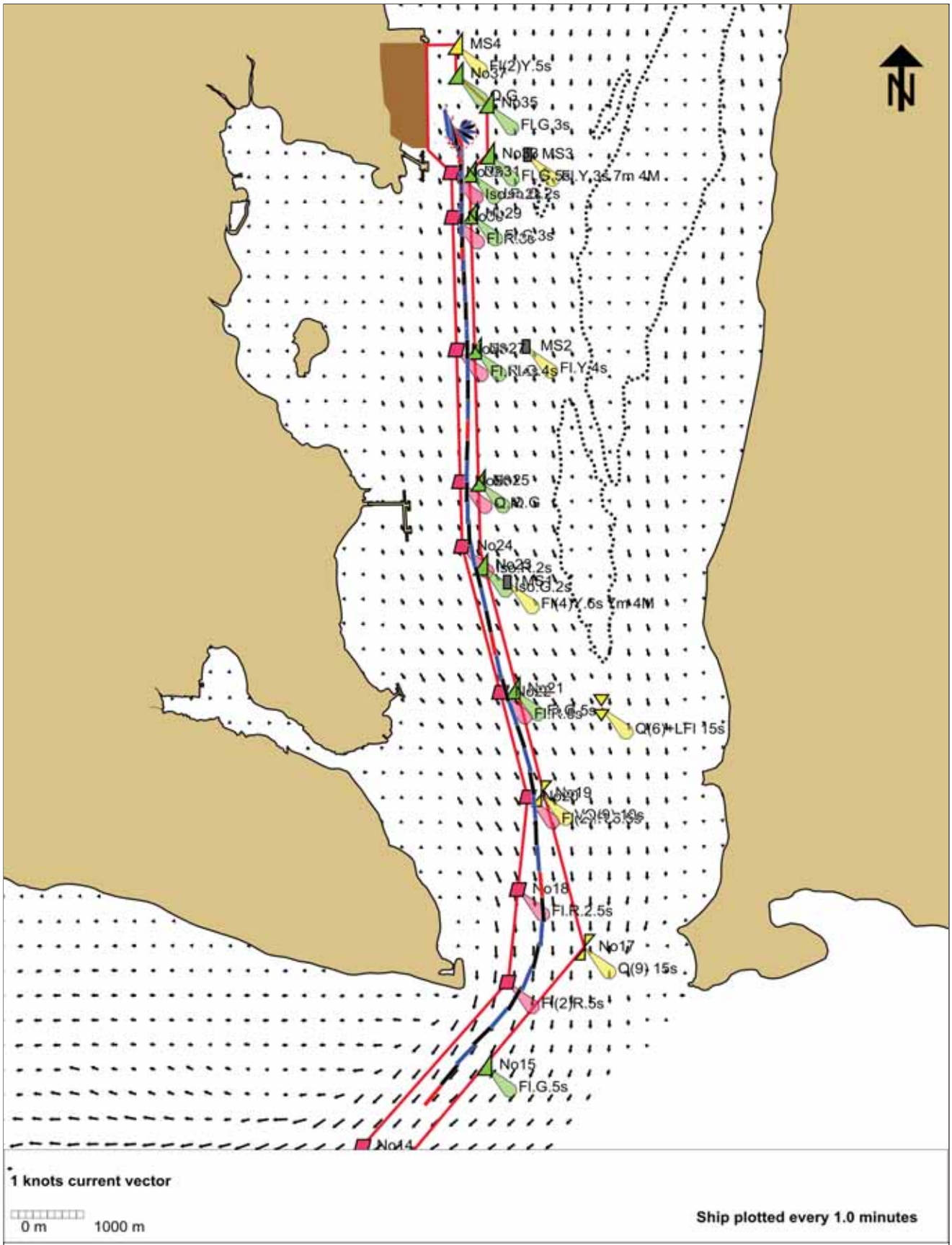






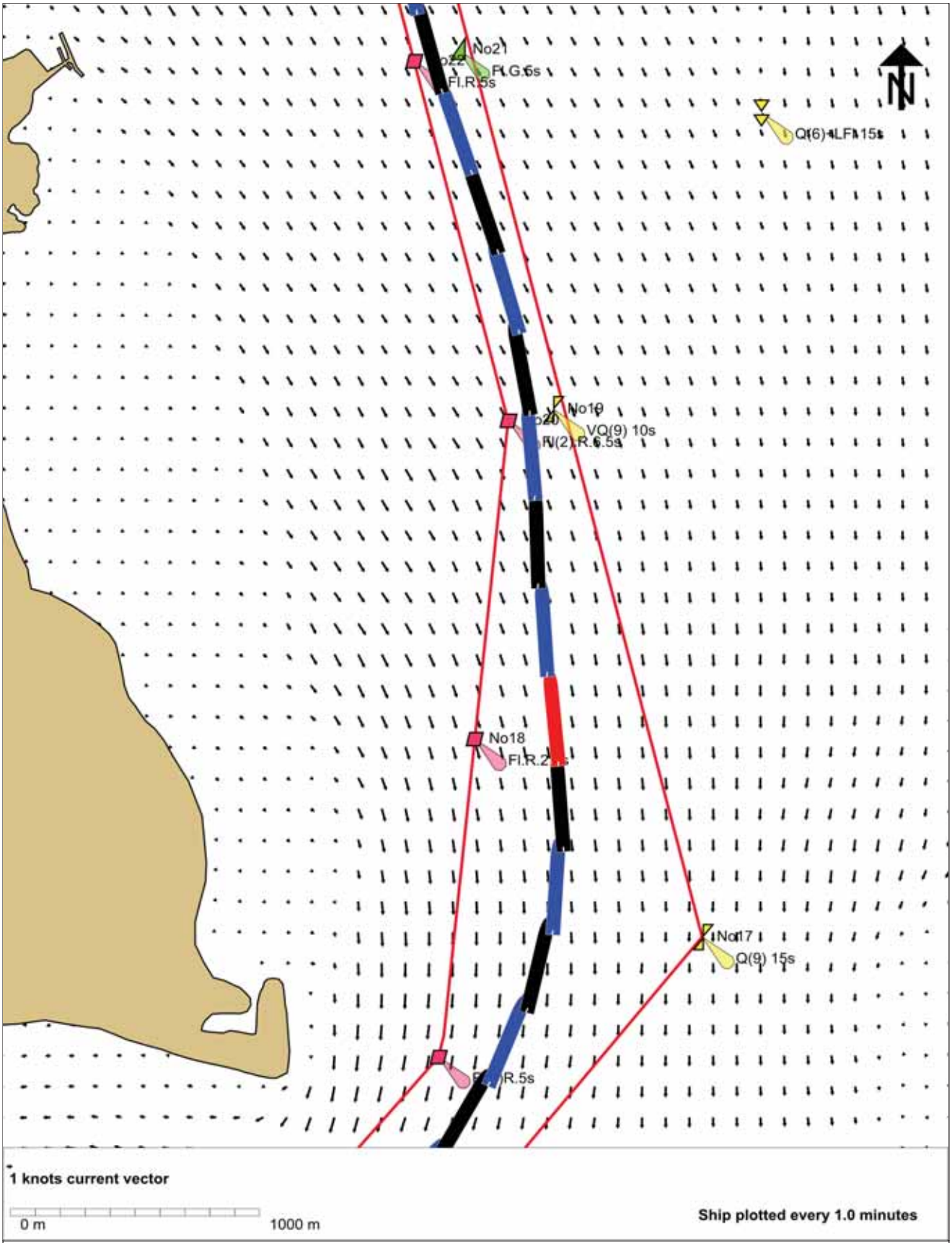
March 2015

Run: 04	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



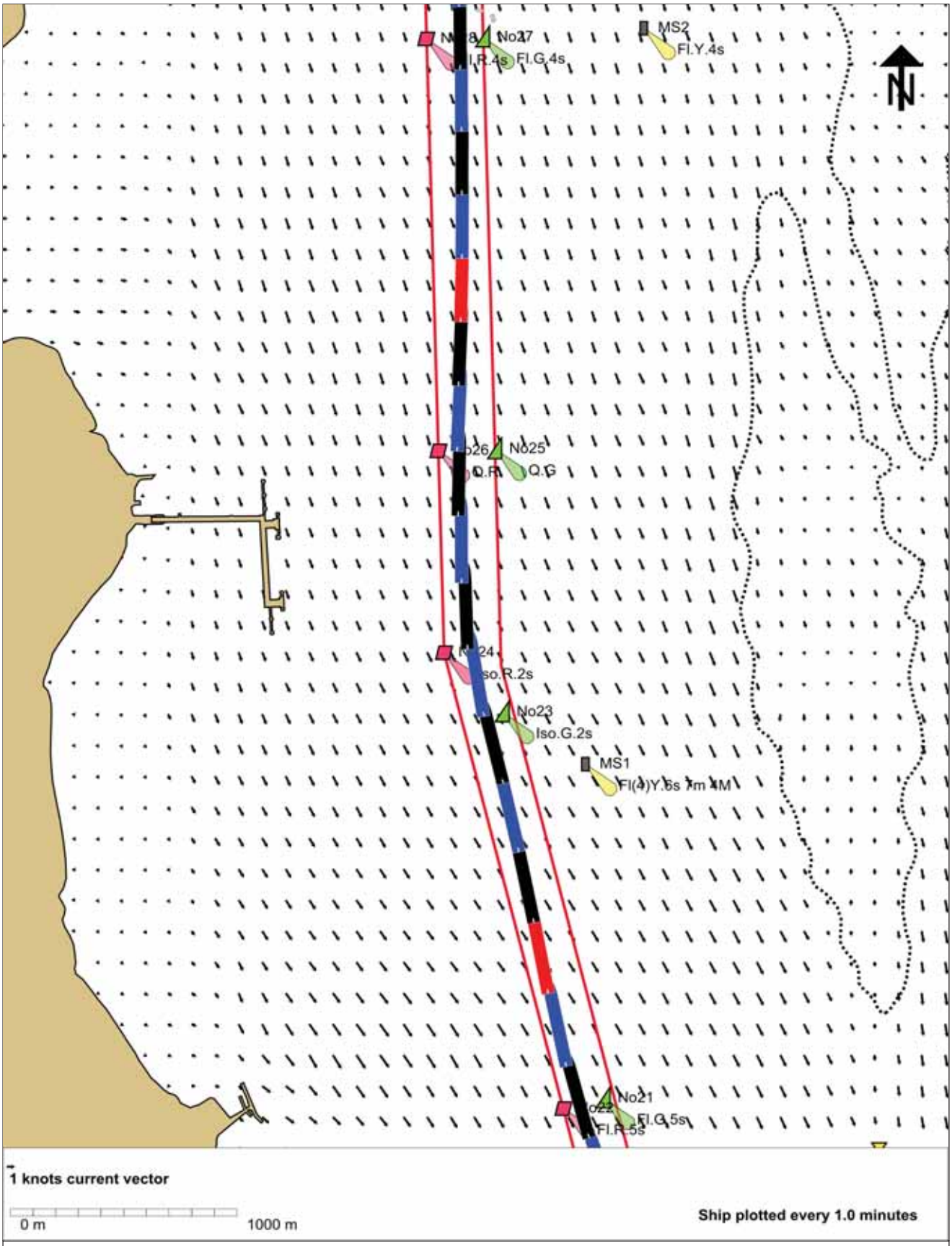
March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



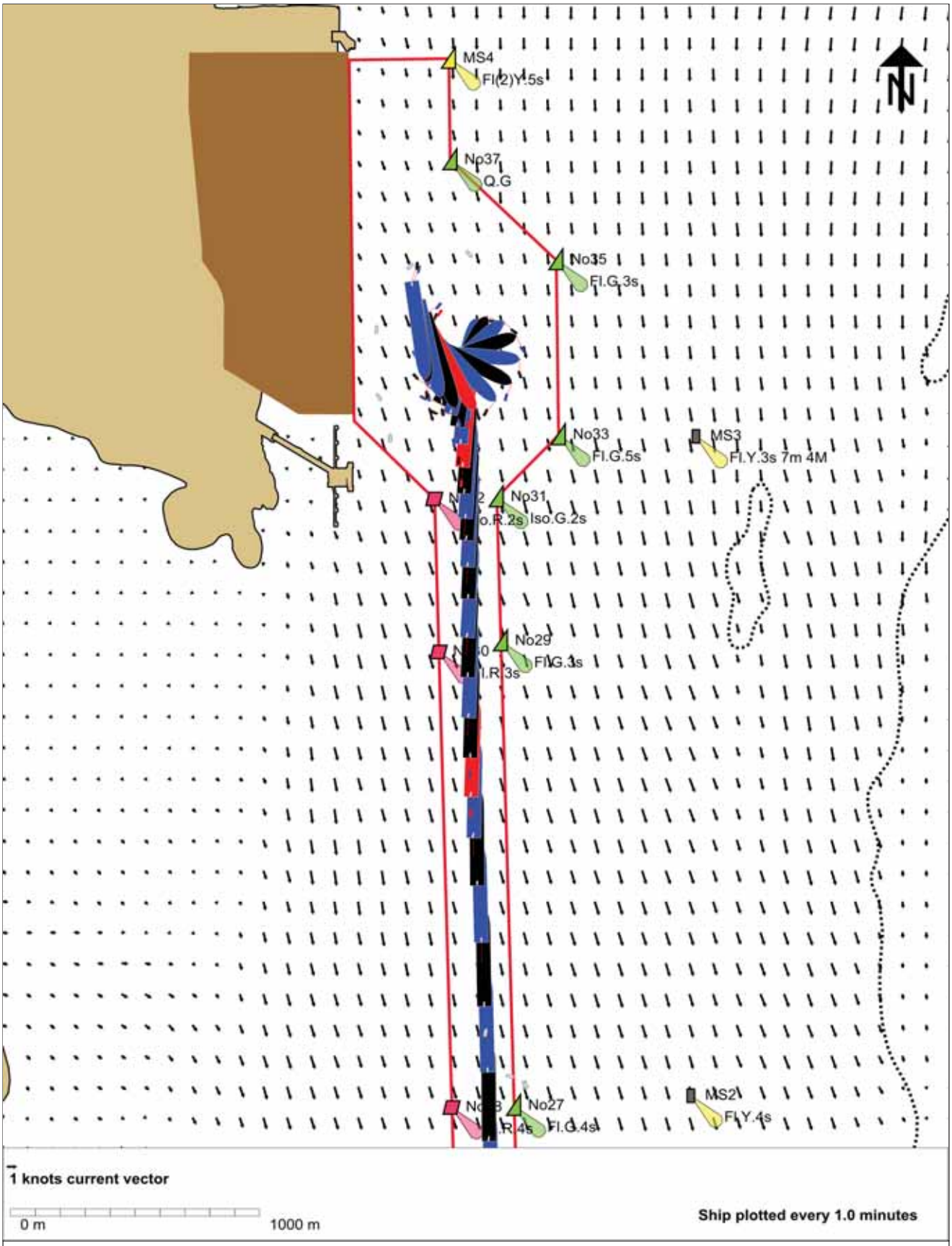
March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



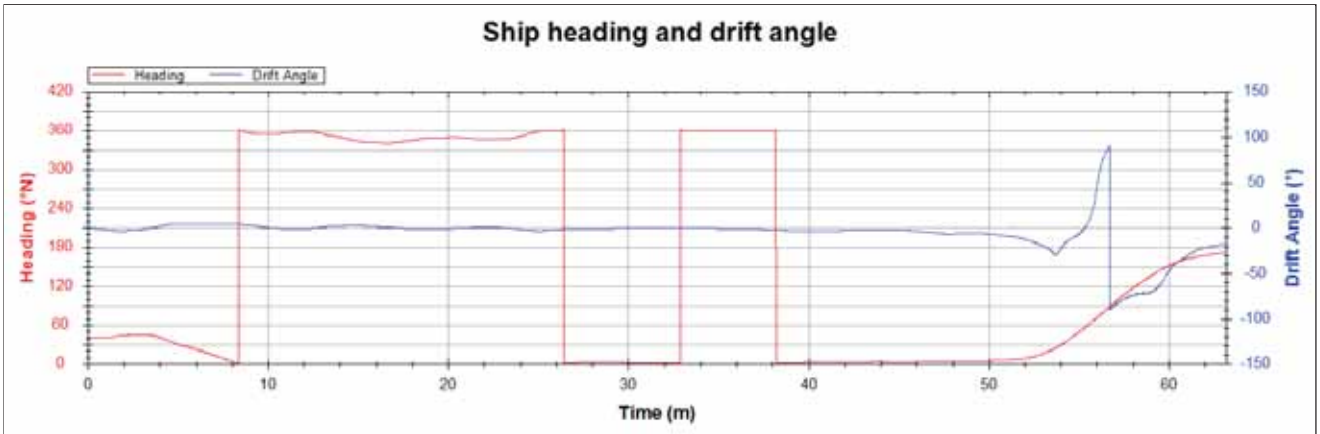
March 2015

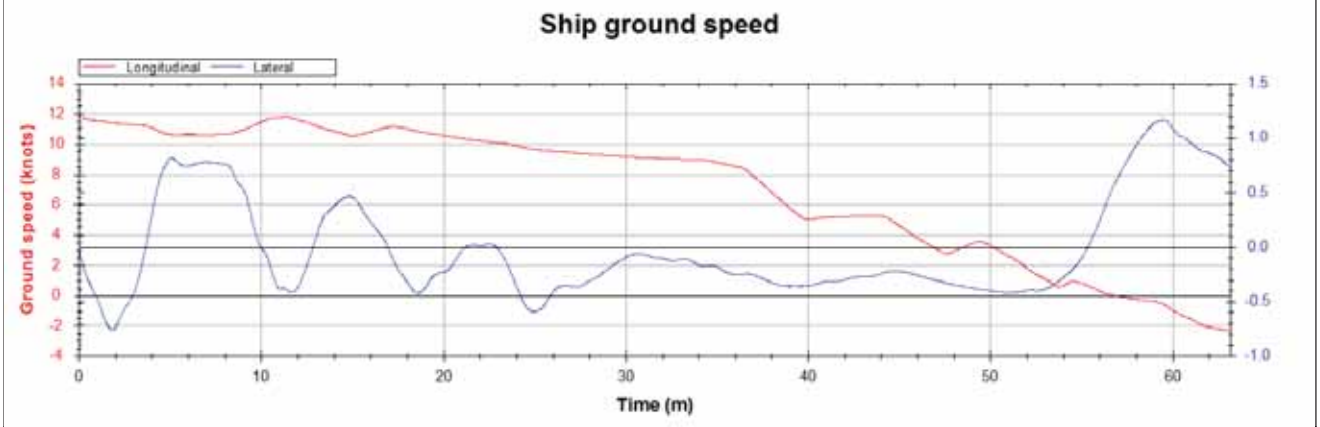
Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

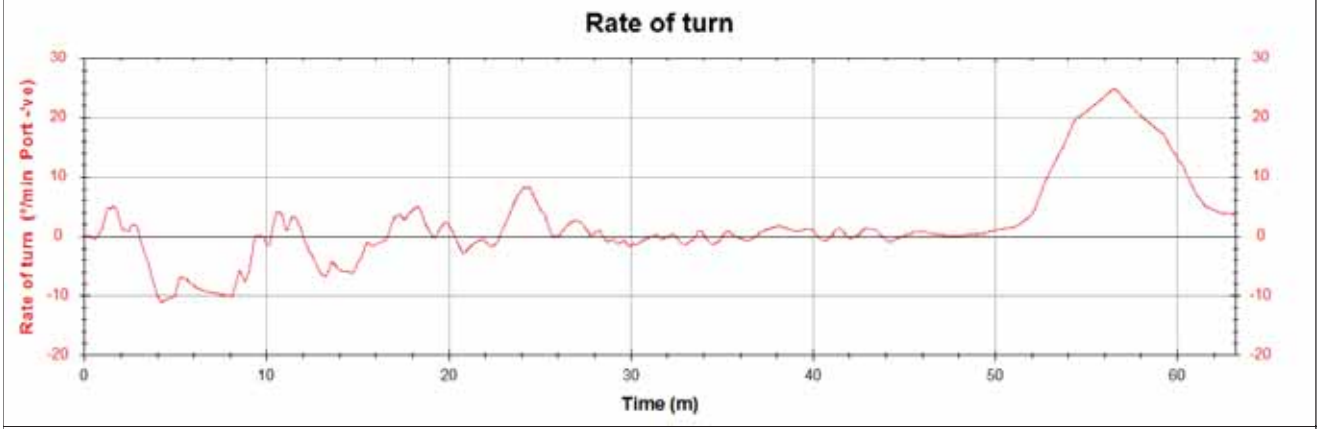


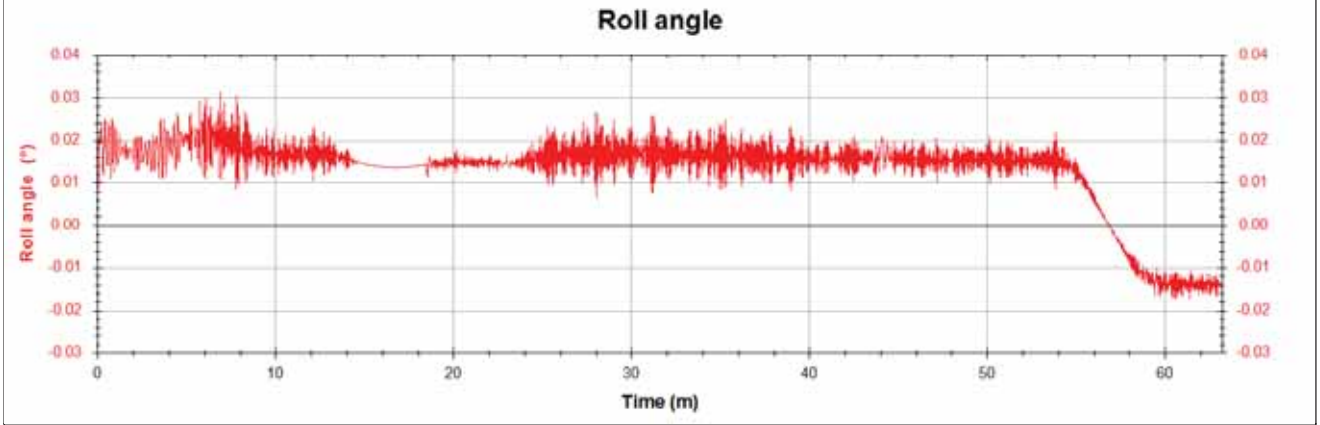
March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



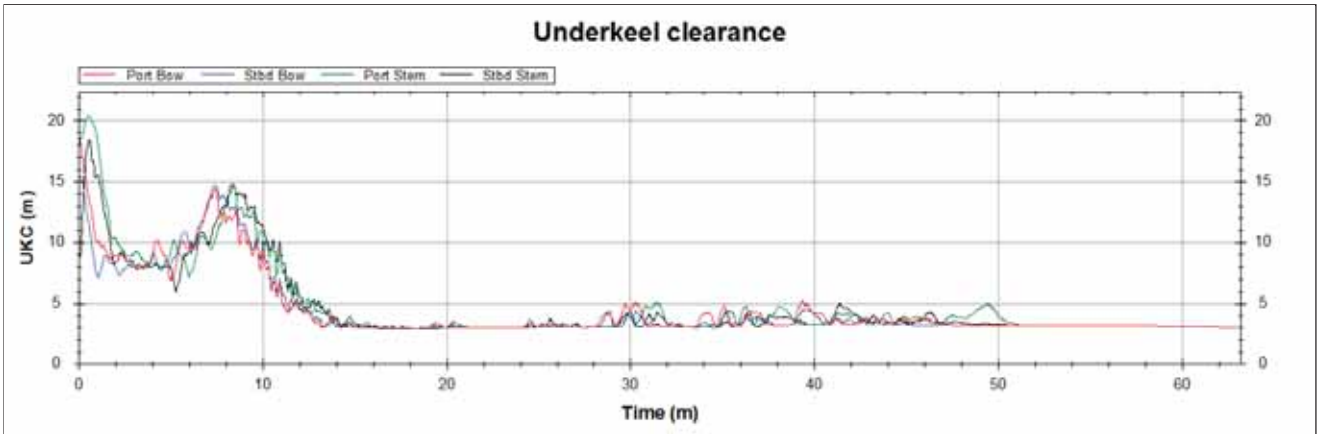


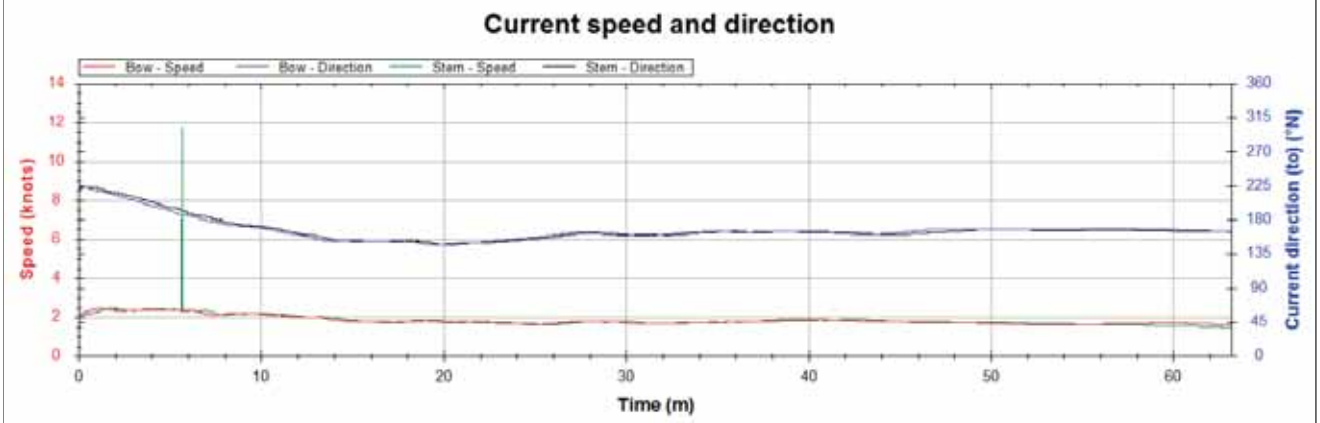


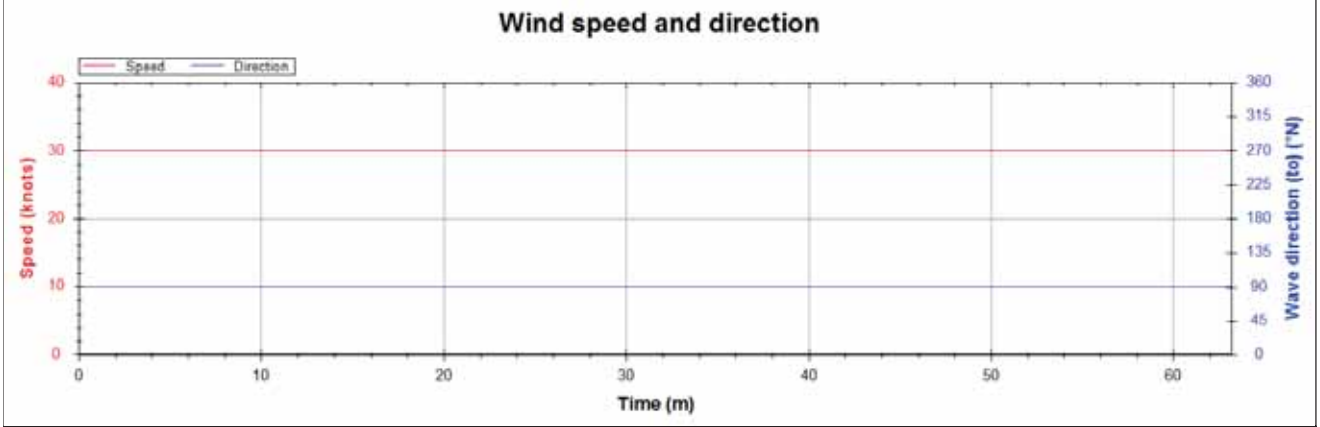


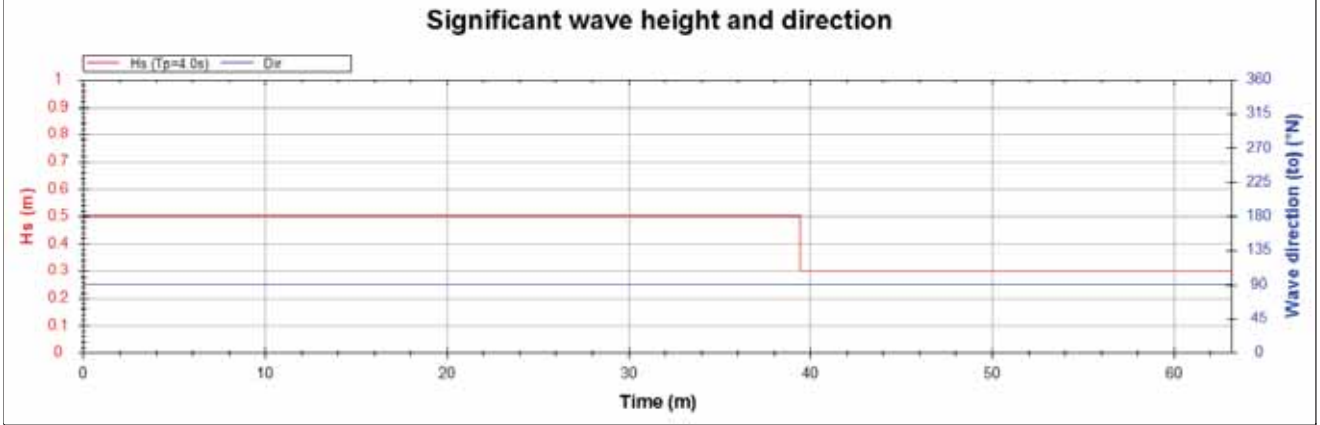
March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



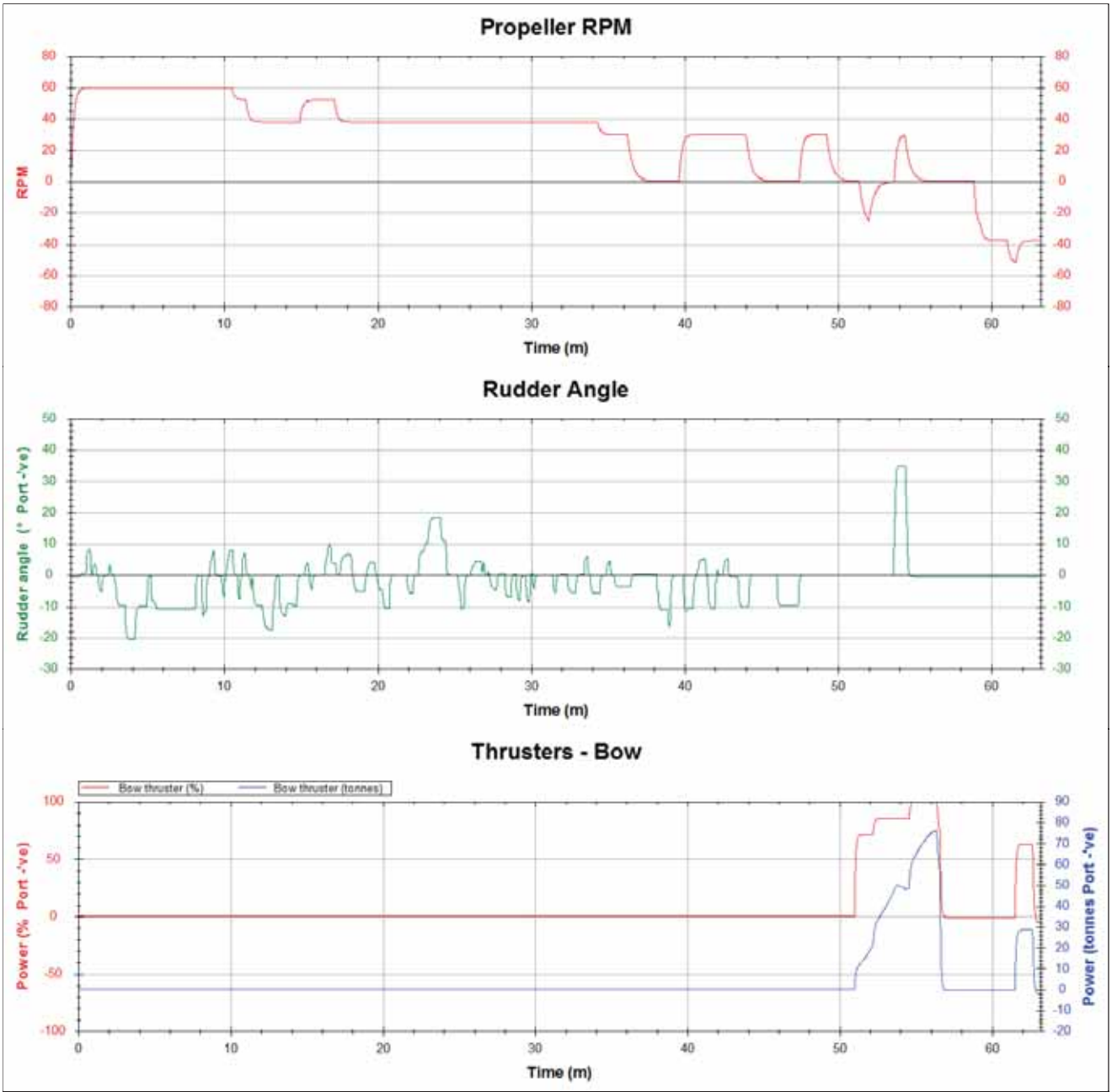






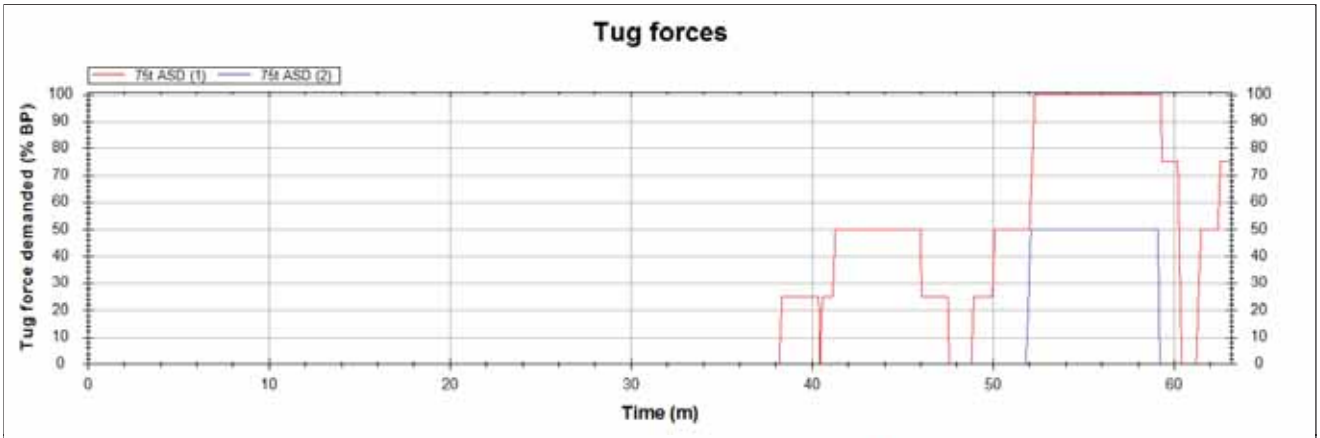
March 2015

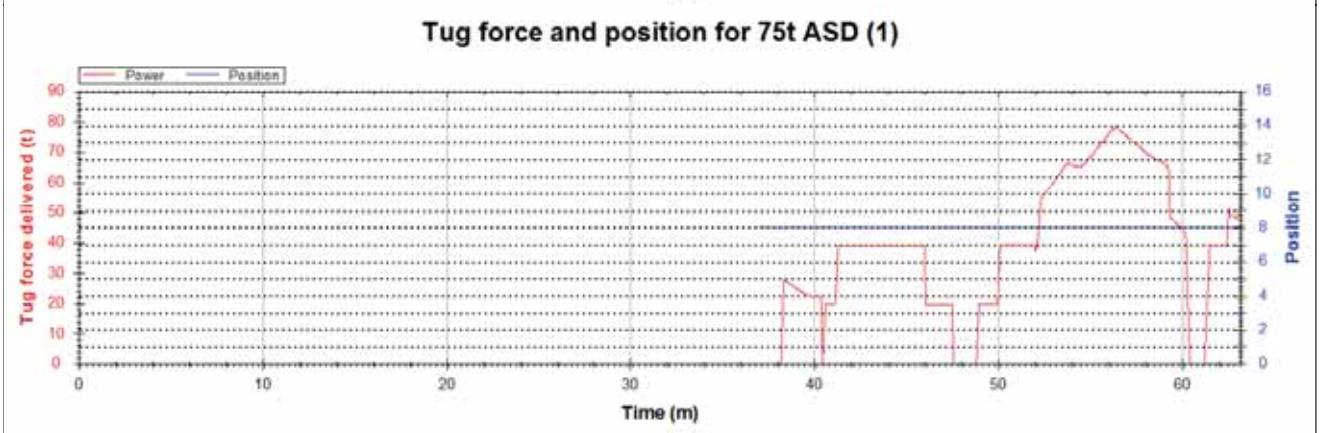
Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

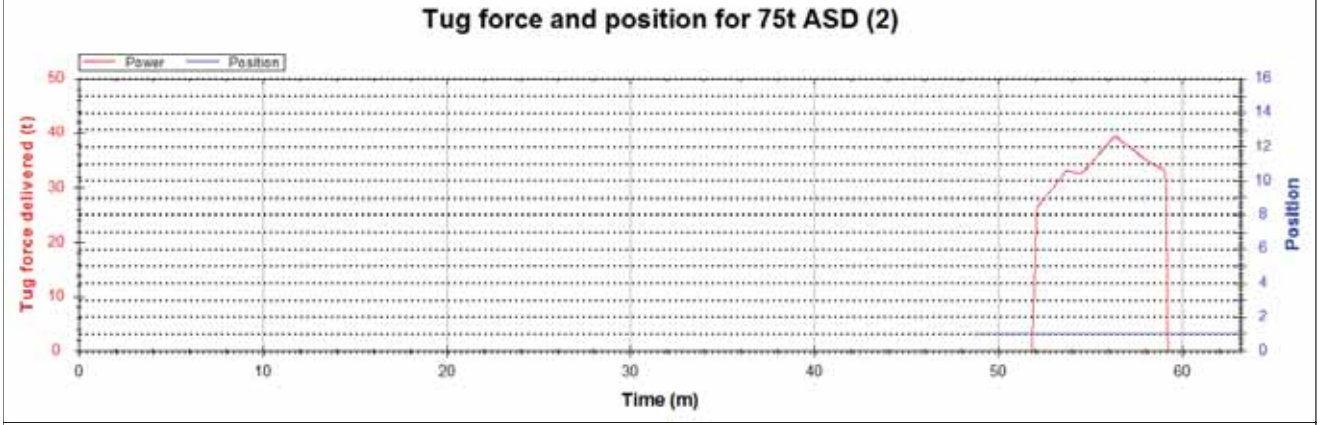


March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

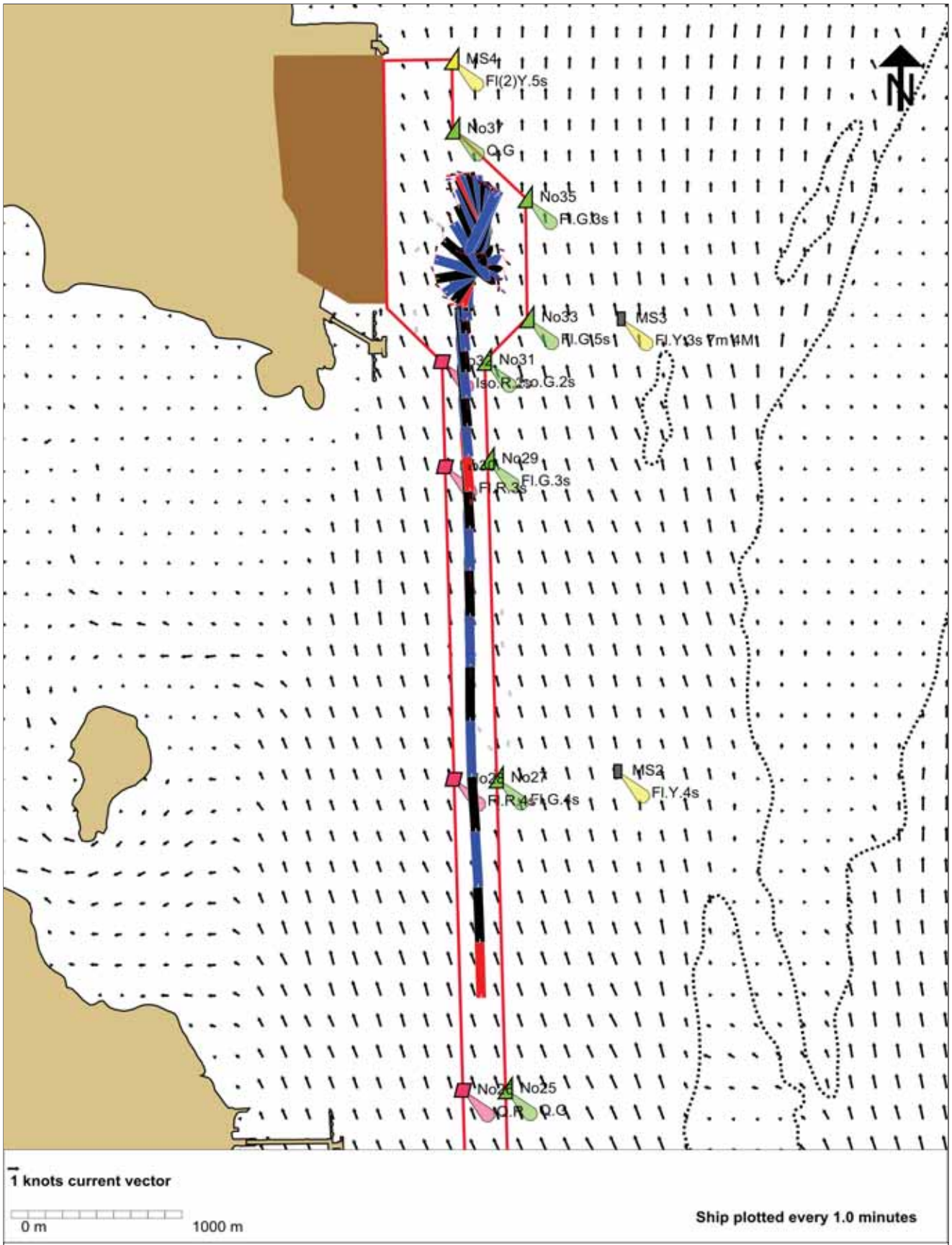






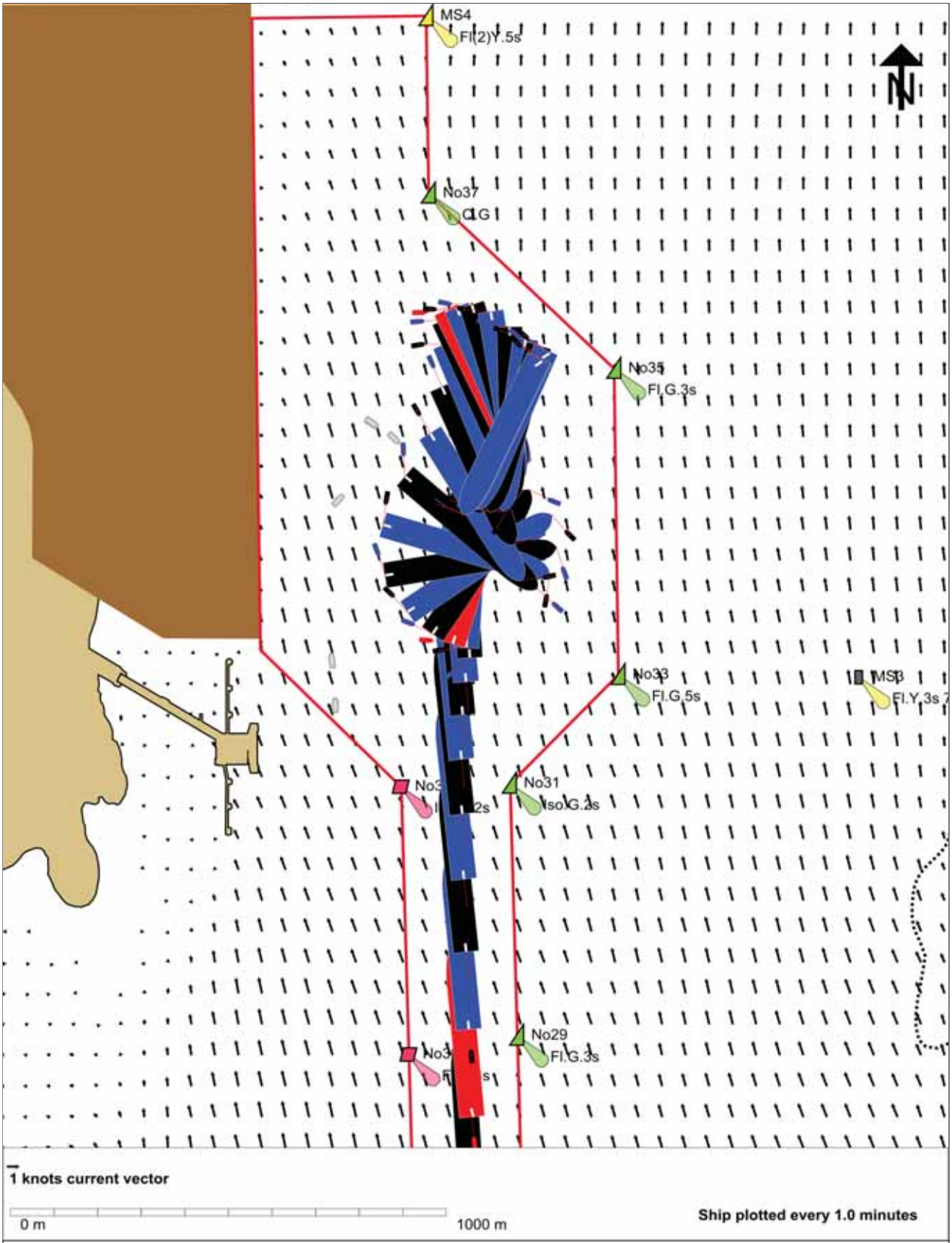
March 2015

Run: 05	Pilot: IS	Ship: 399m Container Ship
Initial wind: 090°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



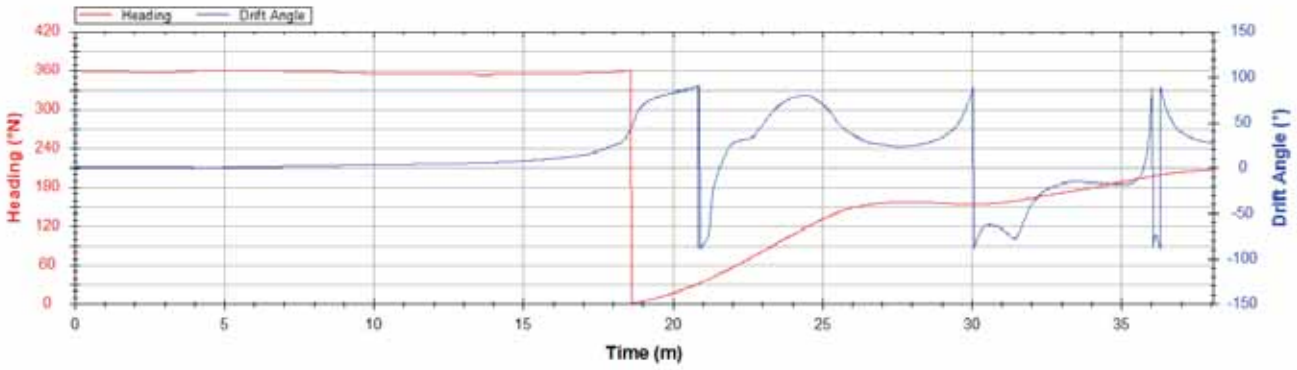
March 2015

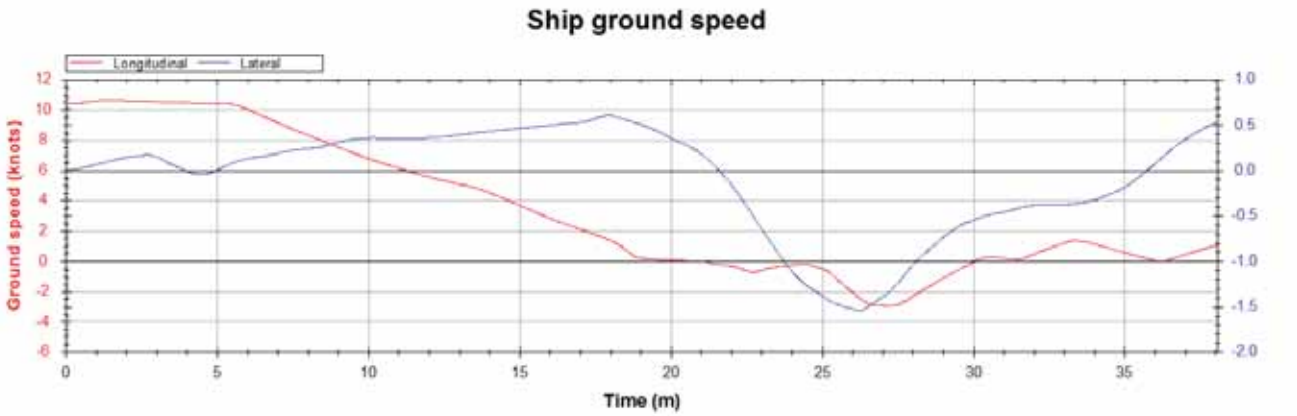
Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

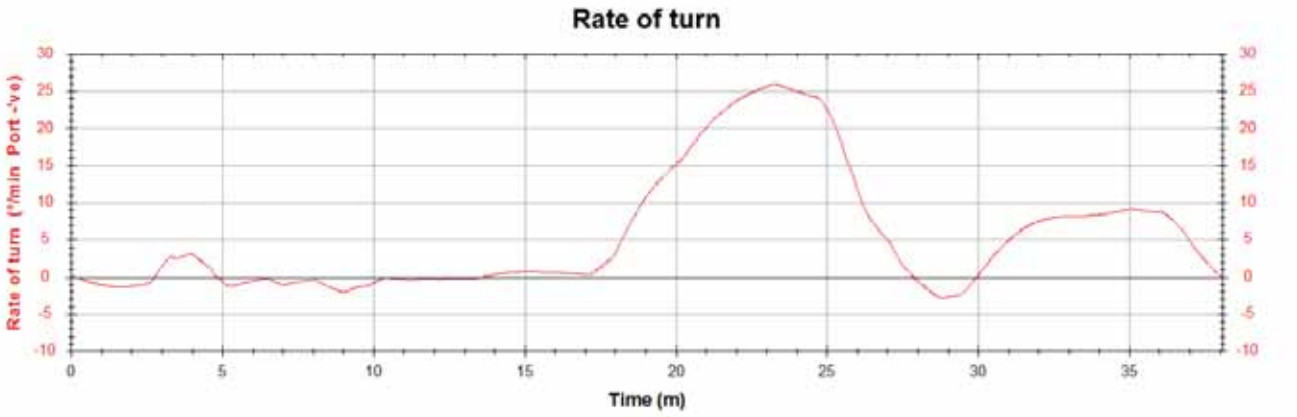


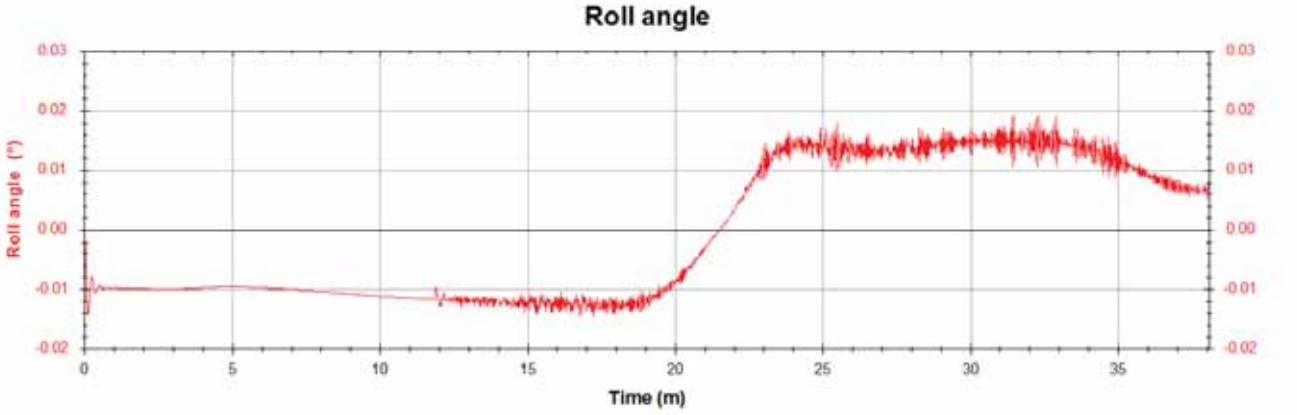
March 2015

Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)





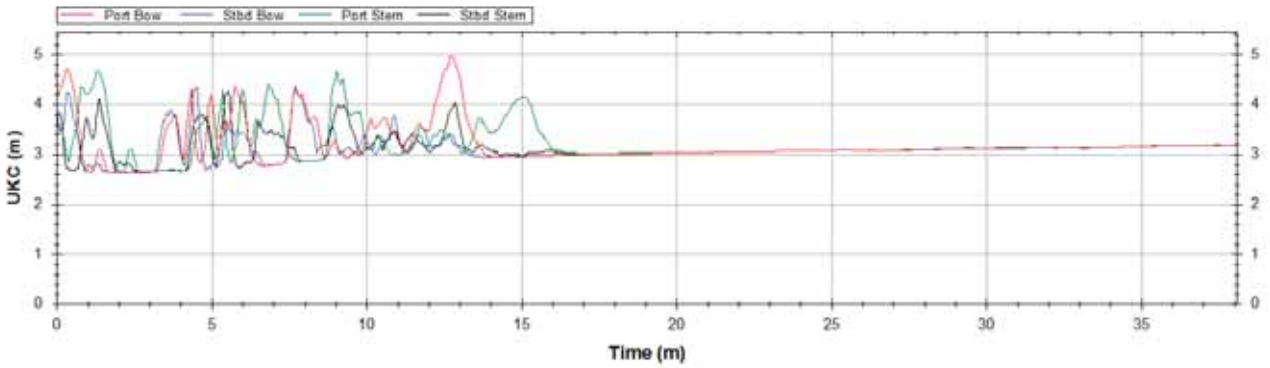




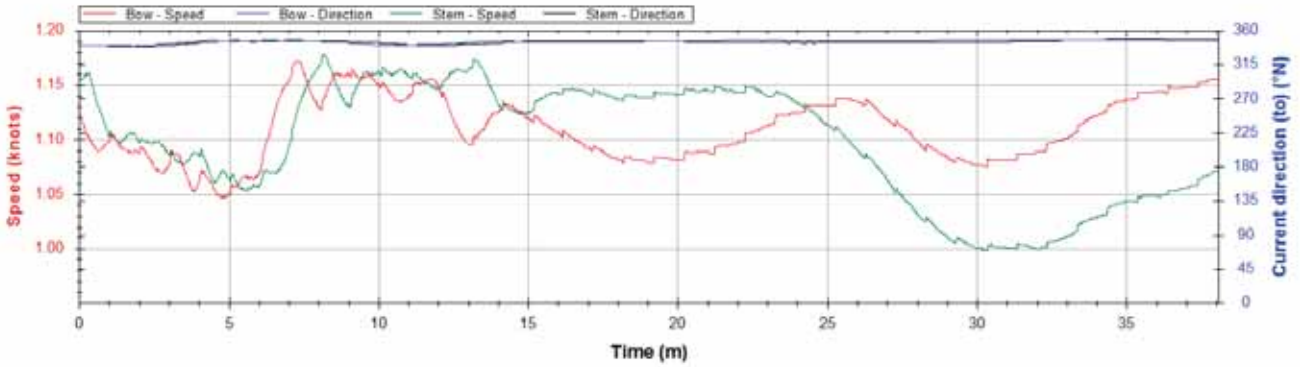
March 2015

Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

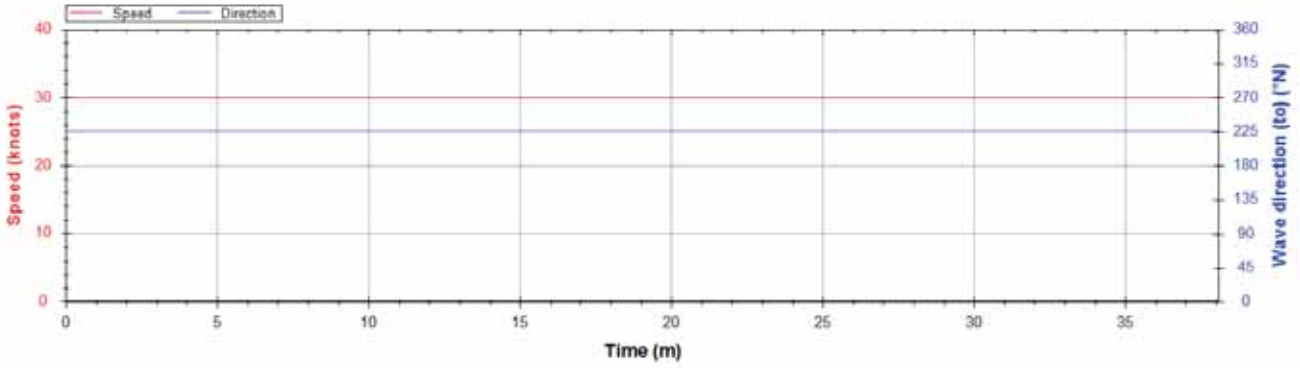
Underkeel clearance



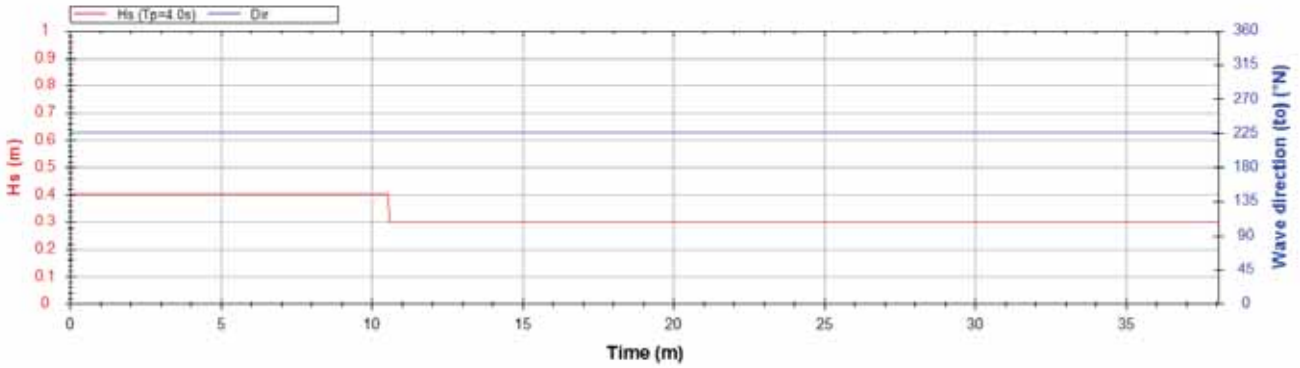
Current speed and direction



Wind speed and direction

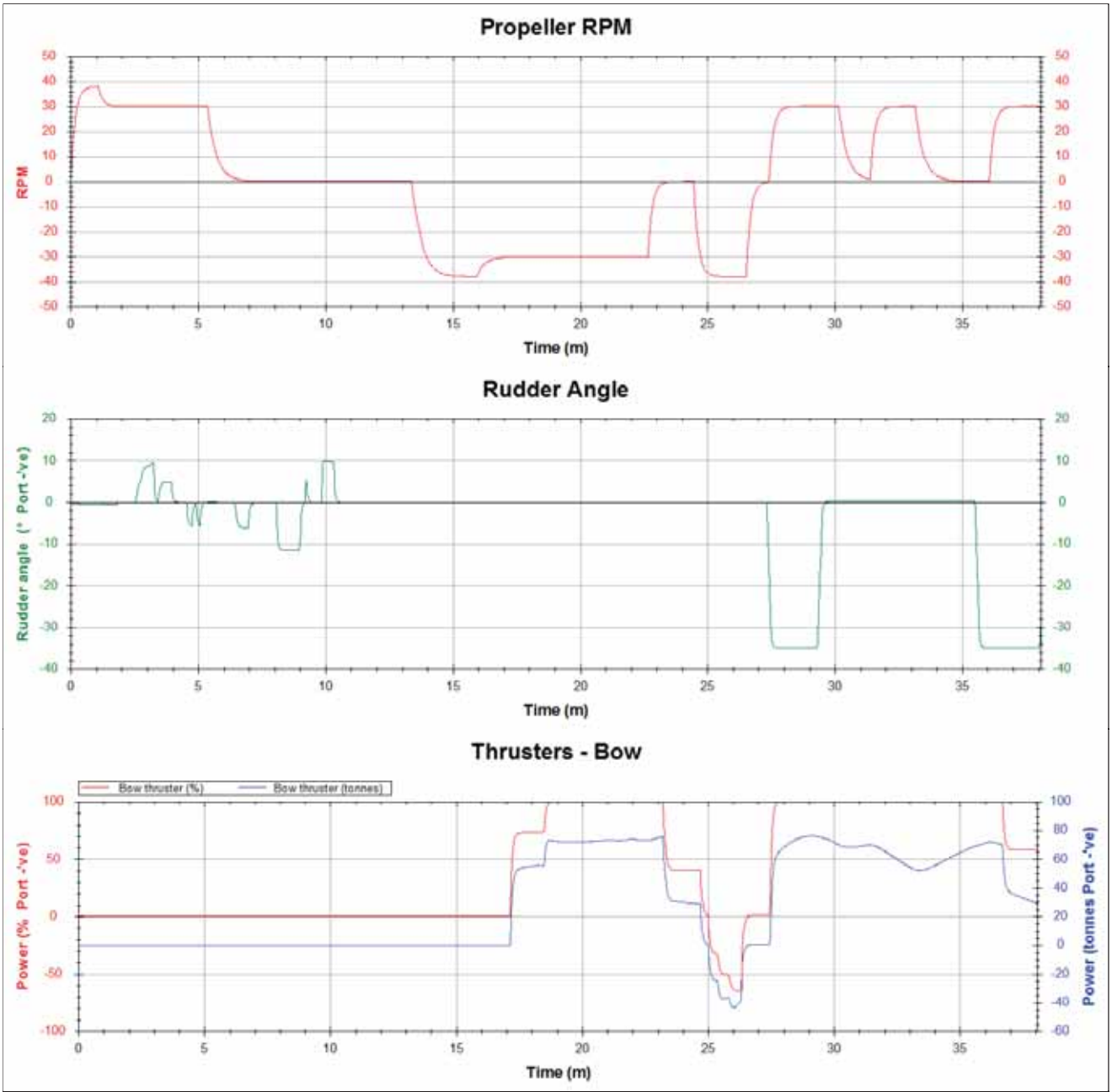


Significant wave height and direction



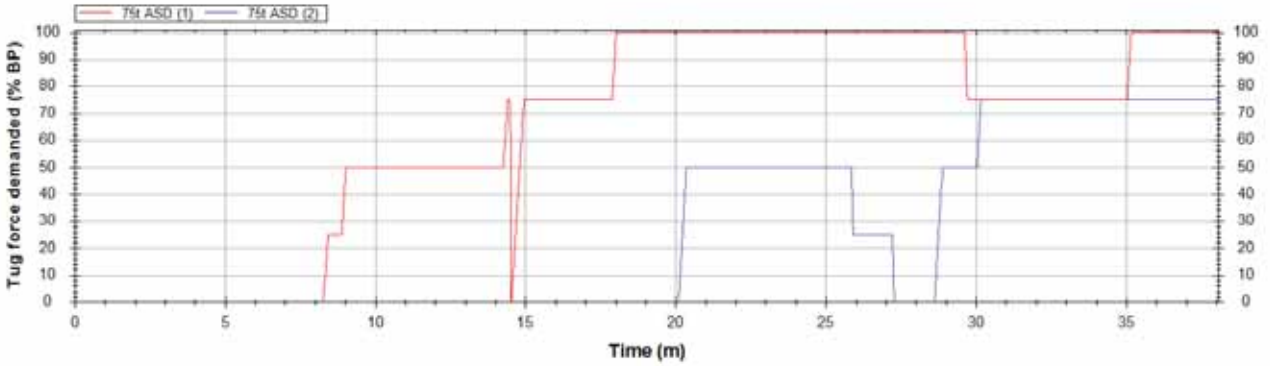
March 2015

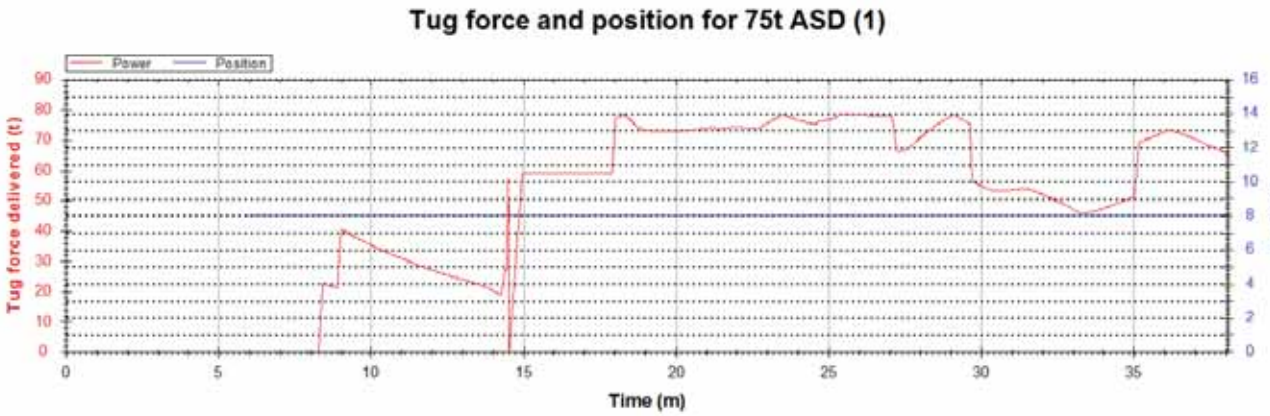
Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

