APPENDIX E

Marine Operations Plan (R1)

FIBRECO

Fibreco Export Terminal Enhancement
Permit Application Document

FIBRECO

APPENDIX E

Marine Operations - Executive Summary (R1)

Purpose: To illustrate the changes to the Fibreco Marine Operations as a result of terminal enhancement project.

Highlights of the studies include

- Marine Structures
  - Add infrastructure to handle Panamax sized vessels
    - 2 additional berthing dolphins
    - 2 additional breasting dolphins
    - Increase 'waterlot' lease 27 m to the east
  - Remove old conveyor cradle
  - Maintenance dredge to original design depth (13.5 m)
- Upgrade Shiploader
  - Remove old 'woodchip' shiploader
  - Design and install new machine
    - 2000 tph design capacity
    - Similar weight as original machine
    - Ability to have full offshore and inshore reach
    - Cascade style chute for superior dust control
    - Travel, luff and shuttle functions
    - New electrical and control systems
  - Low temperature sprinkler systems on conveyors and critical areas
  - Fire and smoke detection systems monitored
- Vessel Traffic

  Increase parcel size to reduce number of vessel handled

- Operating Conditions
  - Pacific Pilots performed a navigational simulation
    - Tide conditions of 2 knot max for berthing (1.5 knot for Panamax)
    - Vessel Design range
      - 180m – 225m LOA
      - 30,000 – 75,000 DWT
  - Vessels will continue to shift along the berth face
  - Bunkering will continue to occur under strict conditions

SEPTEMBER 2016
FIBRECO EXPORT INC.

FIBRECO ENHANCEMENT PROJECT

MARINE DESIGN CRITERIA FOR NEW BREASTING AND MOORING DOLPHINS

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SEPTEMBER 2016
FIBRECO EXPORT INC.

FIBRECO ENHANCEMENT PROJECT

MARINE DESIGN CRITERIA FOR NEW BREASTING AND MOORING DOLPHINS

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CONTENTS

1 Project Definition

1.1 General

This design criteria applies to new marine structures and related modifications to the existing terminal required to handle Panamax class bulk-carriers.

1.2 Location

The Fibreco Export terminal is located on the North Shore of Vancouver Harbour, BC, Canada, as shown in the following figure.

Figure 1-1 Fibreco Terminal Location in Vancouver Harbour, BC, Canada

1.3 Functional Requirements

1.3.1 Design (Service) Life

Design Life is defined as the minimum period of time for a structure to remain in service, with periodic maintenance, before it needs to be replaced.

- New marine structures will have a Design Life of 30 years.
- New marine equipment including fenders and bollards will have a Design Life of 15 years.
- Protective coatings on steel members will have a Design Life of 10 years.
- Sacrificial anodes from the cathodic protection system installed on foundation piles will have a Design Life of 10 years (before the anodes need to be replaced).

1.3.2 Navigation

The terminal is currently subject to tidal and current velocity restrictions for arriving and departing vessels as follows[1]:

- Arrival: 2 knots at First Narrows;
- Departure: 2 knots or over 8.5 m draft at First Narrows; and
- Line boats always required at berth for arrivals.

It is expected that these operating windows will be revised based on the results of the full mission bridge simulations and their live-run corroboration.

1.3.3 Access to Facilities and Equipment

Permanent access will be provided for operating, maintaining and servicing deck-mounted marine equipment. Access structures will include walkways (catwalks) and stairs (where required due to change in elevation). Walkways and stairs will have a minimum width of 1000 mm.

A minimum clear working space of 1.0 will be provided around bollards.

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[1] PPA.GC.CA Marine Terminal Bathymetry and Controlling Depths July 6, 2016

2 Marine Design Criteria

2.1 Codes and Standards

The following codes, guidelines, and standards will be adopted in design of the marine structures and their components.

- BS6349 British Standard Institution, British Standard Code of Practice for Marine Structures – Part 1 through 4.
- IALA Navguide International Association of Marine Aids to Navigation and Lighthouse Authorities, Aids to Navigation Guide.
- OCIMF MEG3 Oil Companies International Marine Forum, Mooring Equipment Guidelines.
- PIANC 2002 World Association for Waterborne Transport Infrastructure, Guidelines for the Design of Fender Systems.
- PIANC N° 24 World Association for Waterborne Transport Infrastructure, Criteria for Movements of Moored Ships in Harbours.
- PIANC N° 34 World Association for Waterborne Transport Infrastructure, Seismic Design Guidelines for Port Structures.
- PIANC N° 51 World Association for Waterborne Transport Infrastructure, Underkeel Clearance for Large Ships in Maritime Fairways with Hard Bottom.
- PIANC N° 121 World Association for Waterborne Transport Infrastructure, Harbour Approach Channels - Design Guidelines.
- CAN/CSA S6 Canadian Standards Association, Canadian Highway Bridge Design Code.
- ASCE 61 American Society of Civil Engineers, Seismic Design of Piers and Wharves.

- UFC 4-152-01 Unified Facilities Criteria, Design: Piers and Wharves.
- IHMA NPI International Harbour Masters Association – Nautical Port Information, Port Information Guide - Port Metro Vancouver.

2.2 List of Reference Documents

The following third-party documents will be used to obtain reference information pertinent to the design of the new facilities.

- H.A. Simons (International) Ltd. Project 4379 B – FIBRECO Export Inc. 1979 Set of Drawings (Refer to appendix for complete list of drawing numbers and revisions).
- Con-Force Products Ltd. Project 9315 – Dock Fibreco Export Inc., 1979 Set of Drawings (Refer to appendix for complete list of drawing numbers and revisions).
- SKS Engineering Project 96083 – Ship Unloading Facility, 1996 Set of Drawings (Refer to appendix for complete list of drawing numbers and revisions).
- CWA's sketch Fibreco Enhancement Project, Shiploader Concept – Bow of Ship Facing East – New Travelling Shiploader, No. 15006-500-SK-008_P2 Nov. 24, 2015.

2.3 Units of Measurement

The International System of Units (SI) will be used throughout the project unless noted otherwise.

The following particular units will be used as required:

Elevations, Ship Dimensions	m (metres)
Ship Displacement	t (tonnes)
Ship Cargo Capacity	DWT (Dead-Weight Tonnage)
Force	kN (kilo-Newton)
Stress	MPa (Mega-Pascal)
Weight	t (tonnes)

2.4 Coordinate System and Project Datum

The horizontal coordinate system for the project will be UTM WGS-84.

Offshore elevations will be referenced to Chart Datum (CD). Elevations of the existing marine facilities are obtained from record drawings and converted to Chart Datum from original N.H.B. Datum[2].

2.5 Environmental Conditions

The following section summarizes the site environmental conditions considered in the design of the marine facilities.

2.5.1 Wind

Wind acting directly on the structures is not expected to govern the design of mooring and breasting dolphins.

In the absence of site-specific wind measurements, the mooring analysis will assume that site wind conditions are similar to those recorded by the Meteorological Service of Canada (MSC) at Point Atkinson. Figure 2-1 shows the annual hourly wind rose derived from the Point Atkinson dataset (1969 to 2015).

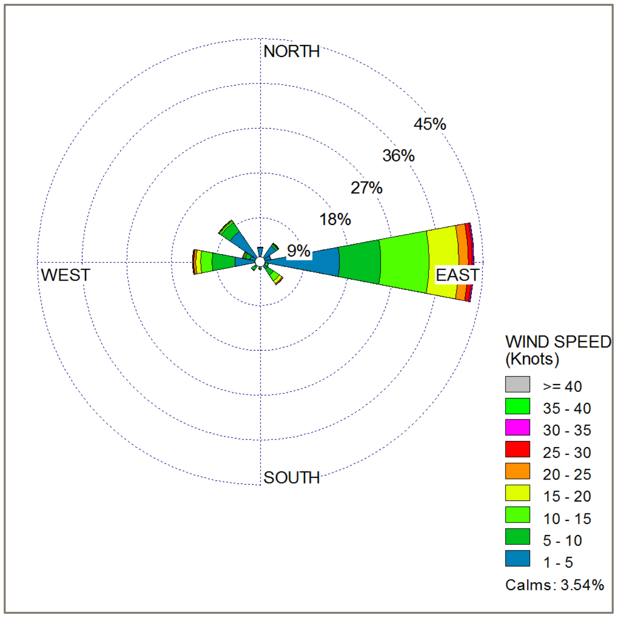

Figure 2-1 Annual Hourly Wind Rose Derived from MSC Point Atkinson Measurements (1969-2015)

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[2] *H.A. Simons (International) Ltd., Project 4379 B, DWG D4379-019-405_01 defines N.H.B. Datum 82.77 feet below zero tide.*

2.5.2 Waves

Waves acting on the structures in Burrard Inlet are considered negligible for structural and mooring purposes and will not be considered a design factor for the preliminary design of the new dolphins.

2.5.3 Currents

Currents at the berth were derived from an interpretation of numerical current modelling and field measurements undertaken for Fibreco by Tetra Tech during a period of strong tides, from May to July 2012. Figure 2-2 shows the current rose derived from the current predictions.

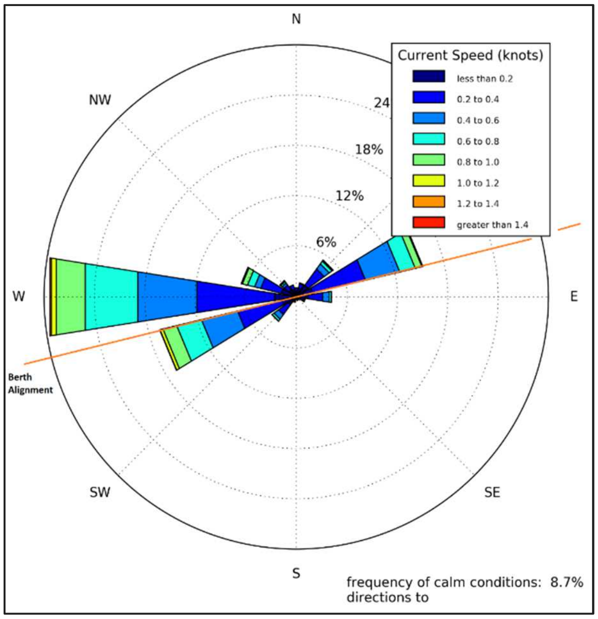


Figure 2-2 Current Rose at the Berth

Figure 2-3 shows the maximum long-term surface tidal current speed by direction. The maximum current at the Fibreco berth is approximately 1.4 knots.

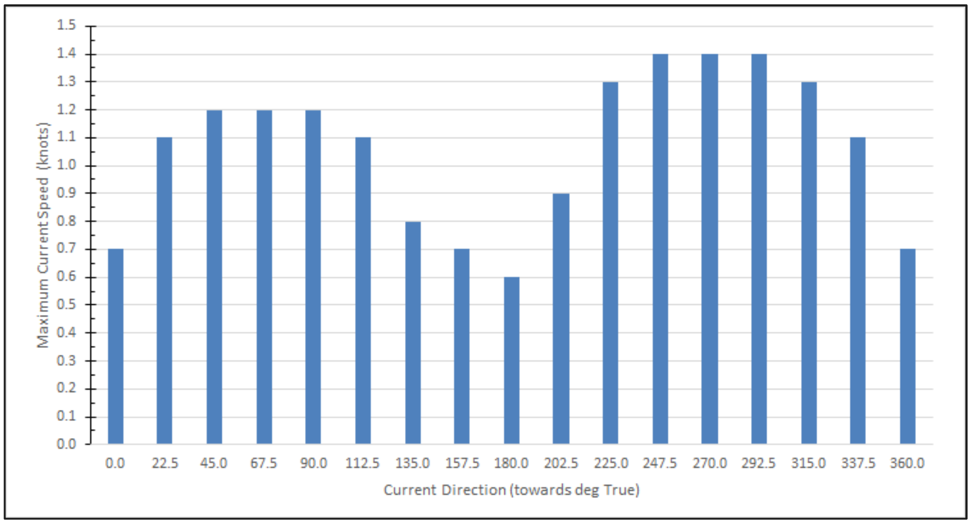


Figure 2-3 Design Current Speed versus Direction at Berth

Currents in Burrard Inlet acting directly on the structures are considered negligible for structural purposes and will not be considered a design factor for the preliminary design of the new structures. The mooring analysis will consider the current regime at the site.

2.5.4 Snow and Rainfall

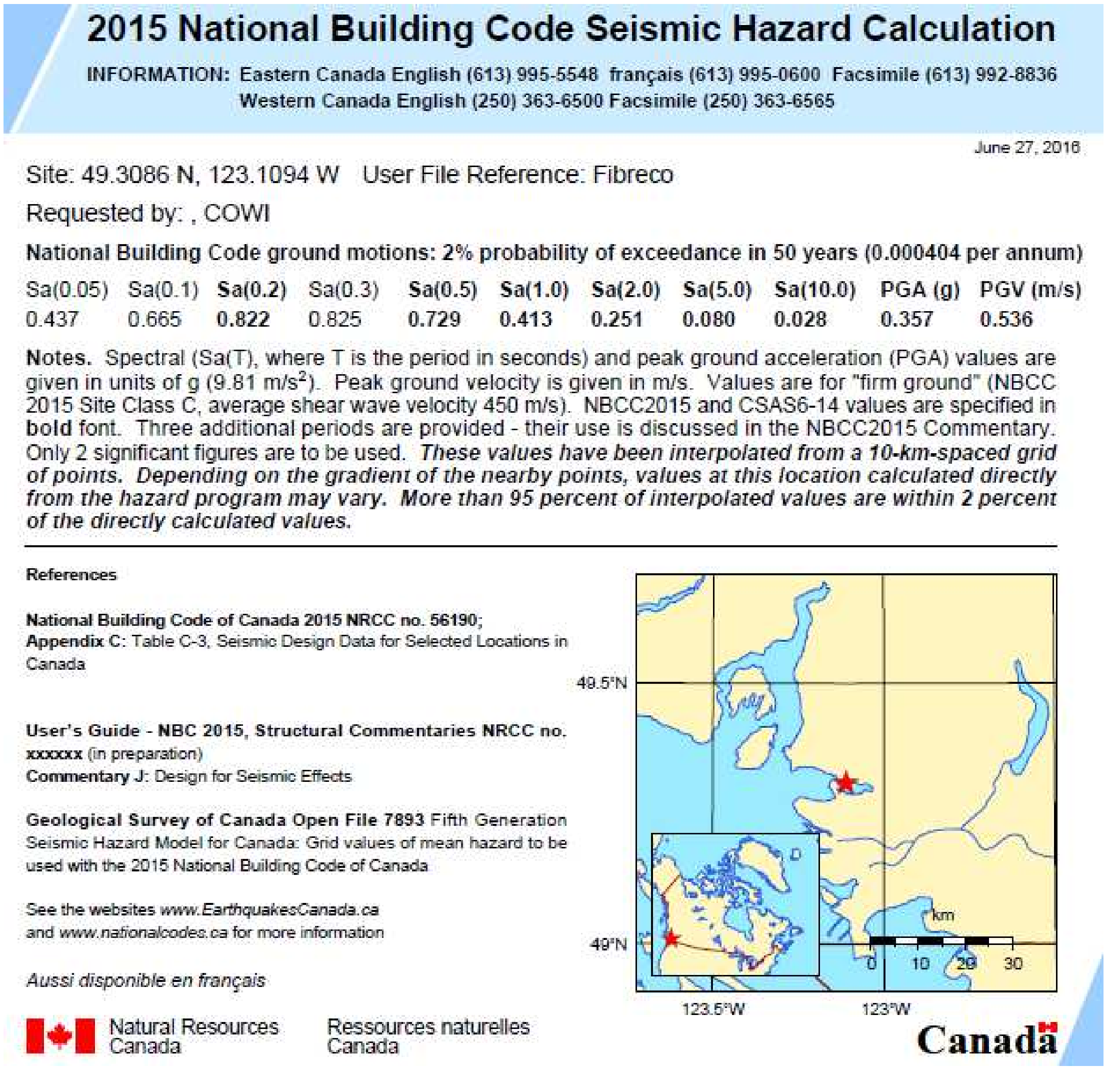
Snow and rainfall effects are considered negligible for structural purposes and will not be considered a design factor for the preliminary design of the new structures.

2.5.5 Temperature

Temperature effects are not deemed critical for the structures envisioned in the project, and will not be considered a design factor for the preliminary design of the new structures.

2.5.6 Earthquake

The site is located in a high seismic-hazard region. Ground motion parameters for the site are provided in the figure below:



2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

June 27, 2016

Site: 49.3086 N, 123.1094 W User File Reference: Fibreco

Requested by: , COWI

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.437	0.665	**0.822**	0.825	**0.729**	**0.413**	**0.251**	**0.080**	**0.028**	**0.357**	**0.536**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

References

National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français

Natural Resources Canada Ressources naturelles Canada

Canada

Figure 2-4 National Building Code Ground Motions 2015 NRCC no. 56190

2.5.7 Tsunami

Top of deck elevation of new structures will be specified to match the top of deck elevation of the existing structures. Tsunami will not be considered a design factor for the preliminary design of the new structures.

2.6 Water Levels

The following met-ocean components influence the still water level at the site, which is usually a determining factor when specifying a minimum recommended deck elevation. However, in this case, the top of deck elevation of new structures will be specified to match the top of deck elevation of the existing structures.

2.6.1 Tides

Tides levels will be defined in accordance with the Canadian Hydrographic Service.

Table 2-1 CHS Tidal Parameters at Fibreco Site

Parameter	**Value (m CD)**	**CHS Definition**
Extreme High Water	5.6 m CD	Highest recorded water level.
Higher High Water Large Tides (HHWLT)	5.0 m CD	Average of the highest high waters, one from each of 19 years of predictions.
Mean Sea Level (MSL)	3.1 m CD	Mean water level - average of all hourly water levels over the available period of record.
Lower Low Water Large Tides (LLWLT)	0.0 m CD	Average of the lowest low waters, one from each of 19 years of predictions (equal to Chart Datum and approximately equal to Lowest Normal Tide).
Extreme Low Water	-0.3 m CD	Lowest recorded water level.

2.6.2 New Deck Elevation

The top of deck elevation of new structures will match the top of deck elevation of the existing structures.

2.6.3 Underkeel Clearance and Dredging Allowance

For the purpose of design, it is assumed that maintenance dredging will take place periodically at the terminal allowing the full original design water depth to be available at the berth (12.8 m water depth at L.L. Water[2]). No additional dredging will take place to deepen the berth beyond its original design draft.

A minimum *net* Underkeel Clearance (UKC) of 1.0 m is assumed to be provided at the berth at all times during arrival, loading, and departure of the vessel. The Port is responsible for establishing the minimum *gross* underkeel clearance requirements at the berth, considering factors such as:

- Siltation allowance and maintenance dredging frequency;
- Maintenance dredging and survey execution tolerances;
- Design vessel and estimated static draft uncertainties (trim, list);
- Potential changes in water salinity/density;

- Tidal assist practices;
- Wave Response at Berth (passing vessels); and
- Minimum *net* UKC.

The design will verify that the *net* UKC provision at berth extends no less than 15% LOA beyond the extreme warping position of the largest vessel, or 30 m, whichever is less.

2.6.4 Tidal Assist

The largest design vessel's (see Section 2.7) static summer draft exceeds the original design draft of the terminal. Tidal assist may be considered by the terminal operator and the port when/if allowing vessels to be loaded beyond the zero tide limits.

2.7 Design Vessels

Table 2-2 presents the design vessels for the terminal. Typical wood pellet carriers (45,000 DWT) are expected to fall within the range of design vessels presented below.

Table 2-2 Design Vessels Particulars

Vessel Particulars	**Smallest Grain Bulker**	**Largest Grain Bulker**
Vessel Class	Handysize	Panamax
Deadweight Tonnage (DWT)	30,000 t	75,000 t
Fully-Laden Displacement (DT)	37,500 t [11]	86,250 t [1]
Ballasted Displacement (DT_b)	14,500 t [2]	45,000 t [2]
Length Overall (LOA)	180 m [10]	225 m [3]
Length Between Perpendiculars (LBP)	162 m [4]	202 m [4]
Beam or Breadth	27.0 m [10]	32.3 m [3]
Moulded Depth	14.0 m [5]	19.6 m [5]
Fully-Laden Draft or Draught (D)	10.0 m [10]	14.0 m [6]
Ballasted Draft or Draught (D_b)	5.0 m [7]	7.8 m [7]
Fully-Laden Wind Lateral Area	Not used	Not used
Fully-Laden Wind Frontal Area	Not used	Not used
Ballasted Wind Lateral Area	Not used	3,580 m^2 [9]
Ballasted Wind Frontal Area	Not used	824 m^2 [9]
Typical Mooring Configuration	2 / 2 / 1 [8]	2 / 2 / 2 [8]
Typical Breast/Head Line MBL	Not used	92 t [9]
Typical Spring Line MBL	Not used	75 t [9]

1 Based on empirical relationship of 1.15 Displacement/DWT ratio from in-house Lloyds dataset, verified against typical PIANC tables data (75% CL).

2 Based on empirical General Cargo ship relationship DT_b = 0.199 x DT^1.084 after Thoresen.

3 *Provided by Fibreco. Checked with typical range for bulk carriers 70,000 to 75,000 DWT from in-house Lloyd dataset, verified against typical values from PIANC tables data (75% CL).*

4 *Assuming LBP = 0.9 x LOA.*

5 *Based on empirical relationship of 1.4 Moulded-Depth/Draft ratio from in-house Lloyds dataset, verified against typical PIANC tables data (75% CL).*

6 *Based on typical draft range for bulk carriers 70,000 DWT to 75,000 DWT from in-house Lloyd dataset, verified against typical values from PIANC tables data (75% CL).*

7 *Based on empirical General Cargo ship relationship* D_b *= 0.352 x D^1.172 after Thoresen.*

8 *Bulk Carrier Practice by The Nautical Institute.*

9 *From in-house data.*

10 *Based on typical range for 30,000 DWT bulk carriers from in-house Lloyd dataset, verified against typical values from PIANC tables data (50% CL).*

11 *Based on empirical relationship of 1.25 Displacement/DWT ratio from in-house Lloyds dataset, verified against typical PIANC tables data (50% CL).*

2.8 Berthing Equipment

The berthing equipment (including fenders, panels, support and reaction chains) will be sized to match the capacity requirements and reaction limits of the currently installed fender units.

2.8.1 Vessel Berthing Conditions

<u>Loaded Condition at Berthing</u>

The design vessels will be considered to be partially loaded (up to 43,000 tonne displacement) while berthing at the terminal.

<u>Tug Assistance Considerations</u>

Tug assistance is assumed for all berthings. Approach and berthing manoeuvres are assumed to occur with the assistance of adequate number and power of tugs.

<u>Environmental Conditions at Berthing</u>

Berthing is assumed to occur under good conditions at the berth in accordance with by BS6349 definitions.

Berthing manoeuvres are assumed to occur under minimal exposure to wind, currents, and/or waves. Refer to Section 1.3.2 for additional considerations.

The berthing conditions are characterised as good-sheltered in accordance with BS6349.

Berthing Velocity

The berthing velocities assumed for the calculation of *Normal* or *Characteristic* Berthing Energy are presented in the following table.

Table 2-3 Normal Berthing Velocity

Design Vessel	**Normal or Characteristic Berthing Velocity [m/s]**	**Approach Angle [degrees]**
Largest Grain Bulker	0.10 m/s	6º
Smallest Grain Bulker	0.10 m/s	10º

All berthing velocities are considered normal to the berthface. Approach angles selected in accordance with PIANC 2002 or BS6349 recommendations.

Abnormal Energy Factors

The Abnormal or Design Berthing Energy for each design vessel will be obtained by multiplying the Normal or Characteristic Berthing Energy by the following factors in accordance with PIANC 2002 or BS6349.

Table 2-4 Abnormal Energy Factor

Design Vessel	**Abnormal Energy Factor**
Largest Grain Bulker	1.25
Smallest Grain Bulker	1.75

2.8.2 Fender Equipment Selection Criteria

The fender selection will be based on the calculated Abnormal or Design Berthing Energy, and considering the fender performance reduction factors listed below.

Temperature Effects on Fender Performance

Temperature effects on the fender Rated Energy Absorption capacity will be considered in fender selection.

The minimum design temperature under berthing conditions is -7°C.

The maximum design temperature under berthing conditions is 28°C.

Angular Berthing Effects on Fender Performance

Angular compression effects on the fender Rated Energy Absorption capacity will be considered in fender selection. Fender geometry under angular compression will be estimated based the estimated design vessel bow radius and the assumed point of contact along the length of the vessel.

Manufacturing Tolerances

A manufacturing tolerance of no less than 10% will be applied to the Rated Energy Absorption capacity of the fenders.

2.8.3 Hull Pressures

Hull pressures will be estimated based on the size of the fender panel and the nominal Rated Reaction of the fender, unless a reduction to the Rated Reaction can be justified by analysis. Calculated hull pressures will also consider the effect of wind on the moored vessel under the wind conditions specified herein.

The calculated hull pressures shall not exceed 200 Pa, which is the Allowable Hull Pressures for the design vessels in accordance with PIANC 2002.

The new panel dimensions will match the panels currently installed at the terminal. The terminal will monitor the fender contact in the unusual event that vessels with small freeboard are expected to be alongside the pier at extreme low tide.

2.9 Mooring Equipment

2.9.1 Mooring Conditions

The mooring analysis will determine the following conditions for the terminal, as they apply to the design of the mooring systems and the marine structures.

- **Normal Operational:** Refers to the upper limit of the typical operating conditions for the terminal. Typically, when these forecast conditions are exceeded, the ship is ordered to leave the berth. These conditions are usually more severe than the conditions at which loading/unloading of material ceases. Service Loads and associated load combinations are typically considered at this design level.
- **Extreme Operational:** Refers to the extreme conditions at which the ship may occasionally be moored at the berth, beyond the Normal Operational conditions. Ultimate Design Loads and associated load combinations are typically considered at this design level.

- **Accidental or Survival:** Refers to an unforeseen condition, at which a nominal maximum mooring load is generally considered for the design of the mooring equipment and/or the mooring structure. This nominal maximum mooring load is taken as a factor of the mooring equipment rated capacity (SWL). This condition is applicable to the design of these marine facilities.

2.9.2 Wind Loads on Moored Vessel

Wind loads on the moored vessel will be estimated in accordance to OCIMF MEG3.

- Wind loads for the Normal and Extreme Operating condition will be analysed considering the limits of the existing mooring system (based on 30-sec gust wind speeds) and compared to the expected wind regime at the site to derive meaningful downtime and vacant-berth statistics.

2.9.3 Current Loads on Moored Vessel

Current loads on the moored vessel will be estimated in accordance to OCIMF MEG3.

- Current loads for the Normal and Extreme Operating condition will be analysed considering the limits of the existing mooring system and compared to the expected current regime at the site (recent measurement campaign by TetraTech) to derive meaningful downtime and vacant-berth statistics.

2.9.4 Wave Loads on Moored Vessel

Wave loads acting on the moored vessel are considered negligible due to the sheltered location of the site.

2.9.5 Passing Vessel Considerations

Passing vessel effects are not considered critical to the design of the mooring system due to the berth location in relation to the harbour channel location, vessel transit, and available water depth.

2.9.6 Minimum Mooring Equipment Requirements

Since the existing mooring dolphins and pier are already equipped with bollards, the new mooring structures will also be equipped with bollards to match operational practices at the terminal. Mooring equipment capacity selection will be based on the three conditions stated below.

Individual Point Capacity

The Safe Working Load (SWL) of the bollard should be at least equal to the Minimum Breaking Load (MBL) of the largest line expected to be carried by the design vessels.

Number of Mooring Points/Hooks

The number of lines that can be carried by a single tee bollard is 2-3 in accordance with the manufacturer's recommendations.

Location of Mooring Points/Hooks

The number and location of mooring points will take into consideration that horizontal and vertical angles should remain within the recommended limits by BS6349 and OCIMF MEG 3 for all design vessels in their most common positions.

The number and capacity of mooring points will be verified against the following tension loads and ship motion limits recommended by OCIMF MEG 3 and PIANC N°24, respectively.

Table 2-5 Mooring System Design Limits

Design Vessel	**Maximum Allowable Mooring Line Tension**	**Maximum Allowable Ship Motions**
Largest Grain Bulker	Normal Operational: 40% MBL Extreme Operational: 55% MBL	Surge: + 5.0 m Sway: +/- 2.5 m

2.10 Other Marine Items

2.10.1 Emergency Ladders

Emergency access ladders to the waterline will be provided at new marine structures. Ladder rungs will extend 1 m below the Mean Lowest Low Water elevation.

Ladder details will be in accordance with BS6349 – Part 2.

2.10.2 Bullrails and Handrails

Handrails will be provided along the perimeter of all marine structures where personnel access is anticipated, including maintenance areas. Handrail details will be in accordance with National Building Code regulations, complemented by the recommendations set forth in BS6349 – Part 2.

Since vehicular access is not provided to the new dolphin structures, bullrails are not deemed required. The seaward edge of the mooring and breasting dolphins will be provided with steel nosing to minimize wear of mooring lines against the structure edge.

2.10.3 Life-Saving Equipment

Life-saving equipment should be installed on all marine structures where personnel access is permitted. Life-saving equipment requirements will be provided in accordance with BS6349 – Part 2.

2.10.4 Access to Ship (to be defined)

The marine structures will be accessible from the ship via:

- Ship’s gangway when the vessel is moored alongside the dock; and
- When the ship’s gangway cannot be used, access to/from the ship will be from a man lift.

2.10.5 Navigational Aids

The following navigational aids will be provided at the terminal:

- Perimeter lights on the marine structures.

2.11 Loads and Load Combinations

2.11.1 Berthing Loads on Structures

Berthing loads on structures will be taken as the Rated Fender Reaction published by the fender manufacturer. The berthing load factor will consider the nature of the fender load-deflection curve for the appropriate load combination (Service Loads, Fatigue, Ultimate Limit States), and is assumed to include the manufacturer's fabrication tolerance on the fender rated reaction.

The berthing load of 780 kN will be applied normal to the fender support face, and will include the effects of friction between the ship hull and the fender panel in accordance with BS6349 and/or PIANC 2002.

2.11.2 Mooring Loads on Structures

Mooring loads on structures will be estimated for the Normal Operating, the Extreme Operating and the Accidental conditions. Maximum mooring loads corresponding to the Accidental Conditions will be equal to the SWL of the bollards (100 tonnes), with a minimum load factor of 2.0.

The mooring load will be applied in the expected working range of the mooring equipment shown on the Drawings, with an additional 10-degree variance in plan to account for irregular fairlead locations.

2.11.3 Other Live Loads

Operational Areas on Marine Structures

Live loads on access walkways and elevated platforms not accessible to vehicles, including mooring and breasting dolphins, catwalks, will be taken as 3.0 kPa.

2.11.4 Earthquake Load and Effects

Earthquake effects, structural performance criteria, and detailing requirements will be in accordance with CAN/CSA S6, with applicable recommendations adopted from ASCE 61.

- Structure: "Other Bridges".
- Seismic Performance Category: To be determined based on spectral values.

For structures located in Canada, the Design Earthquake (DE) will correspond to 2% probability of occurrence in 50-years (2,475-year return period) in accordance with CAN/CSA S6 and as determined by the Geological Survey of Canada (refer to Section 2.5.6 for details).

2.11.5 Load Combination Tables

The following basic load combinations will be considered in the preliminary design of new mooring and breasting structures.

Table 2-6 Load Combinations for the Design of New Structures

Load Combination	Dead*	Live	Berthing	Mooring	EQ
ULS1A	αd	1.7			
ULS2A	αd max	1.6	1.25		
ULS2B	αd min		1.25		
ULS3A	αd max	1.6		2.0	
ULS3B	αd min			2.0	
ULS4A	αd max	0.5	1.25	2.0	
ULS4B	αd min		1.25	2.0	
ULS5A	αd max				1.0
ULS5B	αd min				1.0

*αd in accordance with CAN/CSA S6

2.12 Deflections

Deflection criteria for marine structures will be adopted during the detailed design phase.

2.13 Materials

2.13.1 Steel

Structural and miscellaneous steel materials will conform to API or ASTM/CSA equivalent standards.

2.13.2 Concrete

Concrete in marine structures will have a minimum specified compressive strength (28 days) of 35 MPa.

2.13.3 Corrosion Prevention

Corrosion damage will be minimized by providing protective measures, as defined in this section, on all new marine structures.

For practical purposes the corrosion regions are divided into Atmospheric, Heavy, Moderate and Mild corrosion zones.

- Atmospheric corrosion zone is located above the splash zone.
- Heavy corrosion zone includes splash, tidal, and low water zones.
- Moderate corrosion zone consists of the immersion zone.
- Mild corrosion zone is the buried part of the pile below the seabed.

Corrosion Allowance for Steel Members

Where structural steel is not easily accessible for maintenance coating and coating repairs (including all steel below deck and immersed steel), thickness of structural steel members will consider a corrosion allowance based on the mean corrosion rate presented in Table 25 of BS3649 – Part 1, the corrosion zone, and the Design Life of the structure defined in Section 1.3.1.

Steel Coating and Galvanizing of Steel Members

Unless hot-dip galvanizing is provided, all structural and miscellaneous steel will be provided with protective coating to suit its corrosion zone.

Cathodic Protection of Steel Members

Cathodic protection in the form of galvanic sacrificial anodes will be provided for the steel piles.

Concrete Cover

A minimum reinforcement concrete cover of 70 mm will be provided in Heavy and Moderate corrosion zones.

2.13.4 Marine Growth

Marine growth allowances will be considered in accordance with BS6349 – Part 1 for elements below MLLW. A relative density of 1.5 will be adopted for the calculation of the marine growth thickness. The impact of marine growth will be considered, including its effects on additional weight on structures, increase of current drag loads, and seismic added mass calculations.

2.14 Geotechnical Criteria

Based on the available historical test hole data, it is inferred that the soil stratigraphy at the location of the ship berth structure comprise loose to dense silty sand to sand which is underlain by very dense till and bedrock.

Vertical and batter piles will be driven to refusal into the dense till and bedrock in order to achieve the required compression and tension capacities.

SEPTEMBER 2016
FIBRECO EXPORT INC.

FIBRECO ENHANCEMENT PROJECT

PRELIMINARY STRUCTURAL AND GEOTECHNICAL CAPACITY ASSESSMENT

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SEPTEMBER 2016
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FIBRECO ENHANCEMENT PROJECT

PRELIMINARY STRUCTURAL AND GEOTECHNICAL CAPACITY ASSESSMENT

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APPROVED	SRFH

CONTENTS

1 Executive Summary

Proposed modifications to the loading equipment at the Fibreco dock include the replacement of the existing shiploader and changes to the elevated feed conveyor and tripper.

A preliminary assessment of the proposed modifications was undertaken to confirm if the loads imposed on the support structure by the new equipment are comparable to those of the original equipment. This load comparison aims to determine whether the structure will be "no worse" than it is today once the proposed equipment is installed.

Where load effects were found to be higher with the new equipment, the member structural capacity was checked to see if sufficient reserve capacity existed to resist the new load.

The capacity assessment assumed that the structures are in good condition and did not warrant a reduction in capacity from the original design condition. It assumed that maintenance repairs are implemented swiftly when deficiencies are identified and members restored to original strength.

The results of the preliminary analysis, which is based on estimated weights of the new equipment, are:

- The proposed shiploader is comparable in weight and geometry to the original shiploader and the marginal increase in weight and outbound material loads can be resisted by the original structure without modifications; and
- Loads imposed by the proposed upgraded elevated conveyor and tripper can also be resisted by the original structure without modifications.

2 Introduction

Fibreco Export Inc. is planning to upgrade its shiploading terminal in North Vancouver to handle grain products. As part of this upgrade a new shiploader and modified conveyor system are envisaged.

This report describes the work and summarizes the findings of the preliminary structural and geotechnical capacity assessment carried out for the following marine structures also shown in Figure 2-1:

- Dock (includes breasting structures); and
- Mooring Dolphins.

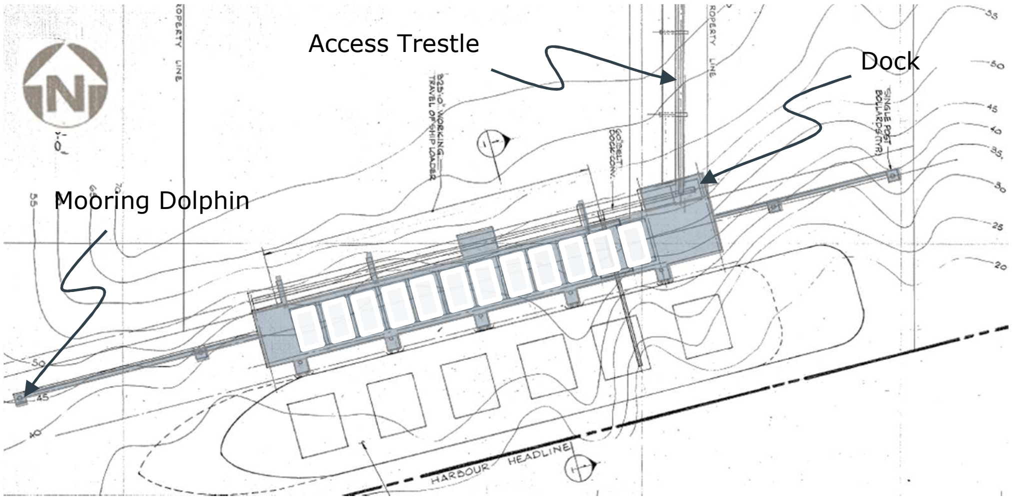


Figure 2-1: Plan of Existing Marine Structures

This capacity assessment reports on the load effects of the proposed bulk handling equipment modifications on the dock, including the replacement of the existing shiploader and modifications to the elevated dock conveyor and tripper.

Proposed modifications to the access trestle and the mooring dolphin structures are minor and considered negligible at this stage, and as such, these structures are not included in this capacity assessment.

Structural capacity of members were estimated based on the original design. The assessment assumes that the structures are in good condition and that maintenance repairs are carried out as they are identified during regularly scheduled condition assessments.

3 Description of Dock Structures

The Fibreco dock supports a travelling shiploader, a transfer tower, a maintenance tower, and an elevated conveyor and tripper. Its main features, shown in the figures below, are:

- The shiploader rails are installed on precast, prestressed & post-tensioned concrete girders (rail girders);
- The rail girders rest on cast-in-place concrete pilecaps supported by precast, prestressed octagonal concrete piles;
- The front and back rail girders are connected transversely by precast, prestressed concrete pile sections installed horizontally (tie-beams);
- Piled extensions on the landside of the dock support steel bents for the elevated feed conveyor (CVYR2) and tripper;
- Breasting structures, where fenders are installed, are built into the dock structure at regular spacing along the berthface;
- The outbound conveyor transfer tower is located on the east end of the dock, next to the shiploader maintenance tower;
- The maintenance tower is currently used to support the shiploader spout and boom in its parked position.

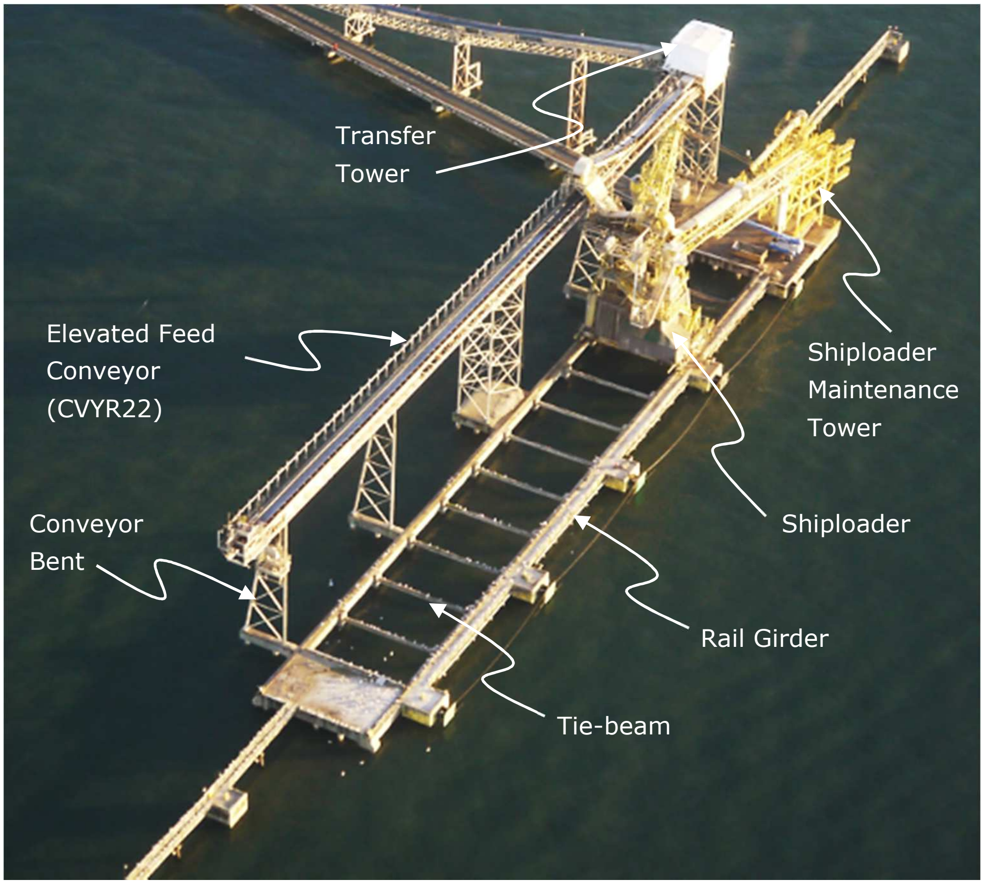


Figure 3-1: Existing Fibreco Dock (Photograph by COWI)

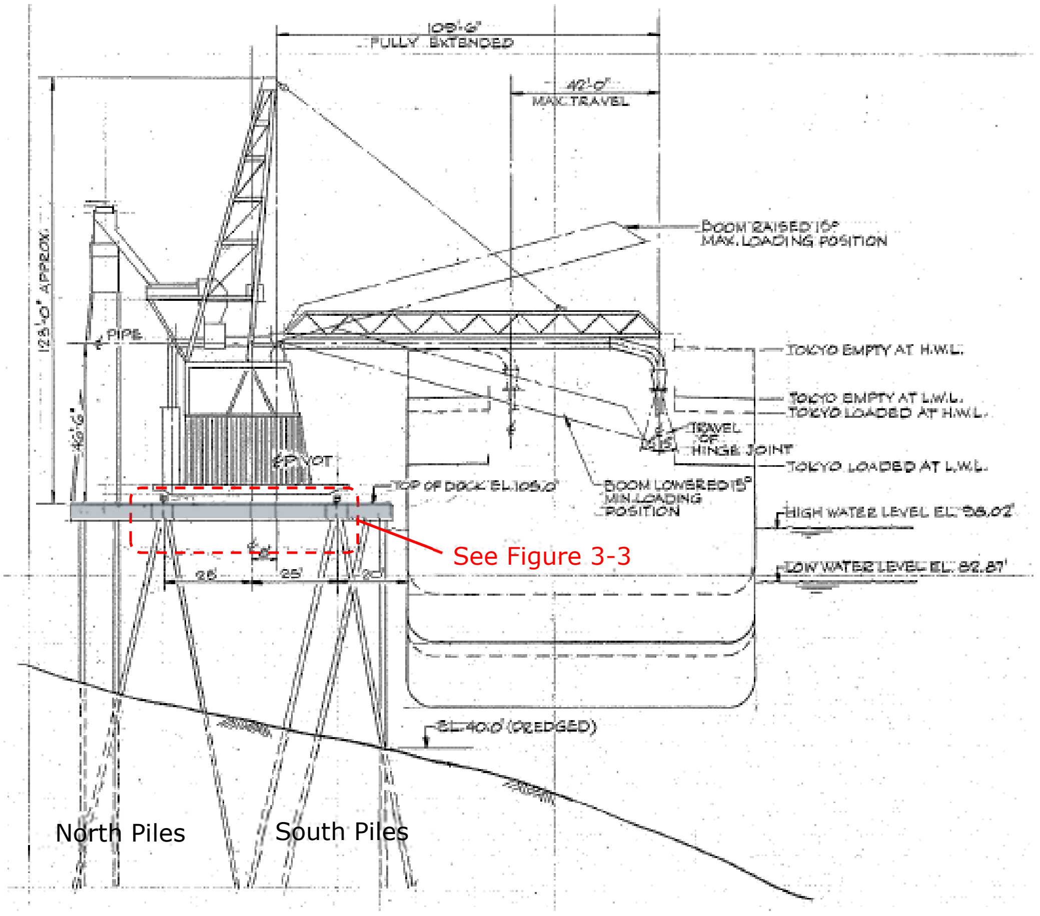


Figure 3-2: Section of Existing Dock (Wood Chip Carrier Shown Alongside)

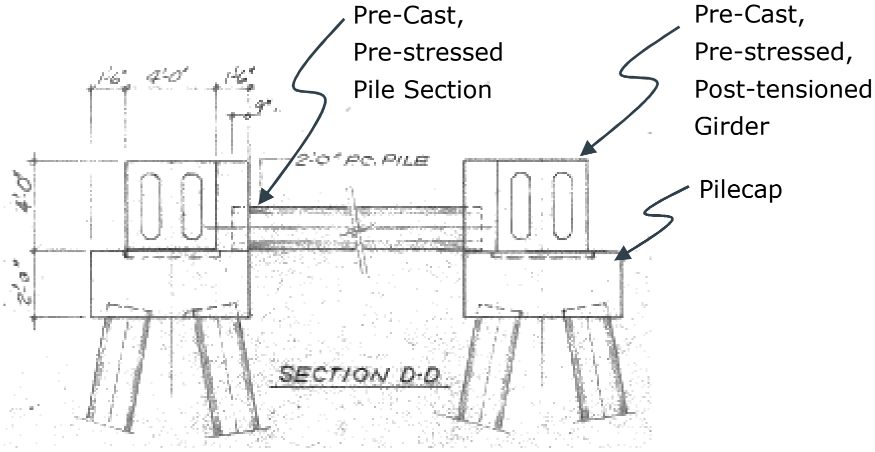


Figure 3-3: Typical Cross-Section of Dock Superstructure (Con-force DWG 9315-1)

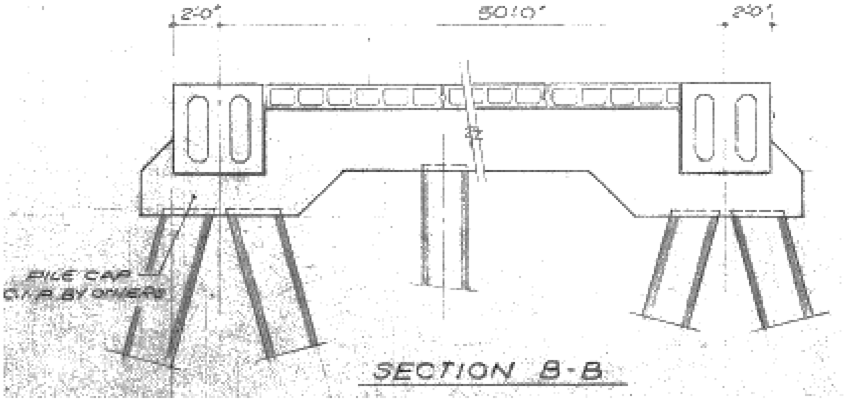


Figure 3-4: *Cross-Section of Dock Superstructure – West End (Con-force DWG 9315-1)*

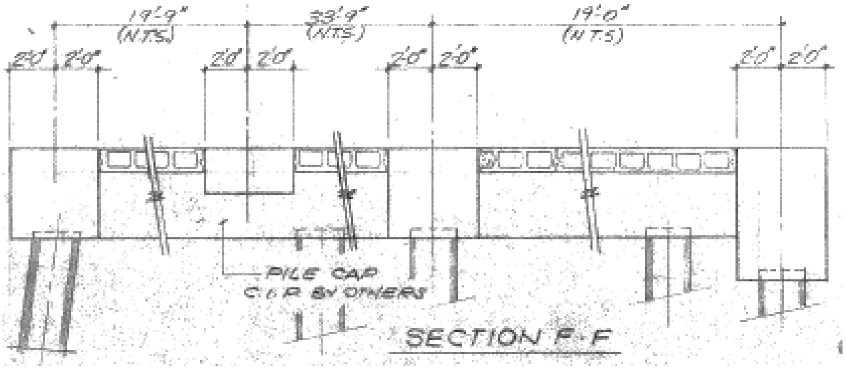


Figure 3-5: *Cross-Section of Dock Superstructure – East End (Con-force DWG 9315-1)*

Based on the available historical test hole data, it is inferred that the soil stratigraphy at the location of the berth structure comprises loose to dense silty sand to sand, which is underlain by very dense till and bedrock. Recent onshore geotechnical investigation completed by GeoPacific Consultants Ltd. in 2015, reported similar soil stratigraphy at similar elevations. Vertical and batter octagonal concrete piles were driven to refusal to tip elevations that varied between -15 m and -30 m (Chart Datum), providing embedment lengths between 6 m and 18 m. Piles were likely driven to a set criteria (reported at approximately 80 blows per foot) within the compact to dense sand deposit.

4 Structural and Geotechnical Capacity Considerations

This preliminary capacity assessment focused on the dock structural members that are directly affected by potential changes in vertical loading due to the proposed equipment modifications, namely the rail girders, supporting pilecaps and foundation piles. Deck diaphragm elements such as deck slabs and tie-beams are not expected to observe significant changes in imposed vertical or lateral loads as a result of the proposed equipment modifications, and therefore a detailed capacity check of these elements has not been included.

Structural and geotechnical pile capacities were estimated based on Con-force pile fabrication records and Fraser River Pile and Dredge (FRPD) pile driving records, which provided insight into the unbraced length and pile slenderness considerations at different locations. The following figures show the pile reinforcement arrangement and average estimated unbraced lengths used in the pile capacity estimates.

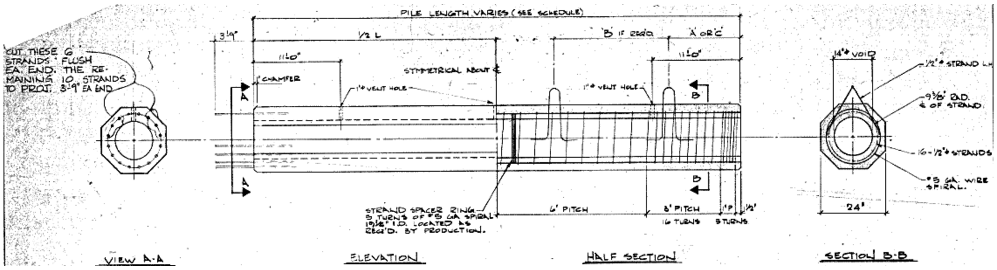
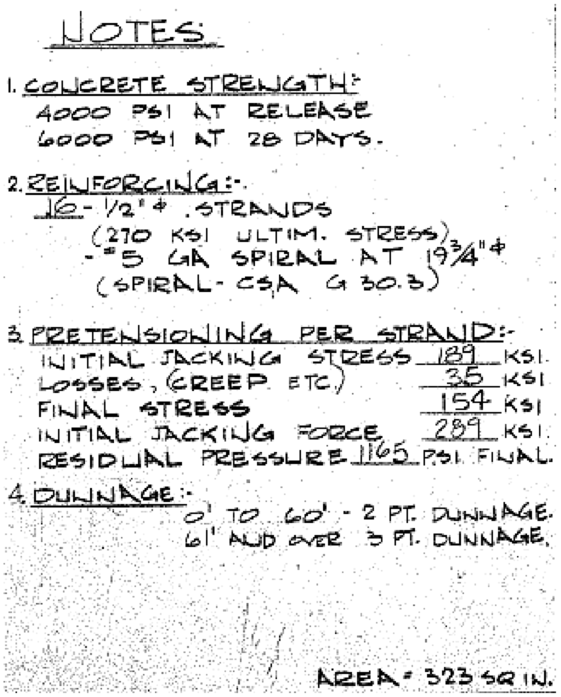


Figure 4-1: Pile Fabrication Diagram (Con-force DWG 0876-1)



NOTES

1. CONCRETE STRENGTH:
4000 PSI AT RELEASE
6000 PSI AT 28 DAYS.

2. REINFORCING:-
16 - 1/2" ϕ . STRANDS
(270 KSI ULTIM. STRESS)
- #5 GA SPIRAL AT 1 3/4" ϕ
(SPIRAL - CSA G 30.3)

3. PRETENSIONING PER STRAND:-
INITIAL JACKING STRESS 189 KSI.
LOSSES, (CREEP ETC.) 35 KSI
FINAL STRESS 154 KSI
INITIAL JACKING FORCE 289 KSI.
RESIDUAL PRESSURE 1165 PSI. FINAL.

4. DUNNAGE:-
0' TO 60' - 2 PT. DUNNAGE.
61' AND OVER 3 PT. DUNNAGE.

AREA = 323 SQ IN.

Figure 4-2: Pile Fabrication Notes (Con-force DWG 0876-1)

Table 4-1: Summary of Pile Unbraced Lengths

Dock Area	Average Unbraced Length
South (seaward)	23.2 m (76 ft.)
North	21.3 m (70 ft.)

Geotechnical pile compression and tension resistances were estimated based on available geotechnical stratigraphy, installation records (blow counts and pile driving formulas), results of completed uplift pile load tests on 4 test piles, empirical correlations as recommended in CAN/CSA S6-2014 and comparison with pile resistance plots provided in recent GeoPacific report. Ultimate axial resistances were estimated to be 3,000 kN (674 Kips) for compression and 1,000 kN (225 Kips) for tension. For static loads, recommended resistance factors of 0.4 and 0.3 were used for compression and tension, respectively.

Prestressed, post-tensioned rail girders capacity estimates consider strand/tendon data as noted in the record drawings, with calculated stress losses due to transfer, shrinkage, elastic shortening, etc., in accordance to

CAN/CSA S6. The following figures show the existing girder cross-section and strand/tendon arrangements.

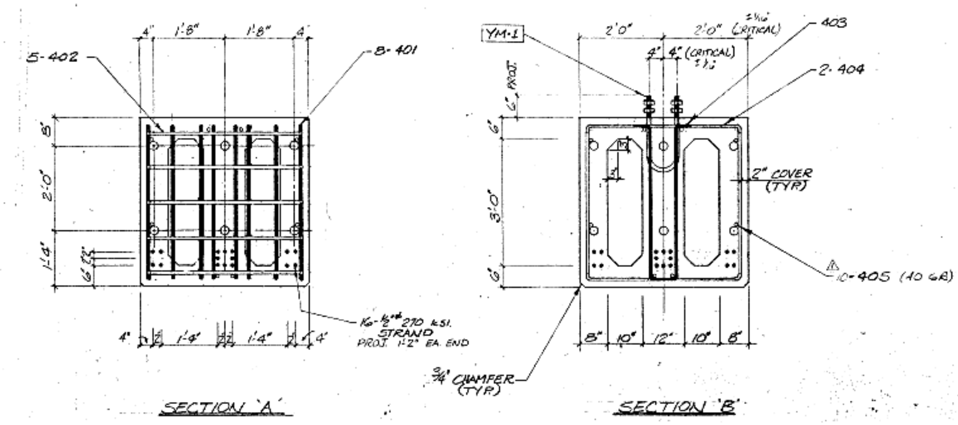
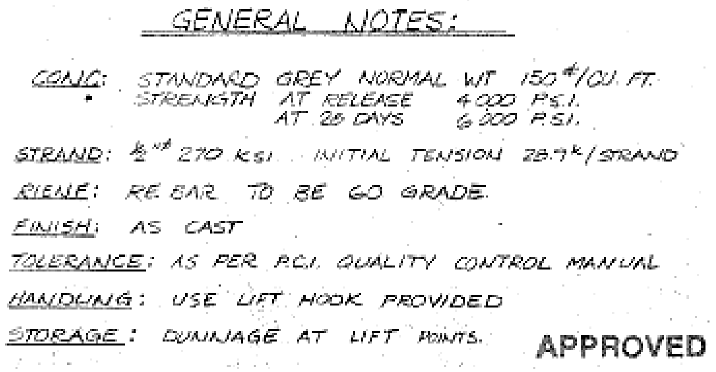


Figure 4-3: Rail Girder Rebar, Pre-Stressing Arrangement (Con-force DWG 0877-1)



GENERAL NOTES:

CONC: STANDARD GREY NORMAL WT 150#/CU. FT.
STRENGTH AT RELEASE 4000 P.S.I.
AT 28 DAYS 6000 P.S.I.

STRAND: ½"ø 270 KSI INITIAL TENSION 28.9k/STRAND

REINF: RE BAR TO BE 60 GRADE.

FINISH: AS CAST

TOLERANCE: AS PER P.C.I. QUALITY CONTROL MANUAL

HANDLING: USE LIFT HOOK PROVIDED

STORAGE: DUNNAGE AT LIFT POINTS.

APPROVED

Figure 4-4 Rail Girder Pre-Stressing Notes (Con-force DWG 0877-1)

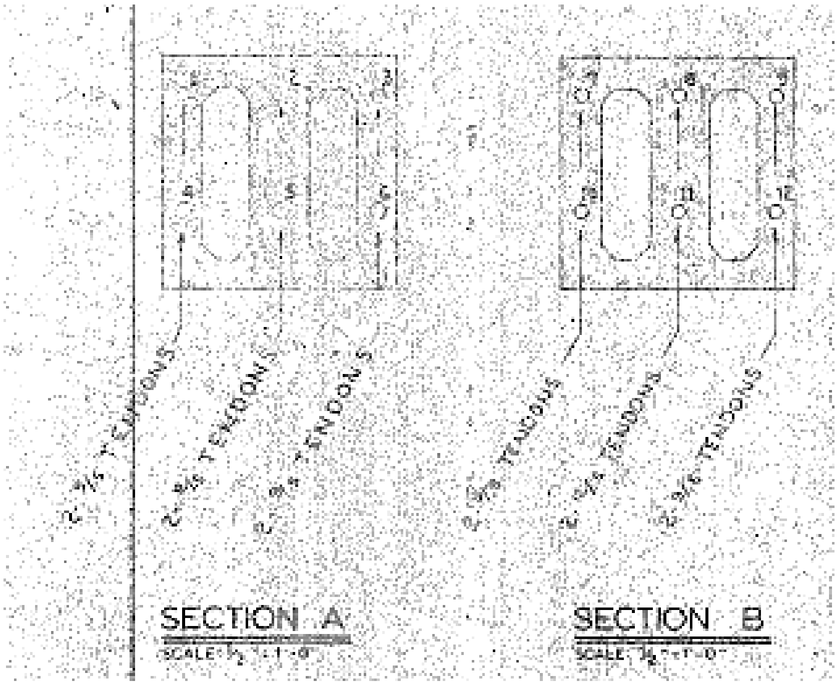
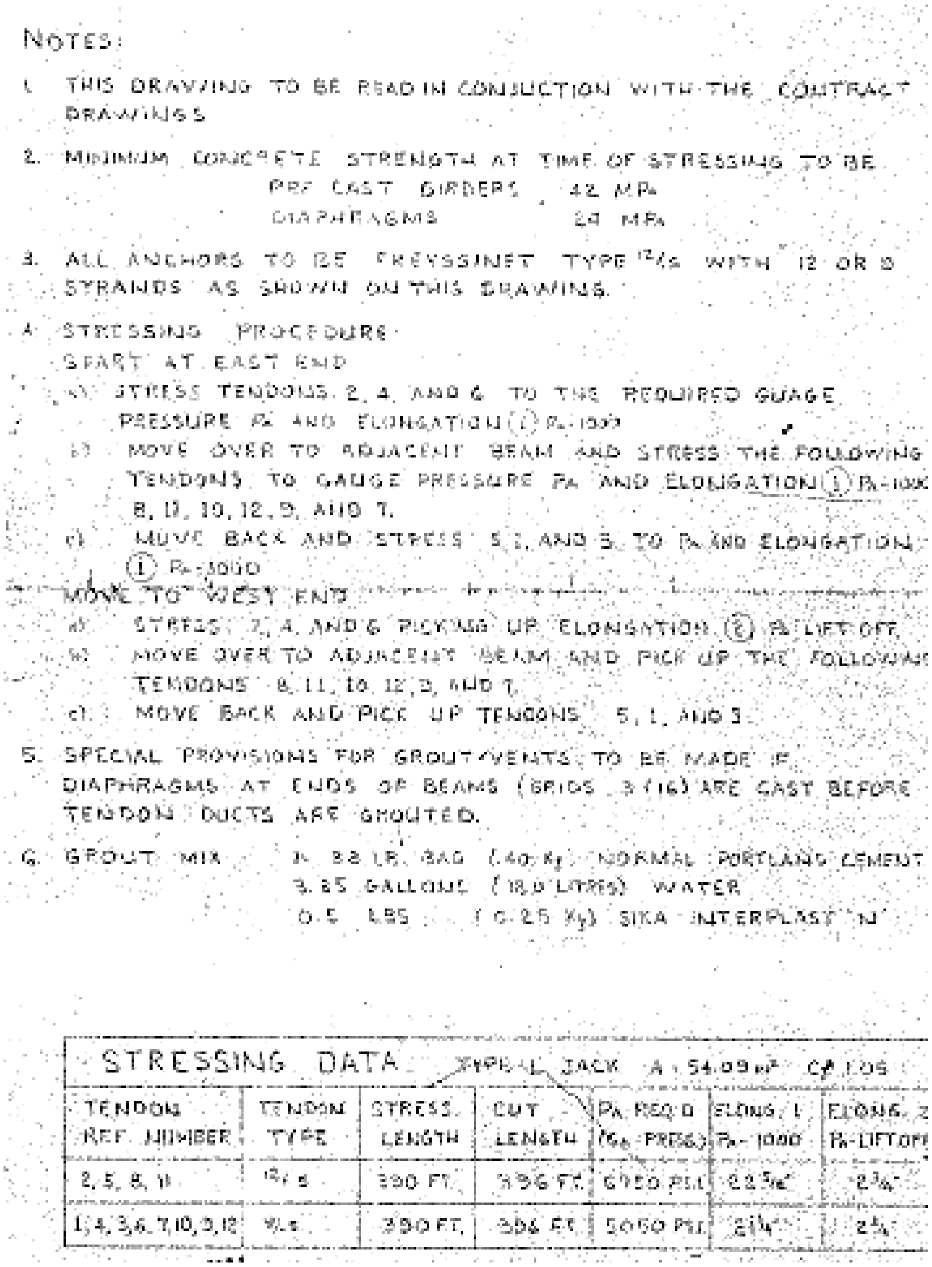


Figure 4-5: Rail Girder Post-Tensioning Arrangement (Con-force DWG 2176-1)



NOTES:

1. THIS DRAWING TO BE READ IN CONJUCTION WITH THE CONTRACT DRAWINGS

2. MINIMUM CONCRETE STRENGTH AT TIME OF STRESSING TO BE
PRE CAST GIRDERS 42 MPa
DIAPHRAGMS 24 MPa

3. ALL ANCHORS TO BE FREYSSINET TYPE 12/15 WITH 12 OR 9 STRANDS AS SHOWN ON THIS DRAWING.

4. STRESSING PROCEDURE
START AT EAST END
a) STRESS TENDONS 2, 4, AND 6 TO THE REQUIRED GUAGE PRESSURE Pa AND ELONGATION ① Pa-1000
b) MOVE OVER TO ADJACENT BEAM AND STRESS THE FOLLOWING TENDONS TO GAUGE PRESSURE Pa AND ELONGATION ① Pa-1000 8, 11, 10, 12, 9, AND 7.
c) MOVE BACK AND STRESS 5, 1, AND 3 TO Pa AND ELONGATION ① Pa-1000
MOVE TO WEST END
a) STRESS 2, 4, AND 6 PICKING UP ELONGATION ② Pa LIFT OFF.
b) MOVE OVER TO ADJACENT BEAM AND PICK UP THE FOLLOWING TENDONS 8, 11, 10, 12, 9, AND 7.
c) MOVE BACK AND PICK UP TENDONS 5, 1, AND 3.

5. SPECIAL PROVISIONS FOR GROUT VENTS TO BE MADE IF DIAPHRAGMS AT ENDS OF BEAMS (GRIDS 3 (16) ARE CAST BEFORE TENDON DUCTS ARE GROUTED.

6. GROUT MIX
1 - 88 LB. BAG (40 Kg) NORMAL PORTLAND CEMENT
3.85 GALLONS (18.0 LITRES) WATER
0.5 LBS (0.25 Kg) SIKA INTERPLAST 'N'

STRESSING DATA TYPE L JACK A = 54.09 in² Cf 1.05

TENDON REF. NUMBER	TENDON TYPE	STRESS. LENGTH	CUT LENGTH	Pa REQ'D (GAUGE PRESS.)	ELONG. 1 Pa-1000	ELONG. 2 Pa-LIFTOFF
2, 5, 8, 11	12/15	390 FT.	396 FT.	6950 PSI	22 5/16"	2 3/4"
1, 4, 3, 6, 7, 10, 9, 12	9/15	390 FT.	396 FT.	5050 PSI	21 1/4"	2 1/4"

Figure 4-6: Rail Girder Post-Tensioning Arrangement (Con-force DWG 2176-1)

5 Loads and Load Combinations

The main loads and load combinations considered in the capacity assessment are summarized in Figure 5-2 through Figure 5-8 and consist of:

- Dock Self-Weight (includes catwalks, rail loads, etc.);
- Original shiploader wheel loads, including original wheel arrangement;
- New shiploader loads, including new wheel arrangement (by Brucks);
- Original elevated feed conveyor CVYR2 bent loads (by CWA);
- Revised elevated feed conveyor CVYR2 bent loads (by CWA);
- Transfer tower loads (from record drawings); and
- Maintenance tower loads (from record drawings).

Lateral loads from fender units and mooring bollards remain unchanged from the original design, but are still considered in the assessment for the operational load combinations that include accompanying shiploader wheel loads on piles and rail girders.

5.1 Dock Self-Weight

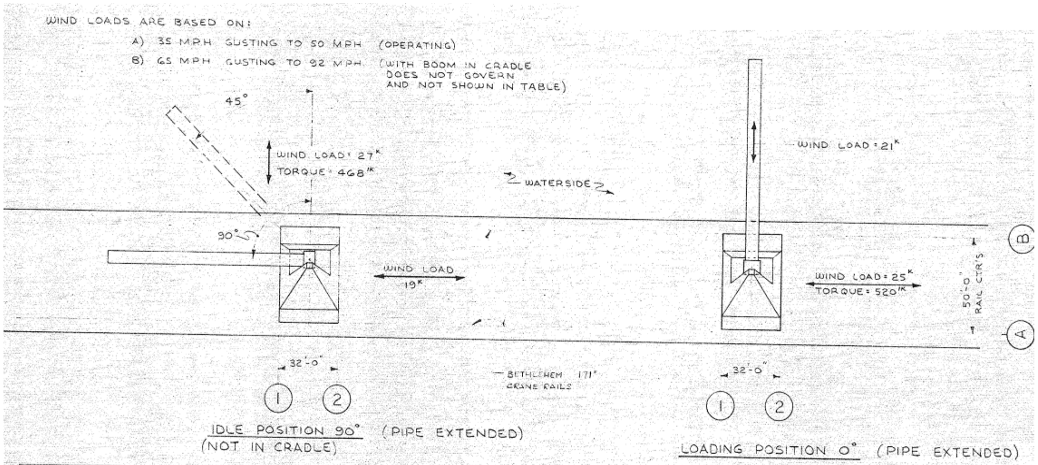
The dock self-weight was captured by introducing the actual member properties in a global computer model (CSiBride by CSI Inc.) as shown in Figure 5-1.

Figure 5-1: Dock Computer Model Isometric View (Left side - CSiBridge by CSI Inc.)

This model was also used to evaluate the effect of other superimposed loads such as shiploader, conveyor bents, towers, etc.

5.2 Shiploader Loads

The following figures show the original and the proposed shiploader wheel loads for several load cases.



WIND LOADS ARE BASED ON:

A) 35 MPH GUSTING TO 50 MPH (OPERATING)
B) 65 MPH GUSTING TO 92 MPH (WITH BOOM IN CRADLE DOES NOT GOVERN AND NOT SHOWN IN TABLE)

IDLE POSITION 90° (PIPE EXTENDED)
(NOT IN CRADLE)

BOGIE LOCATION	DEAD LOAD	100#/LIN. FT. ON BOOM CATWALK.	SNOW	WIND // RAILS	MAX. LOAD COMBINATION	
B1	179^K	14^K	40^K	$\pm 12^K$	219^K	D.L.+S.
B2	47^K	-6^K	15^K	$\pm 12^K$	62^K	D.L.+S.
A1	197^K	12^K	40^K	$\pm 12^K$	237^K	D.L.+S.
A2	66^K	-8^K	15^K	$\pm 12^K$	81^K	D.L.+S.
TOTAL VERTICAL	489^K	11^K	110^K	—	—	—

LOADING POSITION 0° (PIPE EXTENDED)

BOGIE LOCATION	DEAD LOAD	LIVE LOAD 1)	SNOW	WIND // RAILS	MAX. LOAD COMBINATION	
B1	155^K	26^K	36^K	$\pm 17^K$	198^K	D.L.+L.L. + W.
B2	159^K	26^K	36^K	$\pm 17^K$	202^K	D.L.+L.L. + W.
A1	90^K	-7^K	20^K	$\pm 17^K$	110^K	D.L.+S.
A2	85^K	-7^K	20^K	$\pm 17^K$	115^K	D.L.+S.
TOTAL VERTICAL	489^K	38^K	112^K	—	—	—

BOOM AT 45°			
		PIPE EXTENDED	PIPE RETRACTED
B1	D.L.	188^K	171^K
	S.	42^K	42^K
TOTAL		230^K	213^K

1) LIVE LOAD INCLUDES PLUGGED PIPE AND 100#/LIN. FT. ON BOOM CATWALK.

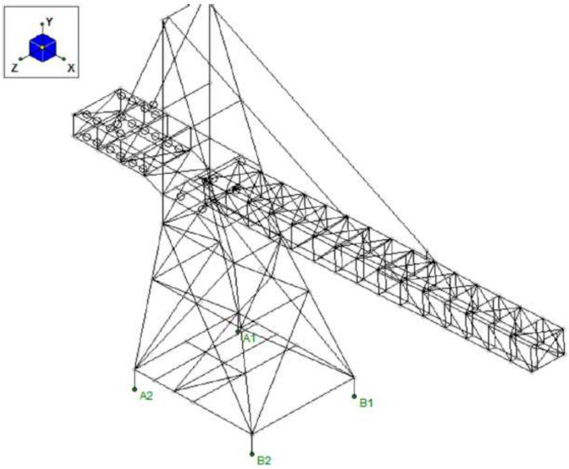
NOTES

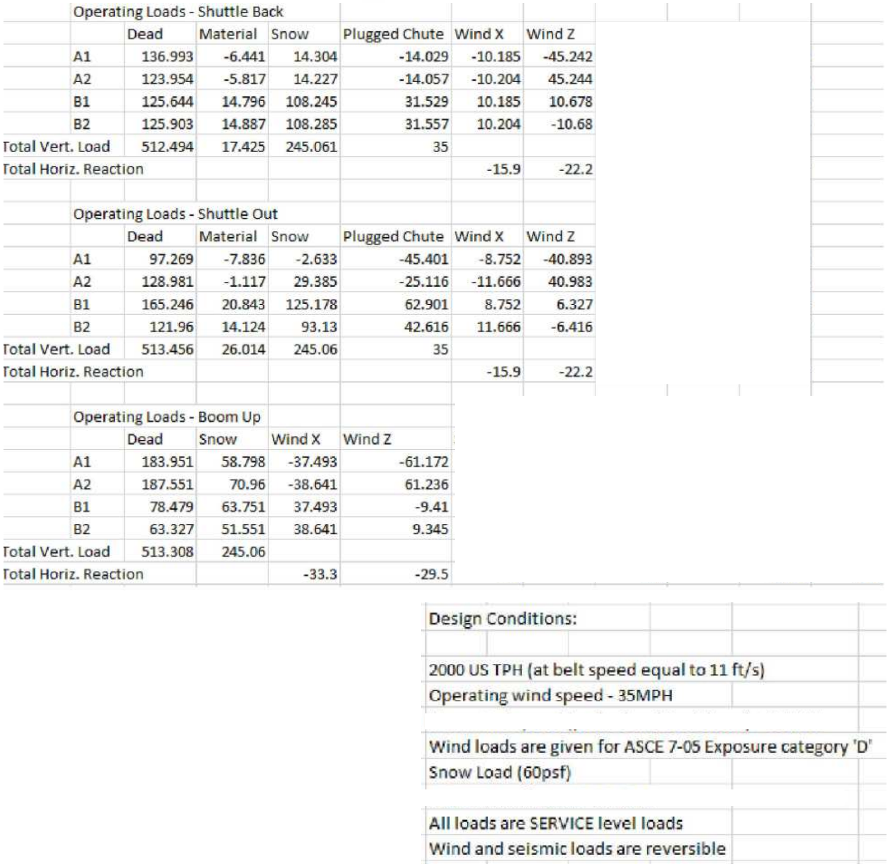
1. IMPACT IS NOT INCLUDED.
2. IF BOOM IS IN CRADLE, LOADS ARE LESS THAN SHOWN ON THIS DWG.
3. MAXIMUM LOADS ARE UNDERLINED.
4. NO ALLOWANCE MADE FOR CABLE REEL

WIND LOADS ARE BASED ON:

A) 35 MPH GUSTING TO 50 MPH (OPERATING)
B) 65 MPH GUSTING TO 92 MPH (WITH BOOM IN CRADLE DOES NOT GOVERN AND NOT SHOWN IN TABLE)

Figure 5-2: Original Shiploader Loads - Reactions in Kips (Rader Canada LTD, DWG C-411-630)





	Operating Loads - Shuttle Back					
	Dead	Material	Snow	Plugged Chute	Wind X	Wind Z
A1	136.993	-6.441	14.304	-14.029	-10.185	-45.242
A2	123.954	-5.817	14.227	-14.057	-10.204	45.244
B1	125.644	14.796	108.245	31.529	10.185	10.678
B2	125.903	14.887	108.285	31.557	10.204	-10.68
Total Vert. Load	512.494	17.425	245.061	35		
Total Horiz. Reaction					-15.9	-22.2

	Operating Loads - Shuttle Out					
	Dead	Material	Snow	Plugged Chute	Wind X	Wind Z
A1	97.269	-7.836	-2.633	-45.401	-8.752	-40.893
A2	128.981	-1.117	29.385	-25.116	-11.666	40.983
B1	165.246	20.843	125.178	62.901	8.752	6.327
B2	121.96	14.124	93.13	42.616	11.666	-6.416
Total Vert. Load	513.456	26.014	245.06	35		
Total Horiz. Reaction					-15.9	-22.2

	Operating Loads - Boom Up			
	Dead	Snow	Wind X	Wind Z
A1	183.951	58.798	-37.493	-61.172
A2	187.551	70.96	-38.641	61.236
B1	78.479	63.751	37.493	-9.41
B2	63.327	51.551	38.641	9.345
Total Vert. Load	513.308	245.06		
Total Horiz. Reaction			-33.3	-29.5

Design Conditions:

2000 US TPH (at belt speed equal to 11 ft/s)
Operating wind speed - 35MPH

Wind loads are given for ASCE 7-05 Exposure category 'D'
Snow Load (60psf)

All loads are SERVICE level loads
Wind and seismic loads are reversible

Figure 5-3: New Shiploader Preliminary Loads - Reactions in Kips (Brucks P5 Rev B)

The bogie/wheel arrangement for the original and proposed shiploader are shown in Figure 5-4 and Figure 5-5, respectively.

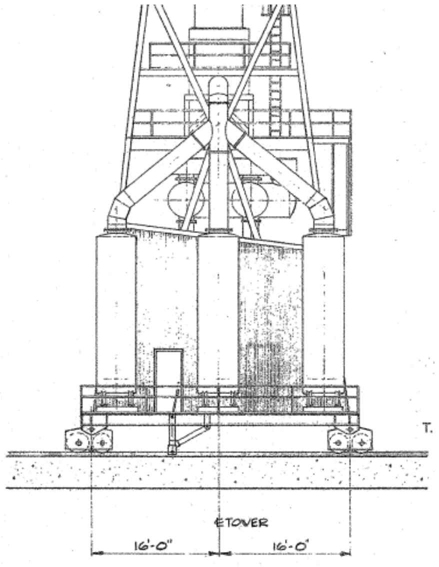


Figure 5-4: Original Shiploader Bogie/Wheel Arrangement (Rader Pneumatics, DWG E-410317)

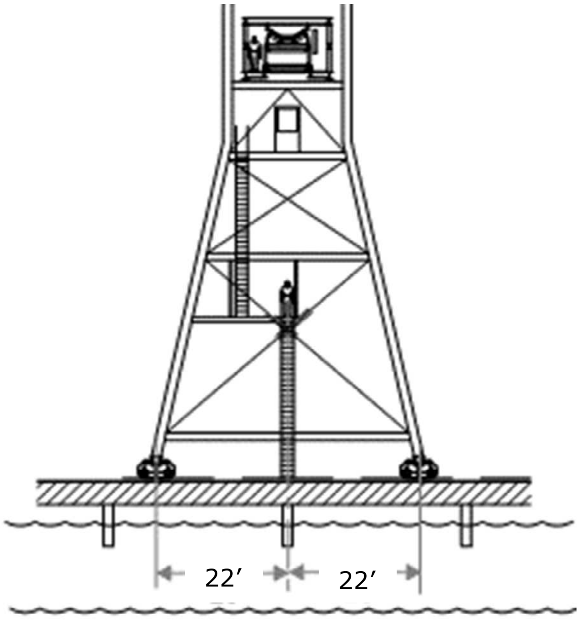


Figure 5-5: Proposed Preliminary Shiploader Bogie/Wheel Arrangement (Brooks P1 Rev B)

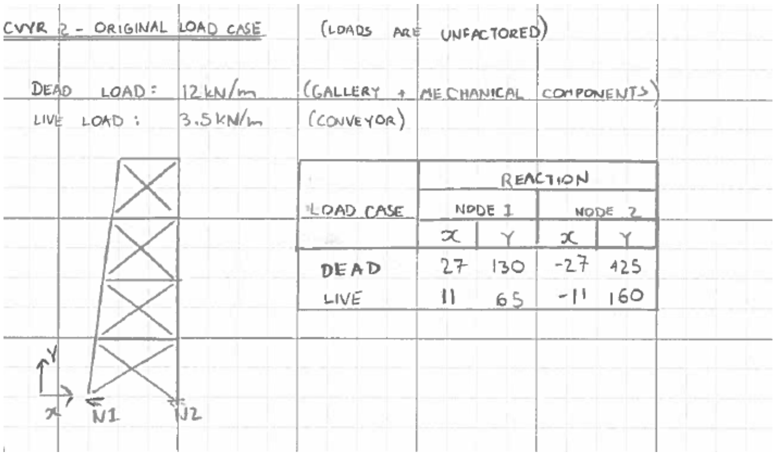
The original shiploader is stated to weigh 489 Kips (222 tonnes) while the proposed shiploader is estimated to weigh 513 Kips (232 tonnes), which represents a weight increase of approximately 5%.

The original shiploader design was based on 1977 National Building Code requirements (as indicated in Rader Canada LTD drawing C-411-640, Shiploader – Design Loads and Safety Factors). As such, wind and snow load estimates used to determine the reactions in Figure 5-2 would have differed from those specified in the current national building code (both in return period and climatic data parameters).

When evaluating the equivalency of the original shiploader to the proposed replacement shiploader, emphasis was made on dead loads (weight) and live loads (material in conveyors). These are the only shiploader loads that are not contingent on the design code.

5.3 Conveyor Bent Loads

The following figures show the original and the estimated proposed conveyor bent loads for several load cases. The reaction loads represent maximum load conditions, with the tripper resting directly over the bent.

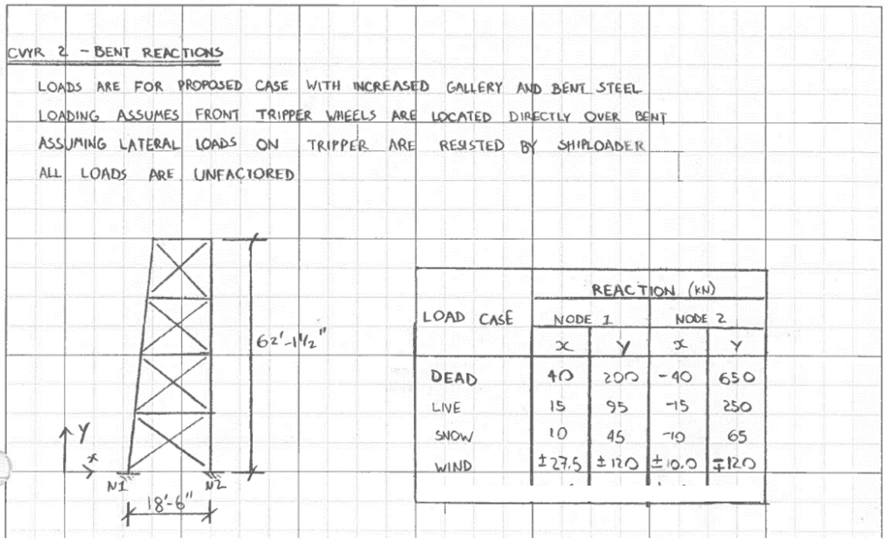


CVYR 2 - ORIGINAL LOAD CASE (LOADS ARE UNFACTORED)

DEAD LOAD: 12 kN/m (GALLERY + MECHANICAL COMPONENTS)
LIVE LOAD: 3.5 kN/m (CONVEYOR)

LOAD CASE	REACTION			
	NODE 1		NODE 2	
	x	Y	x	Y
DEAD	27	130	-27	425
LIVE	11	65	-11	160

Figure 5-6: *Current Estimated Conveyor CVYR2 Bent Loads - Reactions in kN (CWA Engineers 2015)*



CVYR 2 – BENT REACTIONS

LOADS ARE FOR PROPOSED CASE WITH INCREASED GALLERY AND BENT STEEL

LOADING ASSUMES FRONT TRIPPER WHEELS ARE LOCATED DIRECTLY OVER BENT

ASSUMING LATERAL LOADS ON TRIPPER ARE RESISTED BY SHIPLOADER

ALL LOADS ARE UNFACTORED

LOAD CASE	REACTION (kN)			
	NODE 1		NODE 2	
	x	Y	x	Y
DEAD	40	200	-40	650
LIVE	15	95	-15	250
SNOW	10	45	-10	65
WIND	±27.5	±120	±10.0	∓120

Figure 5-7: *New Estimated Conveyor CVYR2 Bent Loads - Reactions in kN (CWA Engineers 2015)*

5.4 Transfer Tower and Maintenance Tower Loads

Transfer tower and maintenance tower loads were estimated by modeling the structures in CSiBridge structural software. A screenshot of the models is shown in the figure below. Although no significant changes in the weight and operational loads are anticipated for these structures, their base reactions have been included in the dock computer model due to their proximity to the shiploader at its east-most position (since they would contribute to the axial loads in nearby piles).

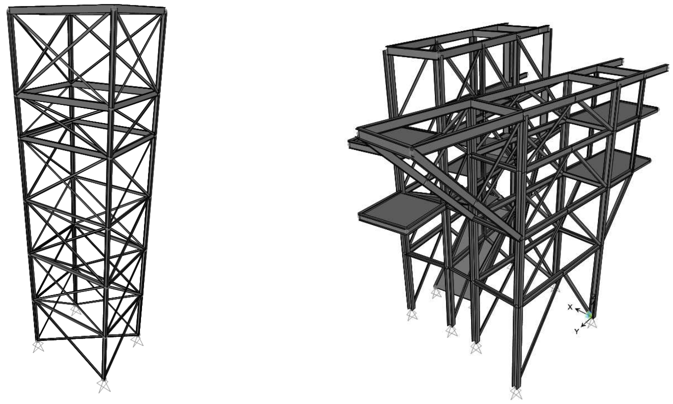


Figure 5-8: *CSiBridge Computer Model Screenshot - Transfer Tower (left) & Maintenance Tower (right) Isometric Views*

5.5 Other Loads

Fender loads considered the original fender reaction of 780 kN (175 Kips), which is of the same magnitude as the proposed replacement fenders, including allowance for friction loads on the frontal panel.

Mooring (bollard) loads considered the installed equipment capacity, taken as the Safe Working Load (SWL) of 35 tonnes (77 Kips), generally applied in the direction of the spring lines. No bollard replacement is anticipated.

5.6 Load Combinations

The following load combinations, in accordance with CAN/CSA S6, were used for this capacity assessment.

Table 5-1: Load Combinations for Capacity Assessment

Combination	Dead*	Live	Berthing	Mooring	Wind^t (Oper.)
ULS1A	αd max	1.7			
ULS2A	αd max	1.6	1.25		
ULS2B	αd min		1.25		
ULS3A	αd max	1.4			0.45
ULS3B**	αd max	0.98		1.0	0.45
ULS3C***	αd max	0.84	1.0	1.0	0.45
ULS4A	αd max			2.0	
ULS4B	αd min			2.0	
SLS1	1.0	0.9			

* Dead load factors vary depending on the component
** Live Load Factor adjusted by 0.7 when considering 2 concurrent load cases as per NBCC
*** Live Load Factor adjusted by 0.6 when considering 3 concurrent load cases as per NBCC
^{t} Wind load factors apply to structure only (as per CAN/CSA S6). Shiploader wind loads assume 35 mph (15.6 m/s) hourly mean wind speed (Bruks) with a wind load factor of 1.0

6 Summary of Results

The load effects of the proposed new shiploader on the marine structures were compared to the load effects of the original equipment. Where load effects were found to be higher for the proposed condition, the member structural capacity was checked to see if sufficient reserve capacity existed in order to resist the new load.