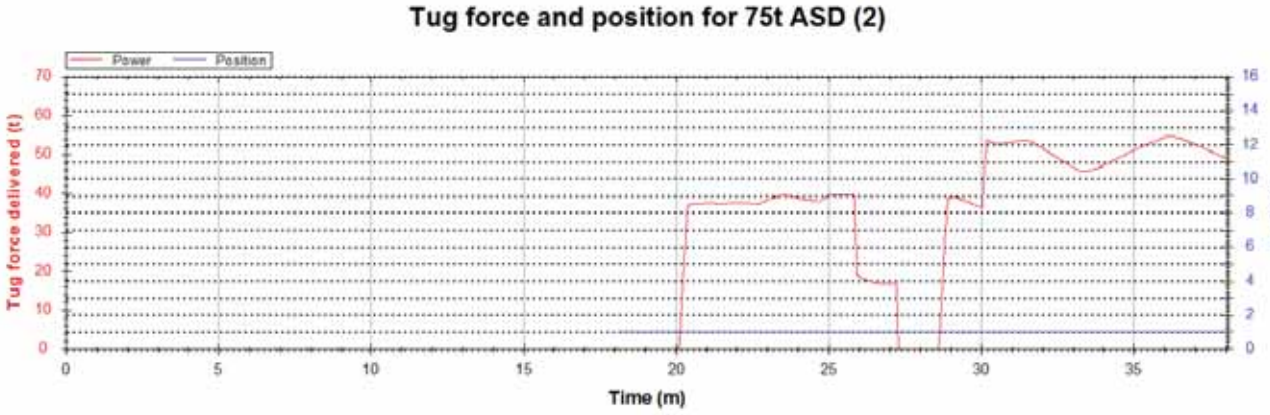


March 2015

Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

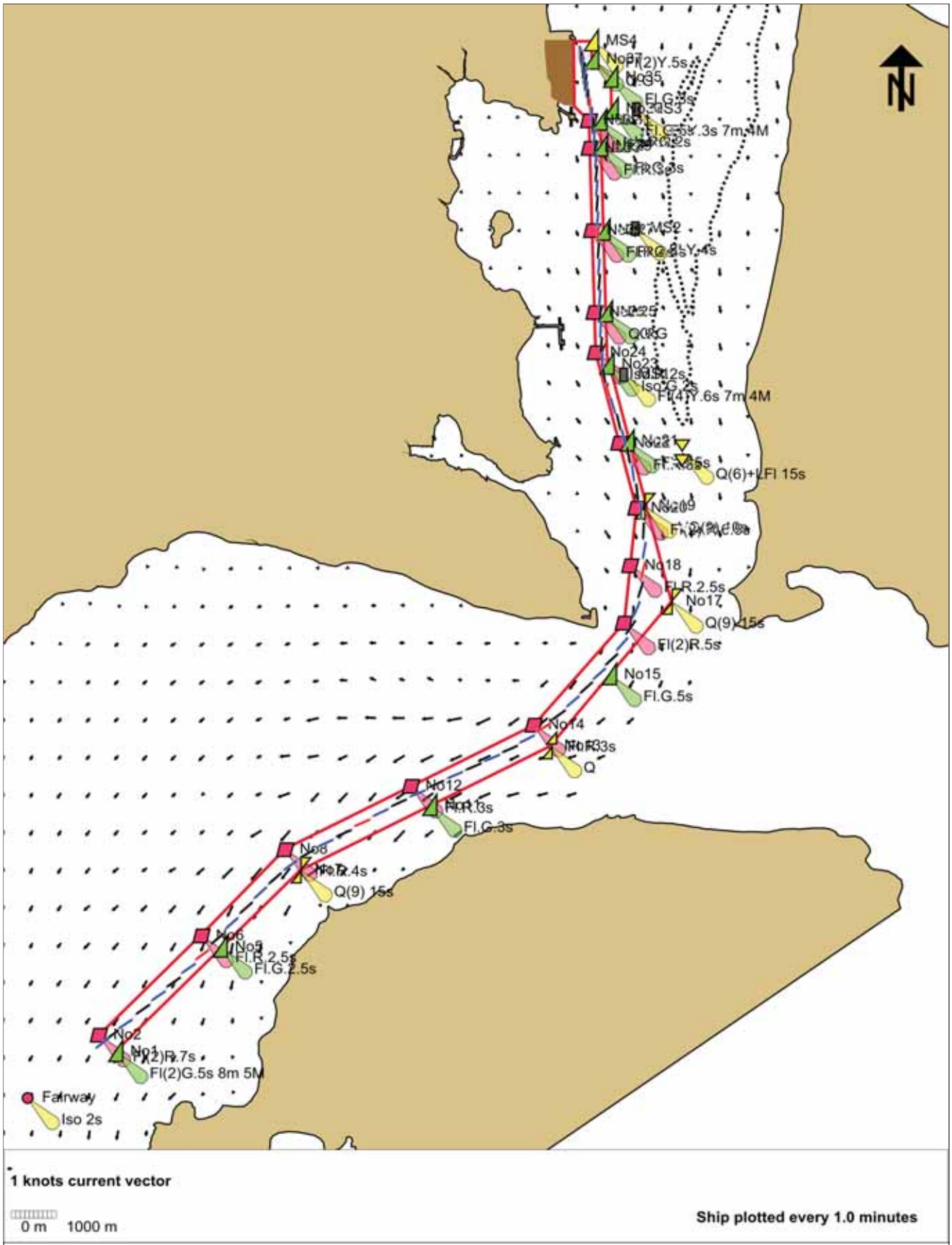






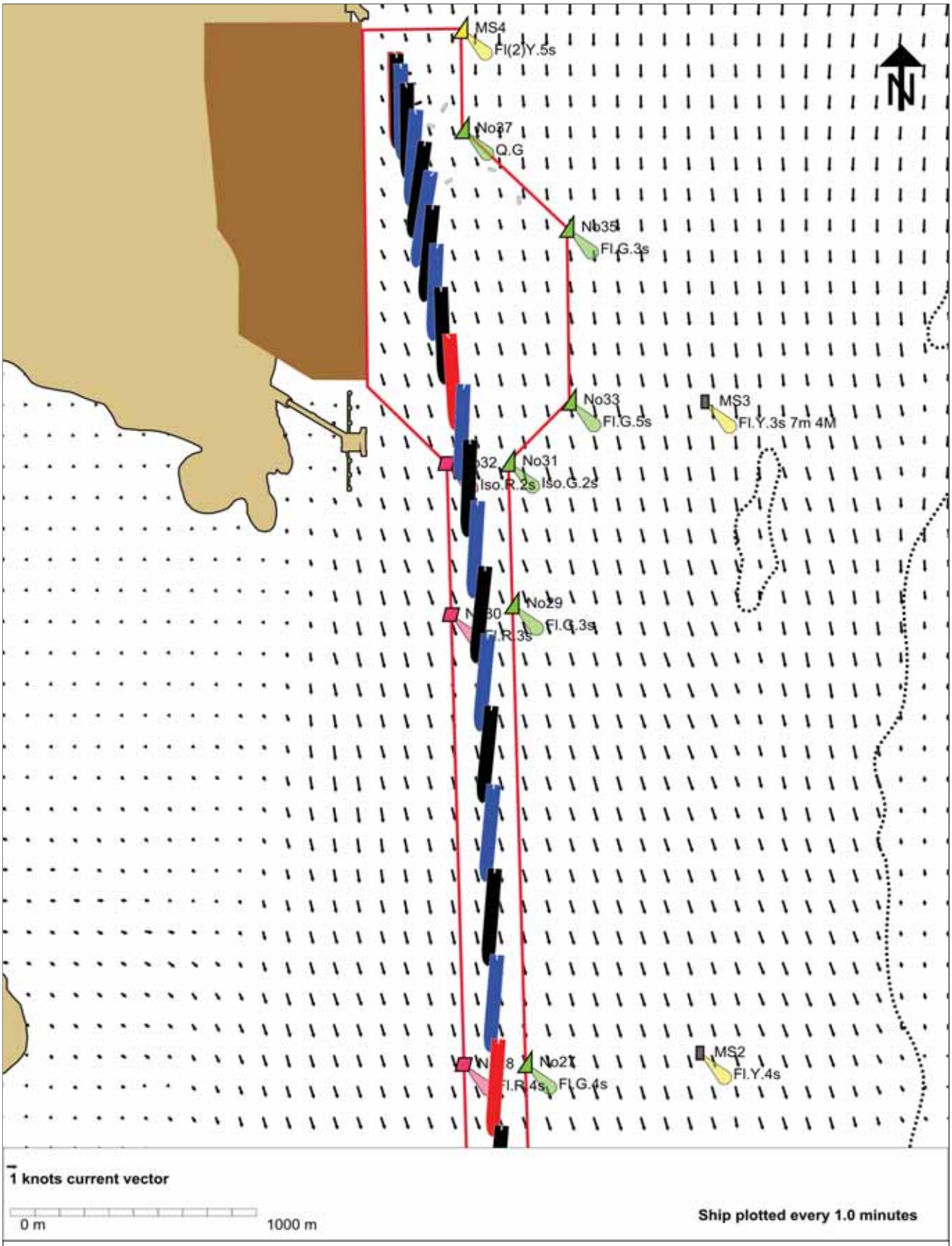
March 2015

Run: 06	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



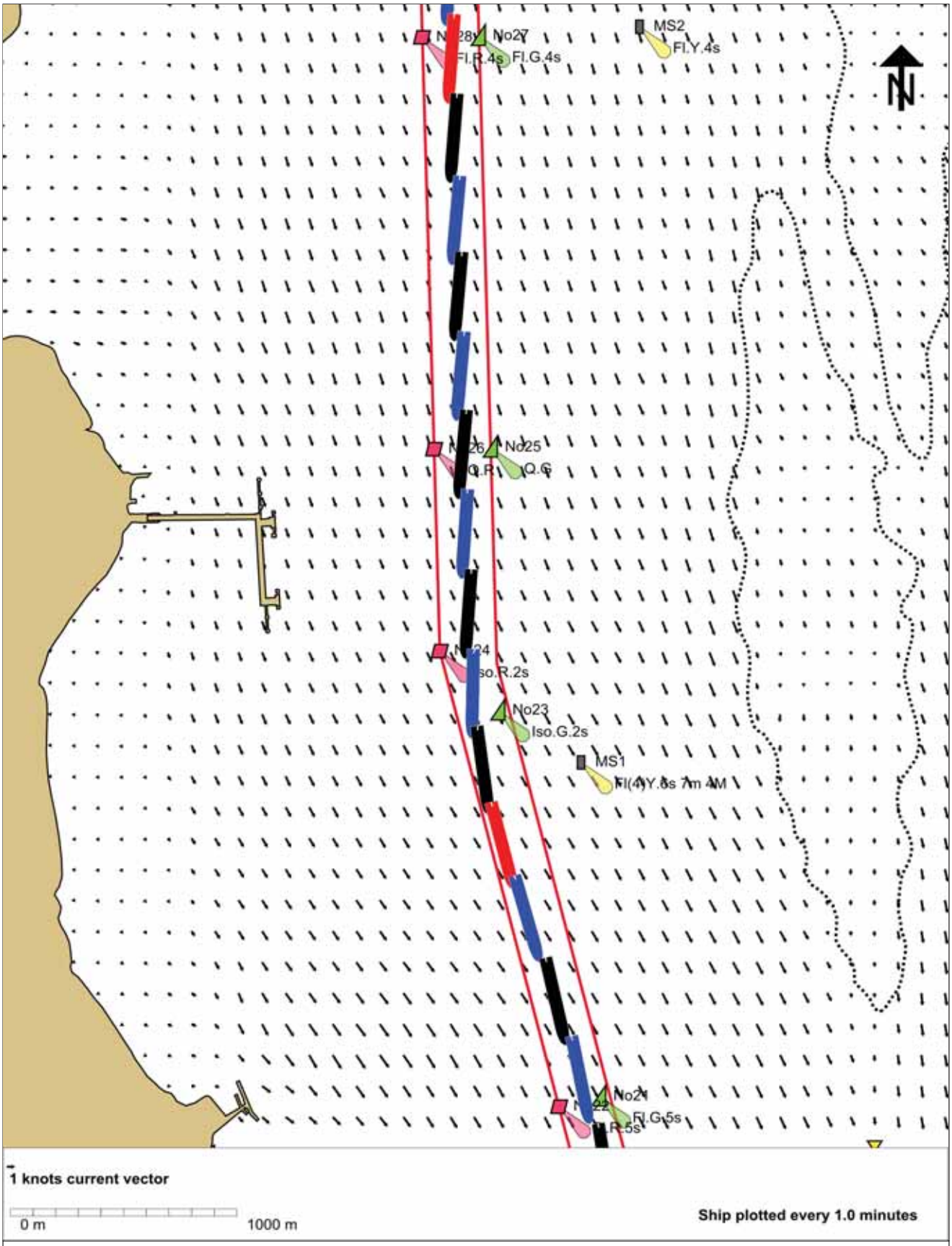
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



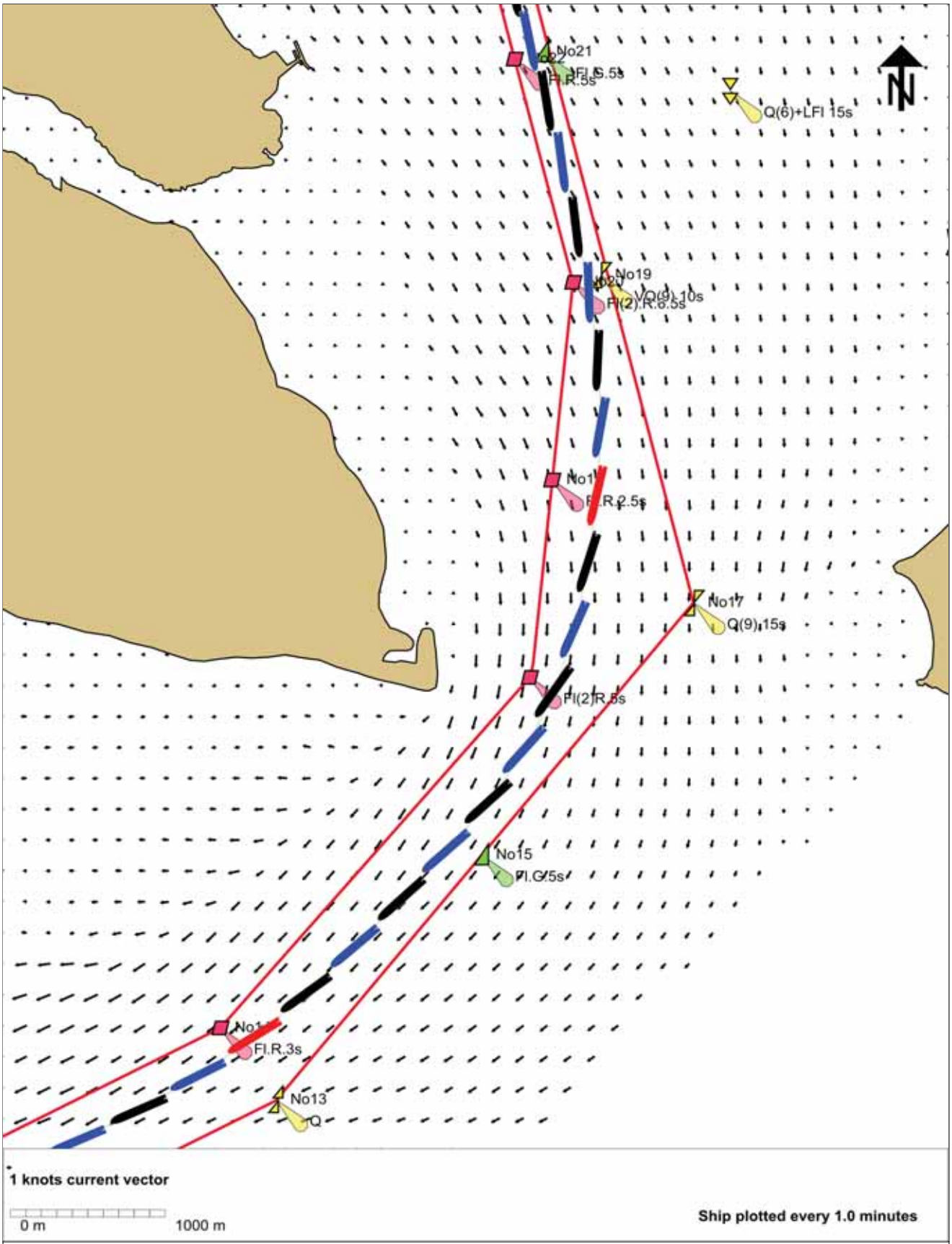
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



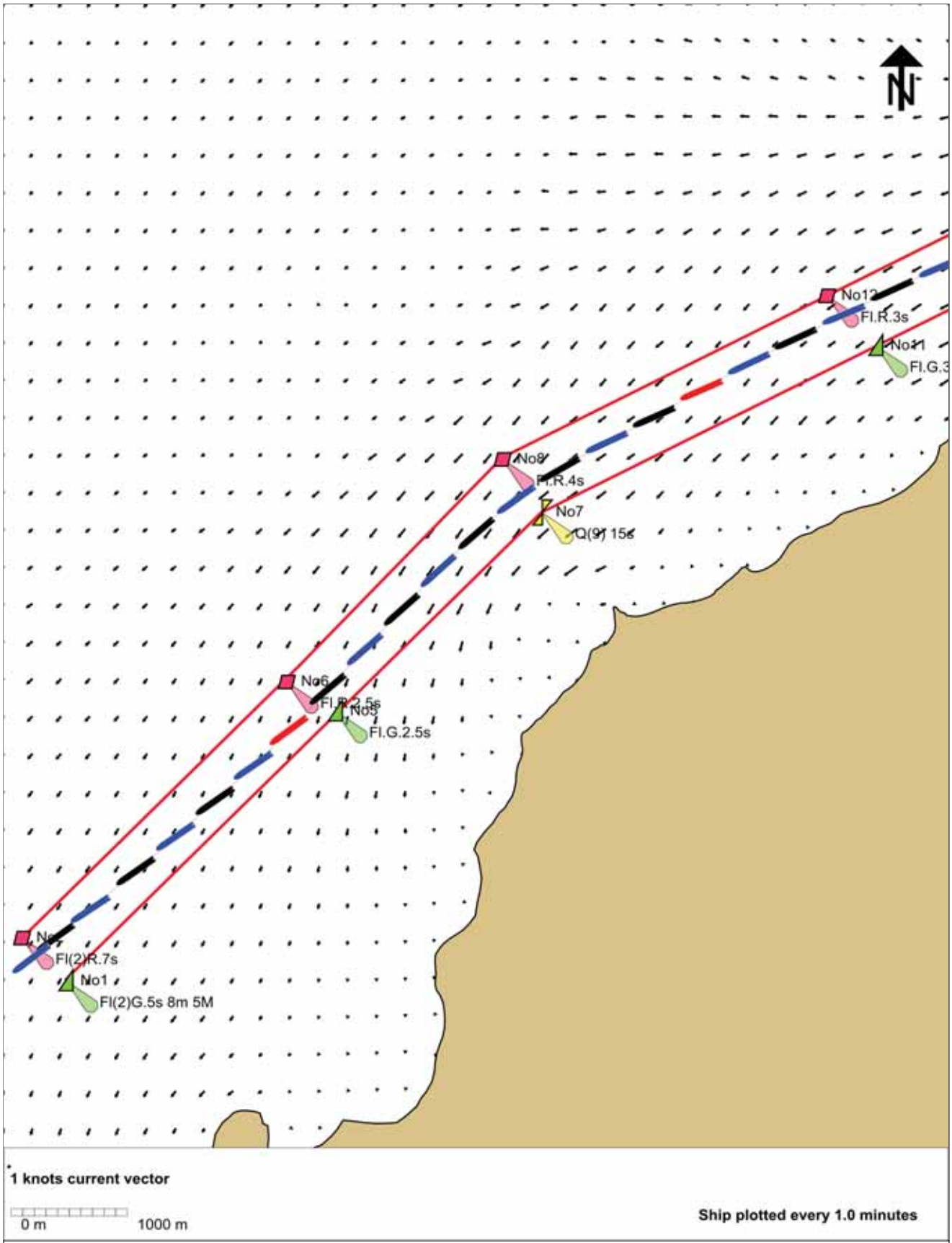
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



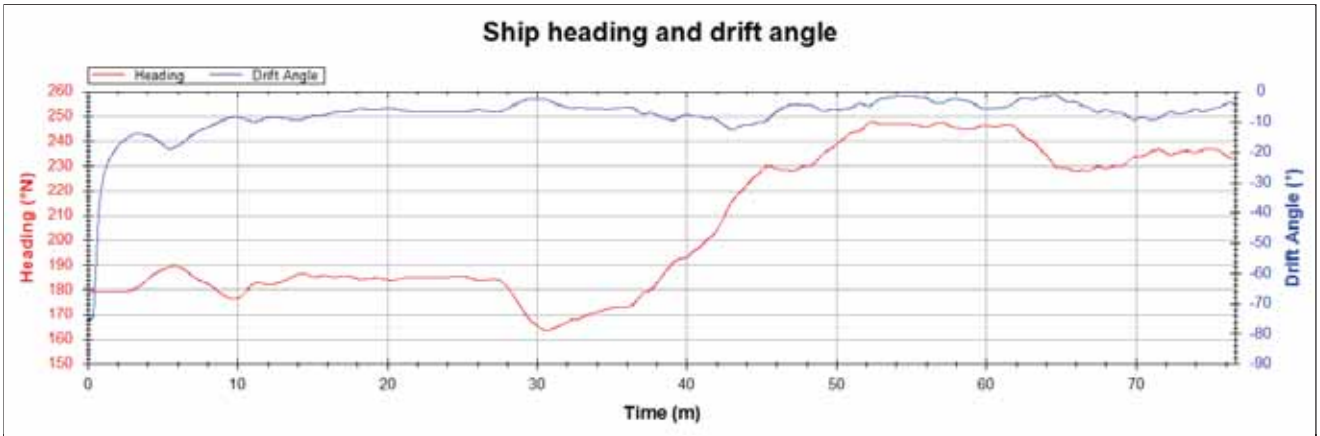
March 2015

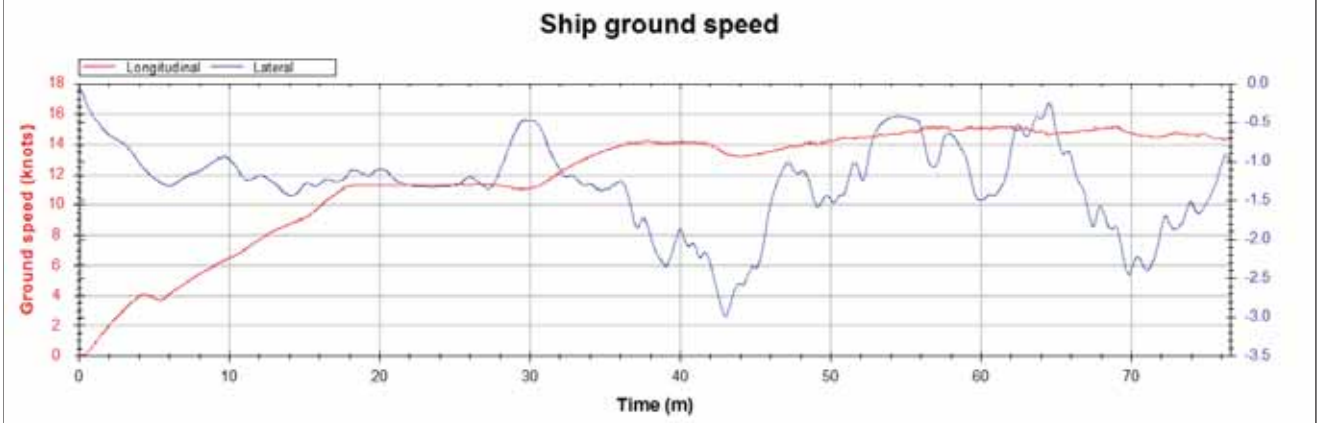
Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

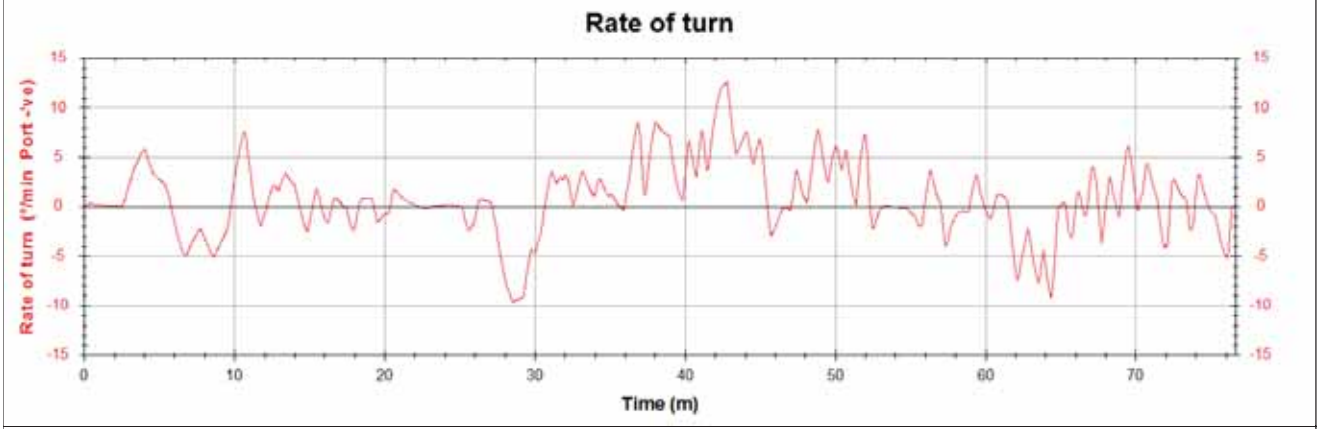


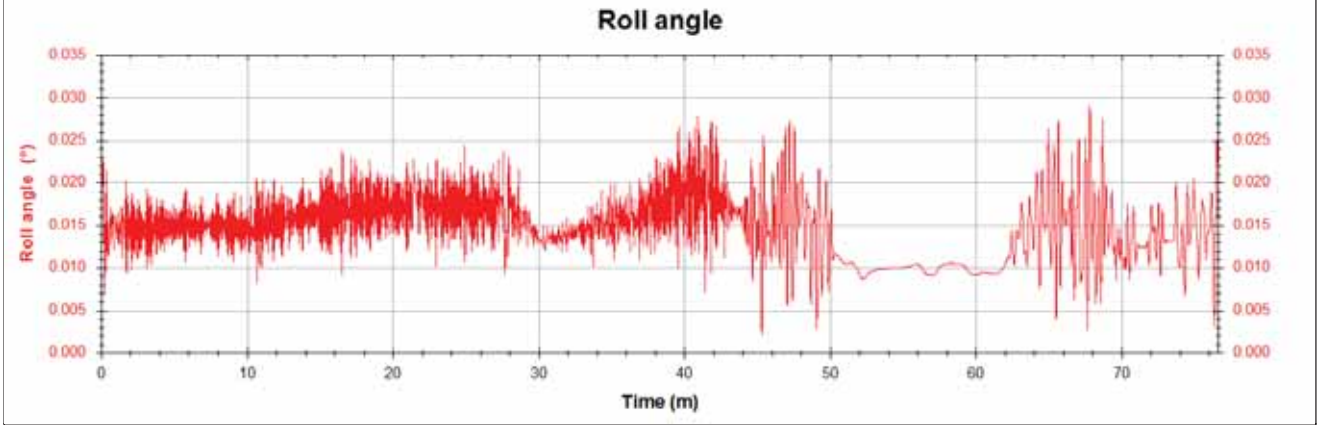
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



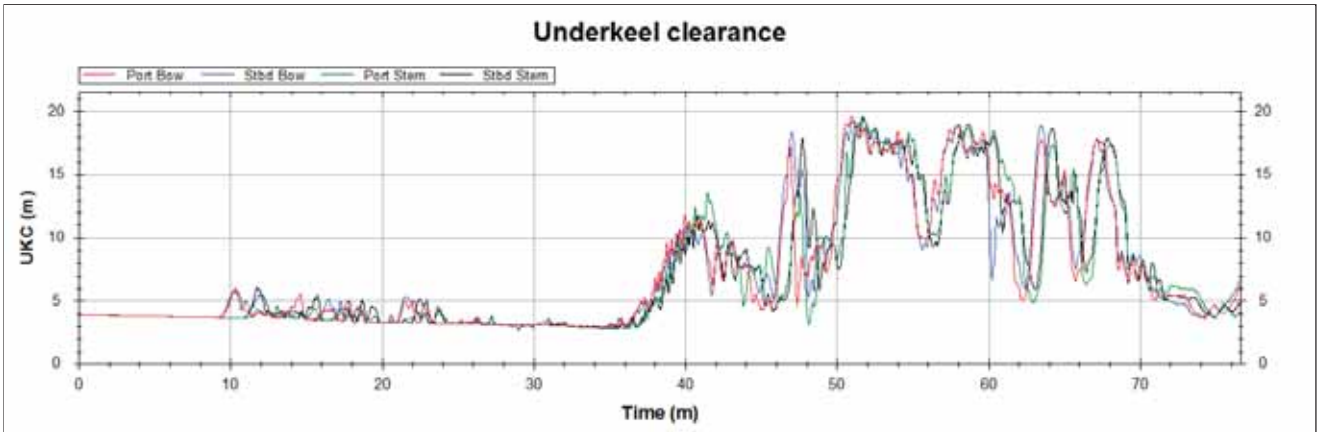


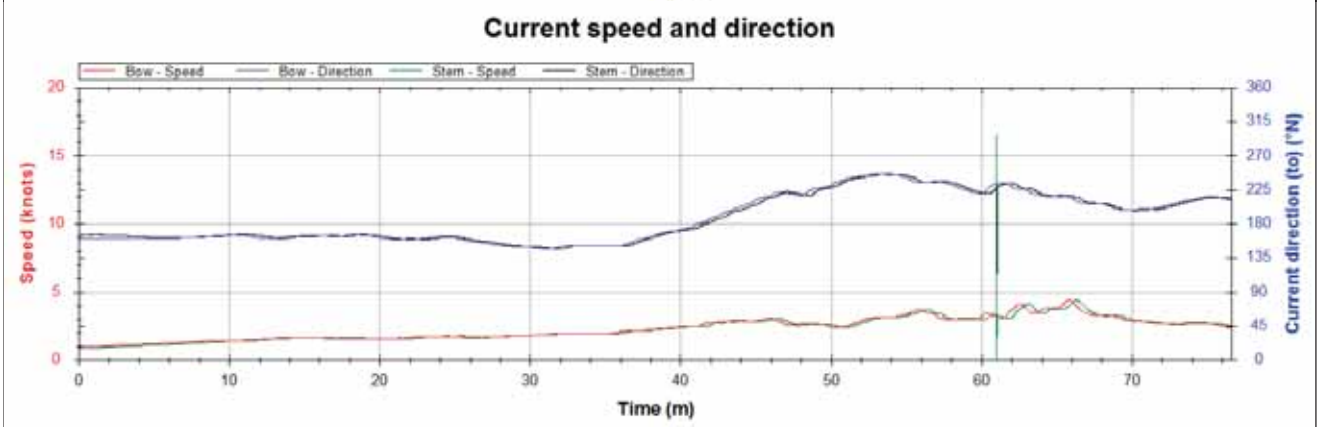


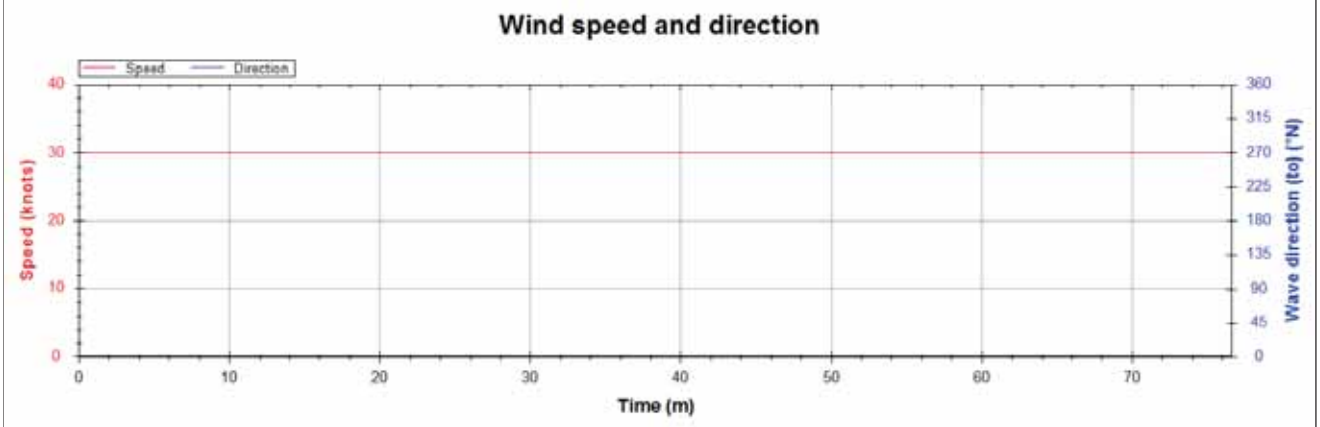


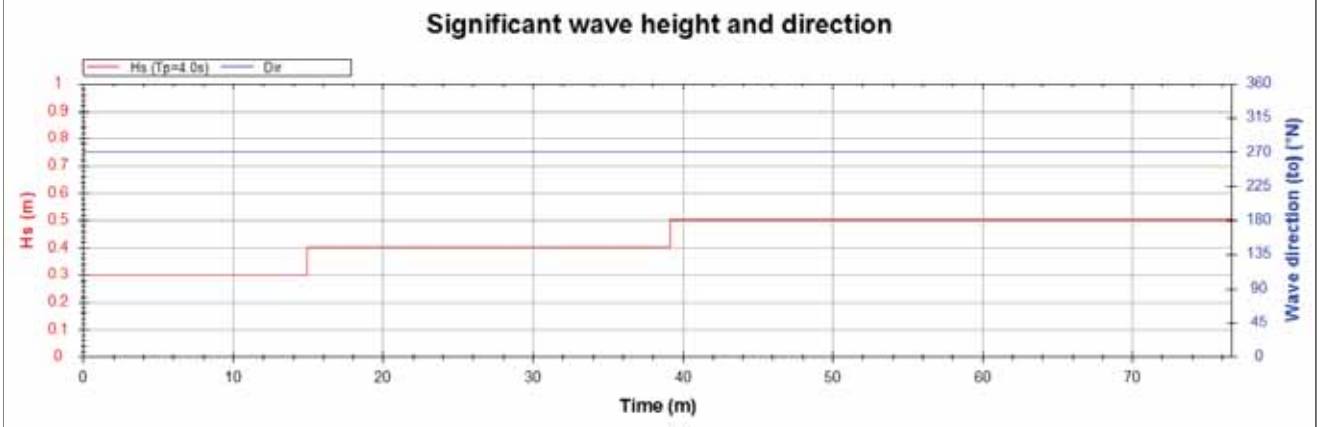
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



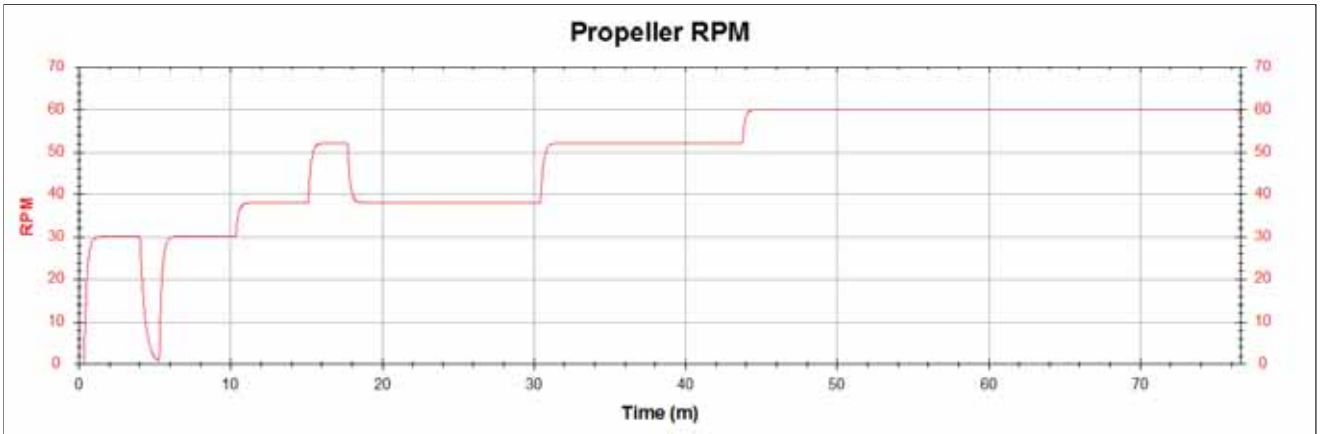


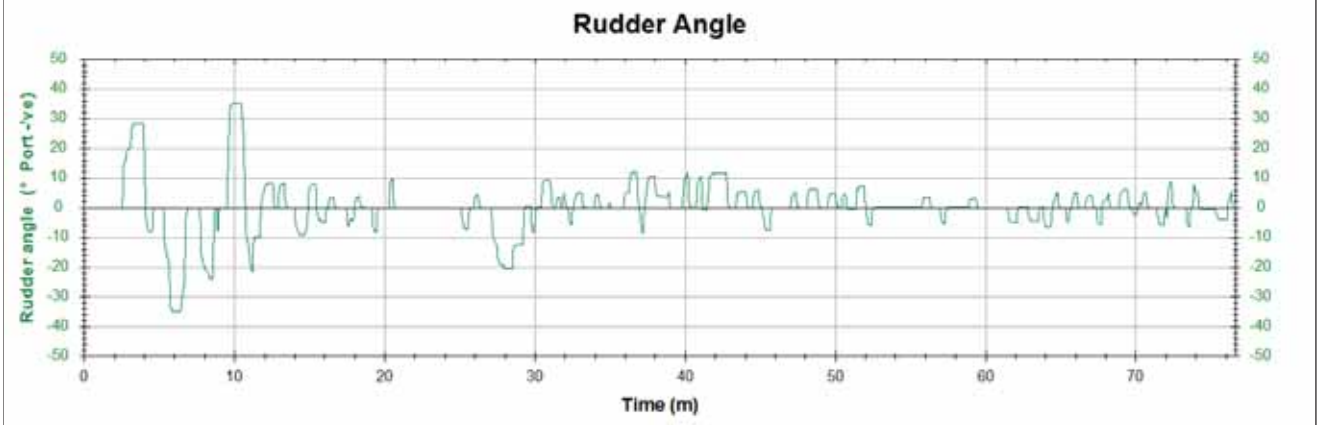


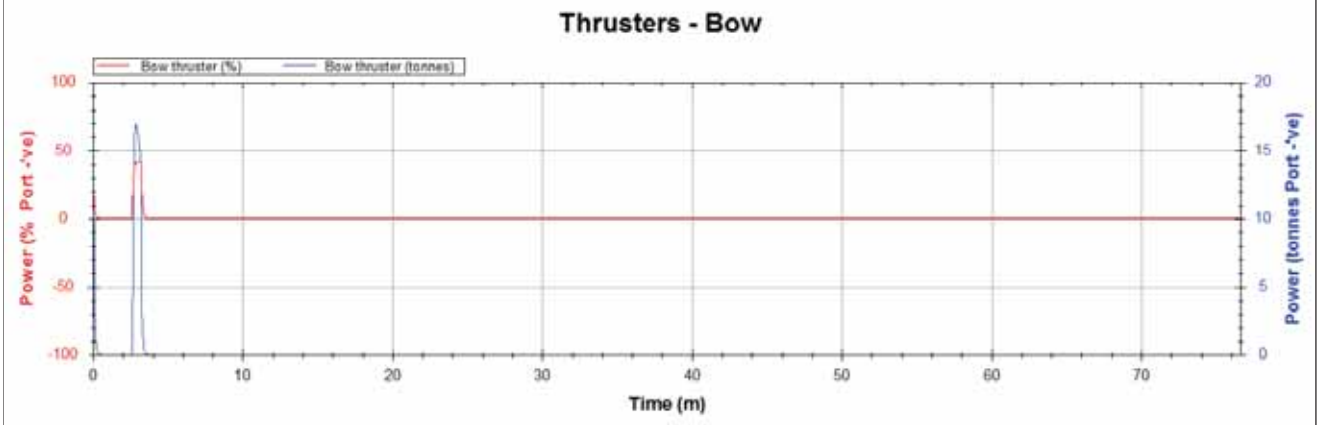


March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

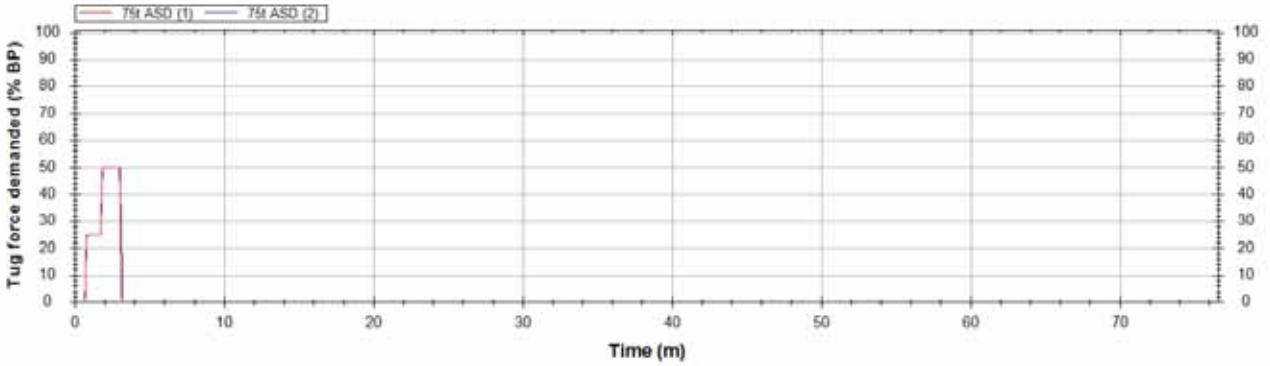


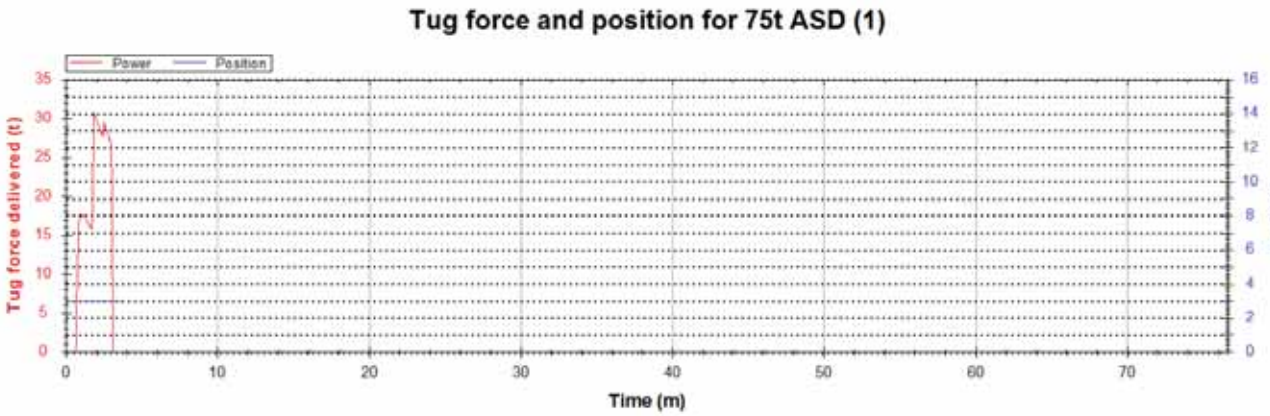


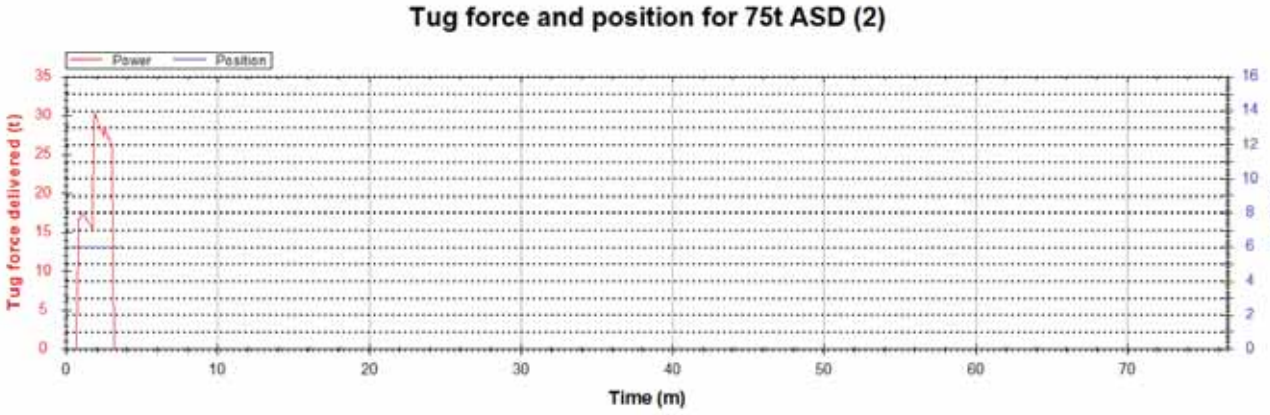


March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)

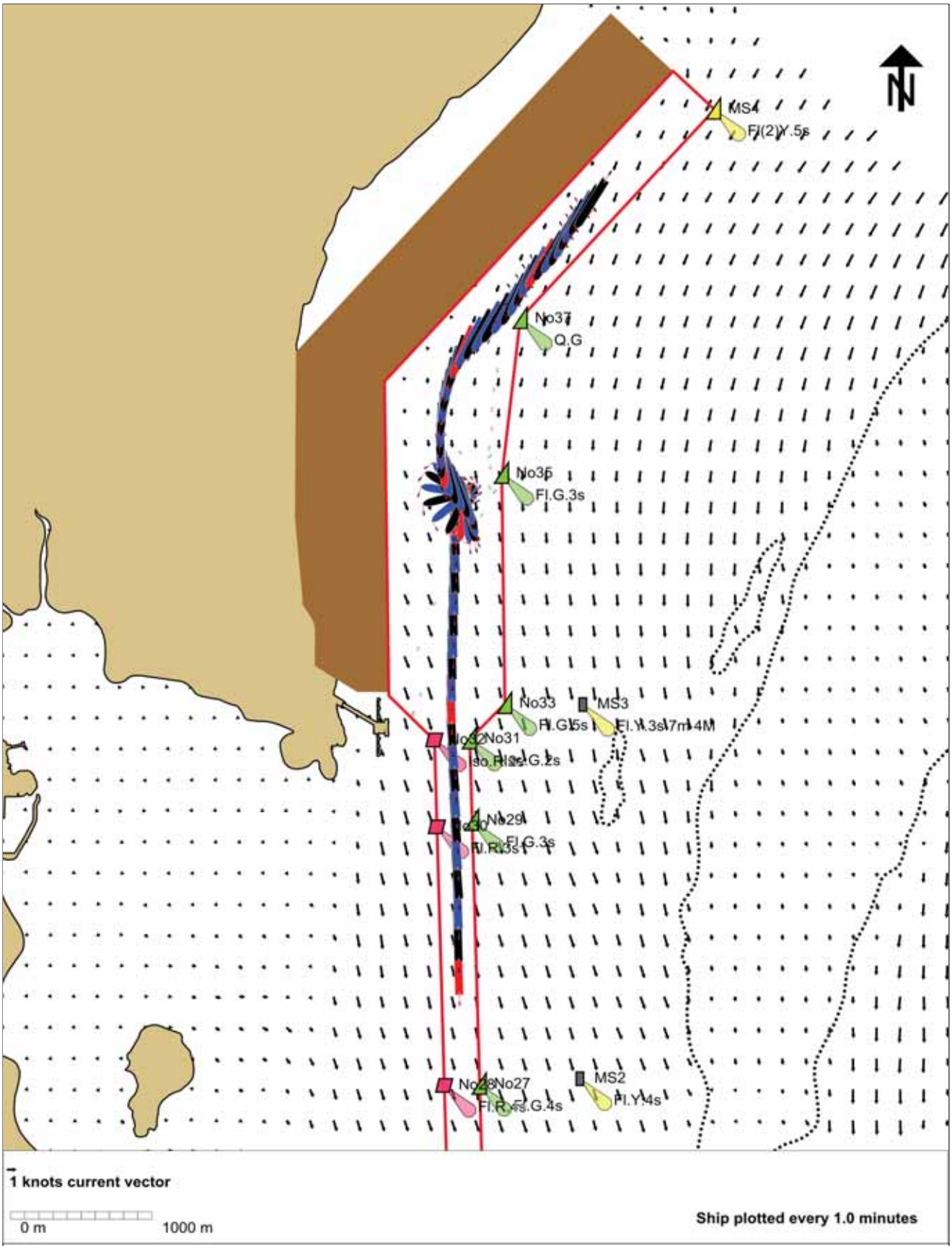






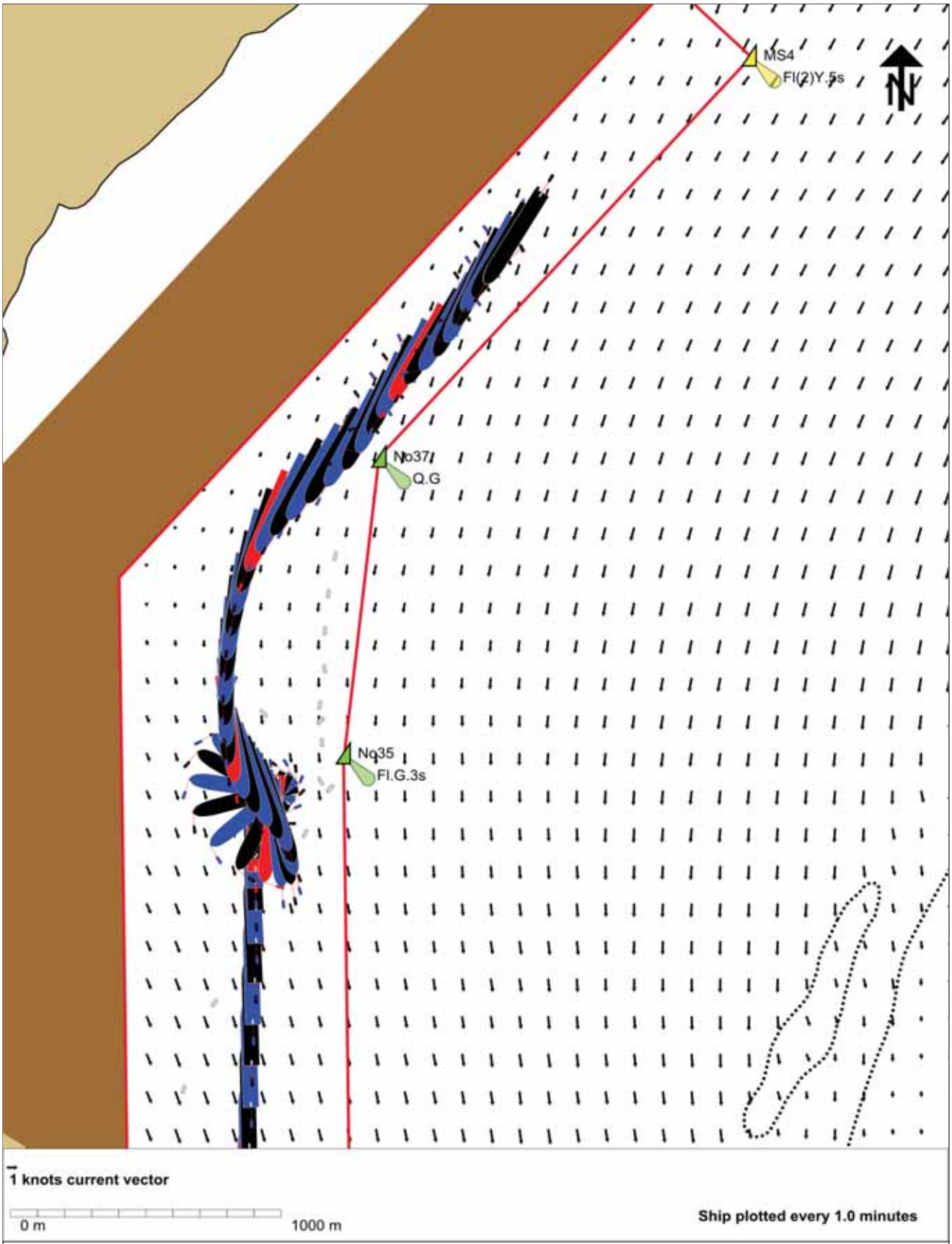
March 2015

Run: 07	Pilot: IS	Ship: 399m Container Ship
Initial wind: 270°N 30 knots	Configuration: Stage 1 south	Type (Condition): Container (Laden)



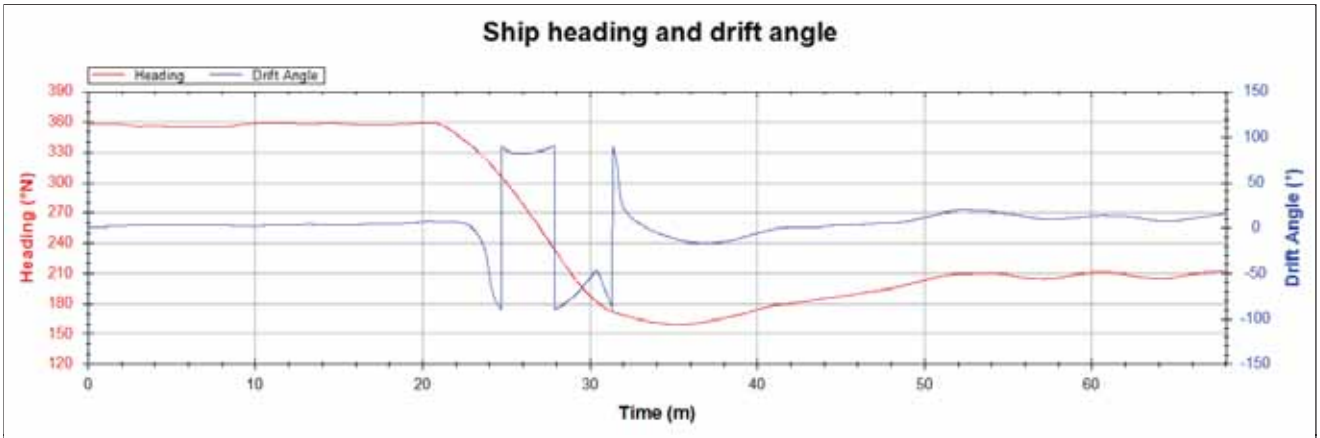
March 2015

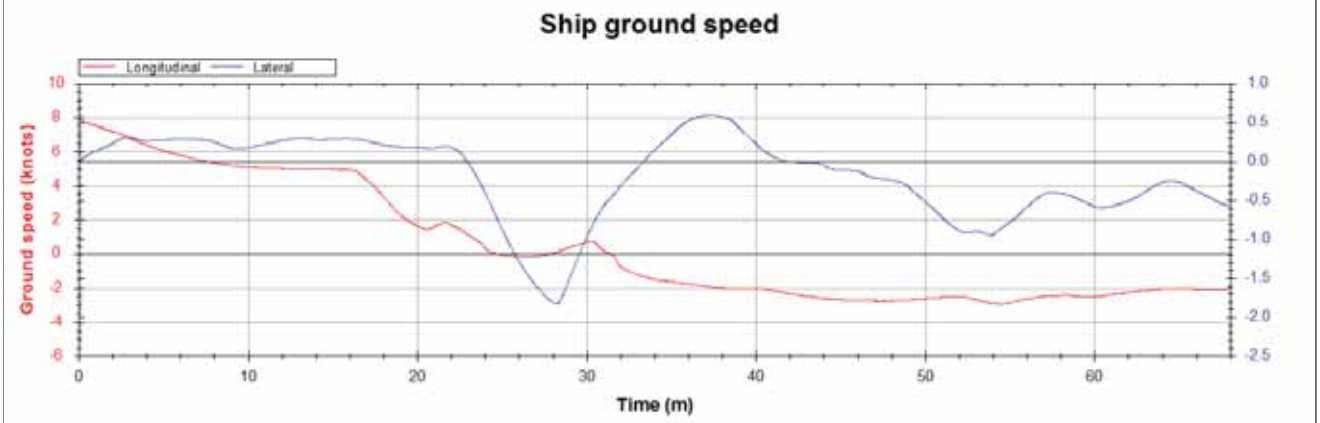
Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)

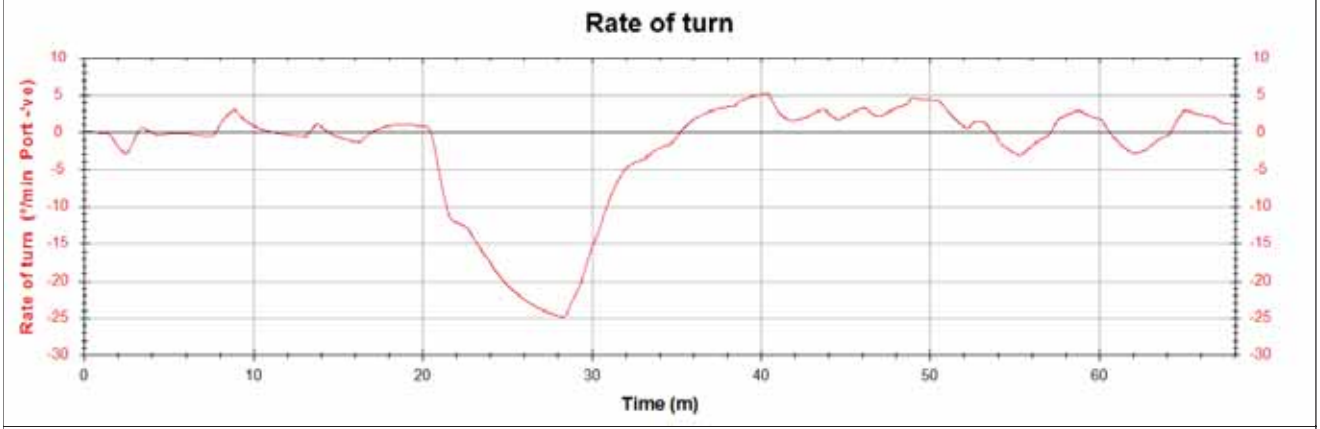


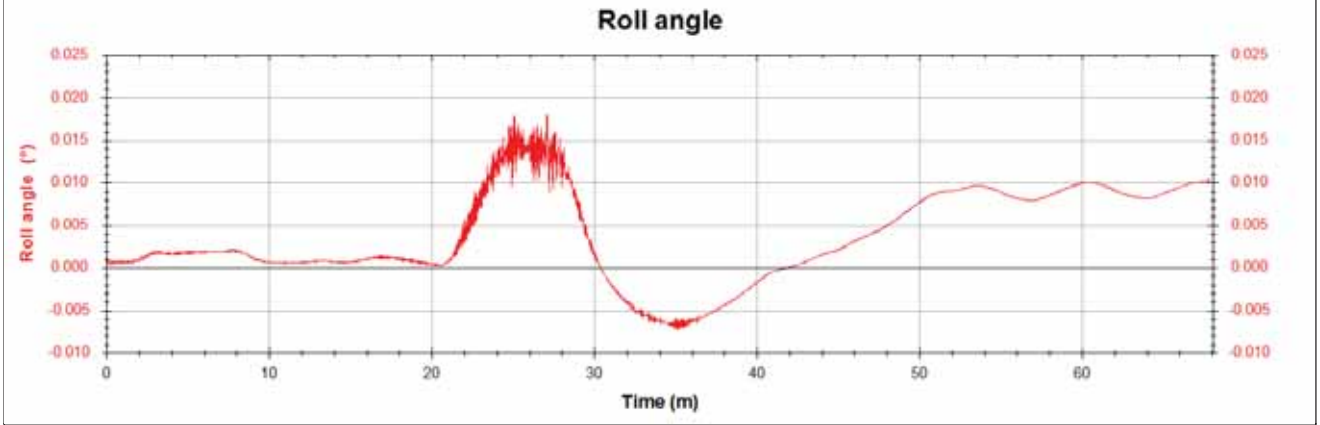
March 2015

Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



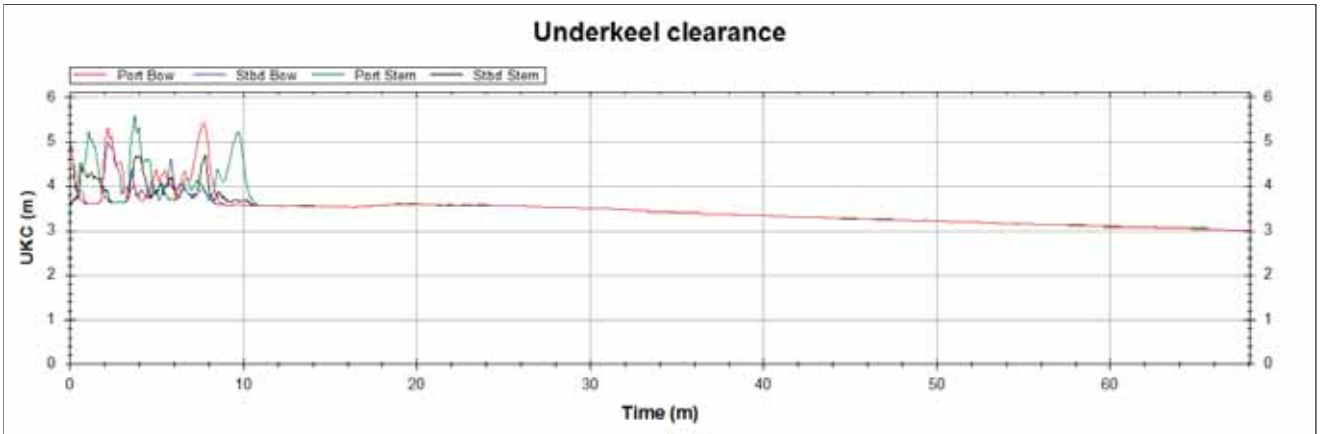


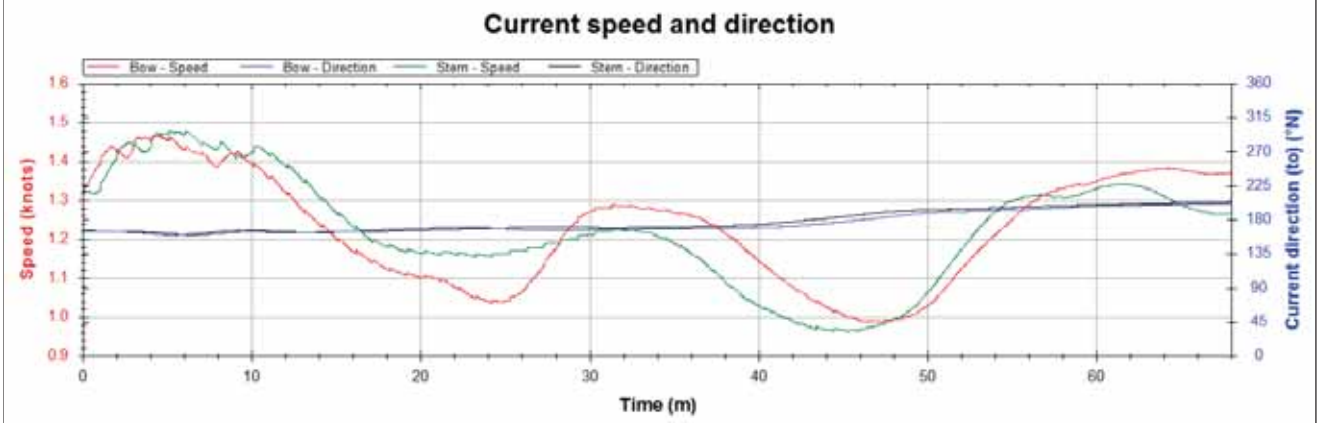


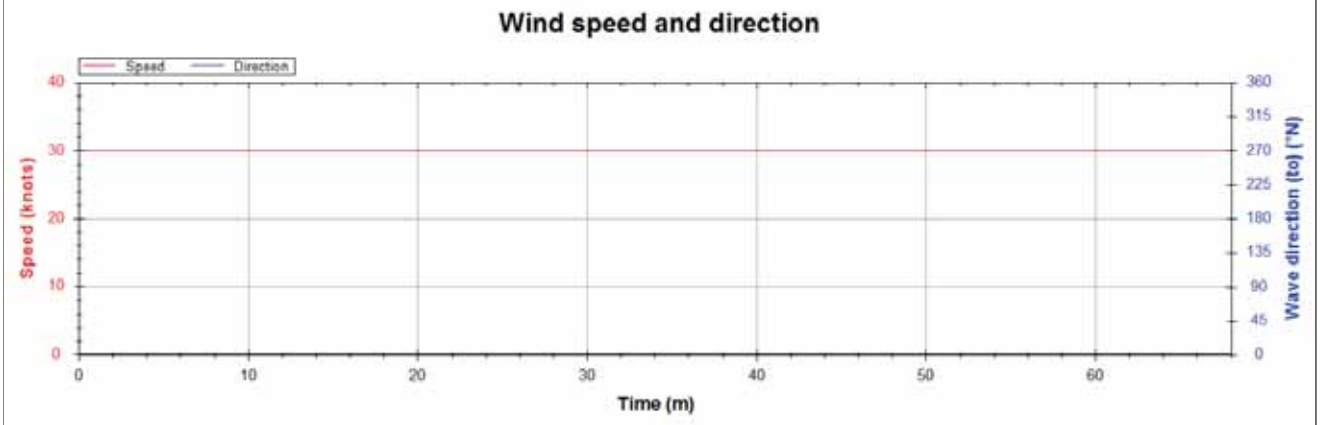


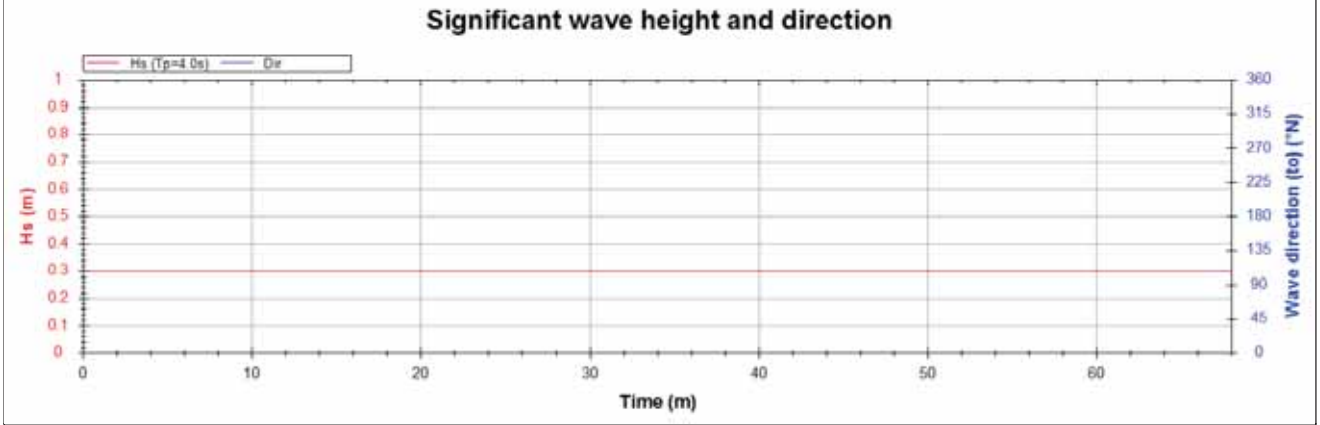
March 2015

Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



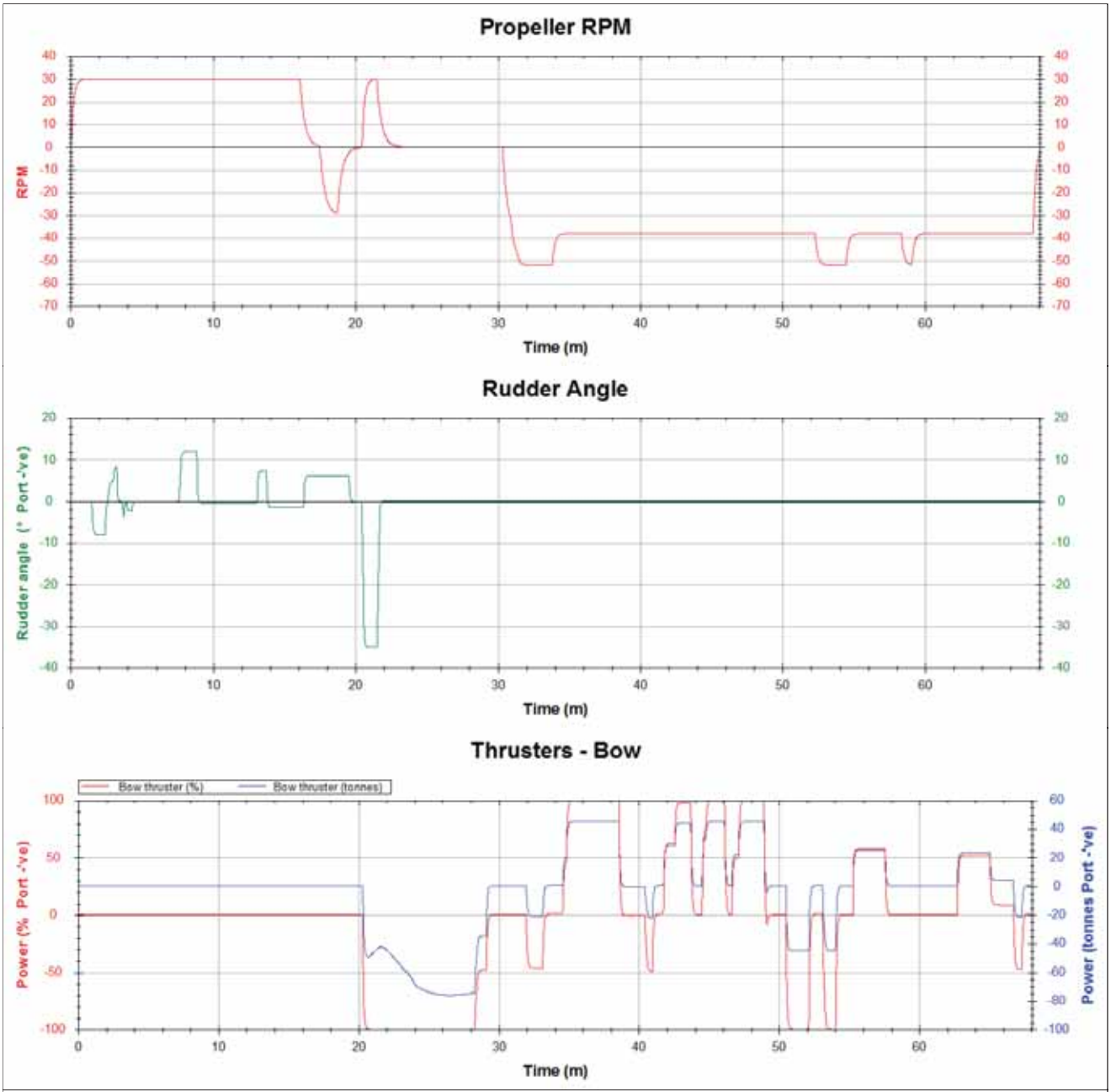






March 2015

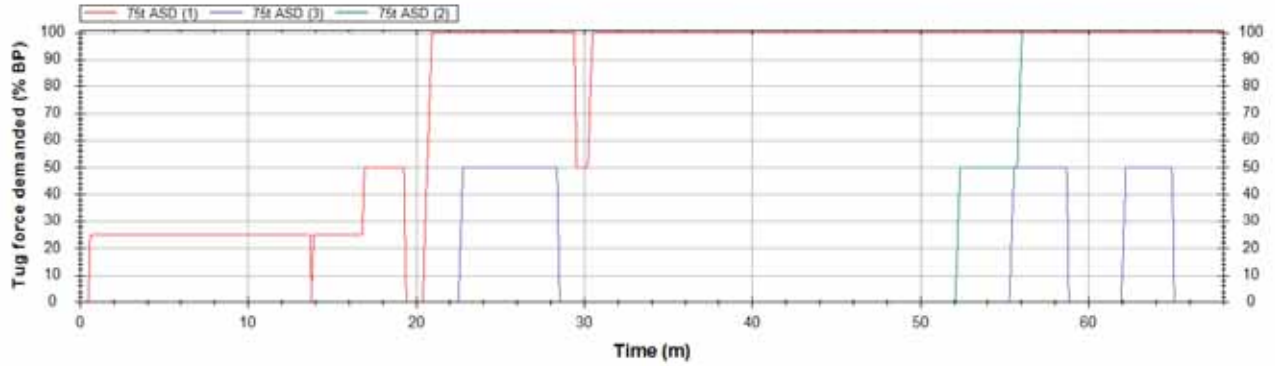
Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