As mentioned in Section 5.2, only the self-weight and (material) live loads were included in the initial *comparative* analysis. This type of comparison aims to determine whether the structure will be "no worse" than it is today once the proposed equipment is installed.

6.1 Loads on Piles

This section presents the load comparison and the pile capacity checks performed for the proposed equipment configuration.

6.1.1 Shiploader Loads

The rail girders supporting the travelling shiploader rest on batter pile pairs as shown in Figure 3-2 and Figure 3-3. The comparison of maximum pile axial loads resulting from the original and proposed shiploader wheel loads under various operating conditions (i.e. shuttle in, shuttle out, boom up) is presented in Table 6-1:

Table 6-1: Comparison of Maximum Pile Axial Loads – Original and Proposed Shiploader

Shiploader	**Compression Load (Dead)**	**Tension Load* (Dead)**	**Compression Load (Dead+Live**)**	**Tension Load* (Dead+Live**)**
Original	97.3 kN (22 Kips)	-	103.7 kN (23 Kips)	-
Proposed	89.5 kN (20 Kips)	-	106.8 kN (24 Kips)	-

* No net tension expected in piles as a result of shiploader dead + live loads
** Live Loads include plugged chute condition
Green Text = Proposed Estimated Value below Original Estimate
Red Text = Proposed Estimated Value above Original Estimate

Axial loads in Table 6-1 represent the worst condition observed from analysis and not all piles in the structure are subject to this maximum load. The marginal increase of 3% in the working axial loads of select piles noted in the Dead+Live load case above is considered negligible.

In order to confirm the adequacy of the existing members, pile capacities were checked against the estimated and the new loads. Results are shown in Section 6.1.4.

6.1.2 Conveyor Bent Loads

The conveyor bents are supported on pilecap extensions that rest on two vertical piles as shown in Figure 3-1. The comparison of estimated pile axial loads resulting from the original and proposed conveyor bent loads is presented in Table 6-2 below.

Table 6-2: Comparison of Pile Axial Loads – Original and Proposed Conveyor Bent Reactions

Conveyor Bent	**Compression Load (Dead)**	**Tension Load* (Dead)**	**Compression Load (Dead+Live)**	**Tension Load* (Dead+Live)**
Original	190 kN (43 Kips)	-	270 kN (61 Kips)	-
Proposed	290 kN (65 Kips)	-	410 kN (92 Kips)	-

* No net tension expected in piles as a result of conveyor bent dead + live loads
Green Text = Proposed Estimated Value below Original Estimate
Red Text = Proposed Estimated Value above Original Estimate

Due to the pile axial load increase observed on the two vertical piles immediately below the conveyor bents, the capacity of these piles was checked to confirm their adequacy to resist the higher loads. These piles are included in the capacity check in Section 6.1.4.

6.1.3 Transfer Tower, Maintenance Tower, and Other Loads

No significant changes in the weight and operational loads are anticipated for the transfer and maintenance tower structures. Berthing and mooring loads remain unchanged and based on the rated capacity of the fenders and bollards, respectively. The loads associated with these structures and equipment were included in the pile capacity checks shown in Section 6.1.4, using the load combinations presented in Section 5.6.

6.1.4 Pile Capacity Check

For the structural pile capacity check, P-Delta effects were considered in the analysis and the applied load data shown in Figure 6-1 and Figure 6-2 include these second order effects. The figures only show pile load data for the governing load combinations.

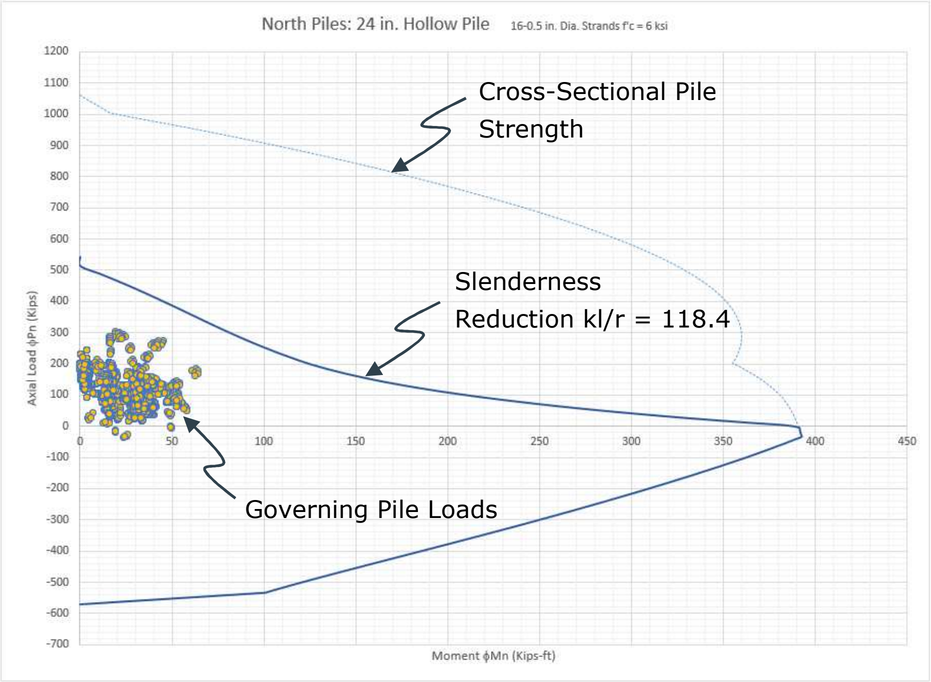


Figure 6-1: Pile Interaction Diagram - North Piles – PCI_PSCPile.xls Version 1.2.15

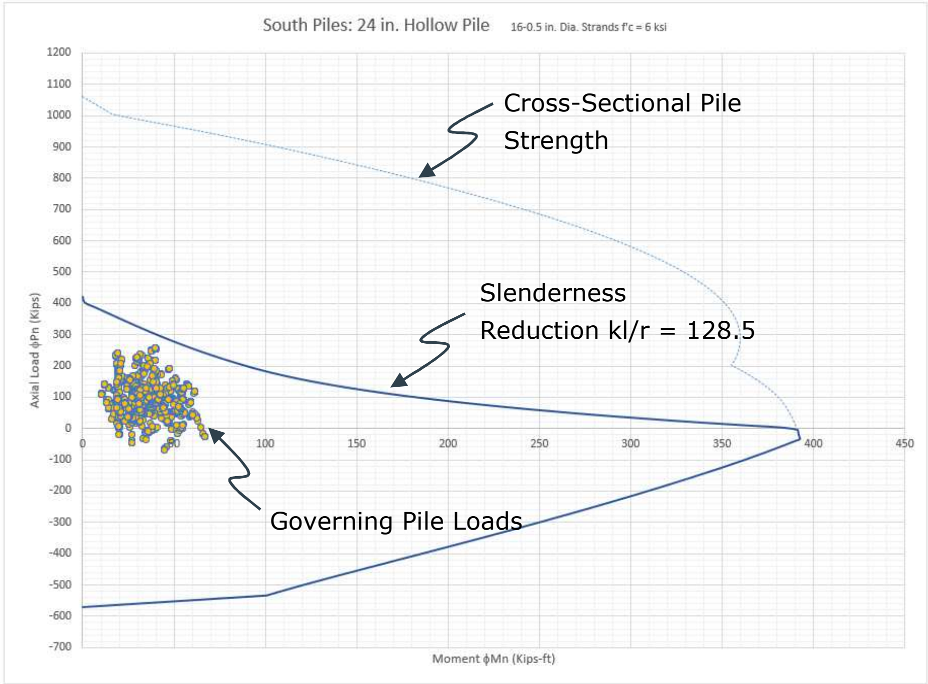


Figure 6-2: Pile Interaction Diagram – South Piles – PCI_PSCPile.xls Version 1.2.15

Geotechnical pile capacities were checked for governing load combinations. The pile loads under the load combinations given in Section 5.6 were compared to the geotechnical capacities using the resisting factors outlined in Section 4. Results show that pile capacities are adequate and all loading from the new proposed shiploader and modified elevated feed conveyor and tripper can be accommodated.

6.2 Shiploader Loads on Rail Girders

The preliminary new shiploader bogie/wheel configuration varies slightly from the original configuration (refer to Figure 5-4and Figure 5-5). This difference causes the moments and shear stresses in the rail girders to differ from those in the original design.

Similar to the analysis carried out for axial loads on piles, a load comparison was made for the pre-stressed, post-tensioned, pre-cast rail girders. The comparison results are shown in Table 6-3 and Table 6-4.

Table 6-3: Comparison of Maximum Moments on Rail Girders – Original and Proposed Shiploader

Shiploader	**Dead Load Sagging Moment (+ve)**	**Dead Load Hogging Moment (-ve)**	**Dead+Live* Sagging Moment (+ve)**	**Dead+Live* Hogging Moment (-ve)**
Original	1,188 kNm (876 Kip-ft)	675 kNm (498 Kip-ft)	1,260 kNm (929 Kip-ft)	778 kNm (574 Kip-ft)
Proposed	1,102 kNm (813 Kip-ft)	855 kNm (631 Kip-ft)	1,421 kNm (1,048 Kip-ft)	884 kNm (652 Kip-ft)

* Live Loads include plugged chute condition
Green Text = Proposed Estimated Value below Original Estimate
Red Text = Proposed Estimated Value above Original Estimate

Table 6-4 Comparison of Maximum Shears on Rail Girders – Original and Proposed Shiploader

Shiploader	**Dead Load Positive Shear**	**Dead Load Negative Shear**	**Dead+Live* Positive Shear**	**Dead+Live* Negative Shear**
Original	814 kN (183 Kips)	818 kN (184 Kips)	867 kN (195 Kips)	863 kN (194 Kips)
Proposed	778 kN (175 Kips)	770 kN (173 Kips)	983 kN (221 Kips)	983 kN (221 Kips)

* Live Loads include plugged chute condition
Green Text = Proposed Estimated Value below Original Estimate
Red Text = Proposed Estimated Value above Original Estimate

Rail girder capacities were checked for SLS Service Loads (Dead + Live, excluding plugged chute) and ULS Ultimate Loads (load combinations presented in Section 5.6). Table 6-3 and Table 6-4 show that the proposed new shiploader will increase the magnitude of the moments and shears on the rail girder sections. A maximum increase of 27% is evident for the shiploader dead load hogging moments. The analysis shows, however, that the rail girders have adequate capacity to resist the estimated loads.

7 Conclusions

Fibreco is planning the replacement of its shiploader and upgrade of the elevated feed conveyor behind the dock. The proposed modifications were assessed to estimate the changes in loads exerted on the dock by the revised equipment. The structural and geotechnical capacity of the members affected by the proposed changes was estimated based on record information and the following preliminary conclusions were reached:

- The proposed shiploader is comparable in geometry to the original shiploader but has slightly larger mass and lateral windage areas;
- The marginal increase in shiploader weight and outbound material loads can be resisted by the original structure;
- Proposed modifications to conveyor CVYR2 are expected to increase the support bent loading when compared to the original condition; and
- Loads imposed by the proposed modifications to the elevated conveyor and tripper can also be resisted by the original structure.

The above conclusions are based on preliminary and limited analysis data but suggest that the proposed modifications can be accommodated by the existing structures.

Summary Report of Manoeuvring Analysis

FIBRECO Export Inc.

PANAMAX Bulk Carrier Docking Operations

11 July 2016
Prepared By:

NAVTEC

Executive Summary

FIBRECO Export Incorporated operates a bulk terminal on the north shore of Burrard Inlet in the Port of Vancouver Canada. A manoeuvring study was commissioned its purpose, to investigate and assess the feasibility of berthing and un-berthing PANAMAX size bulk carriers with dimensions up to 225 metres x 32.25 metres, with tug assistance, and under a range of tidal stream and wind conditions. (Note vessels with beam widths greater than 32.25 metres were not examined). The objective of the simulated manoeuvres was to determine if any restrictions would need to be imposed based on the following considerations:

1) Confirm that a spectrum of manoeuvring options would be feasible for typical PANAMAX-size bulk vessels with loaded draughts ranging from 8.5 to 11.5 metres;
2) Constraints or restrictions that may need to be imposed due to the effect of tidal stream/back eddies on the safe manoeuvring process; and
3) Determine minimum assist tug requirements.

A total of seventeen simulated tug assisted manoeuvres were carried out, fifteen arrivals and two departure manoeuvres. Additionally, three “warping” manoeuvres were conducted using the ship’s mooring lines and winches to shift the vessel along the dock by a distance of approximately 30 metres.

To conclude, the results of the simulation exercises showed that arrivals and departures for PANAMAX bulk carriers up to 225 metres LOA could be conducted under the full range of tidal stream conditions with winds up to 20 knots provided:

- A minimum of two 40 tonne static bollard pull (BP) ASD assist tugs were used for all manoeuvres;
- Doppler tidal stream meters capable of broadcasting via AIS live/actual tidal stream velocity and direction data be installed at both the east and west ends of the FIBRECO berth. The live information provided by these devices would be received on the Pilot’s PPUs***, allowing moves to be conducted under the broadest possible range of tidal windows;
- Initially, these manoeuvres not be attempted with PANAMAX size vessels when the actual tidal stream velocity at the berth exceeds 1.5 knots. After 12 moves have been safely made with PANAMAX size vessels, and real world data has validated simulated findings, this restriction could then be progressively increased in increments of 0.25 knots.

A detailed description of the findings and recommendations is provided in Sections 4 and 5 of this report.

****PPU: Portable Piloting Units are a stand-alone, carry aboard, decision making tool used by the BC Coast Pilots. It utilises a survey grade independent DGPS/GLOANASS positioning system with electronic navigational charts, dynamic AIS feeds of vessel traffic and environmental conditions, and vessel movement prediction features.*

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1 Overview of Simulation Study

FIBRECO Export Incorporated has engaged COWI North America to provide marine engineering services and it in turn sub-contracted NAVTEC S.A. to complete the simulation analysis. The simulation study was conducted 8 and 9 June 2016 using a Kongsberg special task simulator that is jointly owned by the Pacific Pilotage Authority and the British Columbia Coast Pilots. Local area manoeuvring and operational expertise was provided by two senior BC Coast Pilots and COWI's marine consultant from L.J. Swann and Associates Ltd.

1.1 Simulation System

The simulation work was done using a Kongsberg desktop special task simulator comprised of a manoeuvring station with simulated radar, bridge instruments and controls, and four visual channels that could be panned around for a complete 360^0 field of view. The simulator was also coupled with a NAVSIM® Portable Pilot Unit (PPU) and provided through Bluetooth connection ship positional data for the bulk vessel and Automated Identification System (AIS) feed for the assisting tugs. This is the same independent, carry-aboard decision support aid that is used by the British Columbia Coast Pilots. All runs were recorded on the PPU, as well as within the simulation system.

1.2 Test Team

The test team conducting the simulation study consisted of the individuals listed in the following table:

Table 1: Simulation Study Test Team

Name	Role	Organisation
Garland Hardy	Test Director	NAVTEC S.A.
John Swann	Marine Advisor	L.J. Swann and Associates Ltd.
Kevin Vail	Test Pilot	BC Coast Pilots
Brad Tailpus	Test Pilot	BC Coast Pilots

1.3 Study Goals

Goals for the study included a preliminary assessment of the following:

- Identify conditions of tidal stream/ wind that might prevent safe berthing/ un-berthing of a PANAMX size vessel;
- Determine any complications or restrictions that might be imposed on either port or starboard side manoeuvres, approaching the dock with both headway and sternway;
- Establish the minimum tug assist requirements;
- Assess the ability of the pilots to maintain manoeuvring control of the ship in the event of an shipboard or tug propulsion failure; and
- Provide necessary recommendations to mitigate any adverse effects or concerns from all of the above test runs.

1.4 Ship Model

This study was conducted using existing proven models from the Kongsberg simulation model library. Tugs were chosen to reflect the types of tugs currently available in the Port of Vancouver.

Particulars of the vessels are listed in the following table:

Table 2: Vessel Particulars

Vessel Type	Vessel Name	Displacement(tonnes)	Length LOA (m)	Beam (m)	Draught Forward (m)	Draught Aft (m)
PANAMAX Bulker	Magnitogorsk	40,000	215.4	31.8	6.8	8.5
PANAMAX Bulker	Magnitogorsk	60,920	215.4	31.8	11.5	11.5
ASD 5000 HP Skeg forward escort tug (Artificially limited to maximum 40t BP)	Seaspan Eagle	600	28.2	11.7	5.2	5.4

1.5 Area Model

The PPA simulator contains a high-fidelity 3D geographical area model with coverage of all of Burrard Inlet and the FIBRECO dock; compiled by Kongsberg in 2014. Electronic Navigation Charts were used for geo-referencing all pertinent aspects of marine navigation: bathymetric contours (including drying areas), spot soundings, terrain elevation, coast line and man-made structures. Additional bathymetric information in 10- and 25-metre grid spacing was provided from Port Metro Vancouver sources. Satellite imagery and local photography were used to ensure that the visual scenery yielded an accurate area representation including non-charted fixtures commonly used by experienced pilots.

2 Met-ocean Conditions - Burrard Inlet and FIBRECO

Burrard Inlet is a natural basin boarded to the north by a mountainous shoreline, and to the south by the peninsula which forms the central downtown core of the city of Vancouver. Access to the open ocean is to the west via an entry channel know as First Narrows, and to the east at Second Narrows the navigable channel extends further and provides access to Indian Arm and Port Moody. Docks, marine facilities and terminals of all types are located within Burrard Inlet. The maximum water depth in some areas exceeds 60 metres, however the controlling depth in First Narrows, at zero height of tide (Chart Datum) is 15 metres, and limits the navigational draught of transiting vessels accordingly. Due to the geographic constriction, and shallowing of both First and Second Narrows, all of Burrard Inlet experiences strong tidal streams, which reach velocities of up to 6 knots within the confines of the two narrows. In other parts of the inlet, tidal stream velocities of up to 3 knots are not uncommon, and this includes the approaches to the FIBRECO terminal which forms an important consideration for any manoeuvres to and from this facility.

FIBRECO dock's location is adjacent to the point of convergence of the wider, deeper portion of Burrard Inlet with the shallower, more constricted channel of the First Narrows. As a consequence, the tidal stream flow at the face of the dock and in its immediate approaches is not only of high velocity, but also pools and back-eddies in all directions. Additionally, the horizontal flow of the water can be dramatically different at the surface than at deeper depths such as 3 metres, 5 metres, 10 metres, etc. Due to the complex nature of these tidal streams, and their potential adverse effect on vessel manoeuvring, the dock is presently under a restriction that only permits vessel moves when the tidal stream at First Narrows is less than two knots in velocity. Presently, the controlling depth at the dock also limits vessels to a loaded depth of 12.0 metres at zero vertical tide (chart datum) and at all tide levels a minimum under keel clearance of 10% of total draught.

Given the importance of the tidal stream conditions on manoeuvring operations at FIBRECO, prior to conducting the simulation analysis, Tetra-Tech EBD was commissioned to gather ACDP data on the tidal stream flow in the immediate vicinity of the FIBRECO berth. This empirical data was then used to calibrate and refine their detailed 3-D current prediction model. A dynamic tidal stream model was then created by Tetra Tech in a format used by the Kongsberg simulator to replicate actual conditions from selected days from their model year 2012. Most of the runs were conducted at the modelled conditions for a large flood/ebb tide (9/10 May 2012) with additional runs on a day with a moderate ebb/flood tidal stream (18/19 May 2012). Full details of this modelling are provided in Section 2.1.

Wind is also a consideration when manoeuvring bulk ships particularly when they are in ballast as they have a sizable surface area that is affected by wind induced rotation and drift. In Burrard Inlet it is extremely rare for winds to exceed 25 knots, and the wind blows most frequently from either an easterly or westerly direction (nearly parallel to the FIBRECO dock) and as such presents a lesser concern for docking operations at FIBRECO than that of the tidal stream/ current. All simulated runs were conducted with 20 knots of wind, from either an easterly or westerly direction. Due to the very sheltered nature of Burrard Inlet, observed wave heights in the vicinity of the terminal rarely exceed 30 centimetres and are fetch-limited. For all practical purposes it can be stated that their effect on the ship is negligible during docking and undocking operations. Wind and Tidal conditions are described in full detail below.

2.1 Tide and Tidal Stream (Current)

Vancouver harbour experiences a mean vertical tidal range of 4.75 metres, which is accompanied by strong tidal streams routinely achieving velocities of up to 6 knots in First Narrows. Due to the nature of the diurnal inequality tides that are experienced in Vancouver, the direction and velocity of the tidal stream varies considerably from day to day and is always an important ship manoeuvring consideration. Recent field surveys using Acoustic Current Doppler Profilers (ADCP) data and advanced prediction models have confirmed anecdotal evidence that complex and dynamic back eddies form in multiple locations in Burrard Inlet, particularly along the boundaries of the 20 metre depth contour.

Predictions of representative diurnal and semi-diurnal tidal conditions for three different periods (9/10 May, 14/15 May and 18/19 May 2012) were modelled by Tetra Tech of Vancouver. These water flow predictions were dynamic covering an entire 24-hour period, and included the vertical height of tide, as well as current direction and velocity values at horizontal levels for depths of 0.2, 1.2, 2.2, 3.2, 5.0, 7.0, 9.5, and 11.6 metres. This provided a highly realistic representation of both the dynamic water levels (height of tide) and current/ tidal stream velocities at a 25-metre grid spacing any point in Burrard Inlet for the days previously mentioned.

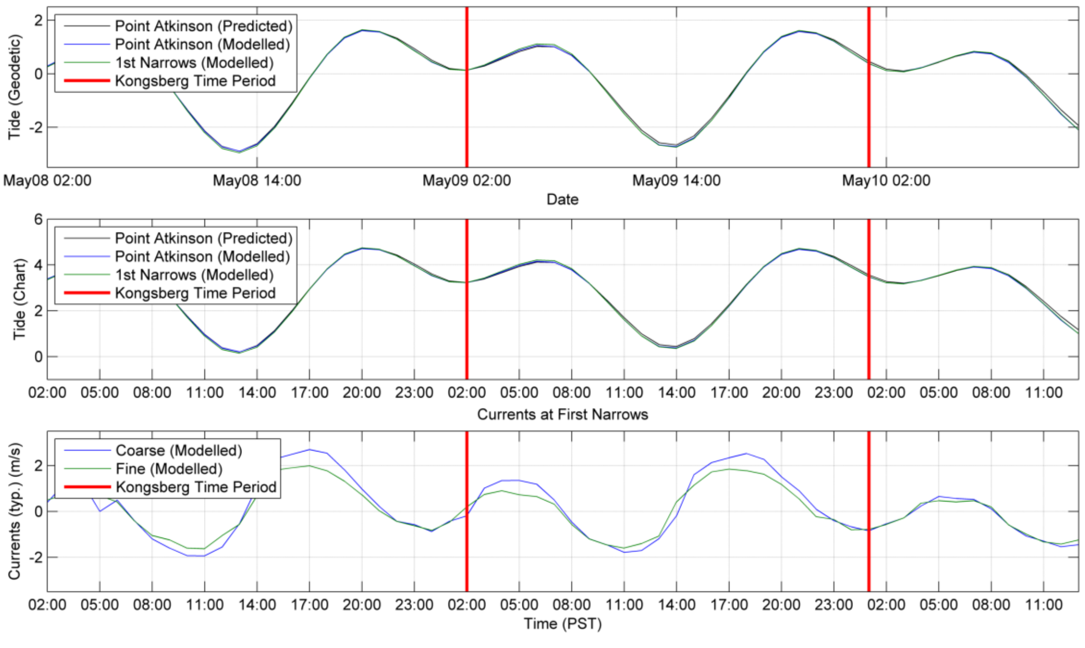


Figure 1: Modelled tidal stream conditions for 9/10 May 2012

Figure 2: Modelled tidal stream conditions for 14/15 May 2012

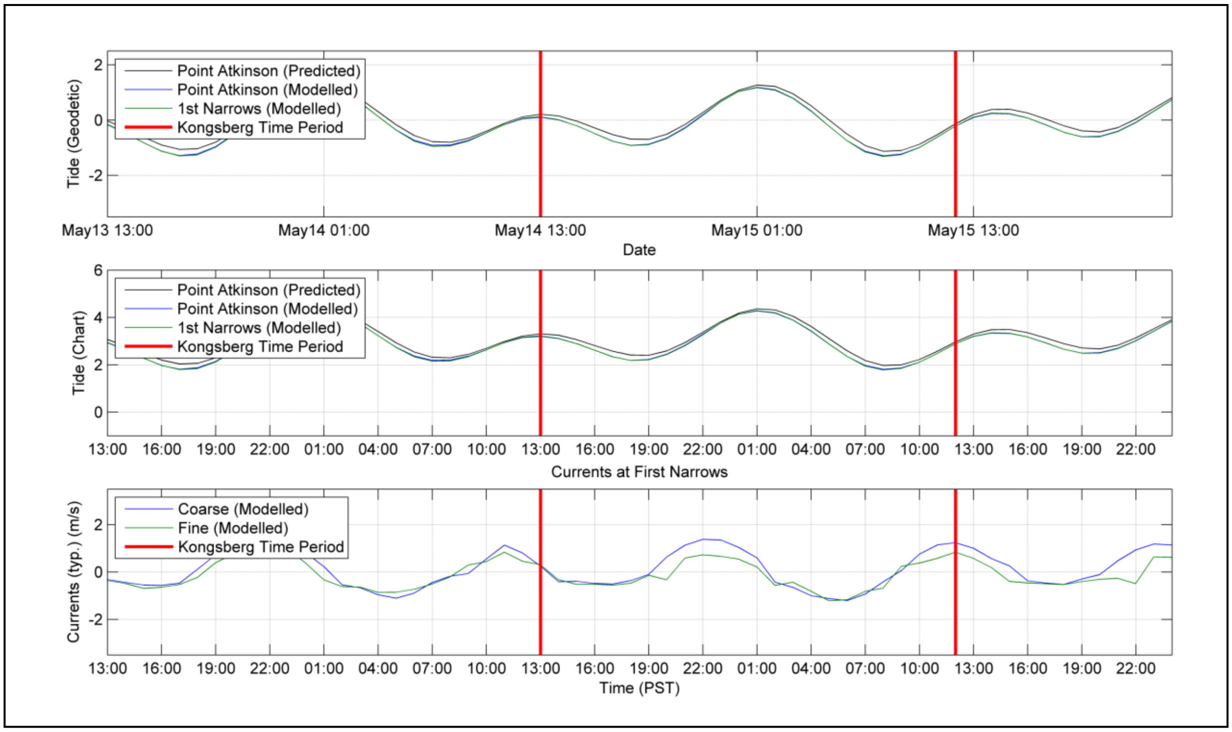
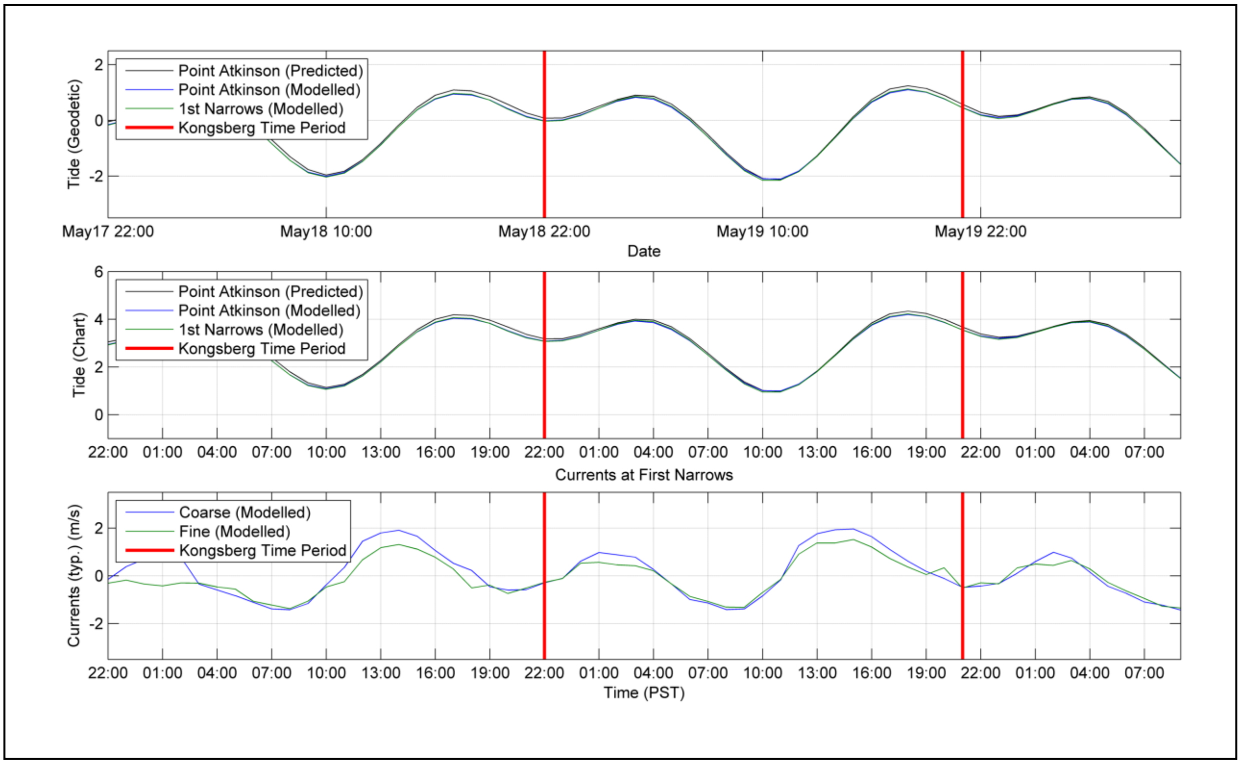


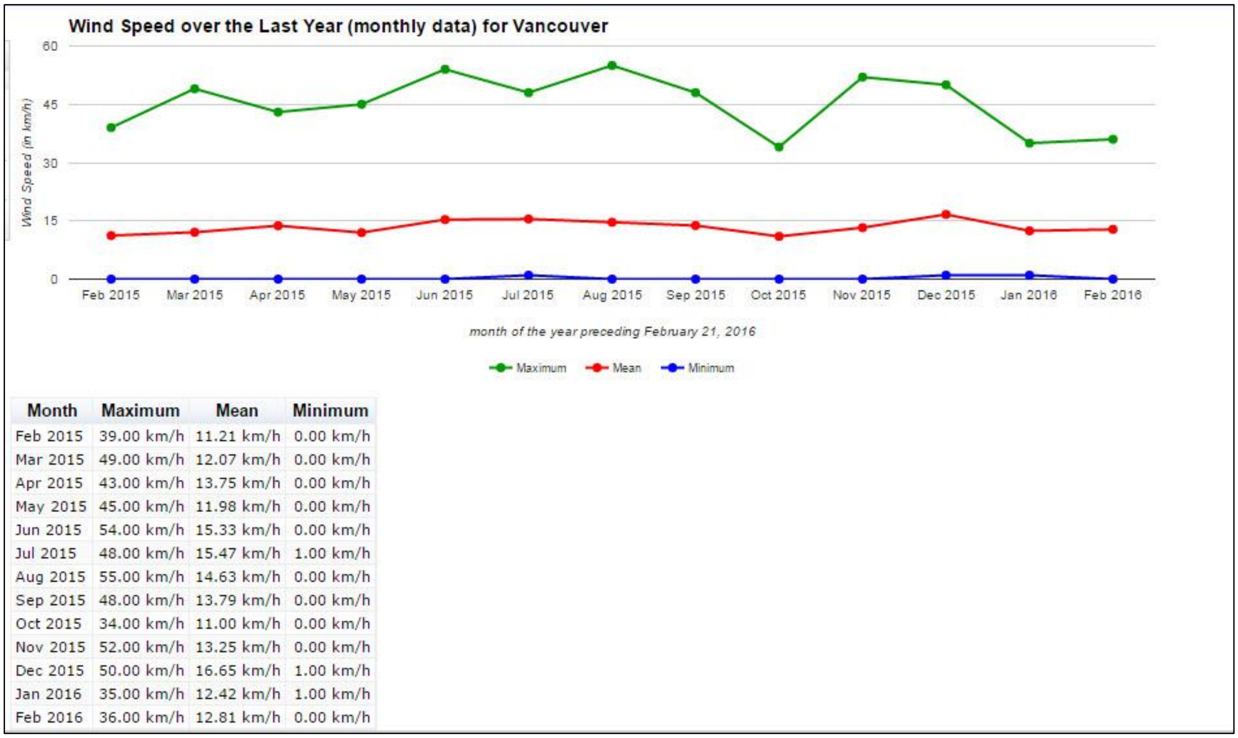
Figure 3: Modelled tidal stream conditions for 18/19 May 2012



2.2 Wind

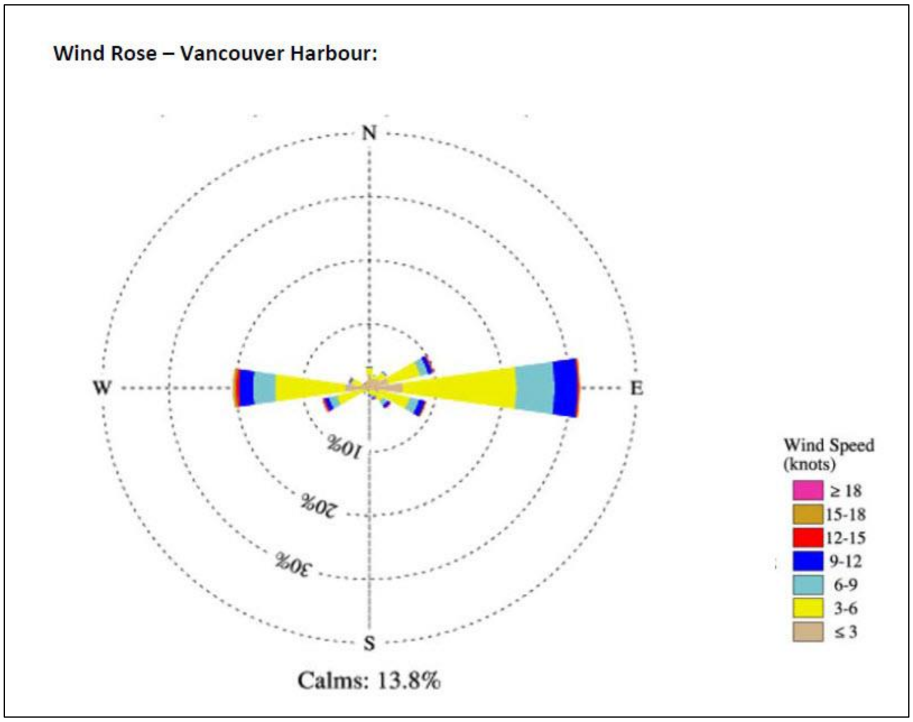
Historical wind data for Burrard Inlet has shown that, for wind speeds above 10 knots, the winds tend to be predominately from either westerly or easterly direction. This is also consistent with the experiential observations of the pilots. The topography provides wind sheltering, and the winds rarely exceed 30 knots, even with some isolated funnelling effects. Winds in excess of 25 knots at FIBRECO are rare. Based on these parameters, 20-knot wind speed was the maximum velocity tested for berthing and un-berthing operations.

Figure 4: Historic annual wind speed for Vancouver



Month	Maximum	Mean	Minimum
Feb 2015	39.00 km/h	11.21 km/h	0.00 km/h
Mar 2015	49.00 km/h	12.07 km/h	0.00 km/h
Apr 2015	43.00 km/h	13.75 km/h	0.00 km/h
May 2015	45.00 km/h	11.98 km/h	0.00 km/h
Jun 2015	54.00 km/h	15.33 km/h	0.00 km/h
Jul 2015	48.00 km/h	15.47 km/h	1.00 km/h
Aug 2015	55.00 km/h	14.63 km/h	0.00 km/h
Sep 2015	48.00 km/h	13.79 km/h	0.00 km/h
Oct 2015	34.00 km/h	11.00 km/h	0.00 km/h
Nov 2015	52.00 km/h	13.25 km/h	0.00 km/h
Dec 2015	50.00 km/h	16.65 km/h	1.00 km/h
Jan 2016	35.00 km/h	12.42 km/h	1.00 km/h
Feb 2016	36.00 km/h	12.81 km/h	0.00 km/h

Figure 5: Historical wind speed and direction for Vancouver



3 Summary of Real Time Simulation Analysis

The BC Coast Pilots (BCCP) have many years of experience berthing HANDYMAX size vessels at FIBRECO. Real world evidence has shown that the more complicated manoeuvring conditions for these vessels tended to be experienced on the flood tidal stream when a counter-clockwise eddy forms at the east end of the FIBRECO dock. Based on this premise, the starting point for the analysis was to conduct arrivals progressing through the beginning of the flood tidal stream flow to maximum tidal stream flow, and then to examine arrivals with the ebb tidal stream, followed by departures, and then manoeuvres where failures of shipboard or assist tug propulsion systems occurred.

3.1 Existing Operational Rules and Protocol

At present, the BC Coast Pilots restrict all movements of vessels to and from FIBRECO to the tidal cycle periods when the tidal stream velocity is less than 2 knots at First Narrows (the geographically closest tidal stream reference station). This restriction has been in place for many years, and was established when there were a limited number of ASD tugs in the port with static bollard pull performance rating of better than 40 tonnes. Additionally, at the time this guideline was implemented, simulation technology was not sufficiently sophisticated to test actual manoeuvring conditions in the manner that has been performed in this analysis.

In this simulation study, only the first runs with each of the flood and ebb were conducted within the existing operation limits window, and all subsequent runs were conducted during periods where the tidal stream velocity at First Narrows was in excess of 2.0 knots.

3.2 Employment of Ship Assist tugs

In the last five years, the performance capabilities of the fleet of ship assist tugs in the Port of Vancouver has increased dramatically, and at present, there are at least a dozen ASD tugs with static bollard pull ratings in excess of 40 tonnes, and in fact most tugs have bollard pull ratings in excess of 55 tonnes. Considering the complex nature of the tidal stream flow in the immediate vicinity of the FIBRECO berth, the fact the bow and stern of the ship are frequently under very different tidal flow effects, and the availability of good tug equipment, it was elected to conduct all manoeuvres with two ASD tugs. For the simulation, the applied tug forces were limited to 40 tonnes per tug, as this would be representative of the lowest level of tug assist power that would be available to the pilot for any manoeuvre. For all manoeuvres one tug was attached forward on “the shoulder” of the ship and the other aft on “the quarter”.

3.3 Summary of Controlled Runs

Familiarisation runs with the ship and the tidal stream models were conducted the afternoon prior to the controlled simulation runs. A summary of all controlled runs conducted 8 and 9 June 2016 are listed below:

Table 3: Berthing Operation Test Runs

Controlled Runs – PANAMAX draught 11.5m			
Run	**Description**	**Wind**	**Manoeuvre**
1	Tidal Stream 9 May @ 14:30, 1 knot Flood.	090° at 20 knots	Berthing port side
2	Tidal Stream 9 May @ 15:00, 2 knot Flood.	090° at 20 knots	Berthing port side
3	Tidal Stream 9 May @ 16:00, 3.5 knot Flood.	090° at 20 knots	Berthing port side
Controlled Runs – PANAMAX draught 8.5m			
Run	**Description**	**Wind**	**Manoeuvre**
4	Tidal Stream 9 May @ 16:00, 3.5 knot Flood.	090° at 20 knots	Berthing port side
Controlled Runs – PANAMAX draught 11.5m			
Run	**Description**	**Wind**	**Manoeuvre**
5	Tidal Stream 9 May @ 09:00, 1 knot ebb.	270° at 20 knots	Berthing port side
6	Tidal Stream 9 May @ 10:30, 3 knot ebb.	270° at 20 knots	Berthing port side
7	Tidal Stream 9 May @ 09:00, 1 knot ebb.	270° at 20 knots	Berthing port side
8	Tidal Stream 9 May @ 16:00, 3.5 knot Flood.	090° at 20 knots	Berthing starboard side
9	Tidal Stream 9 May @ 16:00, 3.5 knot Flood. Ships in Anchorage A and X.	090° at 20 knots	Berthing starboard side
10	Tidal Stream 9 May @ 16:00, 3.5 knot Flood. Ships in Anchorage A and X.	090° at 20 knots	Berthing starboard side
11	Tidal Stream 19 May @ 13:00, 3.5 knot Flood. Ships in Anchorage A and X and meeting outbound vessel.	090° at 20 knots	Berthing port side
12	Tidal Stream 19 May @ 08:30, 3 knot ebb. Ships in Anchorage A and X and meeting outbound vessel.	270° at 20 knots	Berthing port side
13	Tidal Stream 19 May @ 09:00, 3 knot ebb. Ships in Anchorage A and X and meeting outbound vessel.	270° at 20 knots	Un-berthing port side
14	Tidal Stream 19 May @ 13:00, 3.5	090° at 20 knots	Un-berthing port side

	knot Flood. Ships in Anchorage A and X and meeting outbound vessel.		
Controlled Runs – PANAMAX draught 8.5m			
Run	**Description**	**Wind**	**Manoeuvre**
15	Tidal Stream 9 May @ 17:30, 3.9 knot Flood. Ship main engine failure.	090° at 20 knots	Berthing port side
16	Tidal Stream 9 May @ 17:30, 3.9 knot Flood. Bow tug has failure of both engines.	090° at 20 knots	Berthing port side
17	Tidal Stream 9 May @ 17:30, 3.9 knot Flood. Stern tug has failure of both engines.	090° at 20 knots	Berthing port side
Warping Dockside – PANAMAX draught 11.5m			
Run	**Description**	**Wind**	**Manoeuvre**
18	Tidal Stream 9 May @ 09:00, 1 knot ebb.	calm	Port side to, warp aft 30 metres
19	Tidal Stream 9 May @ 15:00, 3 knot Flood.	calm	Port side to, warp aft 30 metres
20	Tidal Stream 9 May @ 17:30, 3.9 knot Flood.	calm	Port side to, warp aft 30 metres

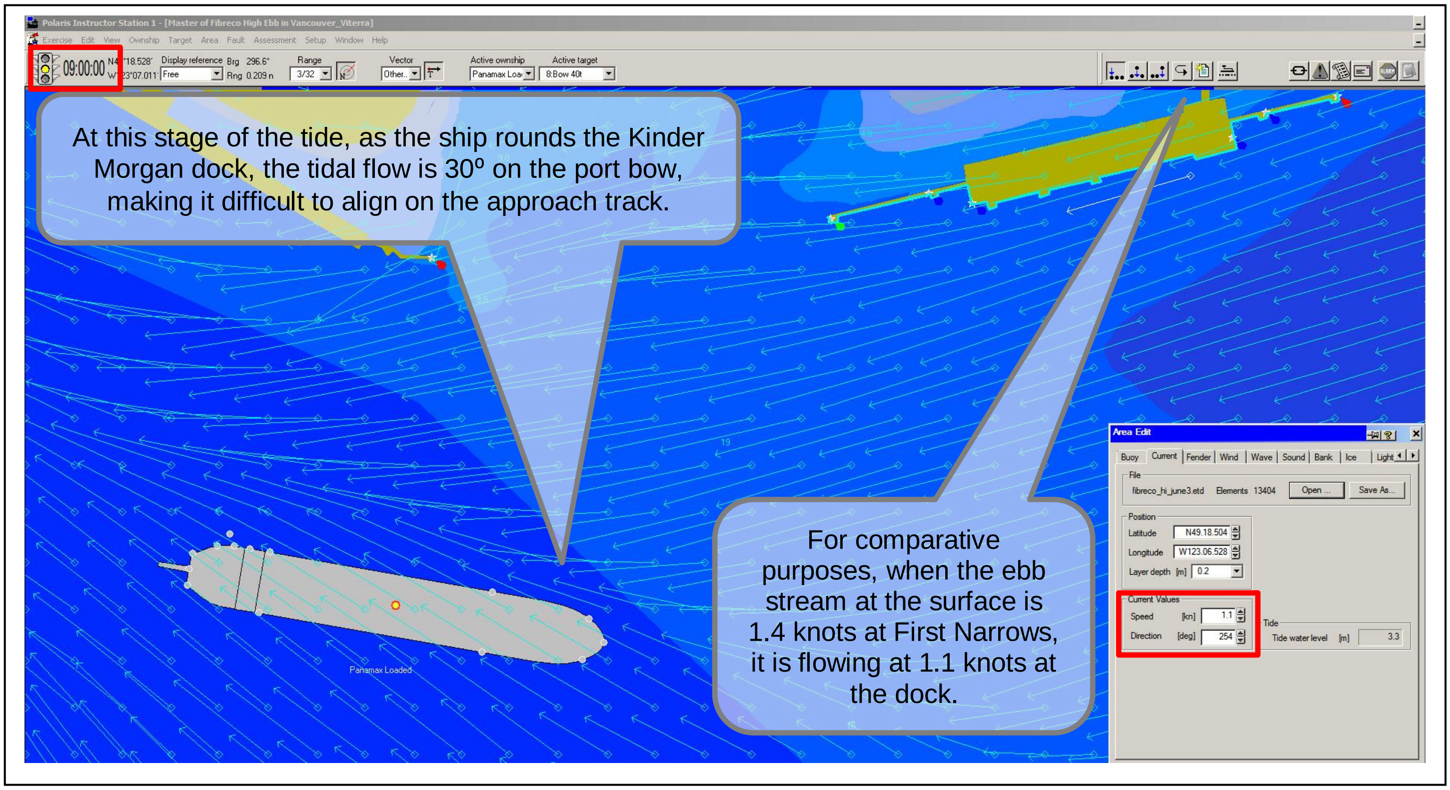
4 Results and Findings

4.1 Tidal Stream Effects

The most significant finding from this simulation analysis, is that using the tidal stream velocity at First Narrows as a gauge for the degree of manoeuvring difficulty at a specific berth in Burrard Inlet, or as the benchmark to impose operational restrictions on vessel moves, is often not the best or most appropriate practice.

In the specific case of FIBRECO's dock, it was found that some manoeuvres, or more correctly the prevailing tidal stream conditions in the immediate vicinity of the berth and its approaches, were actually more difficult to manage when the tidal stream was in the early stages of the ebb and flood versus when the tide was flowing strong in First Narrows. These effects are attributed to numerous factors, not the least of which is the fact that cycloidal tidal patterns tend to form along the boundaries of the 20 metre contour. In relation to the FIBRECO berth, the 20 metre contour runs parallel to the eastern end of the dock at a distance of less than 50 metres from the dock face, and then runs south from the midsection of the berth. As a consequence, during many stages of the tidal flow, the eastern end of the dock is exposed to a counter clockwise rotational tidal flow. See illustrations which follow:

Figure 2: Surface Tidal Stream Flow at FIBRECO First Hour of Ebb Outflow



Polaris Instructor Station 1 - [Master of Fibreco High Ebb in Vancouver_Viterra]

09:00:00 N4 °18.528' W 23°07.011'

Display reference: Free

Brg 296.6°

Rng 0.209 n

Range: 3/32

Vector: Other..

Active ownship: Panamax Loa

Active target: 8:Bow 40t

At this stage of the tide, as the ship rounds the Kinder Morgan dock, the tidal flow is 30º on the port bow, making it difficult to align on the approach track.

For comparative purposes, when the ebb stream at the surface is 1.4 knots at First Narrows, it is flowing at 1.1 knots at the dock.

Area Edit

File: fibreco_hi_june3.etd Elements 13404

Position

Latitude N49.18.504

Longitude W123.06.528

Layer depth [m] 0.2

Current Values

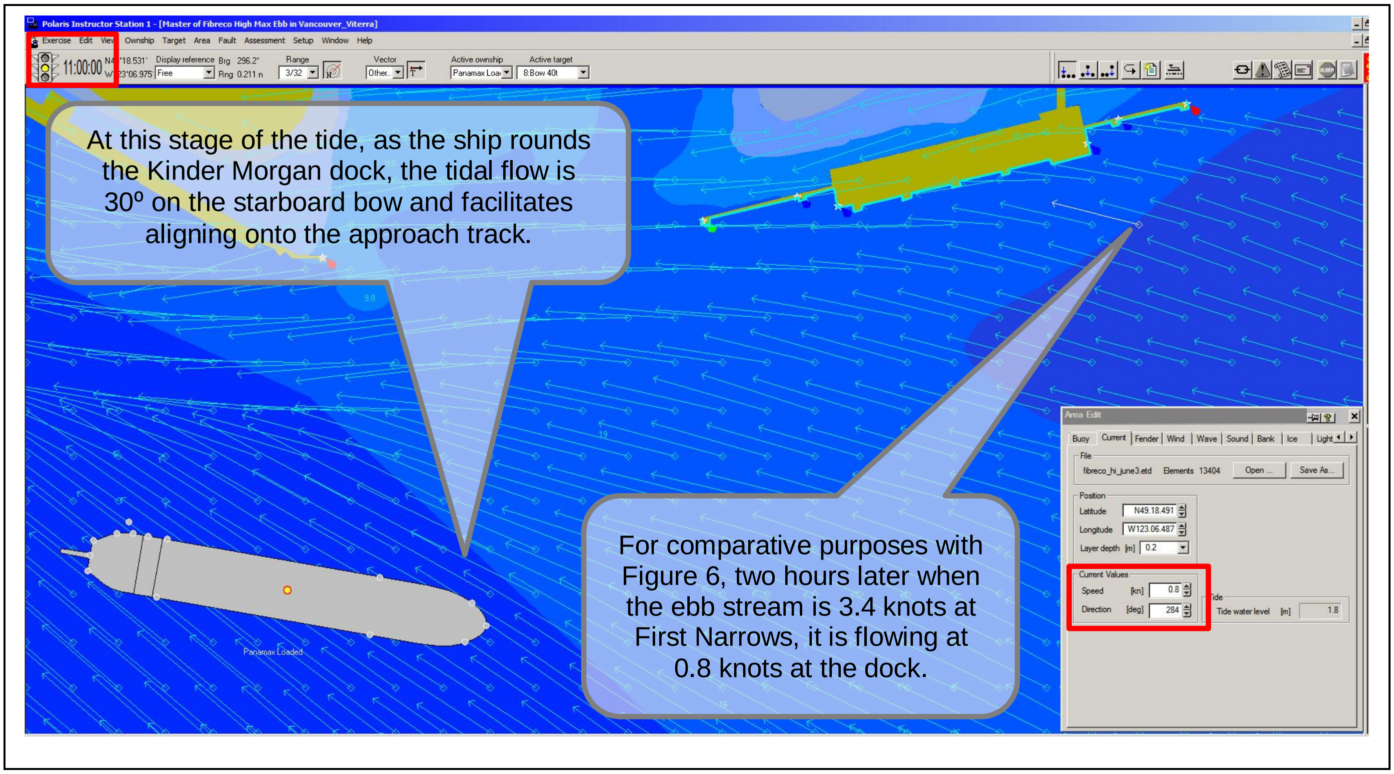
Speed [kn] 1.1

Direction [deg] 254

Tide

Tide water level [m] 3.3

Figure 7: Surface Tidal Stream Flow at FIBRECO at Maximum Ebb


Polaris Instructor Station 1 - [Master of Fibreco High Max Ebb in Vancouver_Viterra]

11:00:00

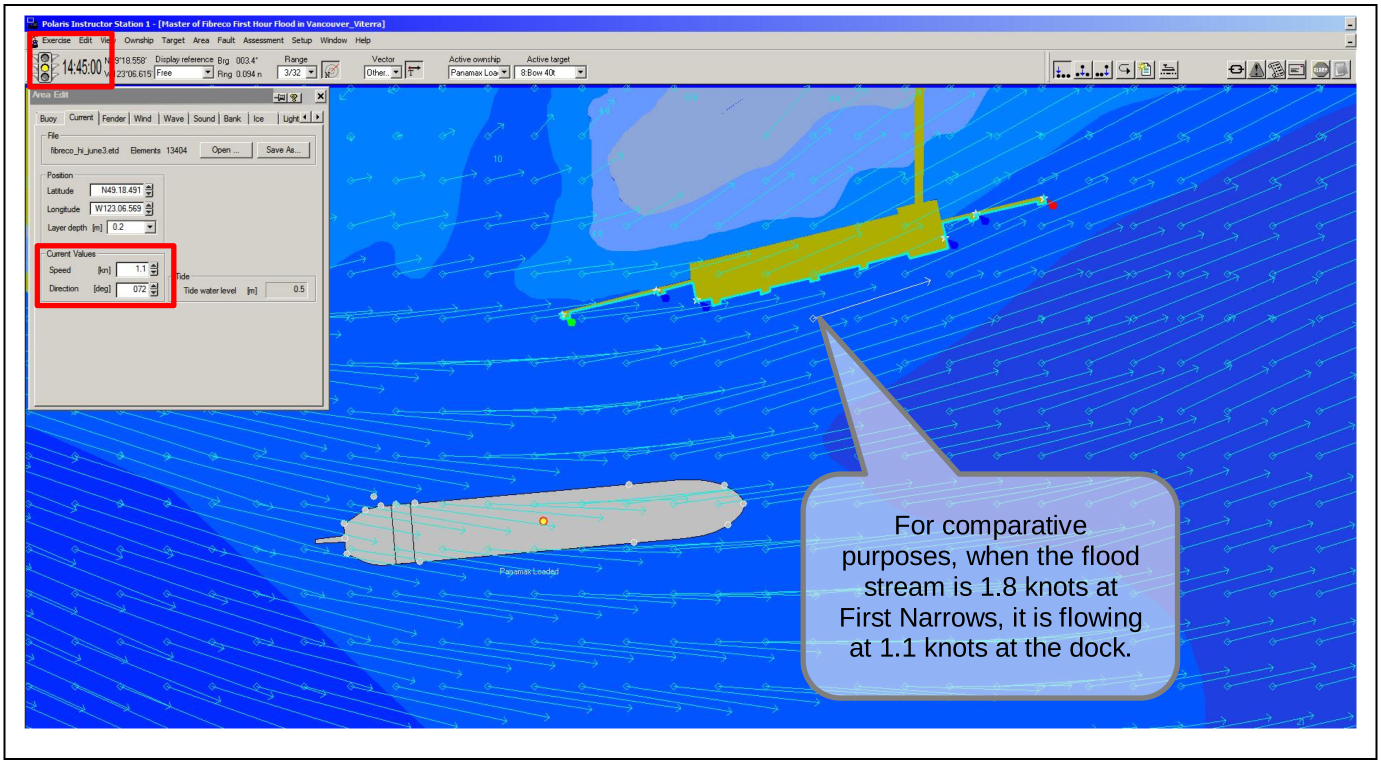
Display reference: Free
Brg 296.2°
Rng 0.211 n
Range: 3/32
Active ownship: Panamax Loa
Active target: 8:Bow 40t

At this stage of the tide, as the ship rounds the Kinder Morgan dock, the tidal flow is 30º on the starboard bow and facilitates aligning onto the approach track.

For comparative purposes with Figure 6, two hours later when the ebb stream is 3.4 knots at First Narrows, it is flowing at 0.8 knots at the dock.

Area Edit
File: fibreco_hi_june3.etd Elements 13404
Latitude: N49.18.491
Longitude: W123.06.487
Layer depth [m]: 0.2
Current Values
Speed [kn]: 0.8
Direction [deg]: 284
Tide water level [m]: 1.8

Figure 8: Surface Tidal Stream Flow at FIBRECO First Hour of Flood


Polaris Instructor Station 1 - [Master of Fibreco First Hour Flood in Vancouver_Viterra]

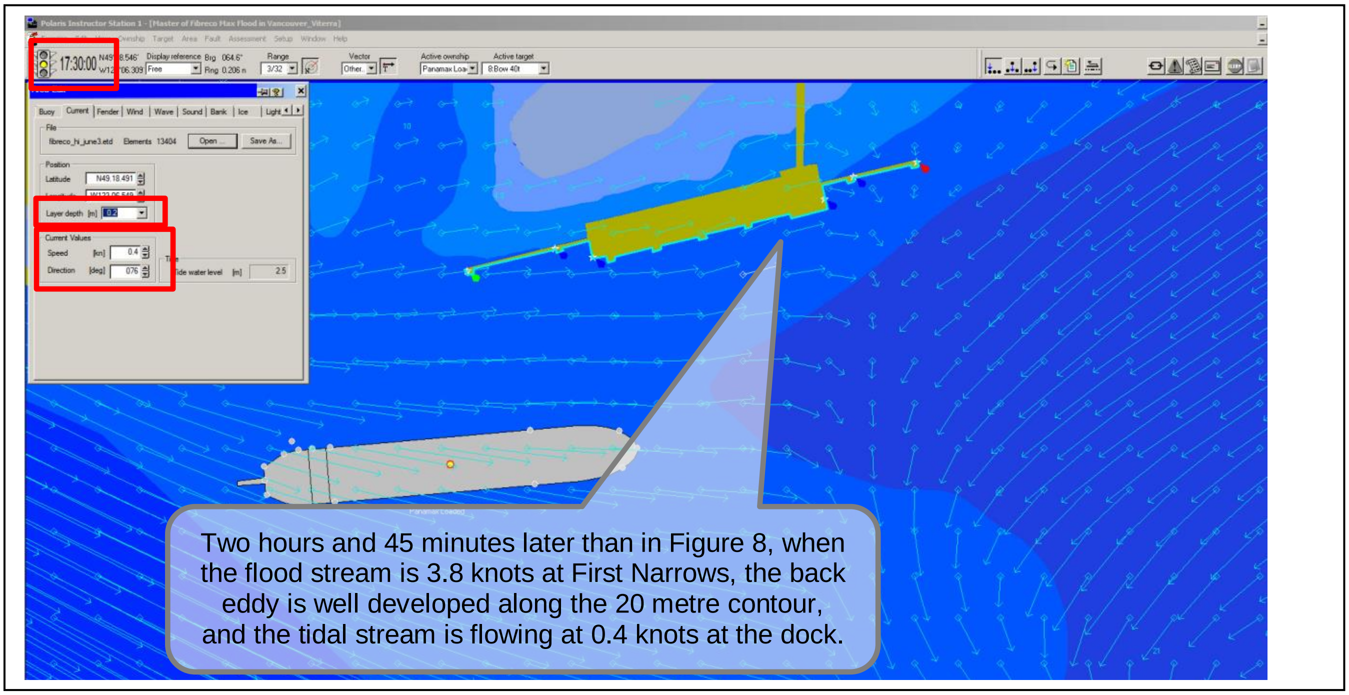
14:45:00

Display reference: Free
Brg 003.4°
Rng 0.094 n
Range: 3/32
Active ownship: Panamax Loa
Active target: 8:Bow 40t

Area Edit
File: fibreco_hi_june3.etd Elements 13404
Latitude: N49.18.491
Longitude: W123.06.569
Layer depth [m]: 0.2
Current Values
Speed [kn]: 1.1
Direction [deg]: 072
Tide water level [m]: 0.5

For comparative purposes, when the flood stream is 1.8 knots at First Narrows, it is flowing at 1.1 knots at the dock.

Figure 9: Surface Tidal Stream Flow at FIBRECO at Maximum Flood



Polaris Instructor Station 1 - [Master of Fibreco Max Flood in Vancouver_Viterra]

17:30:00

Display reference: Free
Brg 064.6°
Rng 0.206 n
Range: 3/32

File: fibreco_hi_june3.etd
Elements 13404

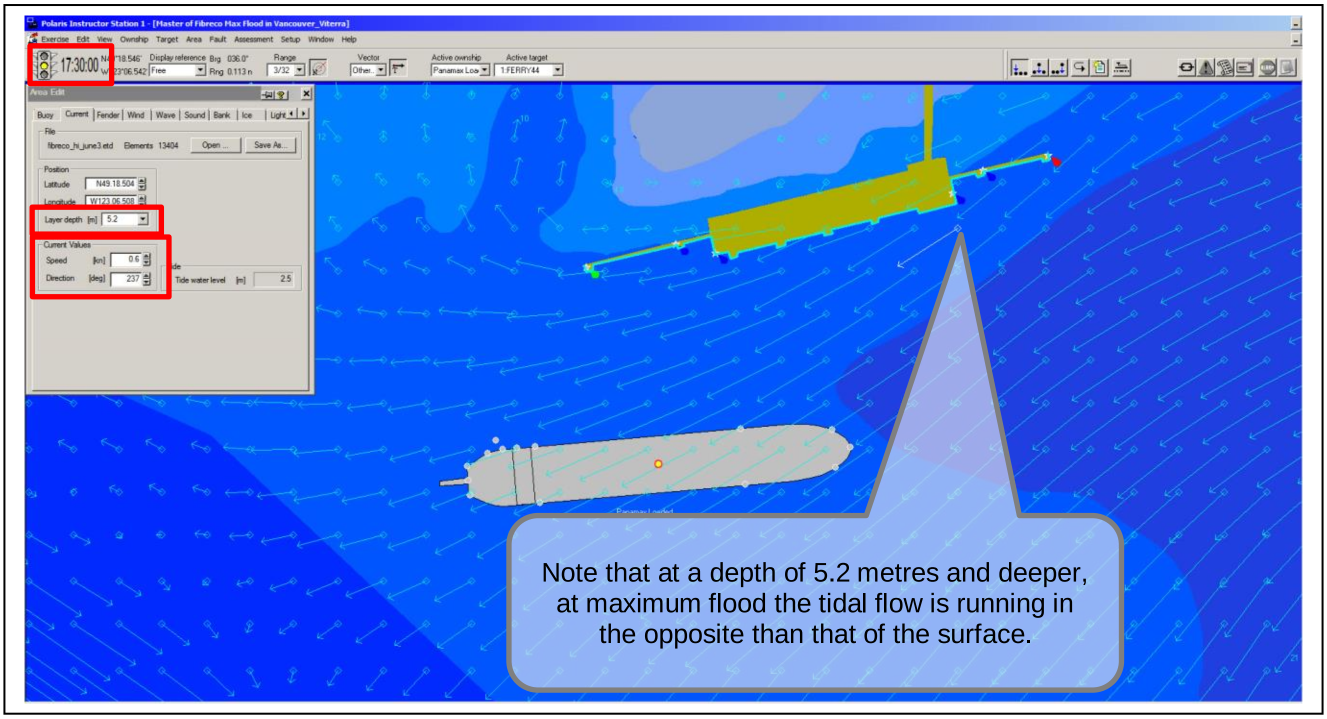
Latitude: N49.18.491
Layer depth [m]: 0.2

Current Values
Speed [kn]: 0.4
Direction [deg]: 076
Tide water level [m]: 2.5

Two hours and 45 minutes later than in Figure 8, when the flood stream is 3.8 knots at First Narrows, the back eddy is well developed along the 20 metre contour, and the tidal stream is flowing at 0.4 knots at the dock.

It is also important to note that particularly in the advanced stages of the flood tidal stream, the water flow at depths greater than 5 metres is often flowing in the opposite direction of the surface current, hence further reducing the overall effect it has on the vessel. Compare Figure 9 above to Figure 10 below.

Figure 10: Tidal Stream Flow Past FIBRECO at Depth of 5.2 Metres during Maximum Flood



Polaris Instructor Station 1 - [Master of Fibreco Max Flood in Vancouver_Viterra]

17:30:00

Display reference: Free
Brg 036.0°
Rng 0.113 n
Range: 3/32

Active target: 1:FERRY44

Area Edit

File: fibreco_hi_june3.etd
Elements 13404

Latitude: N49.18.504
Longitude: W123.06.508
Layer depth [m]: 5.2

Current Values
Speed [kn]: 0.6
Direction [deg]: 237
Tide water level [m]: 2.5

Note that at a depth of 5.2 metres and deeper, at maximum flood the tidal flow is running in the opposite than that of the surface.

4.2 Berthing Runs Flood Tidal Stream

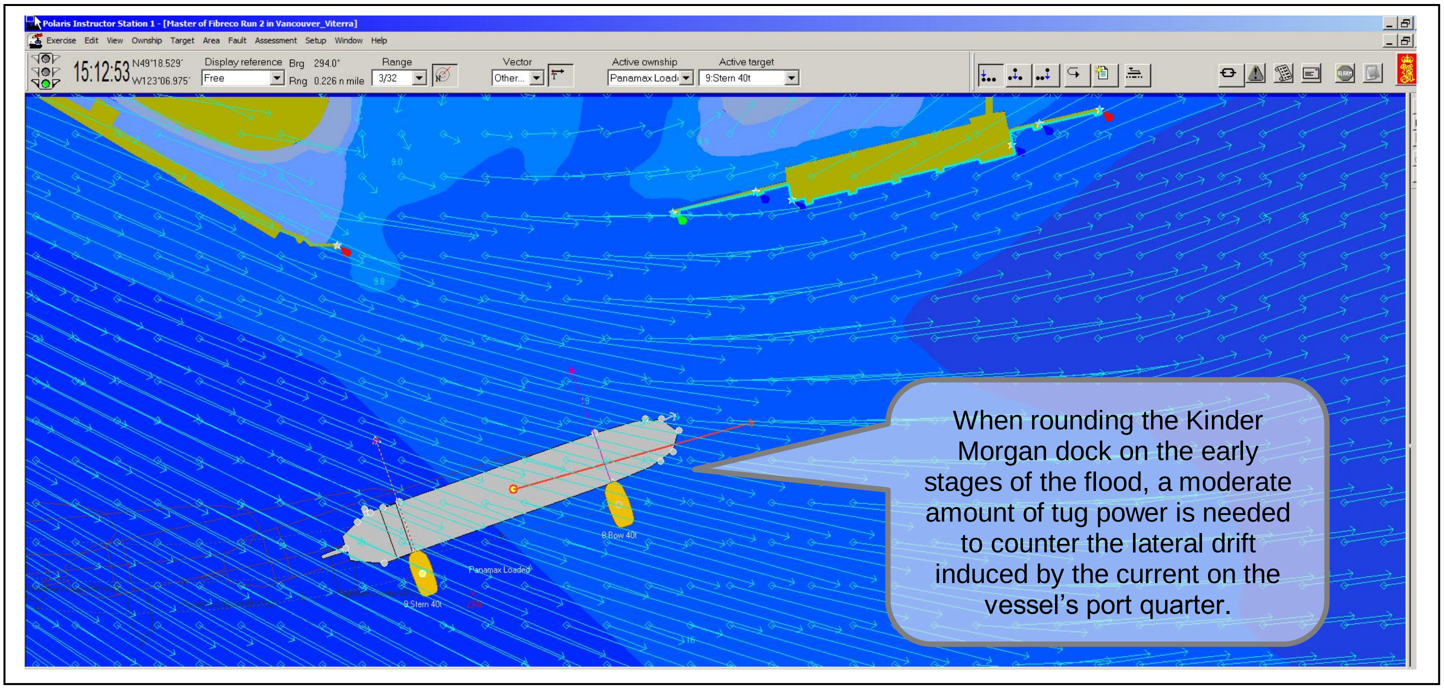
Consistent with the pilot’s experience handling HANDYMAX ships at FIBRECO, manoeuvres with the PANAMAX vessel were more complicated during conditions of flood tidal stream as the current flow is highly dynamic and the vessel is nearly constantly transitioning from one area of tidal influence to another. Of the thirteen arrival runs that were conducted, nine were in conditions of flood tidal stream, and included both port (preferred side for loading) and starboard side berthing with both partially loaded and ballasted vessels. Arrivals were also conducted with vessels in Anchorage position A and X and with outbound vessel traffic that had to be incorporated into the manoeuvre out of the narrows and onto the approach track. All berthing runs with the flood tidal stream were successful and did not require excessive use of tug power, or present any undue risk to the vessel.

The first flood tidal stream arrival was conducted shortly after “turn to flood” when the velocity at First Narrows was approximately 1 knot. The second run was conducted near the end of the first hour of the flood cycle when the velocity in First Narrows was approximately 2 knots. All other runs were conducted in the advanced stage of the flood tide (both on days with a big rise/fall and moderate rise/fall) when the velocity in First Narrows exceeded 3.0 knots. To maintain realism, the pilots were briefed in advance of the stage of the tide, but did not study the complex patterns of the predicted back-eddies and tidal flow until after completing the simulated runs. This practice ensured that the pilots needed to respond to the dynamic effects of the currents throughout the inbound transit. After conducting several runs and developing a better sense of the position and magnitude of the cycloidal back eddy, the pilots were actually able to use this to manoeuvring advantage even under conditions of maximum flood tidal stream in order to affect both port and starboard side landings.

When proceeding to FIBRECO, it is generally preferred to pass outbound vessels “starboard to starboard”, however several runs were conducted where the pilots deliberately passed outbound traffic “port to port” which then forced them to keep to the south side of the Narrows, and then cross the “tidal race” as they approached the berth. Even in this situation the manoeuvre was quite manageable as the two 40 tonne ASD tugs provided sufficient power to both check vessel rotation and to manage lateral drift induced by the cross current. It was also found that with vessels in both Anchorage A and X that it was more efficient to conduct all manoeuvres to the west of the anchorages as opposed to passing between the anchored vessels and approaching FIBRECO from the north/east side of the anchorages.

See illustrations in Figures 11 to 20 on the pages that follow:

Figure 3: Approaching FIBRECO One Hour into Flood Tide


Polaris Instructor Station 1 - [Master of Fibreco Run 2 in Vancouver_Viterra]

15:12:53 N49°18.529′ W123°06.975′

Display reference: Free

Brg 294.0°

Rng 0.226 n mile

Range: 3/32

Vector: Other...

Active ownship: Panamax Load

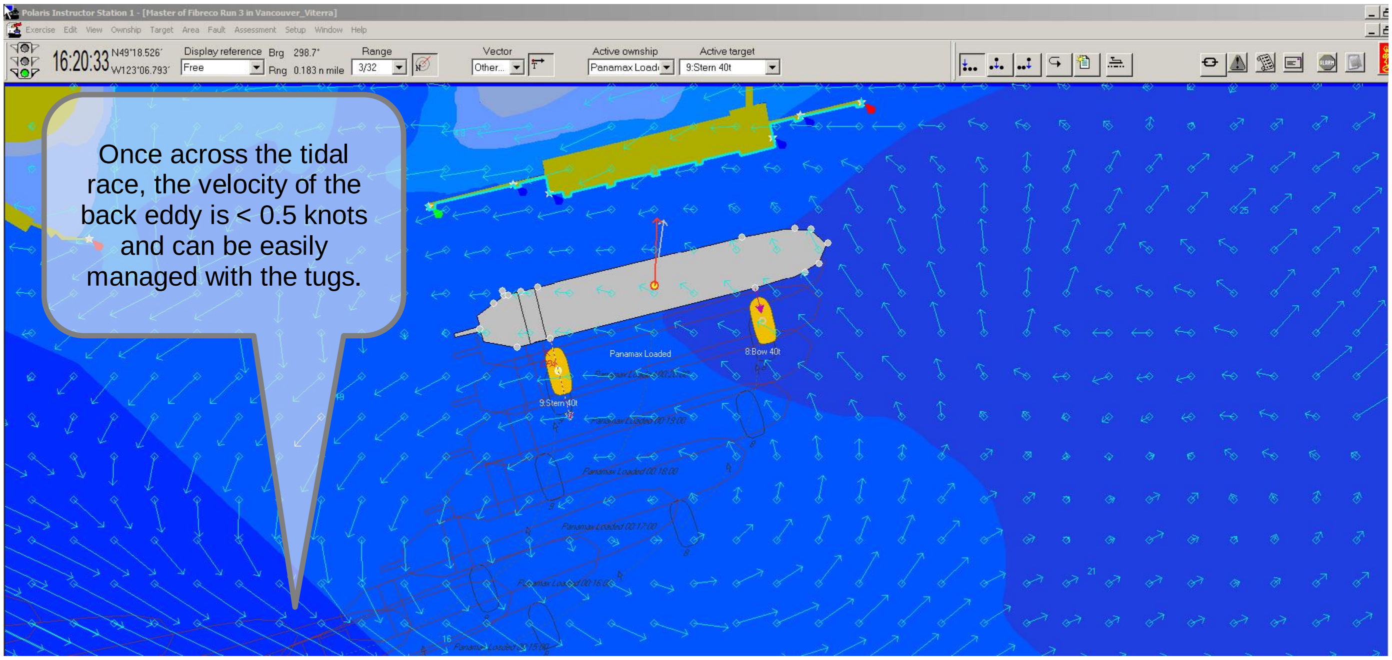
Active target: 9:Stern 40t

When rounding the Kinder Morgan dock on the early stages of the flood, a moderate amount of tug power is needed to counter the lateral drift induced by the current on the vessel's port quarter.

Figure 4: Approaching FIBRECO One Hour into Flood Tide – Applied Tug Forces

The bow tug is used briefly at full power when rounding the Kinder Morgan dock but once steadied on the approach to FIBRECO, less than 20 tonnes of applied tug force was required to complete the manoeuvre.

Figure 13: Approaching FIBRECO Two Hours into Flood Cycle

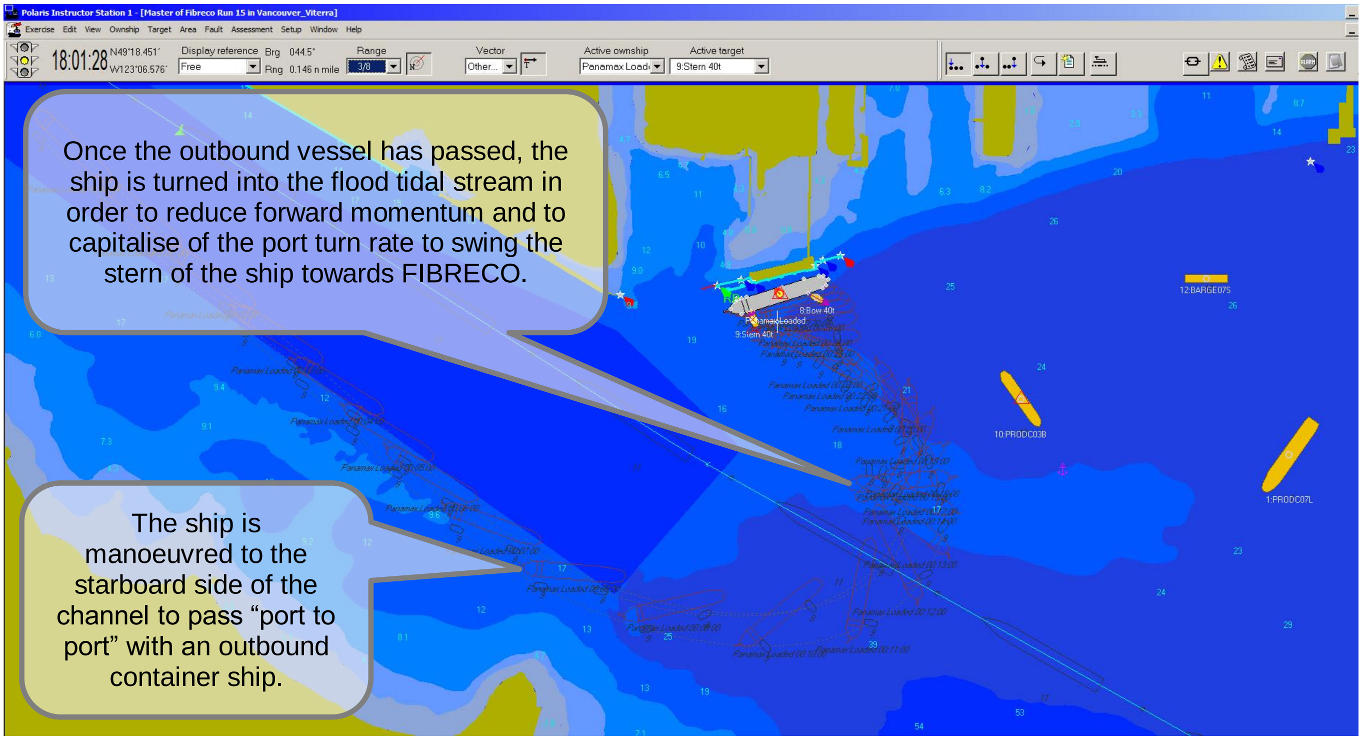


Once across the tidal race, the velocity of the back eddy is < 0.5 knots and can be easily managed with the tugs.

Figure 14: Approaching FIBRECO Two Hours into Flood Cycle – Applied Tug Forces

Full tug power is used for several minutes while crossing the tidal race, but is then reduced to less than 20 tonnes for the remainder of the berthing manoeuvre.

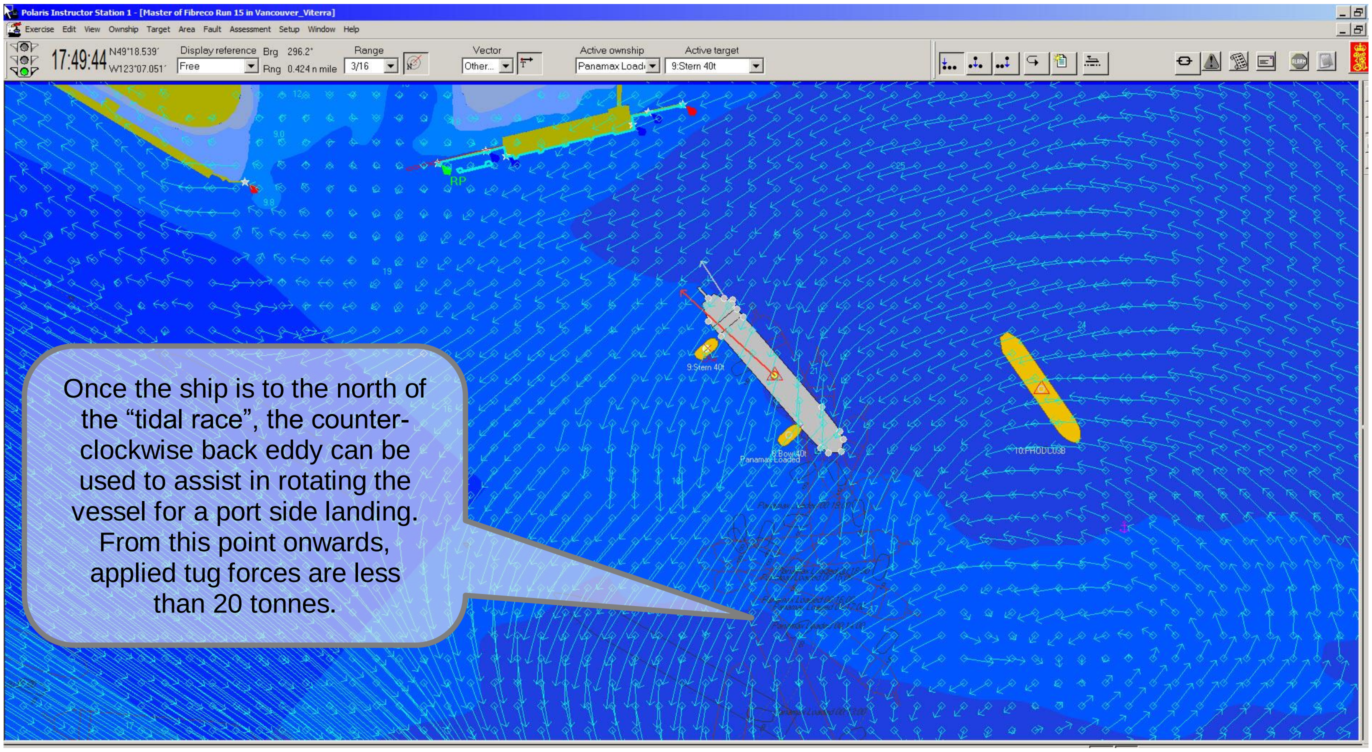
Figure 5: Approaching FIBRECO at Maximum Flood – Passing Outbound Ship to Port



Once the outbound vessel has passed, the ship is turned into the flood tidal stream in order to reduce forward momentum and to capitalise of the port turn rate to swing the stern of the ship towards FIBRECO.

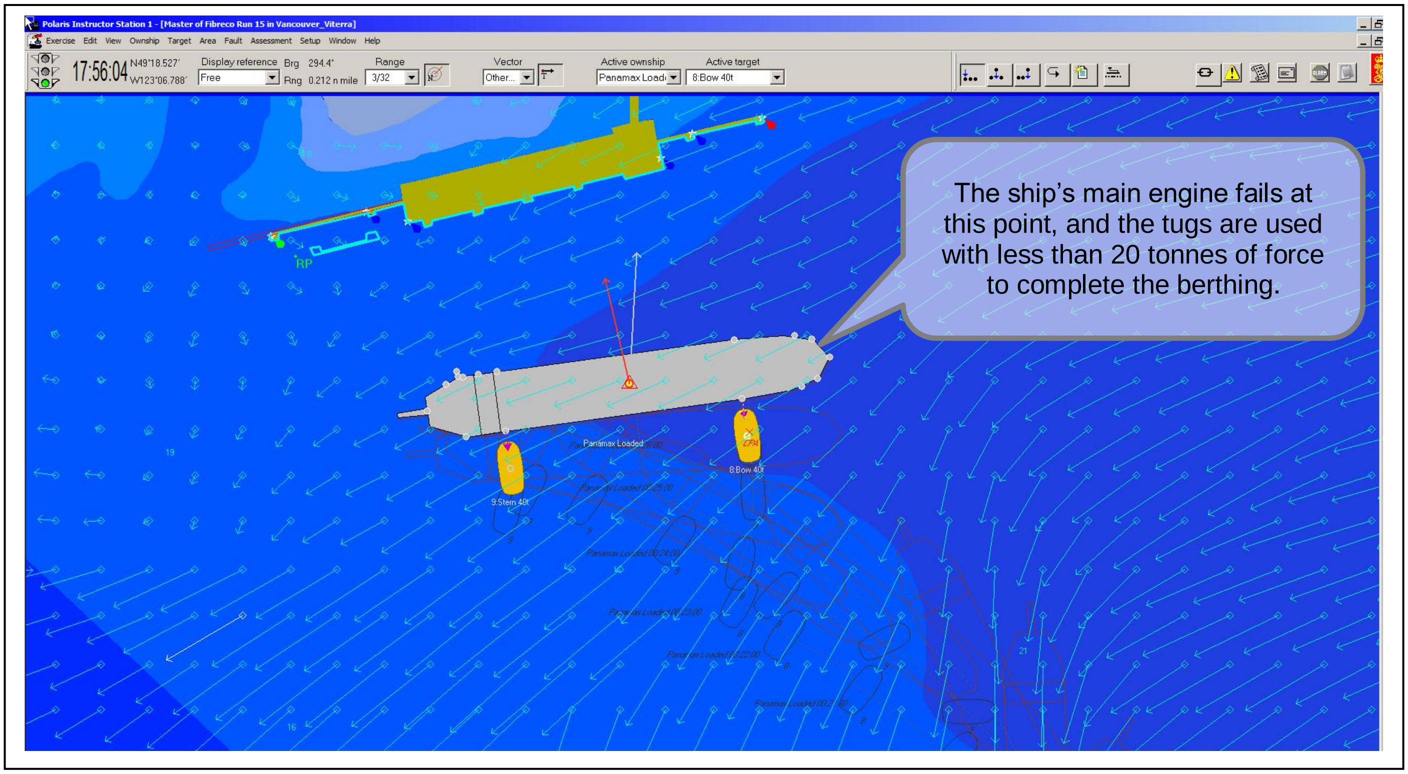
The ship is manoeuvred to the starboard side of the channel to pass "port to port" with an outbound container ship.

Figure 6: Approaching FIBRECO at Maximum Flood – Using Back Eddy to Rotate Vessel



Once the ship is to the north of the "tidal race", the counter-clockwise back eddy can be used to assist in rotating the vessel for a port side landing. From this point onwards, applied tug forces are less than 20 tonnes.

Figure 7: Approaching FIBRECO at Maximum Flood – Ship's Main Engine Failure



Polaris Instructor Station 1 - [Master of Fibreco Run 15 in Vancouver_Viterra]

17:56:04 N49°18.527' W123°06.788'

Display reference: Free

Brg 294.4°

Rng 0.212 n mile

Range: 3/32

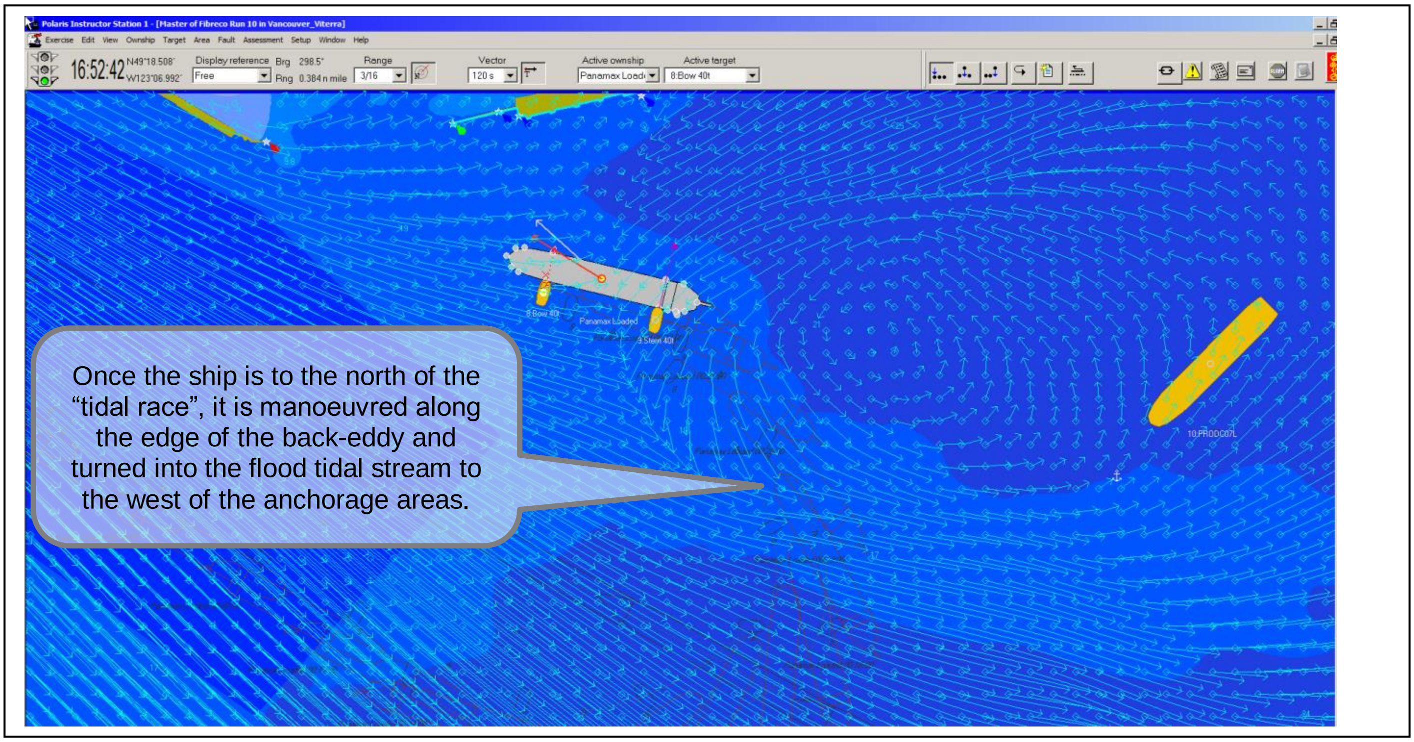
Vector: Other...