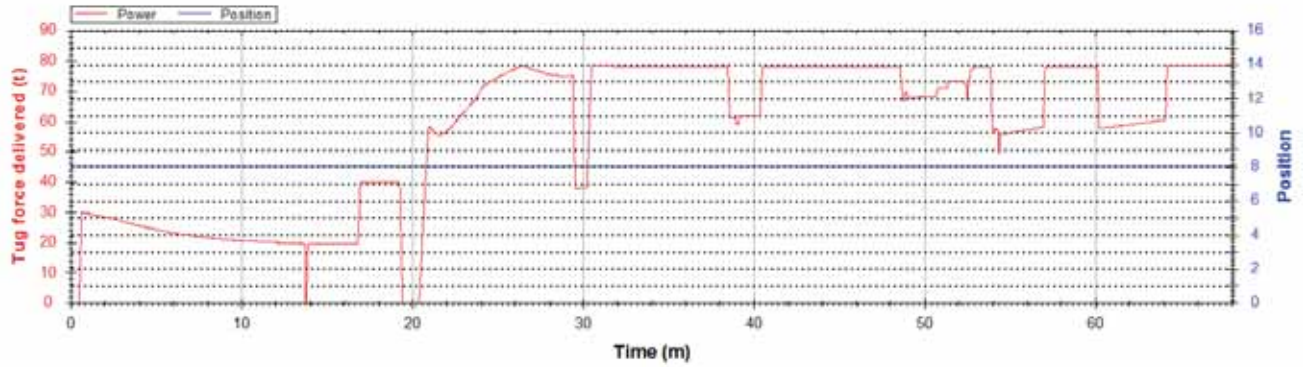
March 2015

Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)

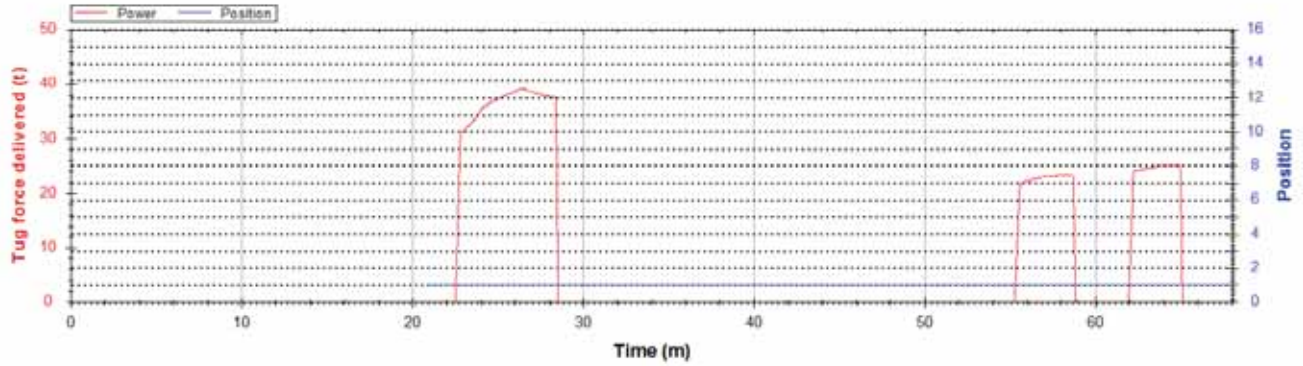
Tug forces



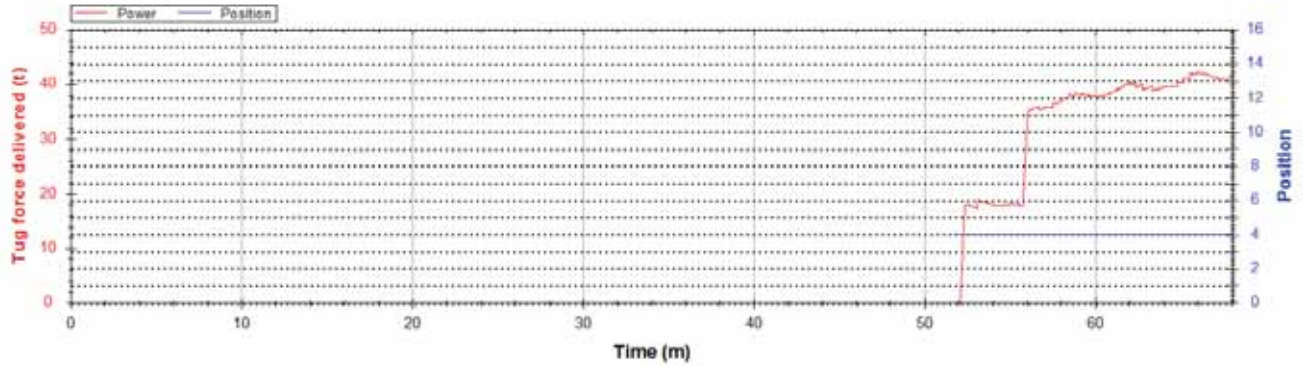
Tug force and position for 75t ASD (1)



Tug force and position for 75t ASD (3)

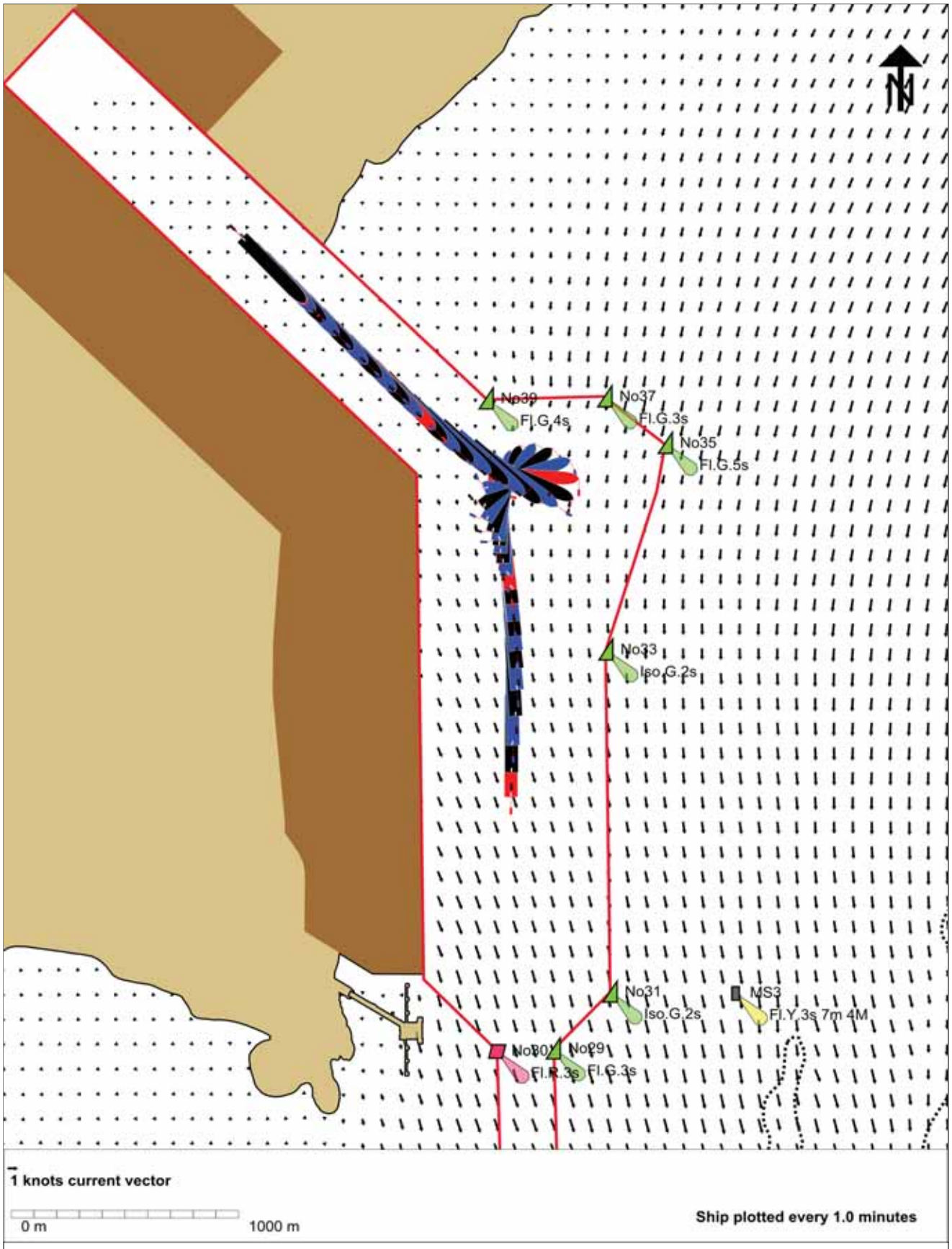


Tug force and position for 75t ASD (2)



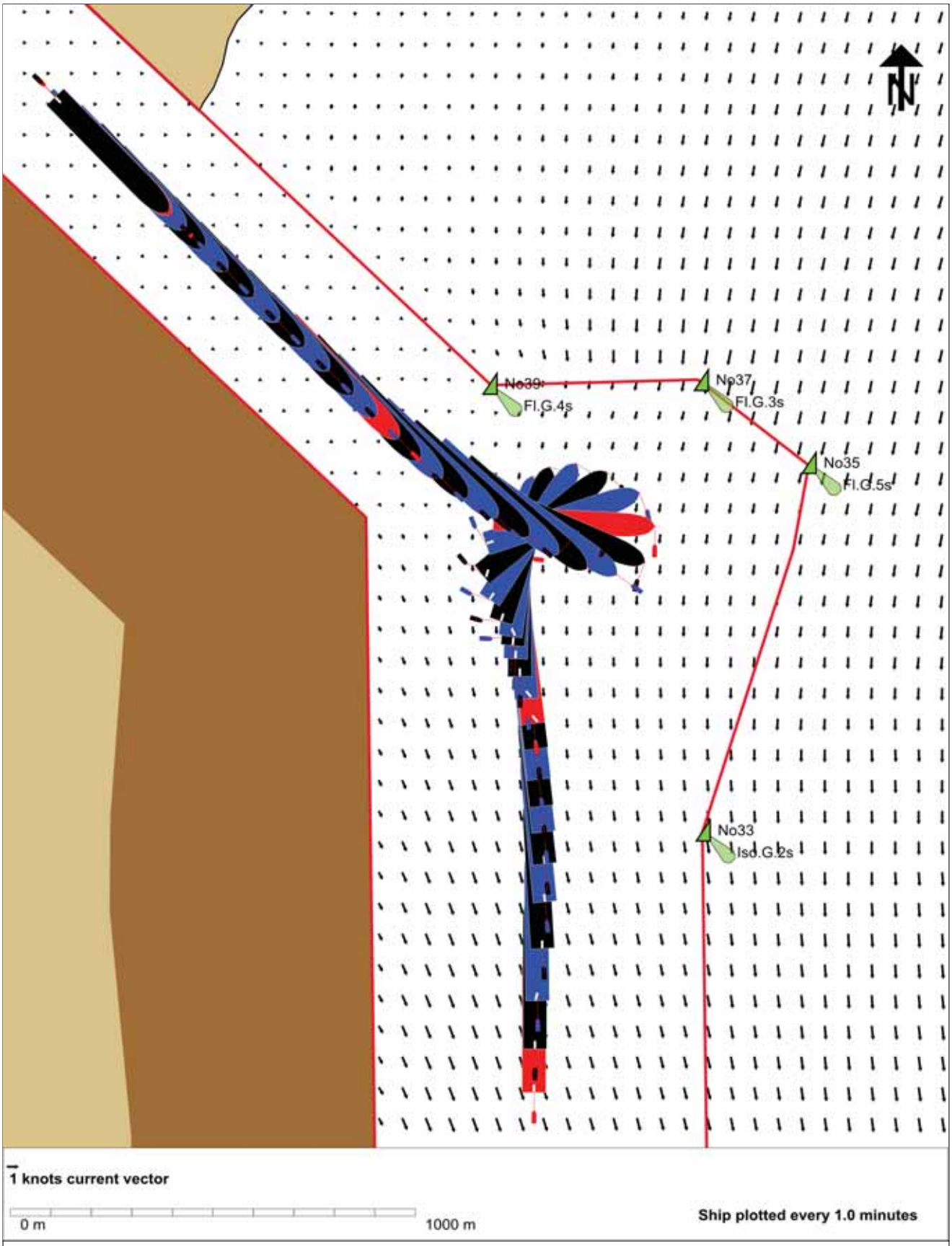
March 2015

Run: 08	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



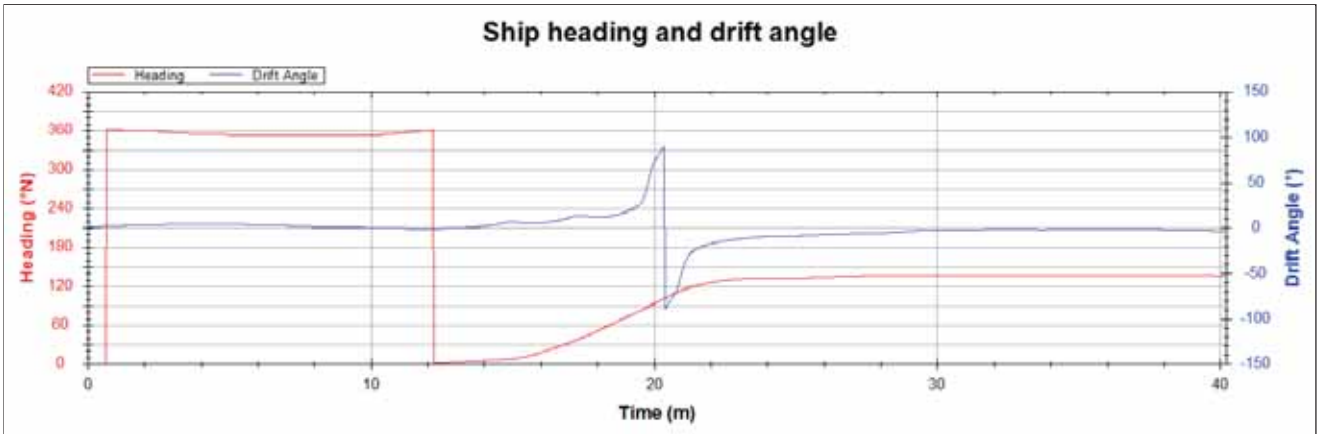
March 2015

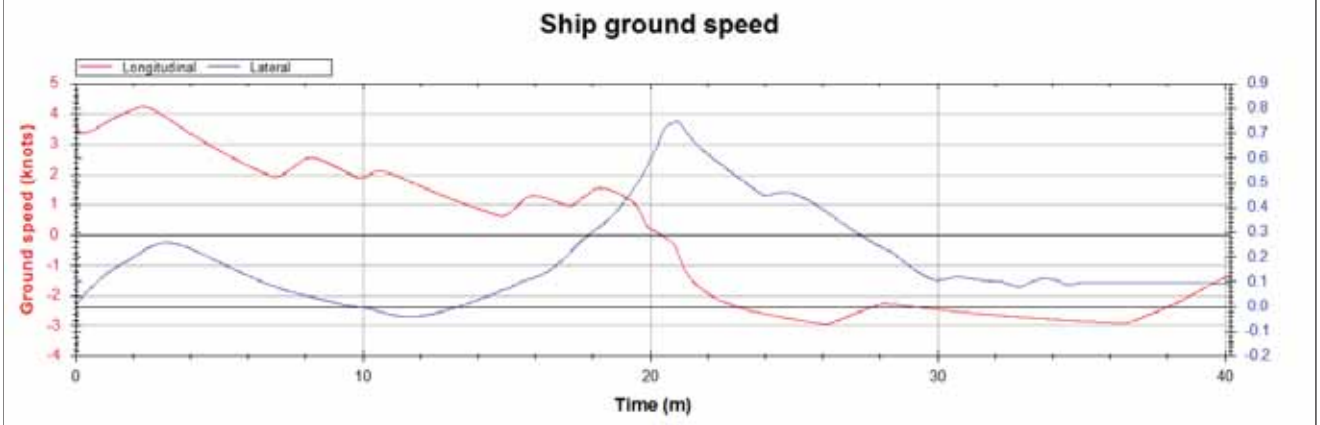
Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

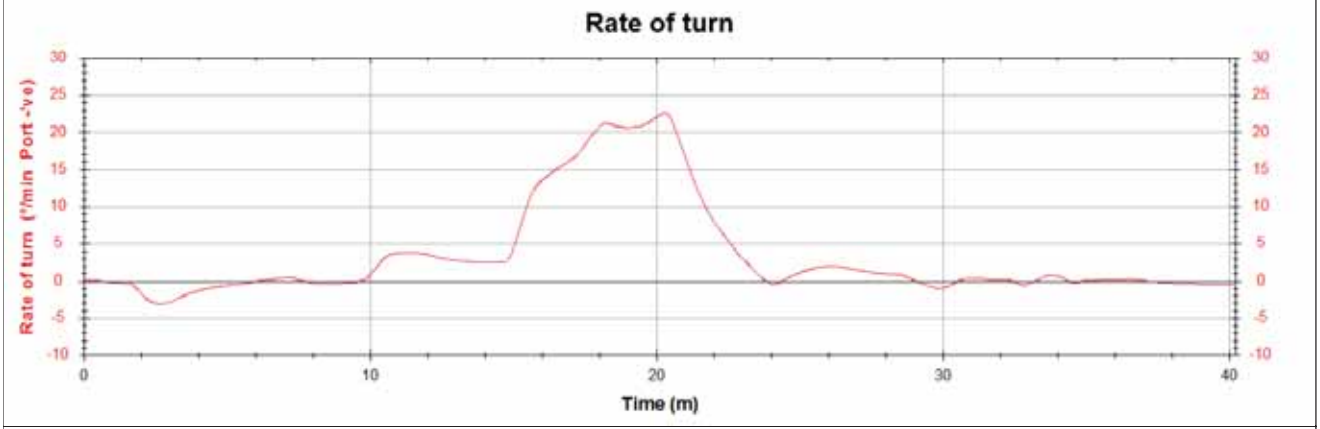


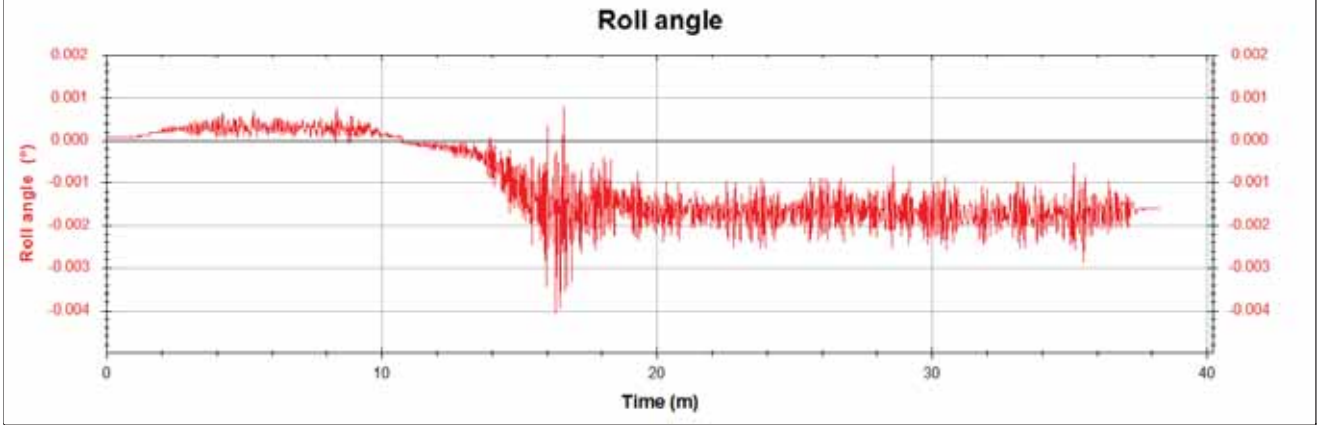
March 2015

Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)





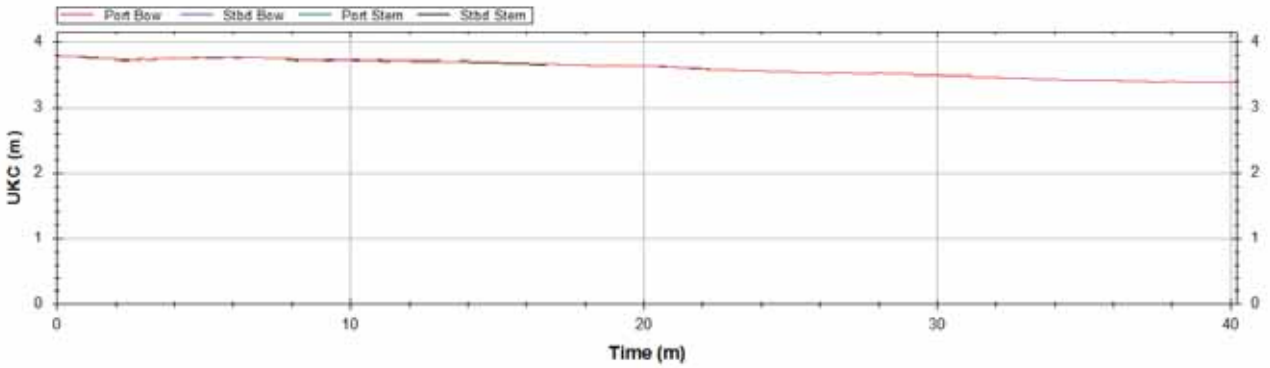




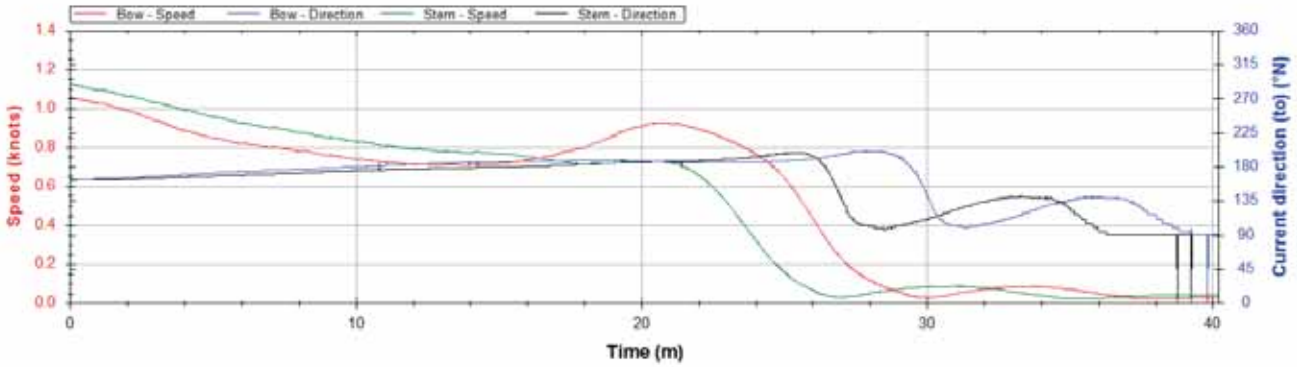
March 2015

Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

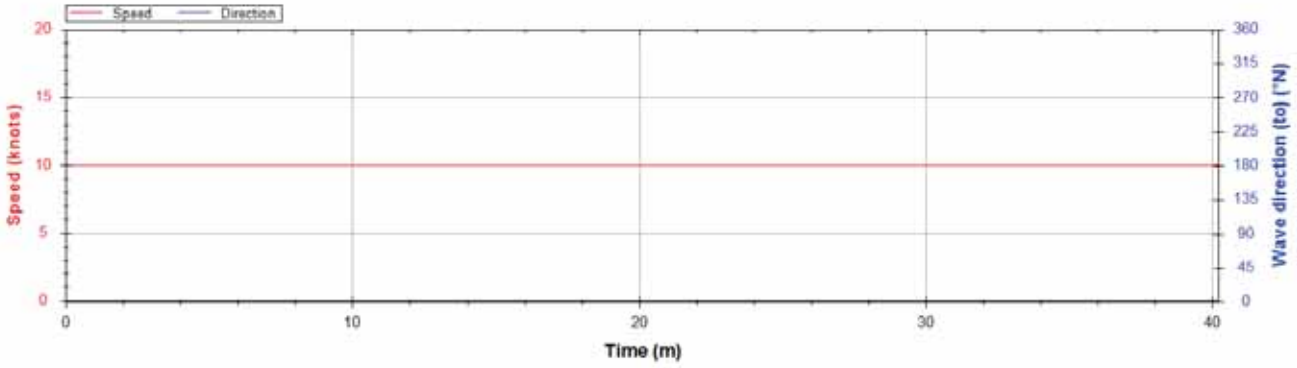
Underkeel clearance



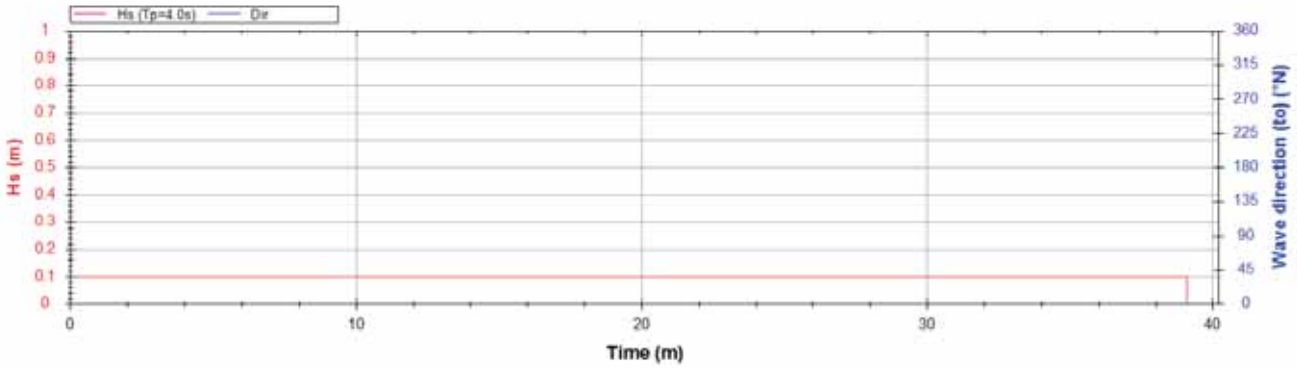
Current speed and direction



Wind speed and direction

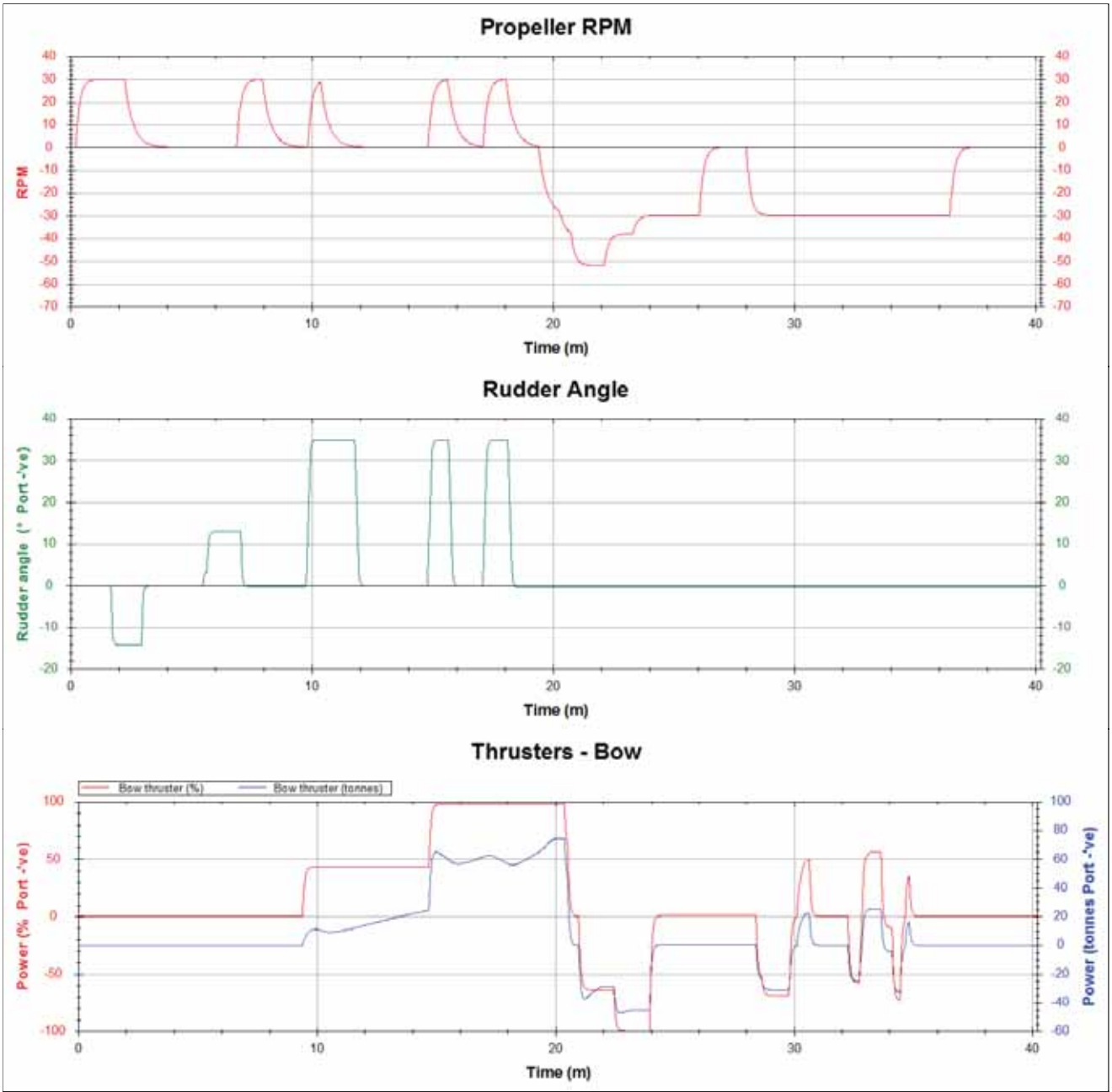


Significant wave height and direction



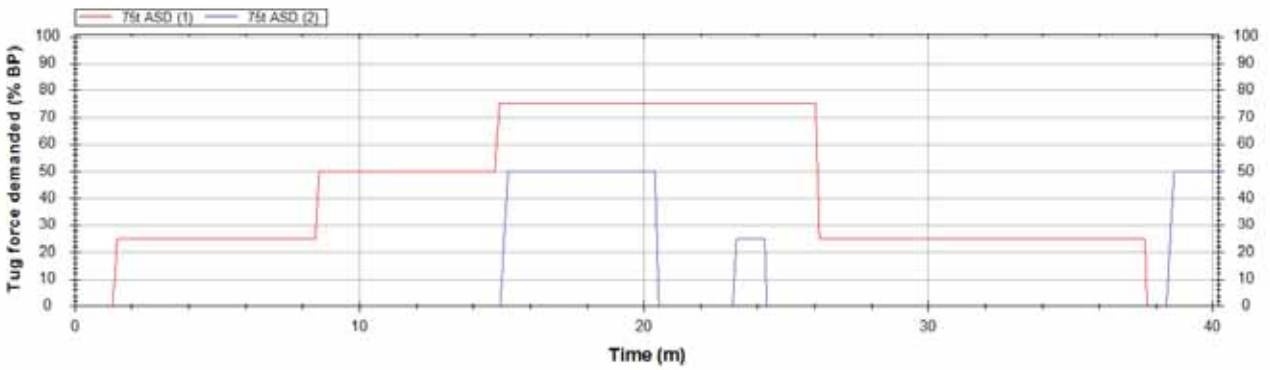
March 2015

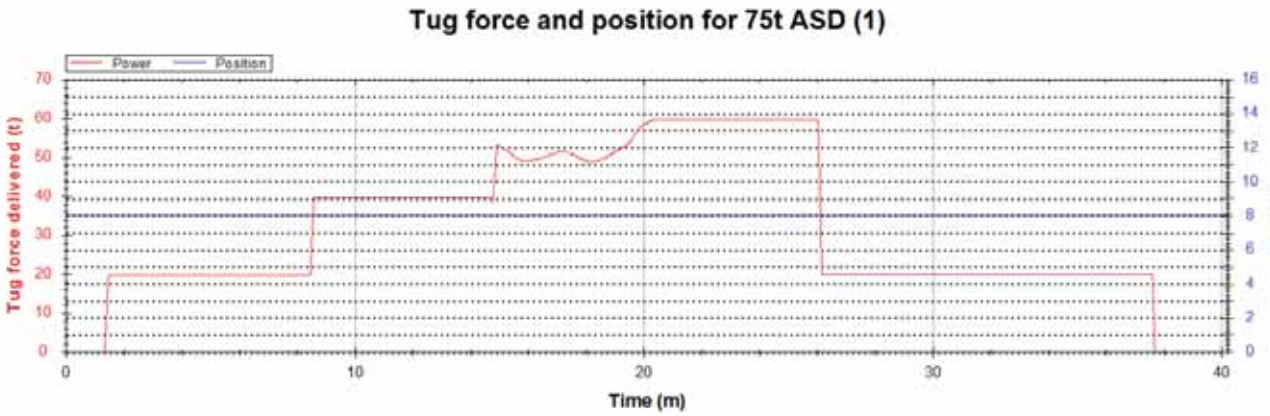
Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

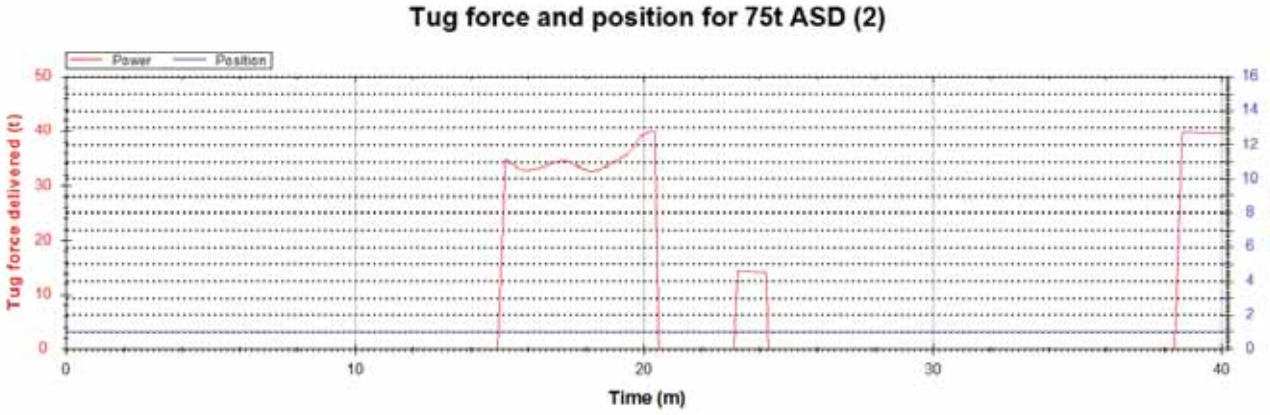


March 2015

Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

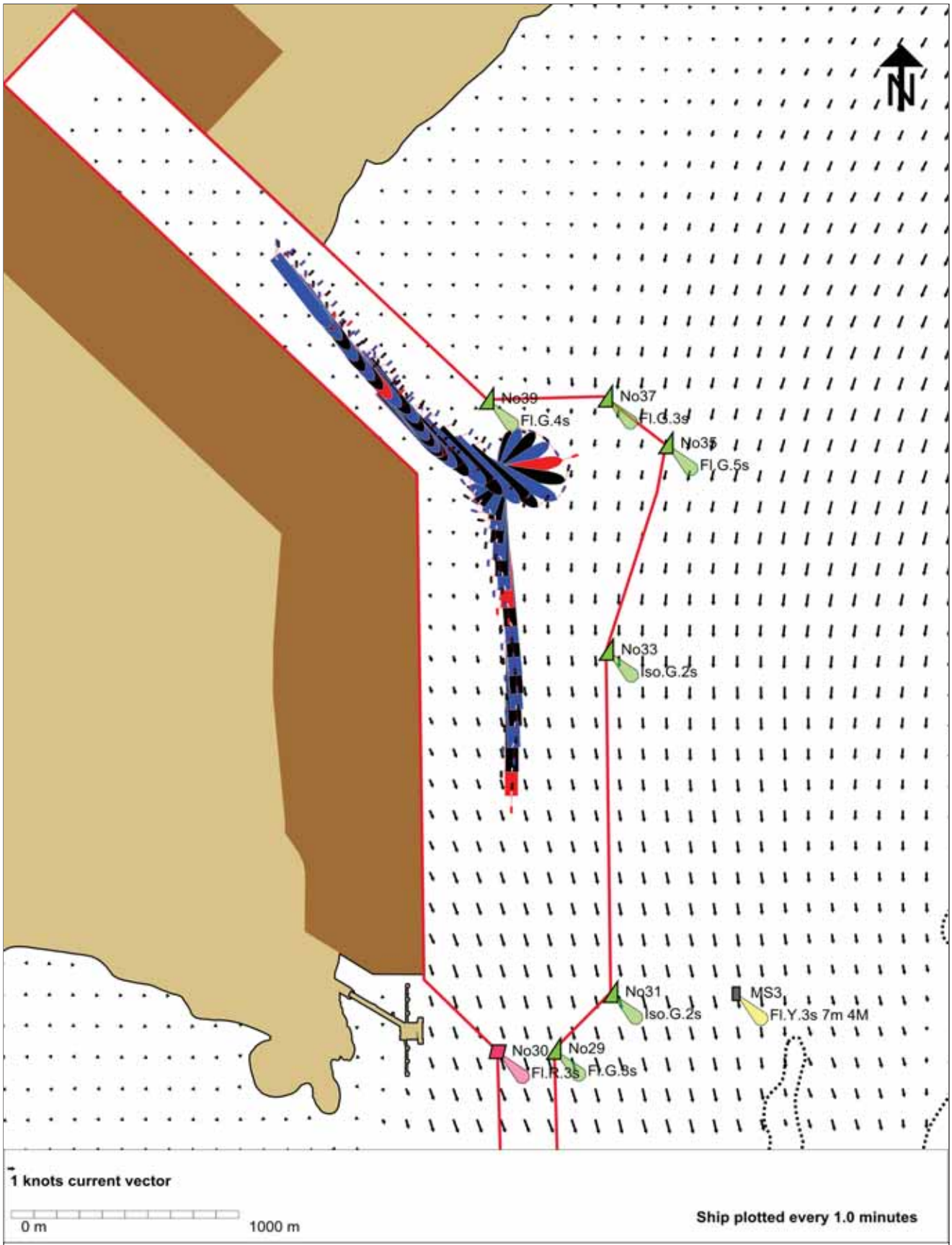






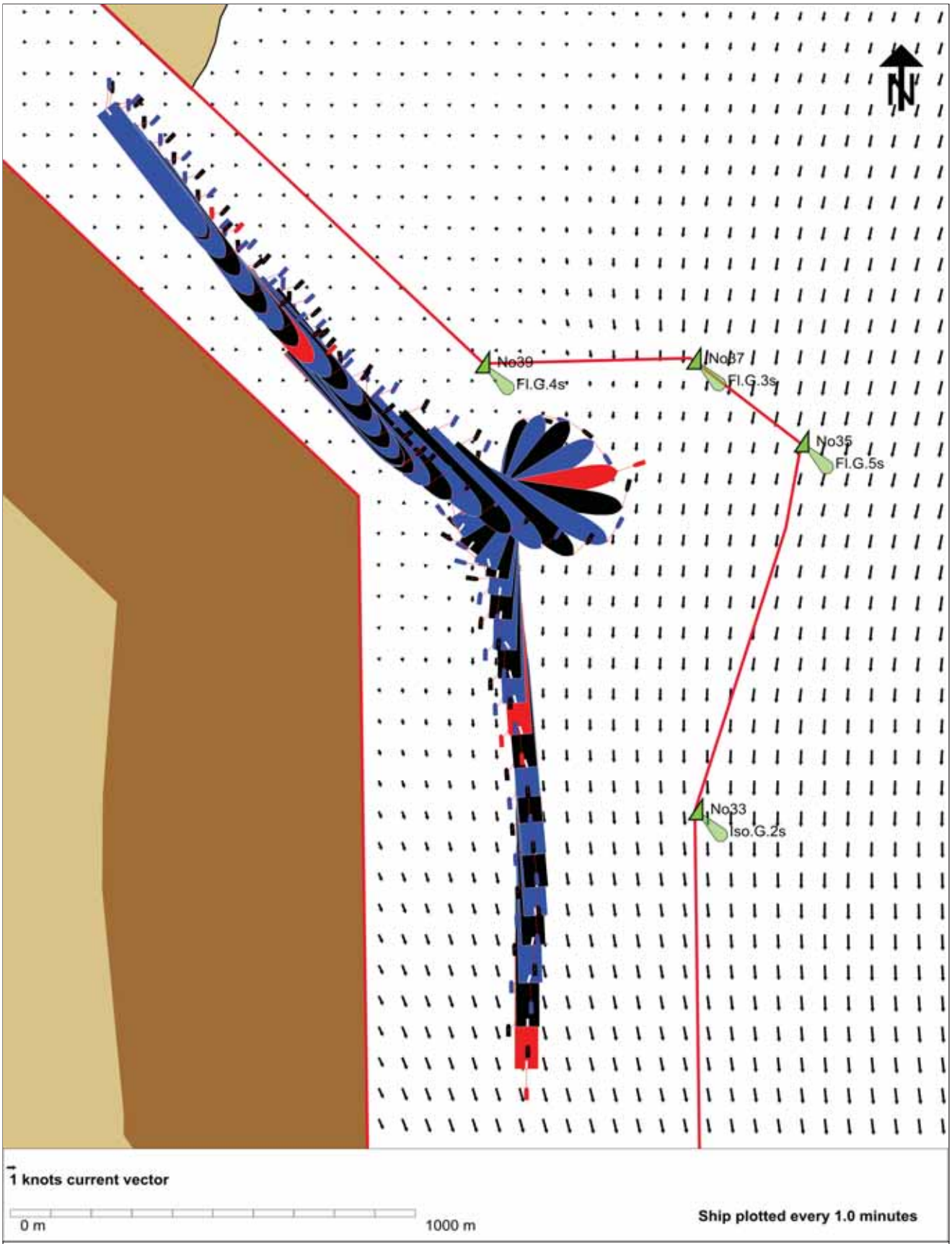
March 2015

Run: 09	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 10 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



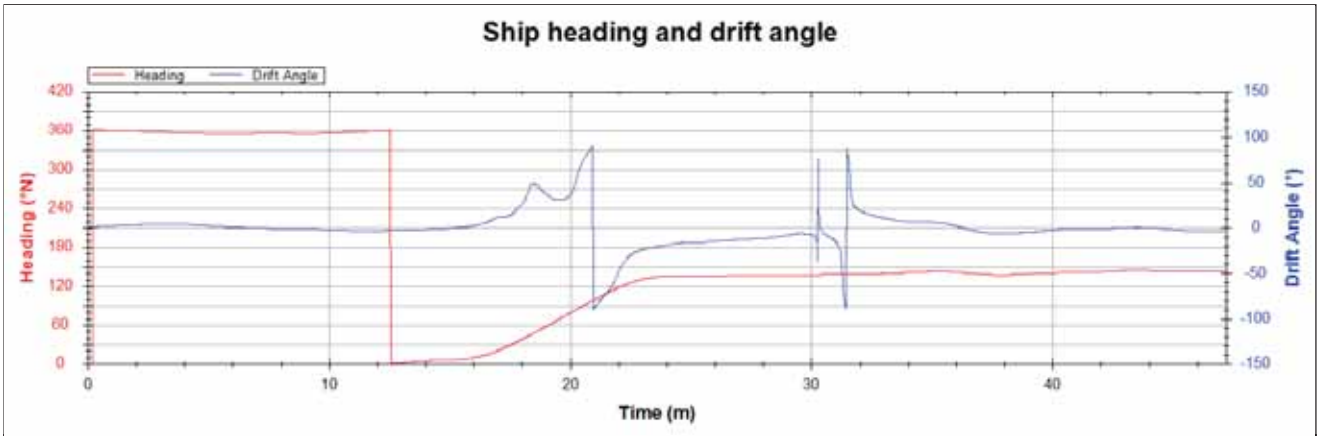
March 2015

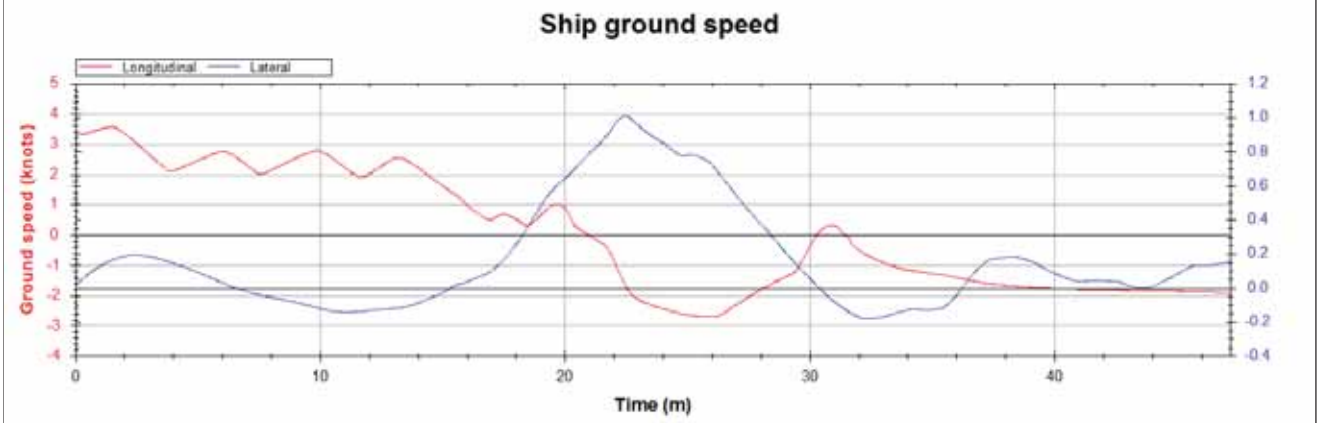
Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

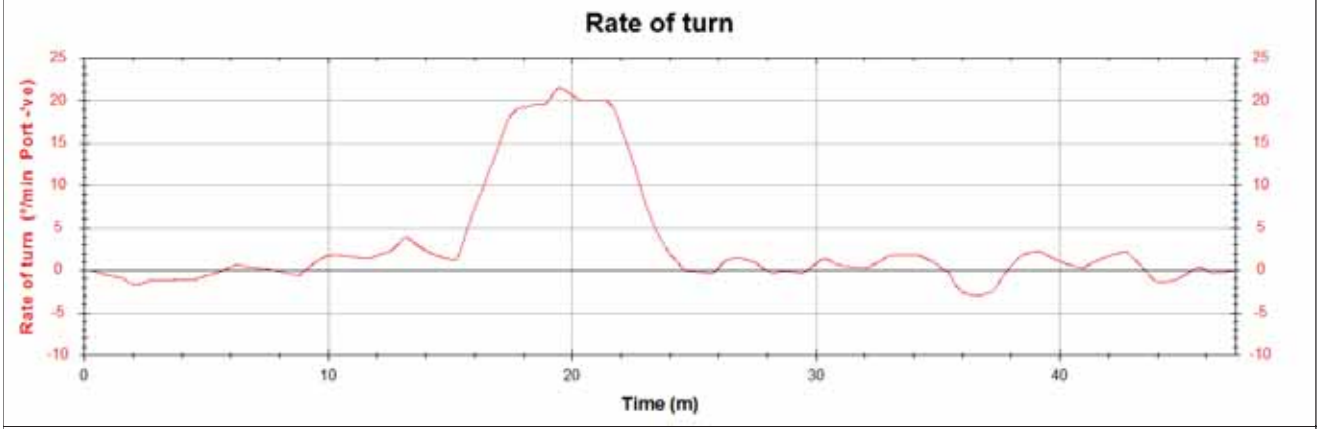


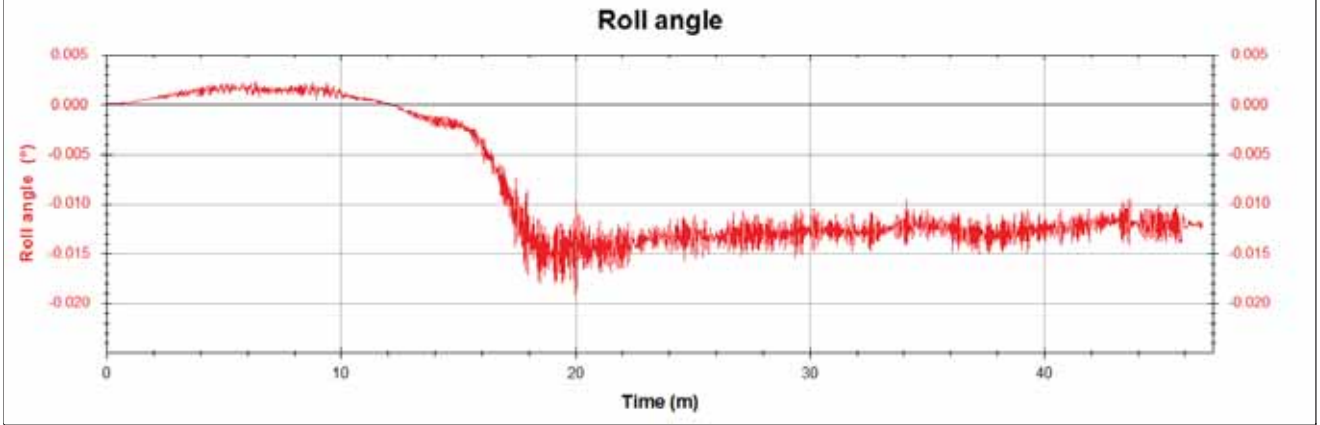
March 2015

Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)





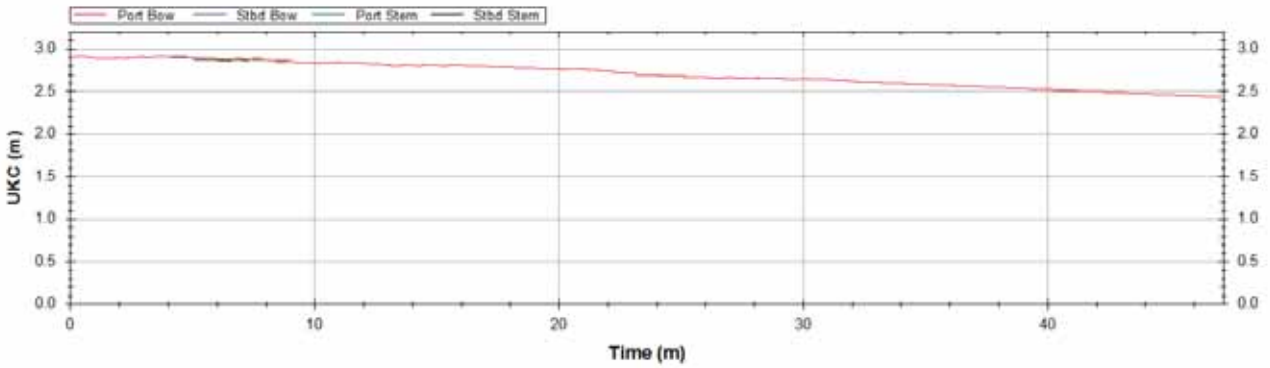




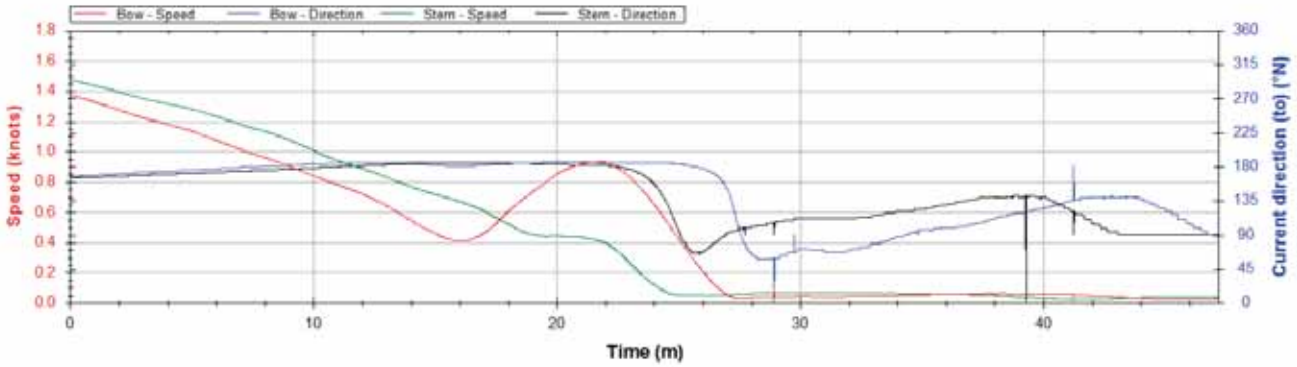
March 2015

Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

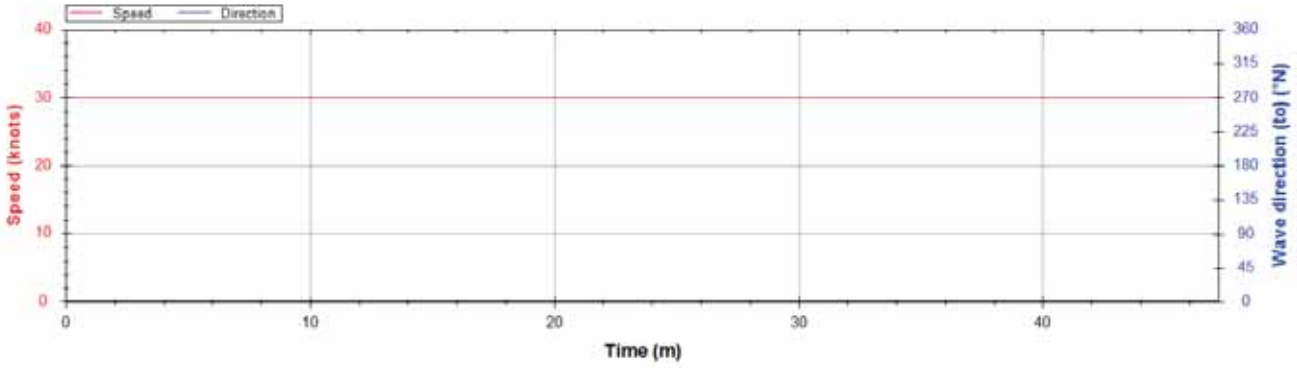
Underkeel clearance



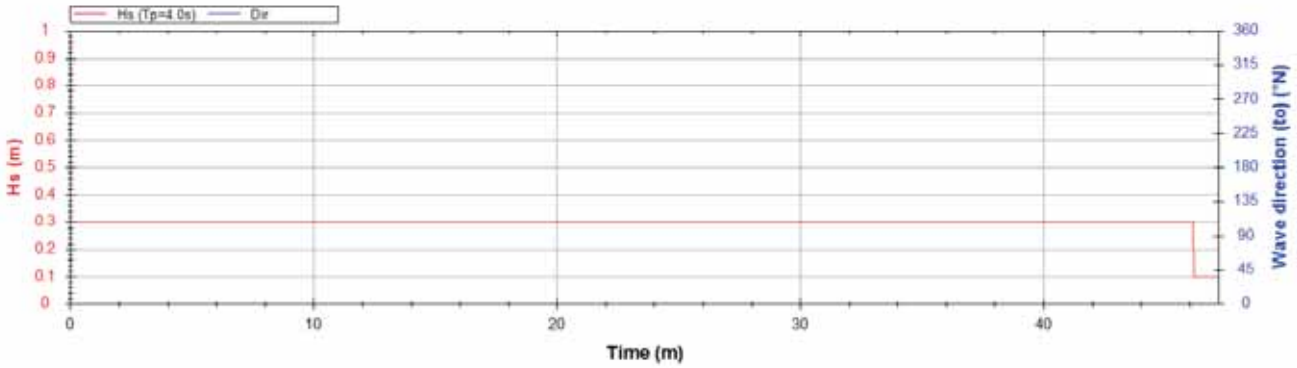
Current speed and direction



Wind speed and direction

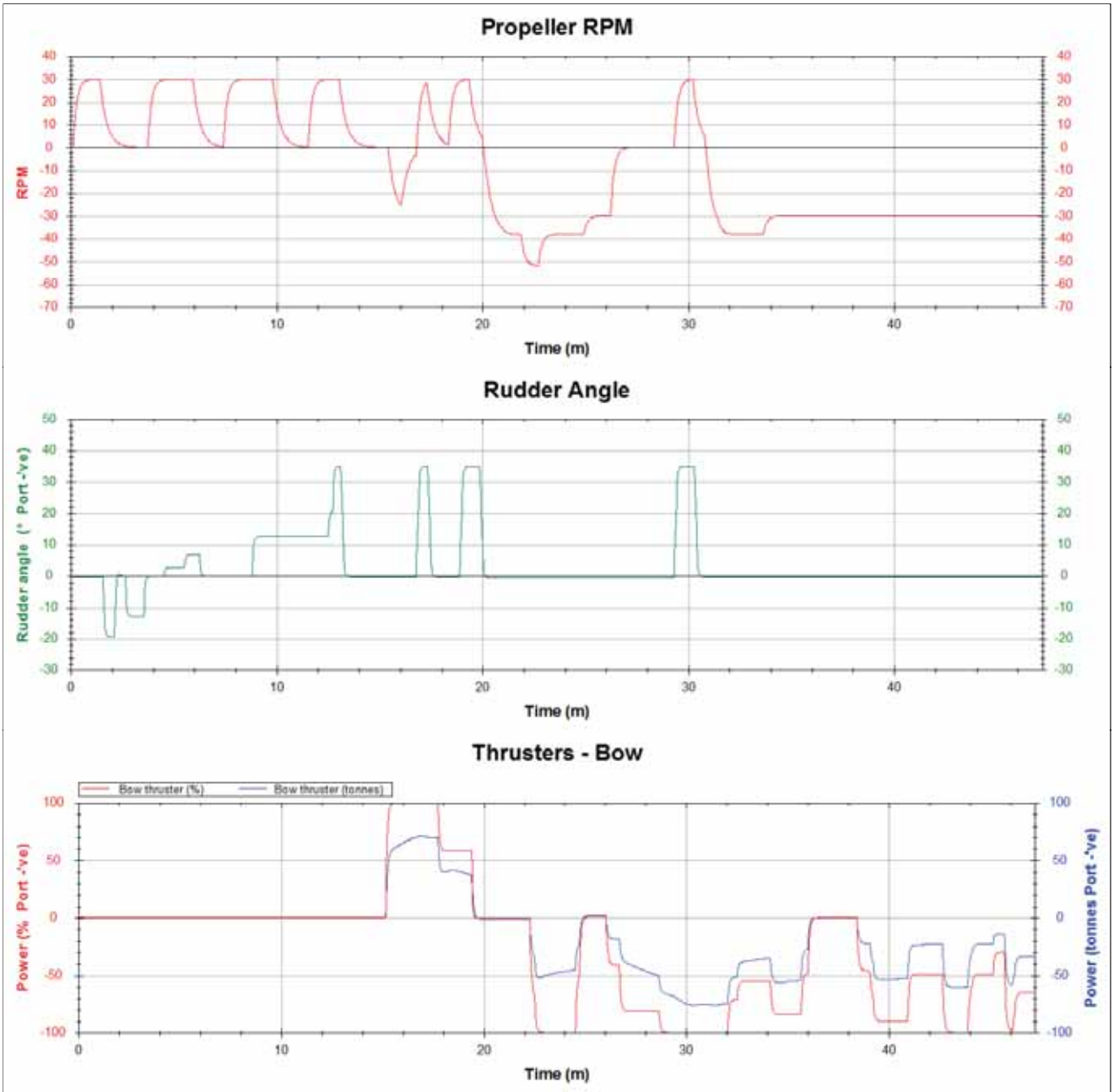


Significant wave height and direction



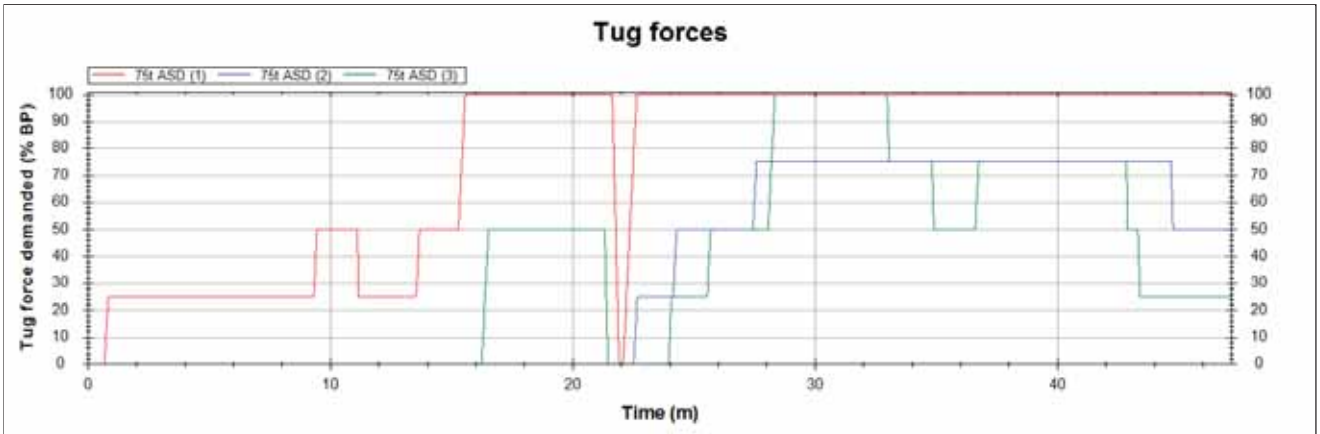
March 2015

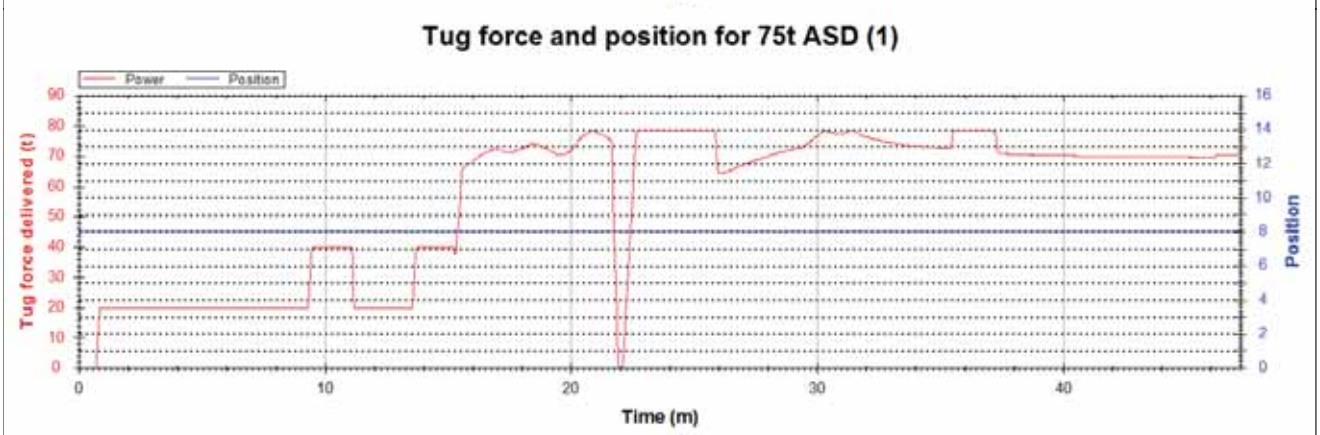
Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