Active ownship: Panamax Loaded

Active target: 8:Bow 40t

The ship's main engine fails at this point, and the tugs are used with less than 20 tonnes of force to complete the berthing.

Figure 18: Approaching FIBRECO at Maximum Flood Starboard Side – Turning into Current



Polaris Instructor Station 1 - [Master of Fibreco Run 10 in Vancouver_Viterra]

16:52:42 N49°18.508' W123°06.992'

Display reference: Free

Brg 298.5°

Rng 0.384 n mile

Range: 3/16

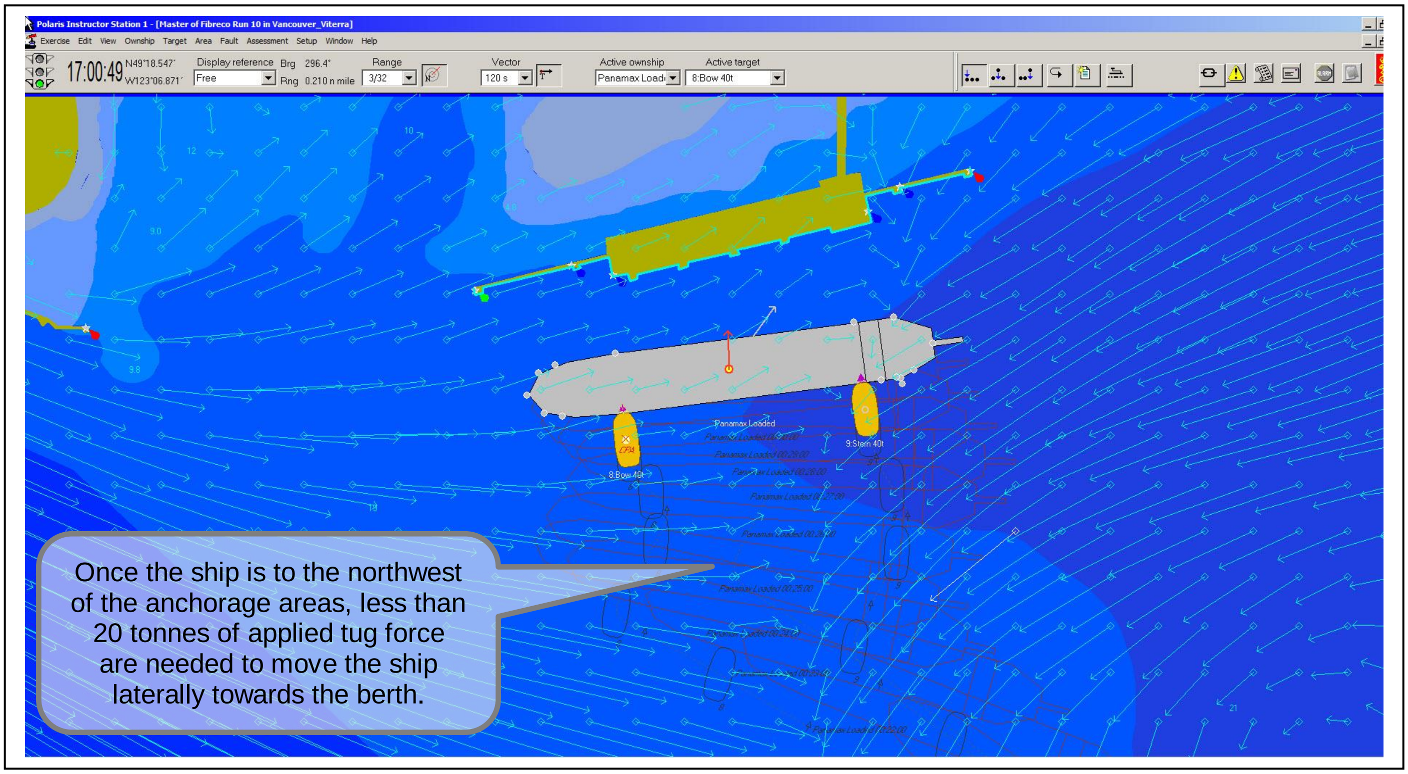
Vector: 120 s

Active ownship: Panamax Loaded

Active target: 8:Bow 40t

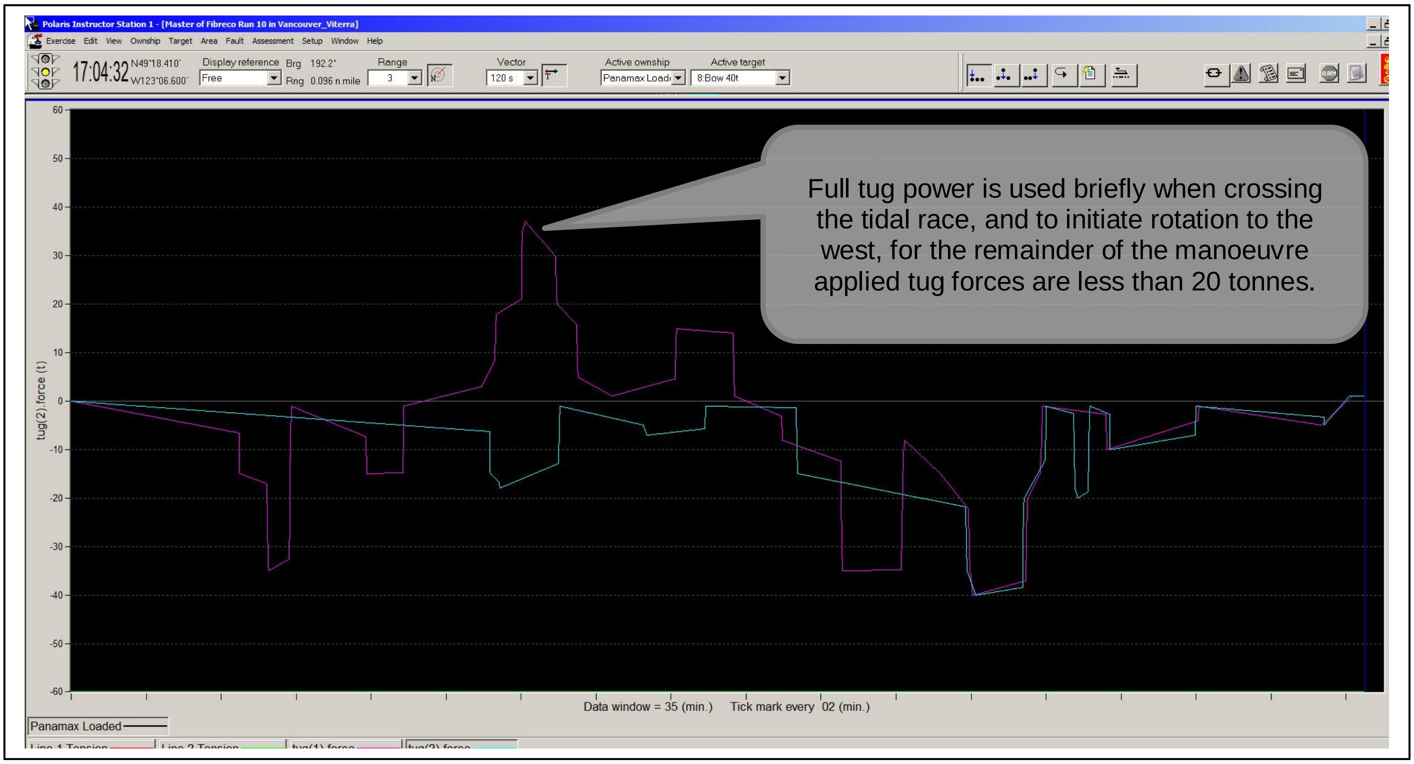
Once the ship is to the north of the "tidal race", it is manoeuvred along the edge of the back-eddy and turned into the flood tidal stream to the west of the anchorage areas.

Figure 8: Approaching FIBRECO at Maximum Flood Starboard Side – Final Approach



Once the ship is to the northwest of the anchorage areas, less than 20 tonnes of applied tug force are needed to move the ship laterally towards the berth.

Figure 20: Approaching FIBRECO at Maximum Flood Starboard Side – Applied Tug Forces



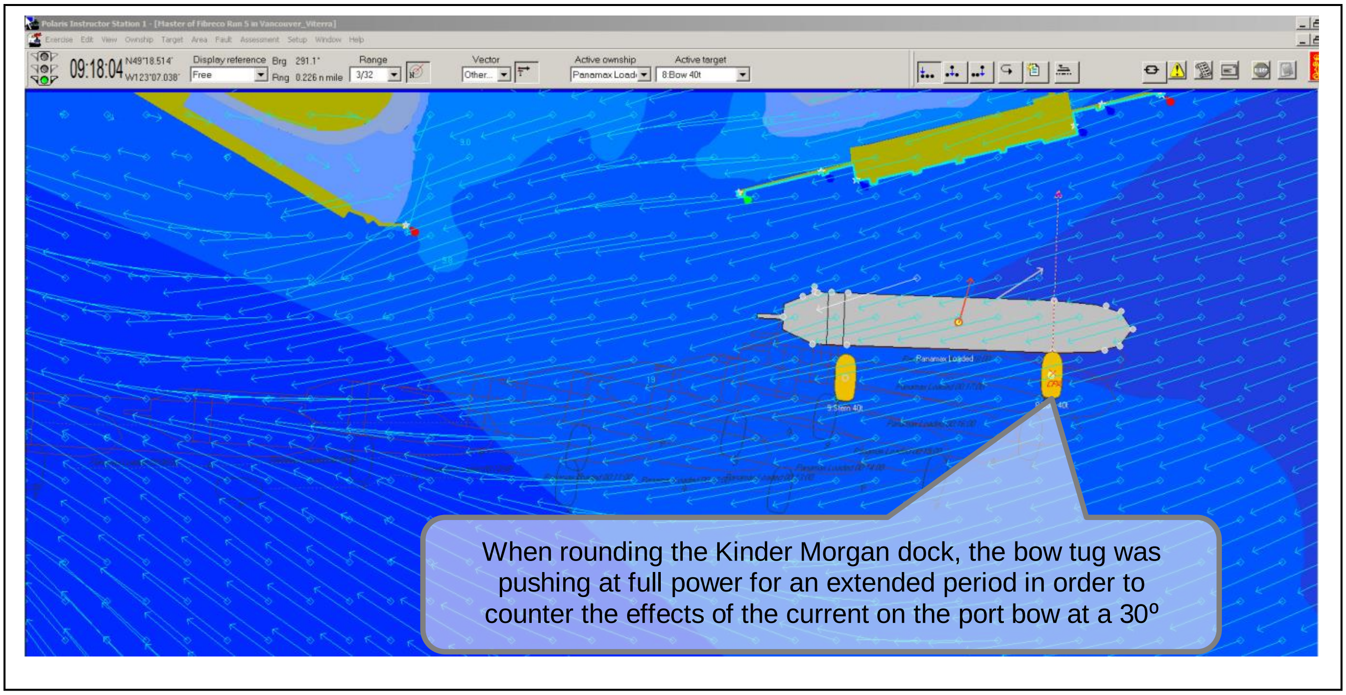
Full tug power is used briefly when crossing the tidal race, and to initiate rotation to the west, for the remainder of the manoeuvre applied tug forces are less than 20 tonnes.

4.3 Berthing Runs Ebb Tidal Stream

The ebb tidal flow in the vicinity of FIBRECO tends to be very linear, with little or no back eddy effect. This phenomena creates conditions for a port side landing that are fundamentally easier to manage than on the flood tidal flow. Four berthing runs were conducted with the ebb stream and they were all port side (preferred side landings). Interestingly, it was noted that on the early stages of the ebb stream that the surface current actually flow faster along the face of the FIBRECO berth than it does during more advanced stages of the ebb stream. As a consequence, more tug force was used to berth the ship when the tidal velocity was 1.4 knots at First Narrows, than when the tidal stream was 3.4 knots at the Narrows.

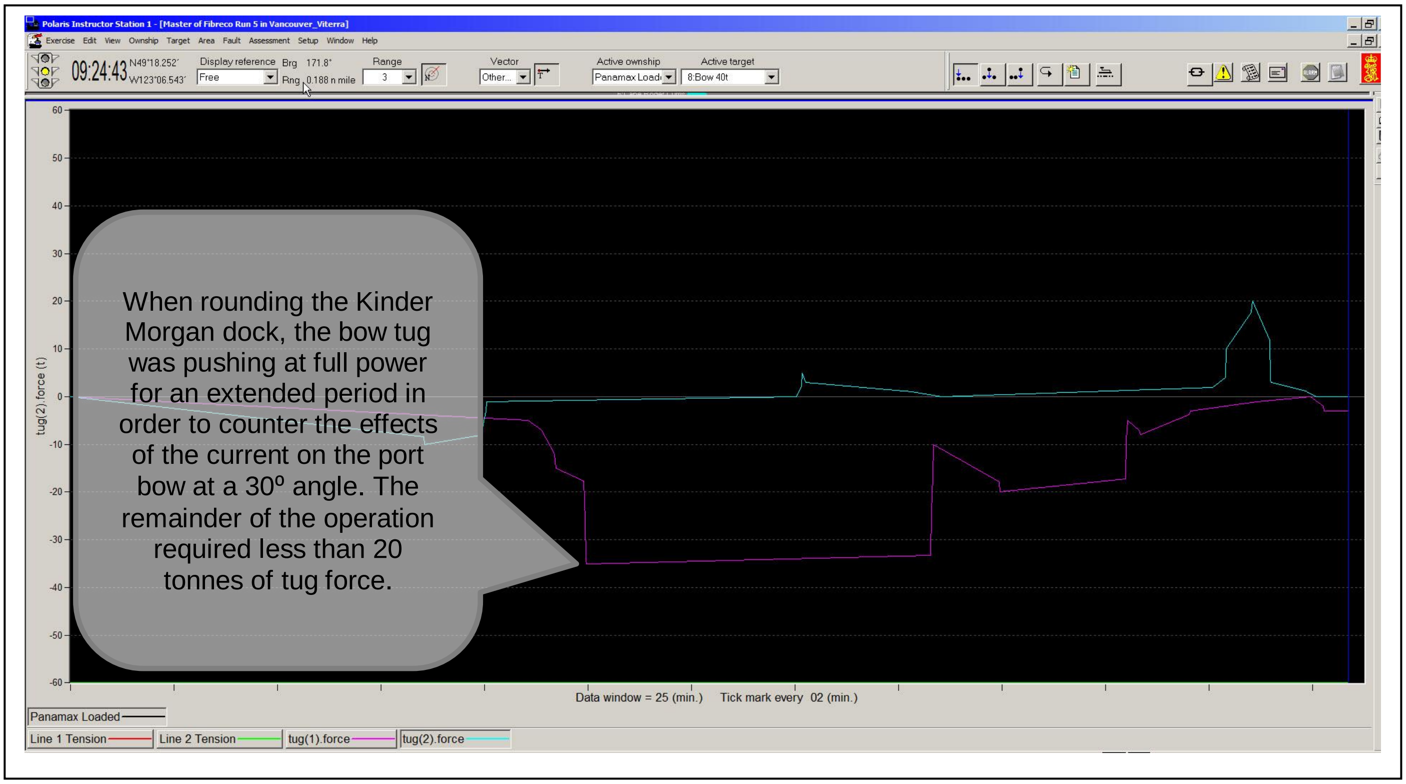
See illustrations in Figures 21 to 25:

Figure 21: Approaching FIBRECO One Hour into Ebb Tide – Aligning on Approach



When rounding the Kinder Morgan dock, the bow tug was pushing at full power for an extended period in order to counter the effects of the current on the port bow at a 30º

Figure 92: Approaching FIBRECO One Hour into Ebb Tide – Applied Tug Forces


Polaris Instructor Station 1 - [Master of Fibreco Run 5 in Vancouver_Viterra]

09:24:43 N49°18.252′ W123°06.543′

Display reference: Free

Brg 171.8°

Rng 0.188 n mile

Range: 3

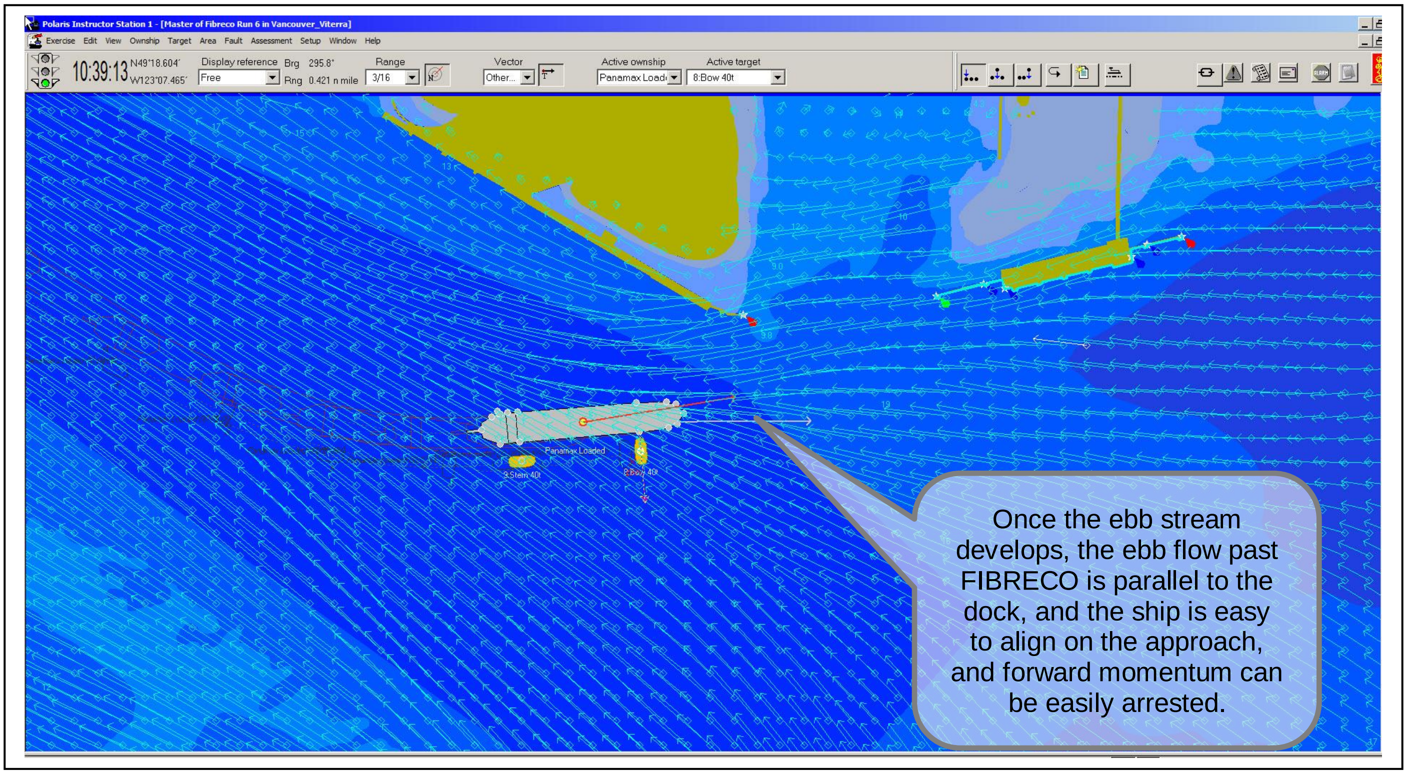
Vector: Other...

Active ownship: Panamax Loadi

Active target: 8:Bow 40t

When rounding the Kinder Morgan dock, the bow tug was pushing at full power for an extended period in order to counter the effects of the current on the port bow at a 30º angle. The remainder of the operation required less than 20 tonnes of tug force.

Figure 103: Approaching FIBRECO at 2.5 hours into Ebb Tide


Polaris Instructor Station 1 - [Master of Fibreco Run 6 in Vancouver_Viterra]

10:39:13 N49°18.604′ W123°07.465′

Display reference: Free

Brg 295.8°

Rng 0.421 n mile

Range: 3/16

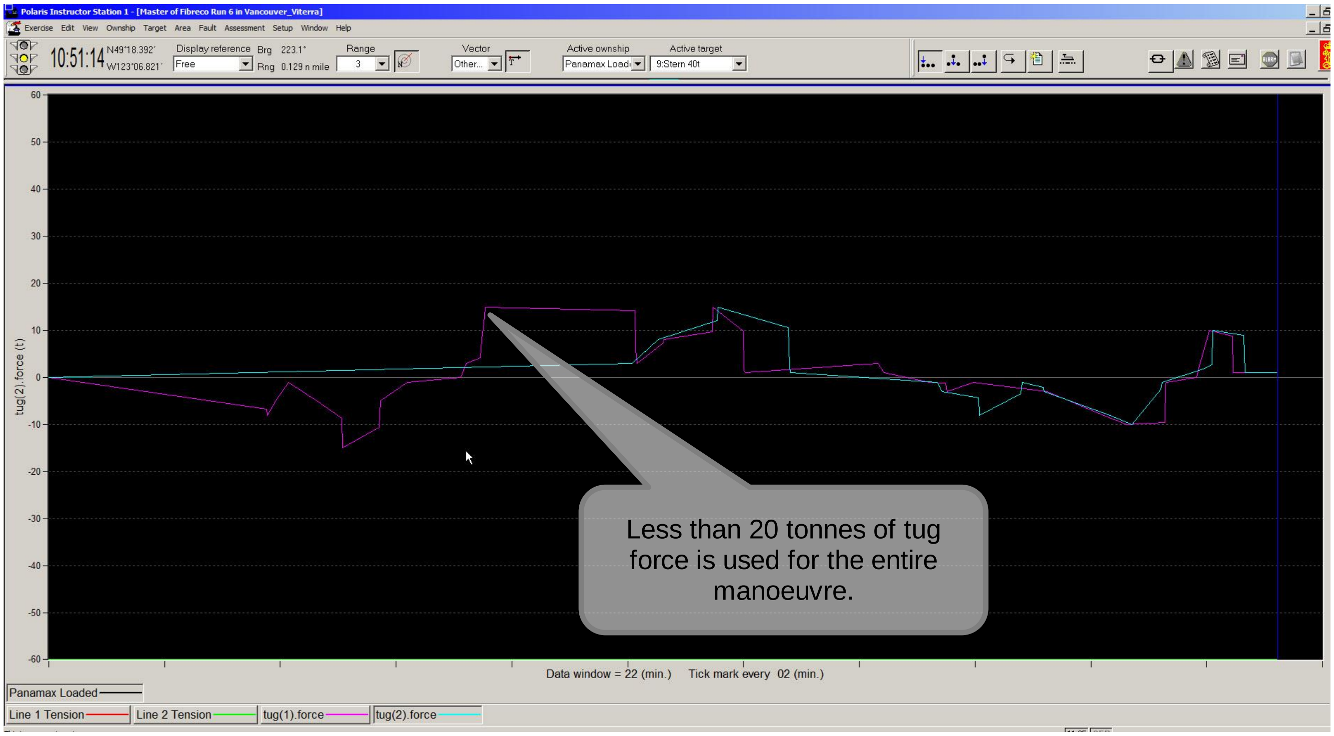
Vector: Other...

Active ownship: Panamax Loadi

Active target: 8:Bow 40t

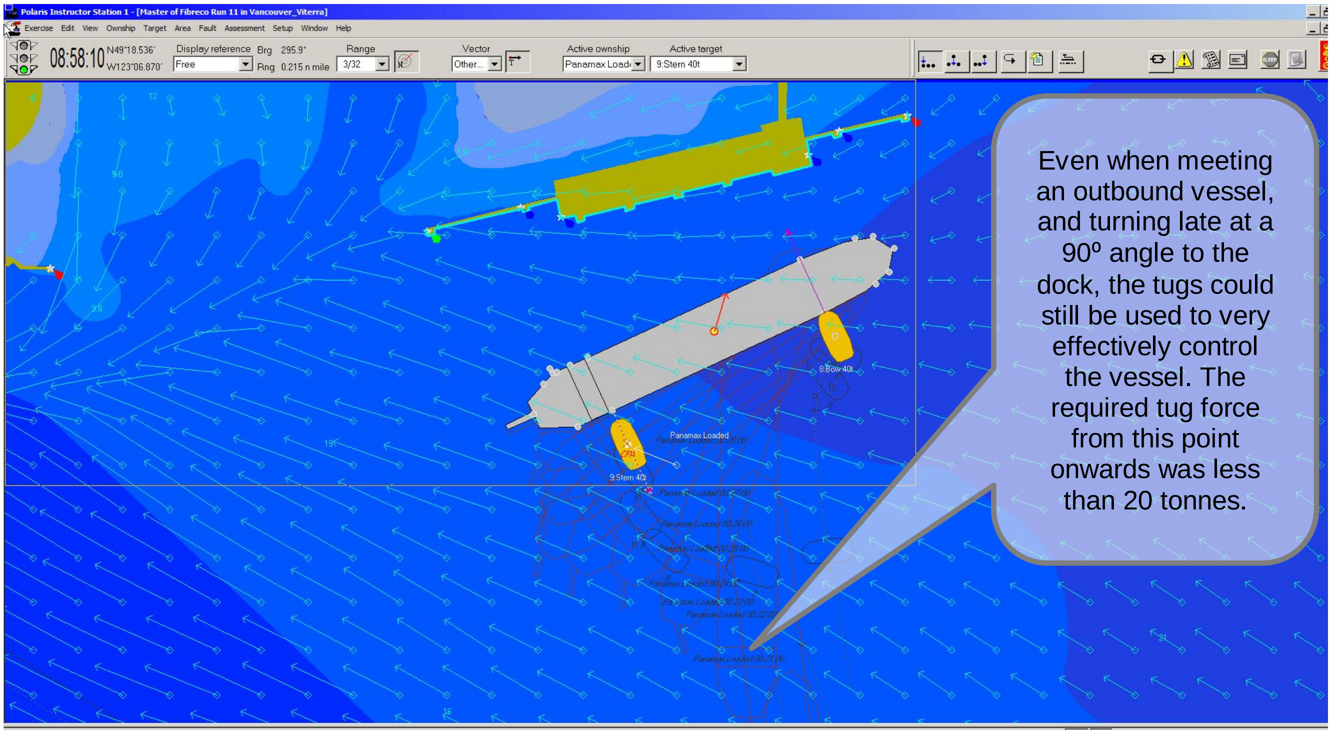
Once the ebb stream develops, the ebb flow past FIBRECO is parallel to the dock, and the ship is easy to align on the approach, and forward momentum can be easily arrested.

Figure 11: Approaching FIBRECO at 2.5 hours into Ebb Tide – Applied Tug Force



Less than 20 tonnes of tug force is used for the entire manoeuvre.

Figure 125: Approaching FIBRECO first hour of Ebb Tide – Meeting Outbound Vessel

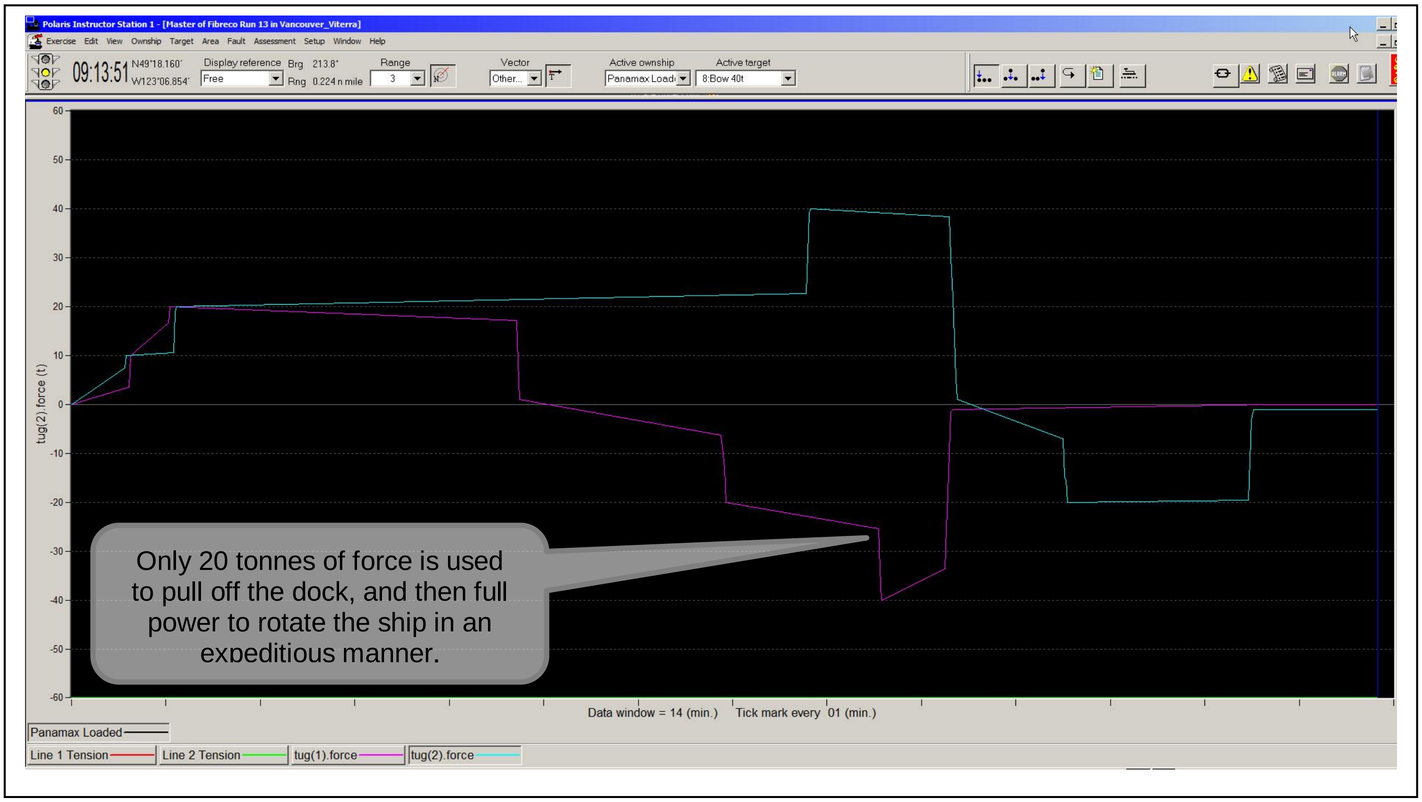


Even when meeting an outbound vessel, and turning late at a 90º angle to the dock, the tugs could still be used to very effectively control the vessel. The required tug force from this point onwards was less than 20 tonnes.

4.4 Un-berthing Runs

Two departure scenarios were conducted; one at maximum ebb tidal stream, the other at maximum flood tidal stream, and both with a vessel loaded to 11.5 metres draught and port side to the dock. For both manoeuvres, less than 20 tonnes of force on each tug was required to pull the ship off the dock. Once sufficient lateral separation was generated between the vessel and the berth, the ship was rotated to port to proceed outbound. To rotate the ship, full tug power was used, mainly to expedite the manoeuvre. See figures 26 and 27:

Figure 13: Departure FIBRECO at Maximum Ebb – Applied Tug Forces

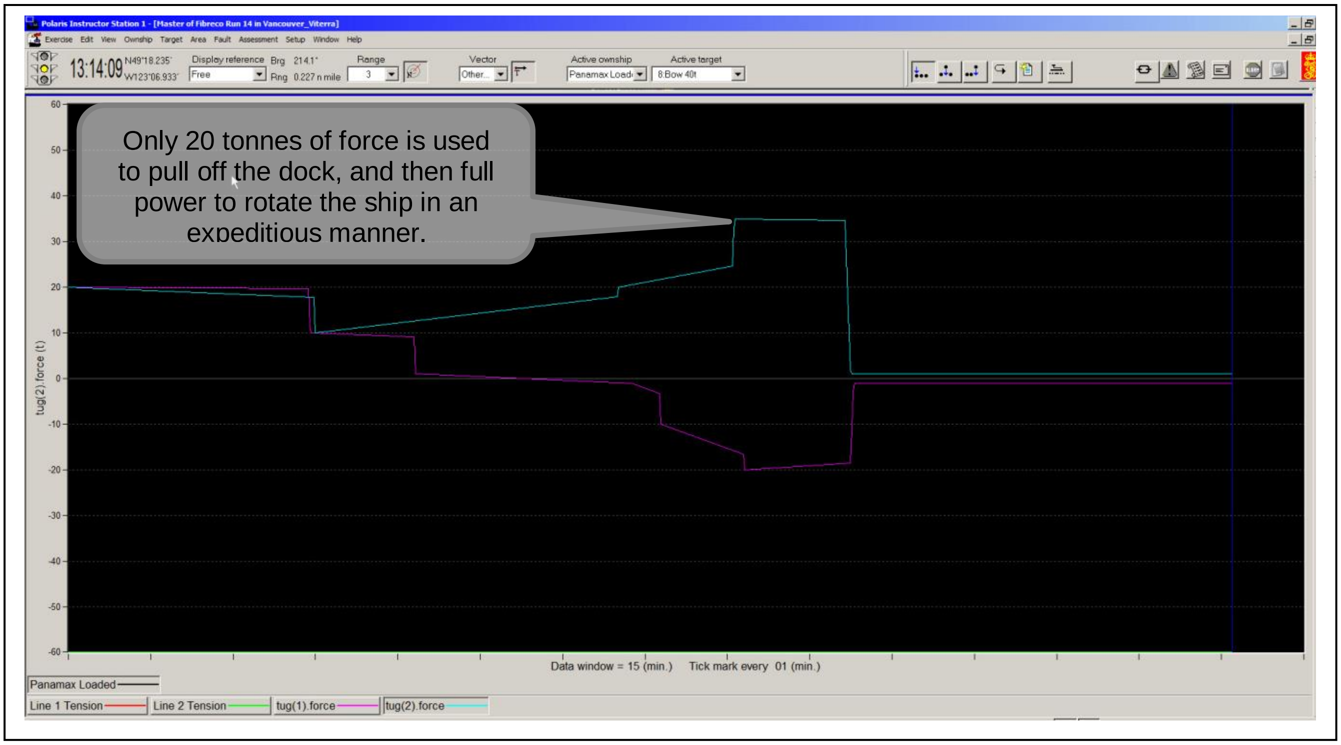


Display reference: Free
Brg 213.8°
Rng 0.224 n mile
Range: 3
Vector: Other...
Active ownship: Panamax Load
Active target: 8:Bow 40t

Data window = 14 (min.) Tick mark every 01 (min.)

Only 20 tonnes of force is used to pull off the dock, and then full power to rotate the ship in an expeditious manner.

Figure 14: Departure FIBRECO at Maximum Flood – Applied Tug Forces



Polaris Instructor Station 1 - [Master of Fibreco Run 14 in Vancouver_Viterra]

13:14:09 N49°18.235' W123°06.933'

Display reference: Free

Brg 214.1°

Rng 0.227 n mile

Range: 3

Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Only 20 tonnes of force is used to pull off the dock, and then full power to rotate the ship in an expeditious manner.

Data window = 15 (min.) Tick mark every 01 (min.)

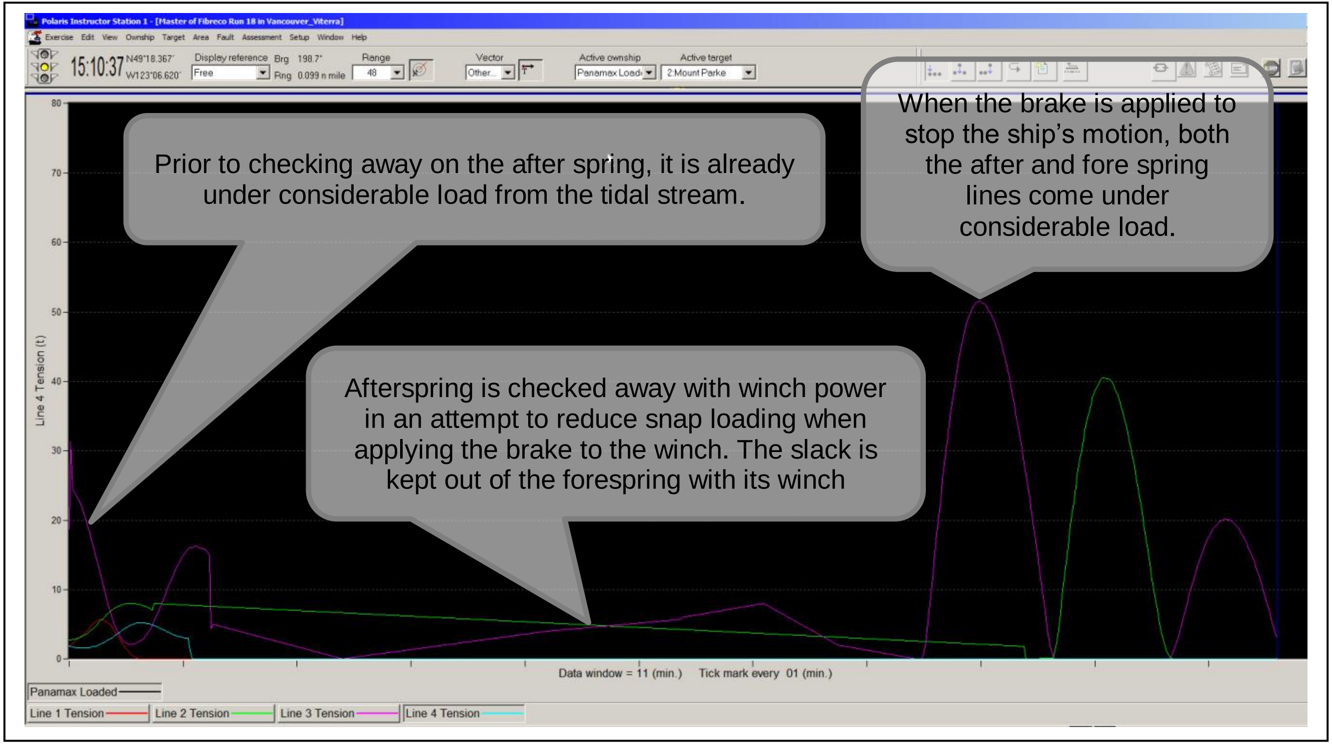
4.5 Assist Tug Requirements

In order to conduct arrival and departure manoeuvres under a full range of tidal conditions, it was found that as a minimum two 40 tonne BP, ASD tugs were required. Contrary to many docking operations, (where the tugs are used primarily in the final stages of the berthing approach), the role of the tugs for vessel moves at FIBRECO, is equally important in manoeuvring the ship onto the optimal approach track, and for assisting with managing the highly variable tidal forces that are exerted on the ship while it is navigating at speeds greater than three knots. It should also be noted that the forces applied to the ship's hull when pushing were always less than 30 tonnes per square metre, and well within the limits that would not inflict damage on the vessel. For the majority of the runs, the highest tug forces were being applied while the ship was either being turned in the back eddy, or crossing the tidal bore, and while the ship's speed through the water of greater than four knots. It is important to note that conventional tugs, even those with static bollard pull ratings of 40 tonnes or more are not suited to this task as they cannot effectively apply the power that is needed at speeds above two knots.

4.6 Warping Along the Dock

Three warping moves were conducted, in all cases the ship as port side to the dock (preferred berthing arrangement). Two warping moves were with conditions of flood tidal stream and one with ebb; in all cases the tidal flow was setting away from the dock. The ship was moved using shipboard winches with a maximum applied force on the winch of 10 tonnes. The procedure consisted of shortening in on the forespring to generate some initial vessel movement in the astern direction, while checking away on the after spring. In most situations, the tidal stream along the face of the dock was running in a westerly direction causing the vessel to move astern as soon as some slack was placed onto the afterspring line. For two of the runs, the winch on the after spring was actually used at 5 to 10 tonnes in an attempt to slow the rate at which the ship was generating astern or westerly velocity. As the ship approached the desired position on the dock, the brake was applied to the afterspring winch in order to arrest the vessel's astern motion. In two cases this resulted in extreme loads being placed on the afterspring line. In the other case, the tidal stream rather than accelerating the ship astern, actually lifted it away from the dock as force was applied to the afterspring. See Figures 28 and 29.

Figure 15: Warping Along the Dock – Resultant Mooring Line Forces

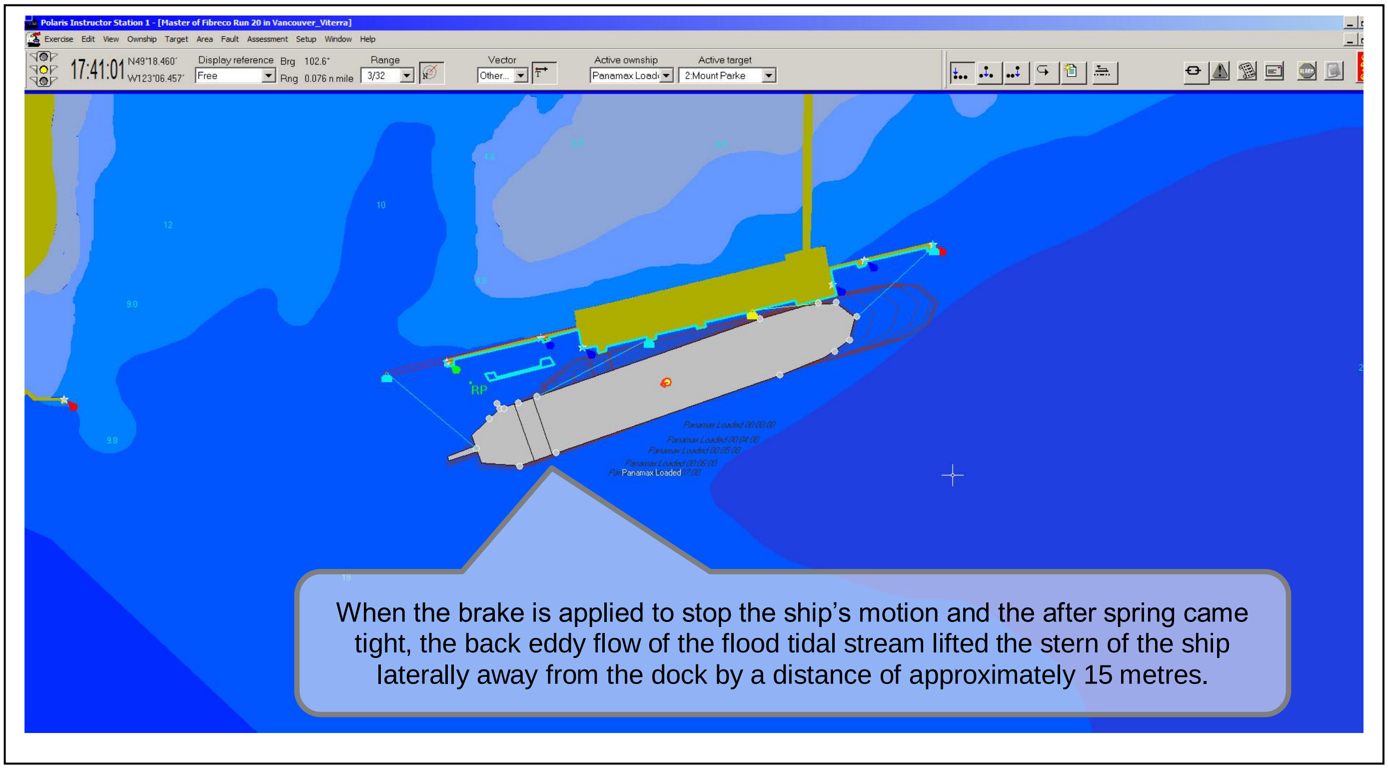


Prior to checking away on the after spring, it is already under considerable load from the tidal stream.

When the brake is applied to stop the ship's motion, both the after and fore spring lines come under considerable load.

Afterspring is checked away with winch power in an attempt to reduce snap loading when applying the brake to the winch. The slack is kept out of the forespring with its winch

Figure 29: Warping Along the Dock – Vessel Motion



Polaris Instructor Station 1 - [Master of Fibreco Run 20 in Vancouver_Viterra]

17:41:01 N49°18.460′ W123°06.457′

Display reference: Free

Brg 102.6°

Rng 0.076 n mile

Range: 3/32

Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

When the brake is applied to stop the ship's motion and the after spring came tight, the back eddy flow of the flood tidal stream lifted the stern of the ship laterally away from the dock by a distance of approximately 15 metres.

5 Recommendations

Based on the findings described above, and supported by the illustrations in Appendix 1, the following actions are recommended.

5.1 Dynamic Tidal Gauges

1 It is recommended that Doppler current meters capable of broadcasting via AIS live/actual tidal stream velocity and direction data be installed at both the east and west ends of the FIBRECO berth. The live information provided by these devices would be received on the Pilot's PPUs*** and allow them to make an assessment of the degree of berthing difficulty based on actual tidal stream velocity. The current meters should provide velocity values for the water flow at the surface, 5 metres, and 10 metre depth levels.

5.2 Minimum Assist Tug Requirements

1 Given the dynamic nature of the tidal stream flow at all stages of the tide, both at the FIBRECO berth, and in the western end of Burrard Inlet, all manoeuvres of PANAMAX size vessels to and from FIBRECO should be conducted with two ASD tugs, each with a minimum static bollard pull rating that is not less than 40 tonnes.

5.3 Environmental Limitations for Berthing and Un-Berthing Operations

1 It is recommended that no restrictions be placed on berthing or un-berthing due to wind, other than at the discretion of the pilot and ship's master to the prevailing conditions.

2 In lieu of the present guideline/practise which limits moves to times when the tidal stream at First Narrows is less than 2.0 knots, it is recommended that any restrictions on moves to and from FIBRECO be based on actual tidal stream values at the berth. This procedure would greatly increase the duration of manoeuvring/ tidal windows at FIBRECO, and permit ships to come outside of the prime transit times that are required for vessels under MRA restrictions. Berthing and un-berthing operations should be restricted to periods when the actual measured tidal stream velocity at the berth does not exceed 1.5 knots. After 12 moves have been safely made with PANAMAX size vessels (225 metres X 32.25 Metres maximum) and real world data has validated simulated findings, this restriction could then be progressively increased in increments of 0.25 knots provided that a suitable degree of manoeuvring control is being maintained.

5.4 Procedures for Warping

This analysis only provides a preliminary assessment of warping operations, however based on the three simulation runs that were conducted, the following is recommended:

1 Given the tidal flow conditions at FIBRECO, it is not recommended that warping be attempted without tug assistance. In the absence of tug assistance it is assessed

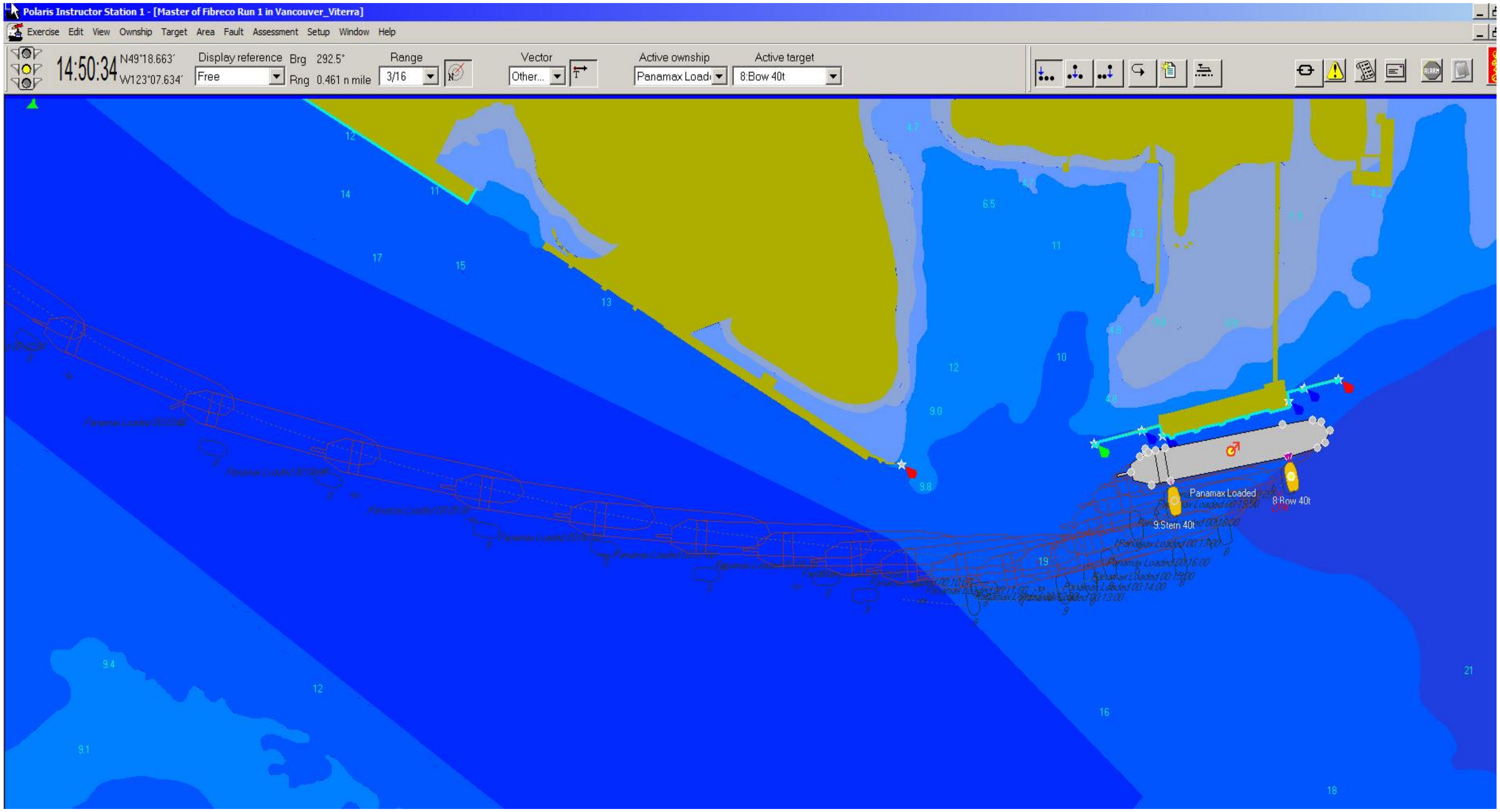
that it would be extremely difficult to control both the vessel’s current induced longitudinal speed, and lateral drift when warping.

2 A further assessment of the warping process needs to take place before exact limiting parameters can be established. This could be done either through simulation, or through real world practise once operations commence. Based on this preliminary analysis, it is recommended, at the risk of losing control of the vessel, that at least one tug (conventional or ASD) be used to ensure that the ship maintains sufficient contact with the dock fenders while warping.

3 In addition the practice of extreme warping, particularly to the west, would require the introduction of one or more additional fender dolphin in order to provide the required support to the vessel along its parallel body when warped fully to the west.

Appendix A: Tethered Escort Simulation Track Plots

Figure A1: Track Plot Simulation Run 1



Polaris Instructor Station 1 - [Master of Fibreco Run 1 in Vancouver_Viterra]

14:50:34 N49°18.663′ W123°07.634′

Display reference: Free

Brg 292.5°

Rng 0.461 n mile

Range: 3/16

Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Figure A2: Applied Tug Forces – Simulation Run 1

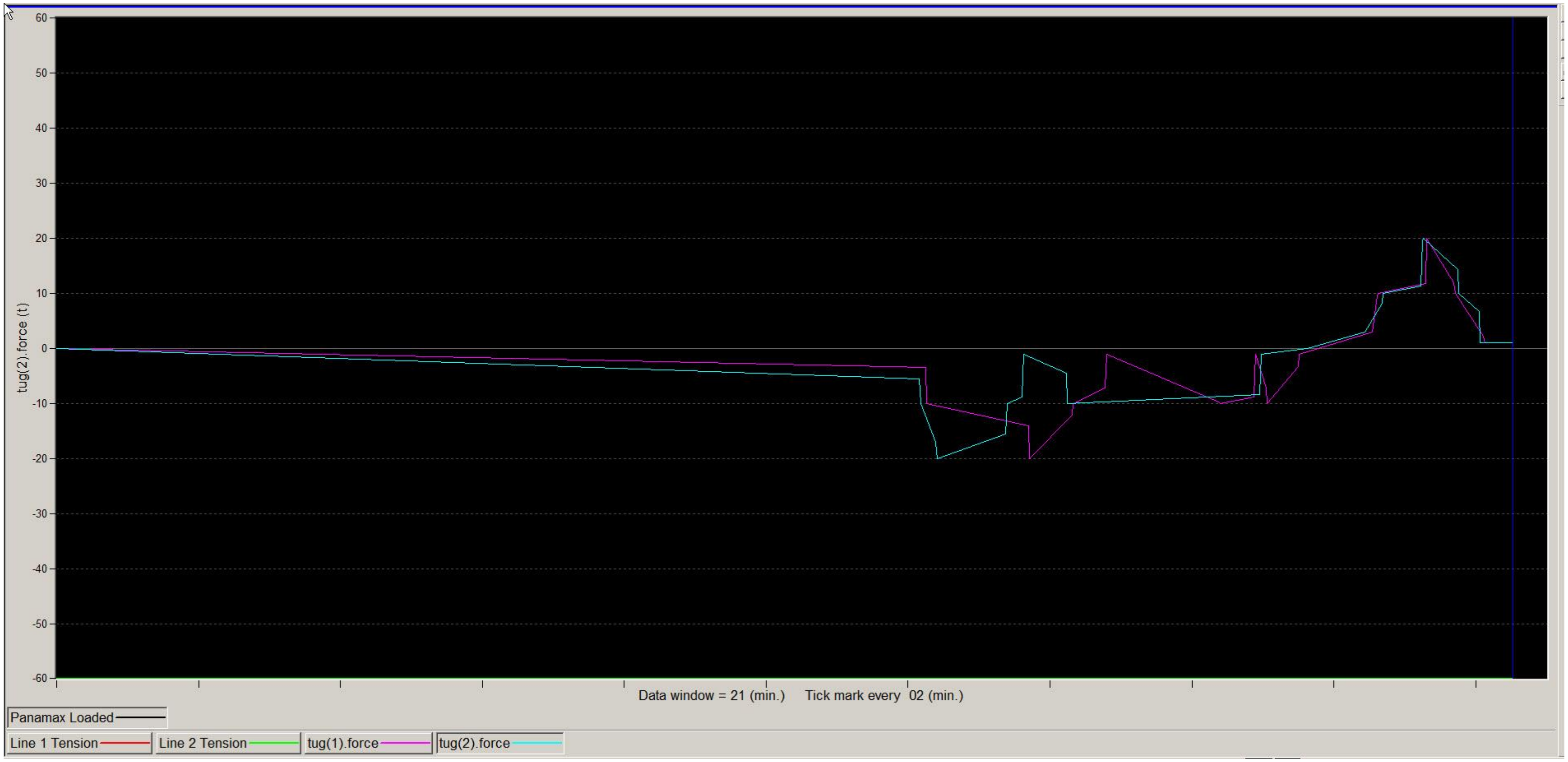
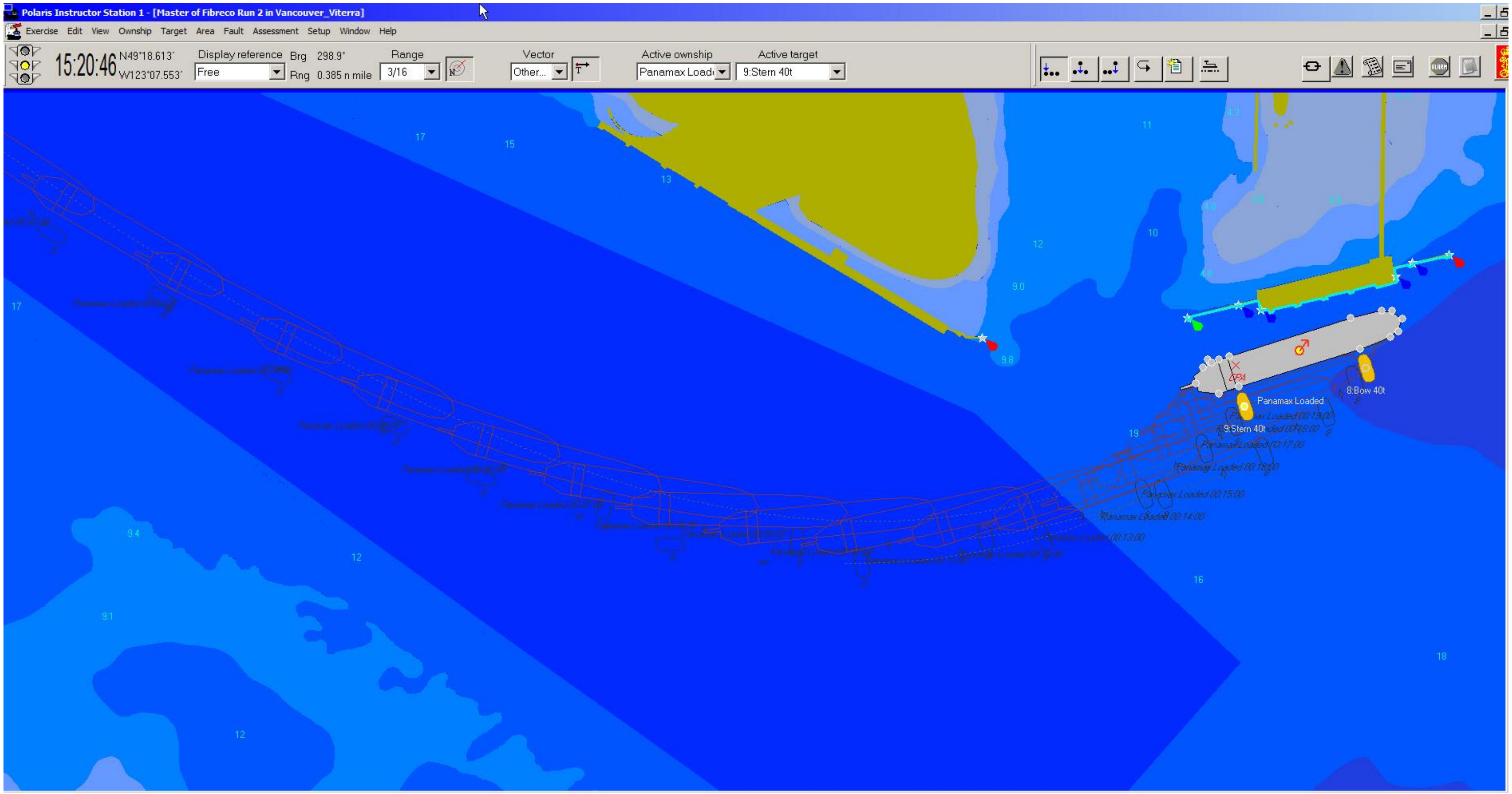


Figure A3: Track Plot Simulation Run 2



Polaris Instructor Station 1 - [Master of Fibreco Run 2 in Vancouver_Viterra]

15:20:46 N49°18.613′ W123°07.553′

Display reference: Free

Brg 298.9°

Rng 0.385 n mile

Range: 3/16

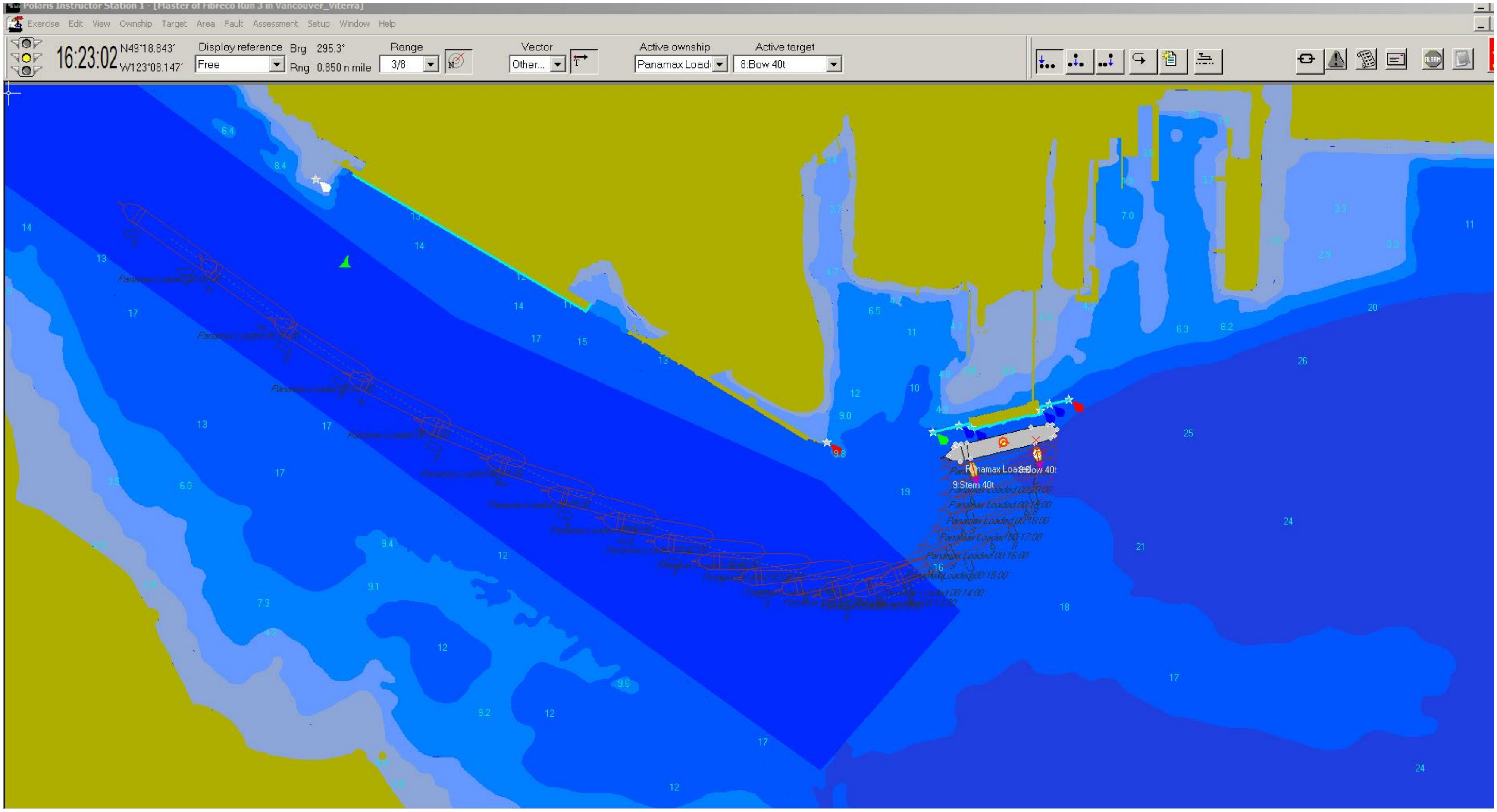
Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A4: Applied Tug Forces – Simulation Run 2

Figure A5: Track Plot Simulation Run 3



Polaris Instructor Station 1 - [Master of Fibreco Run 3 in Vancouver_Viterra]

16:23:02 N49°18.843′ W123°08.147′

Display reference: Free

Brg 295.3°

Rng 0.850 n mile

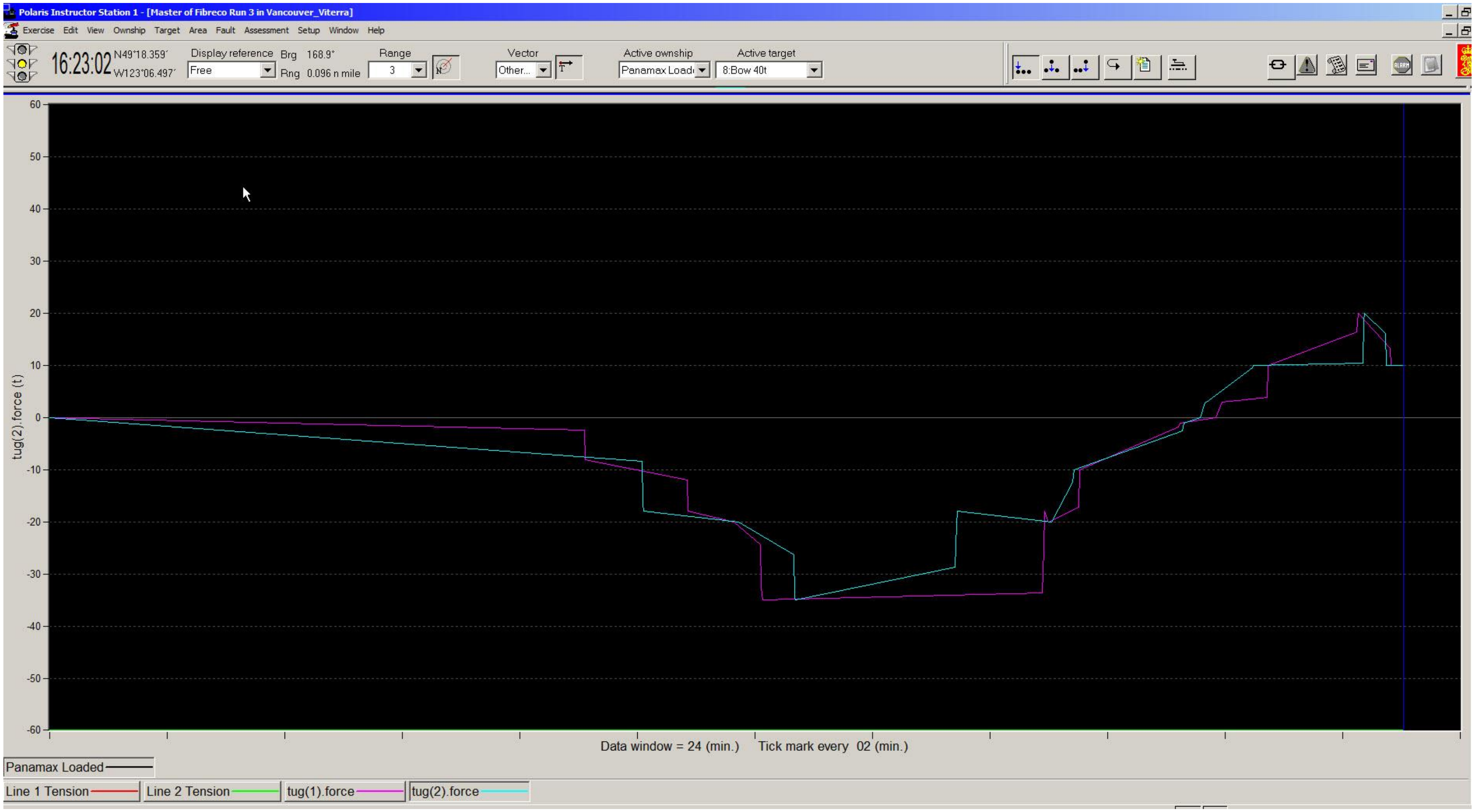
Range: 3/8

Vector: Other...

Active ownship: Panamax Loadı

Active target: 8:Bow 40t

Figure A6: Applied Tug Forces – Simulation Run 3



Polaris Instructor Station 1 - [Master of Fibreco Run 3 in Vancouver_Viterra]

16:23:02 N49°18.359′ W123°06.497′

Display reference: Free

Brg 168.9°

Rng 0.096 n mile

Range: 3

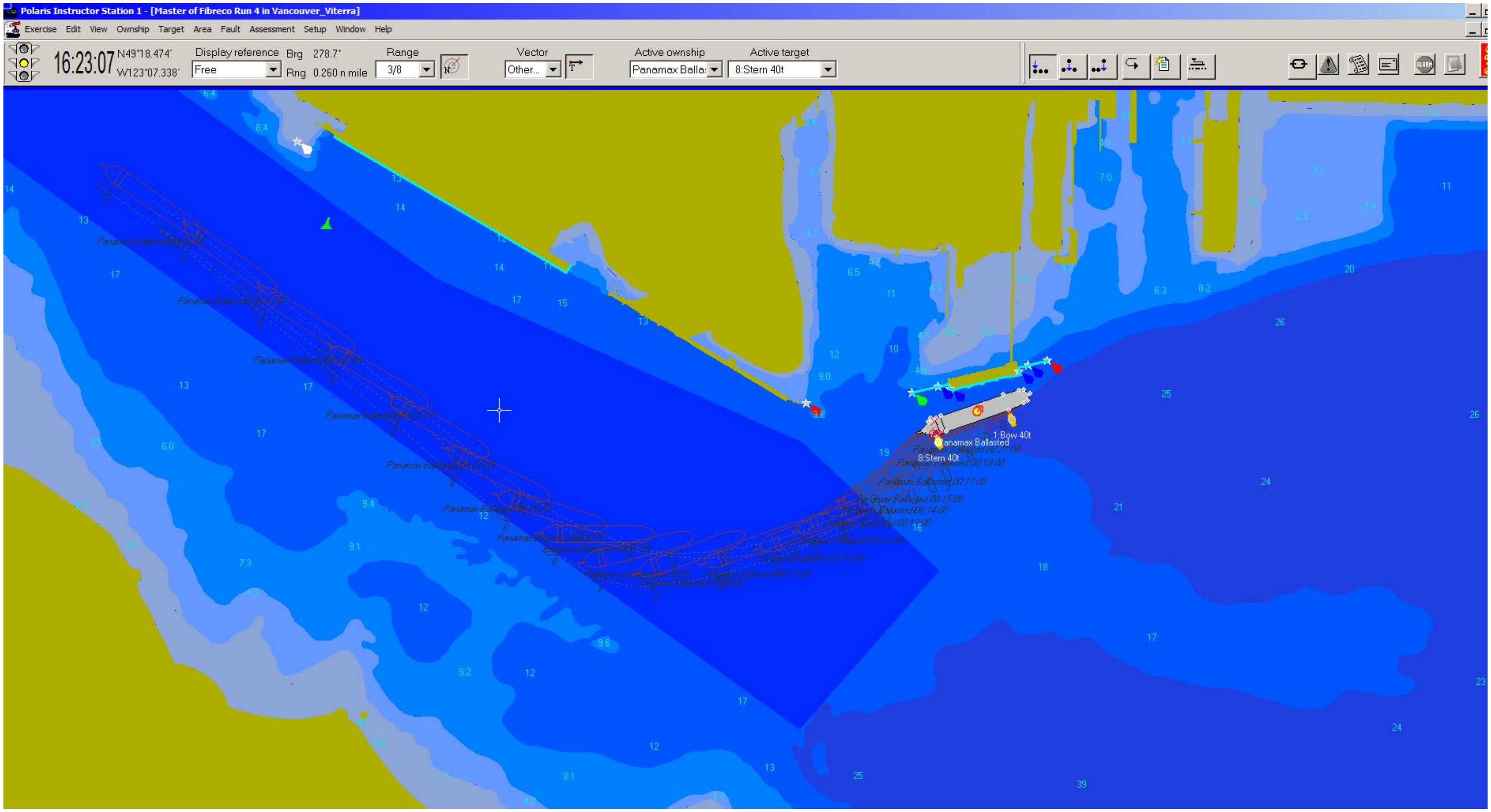
Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Data window = 24 (min.) Tick mark every 02 (min.)

Figure A7: Track Plot Simulation Run 4



16:23:07 N49°18.474′ W123°07.338′

Display reference: Free

Brg 278.7°

Rng 0.260 n mile

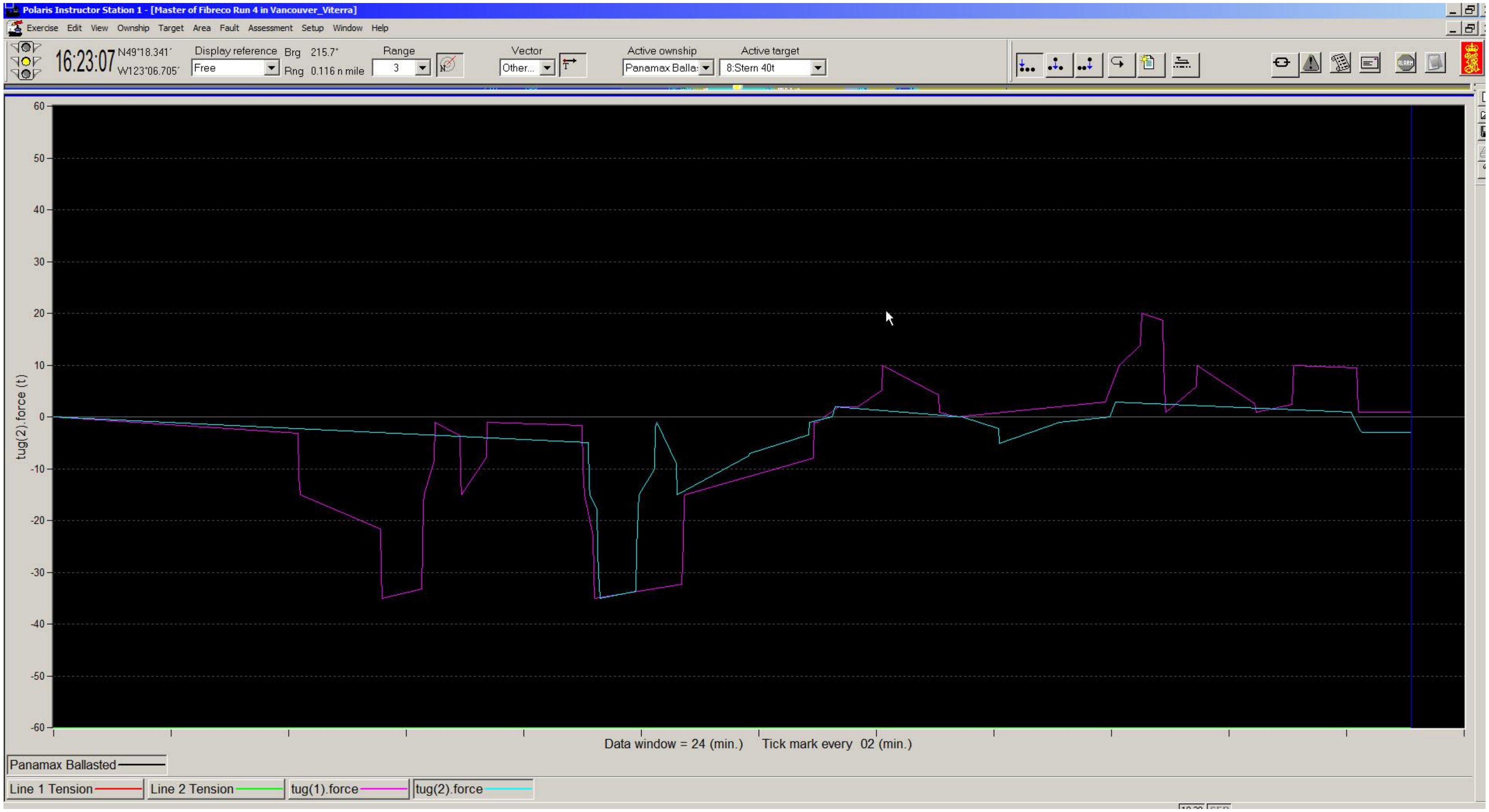
Range: 3/8

Vector: Other...

Active ownship: Panamax Balla:

Active target: 8:Stern 40t

Figure A8: Applied Tug Forces – Simulation Run 4



Polaris Instructor Station 1 - [Master of Fibreco Run 4 in Vancouver_Viterra]

16:23:07 N49°18.341´ W123°06.705´

Display reference: Free

Brg 215.7°

Rng 0.116 n mile

Range: 3

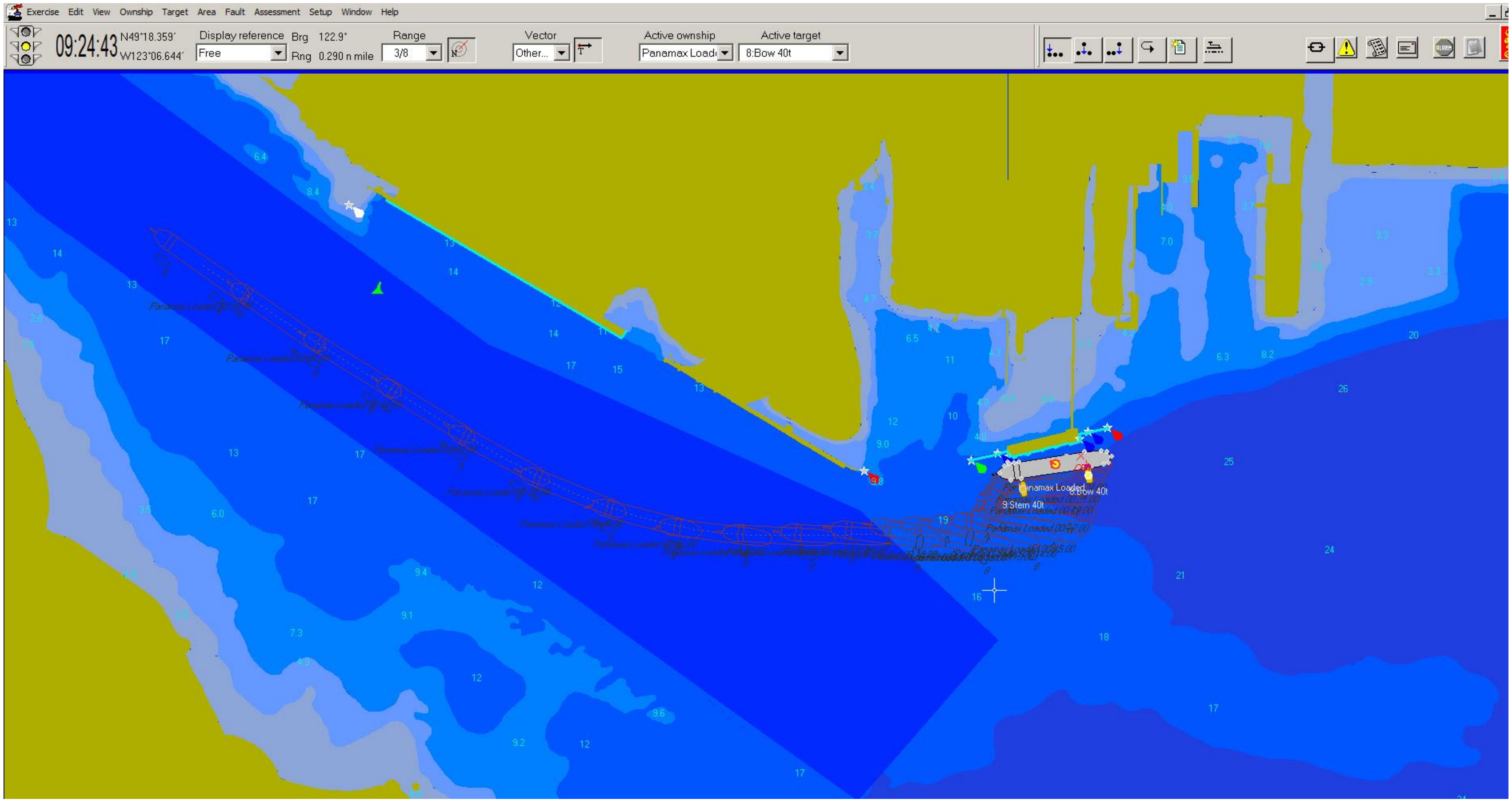
Vector: Other...

Active ownship: Panamax Balla:

Active target: 8:Stern 40t

Data window = 24 (min.) Tick mark every 02 (min.)

Figure A9: Track Plot Simulation Run 5



09:24:43 N49°18.359′ W123°06.644′

Display reference: Free

Brg 122.9°

Rng 0.290 n mile

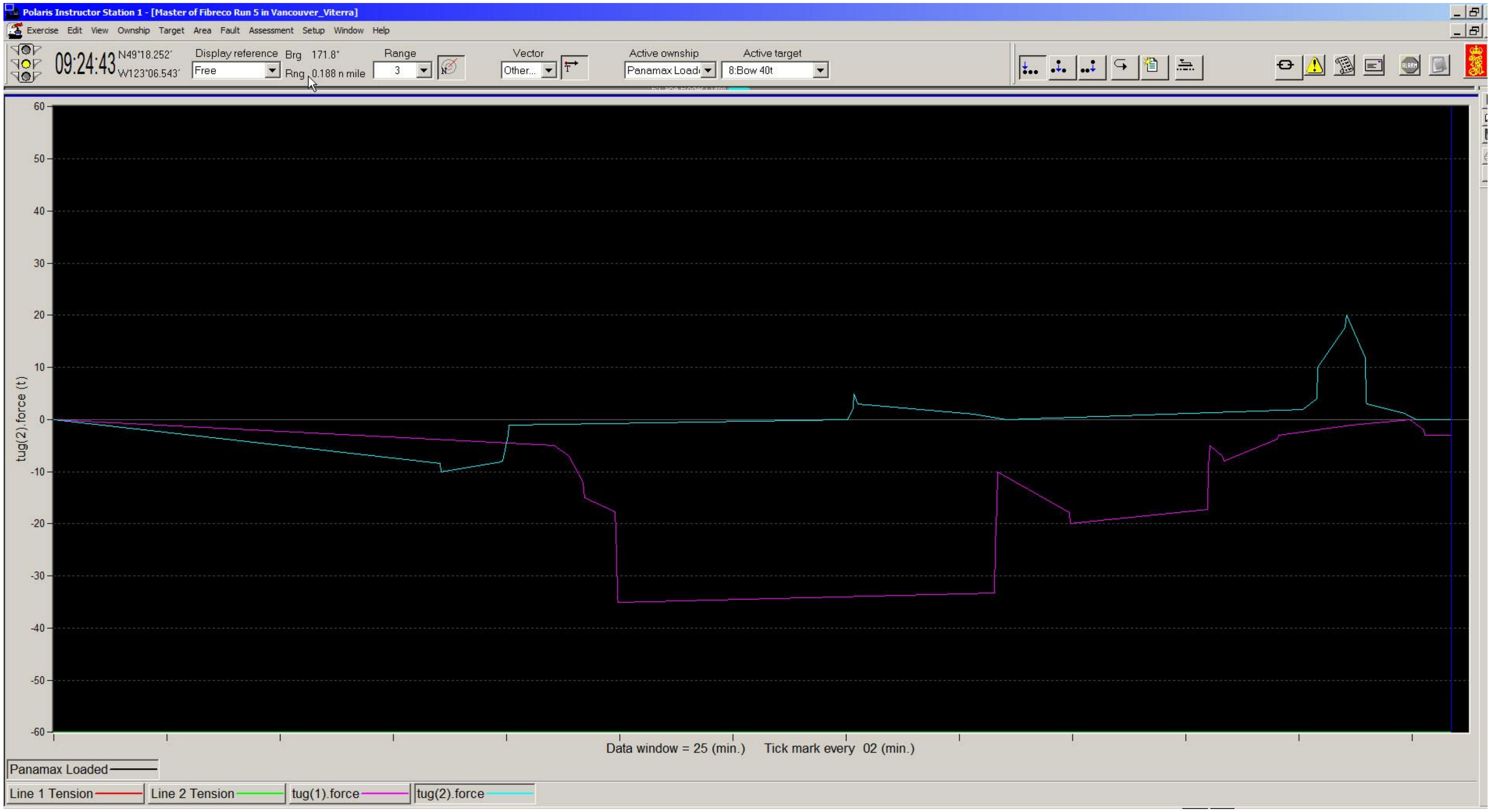
Range: 3/8

Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Figure A10: Applied Tug Forces – Simulation Run 5



Polaris Instructor Station 1 - [Master of Fibreco Run 5 in Vancouver_Viterra]

09:24:43 N49°18.252′ W123°06.543′

Display reference: Free

Brg 171.8°

Rng 0.188 n mile

Range: 3

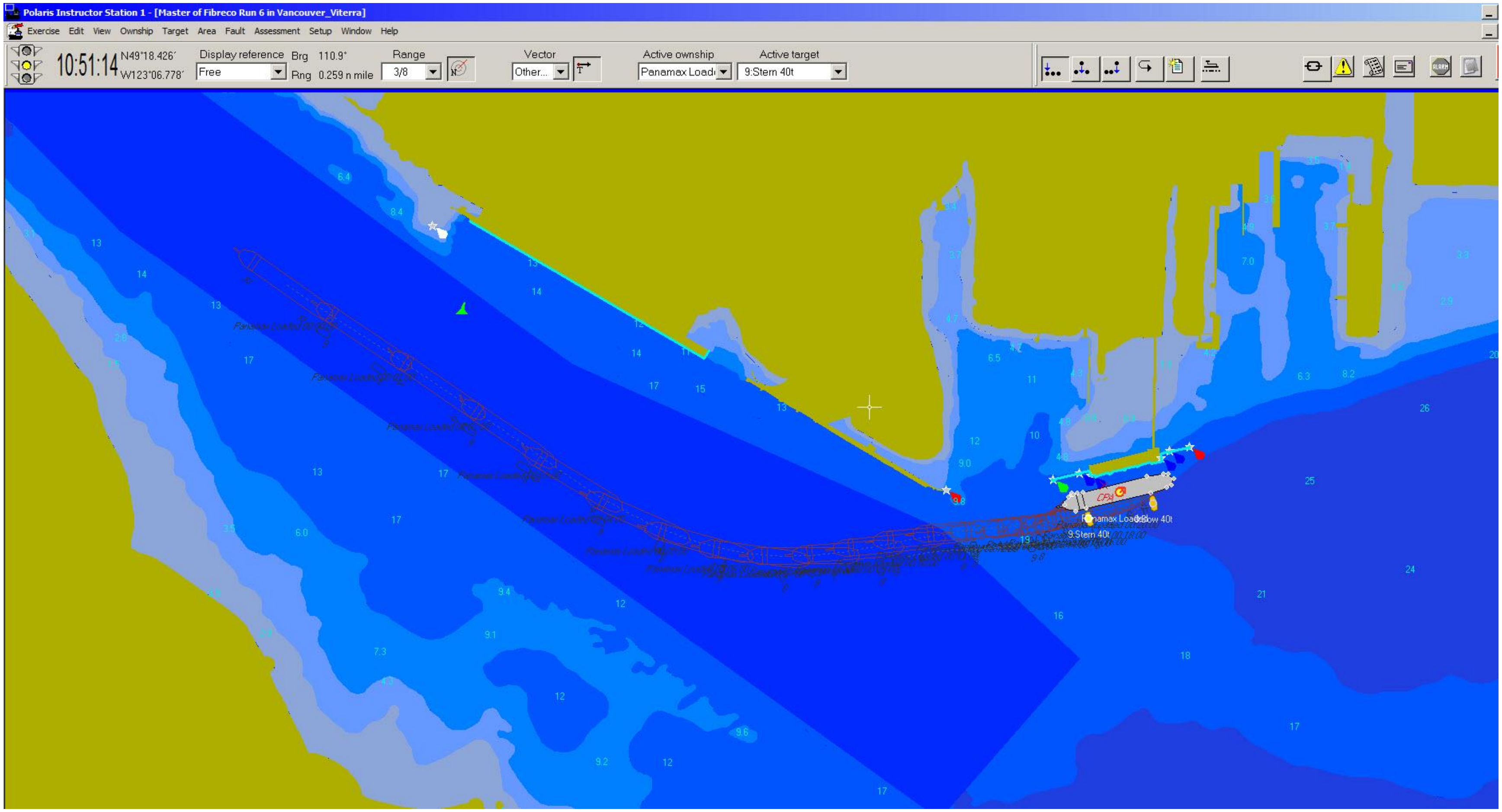
Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Data window = 25 (min.) Tick mark every 02 (min.)