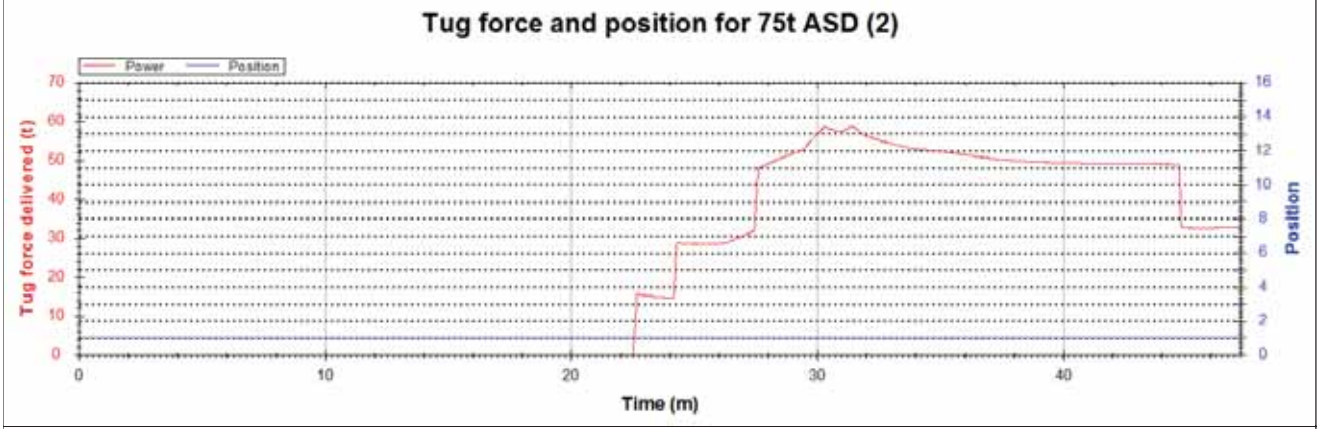


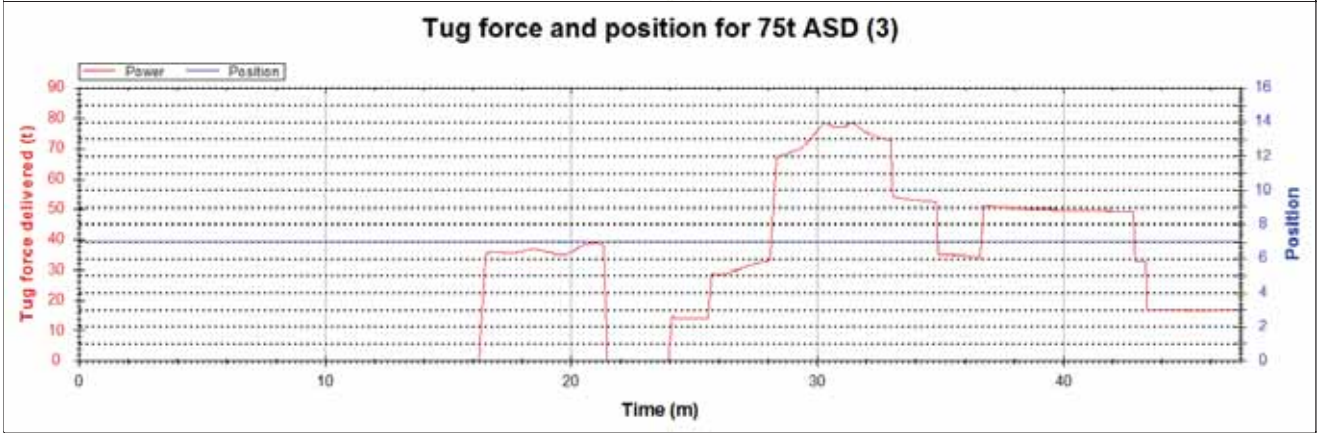
March 2015

Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



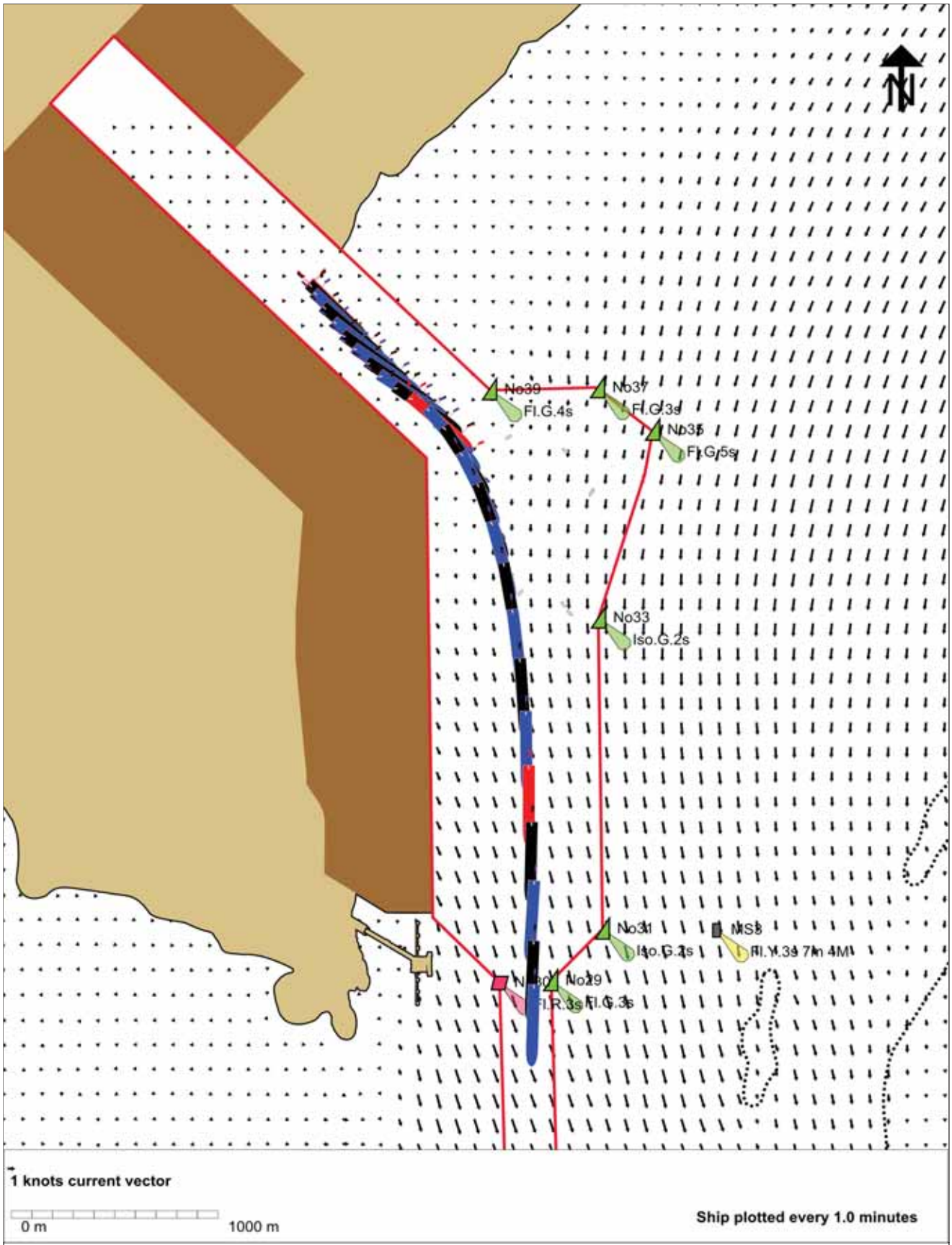






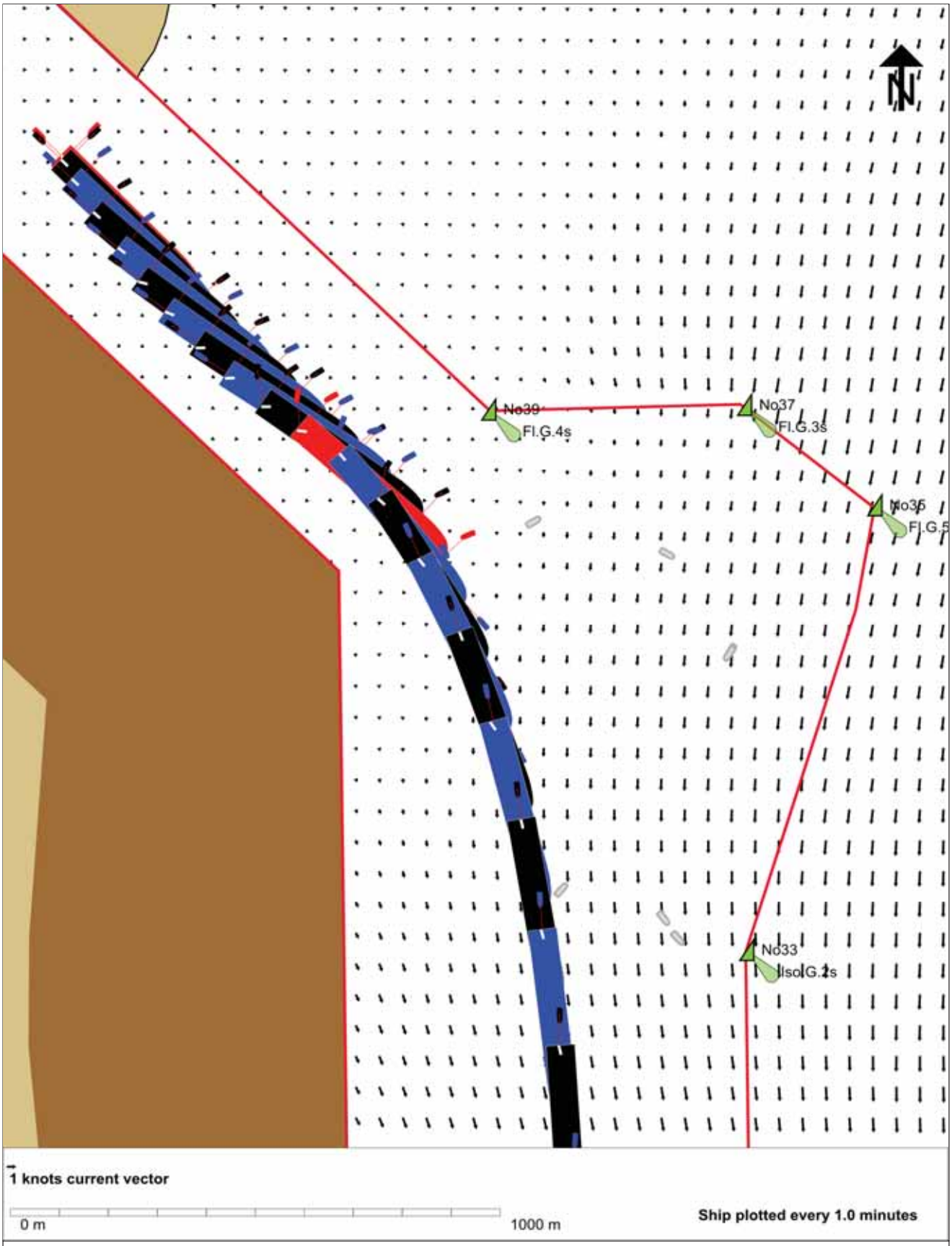
March 2015

Run: 10	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



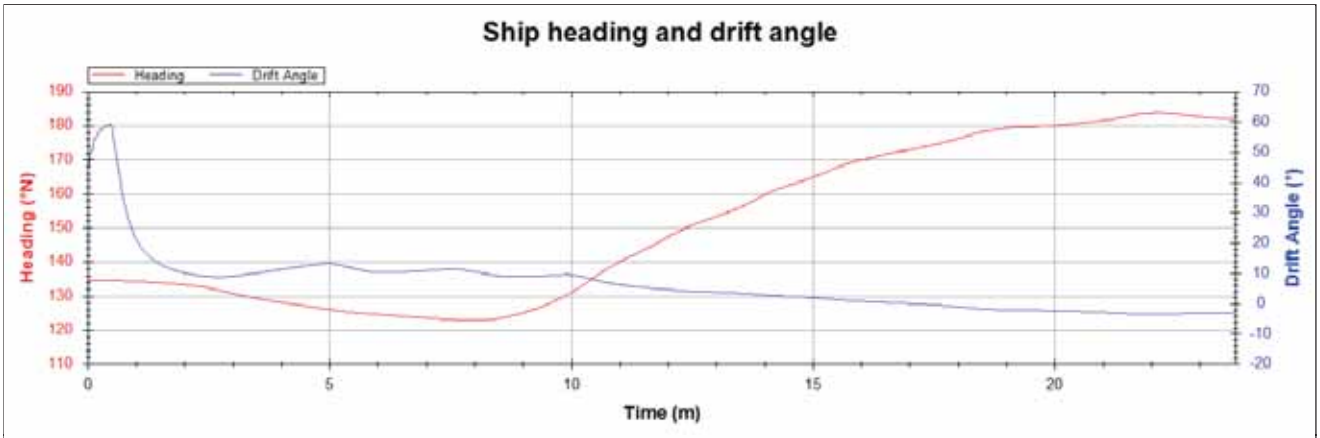
March 2015

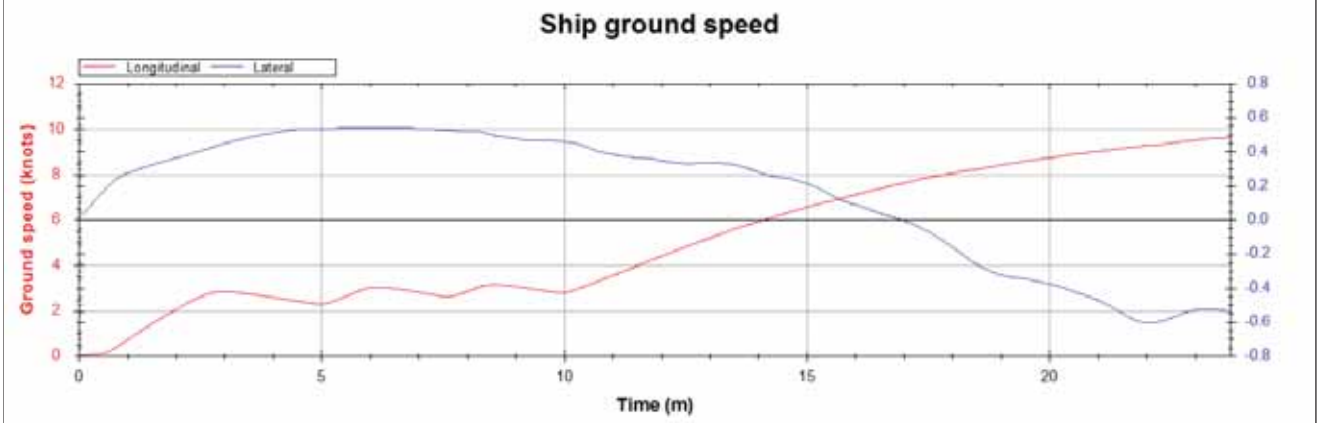
Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

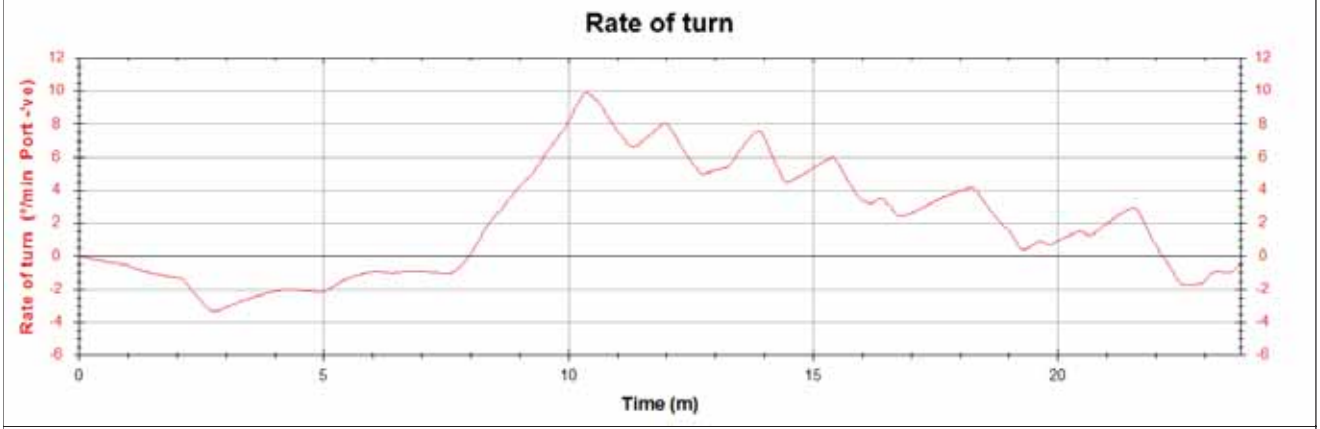


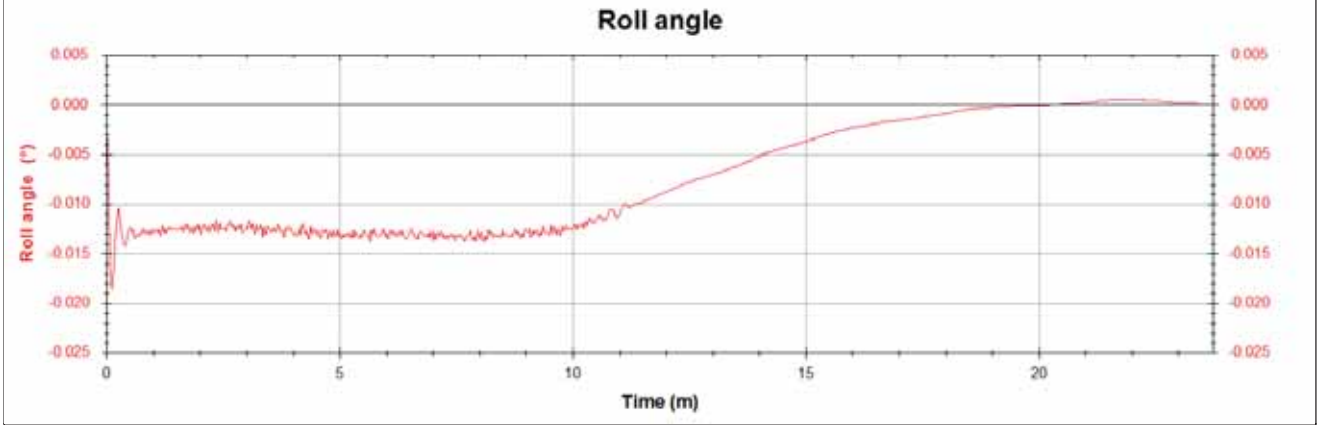
March 2015

Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



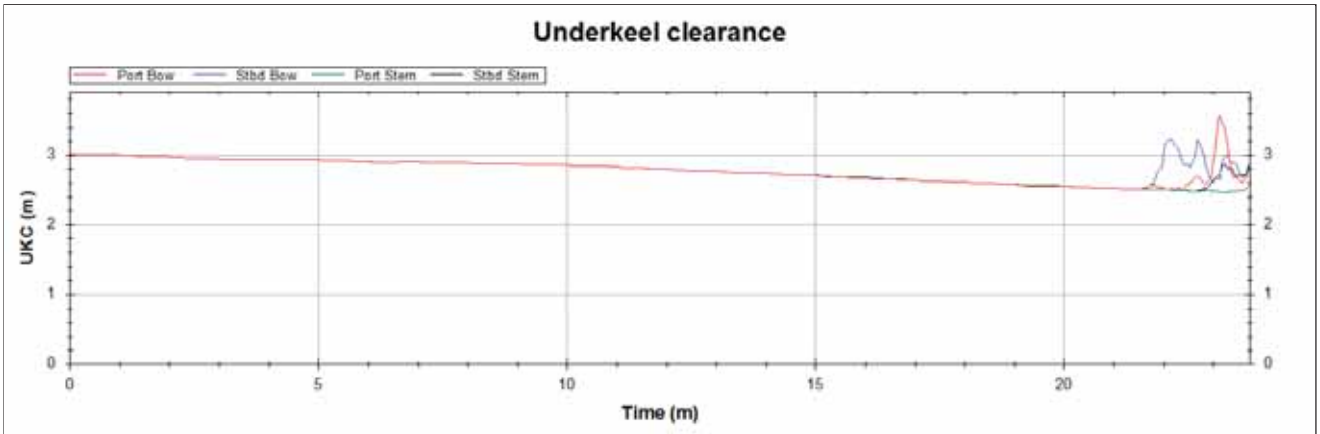


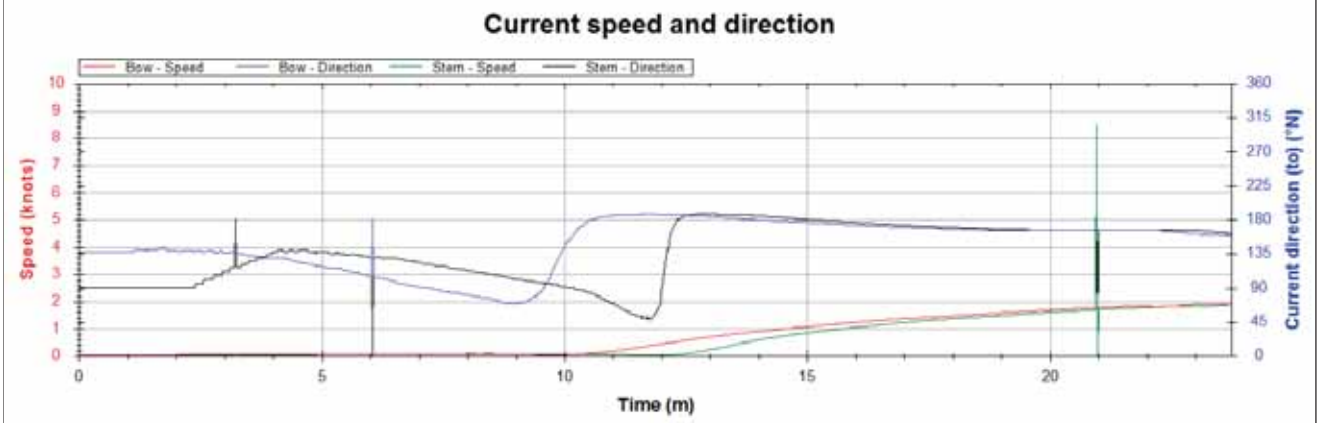


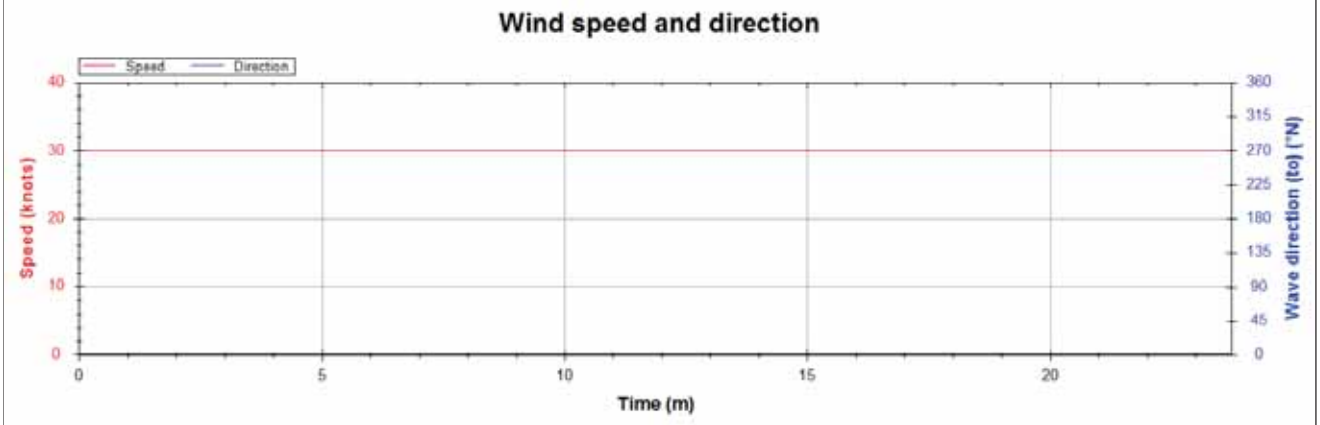


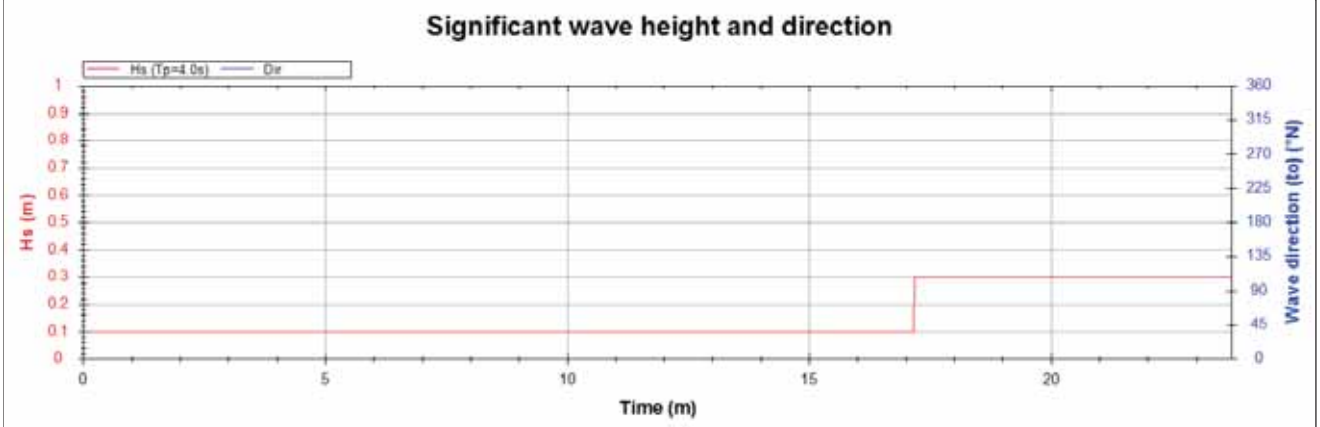
March 2015

Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



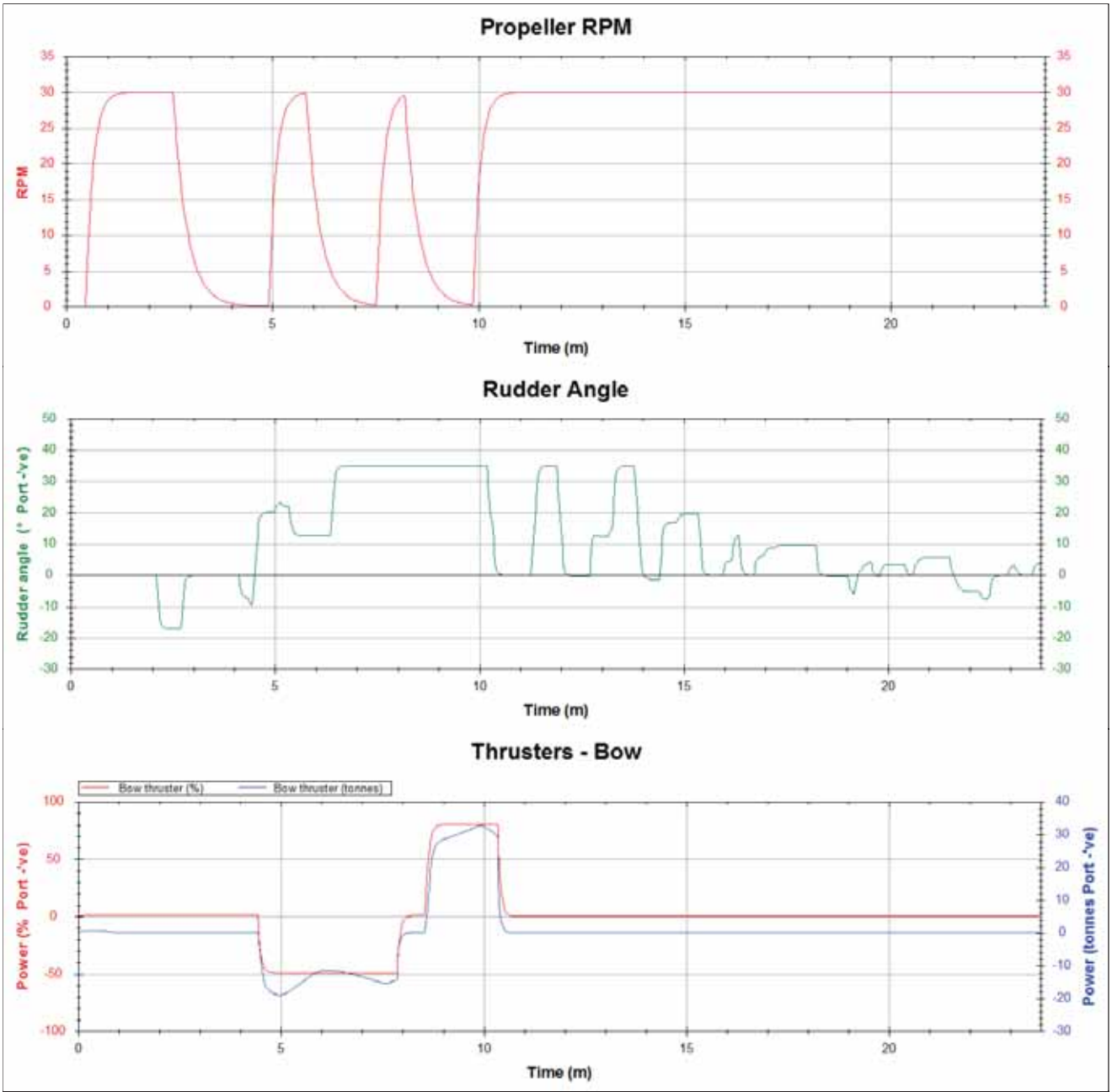






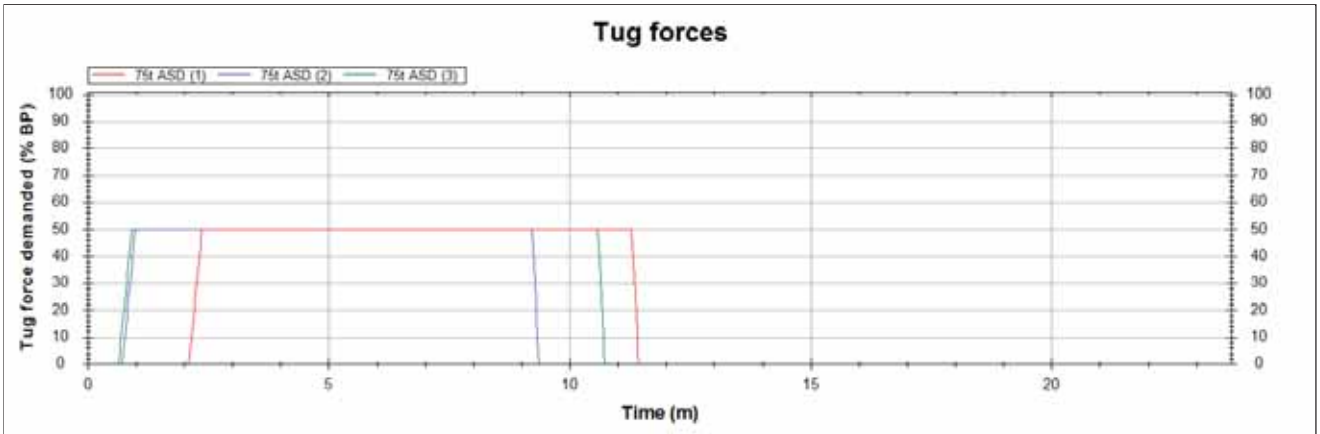
March 2015

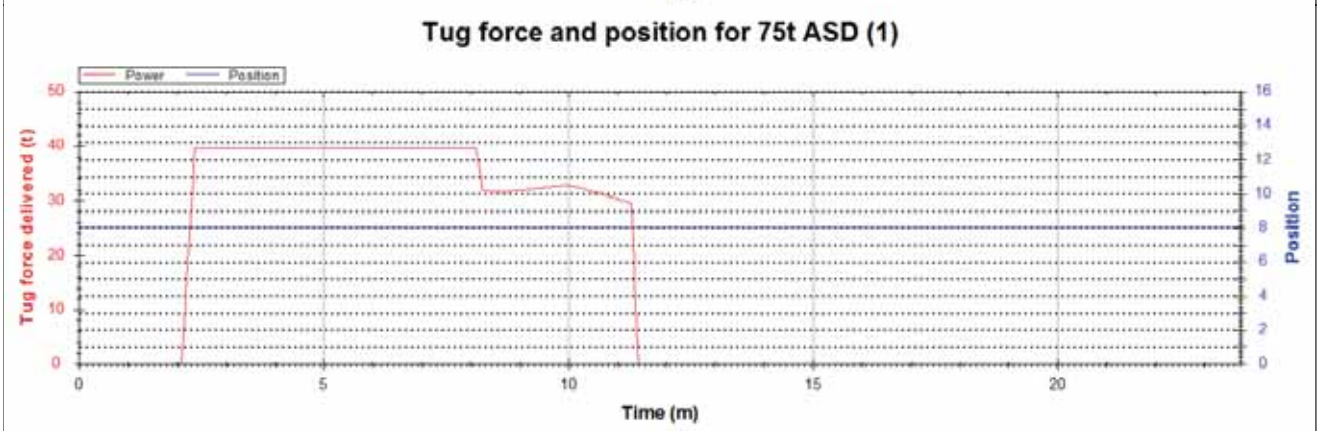
Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

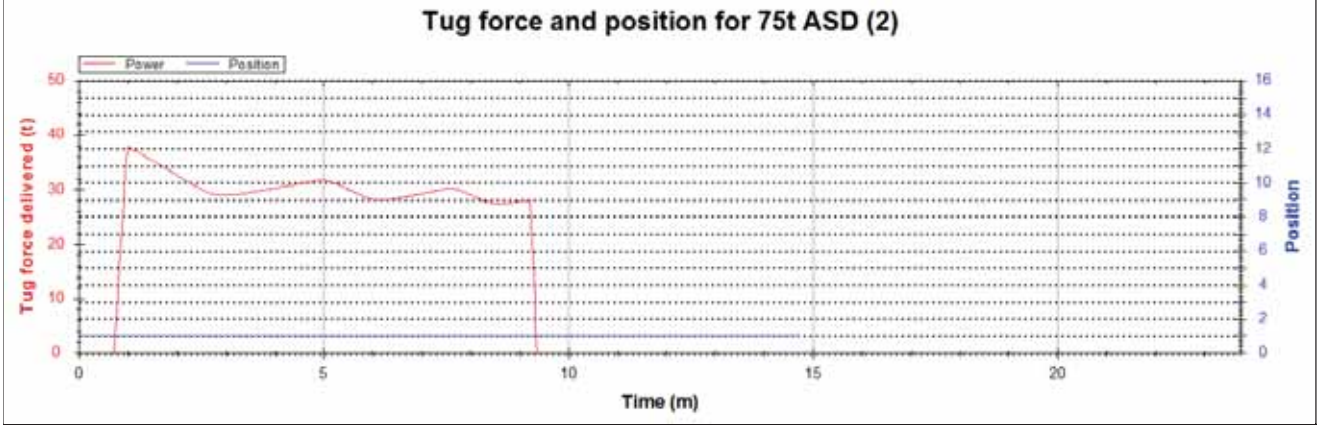


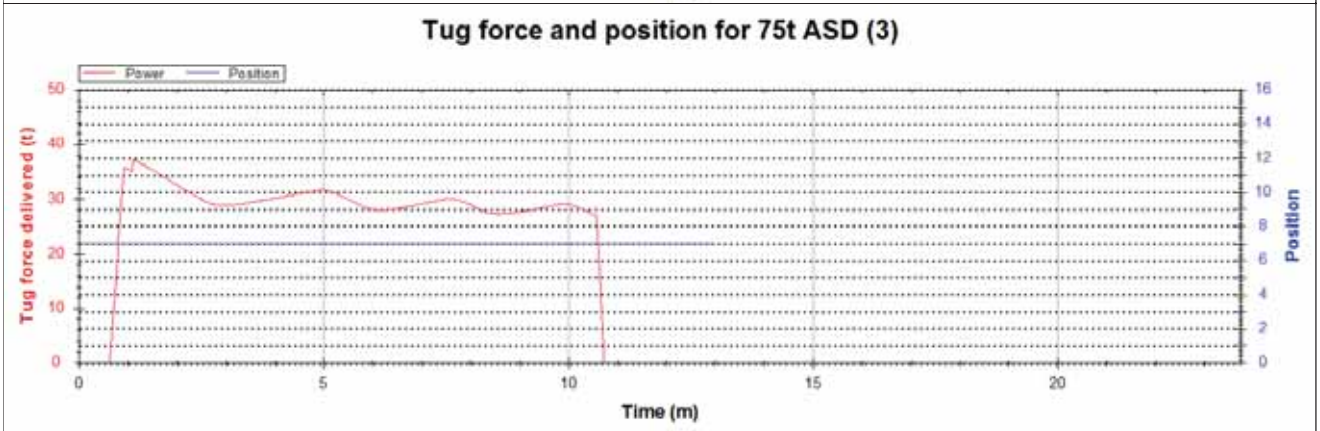
March 2015

Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



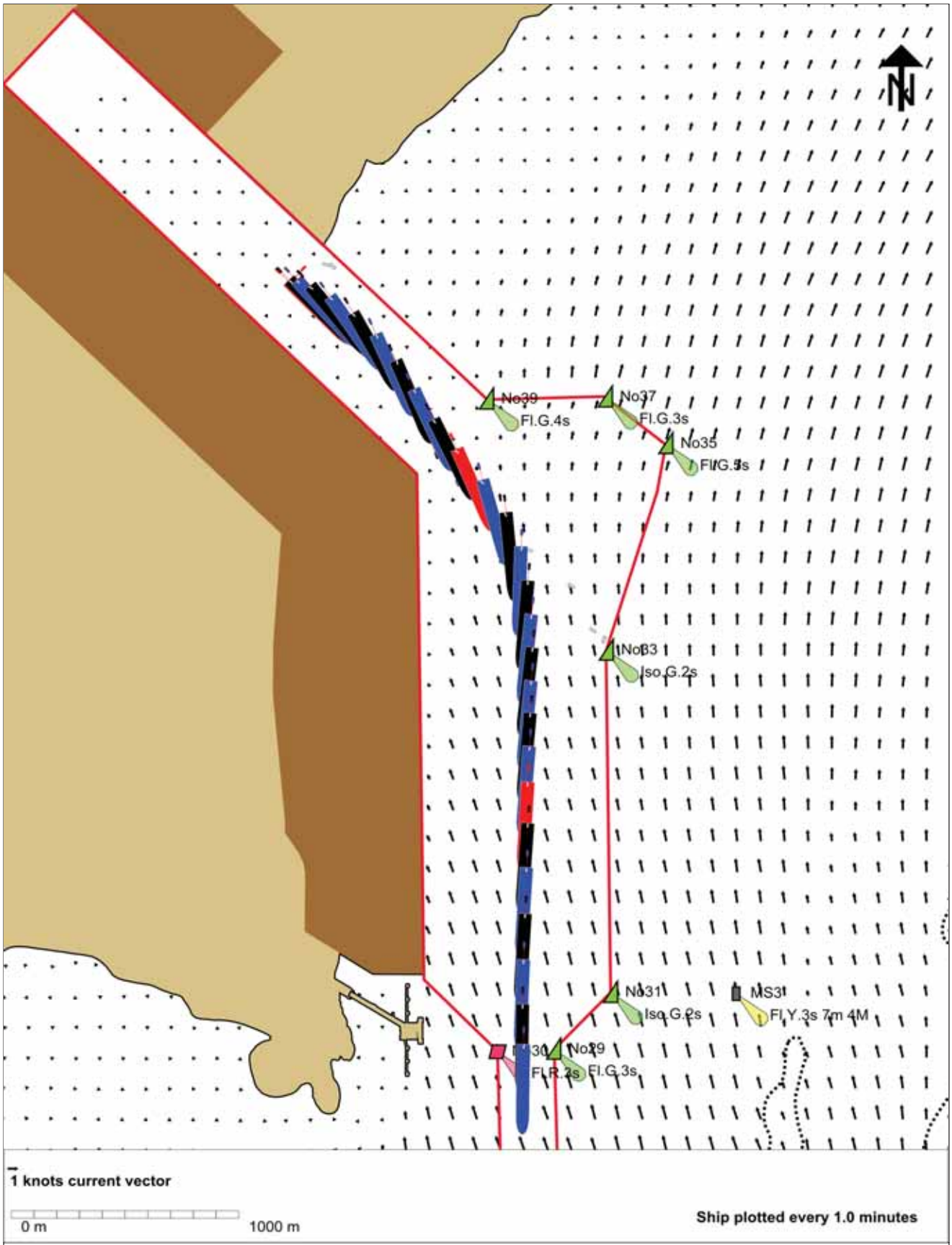






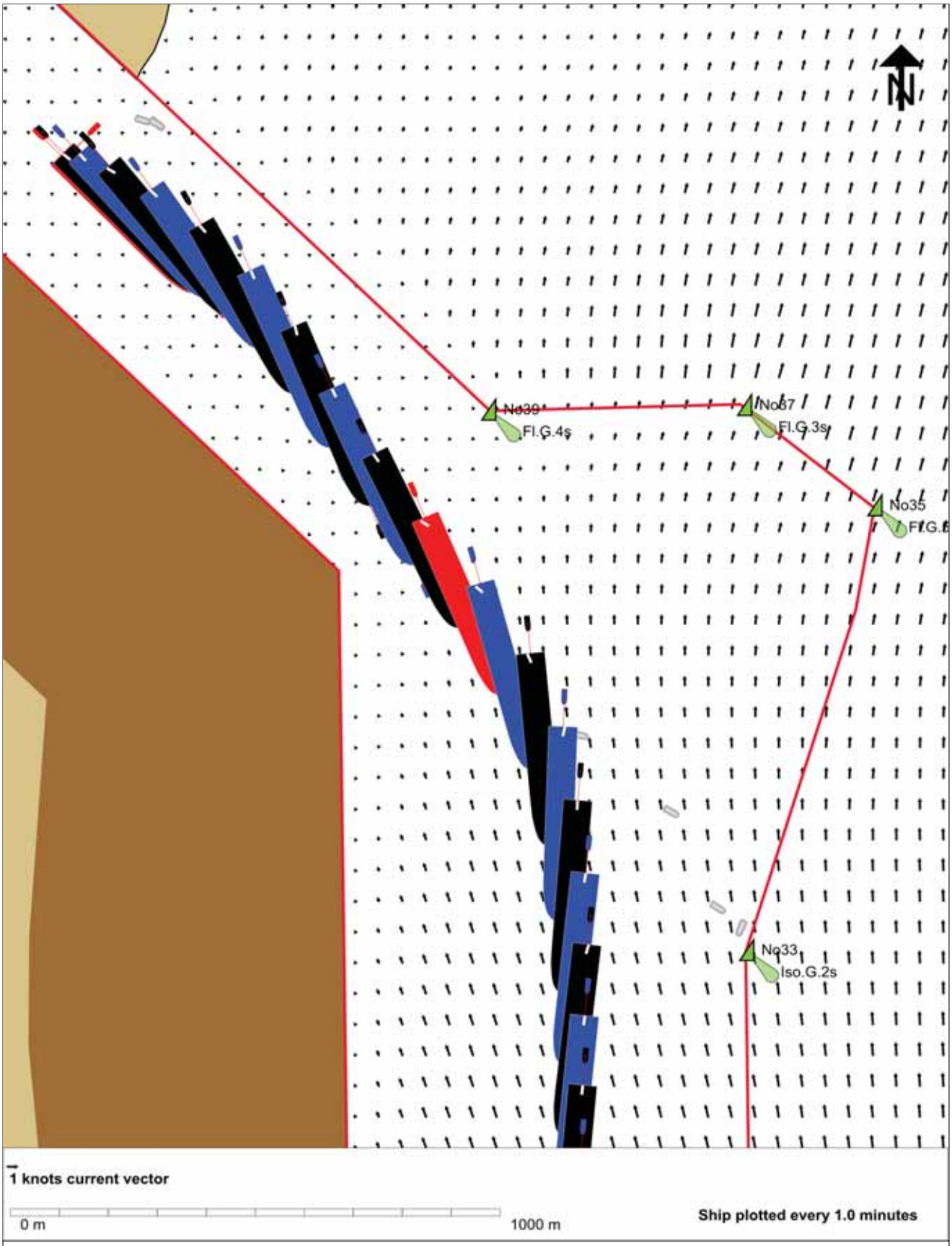
March 2015

Run: 11	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



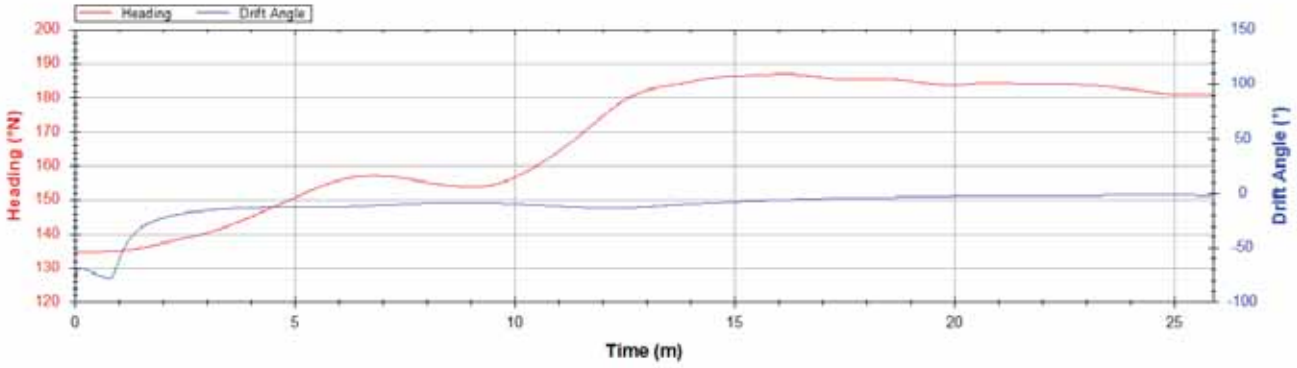
March 2015

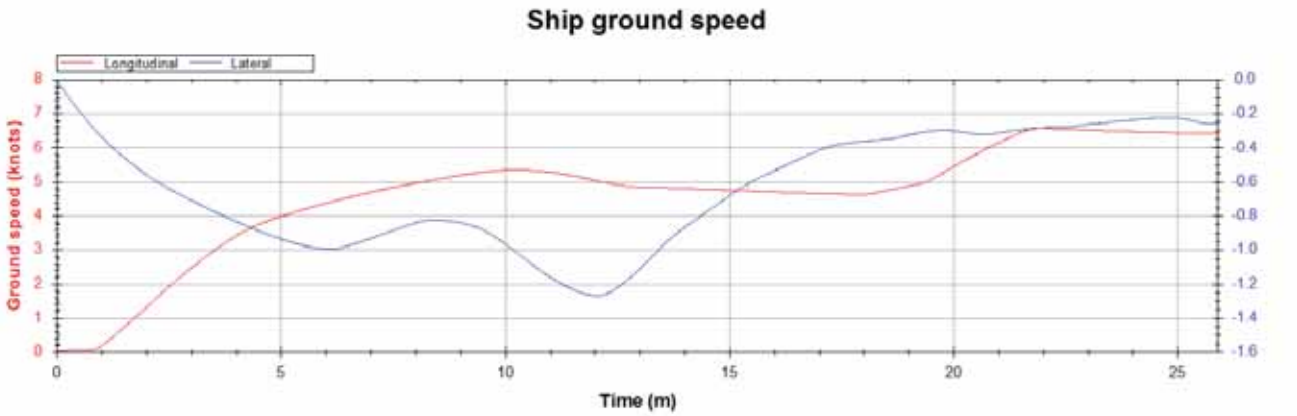
Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

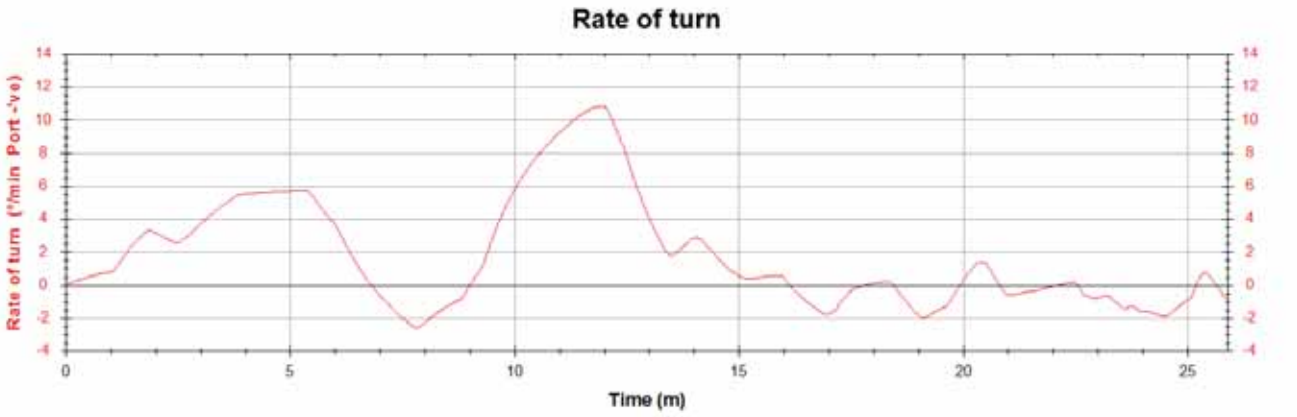


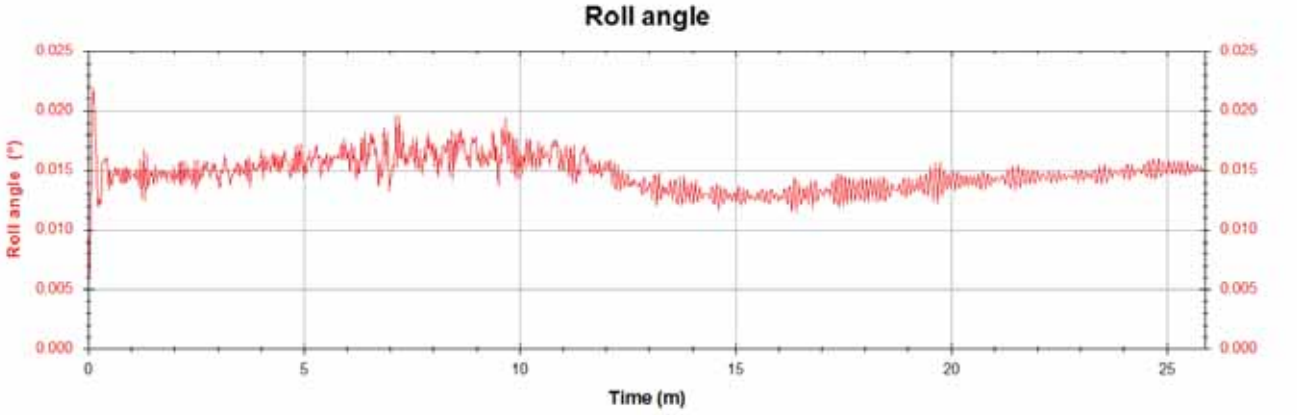
March 2015

Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



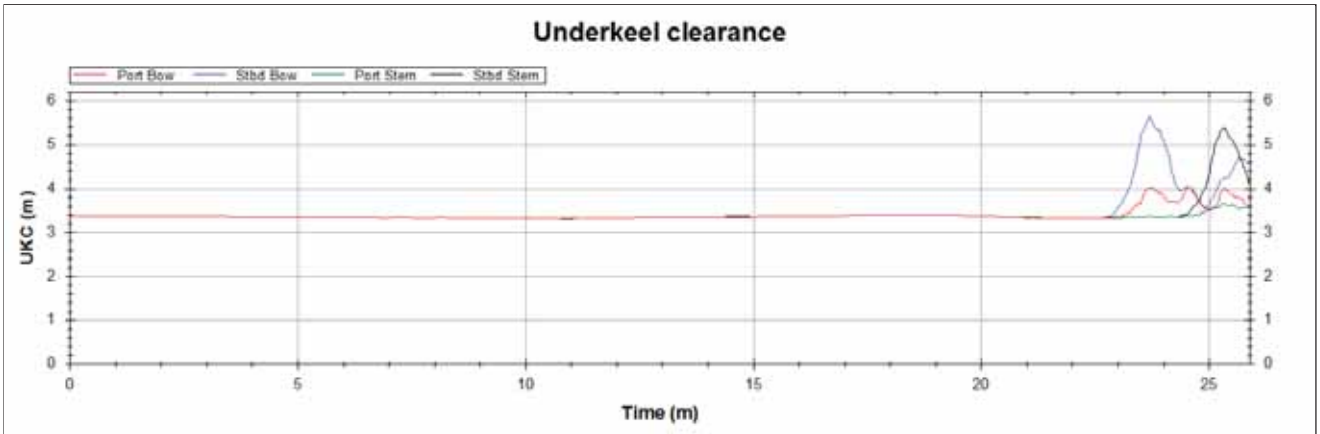


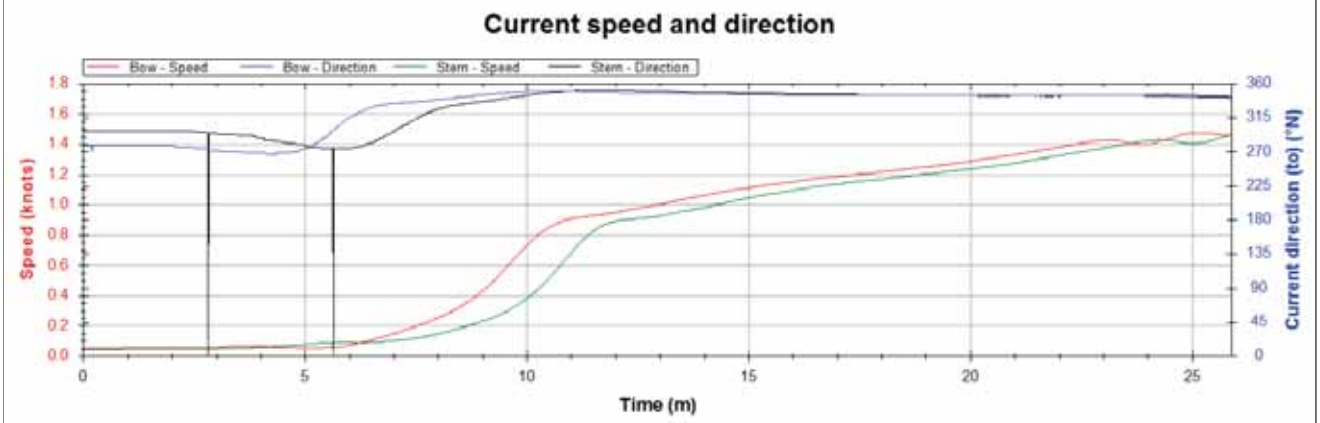


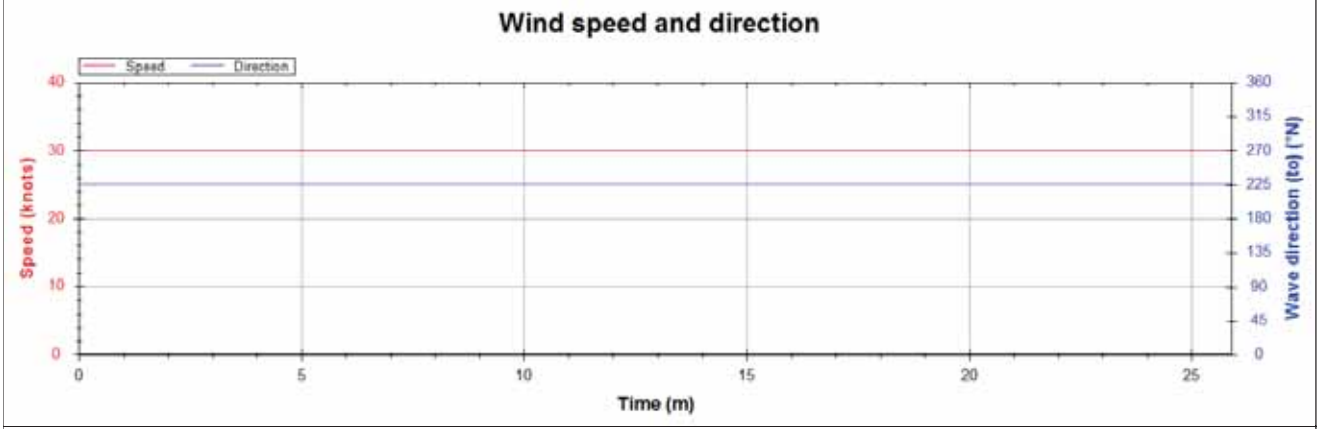


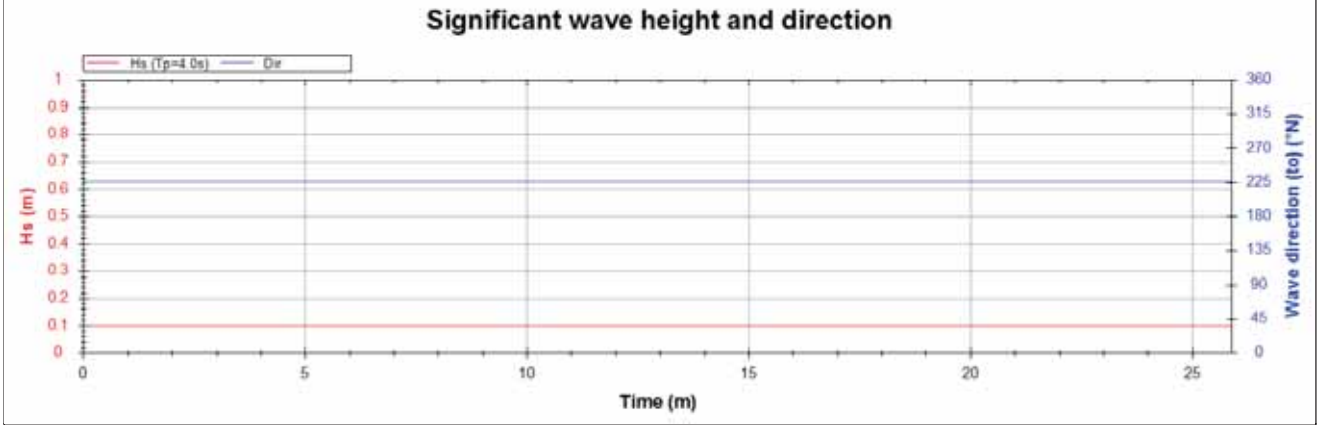
March 2015

Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



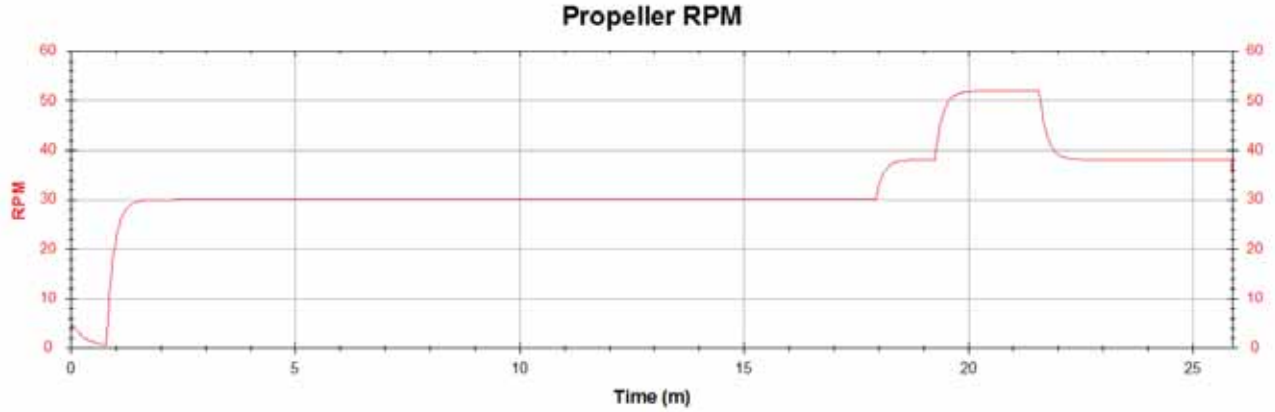


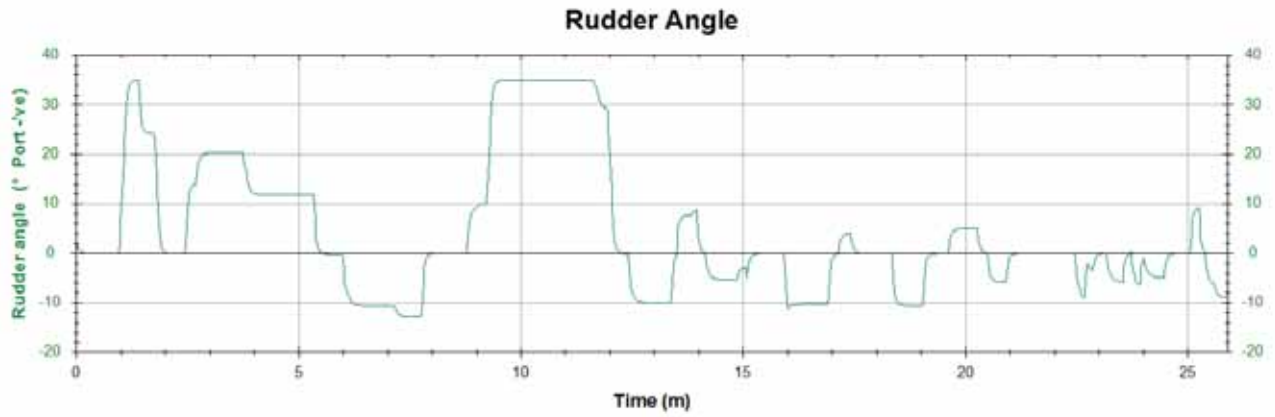




March 2015

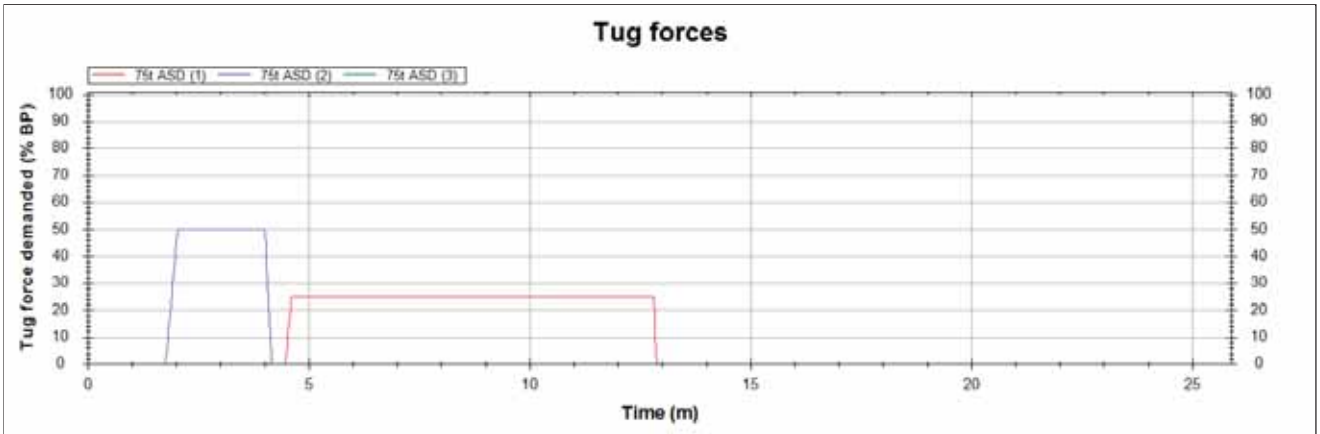
Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

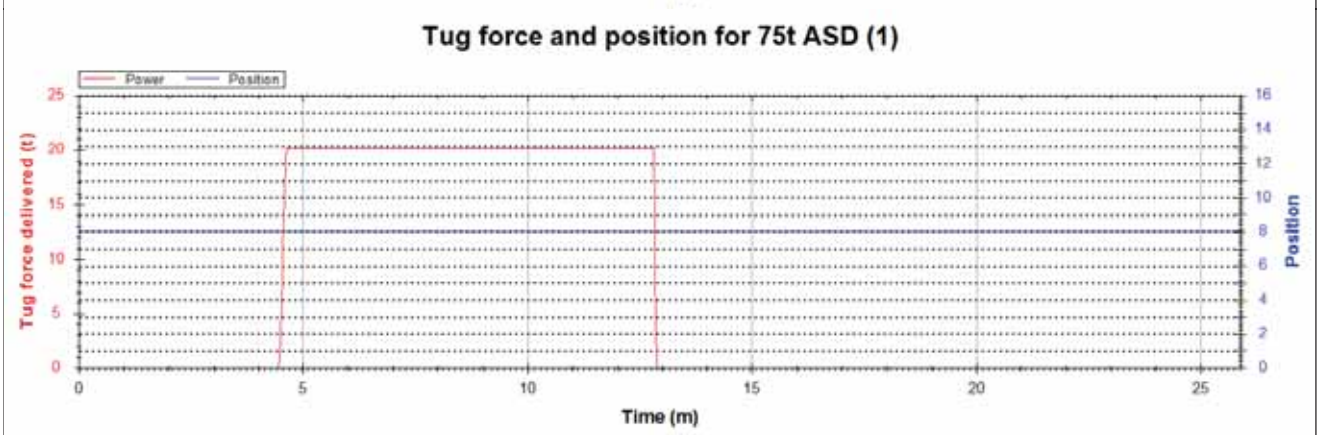


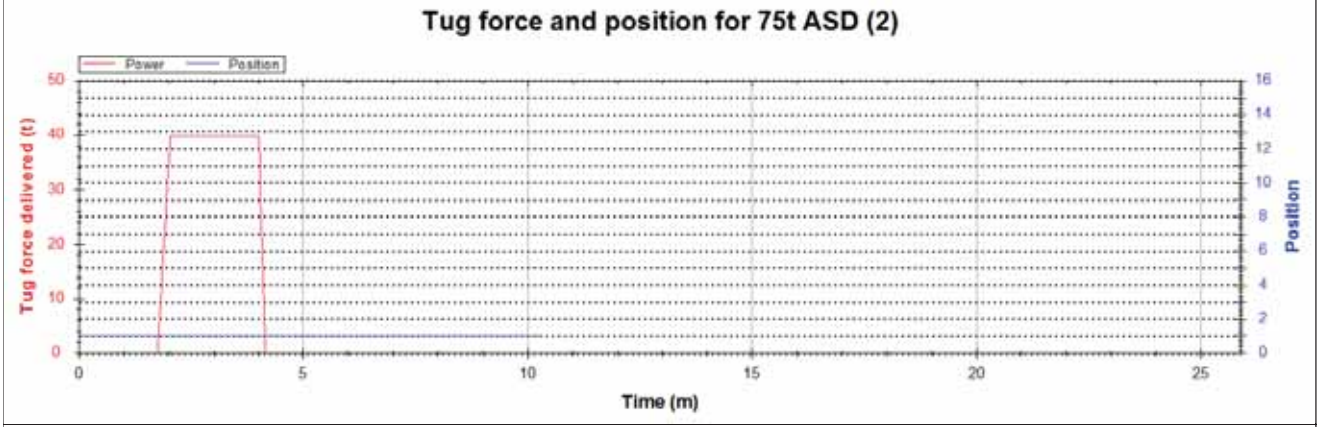


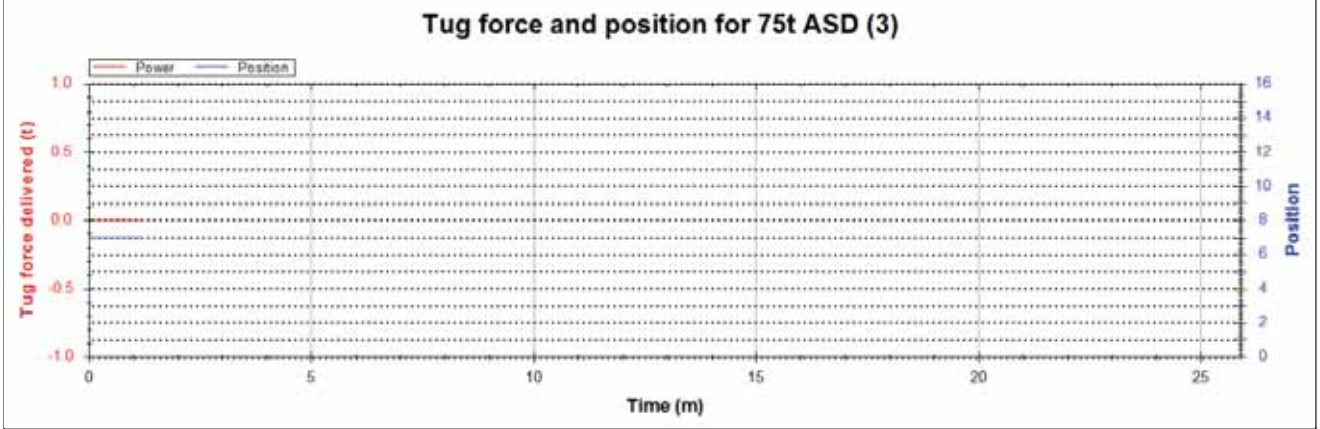
March 2015

Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



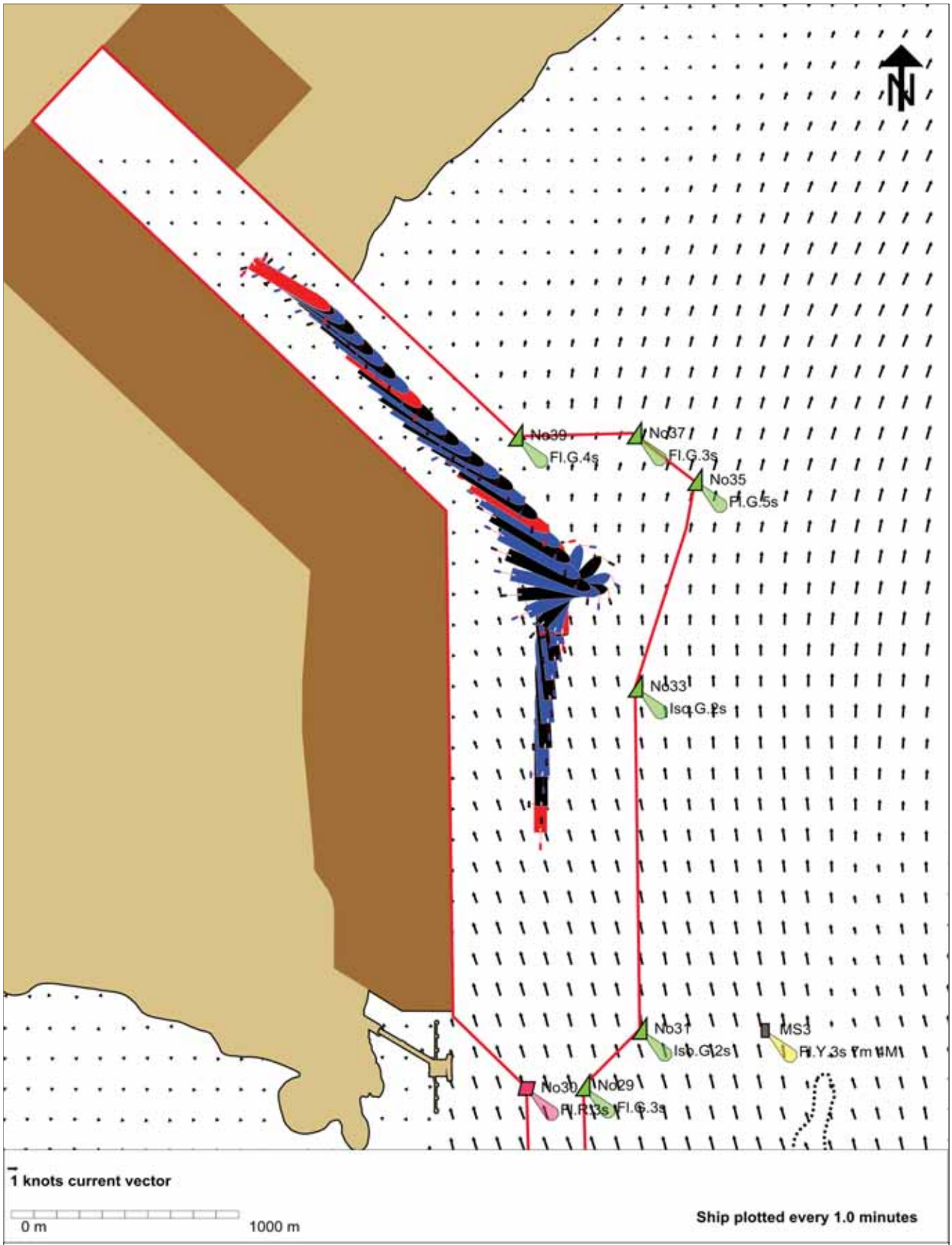






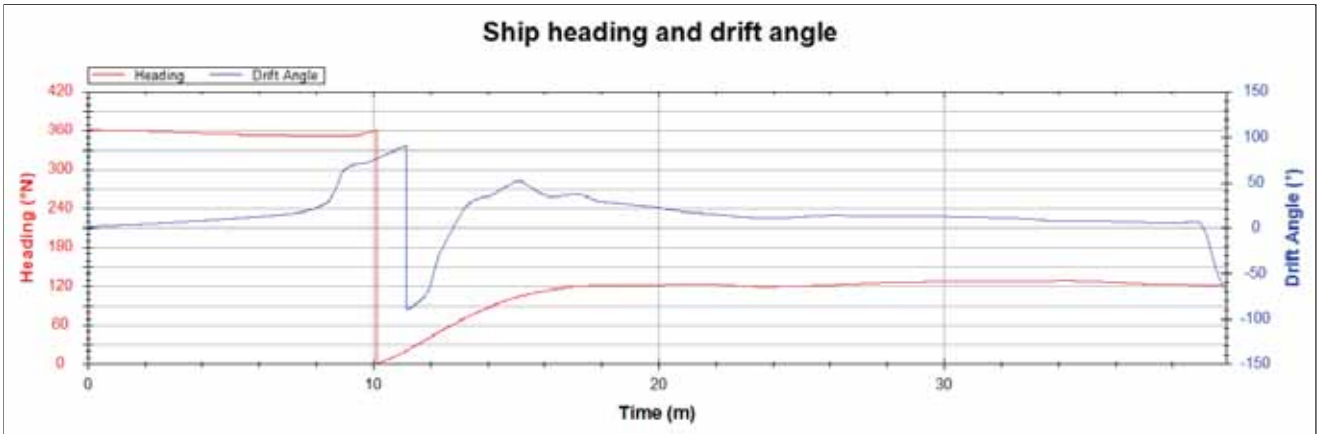
March 2015

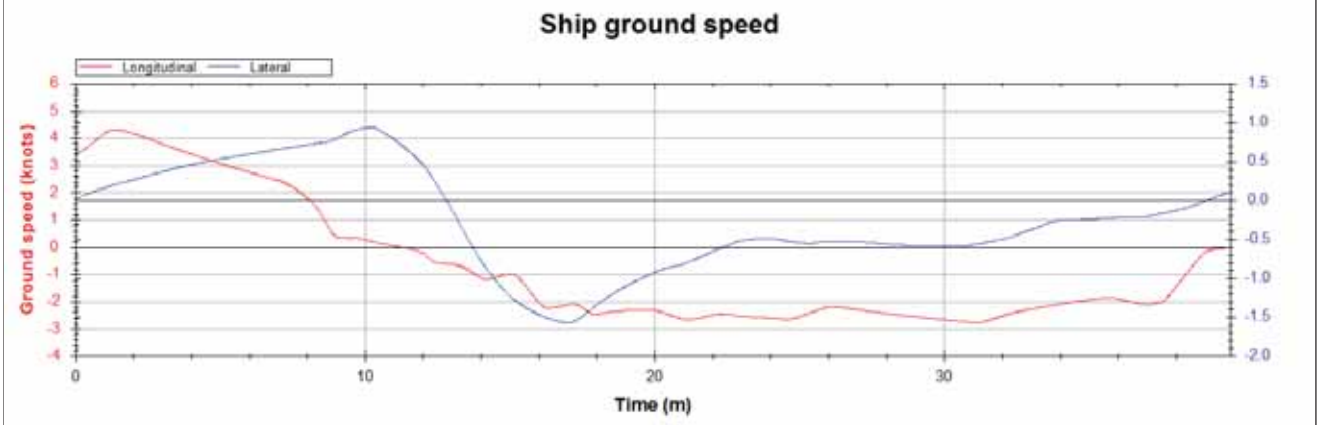
Run: 12	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

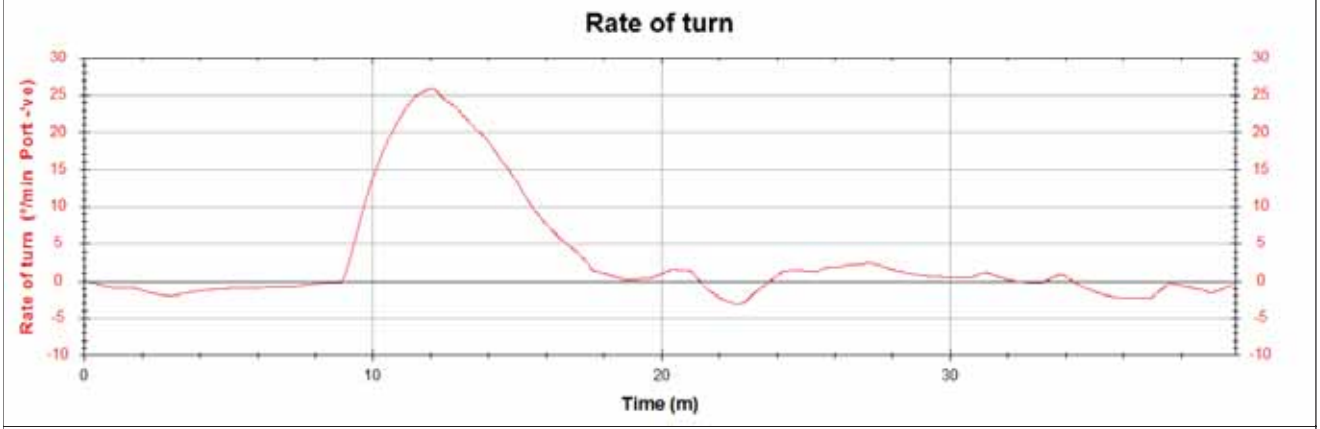


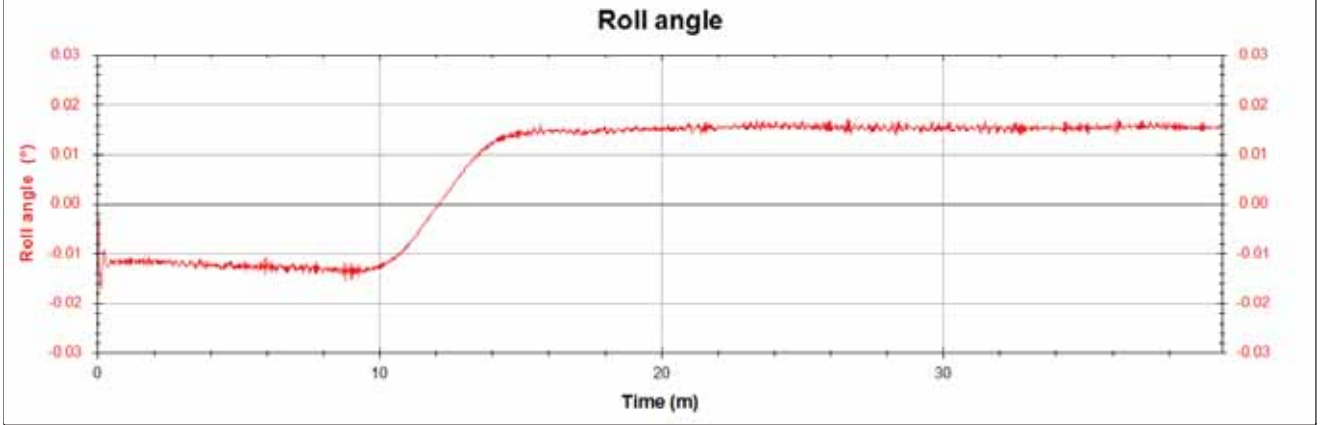
March 2015

Run: 13	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



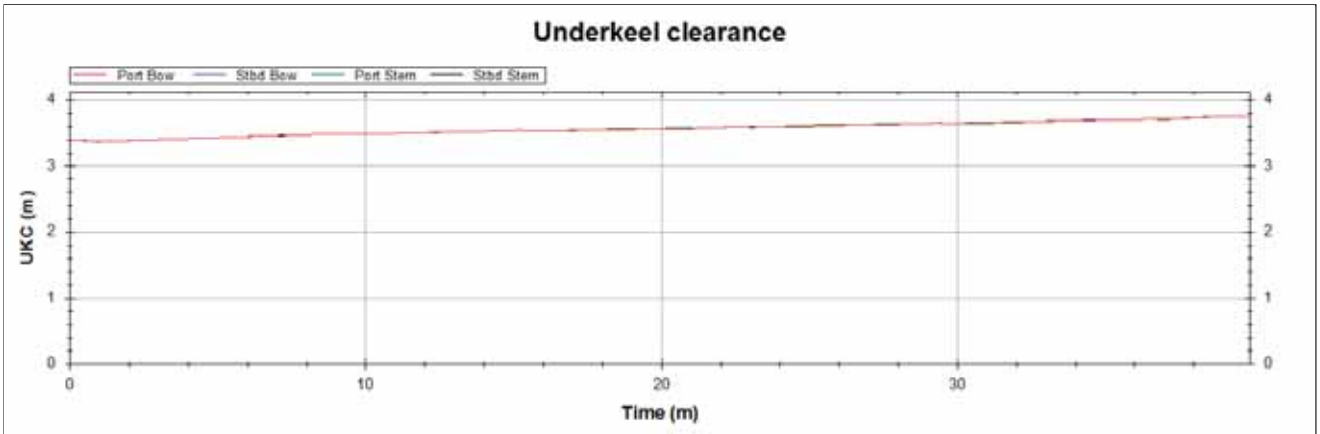


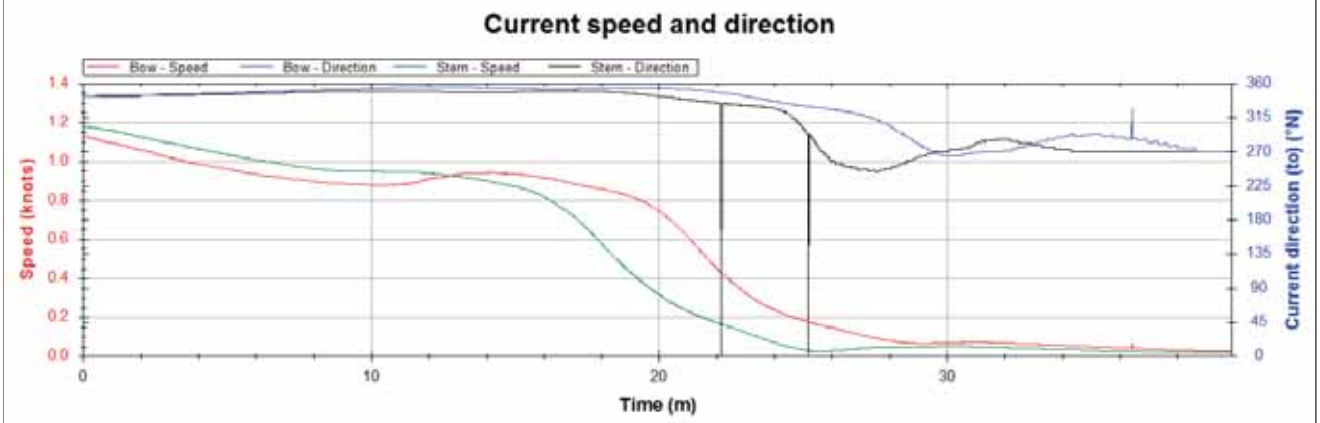


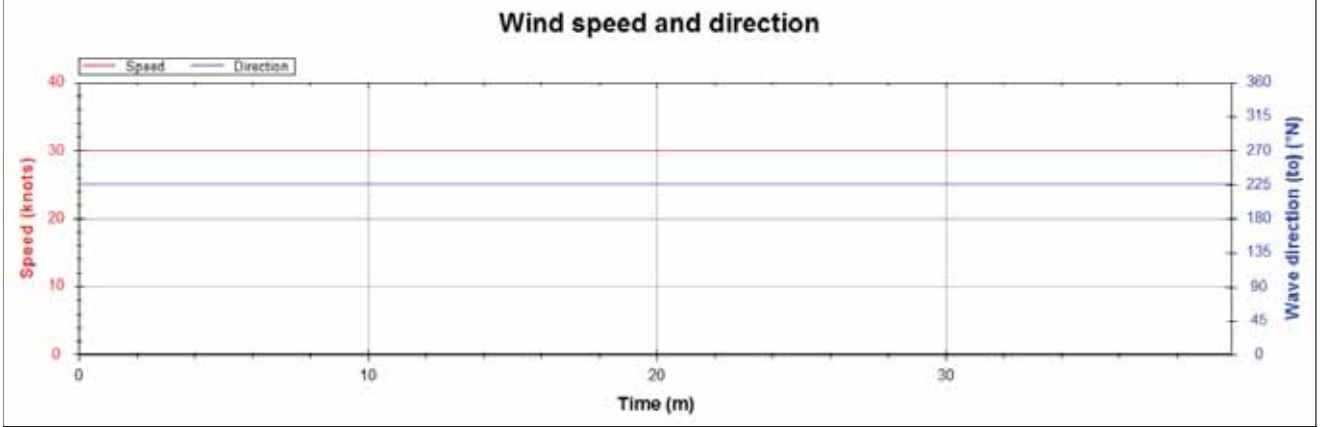


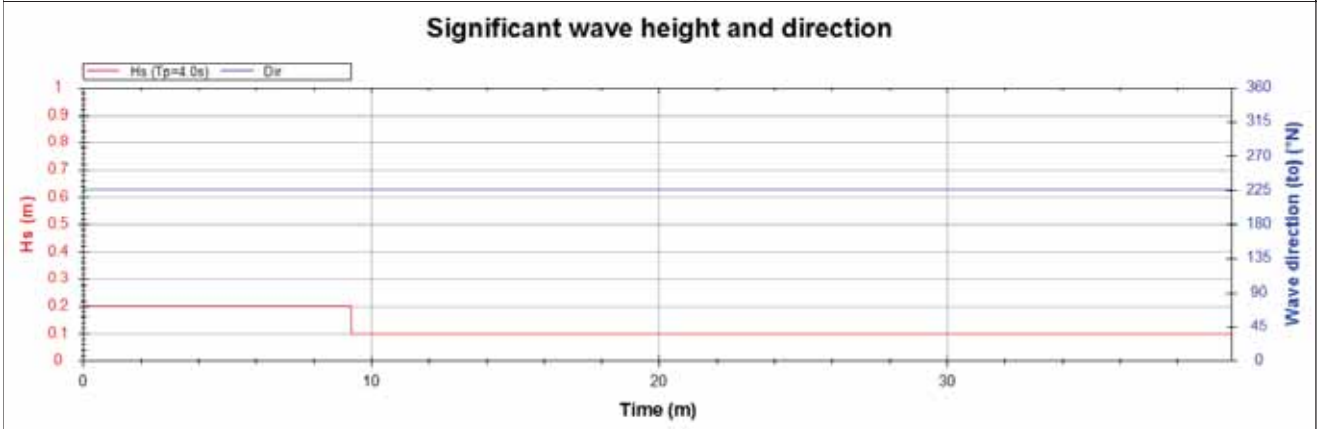
March 2015

Run: 13	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



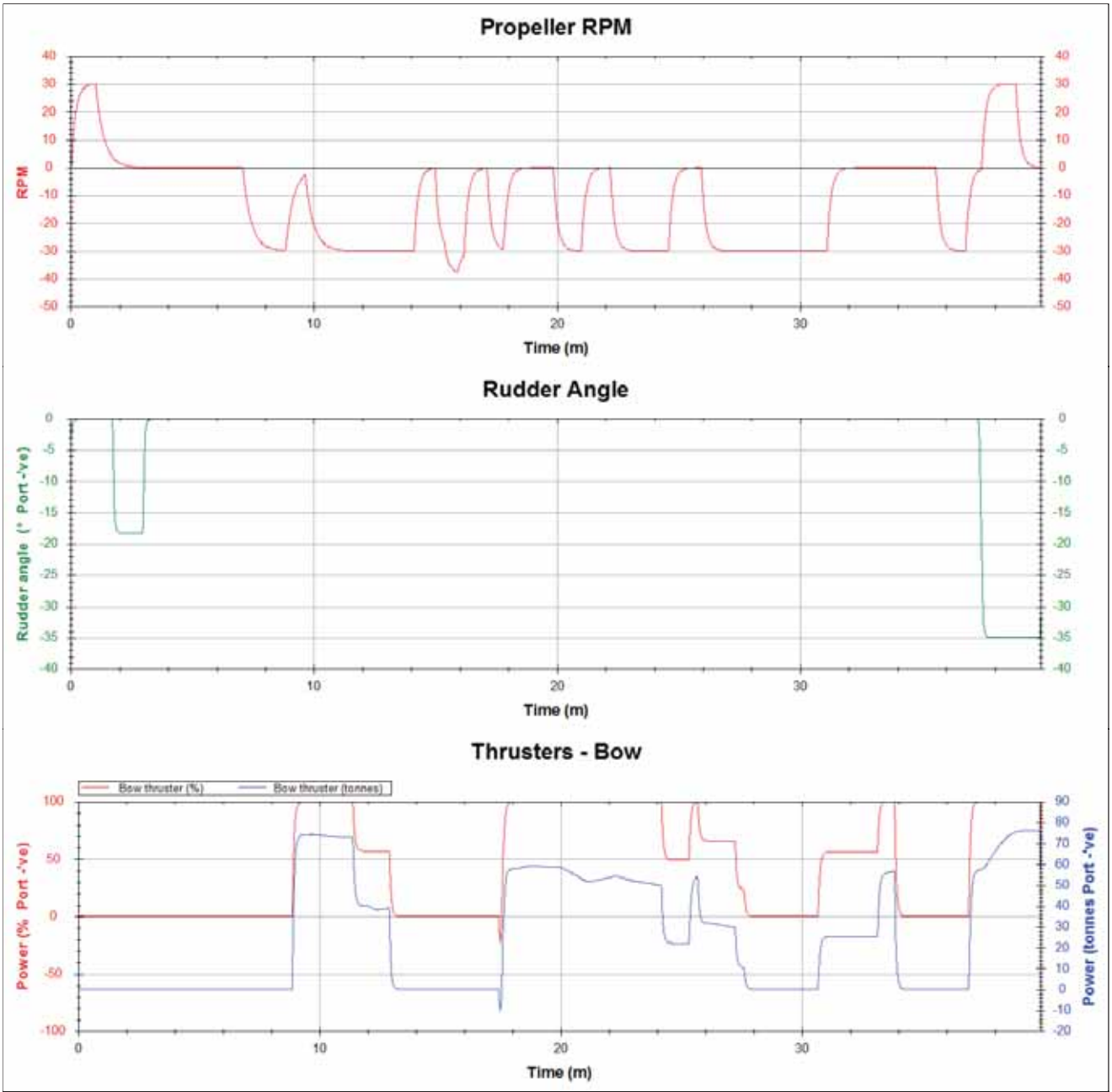






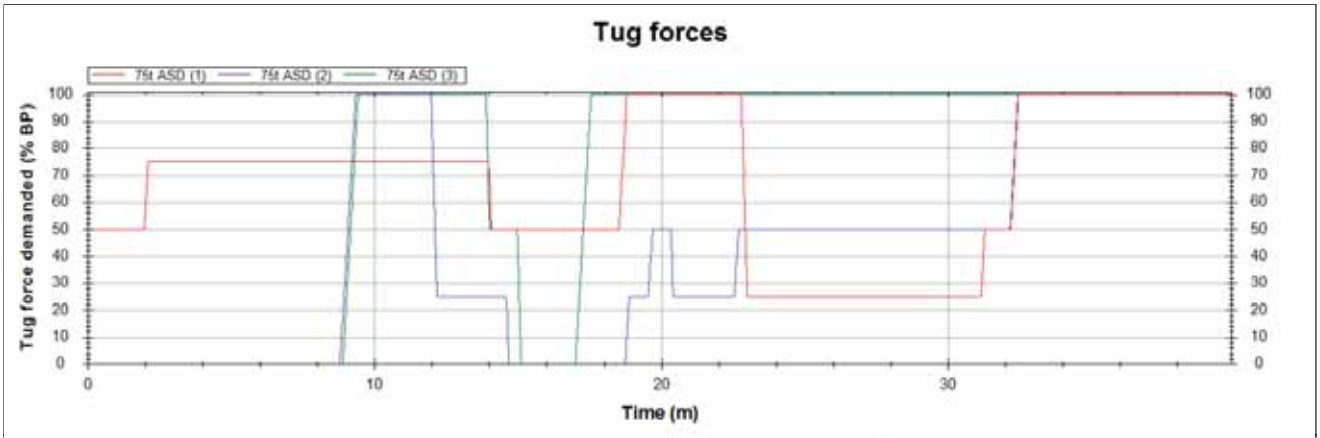
March 2015

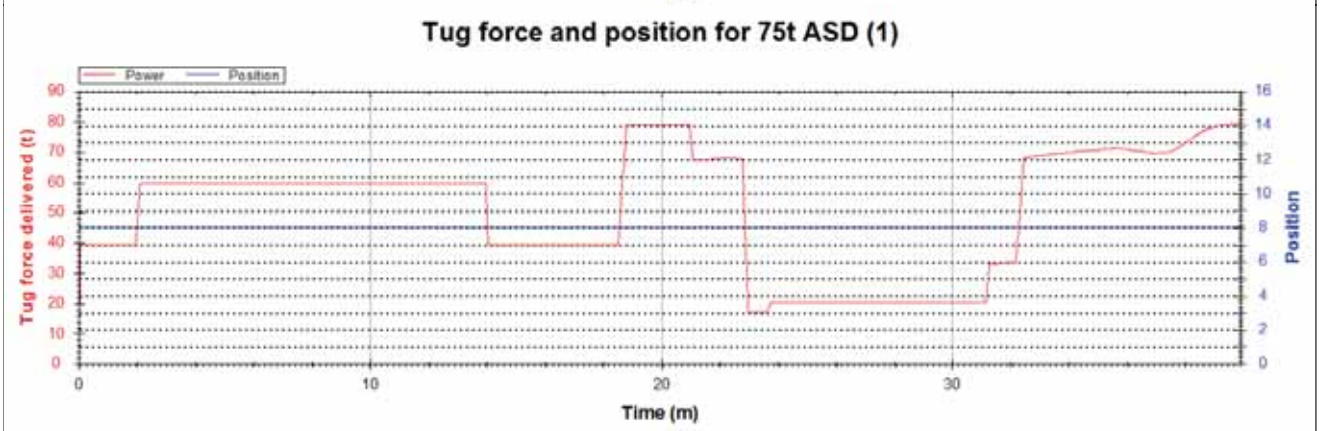
Run: 13	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

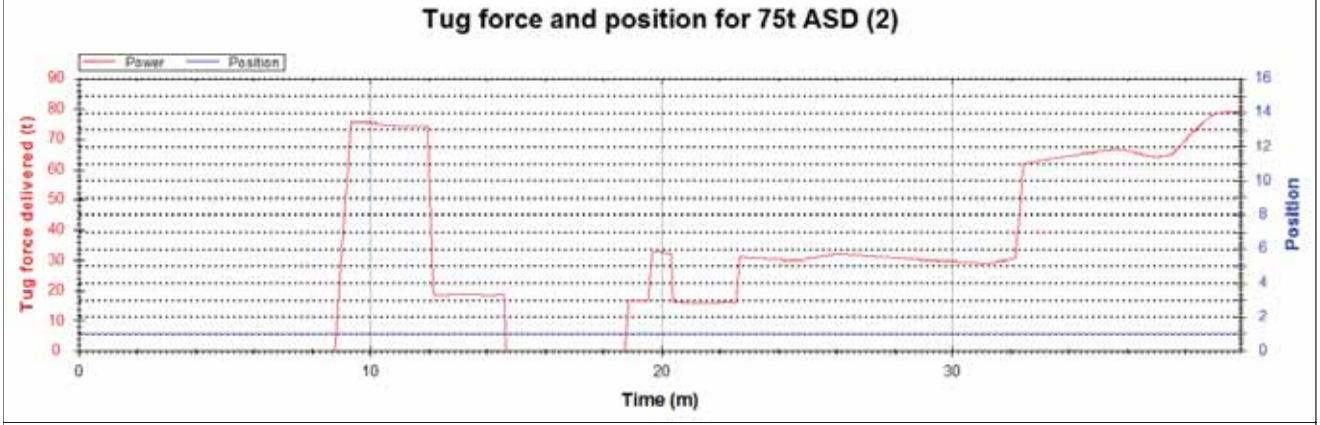


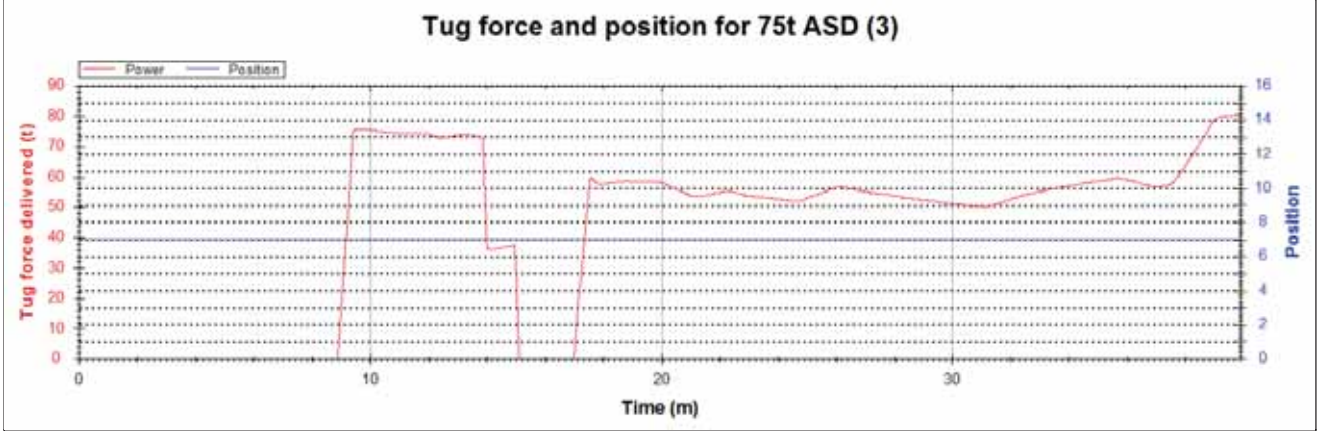
March 2015

Run: 13	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



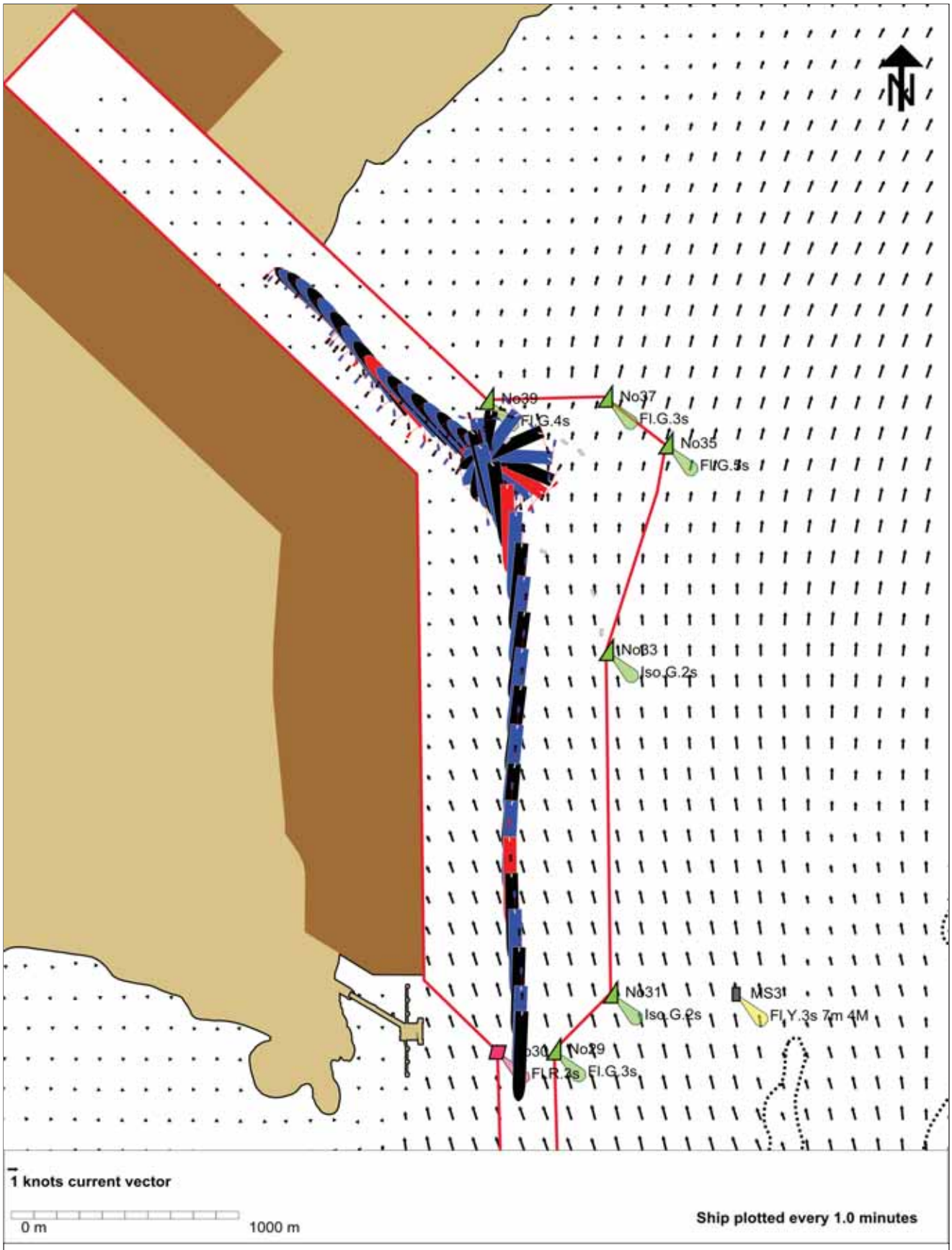






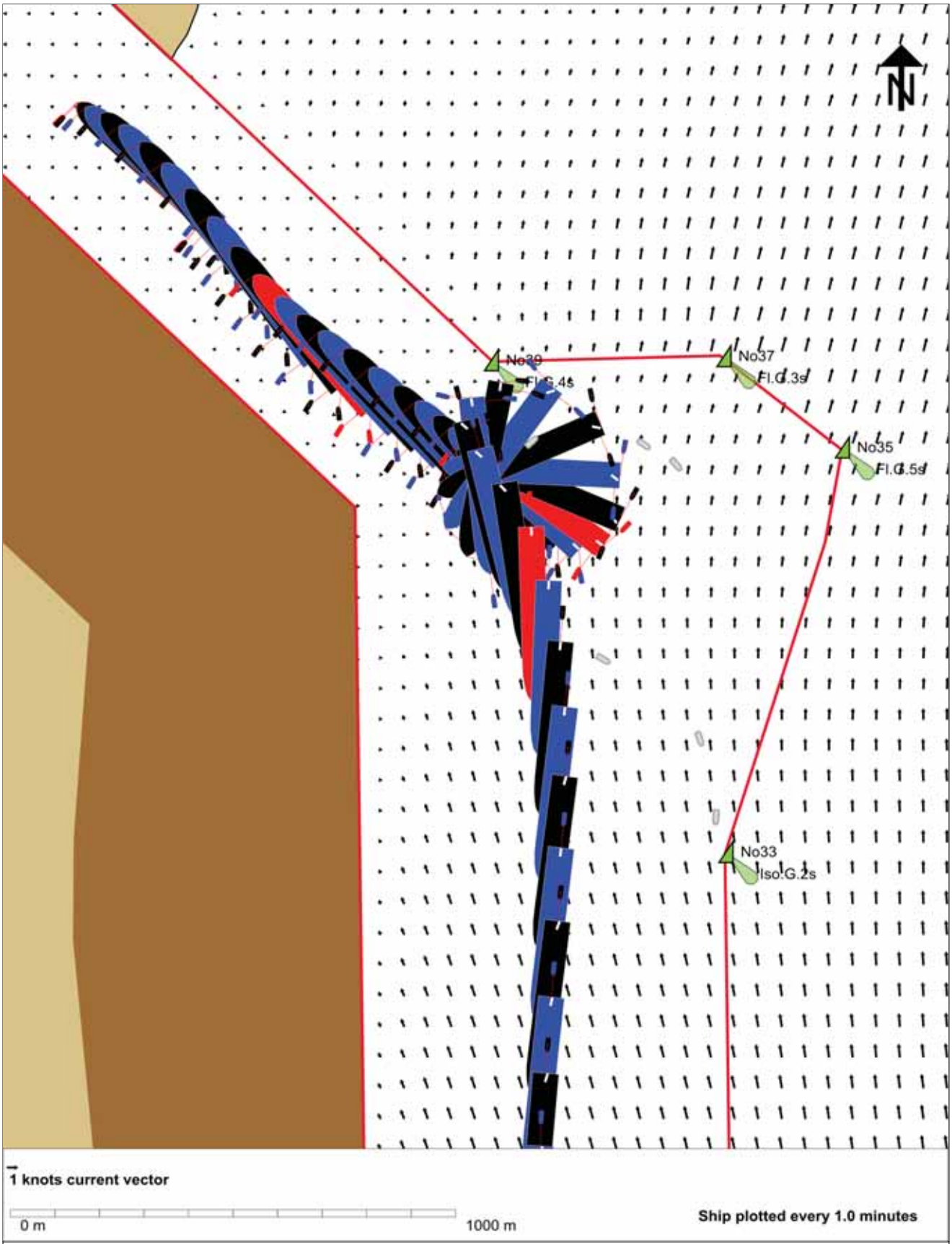
March 2015

Run: 13	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



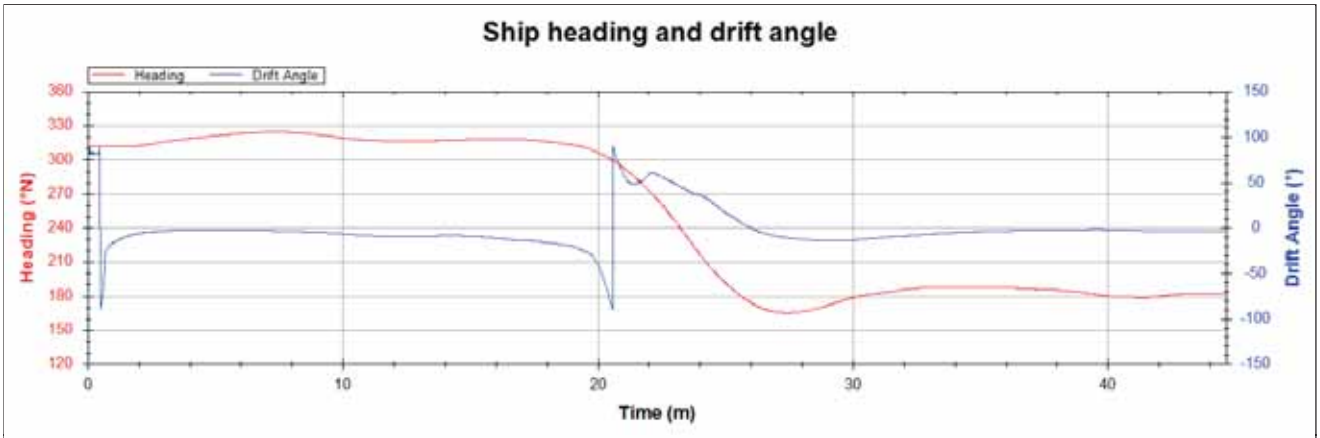
March 2015

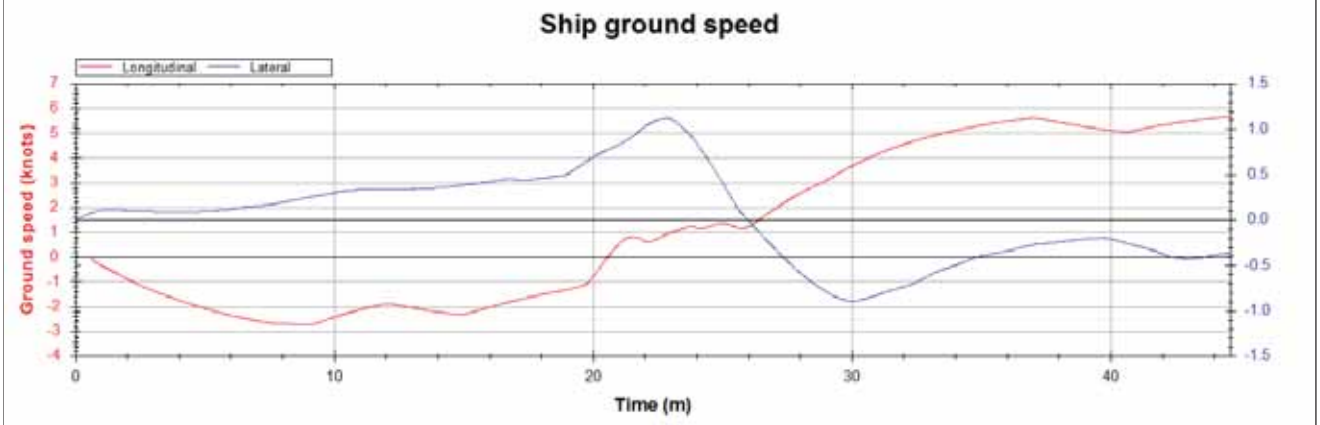
Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

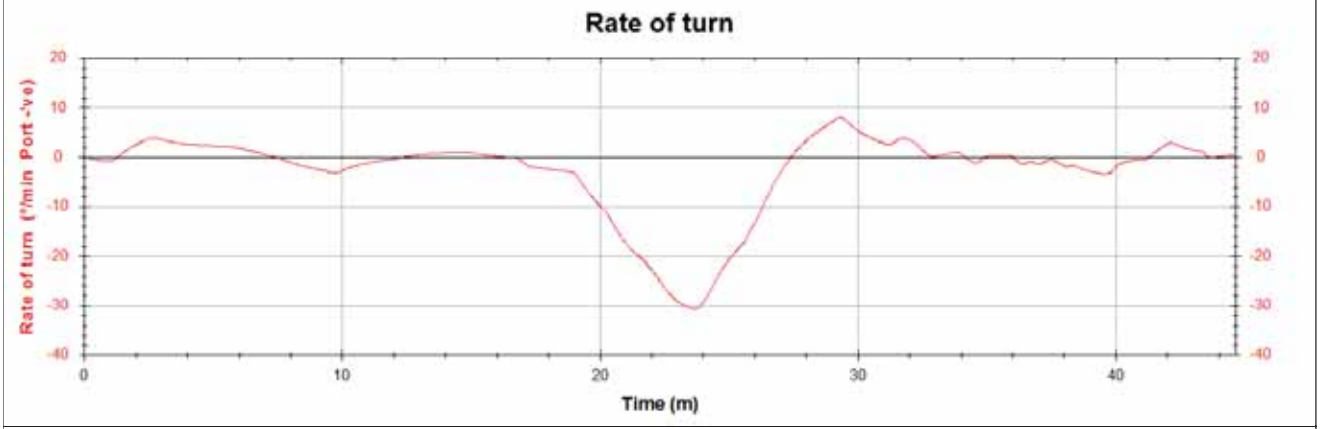


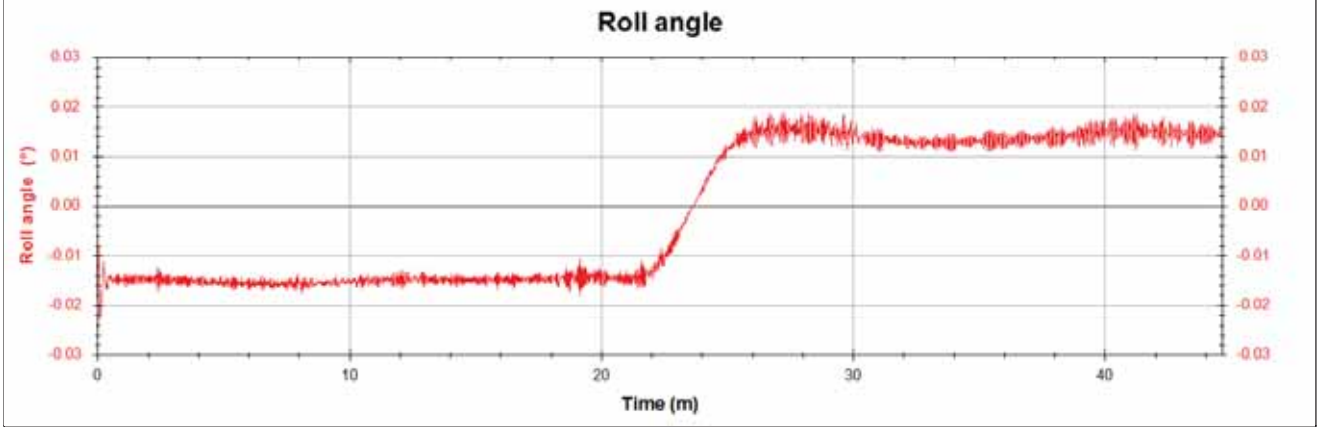
March 2015

Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



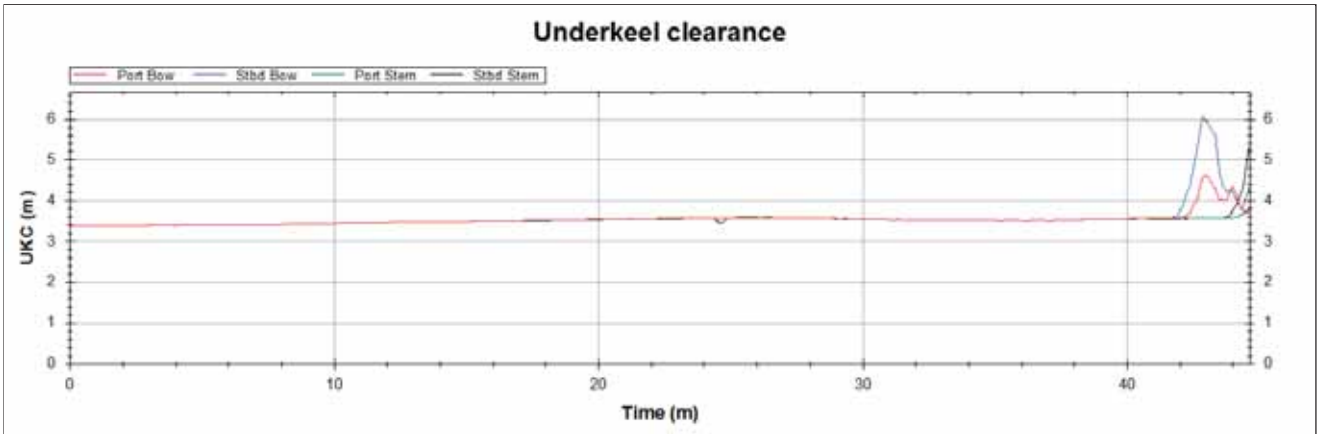


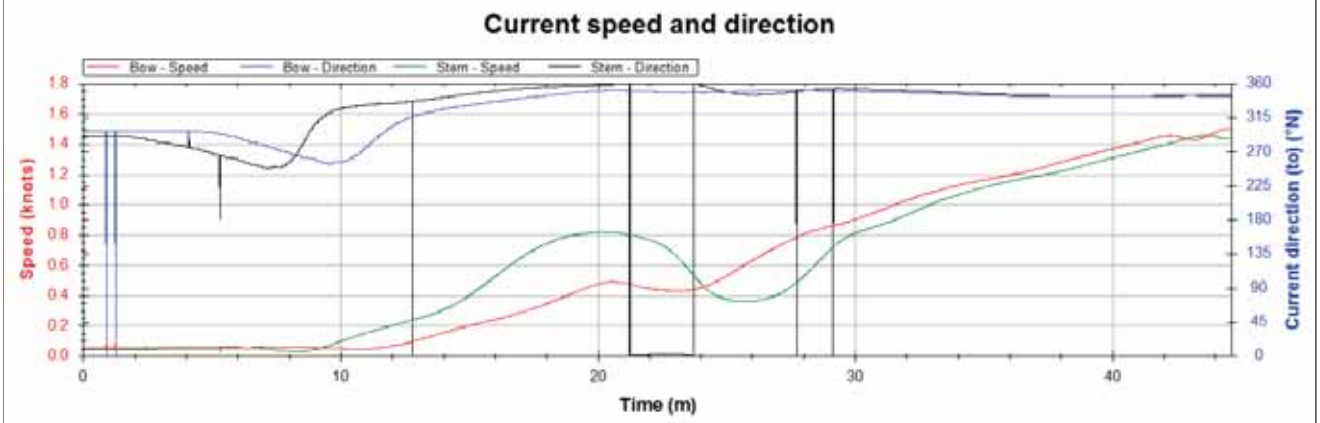


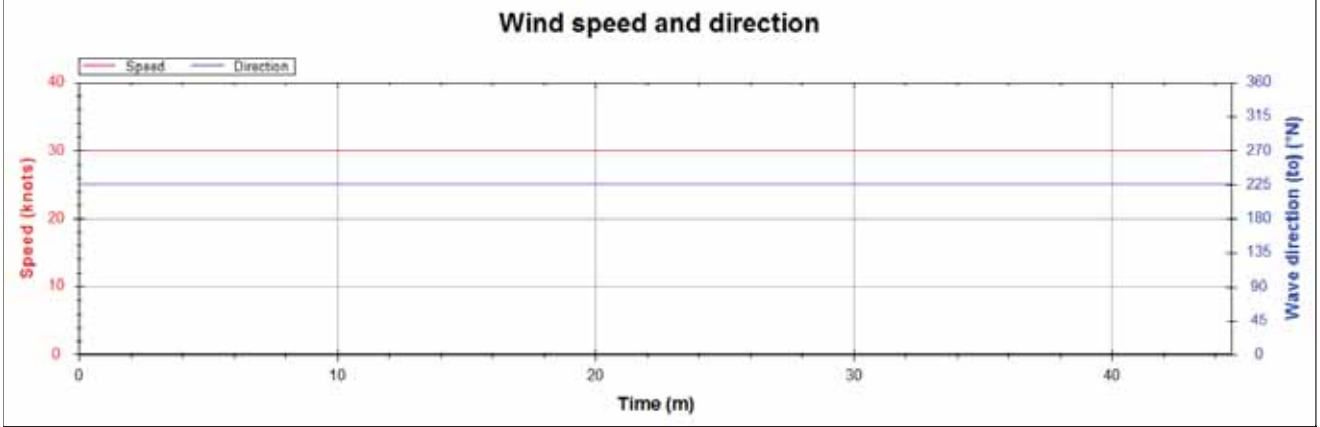


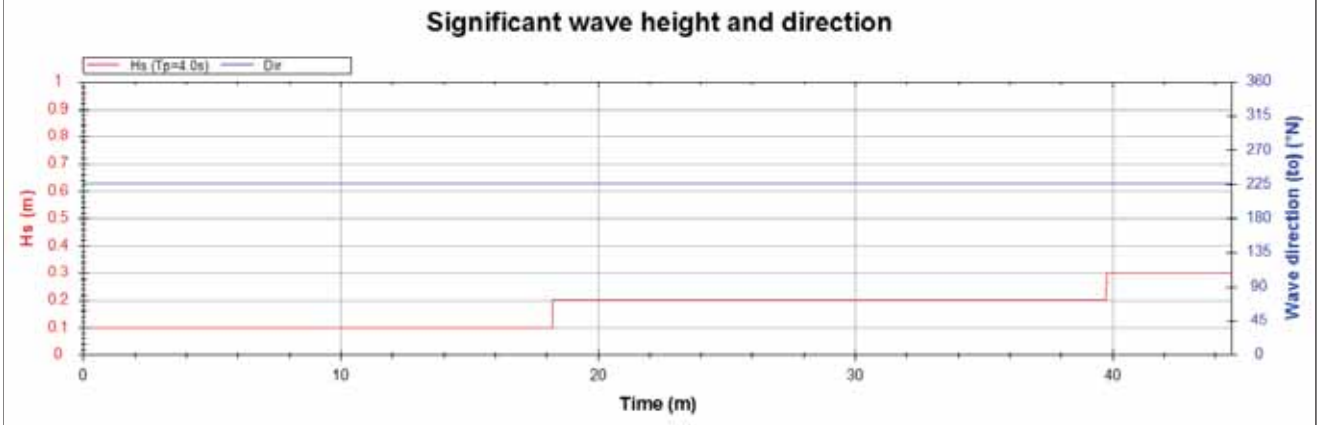
March 2015

Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



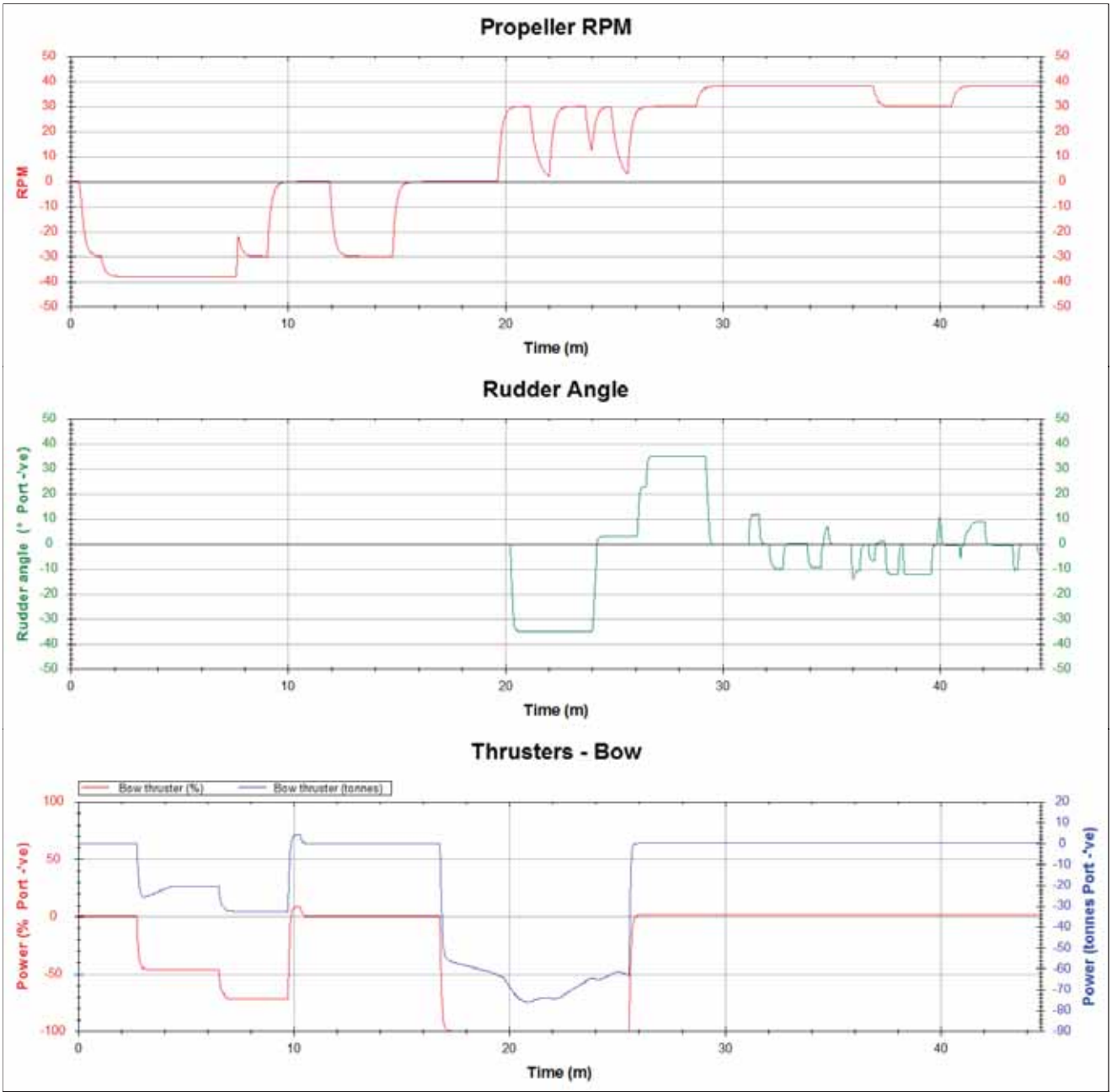






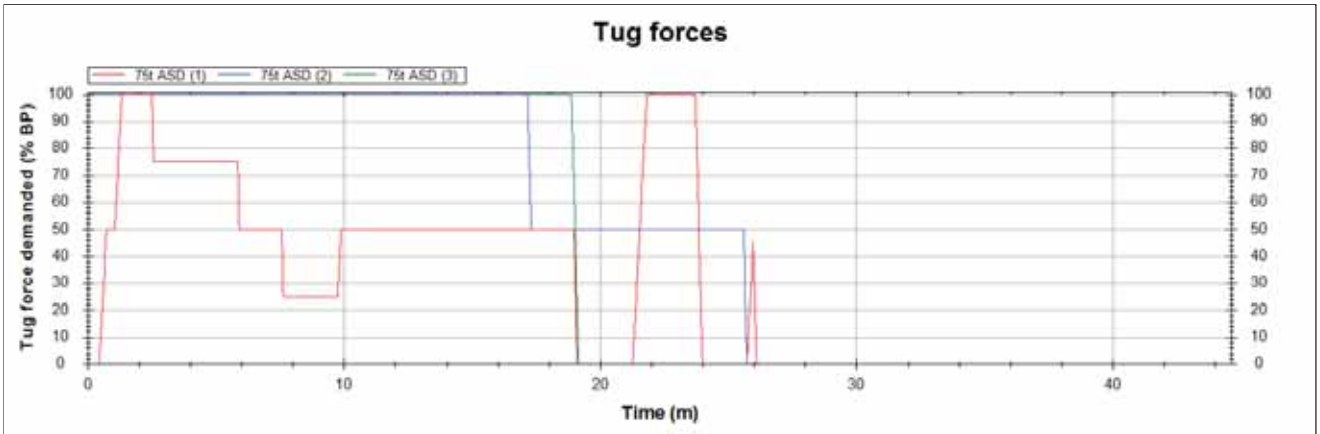
March 2015

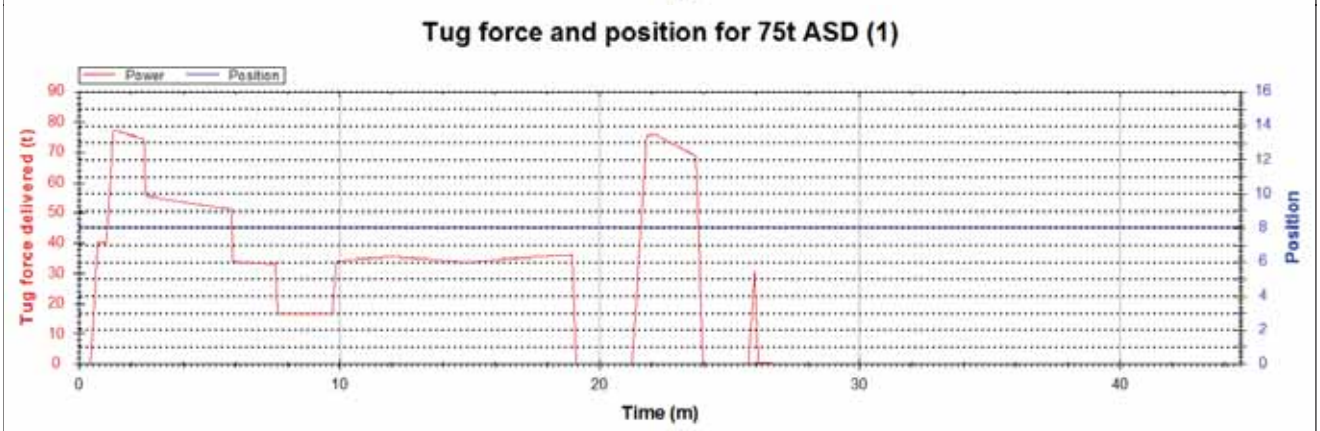
Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

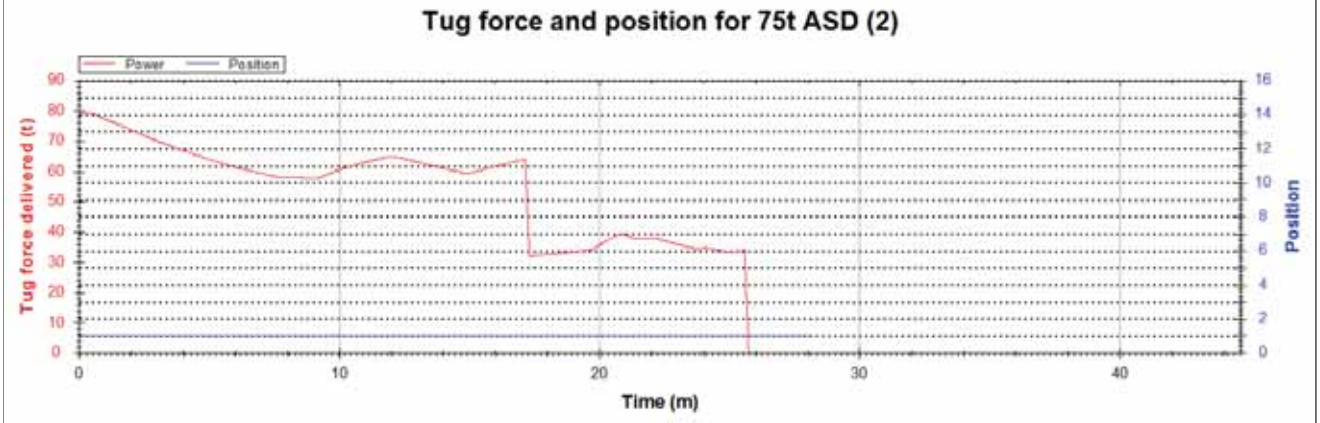


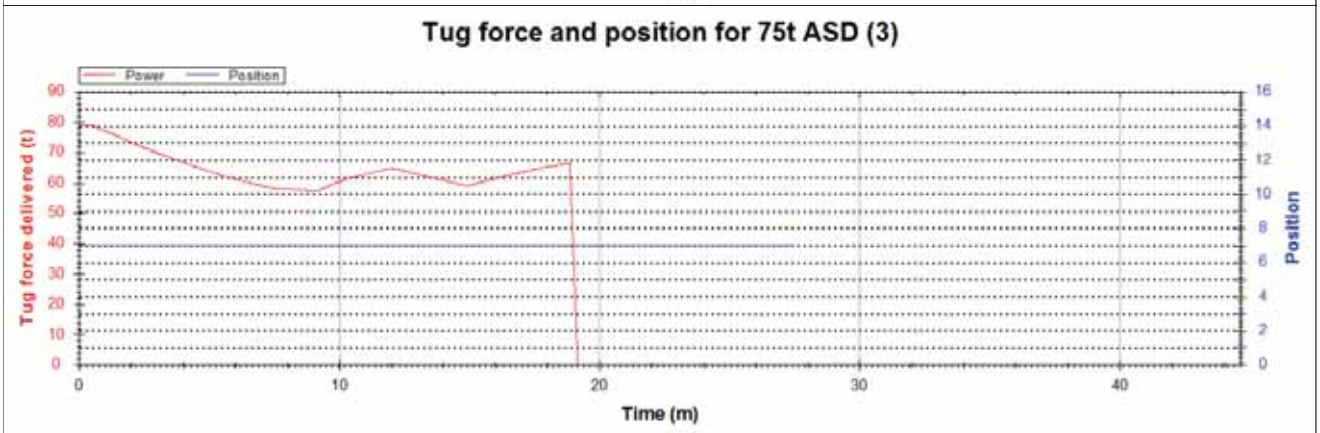
March 2015

Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



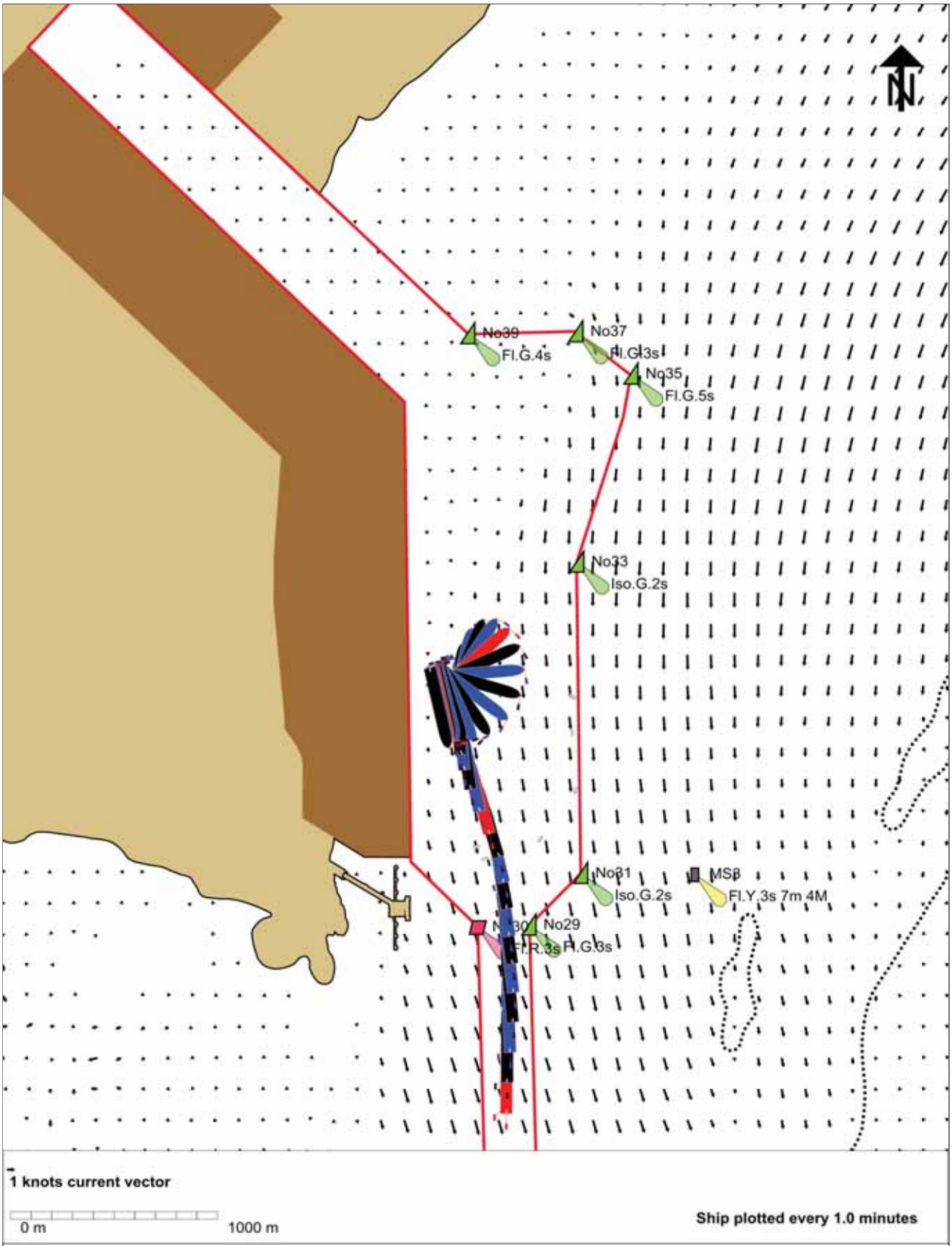






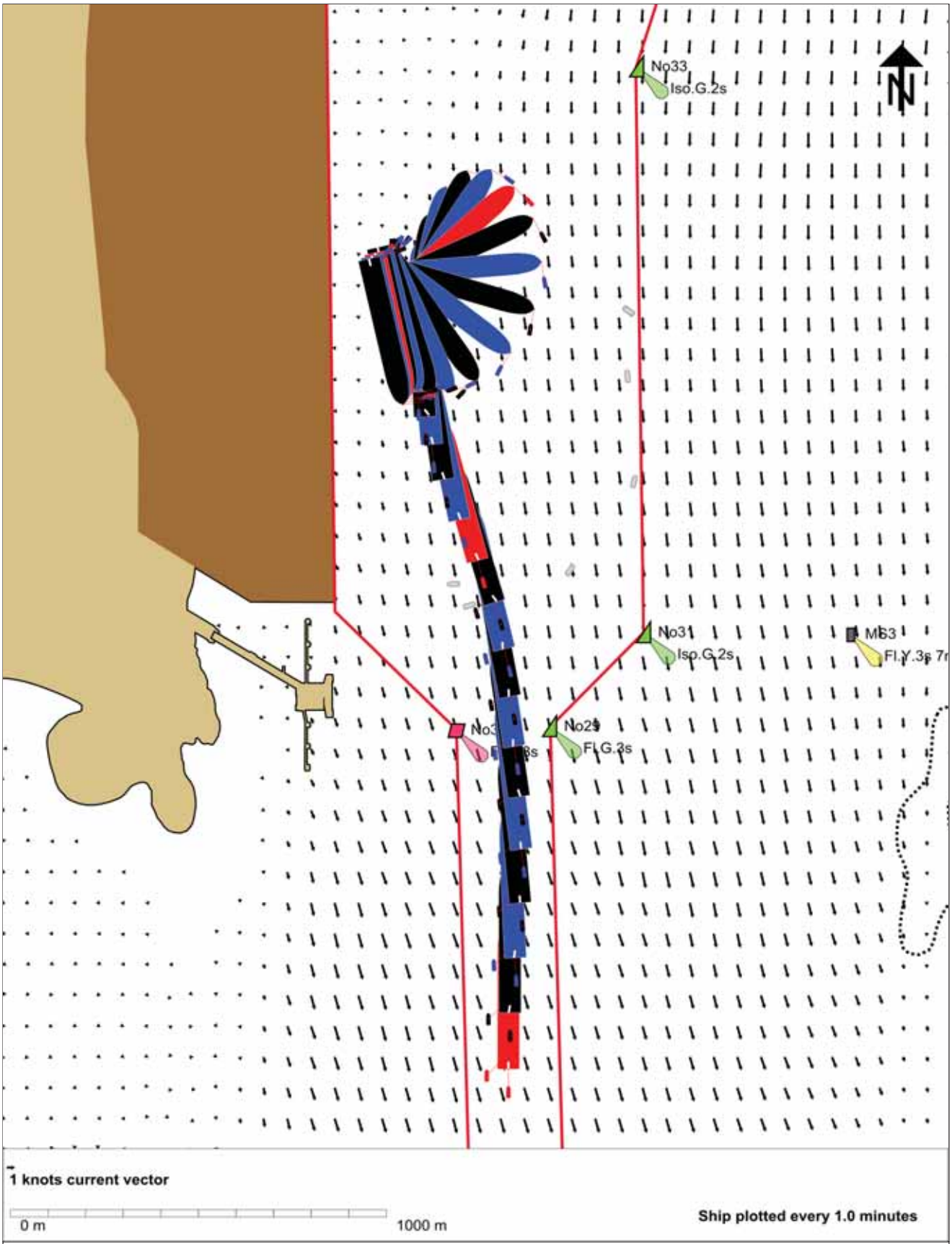
March 2015

Run: 14	Pilot: IS	Ship: 399m Container Ship
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



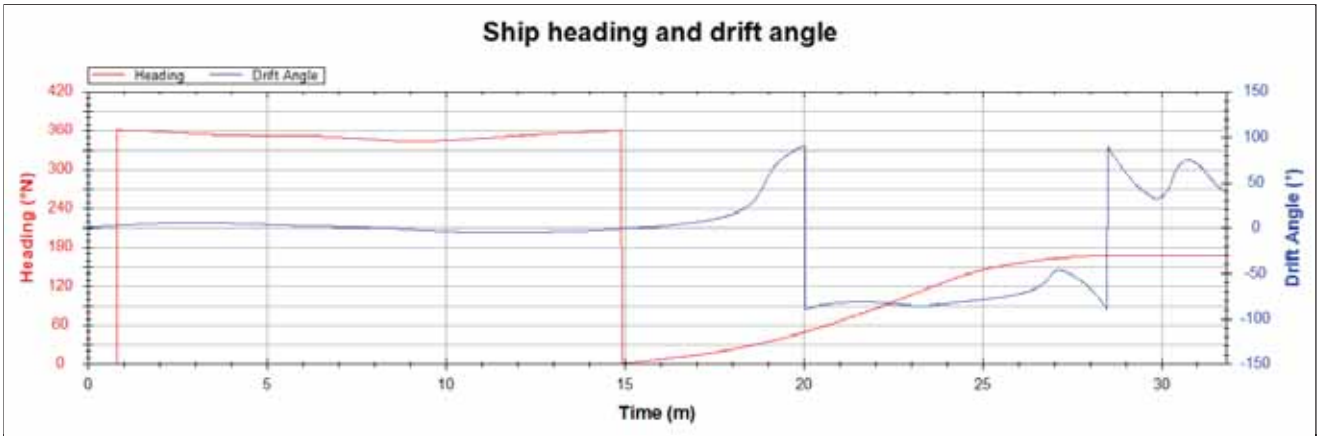
March 2015

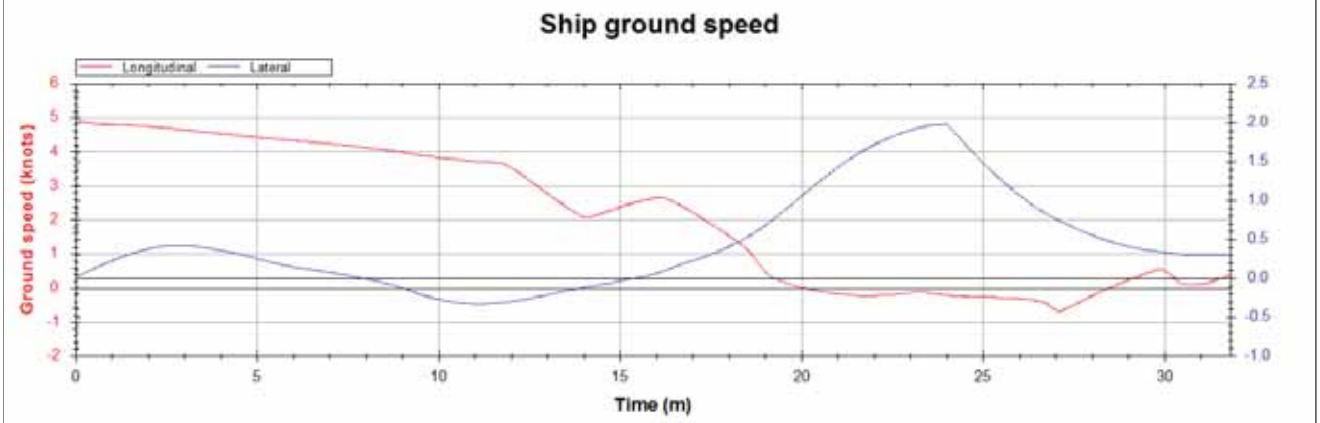
Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)