Figure A11: Track Plot Simulation Run 6



Polaris Instructor Station 1 - [Master of Fibreco Run 6 in Vancouver_Viterra]

10:51:14 N49°18.426´ W123°06.778´

Display reference: Free

Brg 110.9°

Rng 0.259 n mile

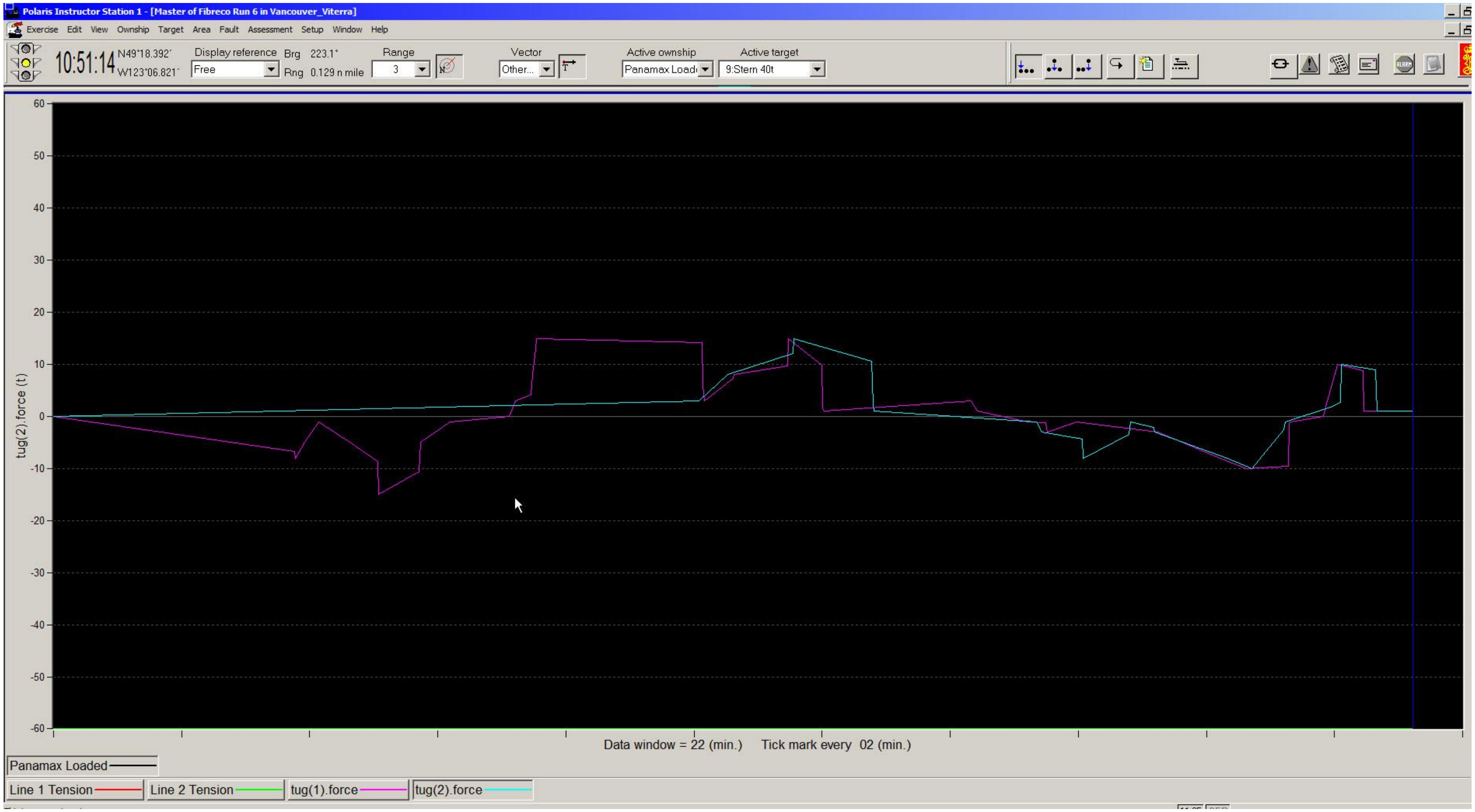
Range: 3/8

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A12: Applied Tug Forces – Simulation Run 6



Polaris Instructor Station 1 - [Master of Fibreco Run 6 in Vancouver_Viterra]

10:51:14 N49°18.392´ W123°06.821´

Display reference: Free

Brg 223.1°

Rng 0.129 n mile

Range: 3

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Data window = 22 (min.) Tick mark every 02 (min.)

Figure A13: Track Plot Simulation Run 7

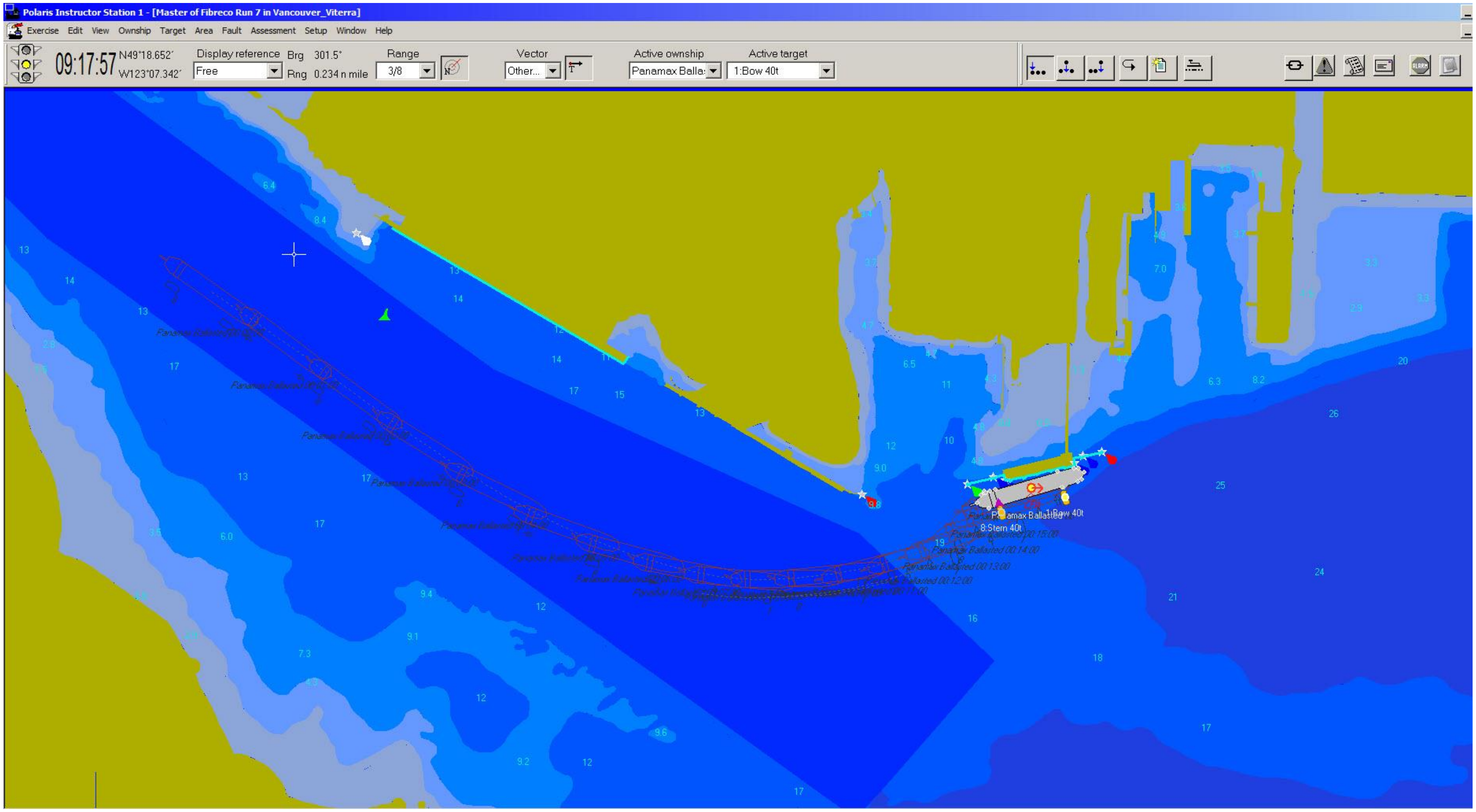


Figure A14: Applied Tug Forces – Simulation Run 7

Polaris Instructor Station 1 - [Master of Fibreco Run 7 in Vancouver_Viterra]

09:17:57 N49°18.371′ W123°06.705′

Display reference: Free

Brg 176.4°

Rng 0.094 n mile

Range: 3

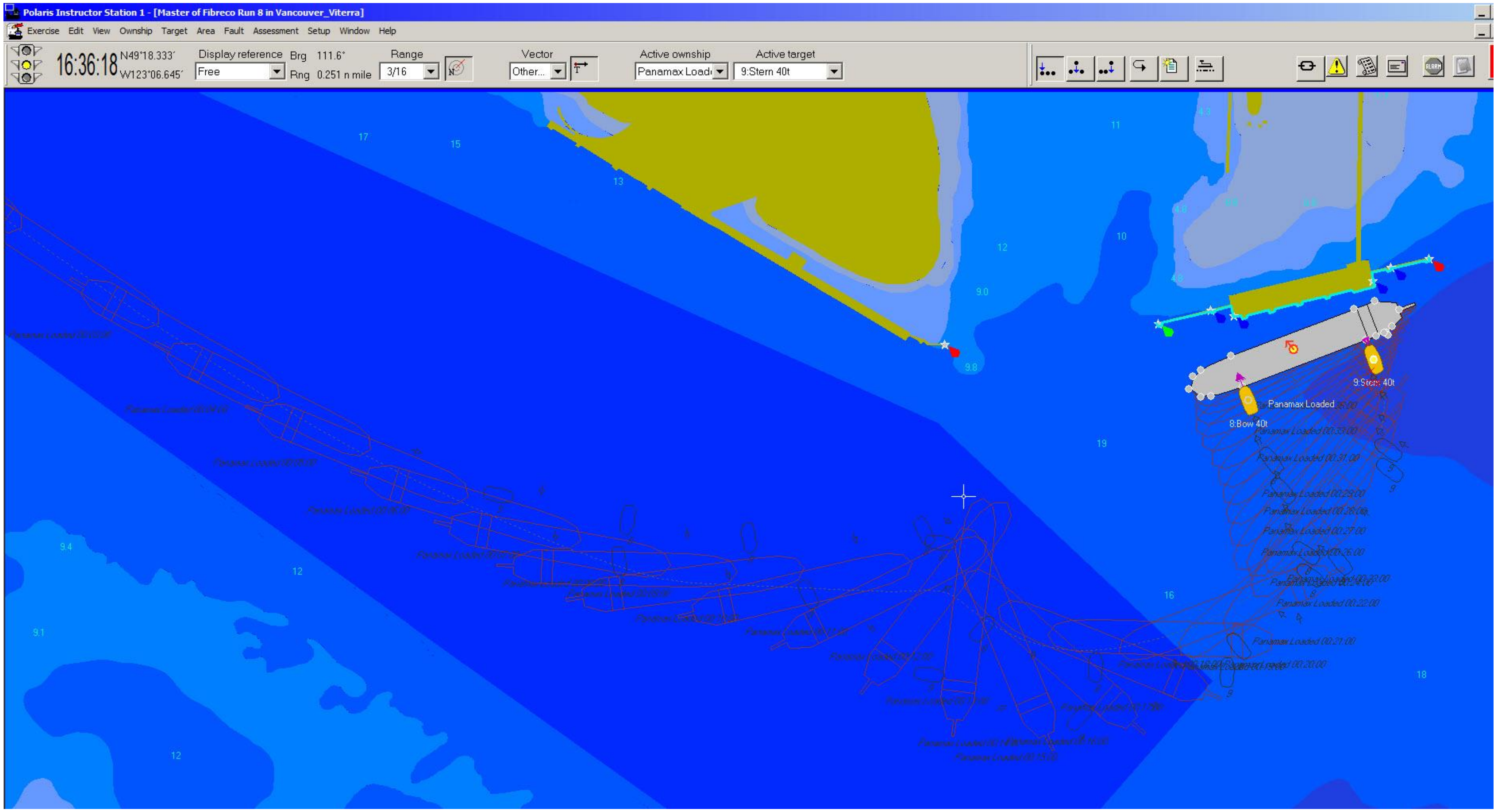
Vector: Other...

Active ownship: Panamax Balla:

Active target: 1:Bow 40t

Data window = 18 (min.) Tick mark every 01 (min.)

Figure A15: Track Plot Simulation Run 8



Polaris Instructor Station 1 - [Master of Fibreco Run 8 in Vancouver_Viterra]

16:36:18 N49°18.333′ W123°06.645′

Display reference: Free

Brg 111.6°

Rng 0.251 n mile

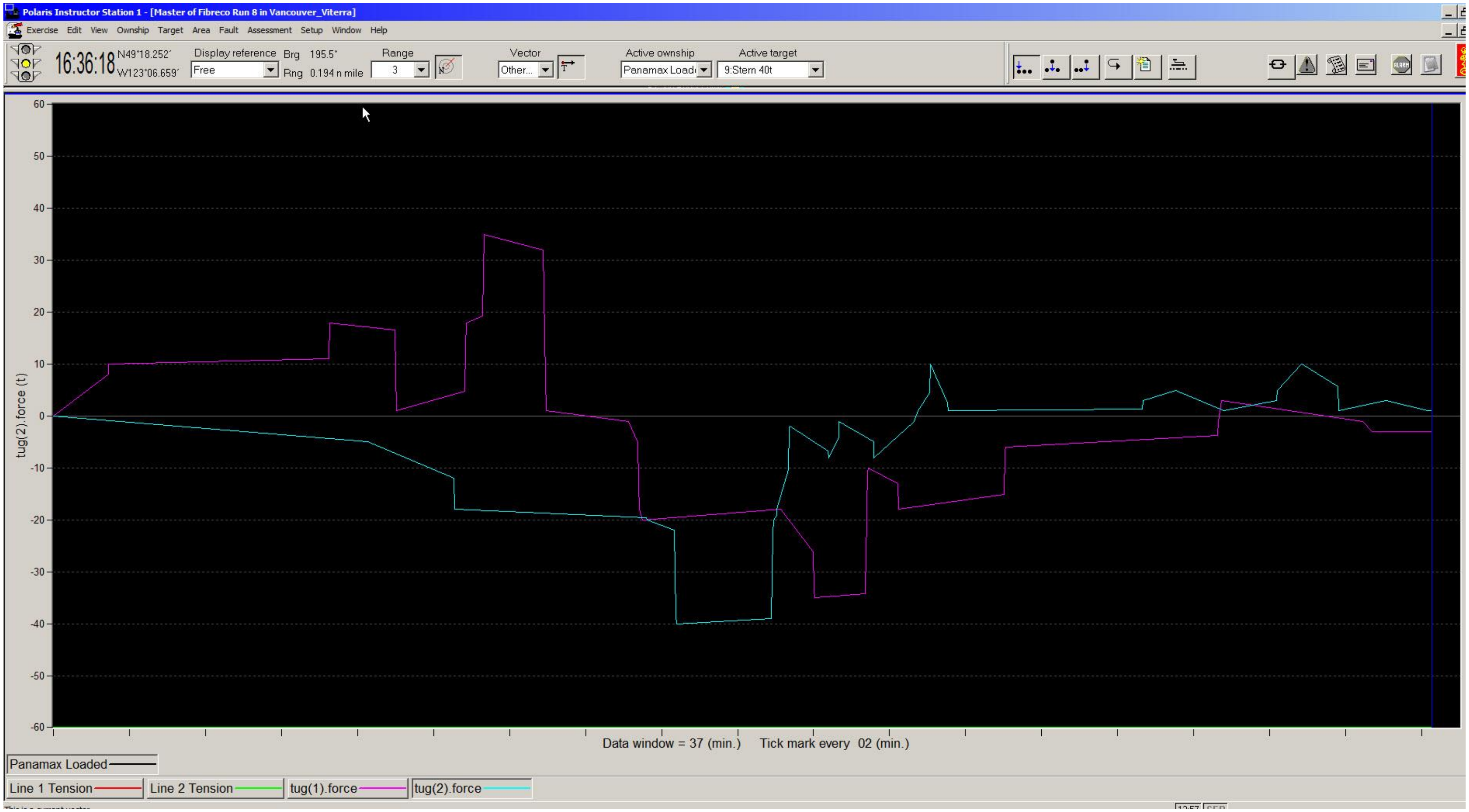
Range: 3/16

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A16: Applied Tug Forces – Simulation Run 8



16:36:18 N49°18.252′ W123°06.659′

Display reference: Free

Brg 195.5°

Rng 0.194 n mile

Range: 3

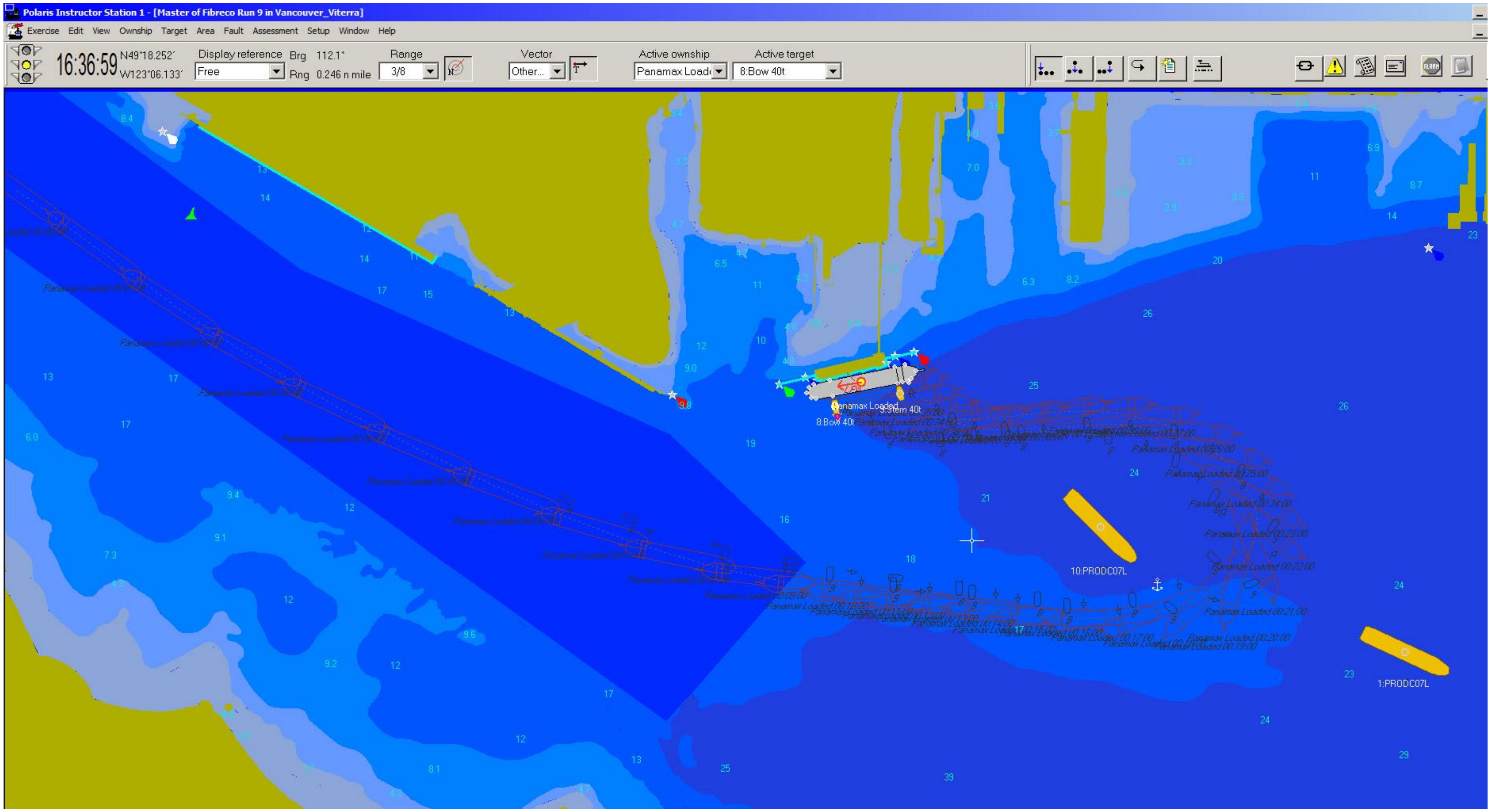
Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Data window = 37 (min.) Tick mark every 02 (min.)

Figure A17: Track Plot Simulation Run 9



Polaris Instructor Station 1 - [Master of Fibreco Run 9 in Vancouver_Viterra]

16:36:59 N49°18.252′ W123°06.133′

Display reference: Free

Brg 112.1°

Rng 0.246 n mile

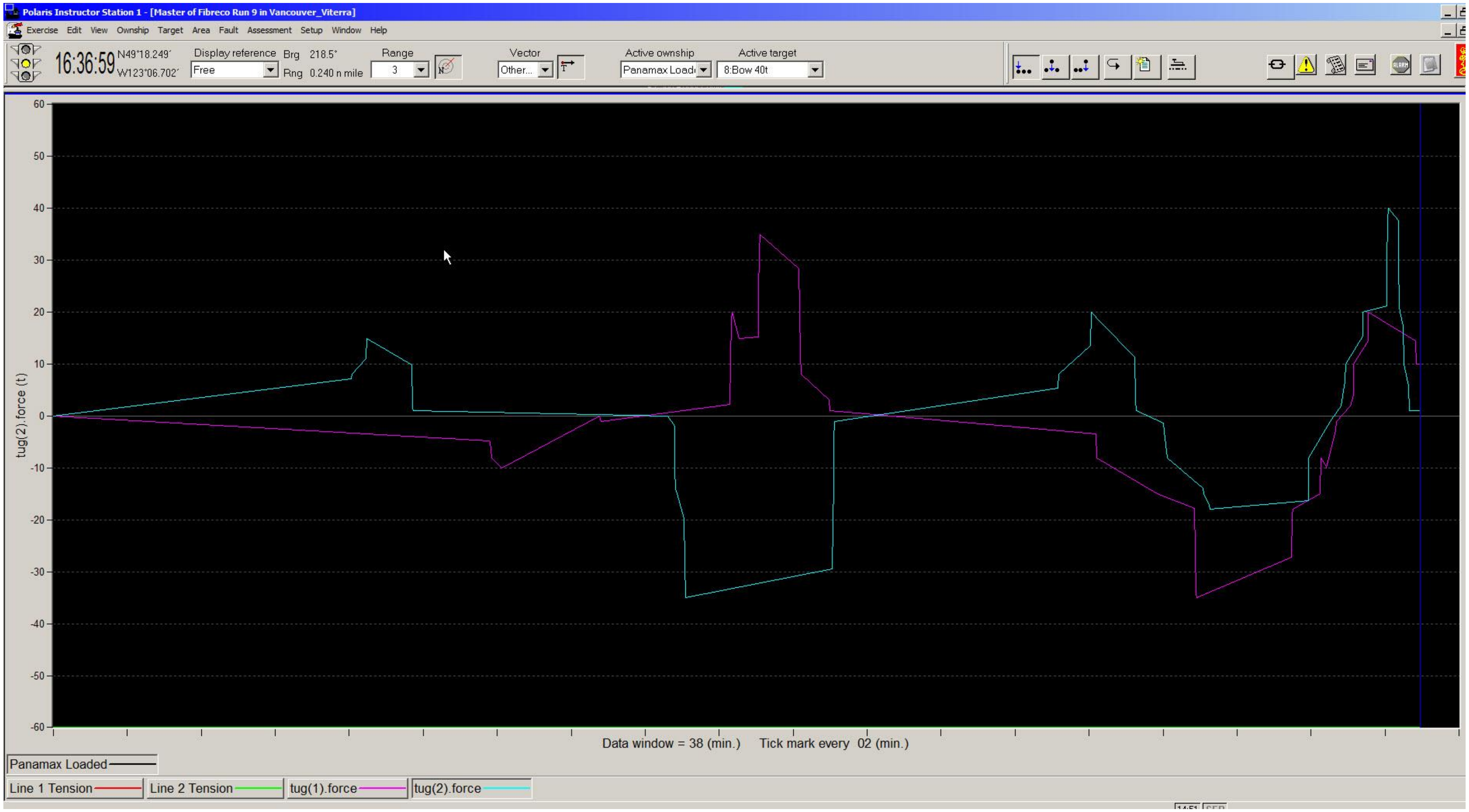
Range: 3/8

Vector: Other...

Active ownship: Panamax Loadi

Active target: 8:Bow 40t

Figure A18: Applied Tug Forces – Simulation Run 9



Polaris Instructor Station 1 - [Master of Fibreco Run 9 in Vancouver_Viterra]

16:36:59 N49°18.249' W123°06.702'

Display reference: Free

Brg 218.5°

Rng 0.240 n mile

Range: 3

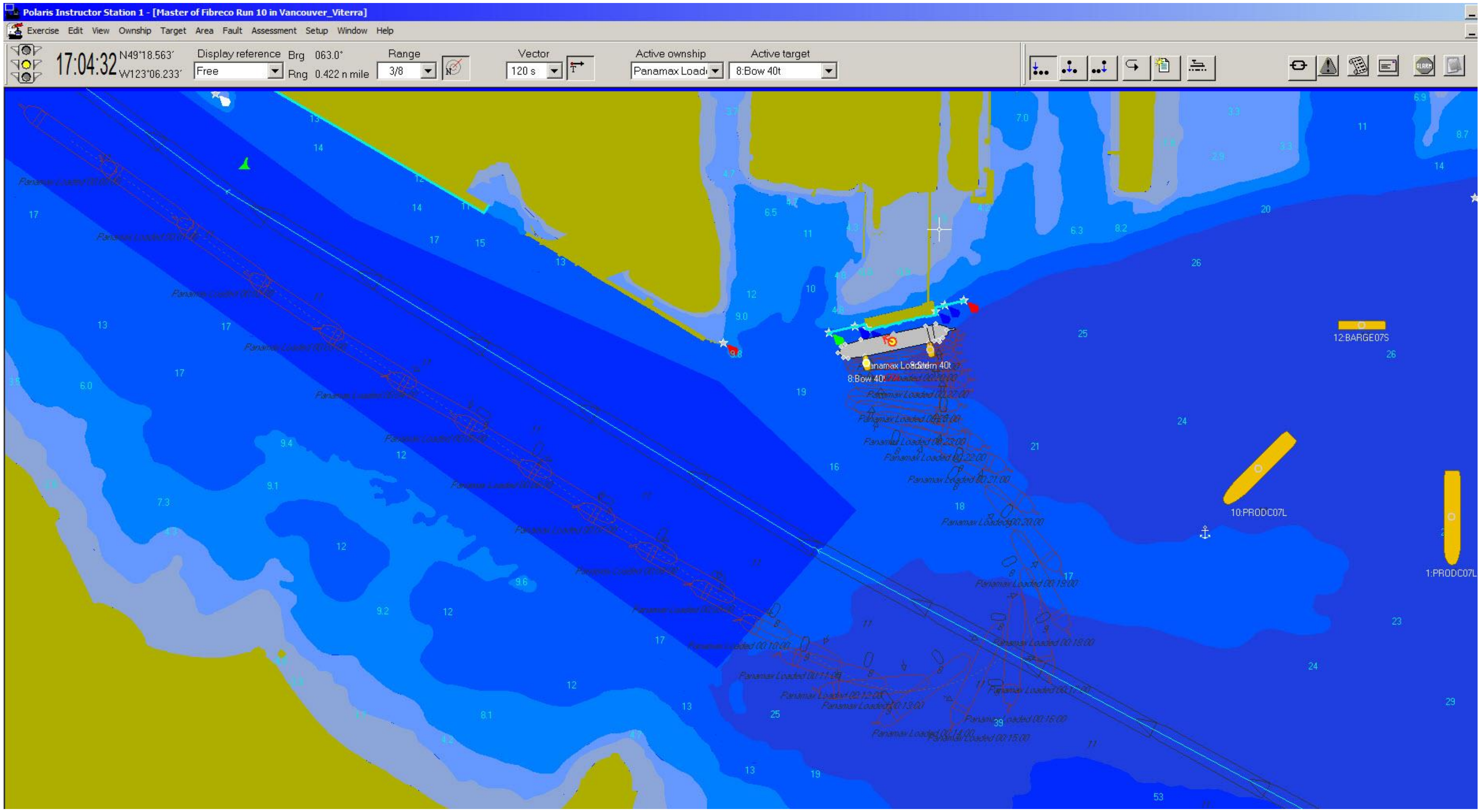
Vector: Other...

Active ownship: Panamax Loadi

Active target: 8:Bow 40t

Data window = 38 (min.) Tick mark every 02 (min.)

Figure A19: Track Plot Simulation Run 10



Polaris Instructor Station 1 - [Master of Fibreco Run 10 in Vancouver_Viterra]

17:04:32 N49°18.563' W123°06.233'

Display reference: Free

Brg 063.0°

Rng 0.422 n mile

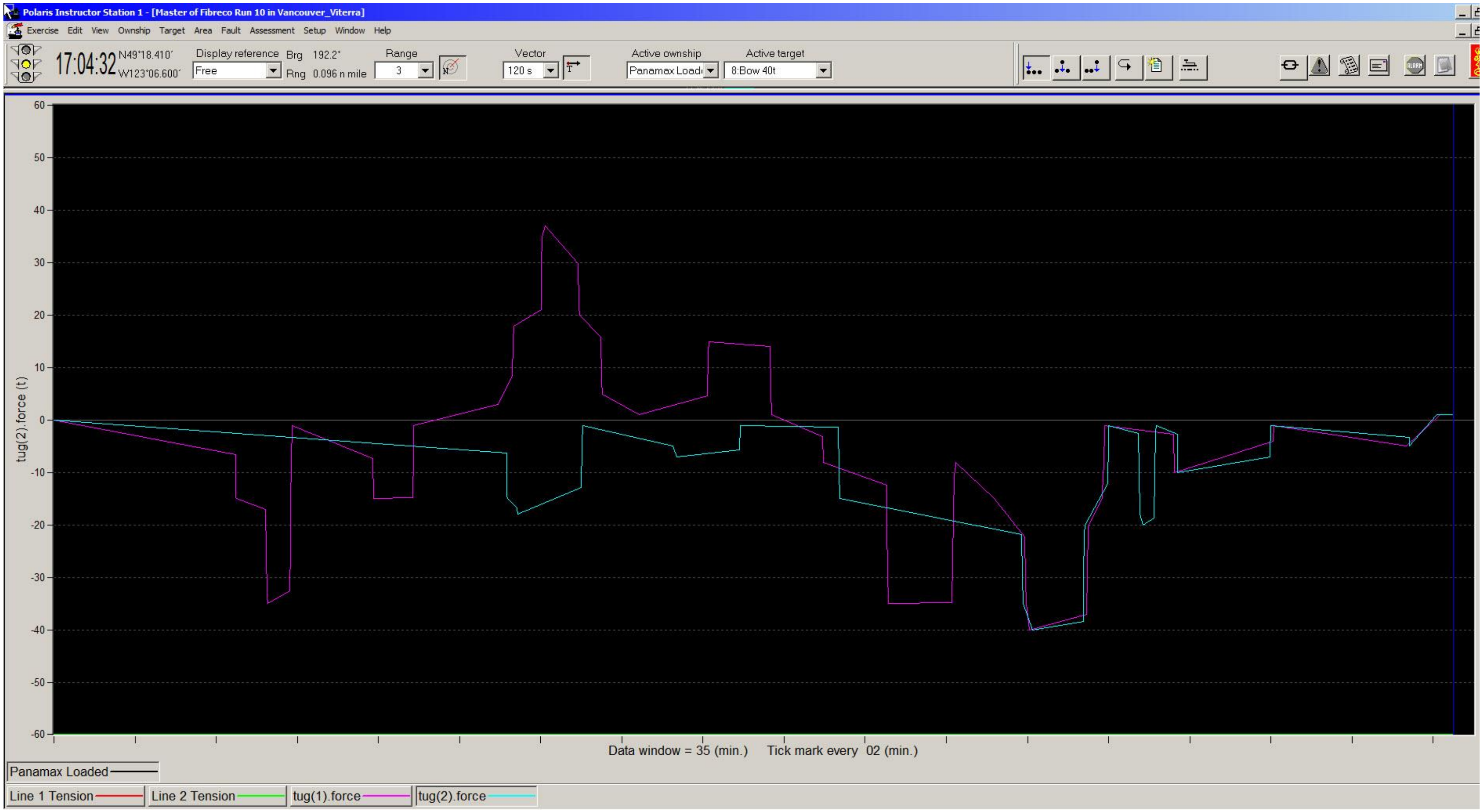
Range: 3/8

Vector: 120 s

Active ownship: Panamax Load

Active target: 8:Bow 40t

Figure A20: Applied Tug Forces – Simulation Run 10



Polaris Instructor Station 1 - [Master of Fibreco Run 10 in Vancouver_Viterra]

17:04:32 N49°18.410' W123°06.600'

Display reference: Free

Brg 192.2°

Rng 0.096 n mile

Range: 3

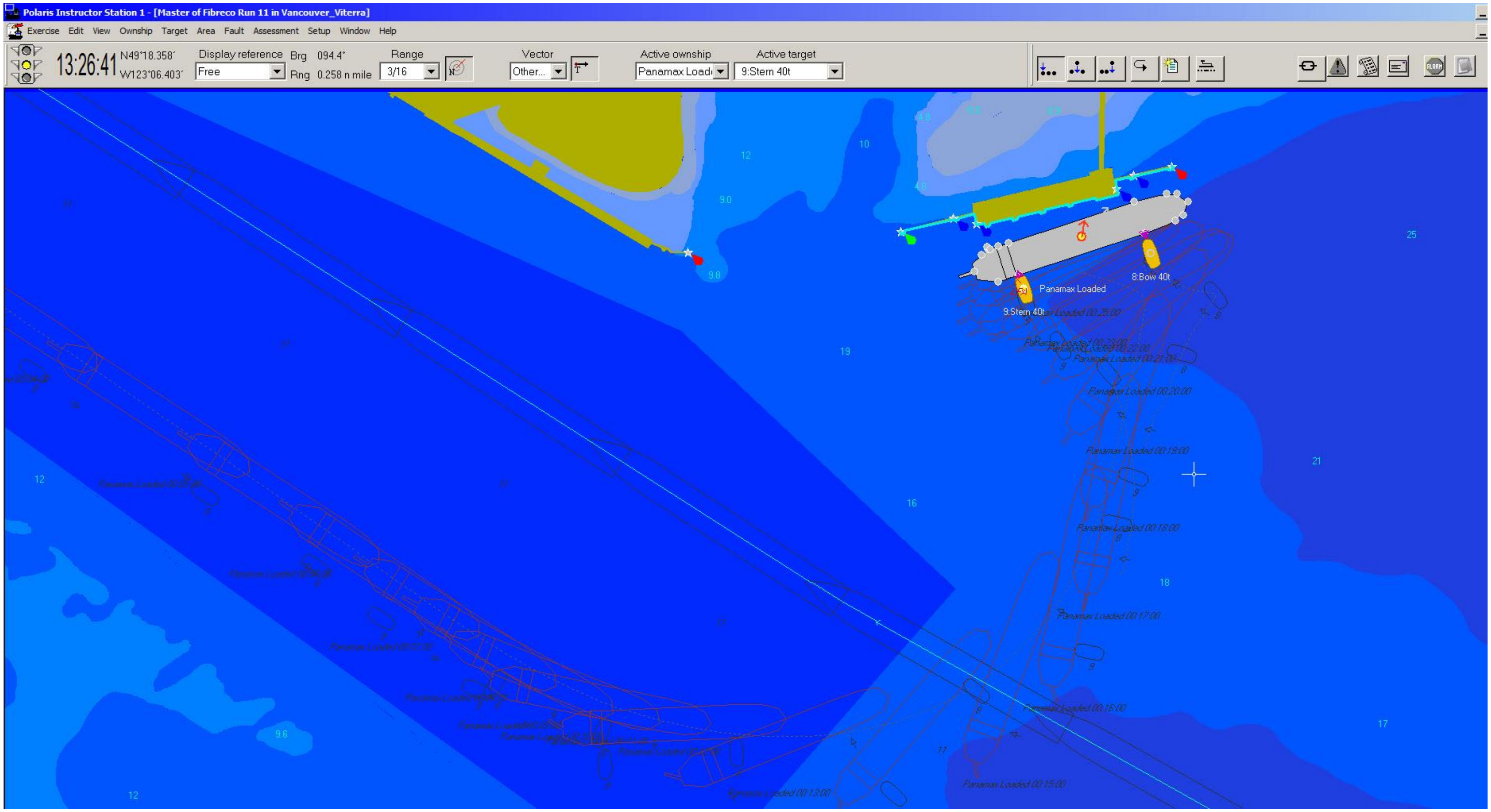
Vector: 120 s

Active ownship: Panamax Load

Active target: 8:Bow 40t

Data window = 35 (min.) Tick mark every 02 (min.)