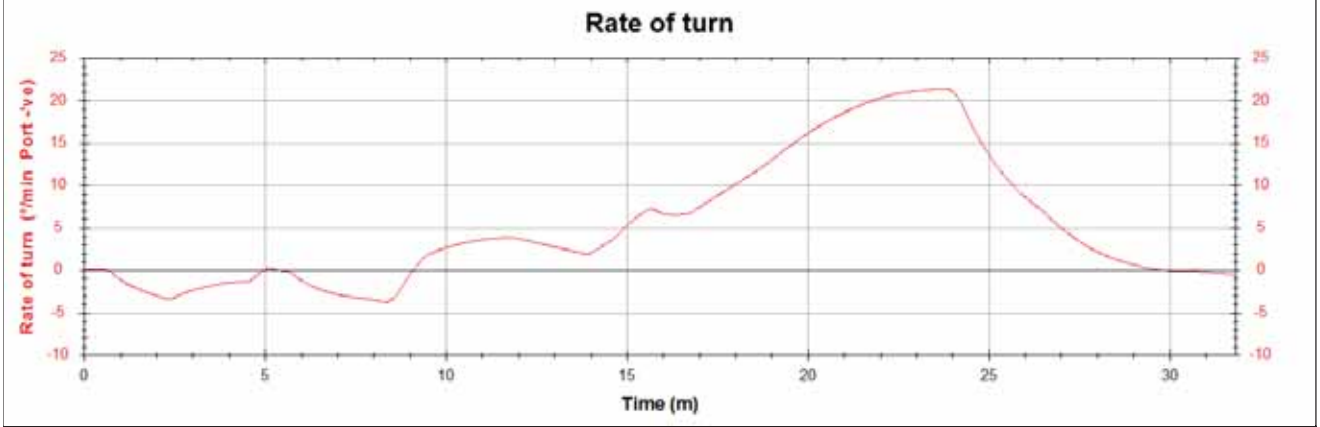


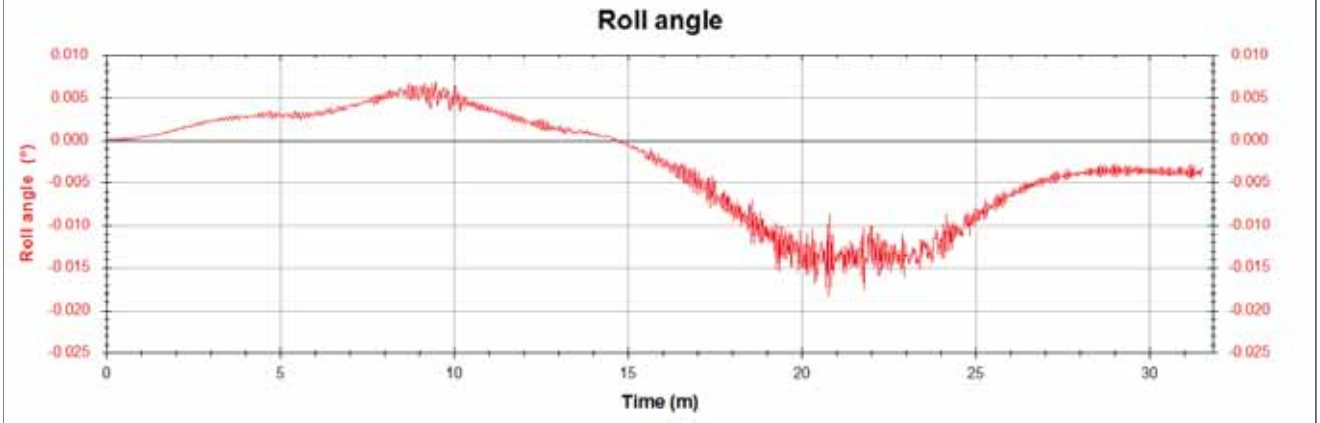
March 2015

Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)



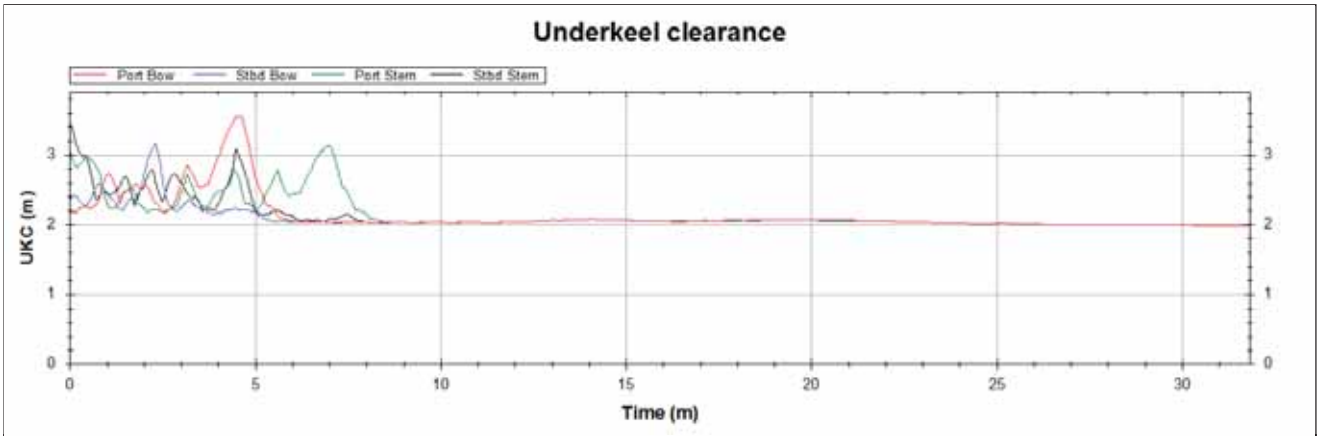


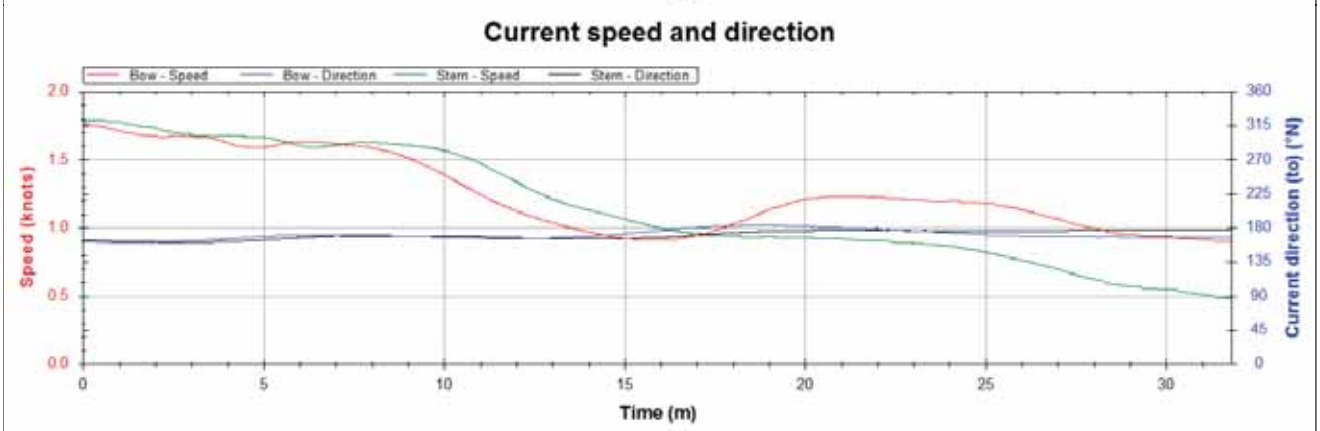


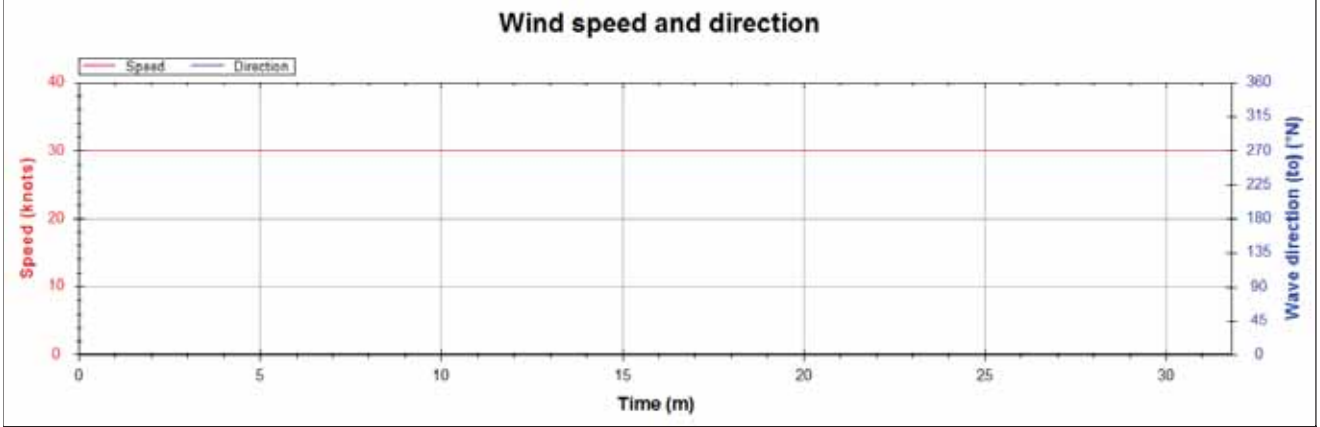


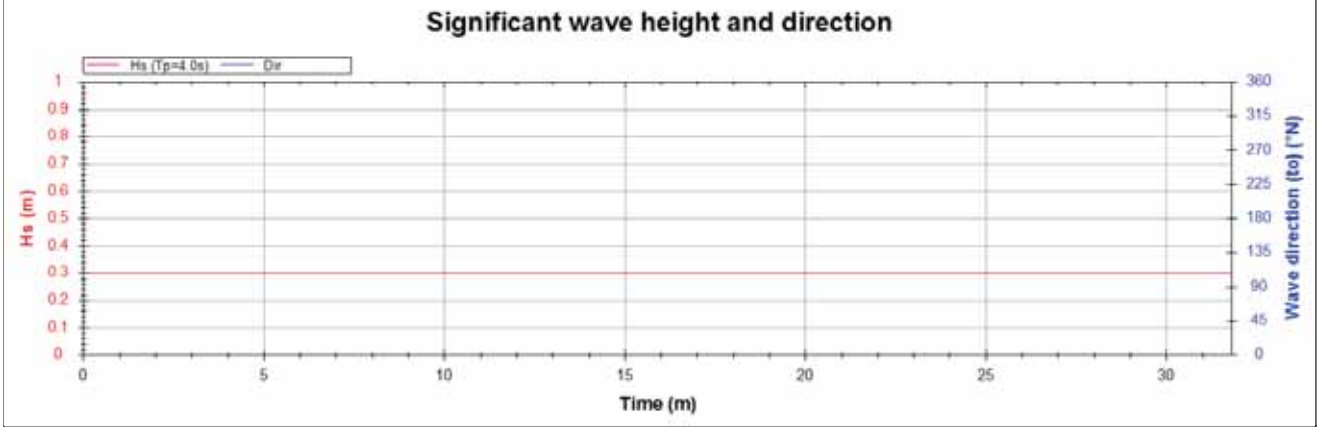
March 2015

Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)



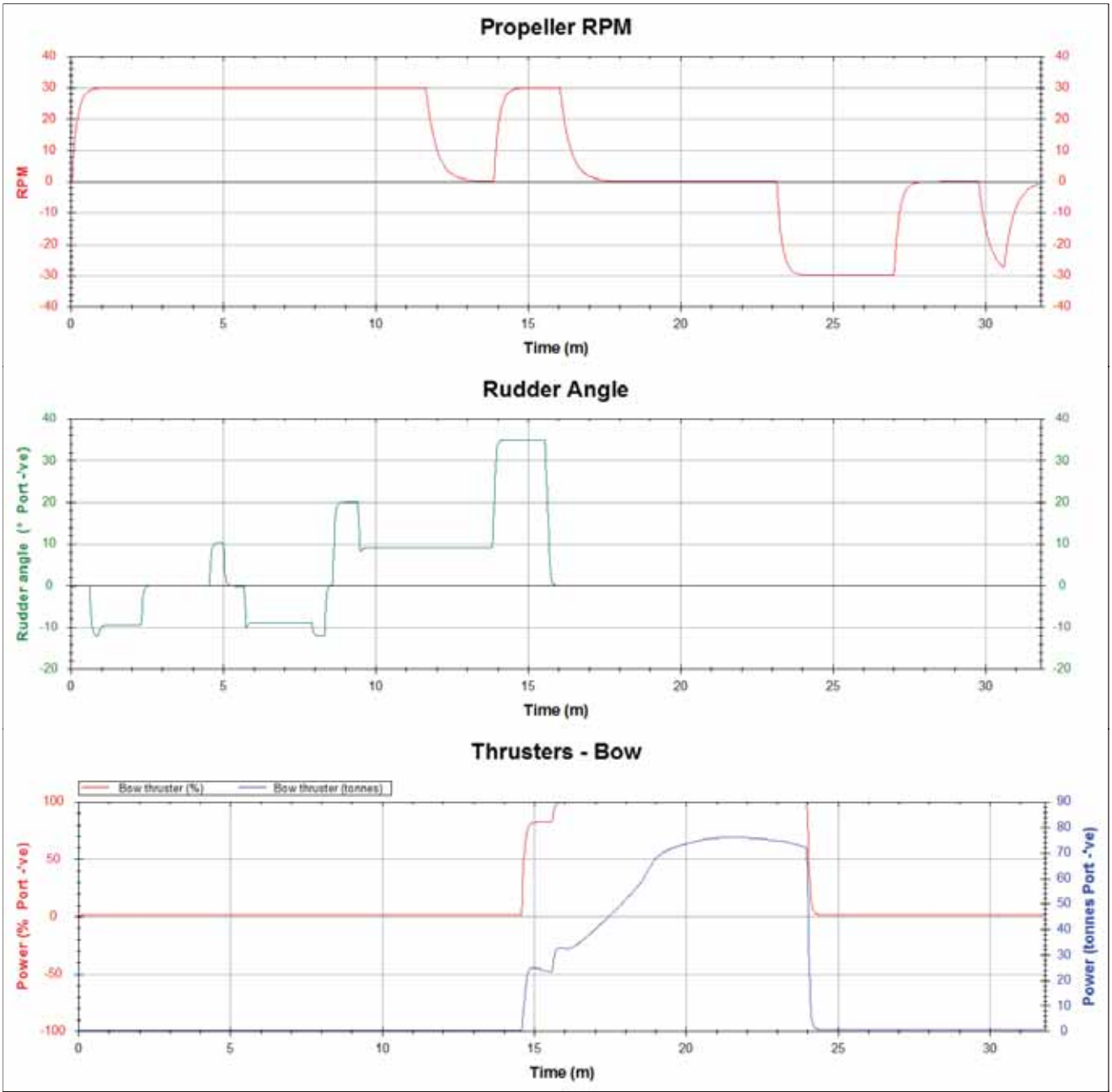






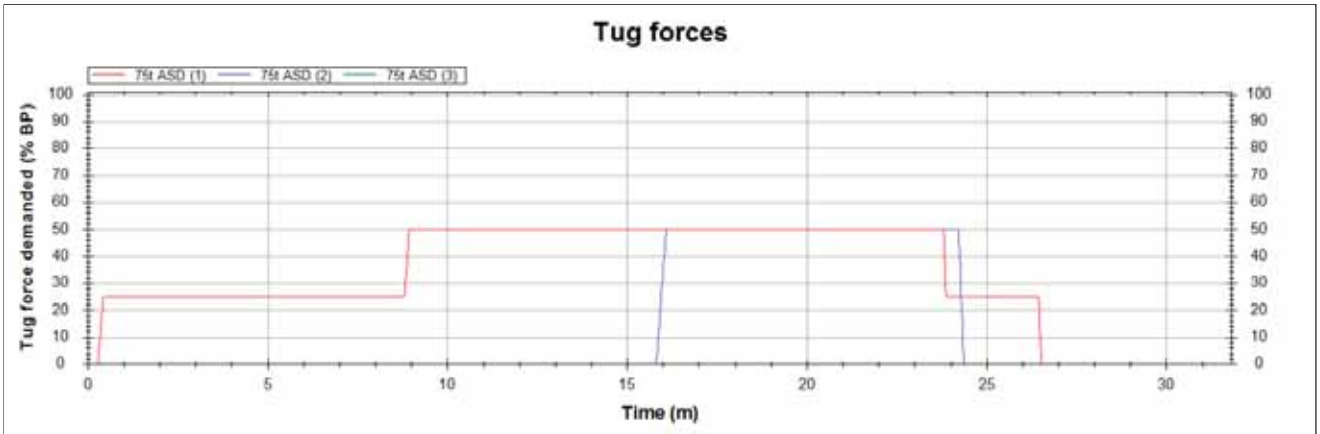
March 2015

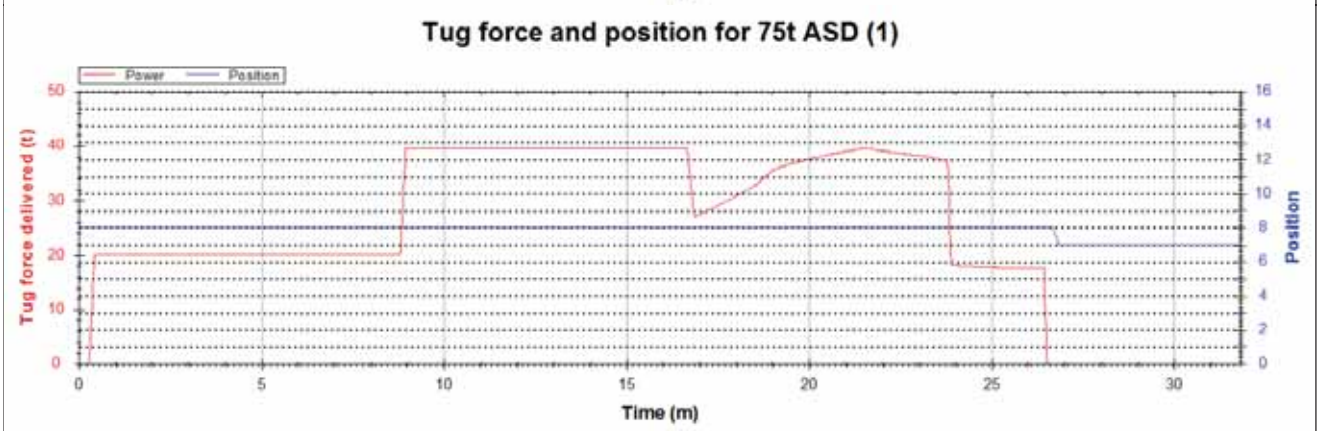
Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)

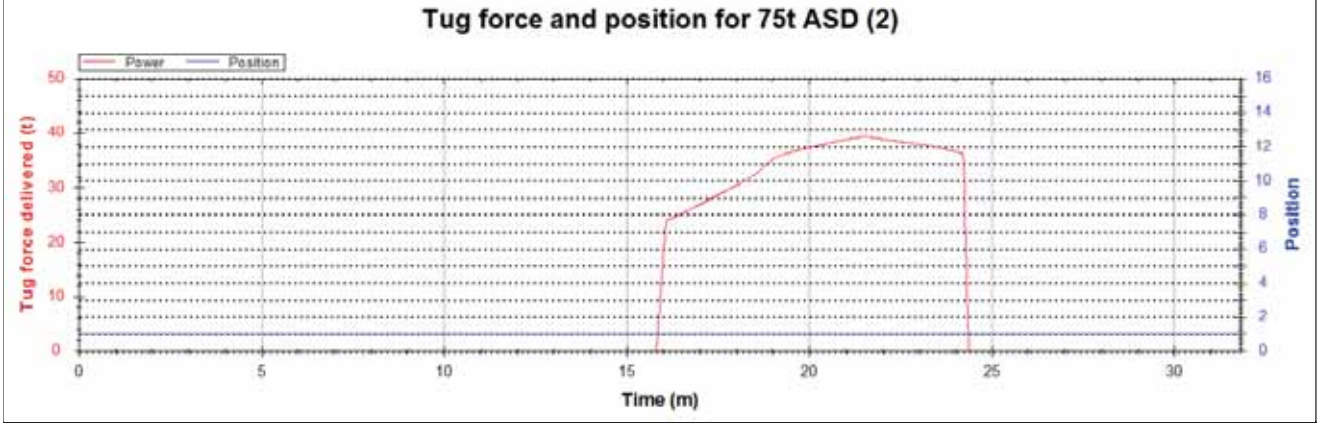


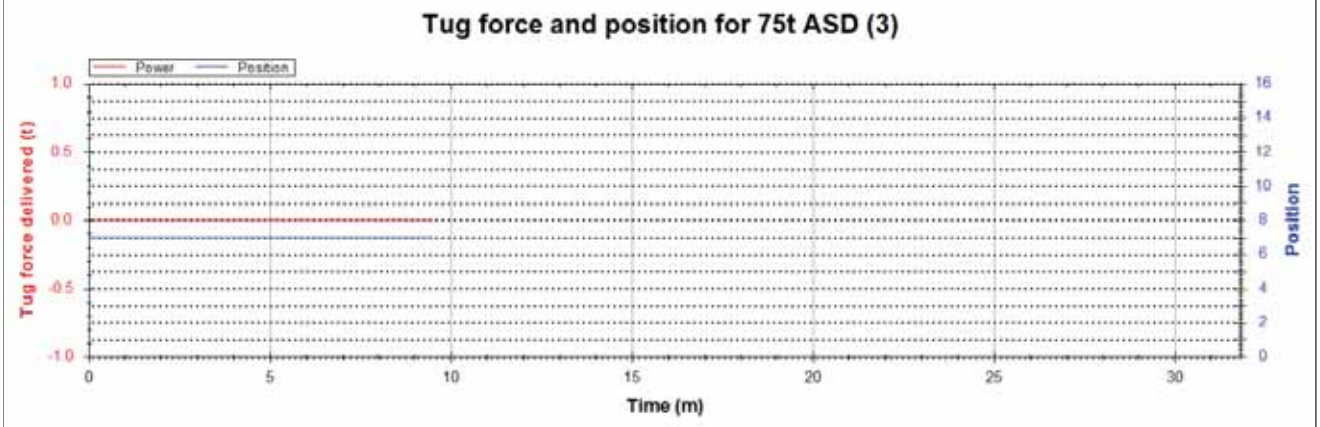
March 2015

Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)



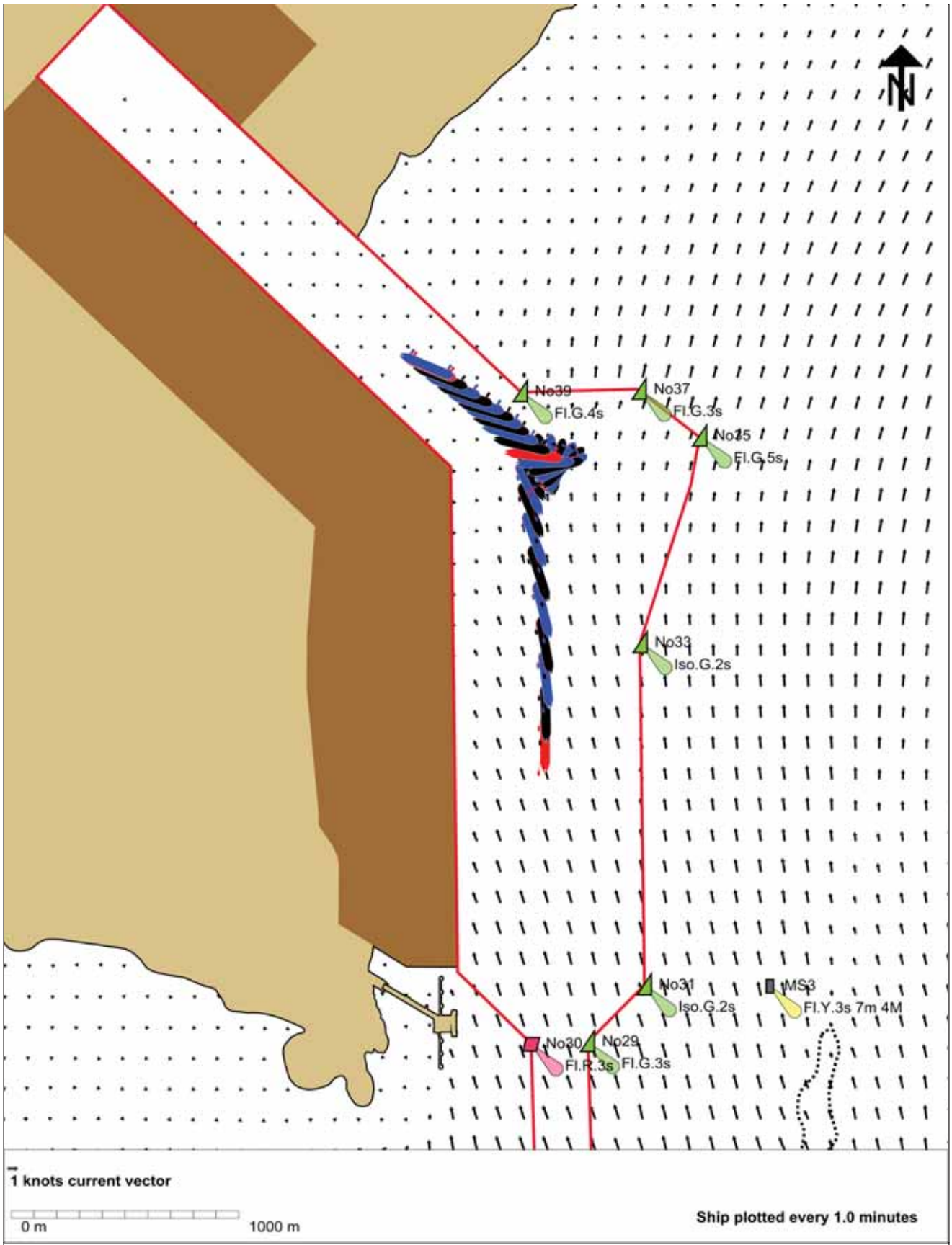






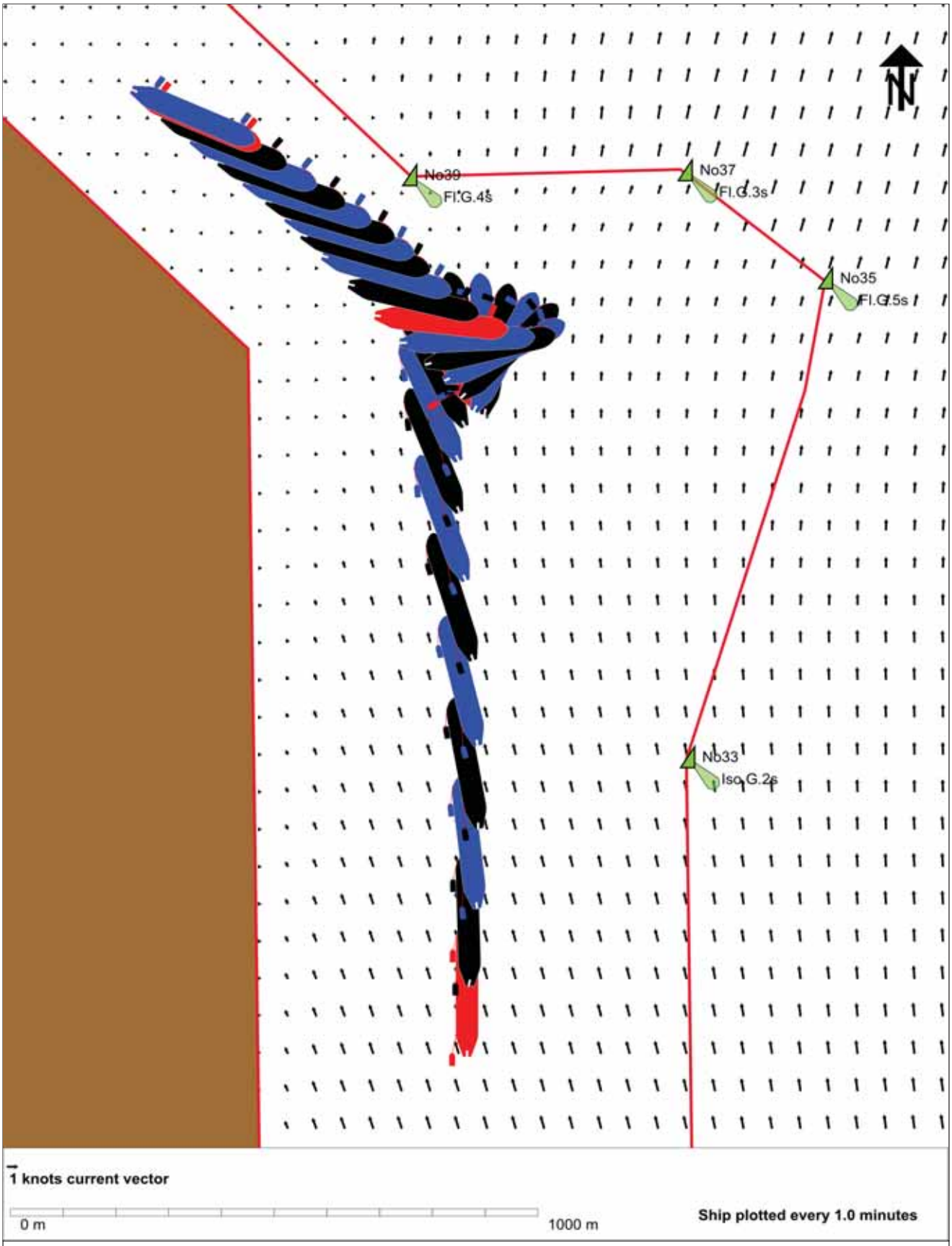
March 2015

Run: 15	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Long	Type (Condition): Container (Laden)



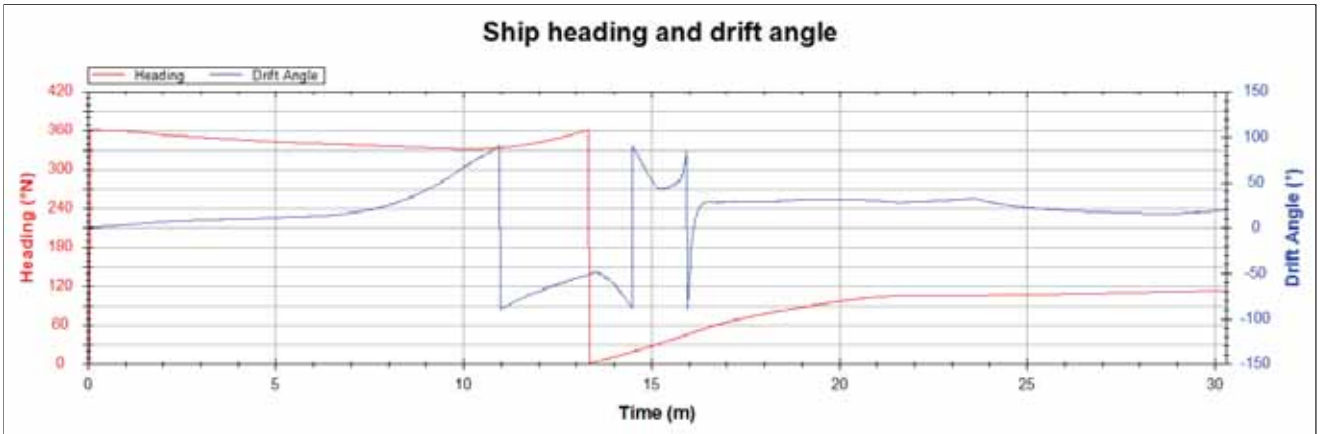
March 2015

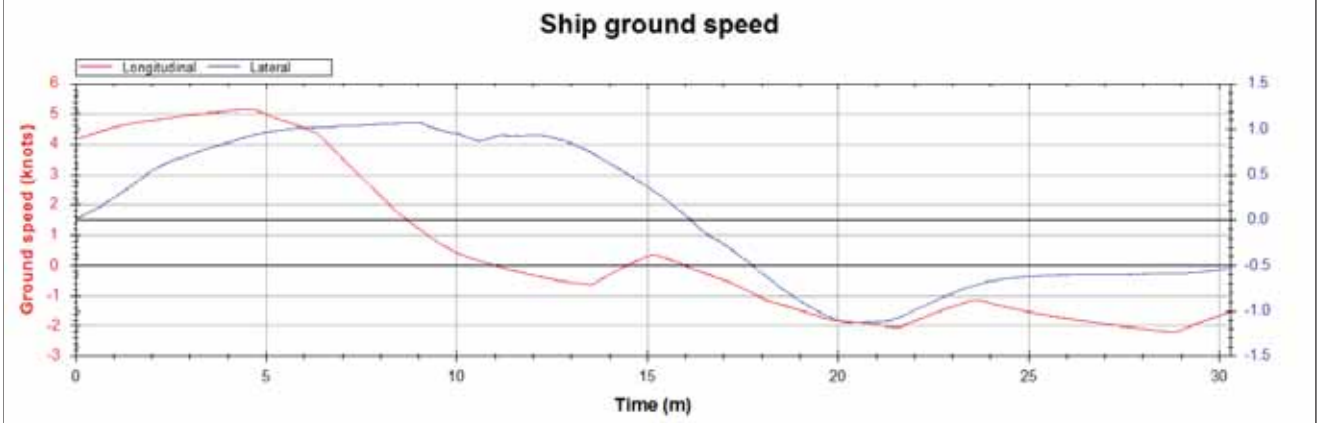
Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)

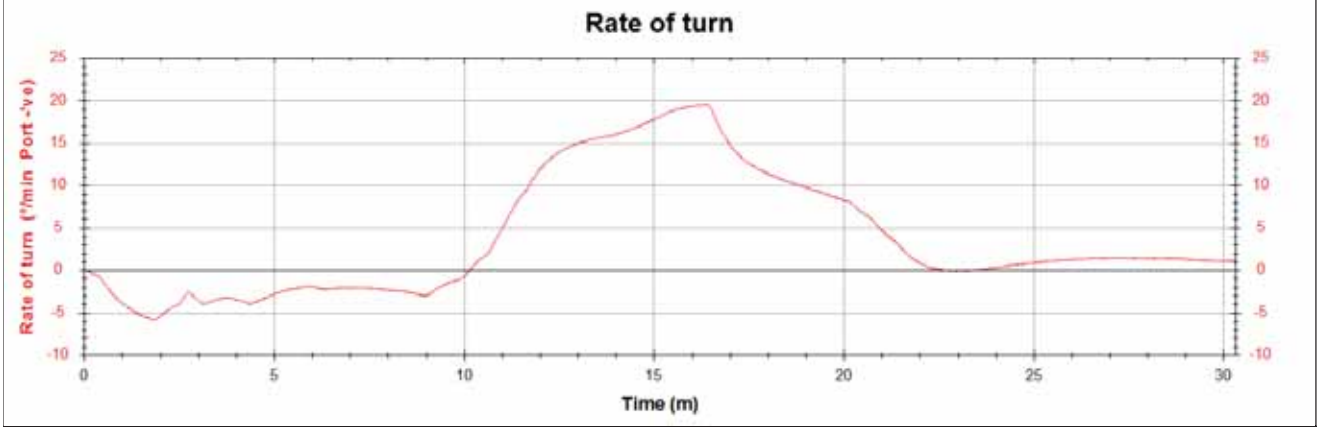


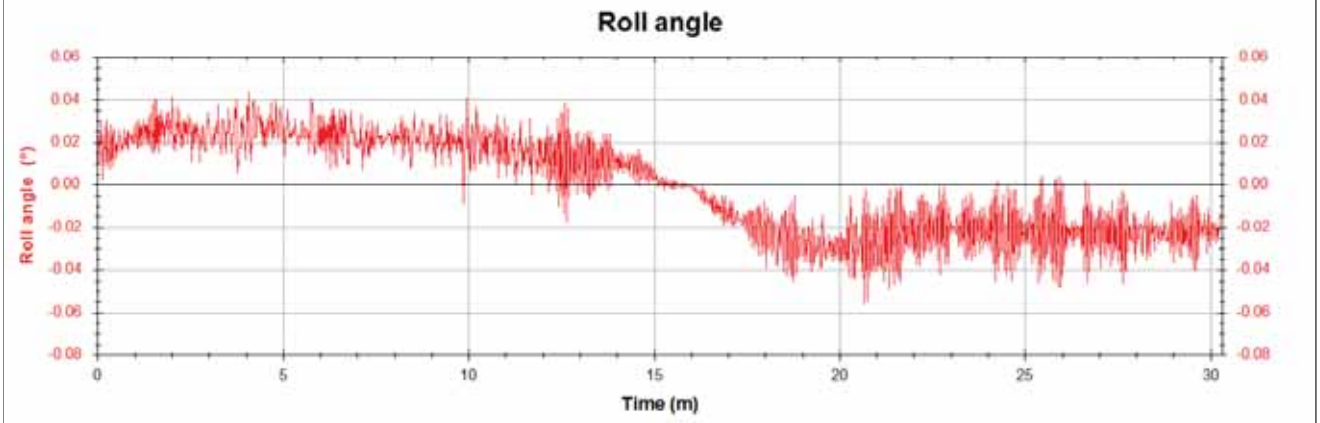
March 2015

Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)





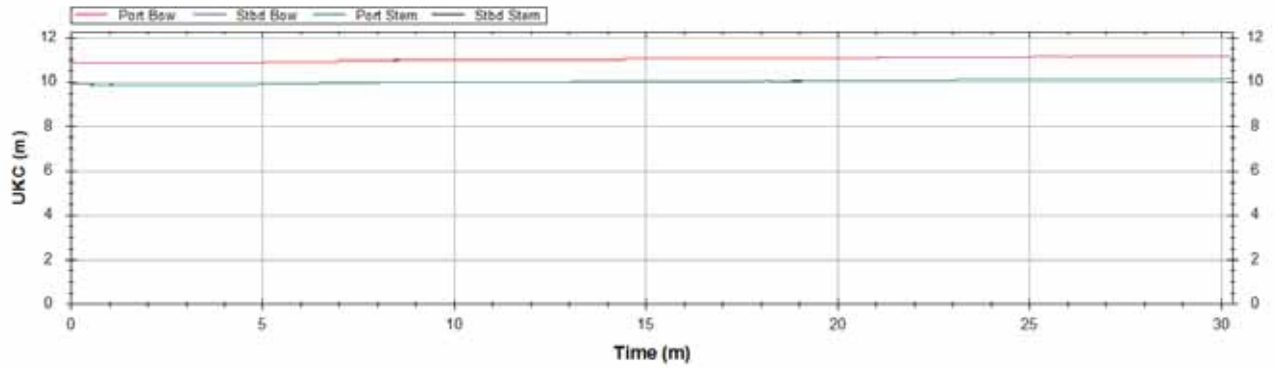




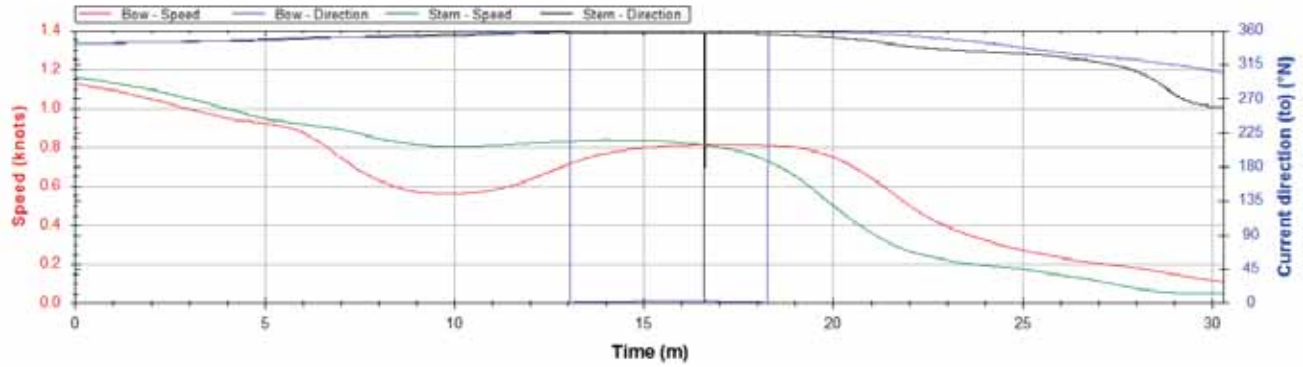
March 2015

Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)

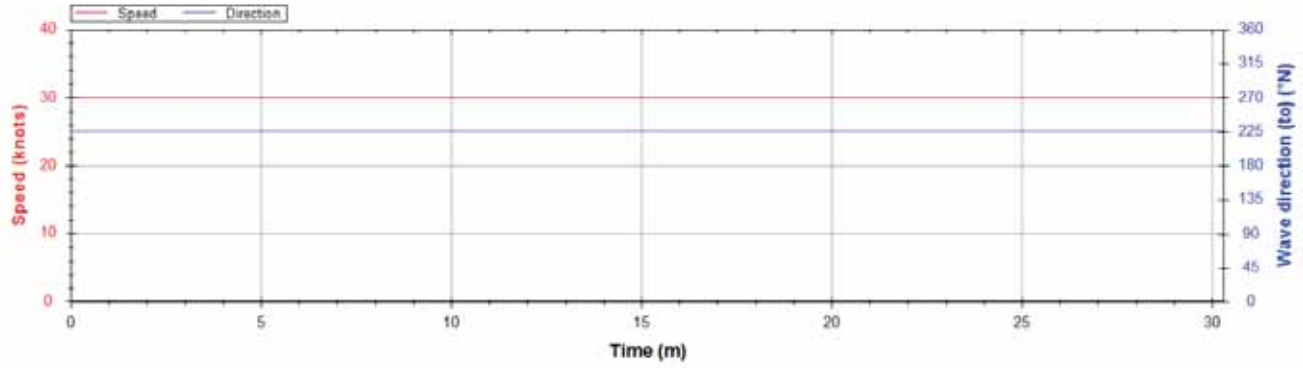
Underkeel clearance



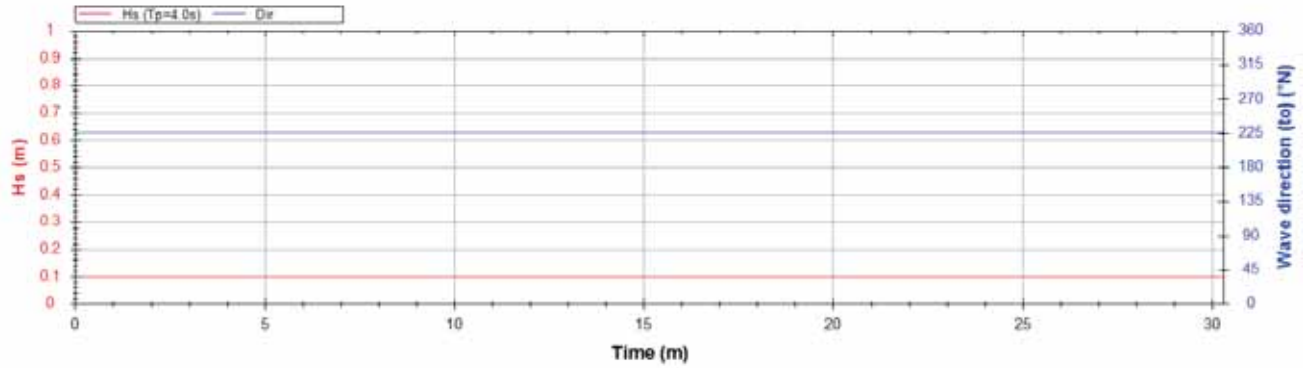
Current speed and direction



Wind speed and direction

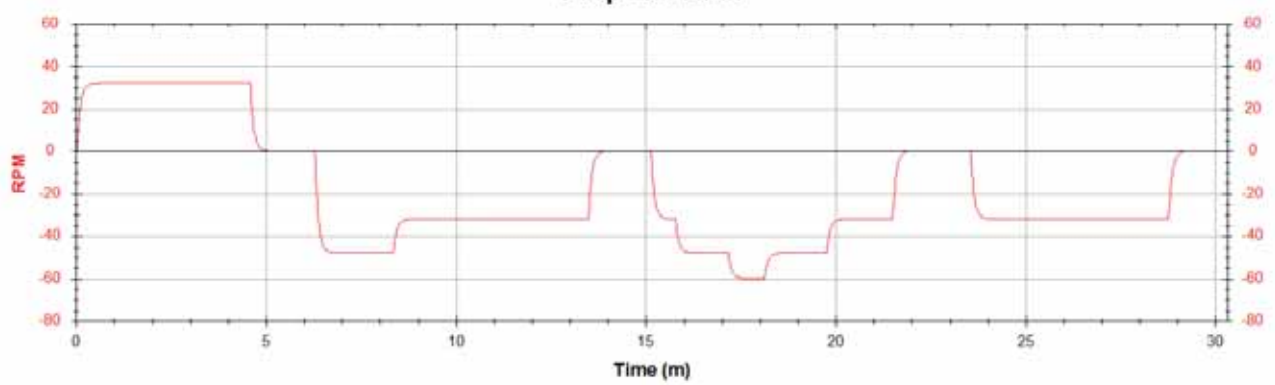


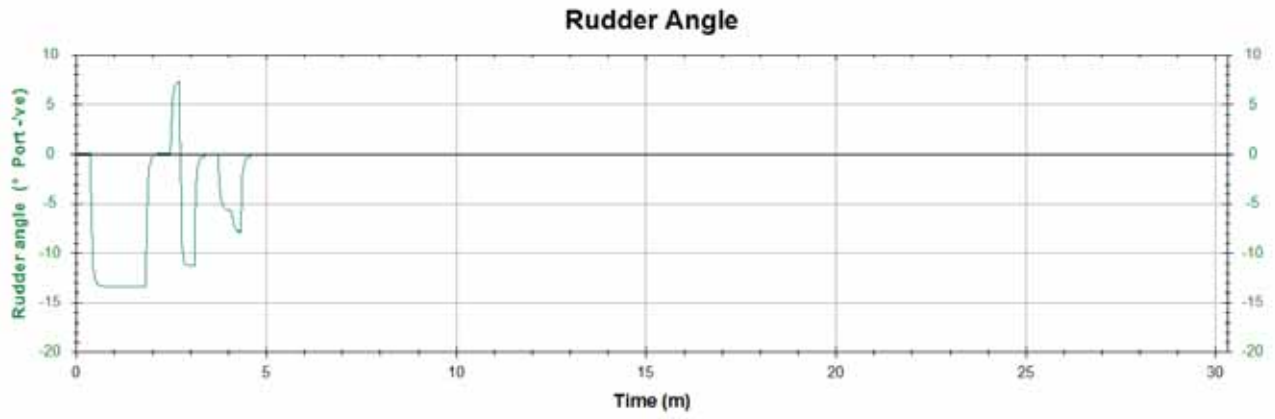
Significant wave height and direction



March 2015

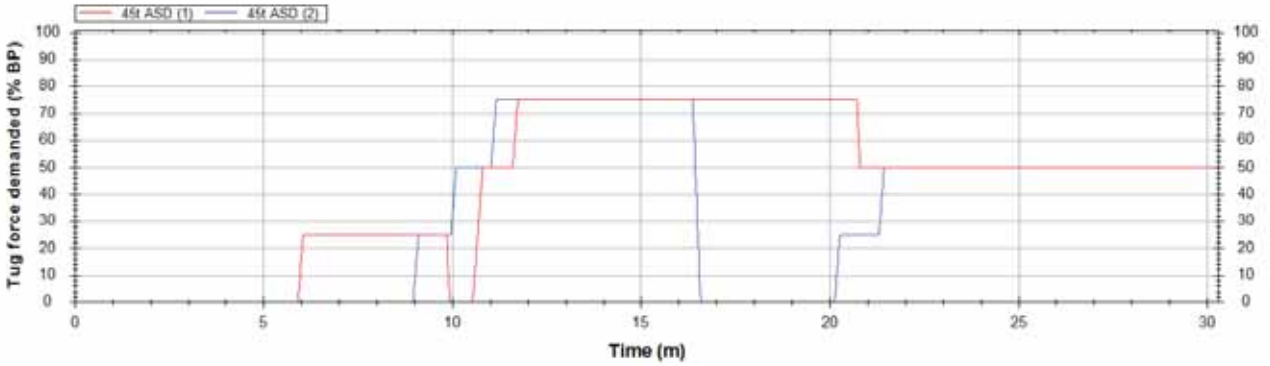
Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)

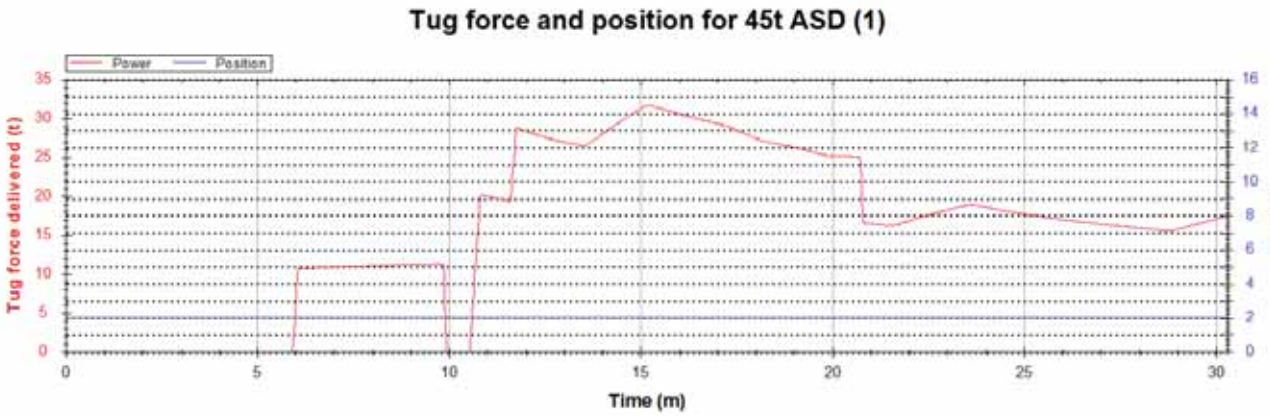


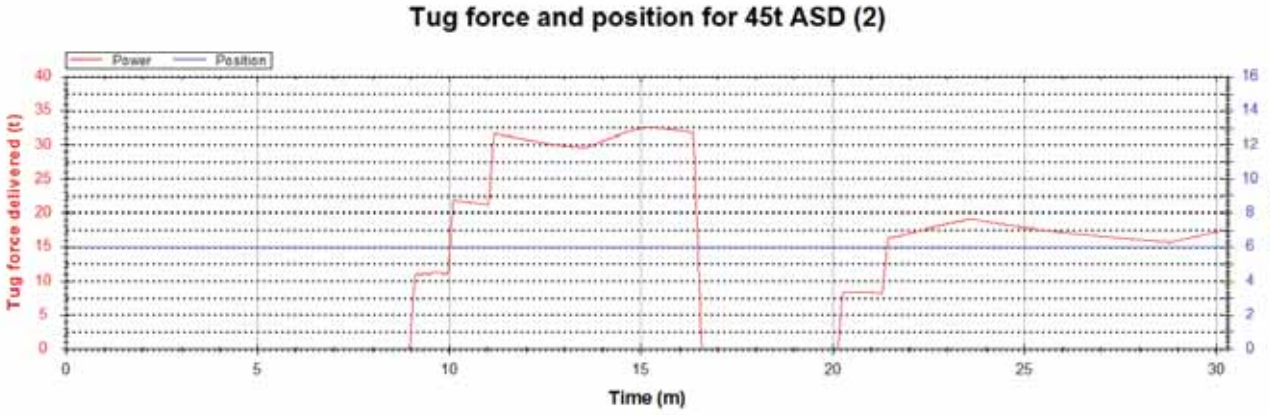


March 2015

Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)

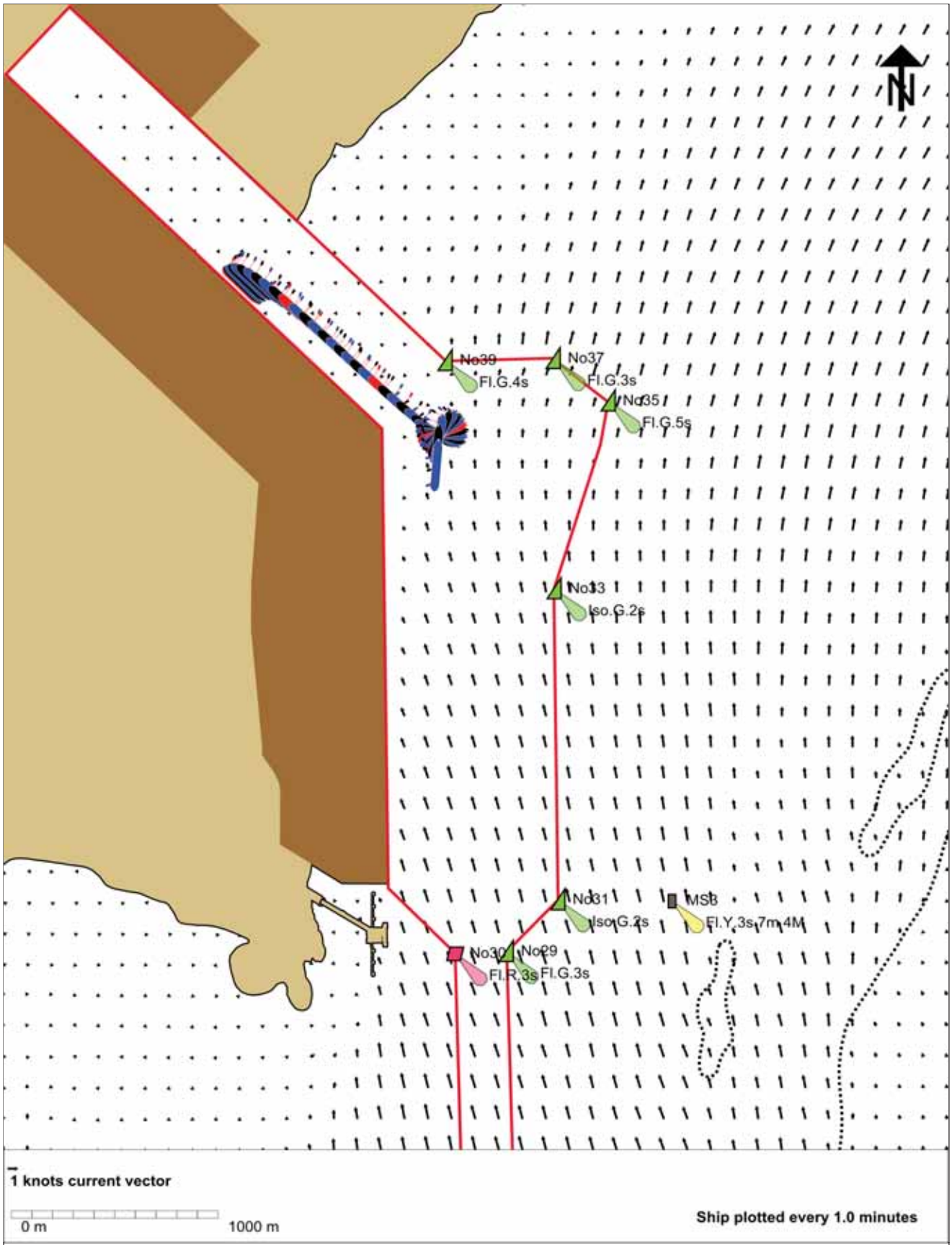






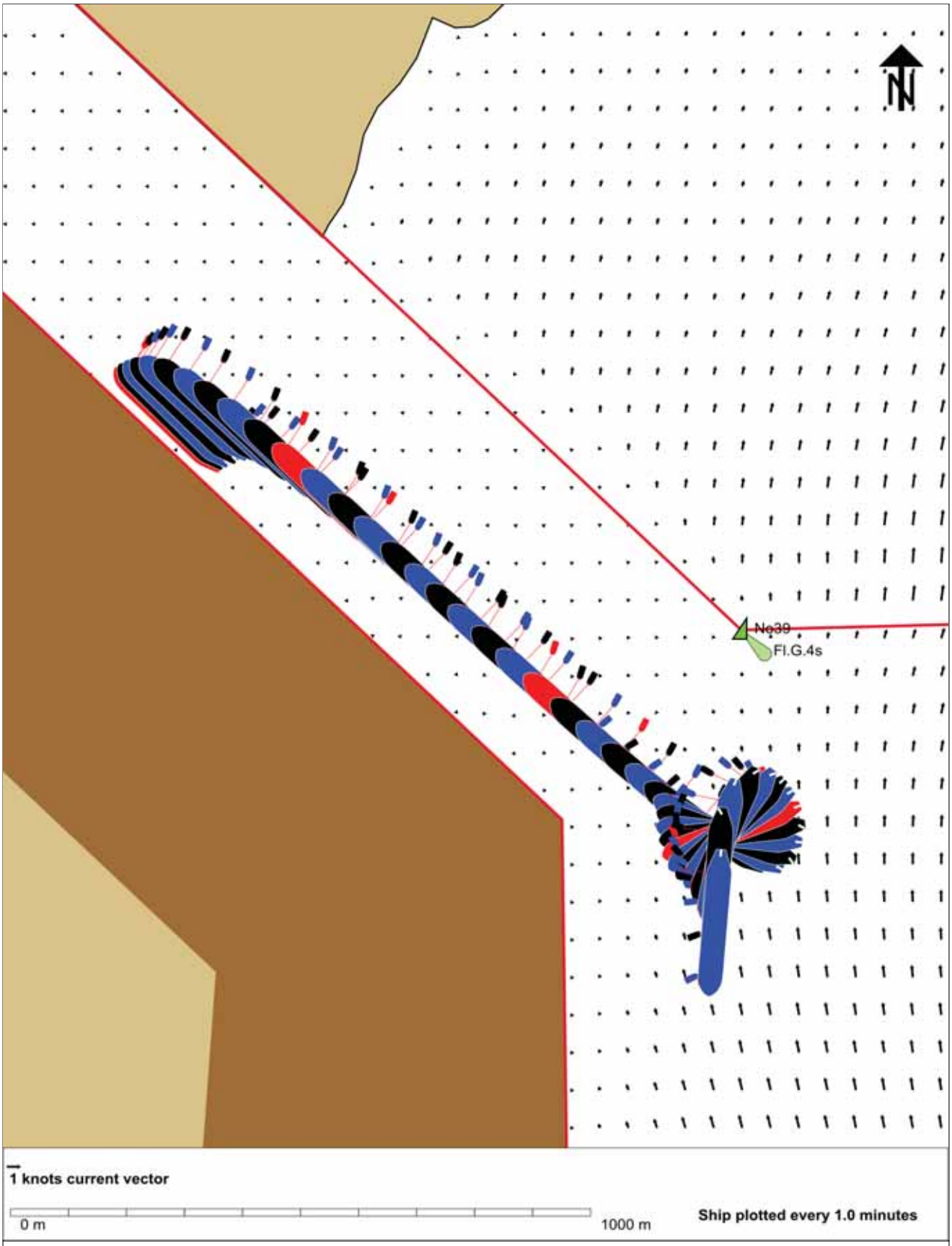
March 2015

Run: 16	Pilot: IS	Ship: 115k DWT Bulker ballast
Initial wind: 225°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Ballast)



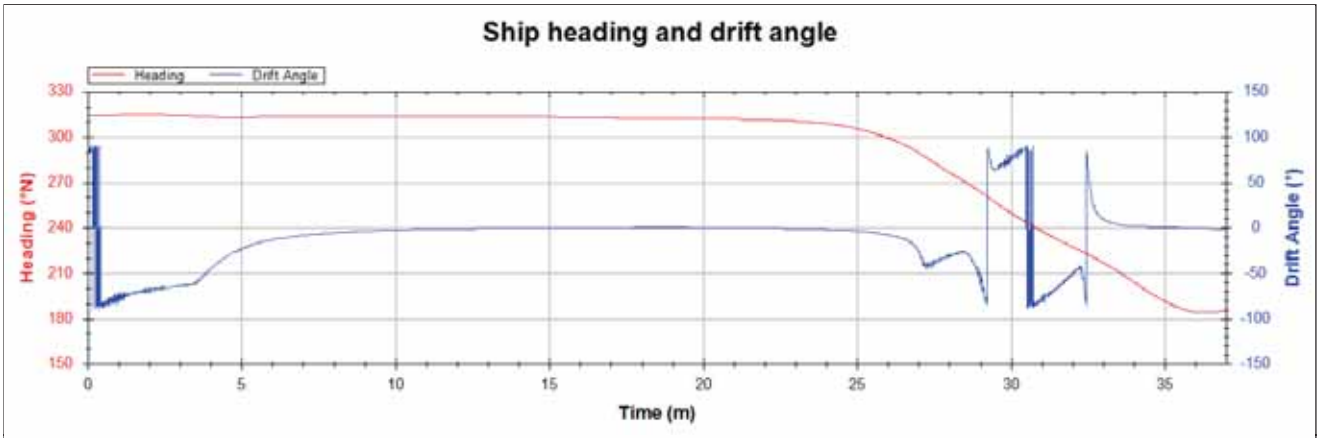
March 2015

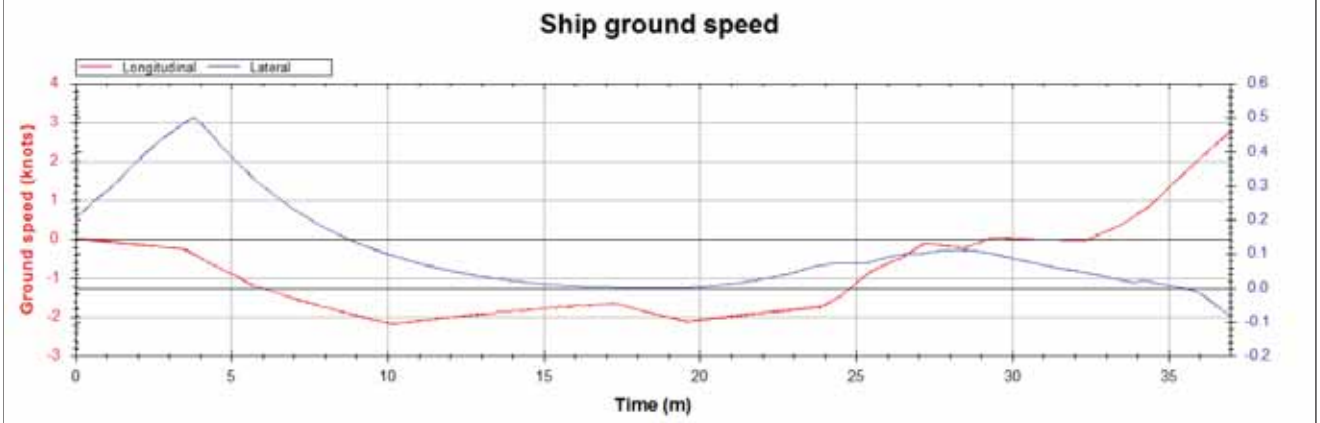
Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)

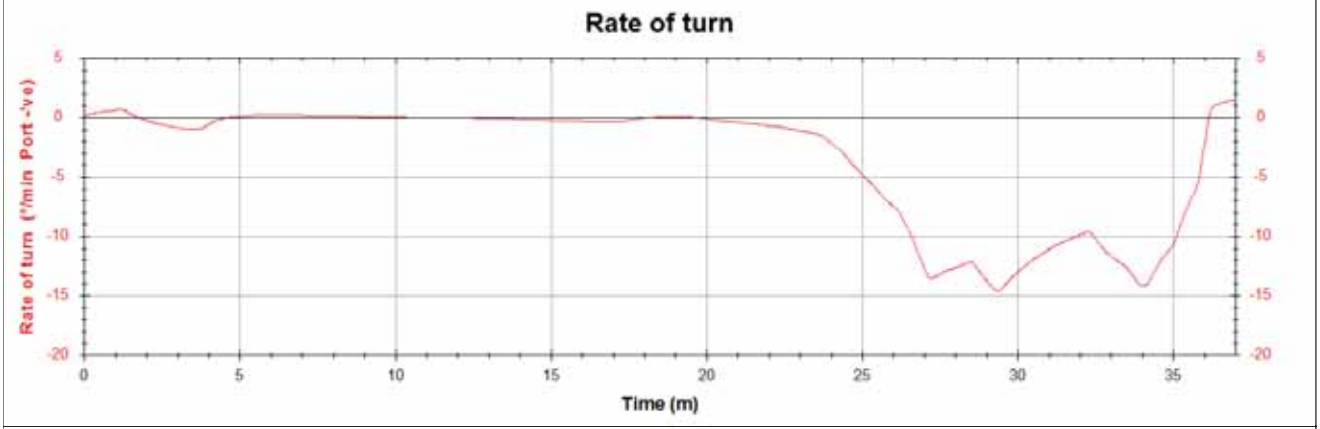


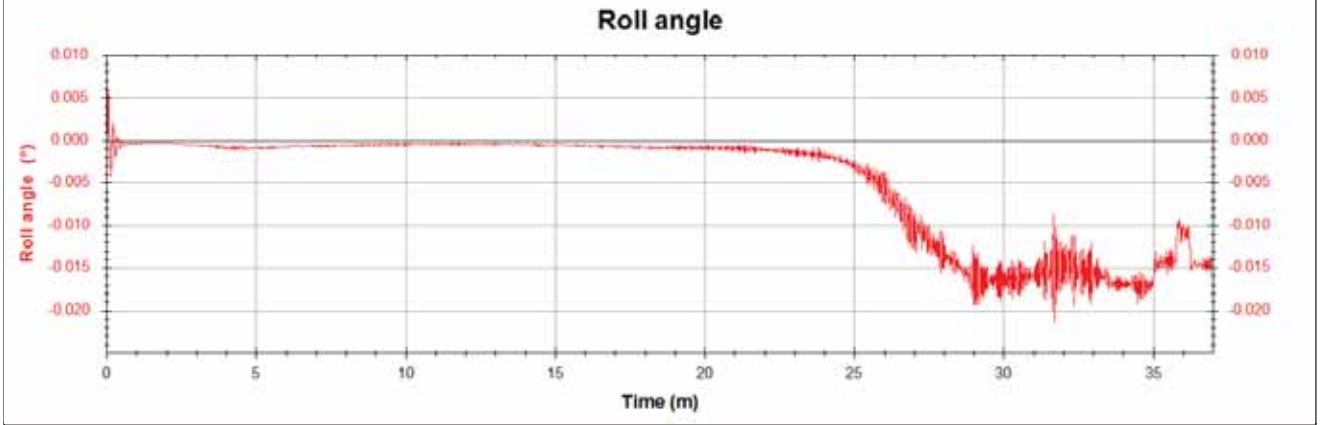
March 2015

Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)



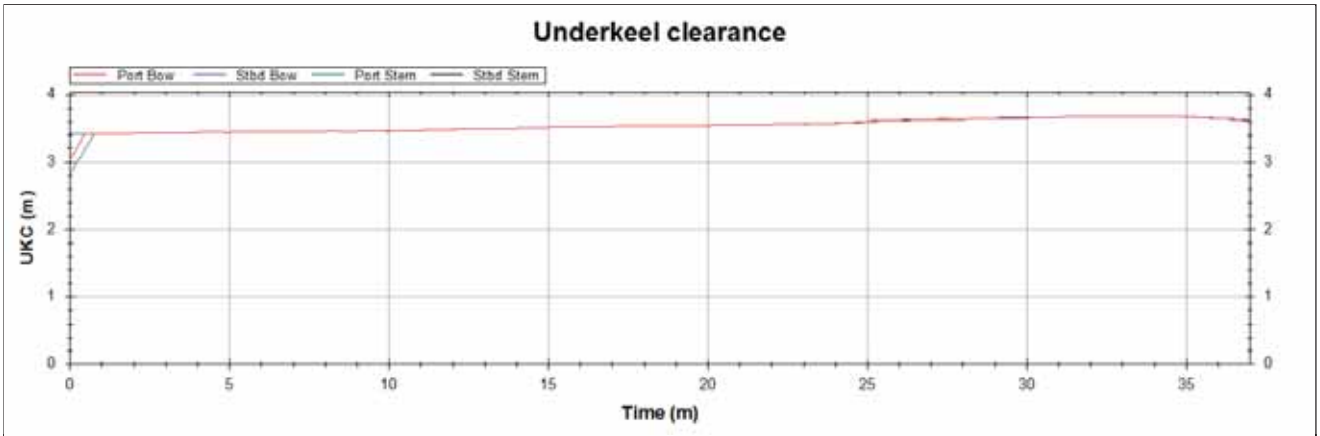


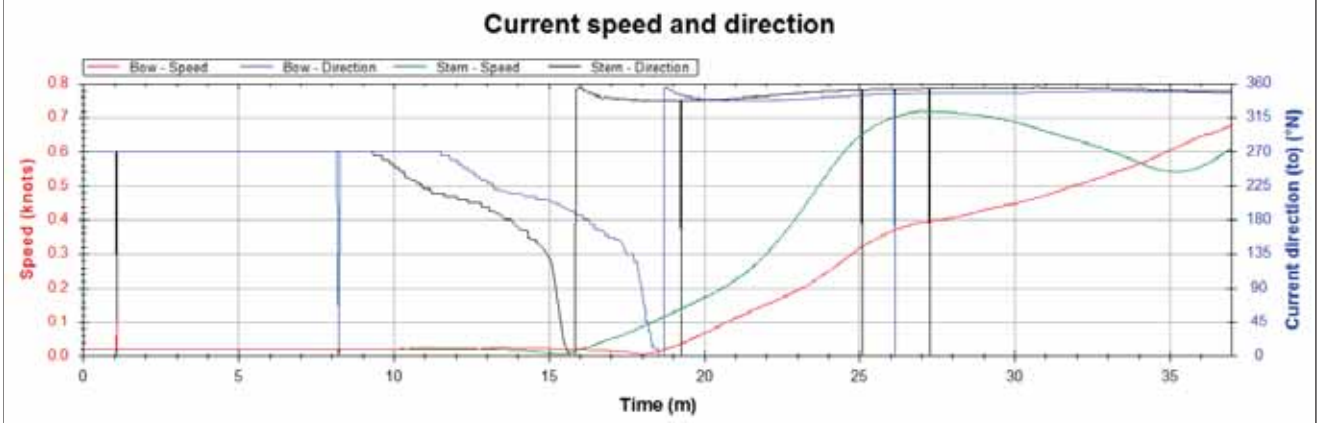


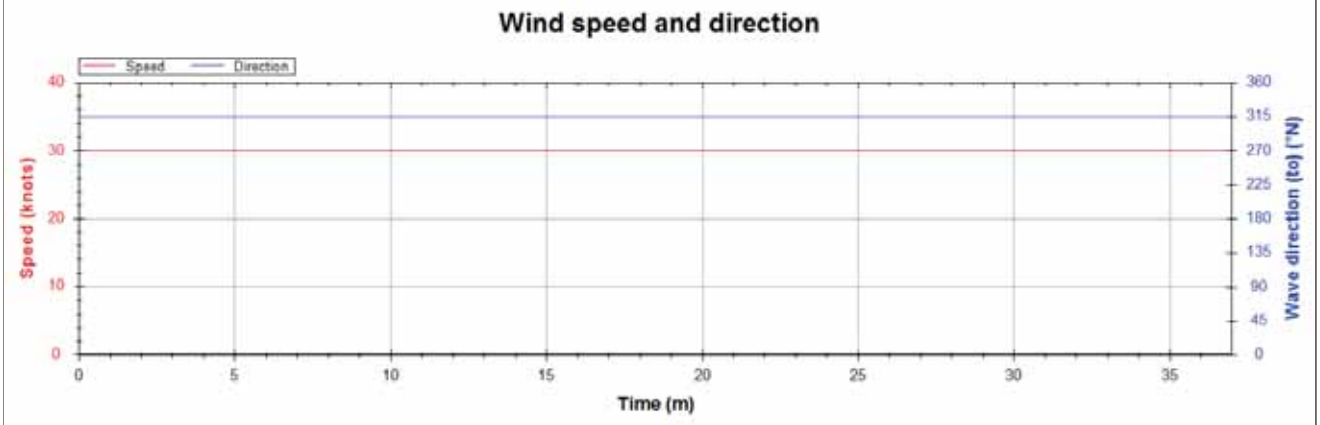


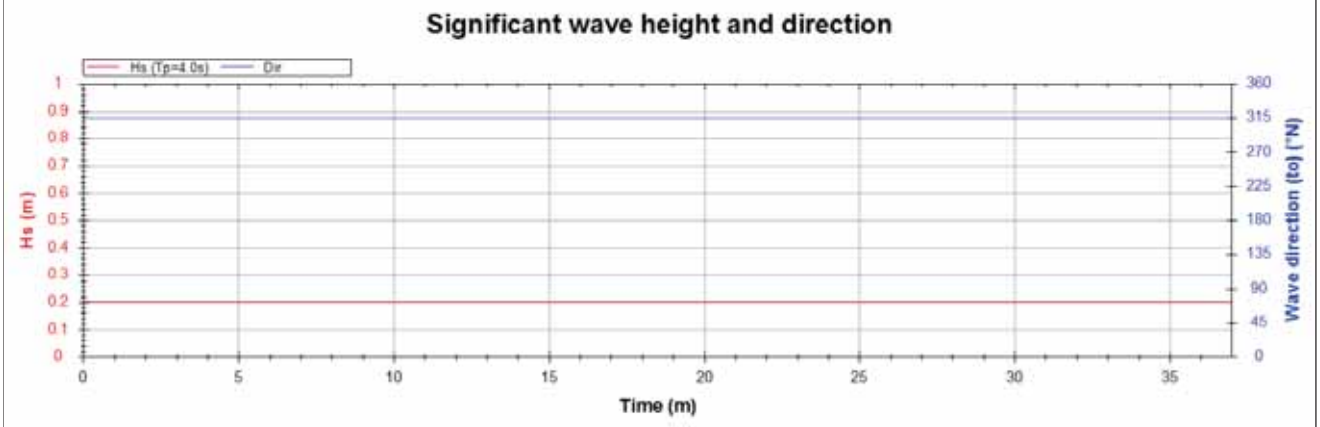
March 2015

Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)



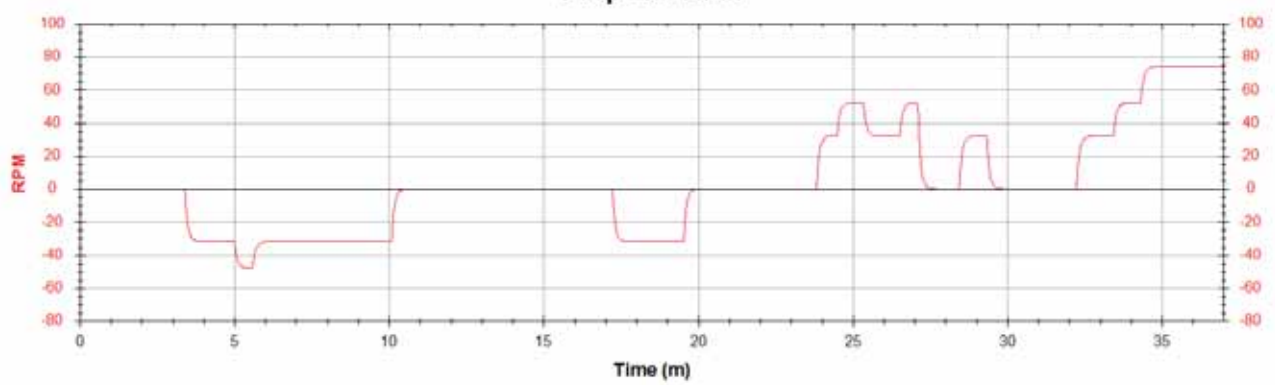


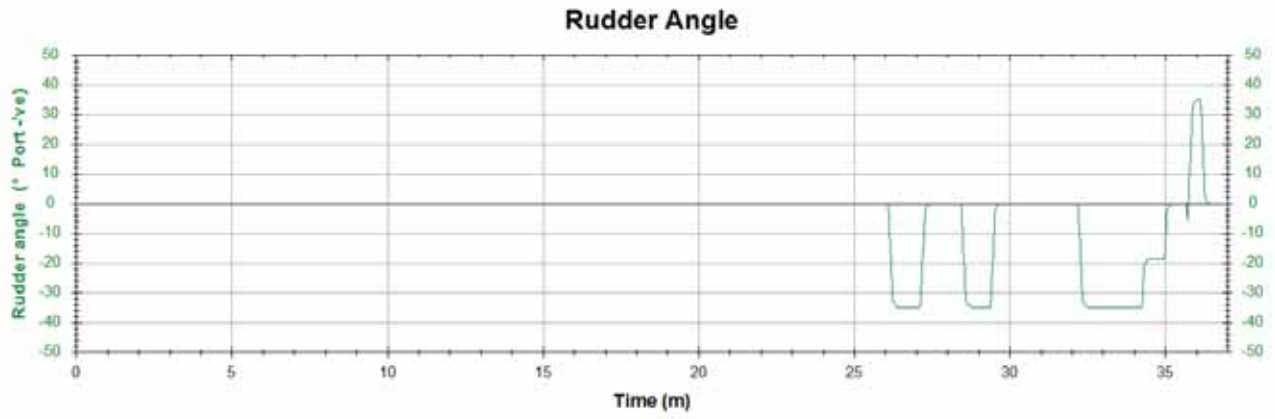




March 2015

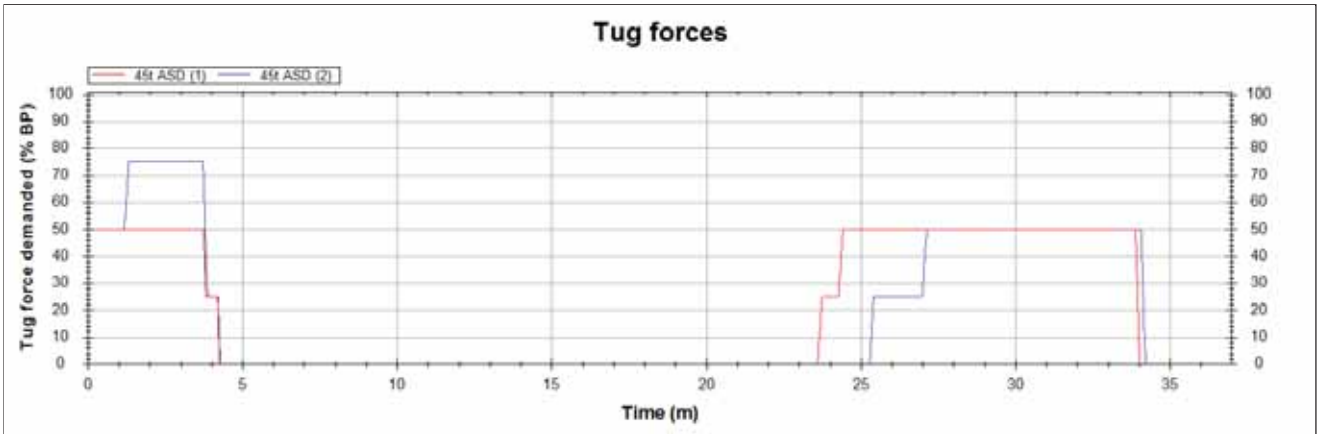
Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)

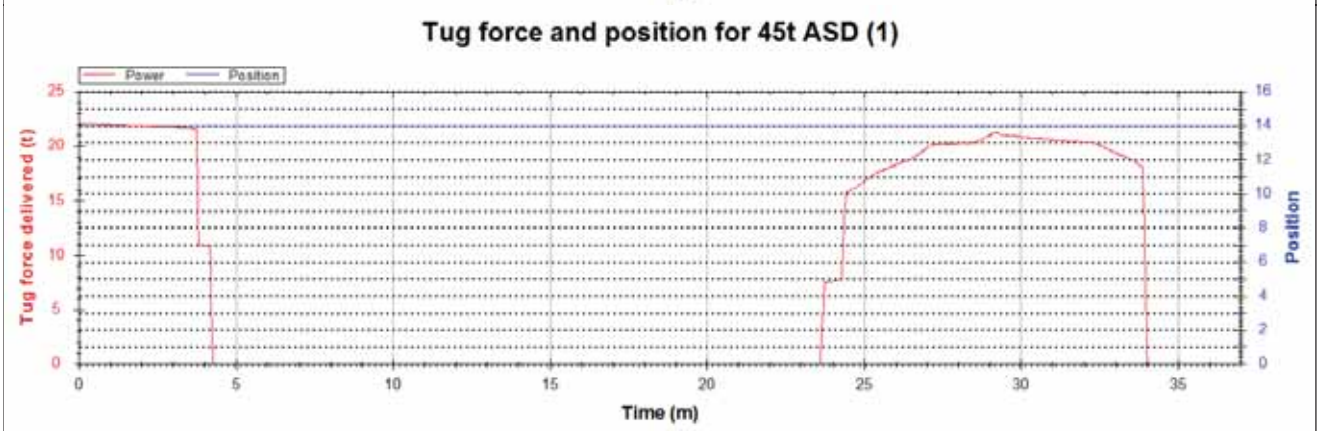


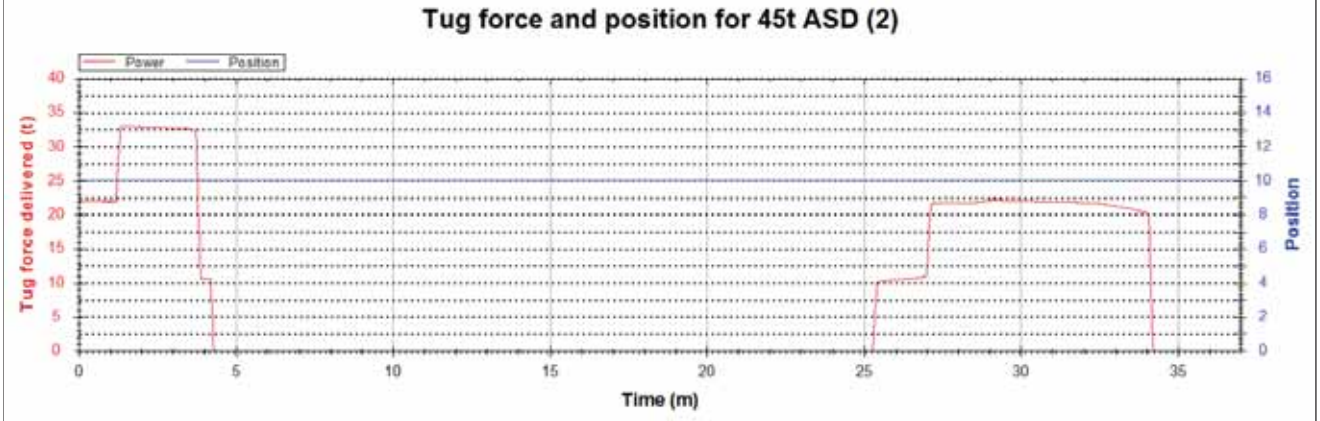


March 2015

Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)

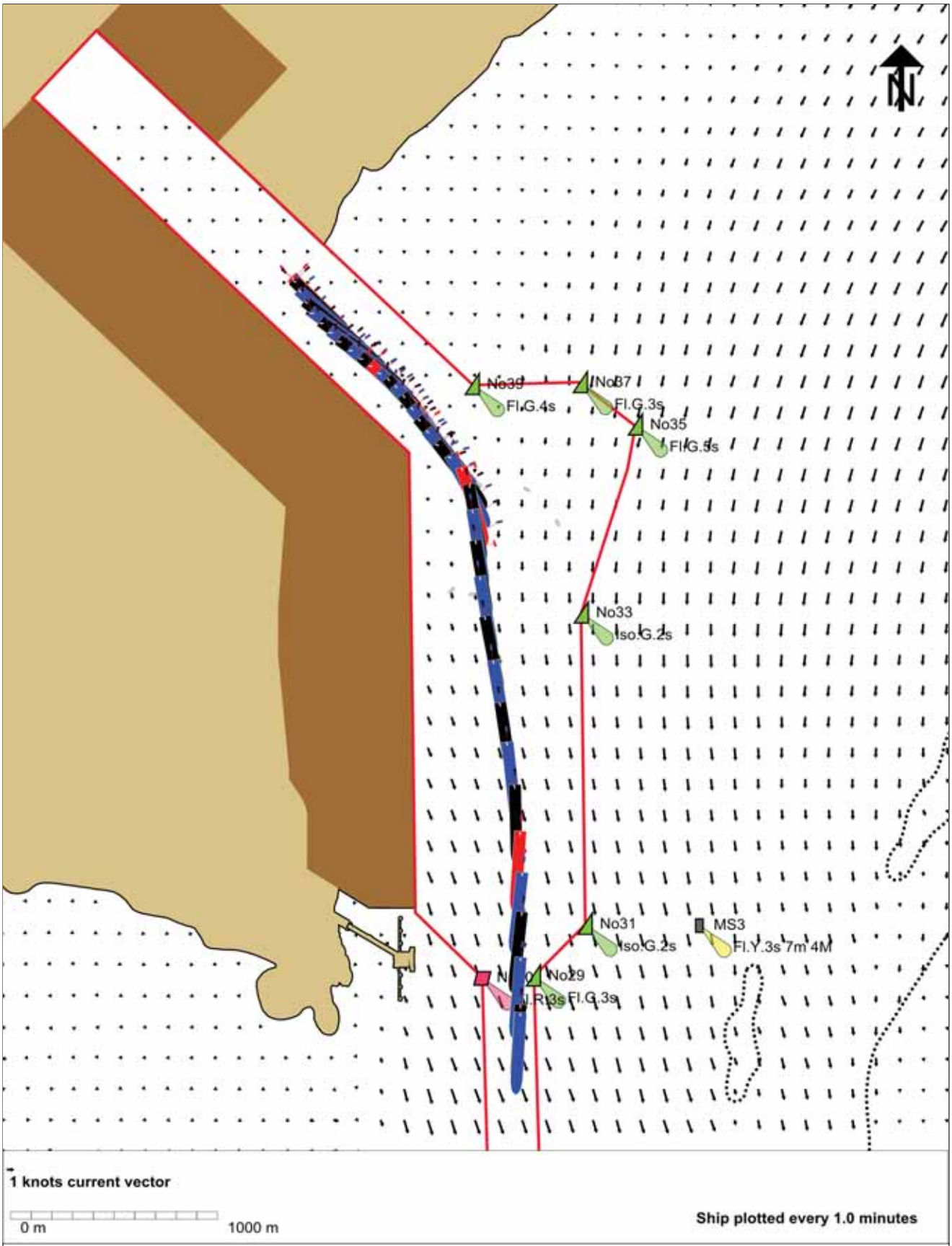






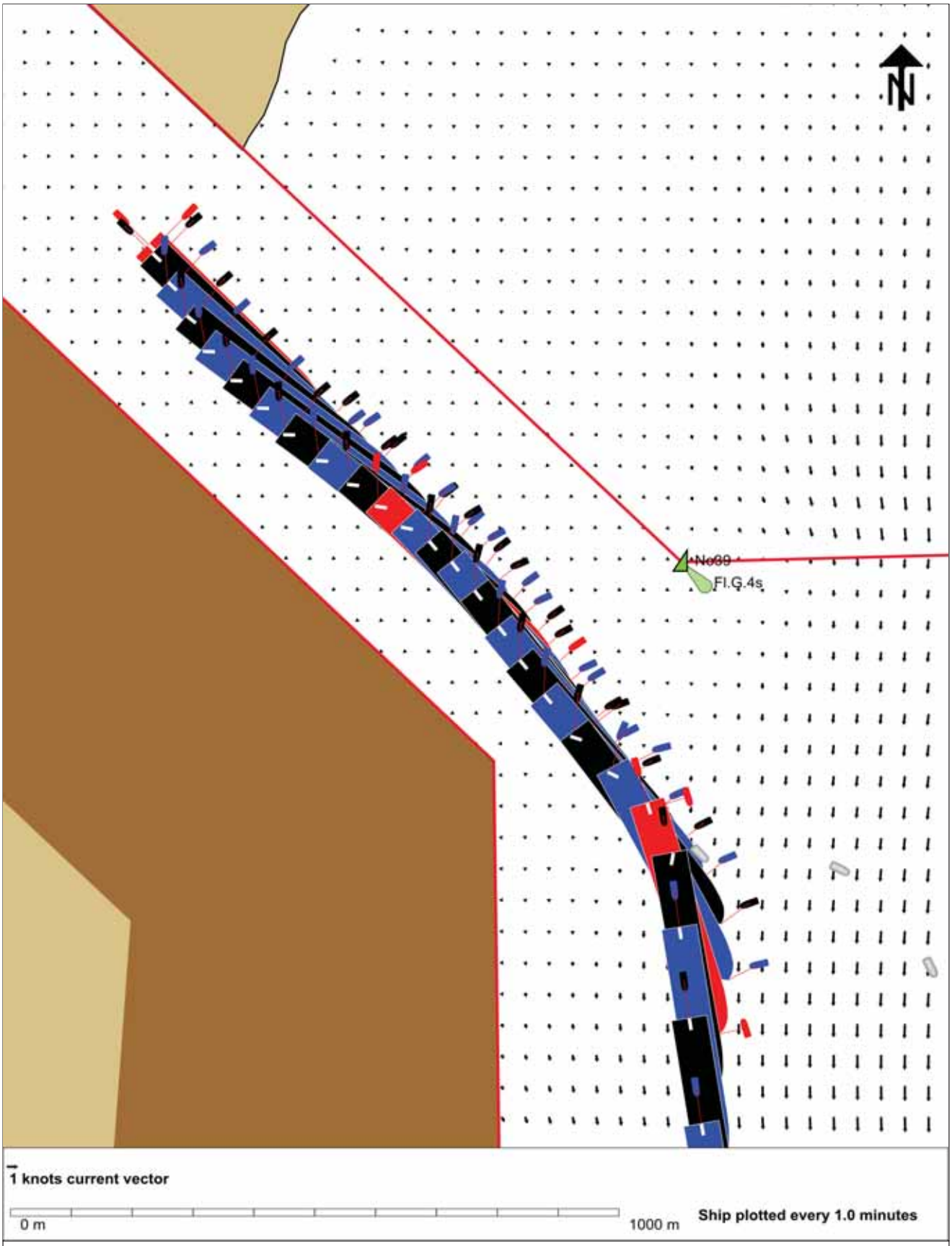
March 2015

Run: 17	Pilot: IS	Ship: 115k DWT Bulker laden
Initial wind: 315°N 30 knots	Configuration: Basin Short	Type (Condition): Bulker (Laden)



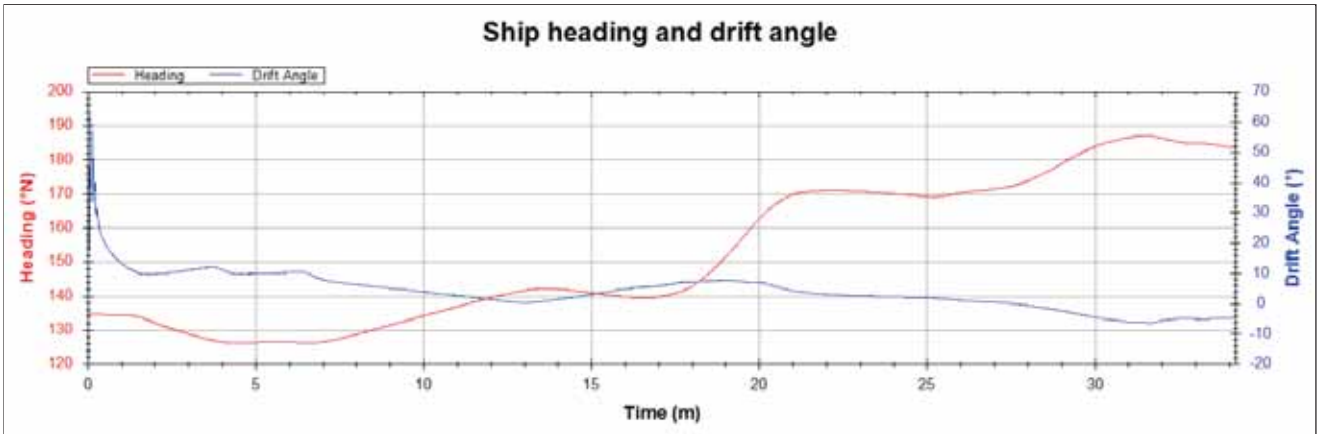
March 2015

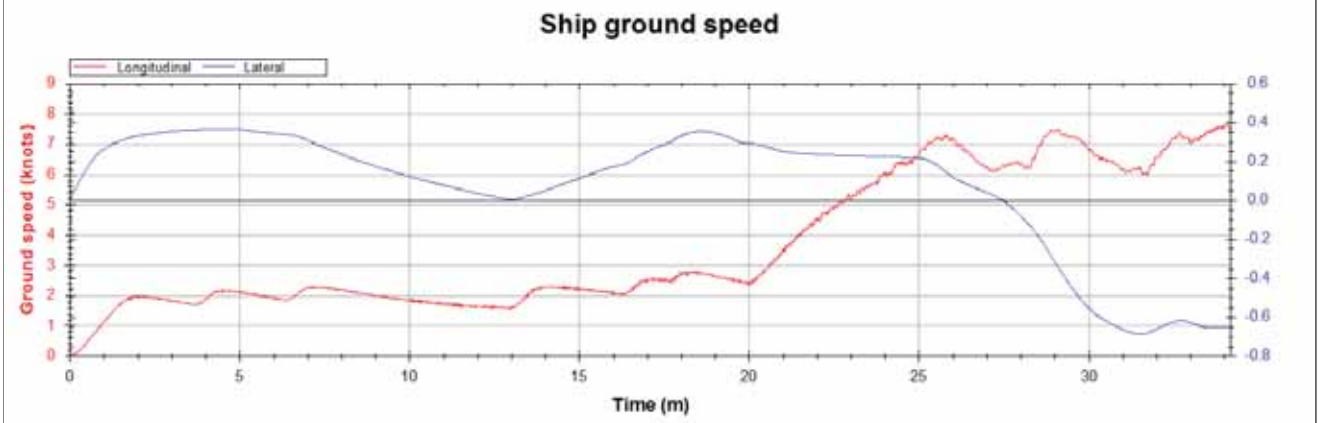
Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

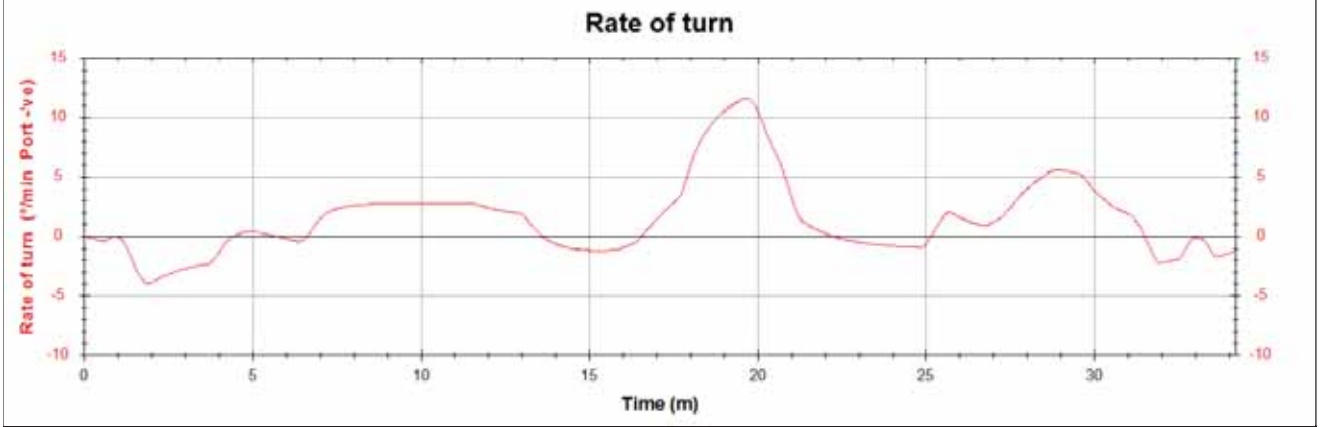


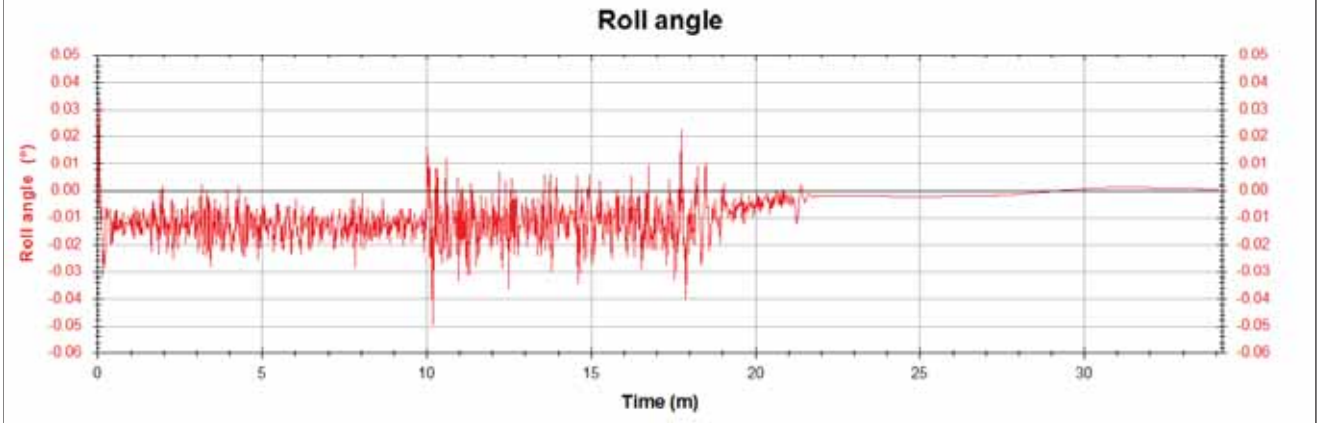
March 2015

Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)





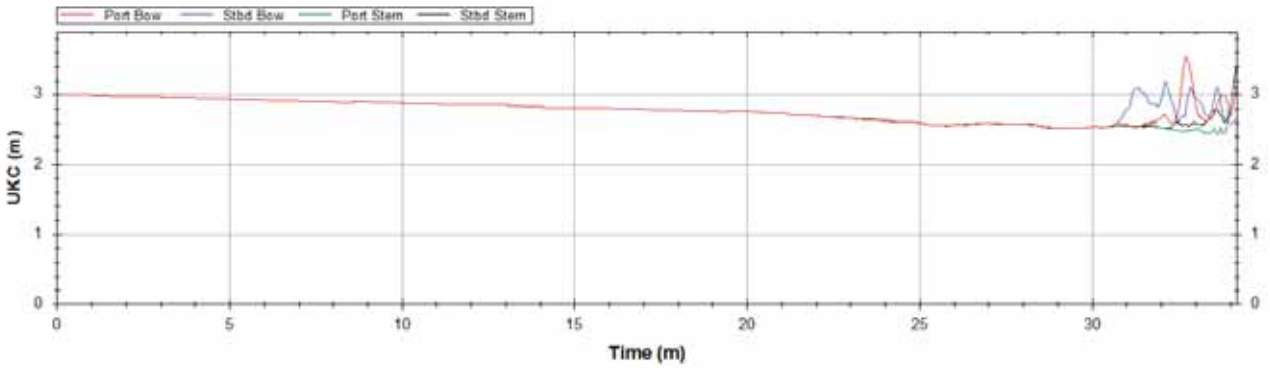




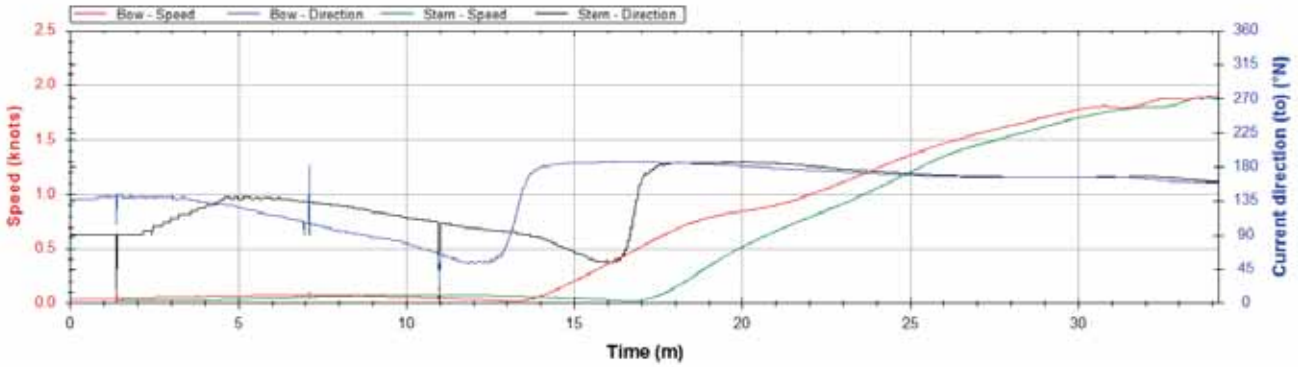
March 2015

Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

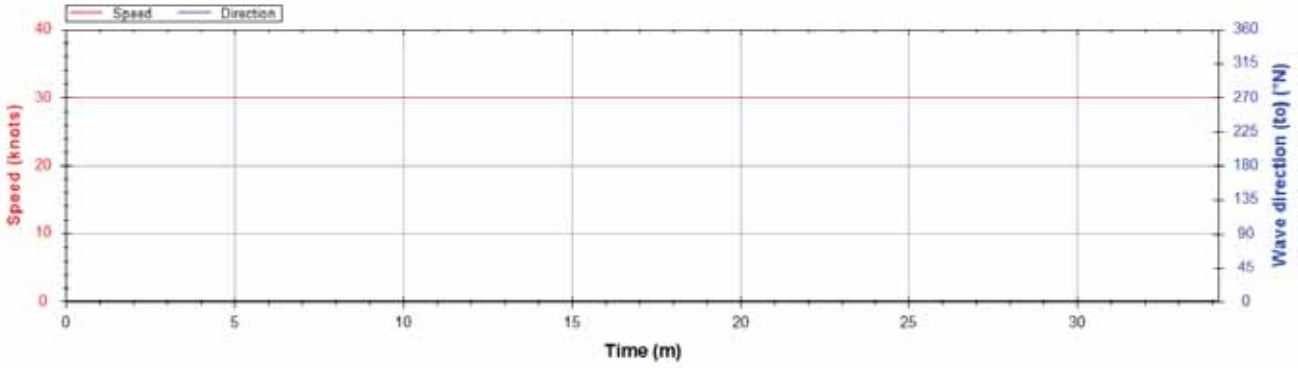
Underkeel clearance



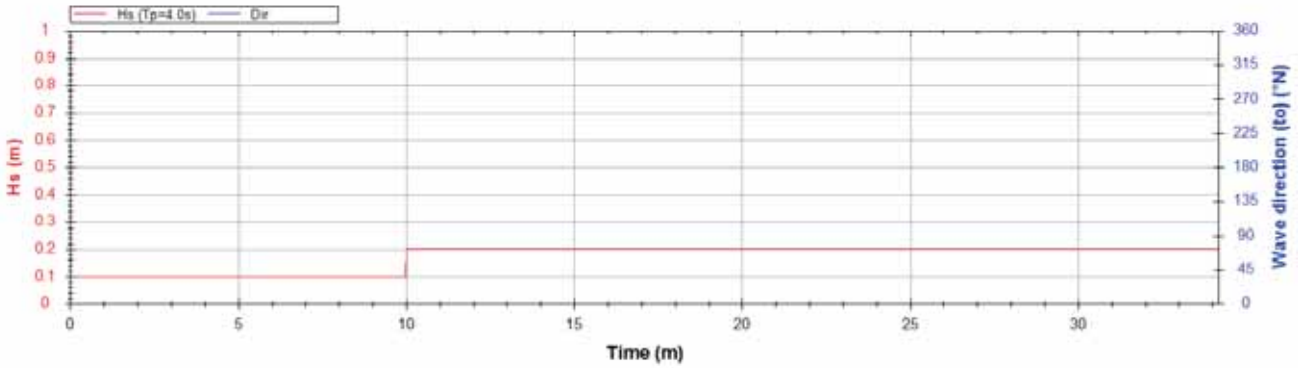
Current speed and direction



Wind speed and direction

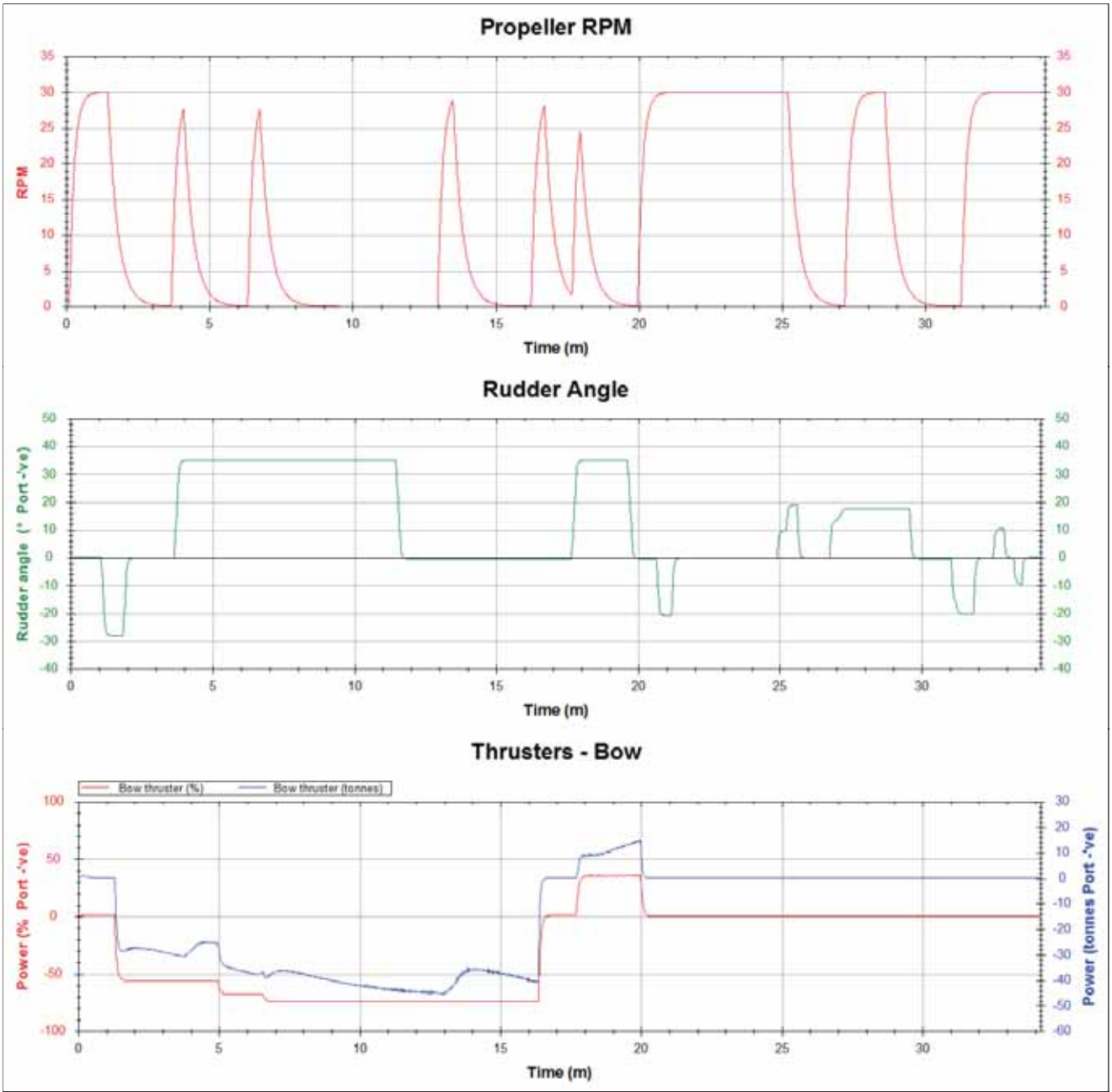


Significant wave height and direction



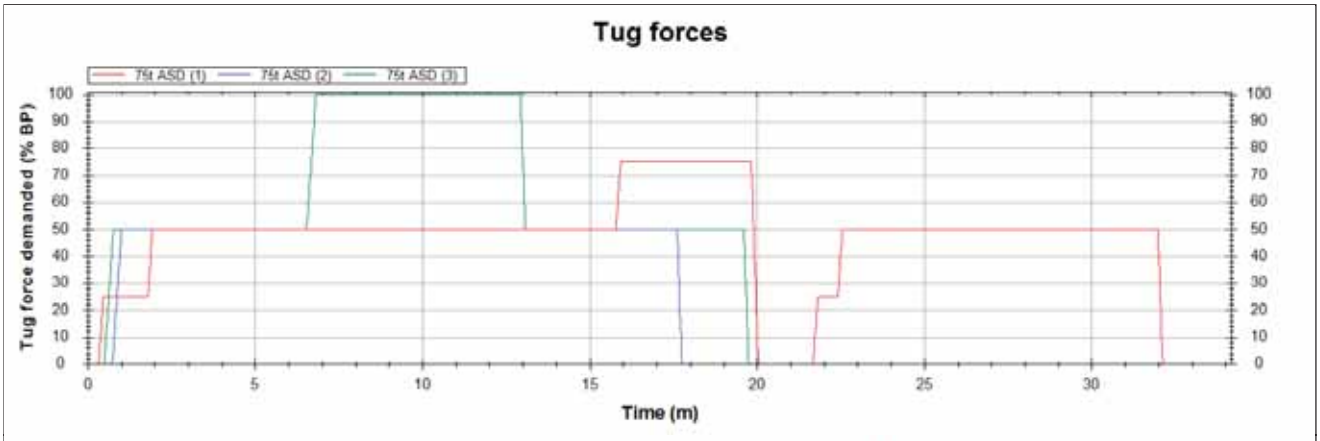
March 2015

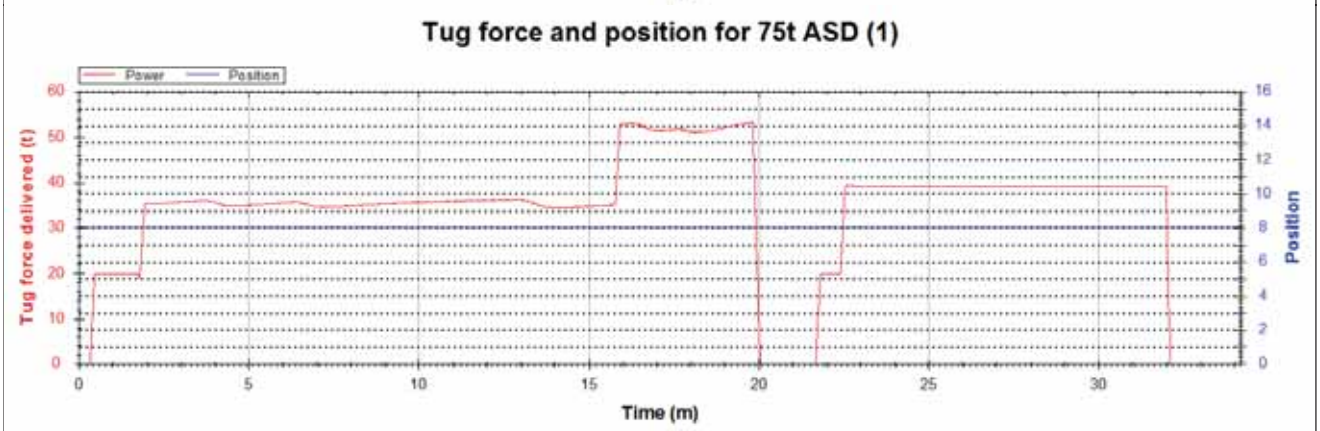
Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)

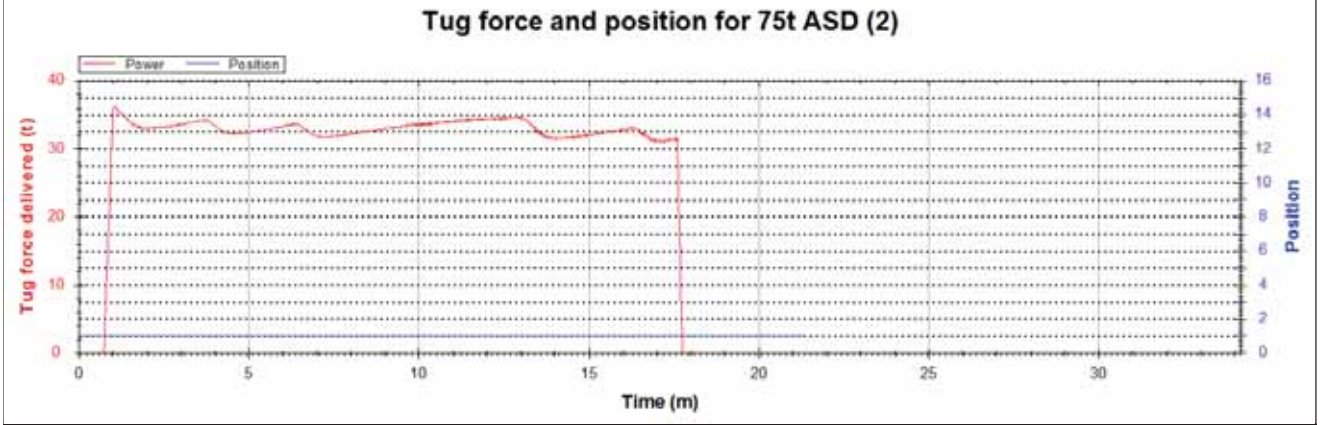


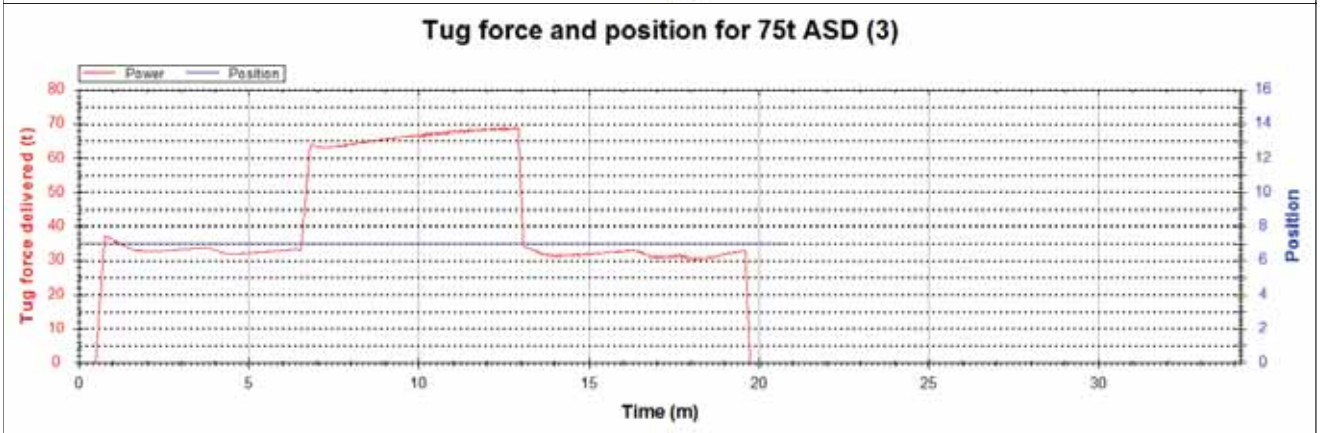
March 2015

Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



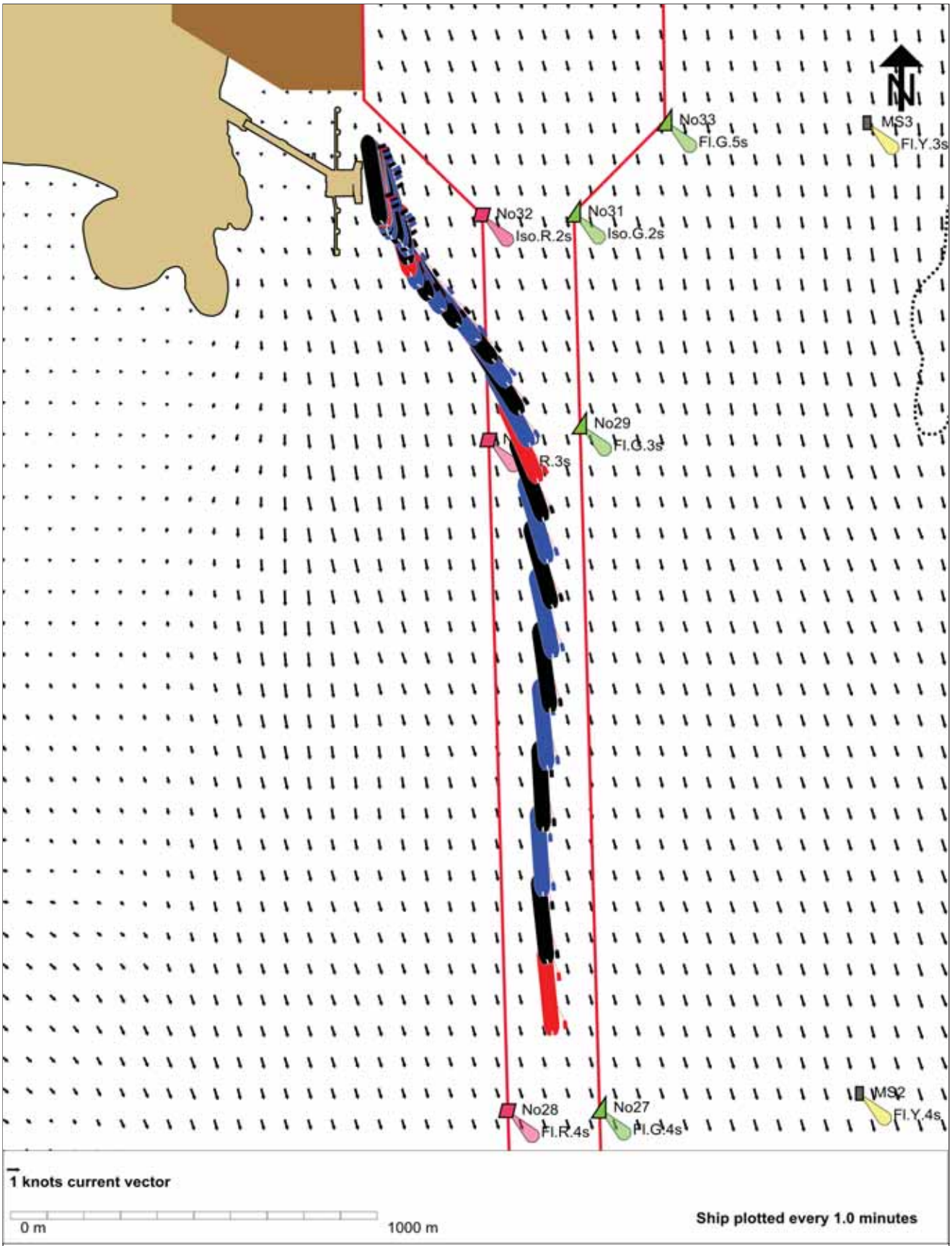






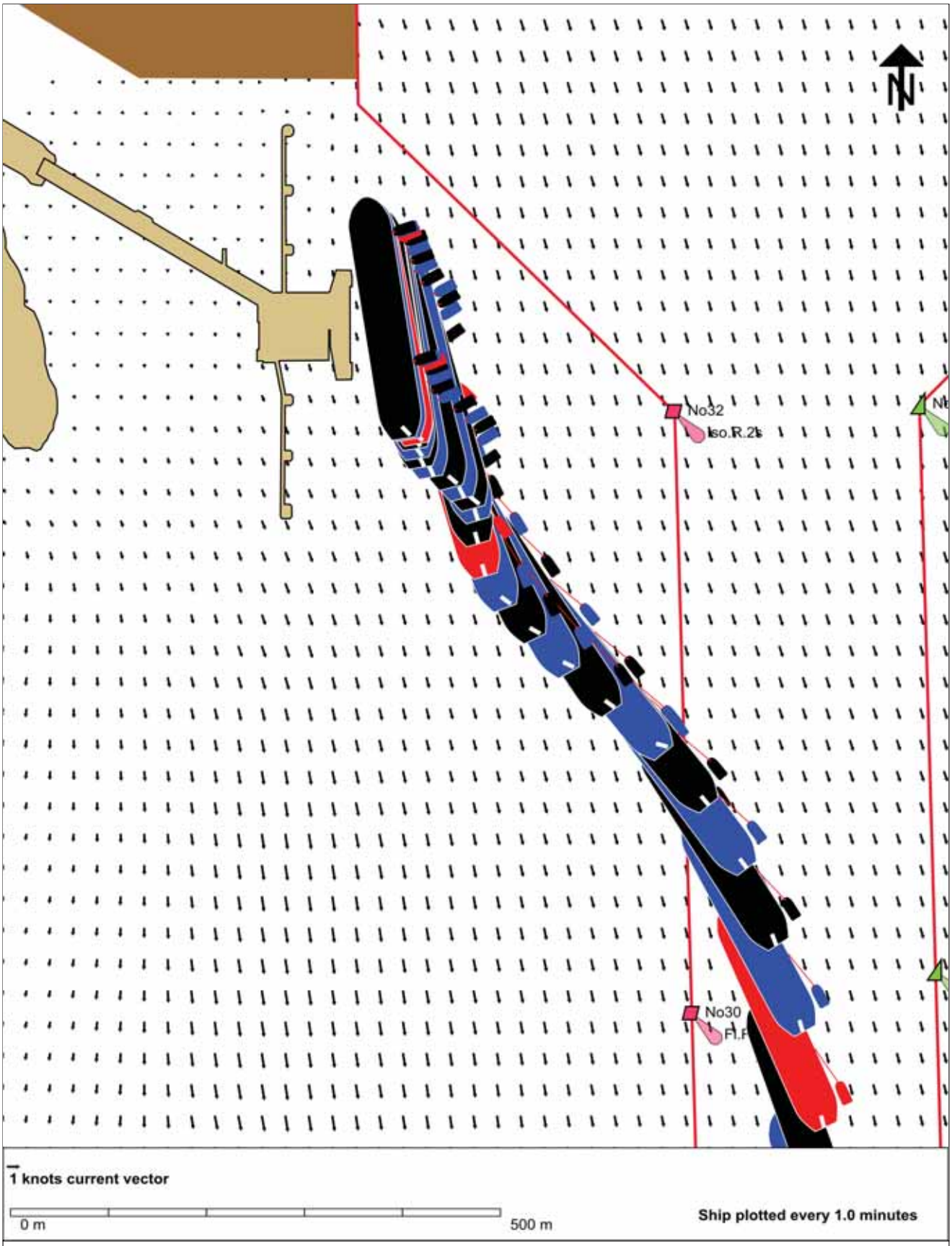
March 2015

Run: 23	Pilot: IS	Ship: 399m Container Ship
Initial wind: 000°N 30 knots	Configuration: Basin Short	Type (Condition): Container (Laden)



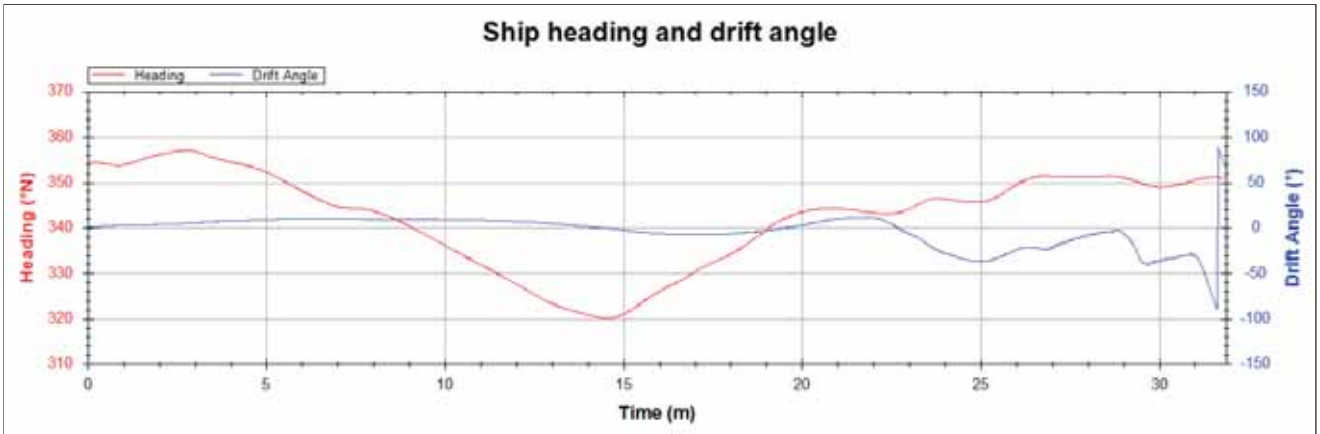
March 2015

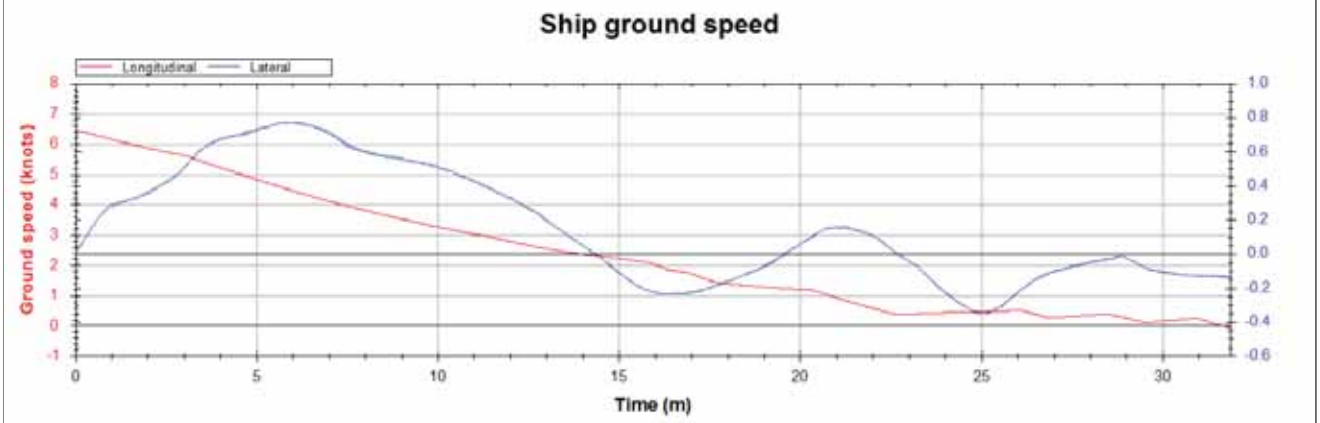
Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)

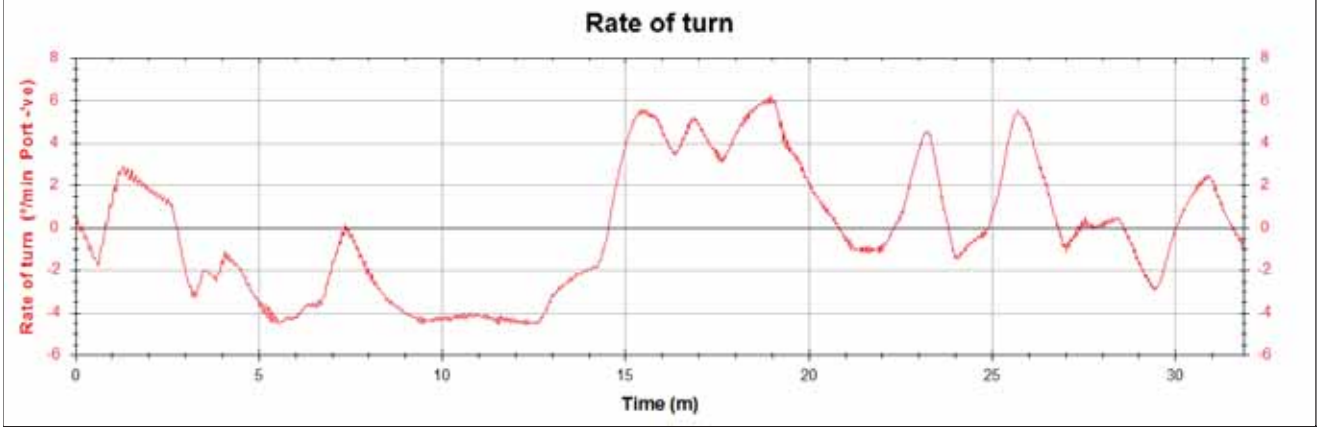


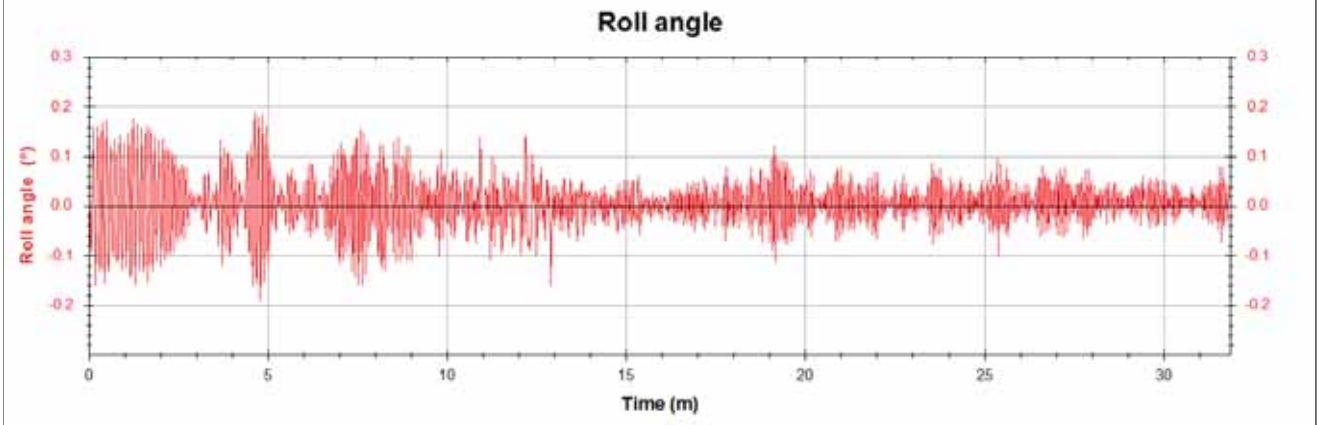
March 2015

Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)



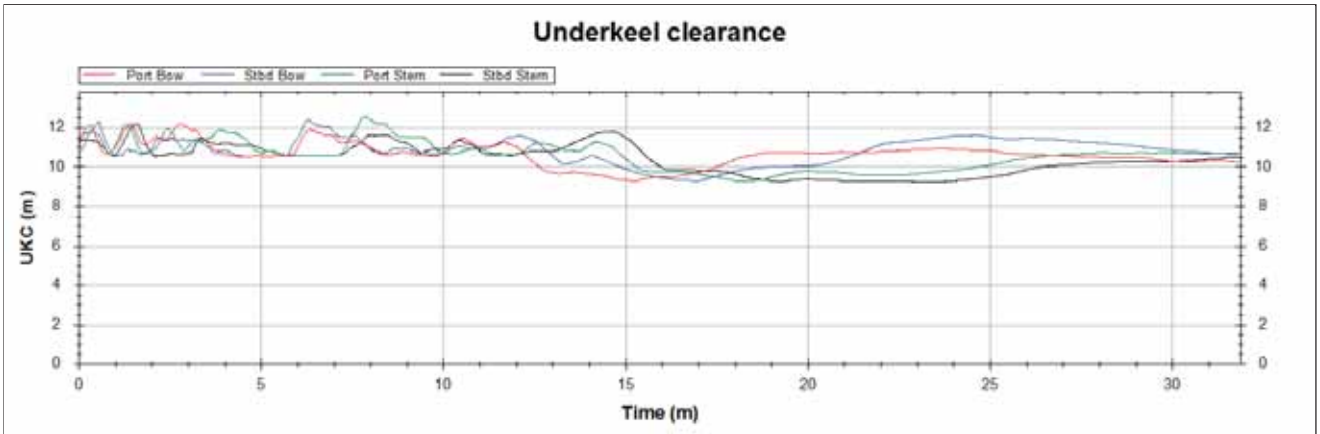


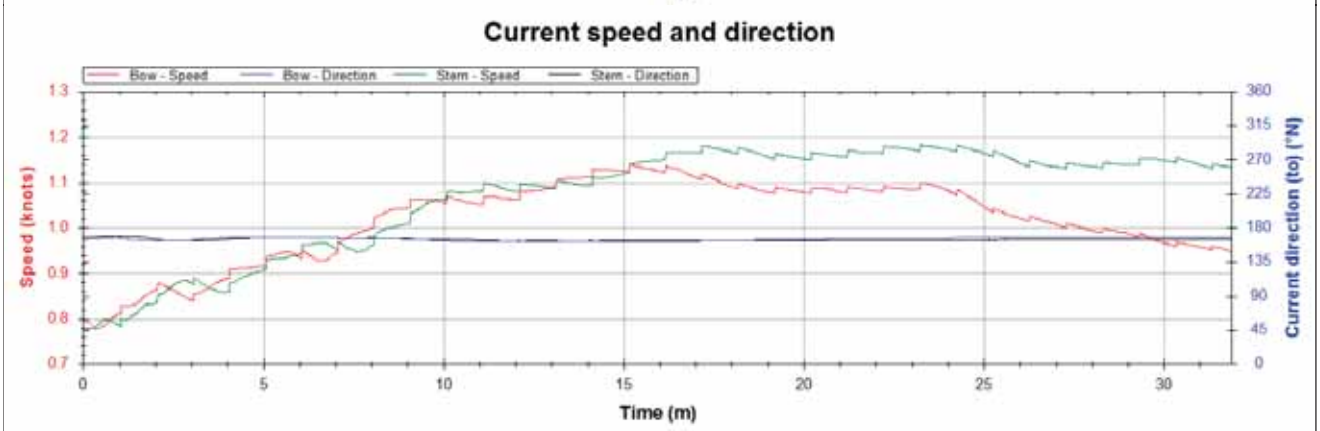


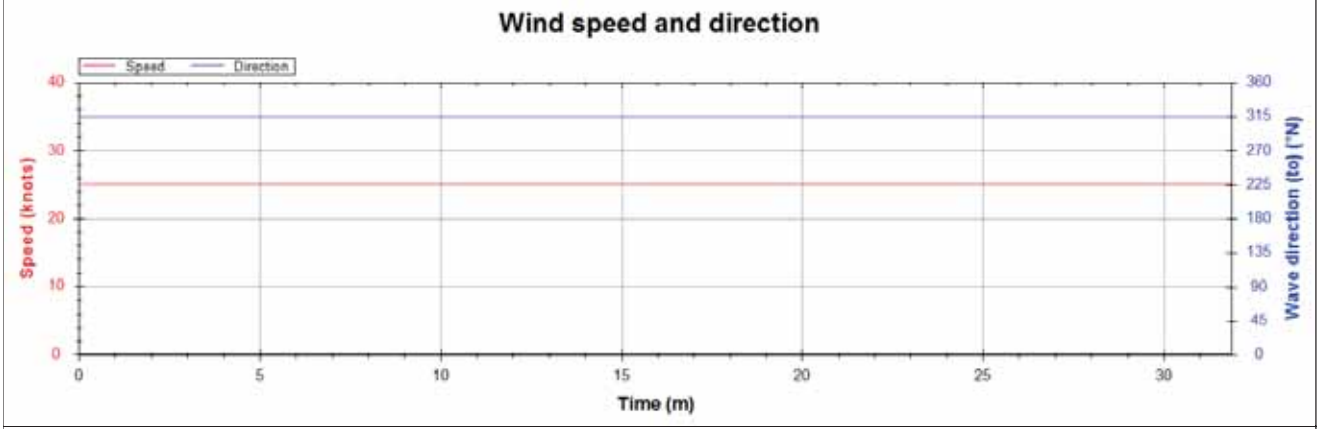


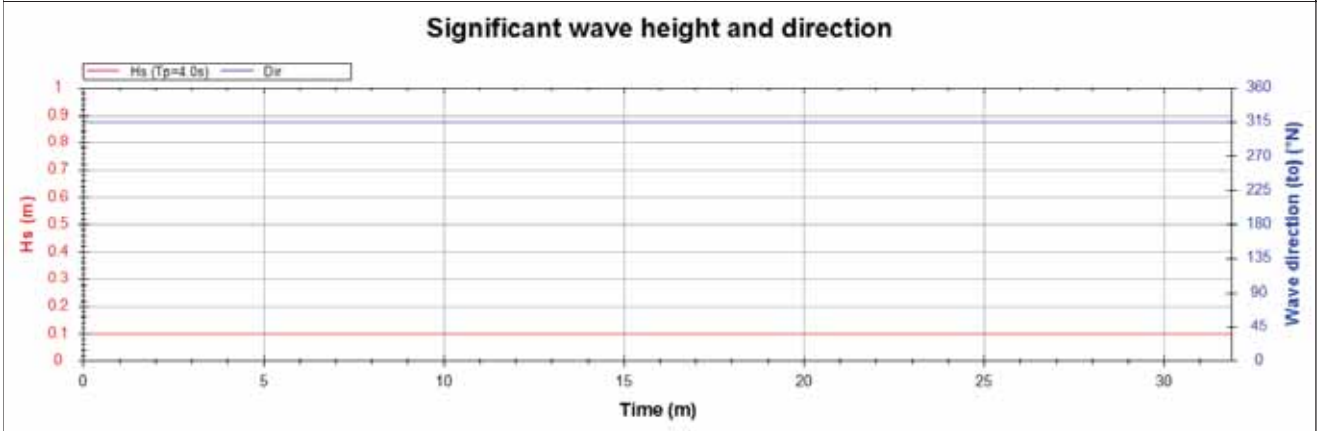
March 2015

Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)



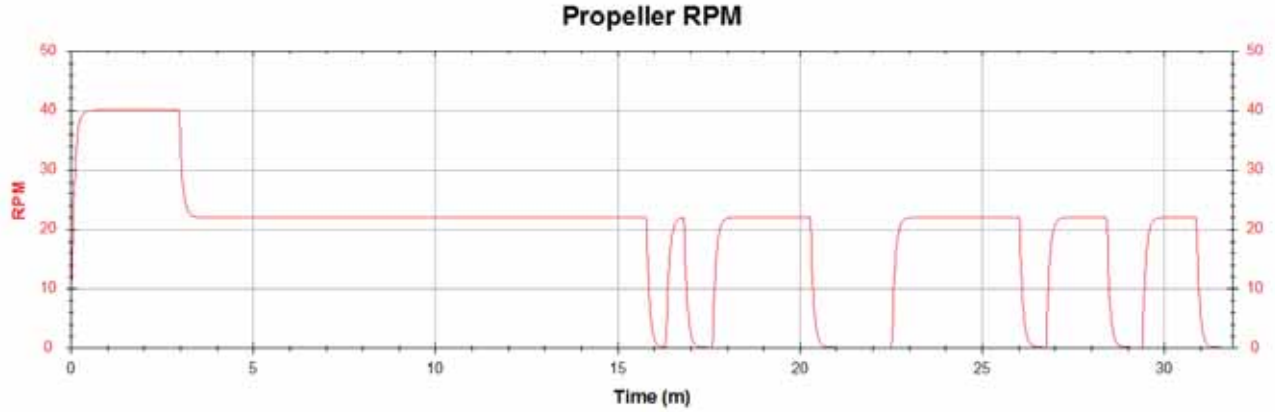


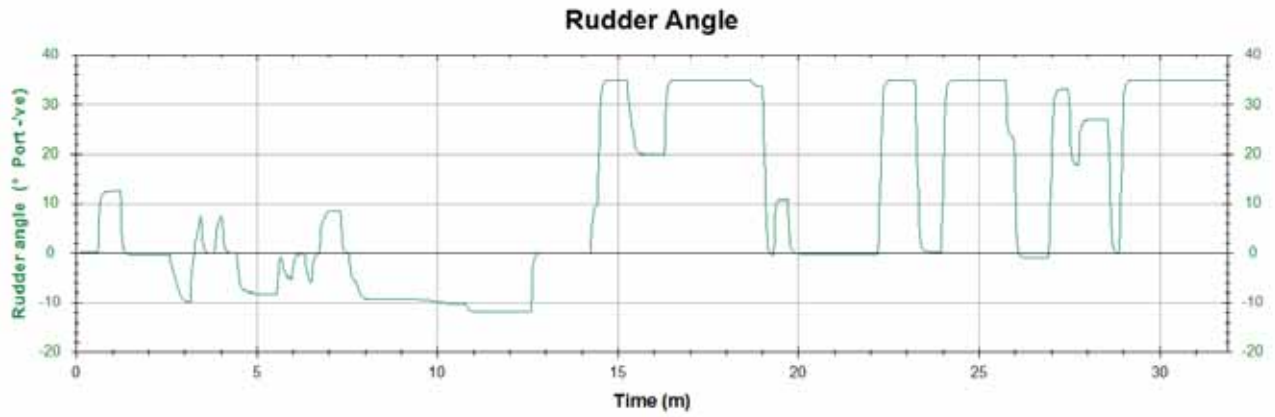




March 2015

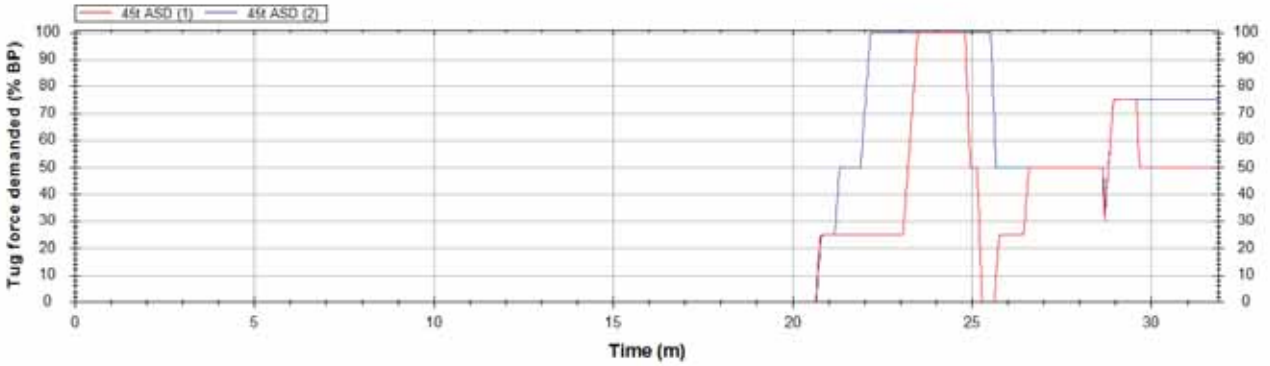
Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)

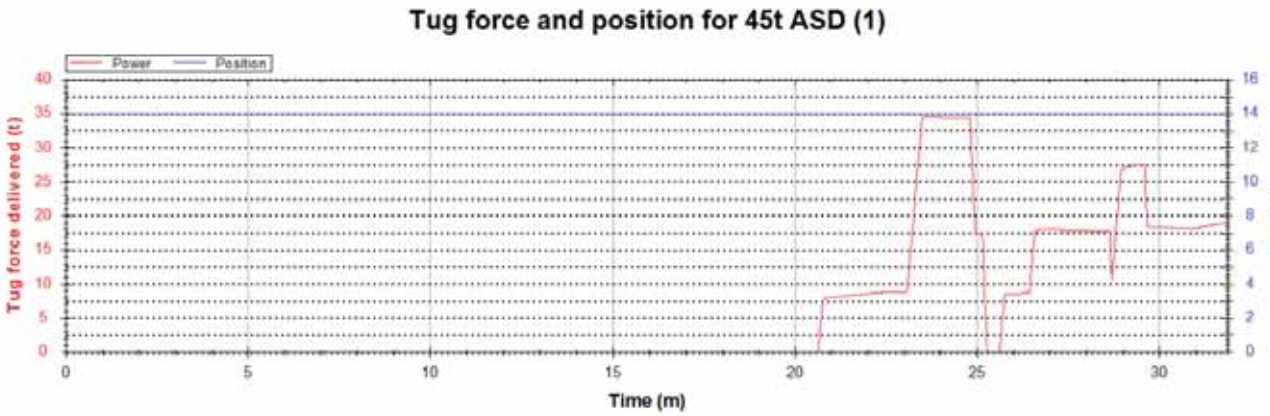


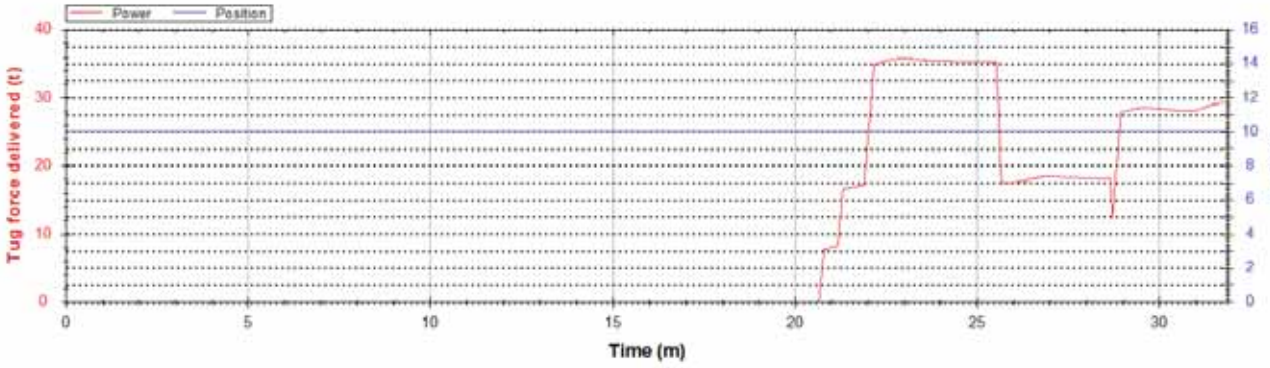


March 2015

Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)

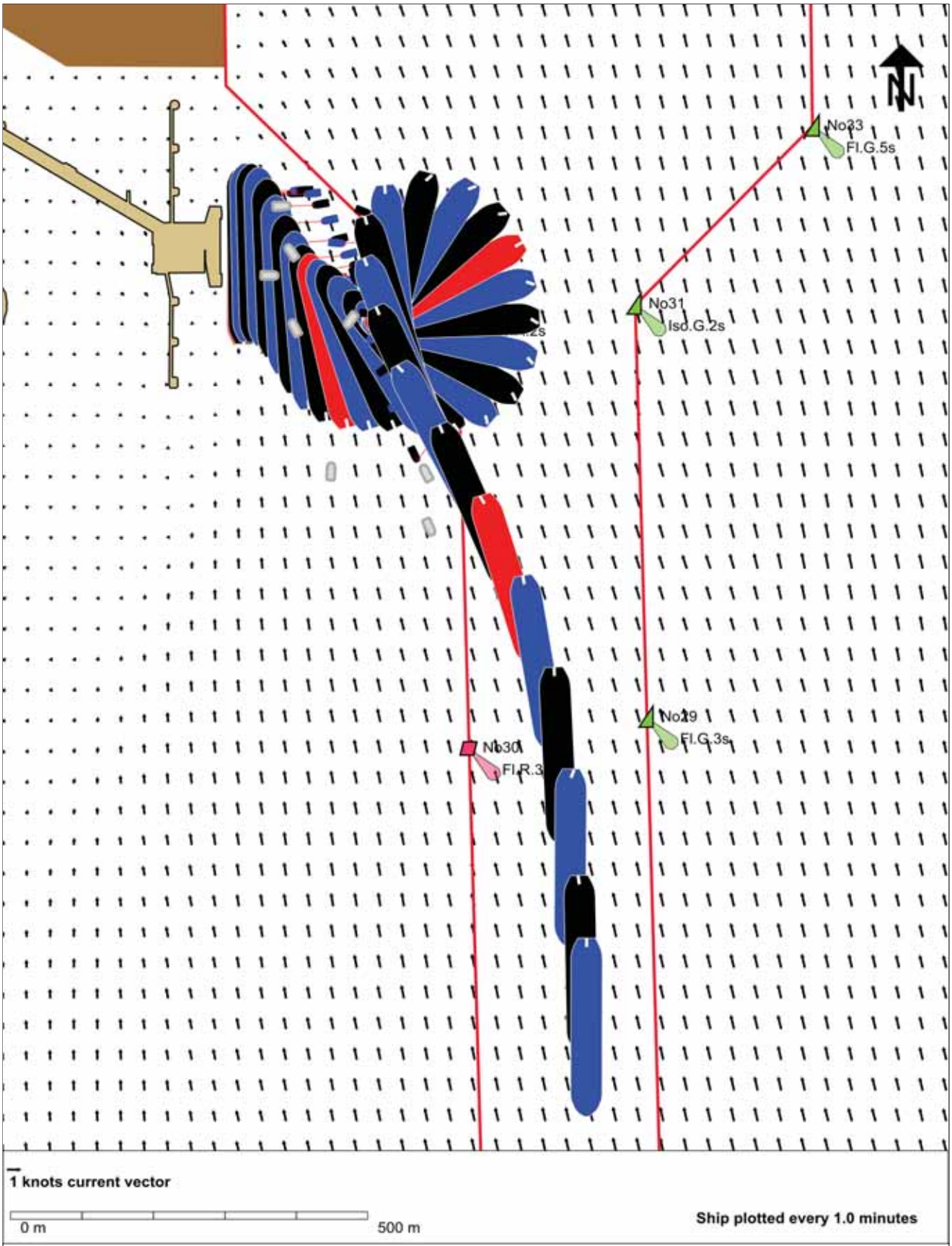






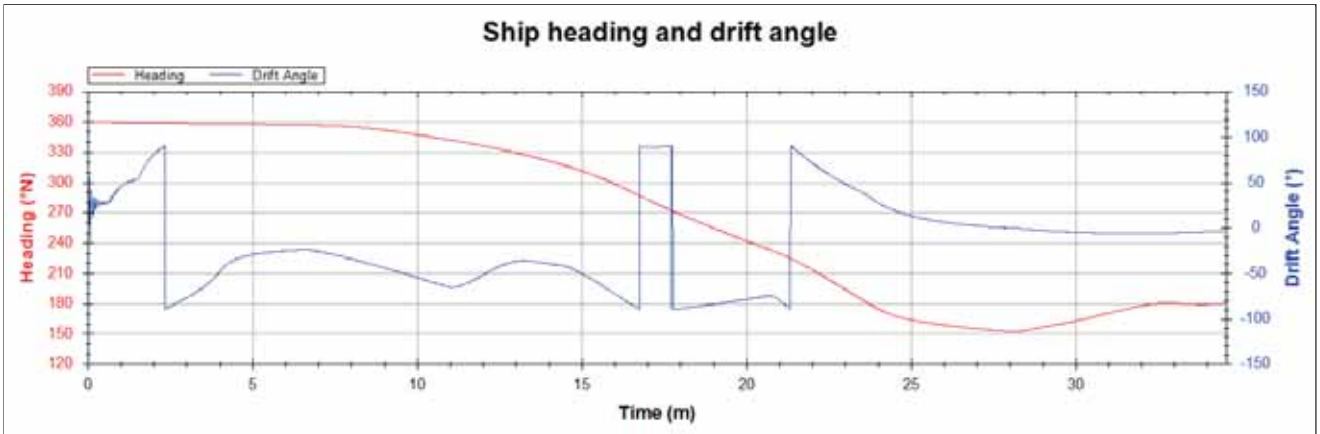
March 2015

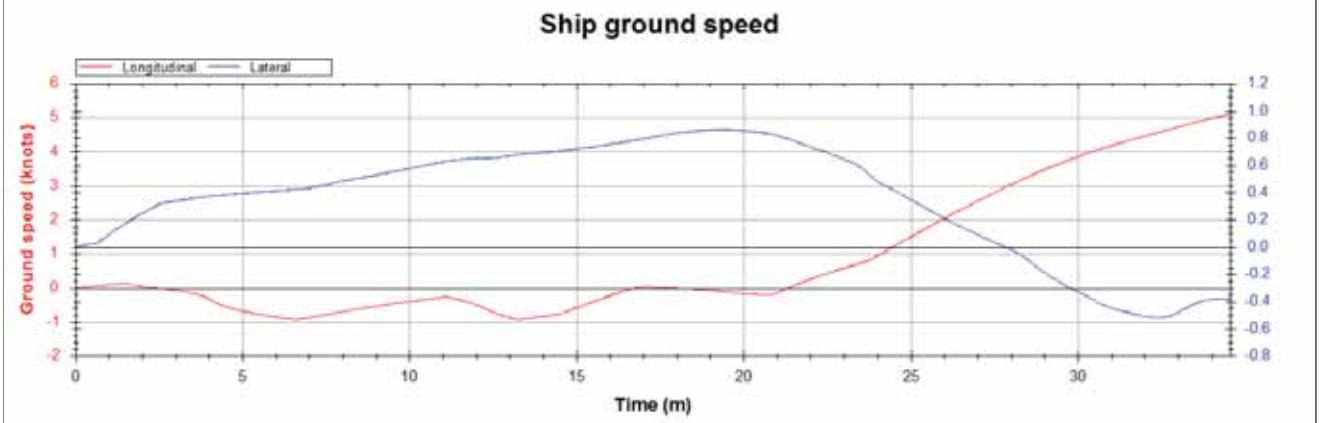
Run: 24	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 315°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Ballast)

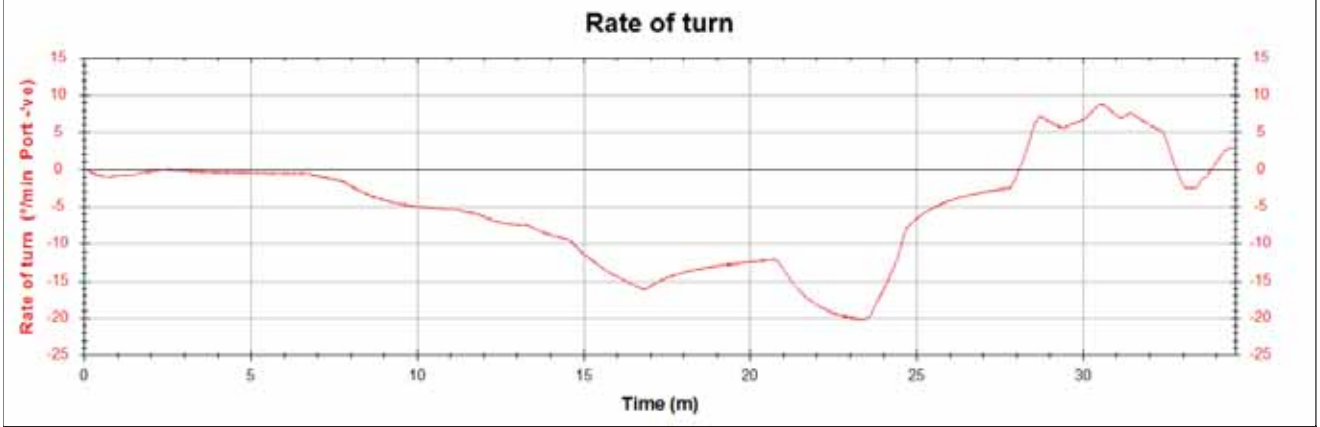


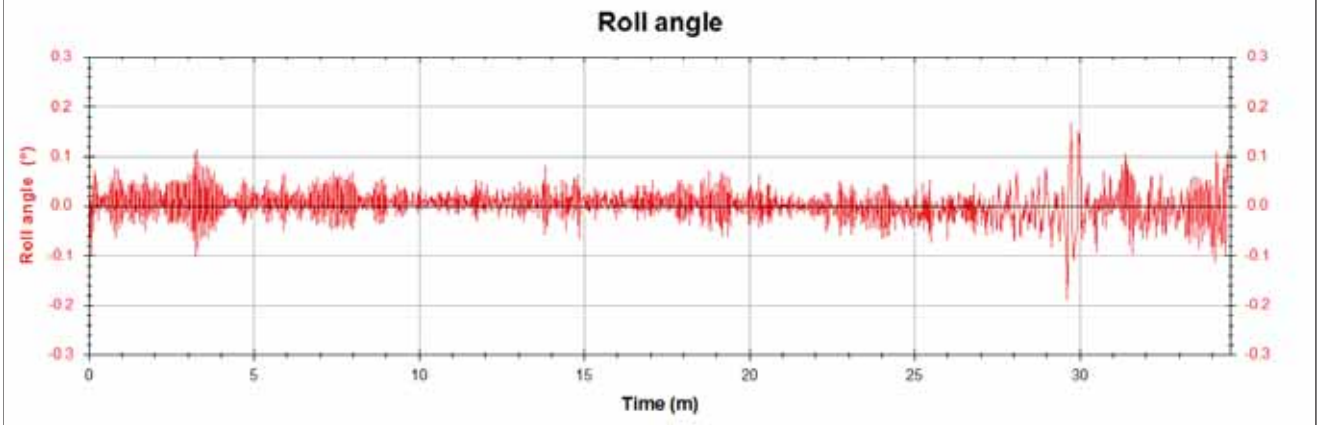
March 2015

Run: 25	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 225°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Laden)





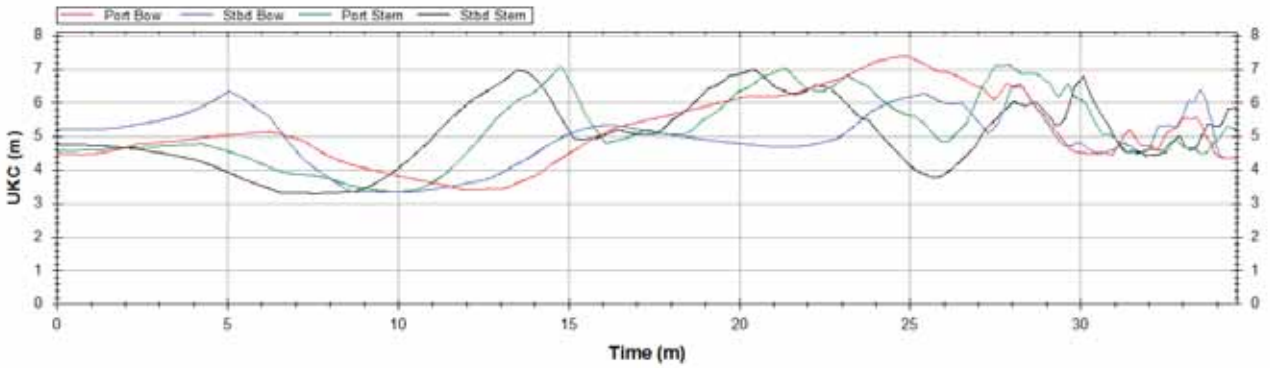




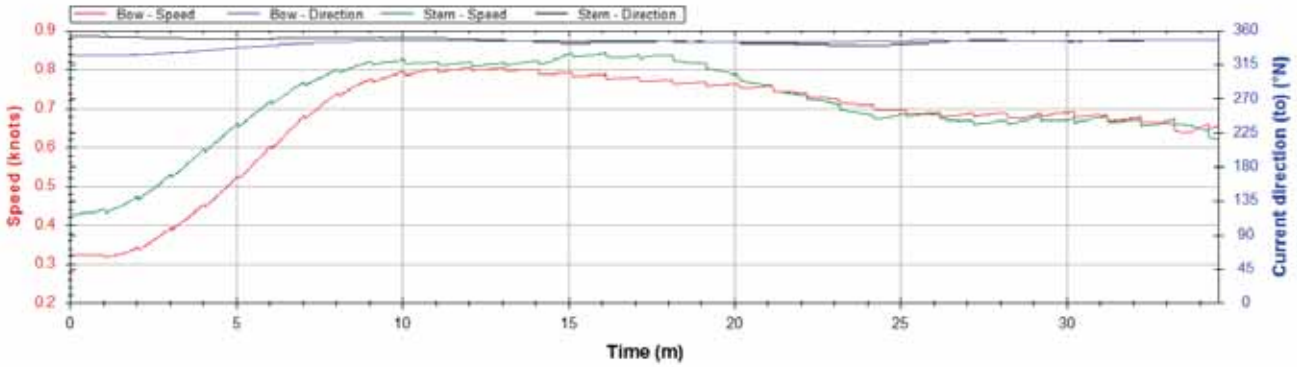
March 2015

Run: 25	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 225°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Laden)

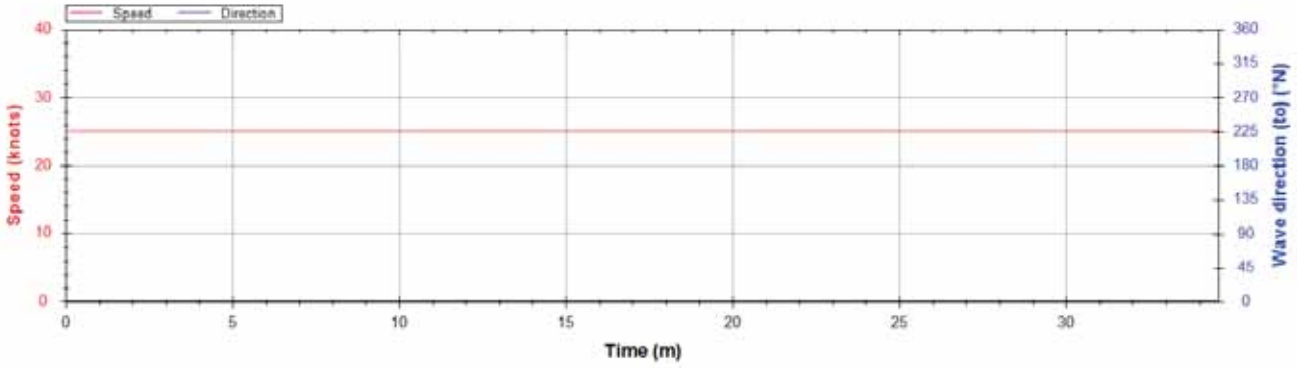
Underkeel clearance



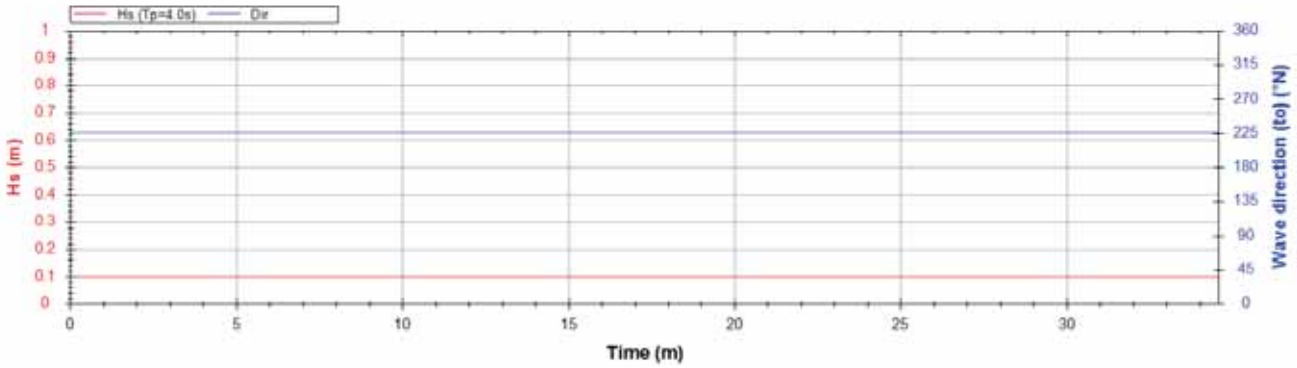
Current speed and direction



Wind speed and direction

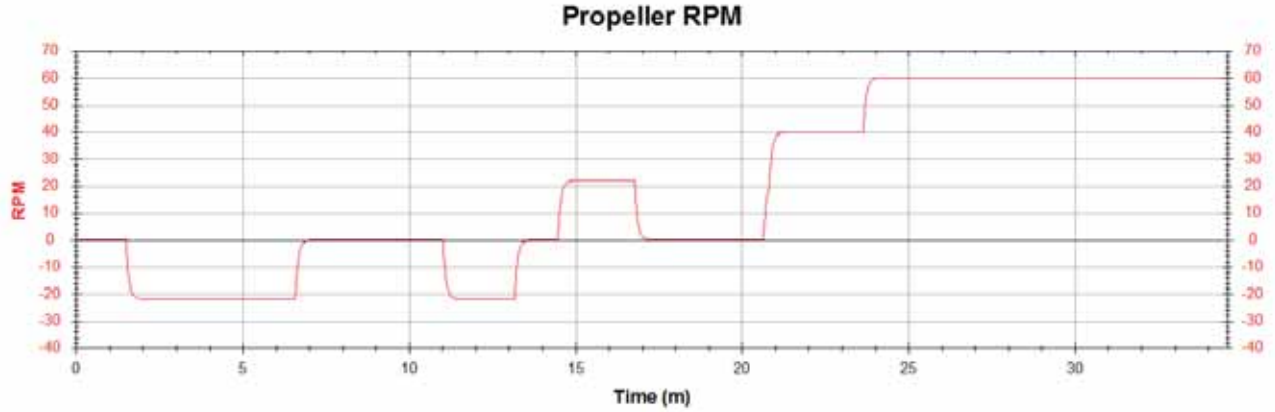


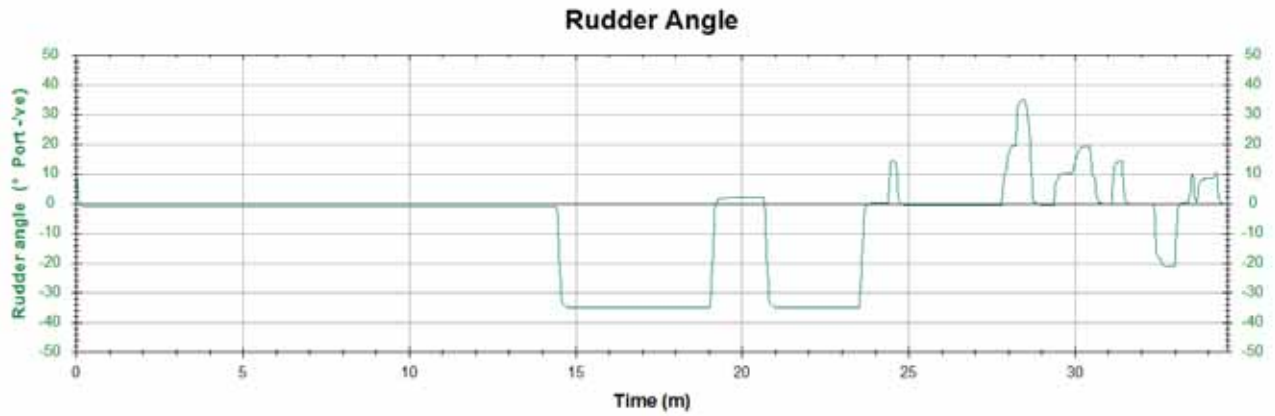
Significant wave height and direction



March 2015

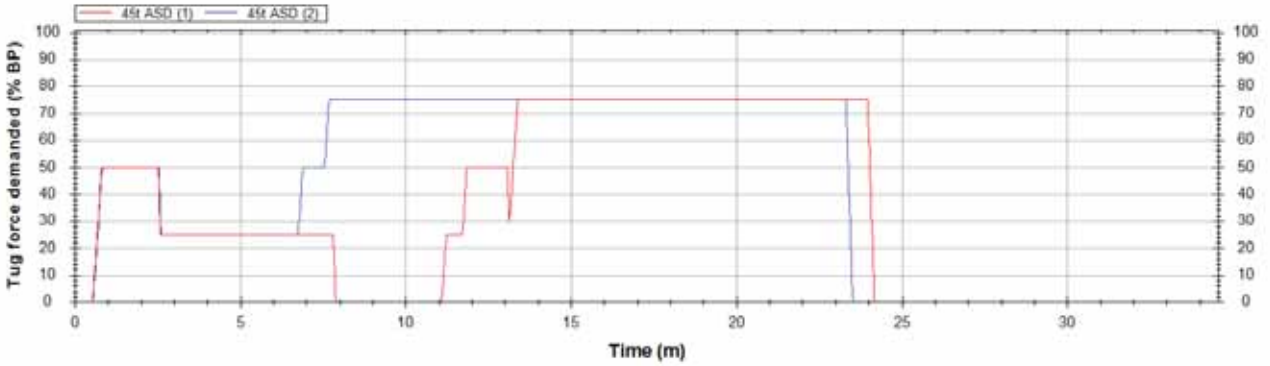
Run: 25	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 225°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Laden)

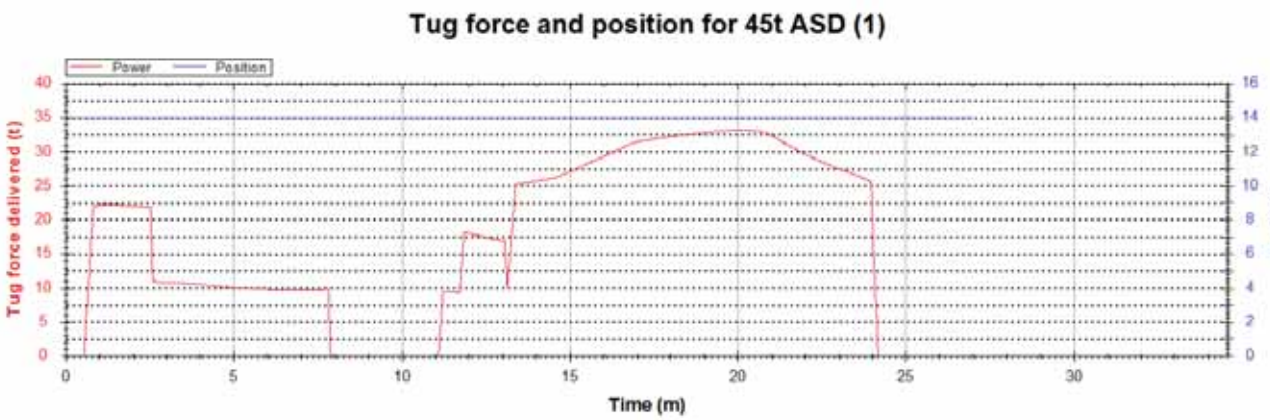


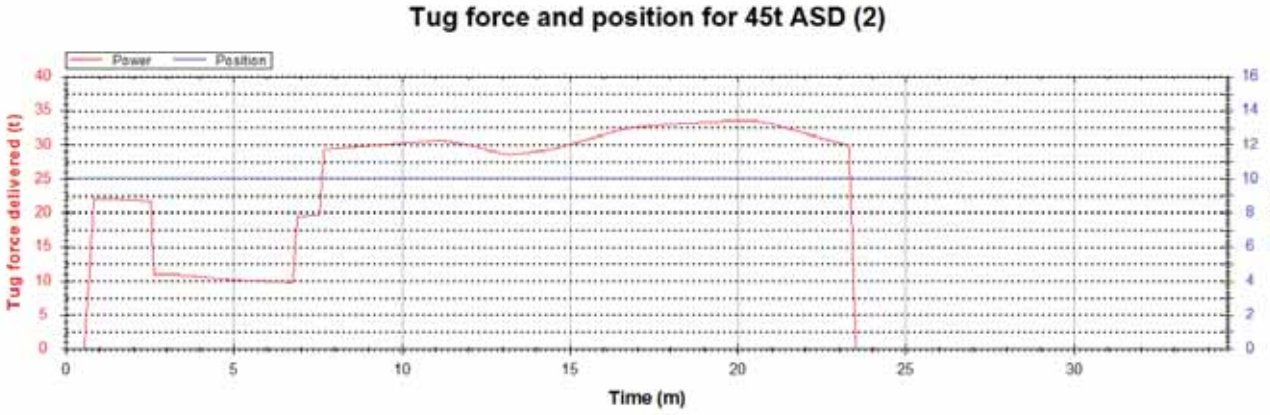


March 2015

Run: 25	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 225°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Laden)

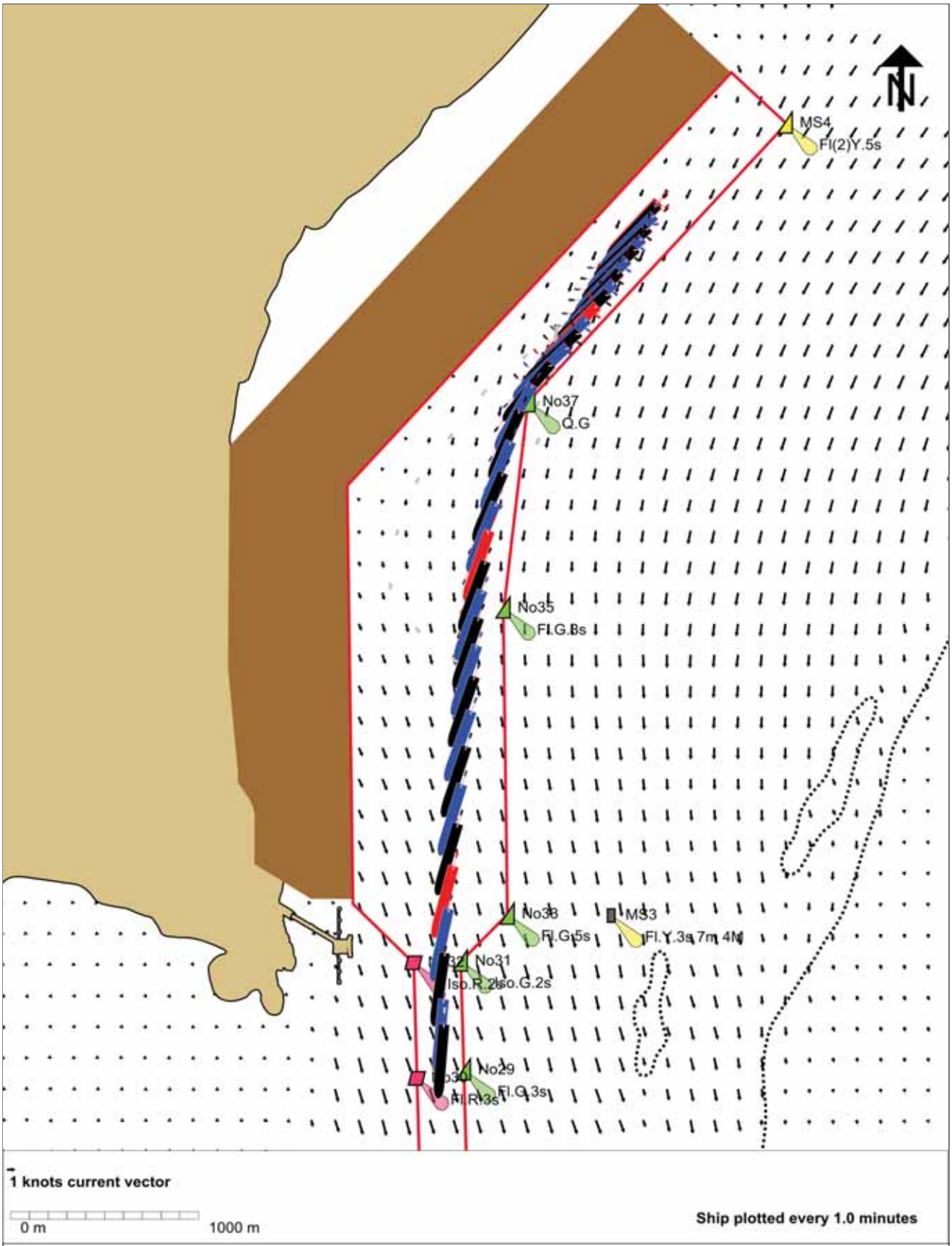






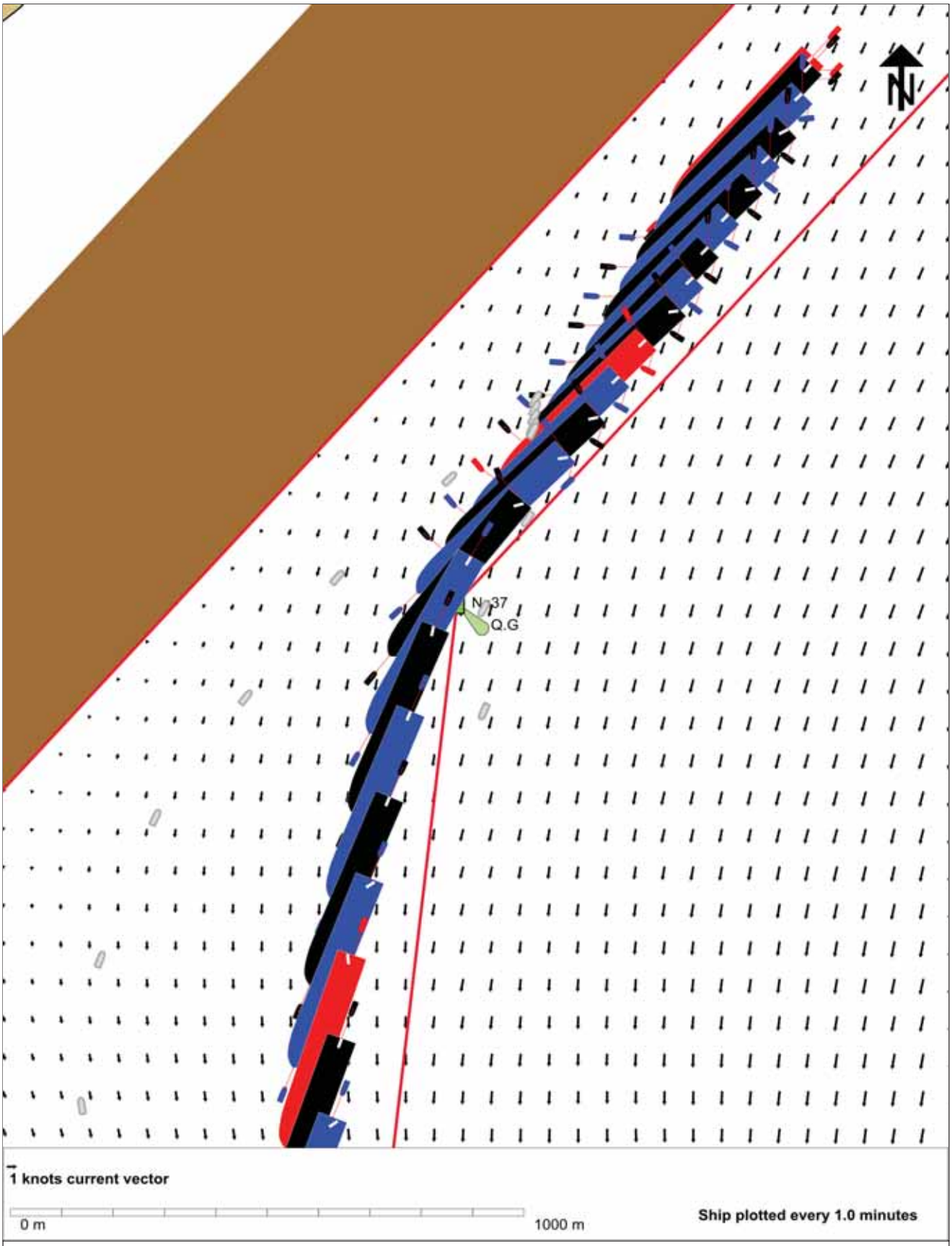
March 2015

Run: 25	Pilot: IS	Ship: 250m x 44m Products Tanker
Initial wind: 225°N 25 knots	Configuration: Stage 1 south	Type (Condition): Tanker (Laden)



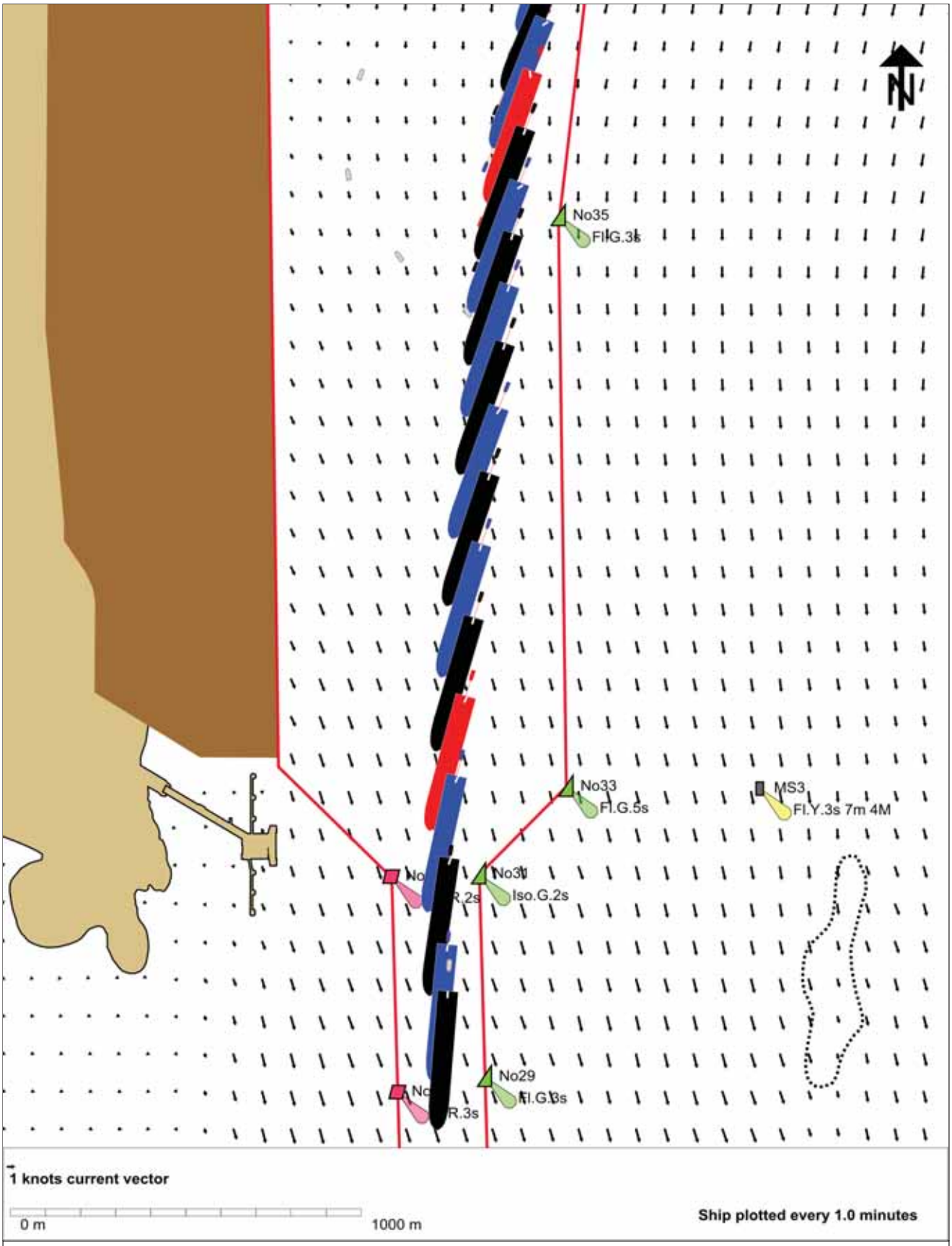
March 2015

Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



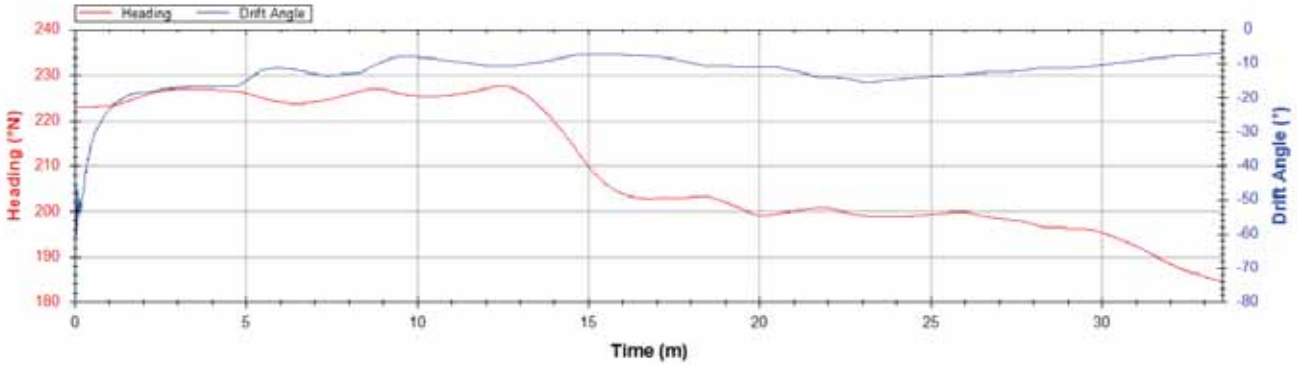
March 2015

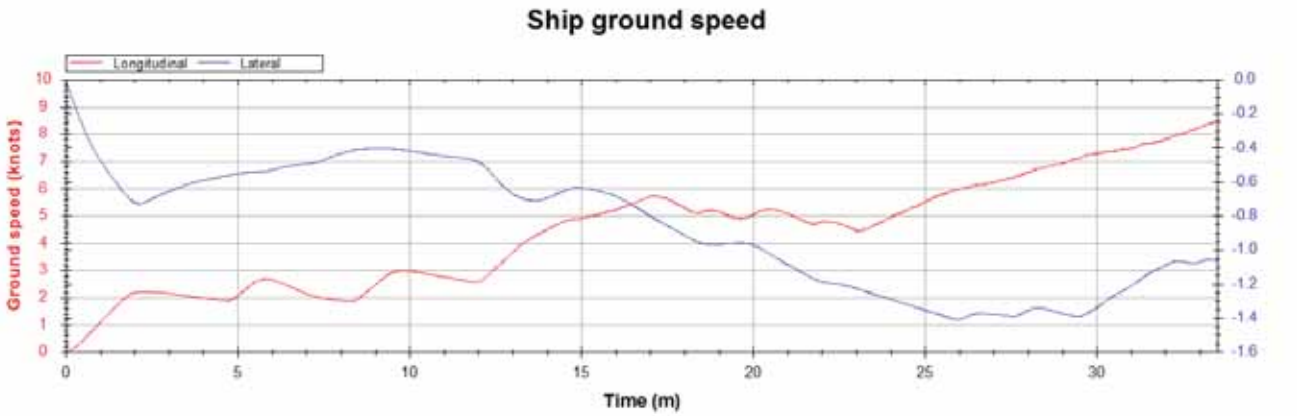
Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)

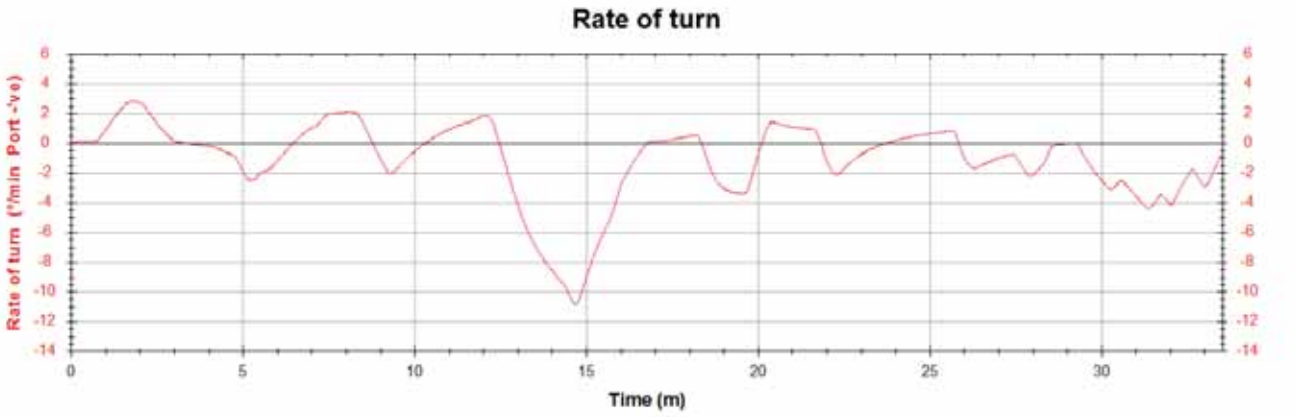


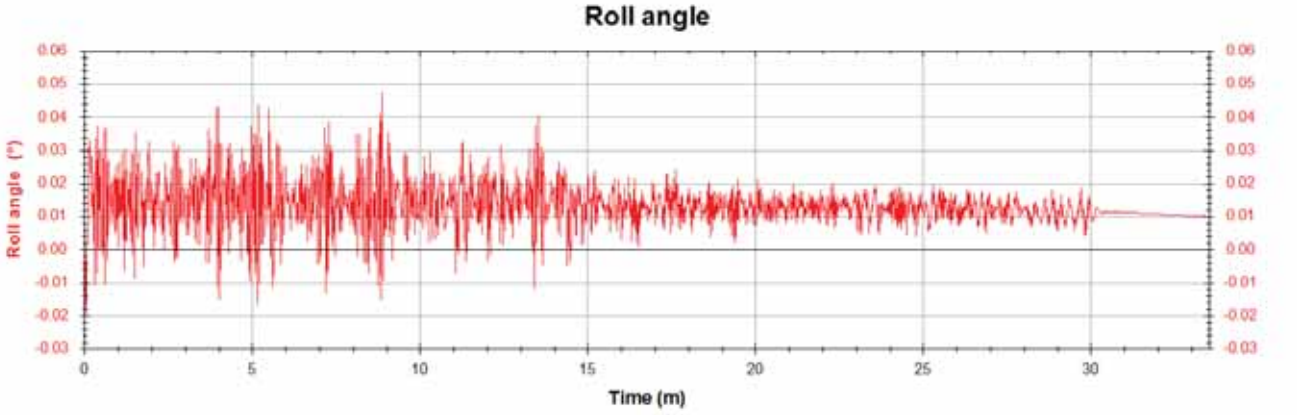
March 2015

Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



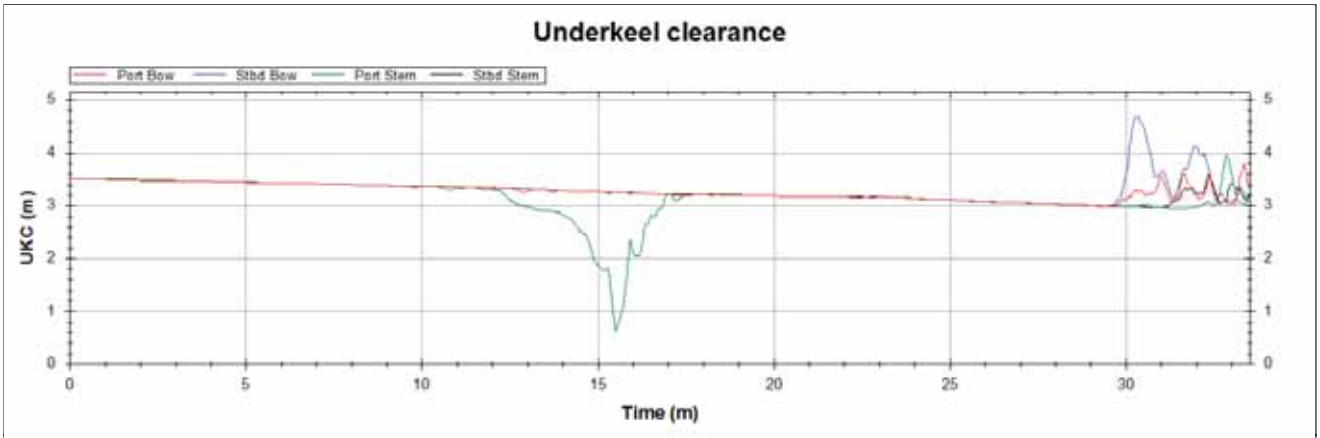


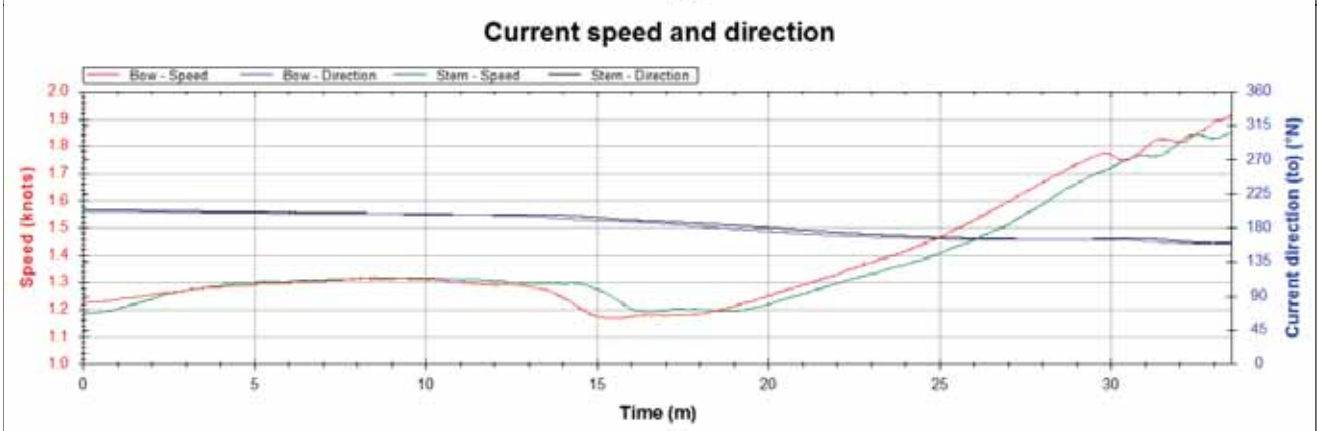


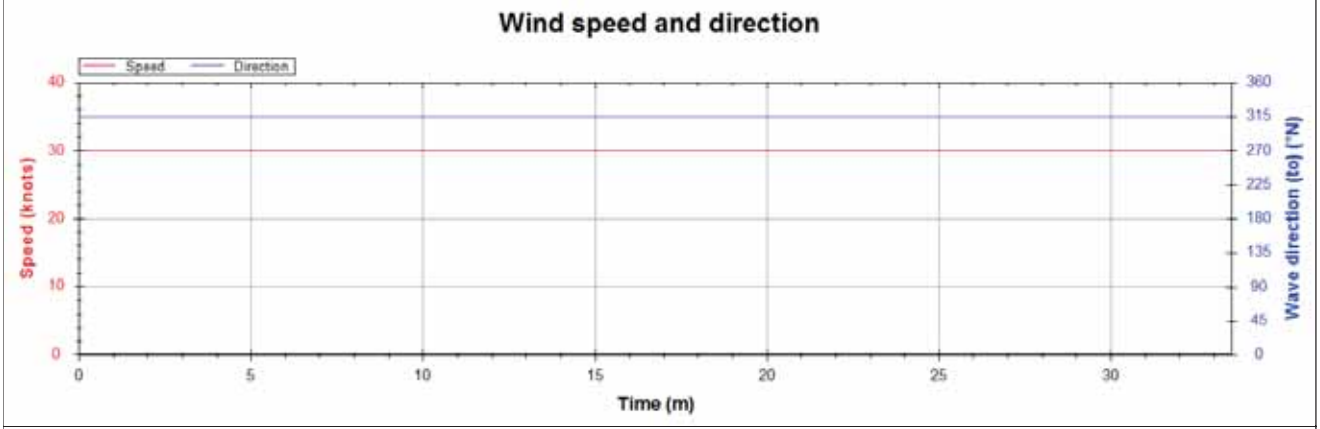


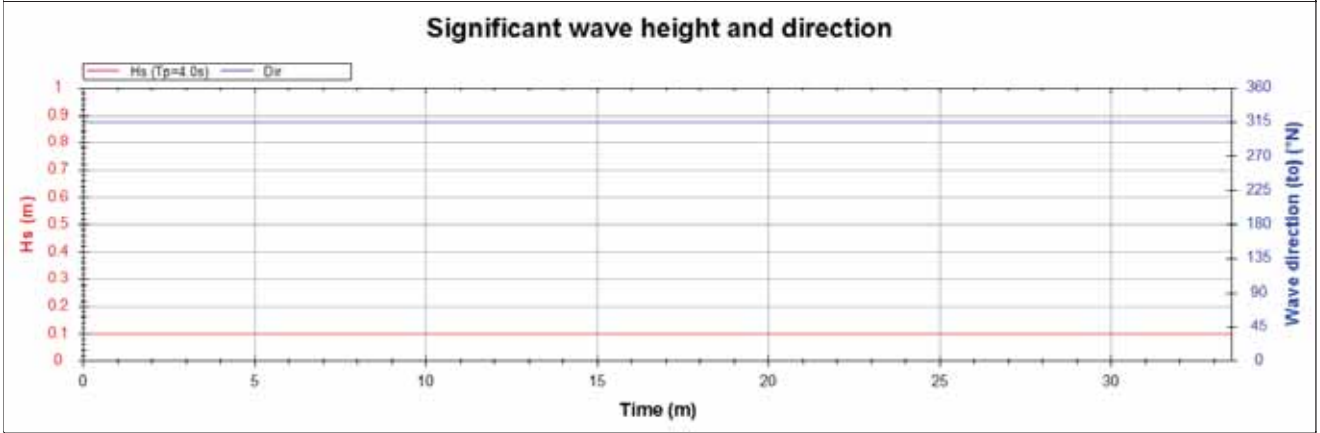
March 2015

Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



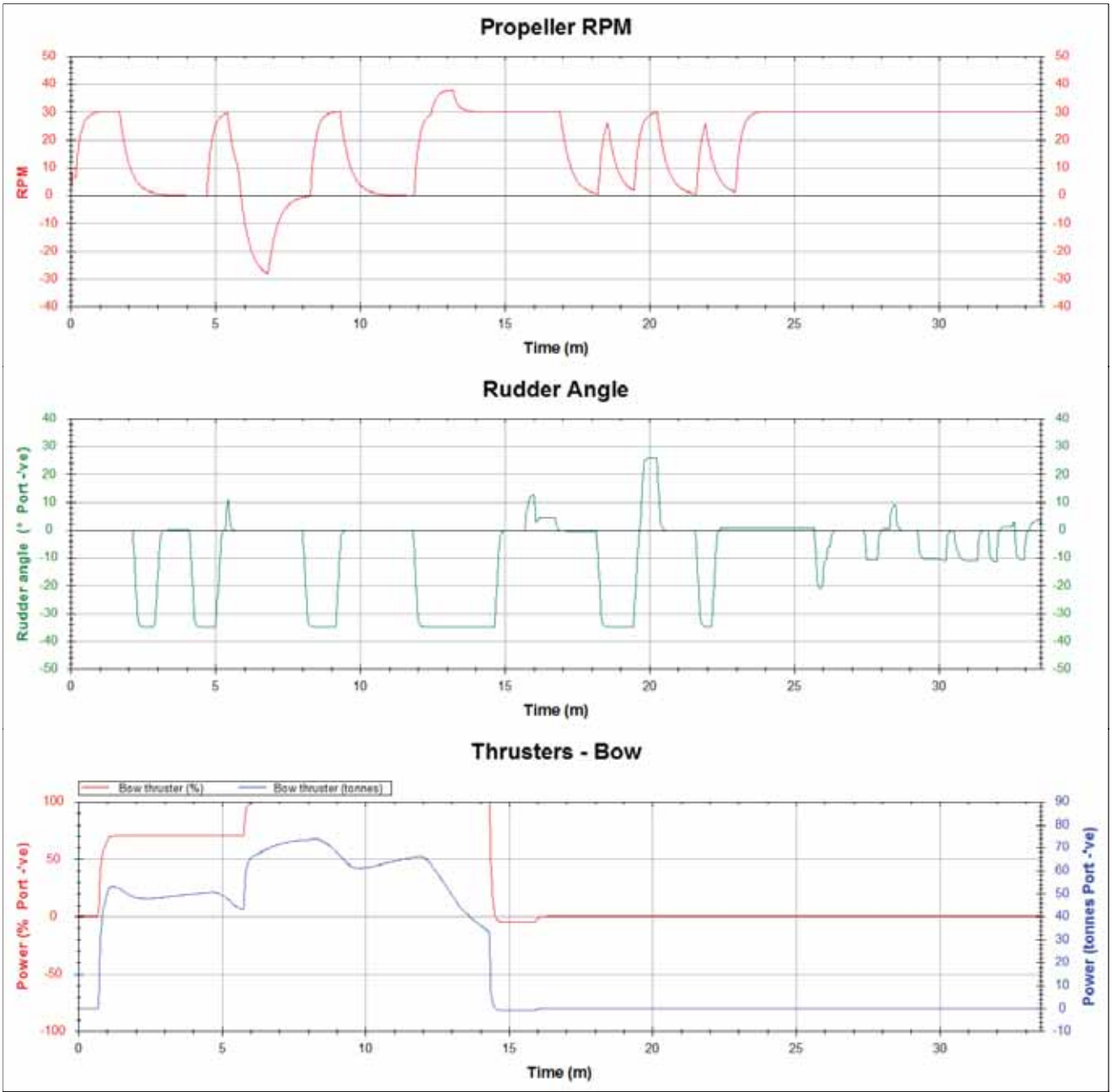






March 2015

Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)



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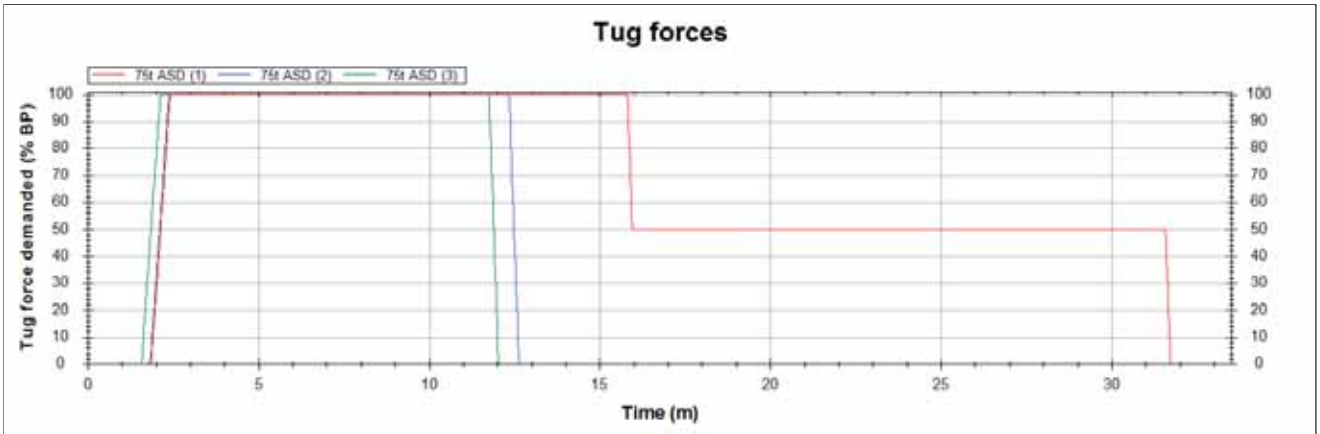

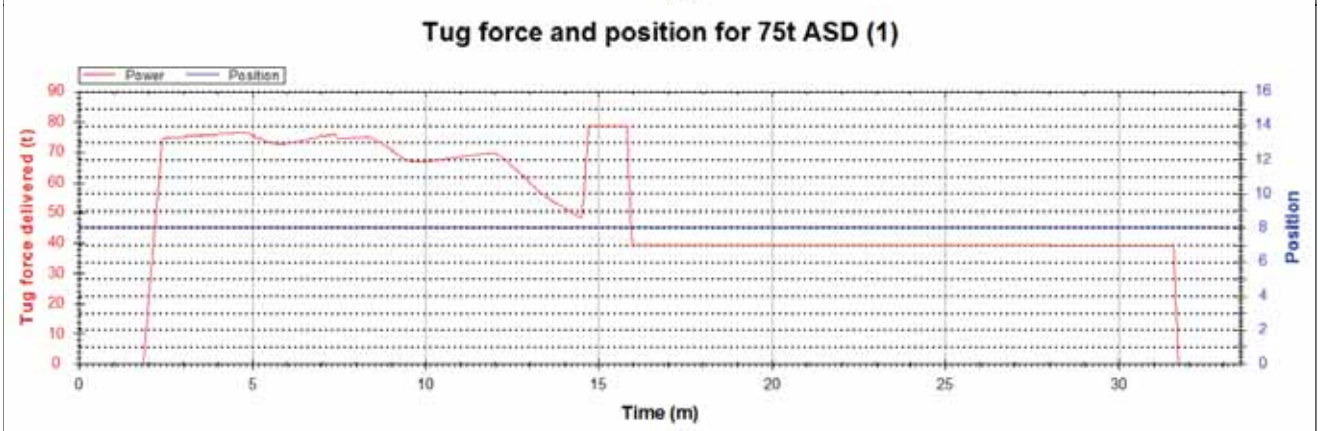

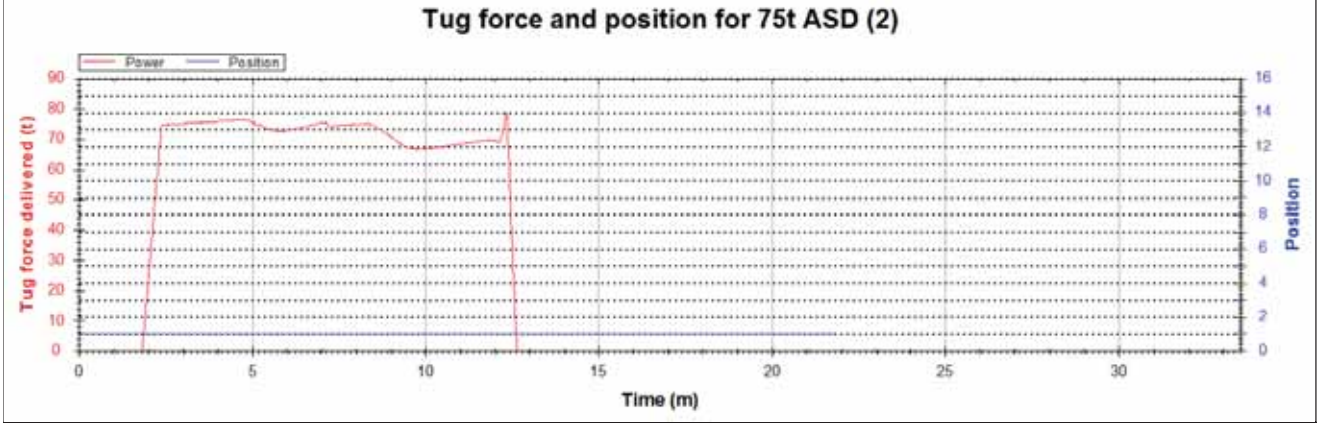

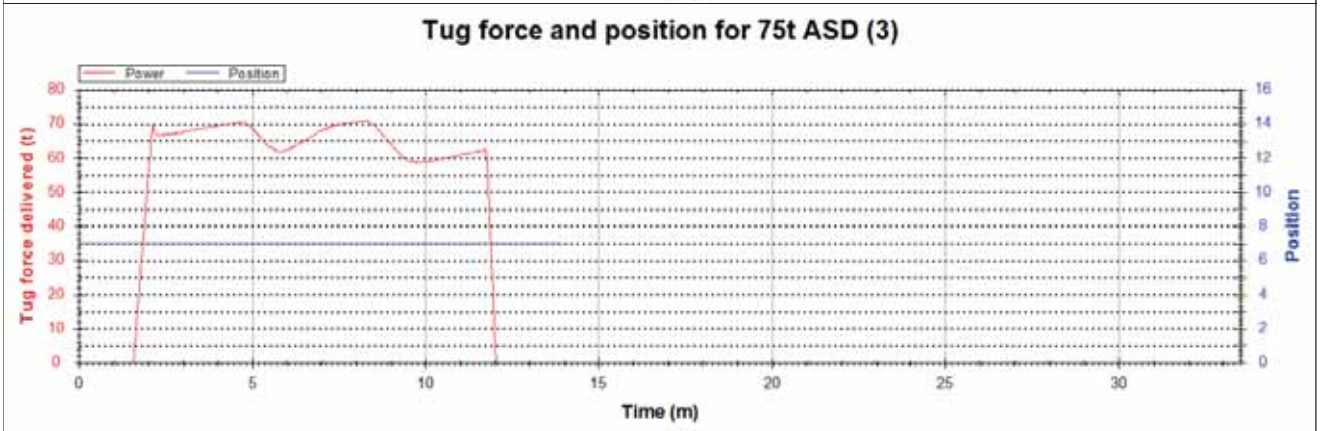

March 2015

Run: 26	Pilot: IS	Ship: 399m Container Ship
Initial wind: 315°N 30 knots	Configuration: Along the Shore	Type (Condition): Container (Laden)

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.

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