Figure A21: Track Plot Simulation Run 11



Polaris Instructor Station 1 - [Master of Fibreco Run 11 in Vancouver_Viterra]

13:26:41 N49°18.358′ W123°06.403′

Display reference: Free

Brg 094.4°

Rng 0.258 n mile

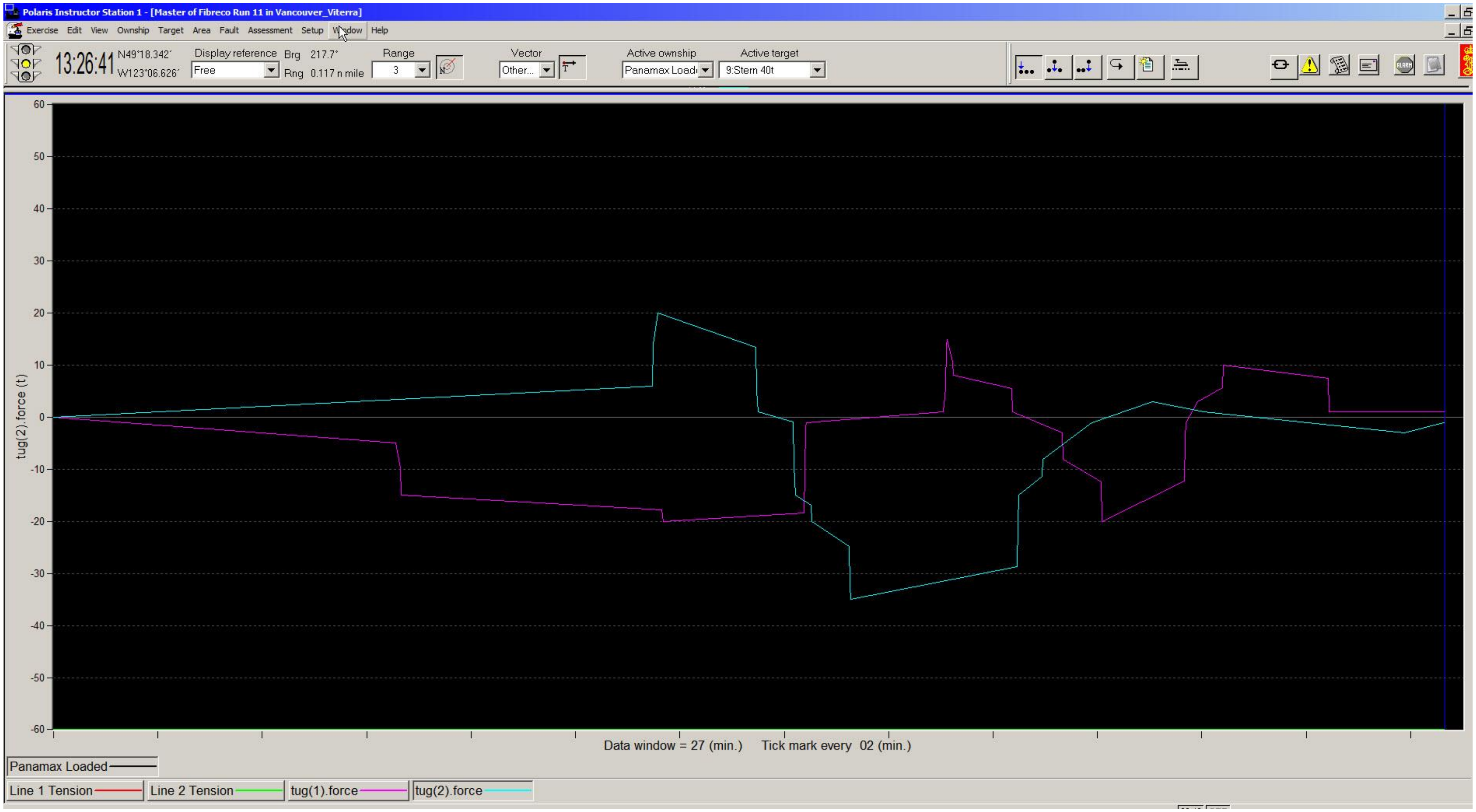
Range: 3/16

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A22: Applied Tug Forces – Simulation Run 11



Polaris Instructor Station 1 - [Master of Fibreco Run 11 in Vancouver_Viterra]

13:26:41 N49°18.342′ W123°06.626′

Display reference: Free

Brg 217.7°

Rng 0.117 n mile

Range: 3

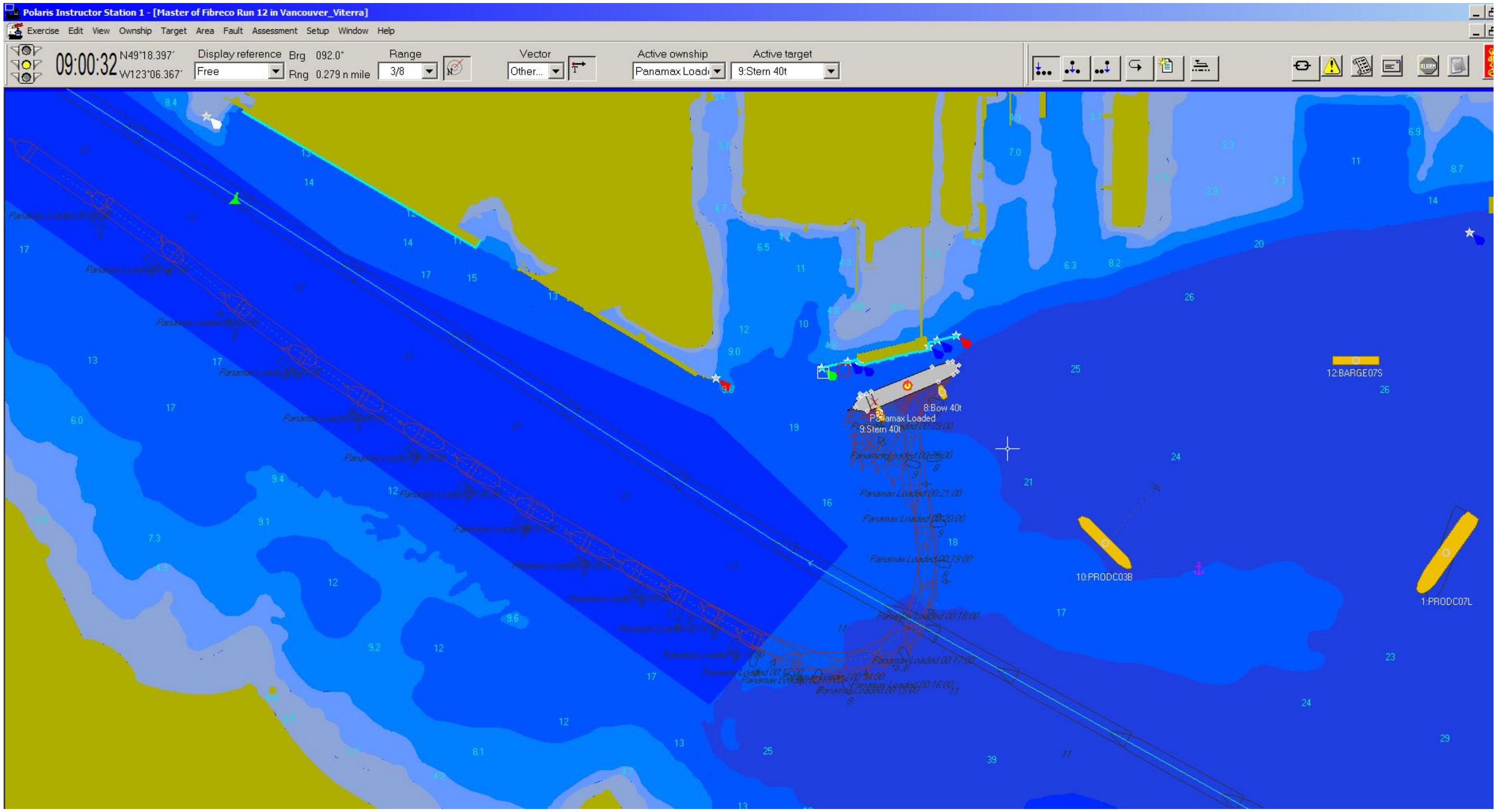
Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Data window = 27 (min.) Tick mark every 02 (min.)

Figure A23: Track Plot Simulation Run 12



Polaris Instructor Station 1 - [Master of Fibreco Run 12 in Vancouver_Viterra]

09:00:32 N49°18.397´ W123°06.367´

Display reference: Free

Brg 092.0°

Rng 0.279 n mile

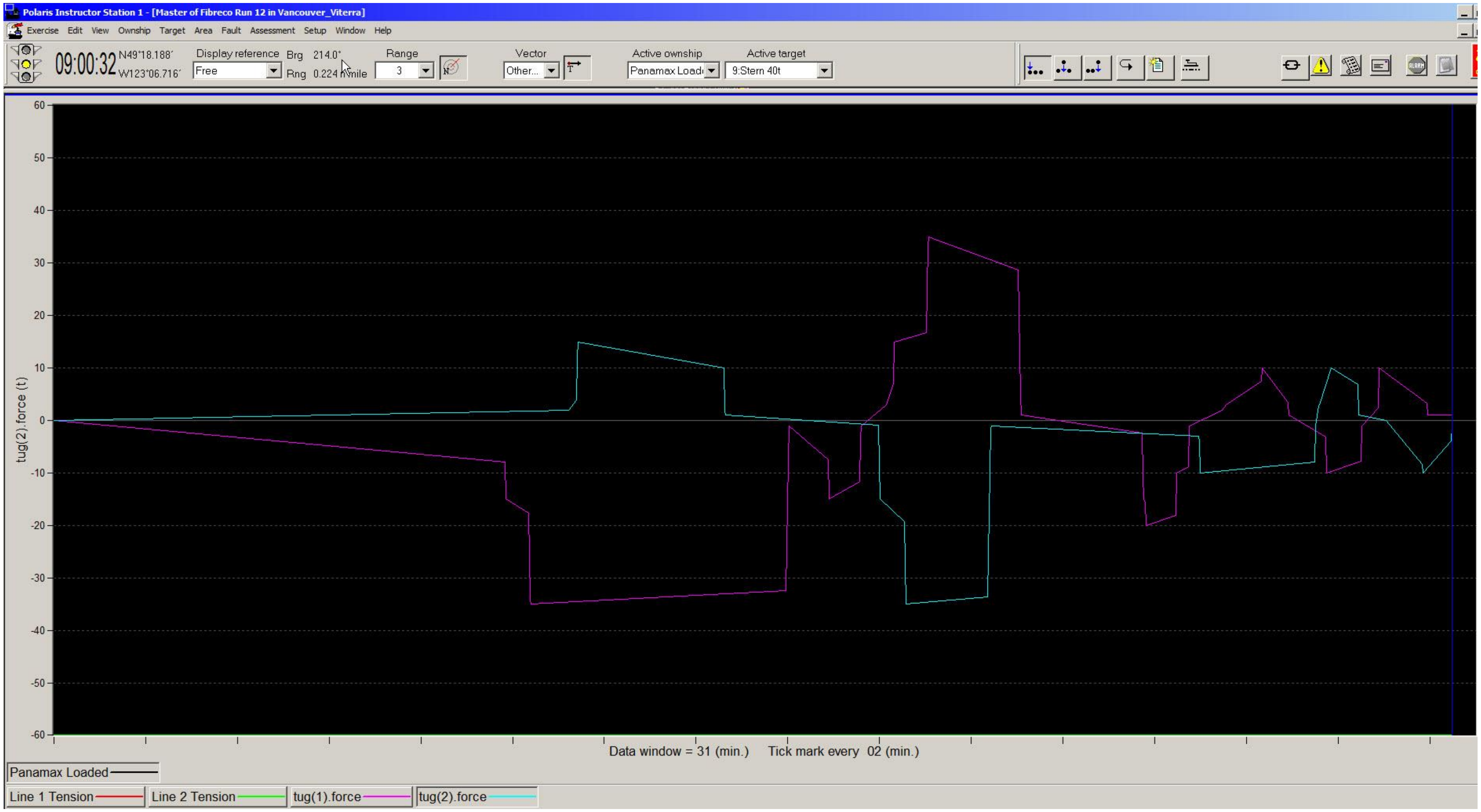
Range: 3/8

Vector: Other...

Active ownship: Panamax Loadi

Active target: 9:Stern 40t

Figure A24: Applied Tug Forces – Simulation Run 12



Polaris Instructor Station 1 - [Master of Fibreco Run 12 in Vancouver_Viterra]

09:00:32 N49°18.188′ W123°06.716′

Display reference: Free

Brg 214.0°

Rng 0.224 nmile

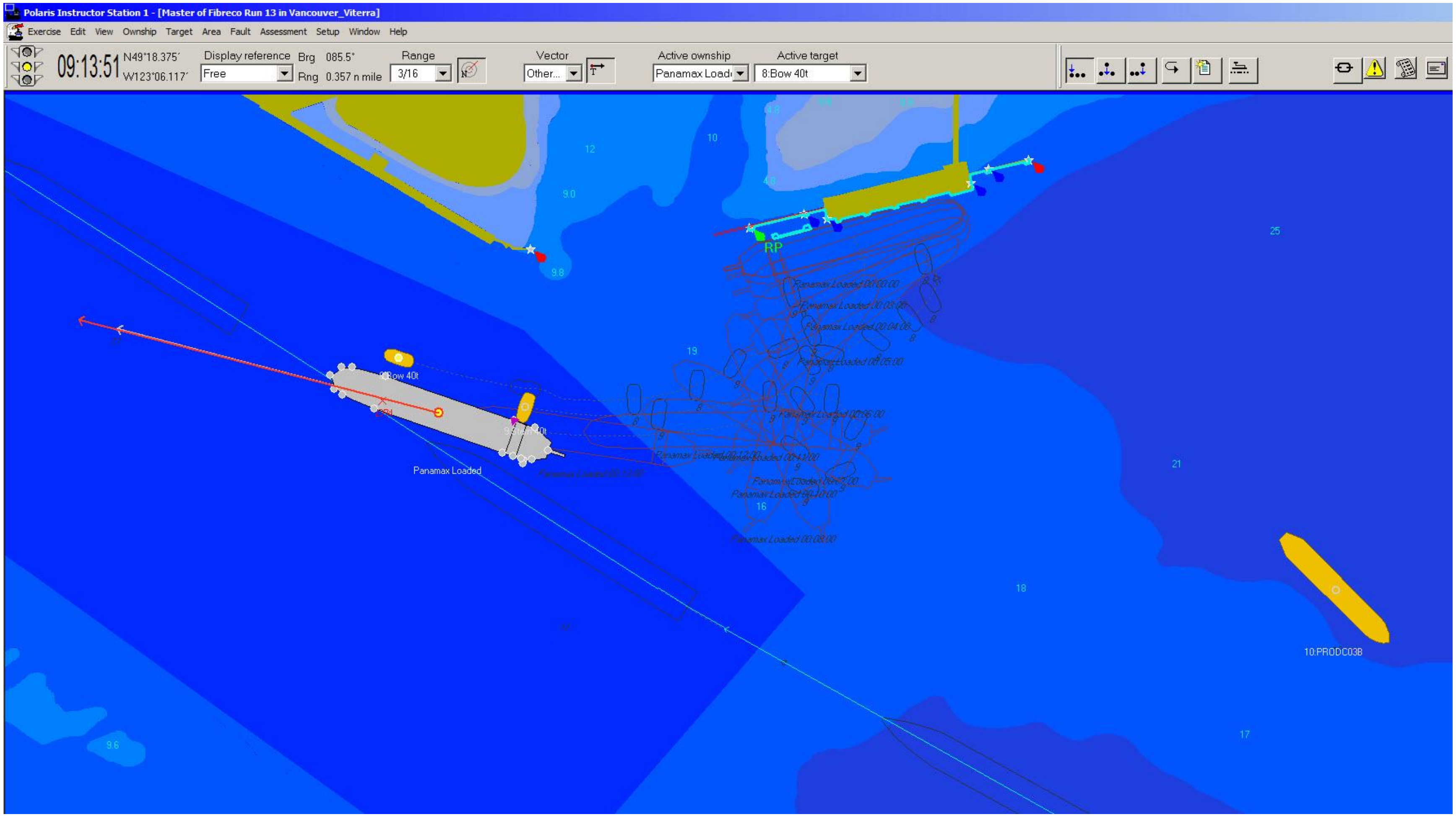
Range: 3

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A25: Track Plot Simulation Run 13



Polaris Instructor Station 1 - [Master of Fibreco Run 13 in Vancouver_Viterra]

09:13:51 N49°18.375´ W123°06.117´

Display reference: Free

Brg 085.5°

Rng 0.357 n mile

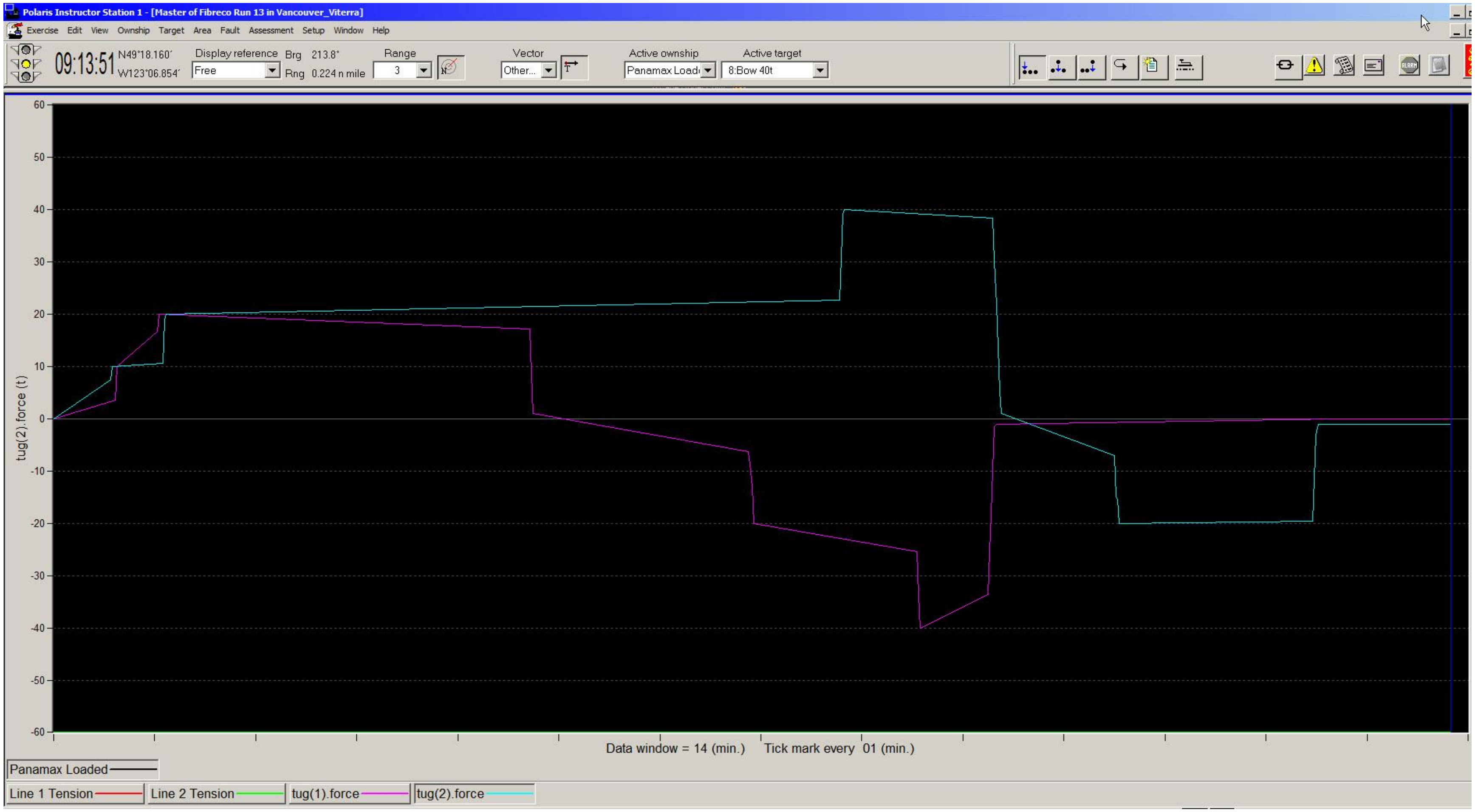
Range: 3/16

Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Figure A26: Applied Tug Forces – Simulation Run 13



Polaris Instructor Station 1 - [Master of Fibreco Run 13 in Vancouver_Viterra]

09:13:51 N49°18.160' W123°06.854'

Display reference: Free

Brg 213.8°

Rng 0.224 n mile

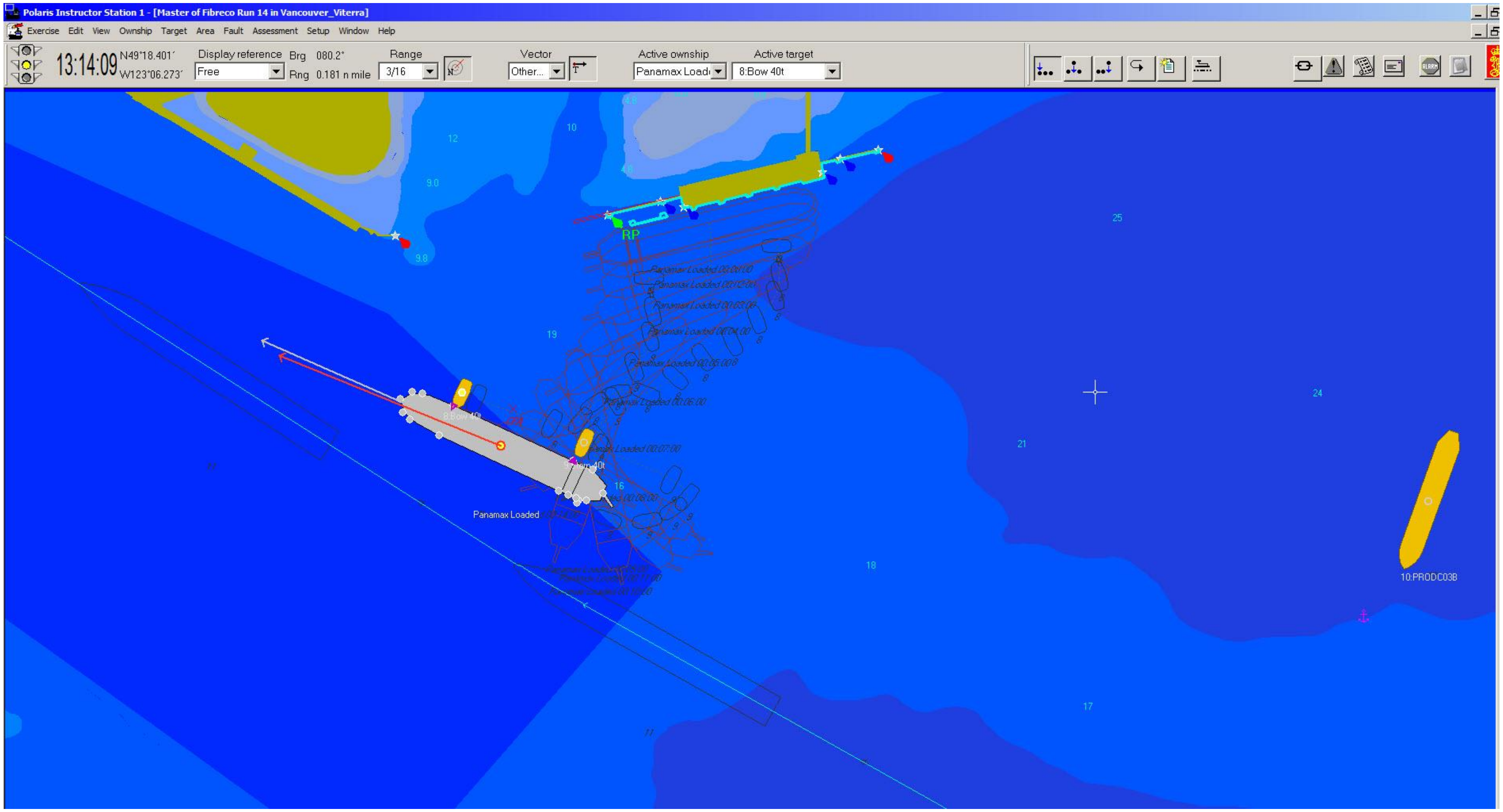
Range: 3

Vector: Other...

Active ownship: Panamax Load

Active target: 8:Bow 40t

Figure A27: Track Plot Simulation Run 14



Polaris Instructor Station 1 - [Master of Fibreco Run 14 in Vancouver_Viterra]

13:14:09 N49°18.401′ W123°06.273′

Display reference: Free

Brg 080.2°

Rng 0.181 n mile

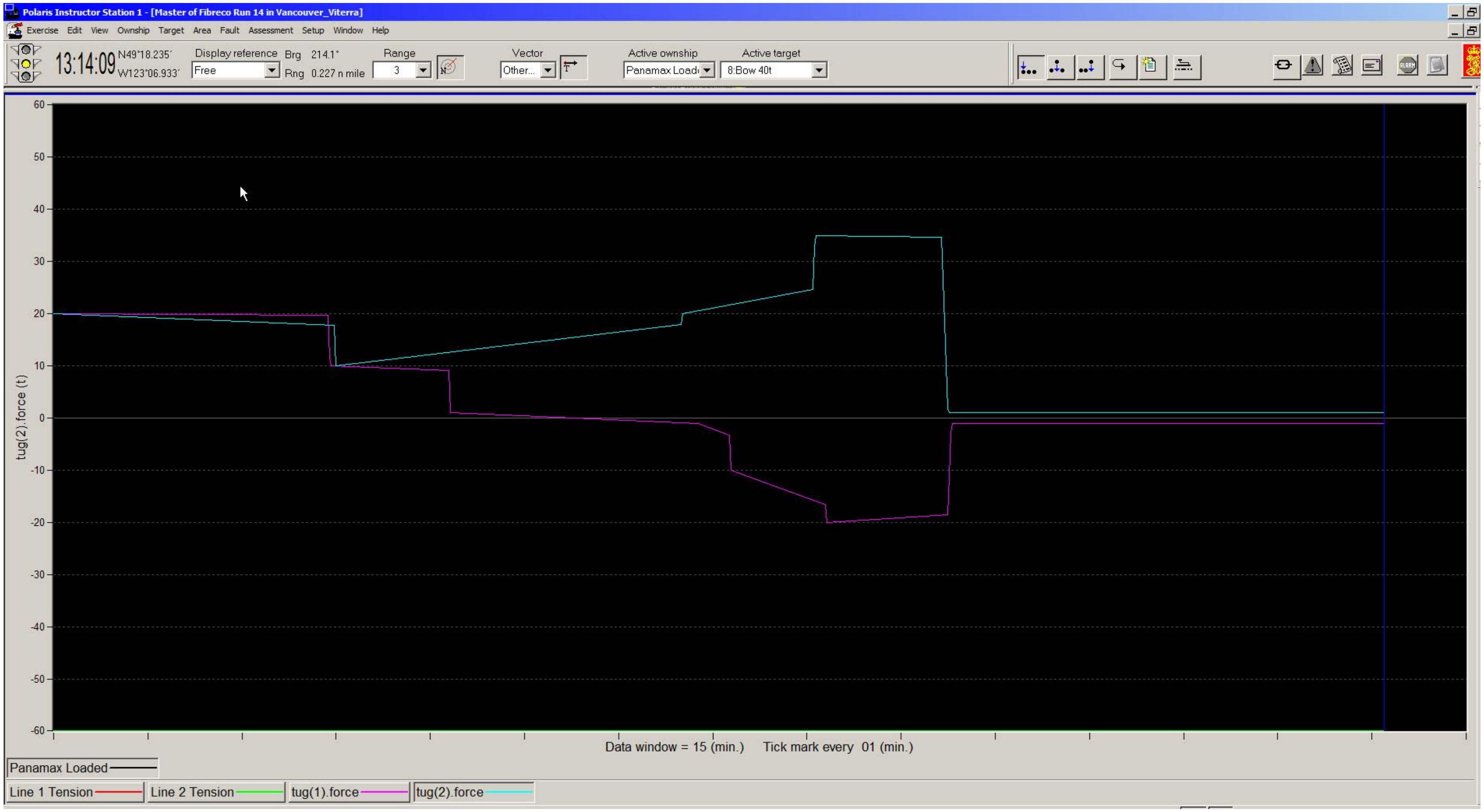
Range: 3/16

Vector: Other...

Active ownship: Panamax Loadı

Active target: 8:Bow 40t

Figure A28: Applied Tug Forces – Simulation Run 14



Polaris Instructor Station 1 - [Master of Fibreco Run 14 in Vancouver_Viterra]

13:14:09 N49°18.235′ W123°06.933′

Display reference: Free

Brg 214.1°

Rng 0.227 n mile

Range: 3

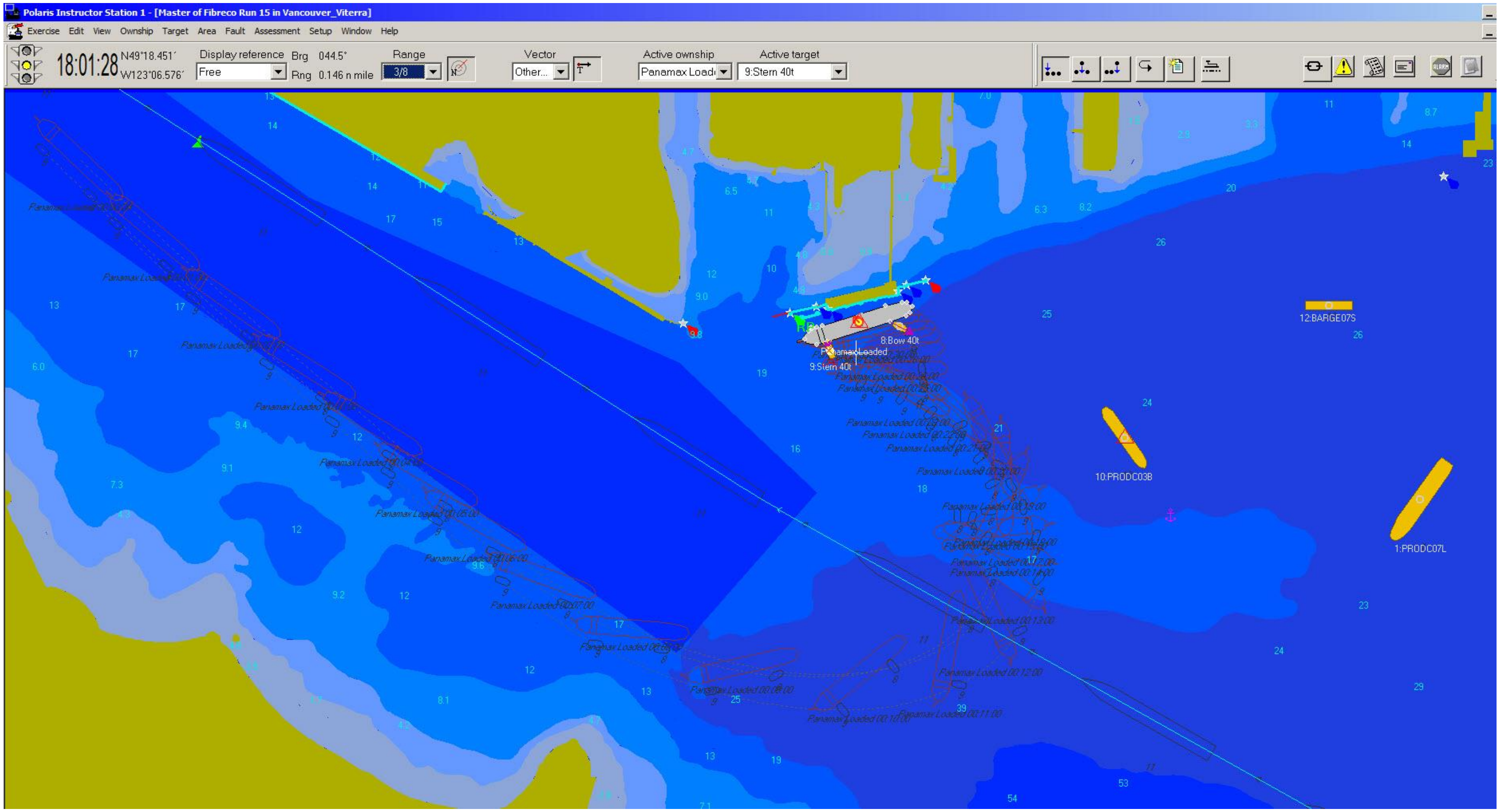
Vector: Other...

Active ownship: Panamax Loade

Active target: 8:Bow 40t

Data window = 15 (min.) Tick mark every 01 (min.)

Figure A29: Track Plot Simulation Run 15



Polaris Instructor Station 1 - [Master of Fibreco Run 15 in Vancouver_Viterra]

18:01:28 N49°18.451′ W123°06.576′

Display reference: Free

Brg 044.5°

Rng 0.146 n mile

Range: 3/8

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A30: Applied Tug Forces – Simulation Run 15

Polaris Instructor Station 1 - [Master of Fibreco Run 15 in Vancouver_Viterra]

18:01:28 N49°18.345′ W123°06.512′

Display reference: Free

Brg 187.8°

Rng 0.095 n mile

Range: 3

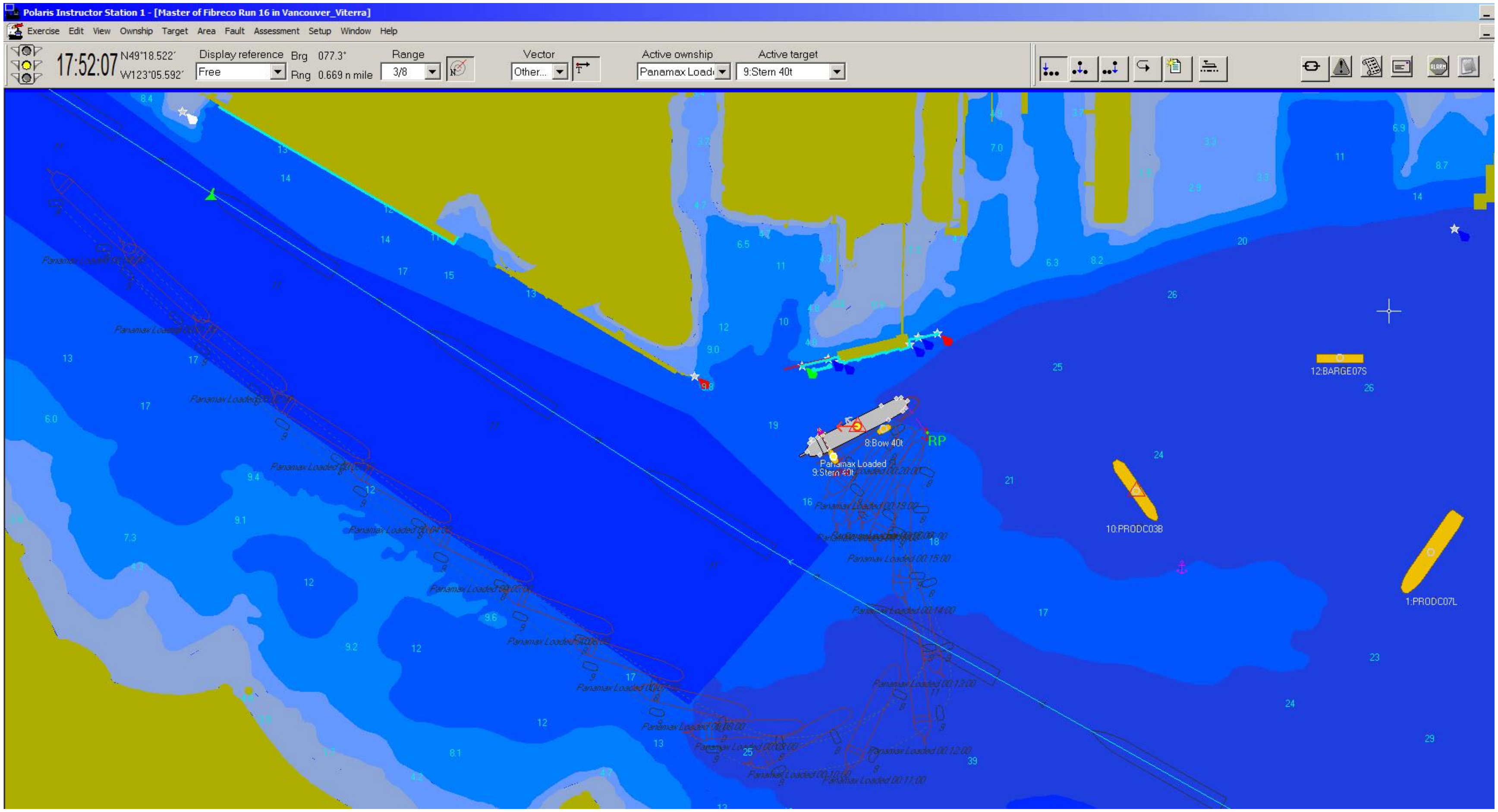
Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Data window = 32 (min.) Tick mark every 02 (min.)

Figure A31: Track Plot Simulation Run 16



Polaris Instructor Station 1 - [Master of Fibreco Run 16 in Vancouver_Viterra]

17:52:07 N49°18.522′ W123°05.592′

Display reference: Free

Brg 077.3°

Rng 0.669 n mile

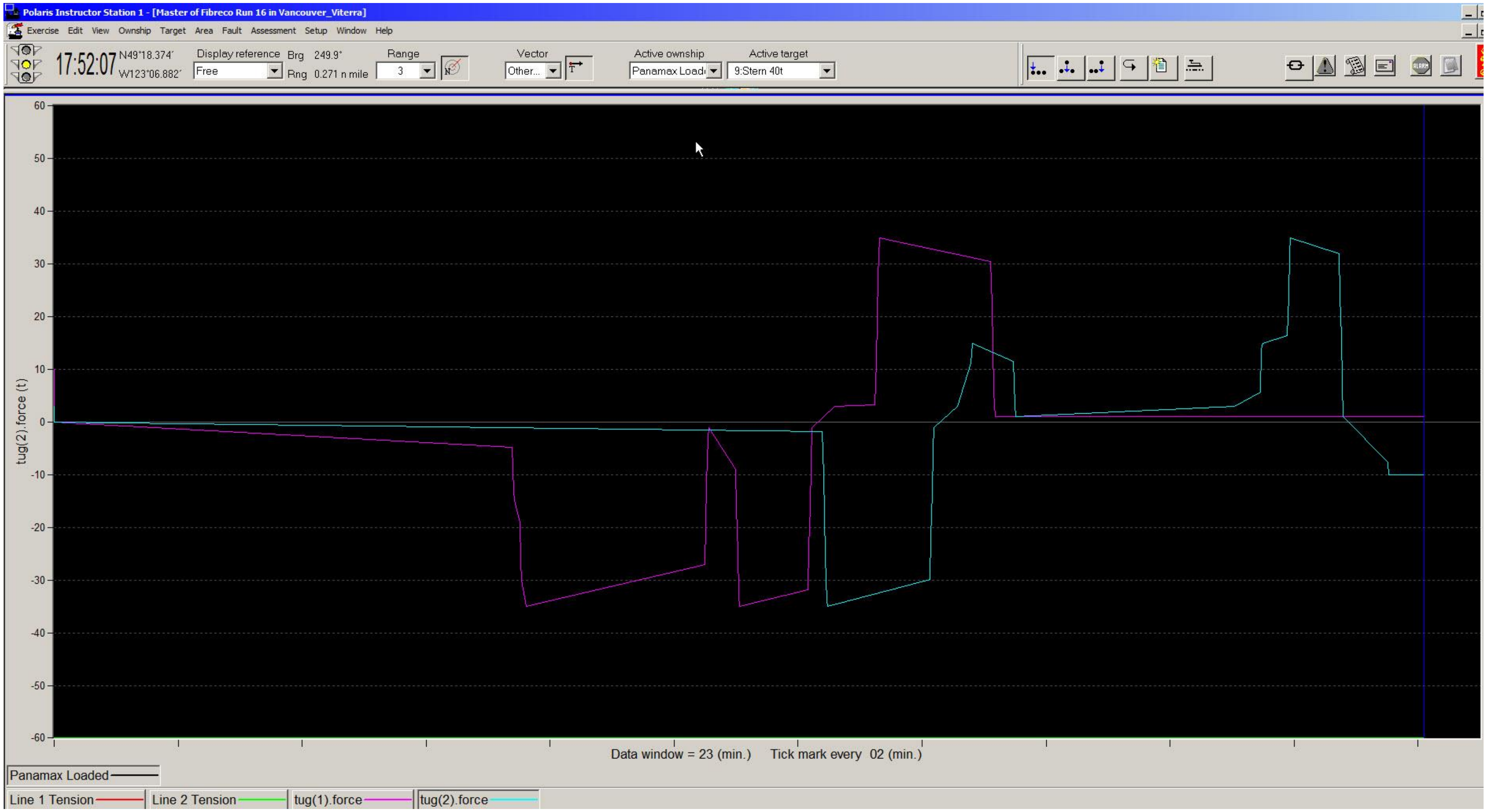
Range: 3/8

Vector: Other...

Active ownship: Panamax Load

Active target: 9:Stern 40t

Figure A32: Applied Tug Forces – Simulation Run 16


Polaris Instructor Station 1 - [Master of Fibreco Run 16 in Vancouver_Viterra]

17:52:07 N49°18.374′ W123°06.882′

Display reference: Free

Brg 249.9°

Rng 0.271 n mile

Range: 3

Vector: Other...

Active ownship: Panamax Loadi

Active target: 9:Stern 40t

Data window = 23 (min.) Tick mark every 02 (min.)

Panamax Loaded

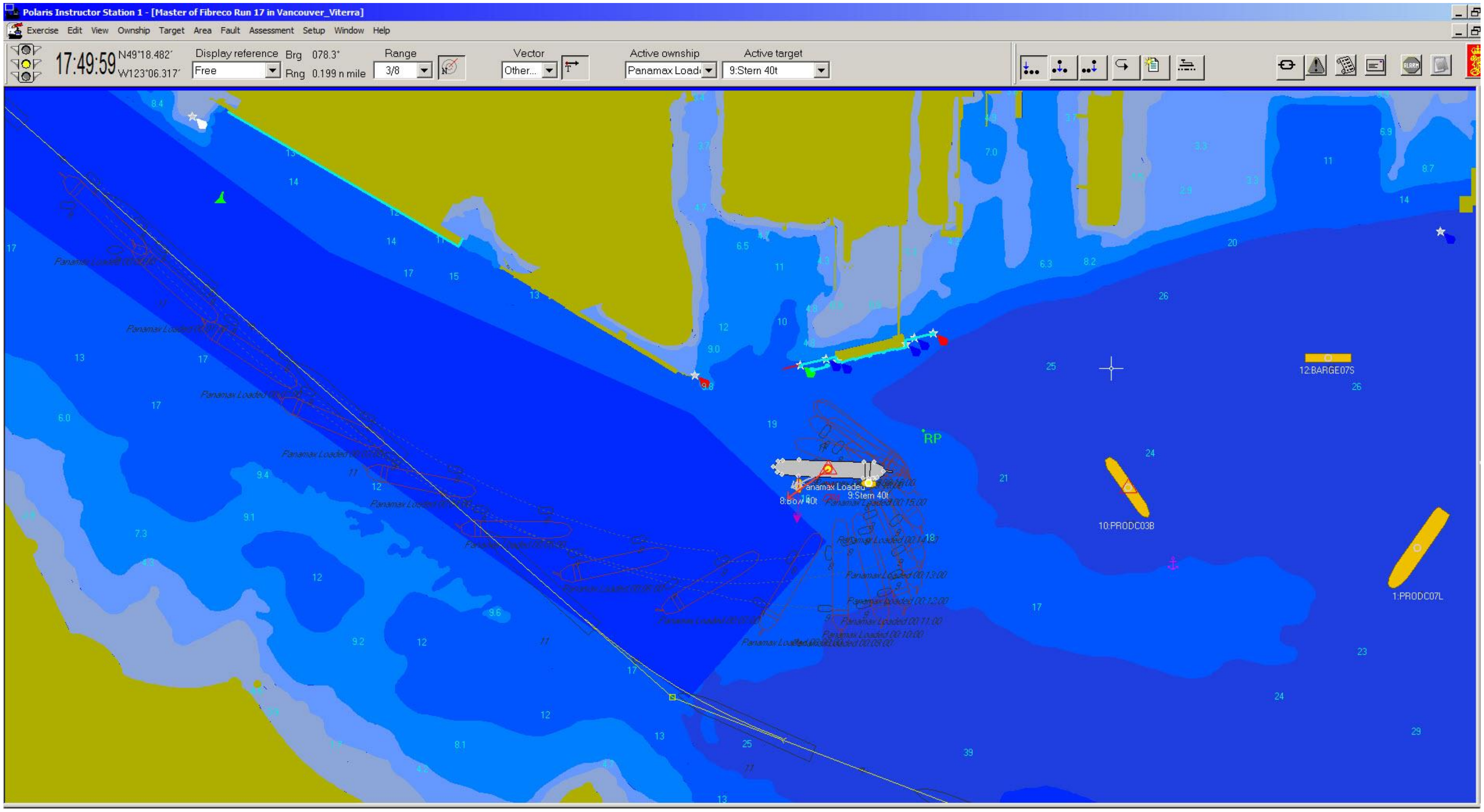
Line 1 Tension

Line 2 Tension

tug(1).force

tug(2).force

Figure A33: Track Plot Simulation Run 17



Polaris Instructor Station 1 - [Master of Fibreco Run 17 in Vancouver_Viterra]

17:49:59 N49°18.482′ W123°06.317′

Display reference: Free

Brg 078.3°

Rng 0.199 n mile

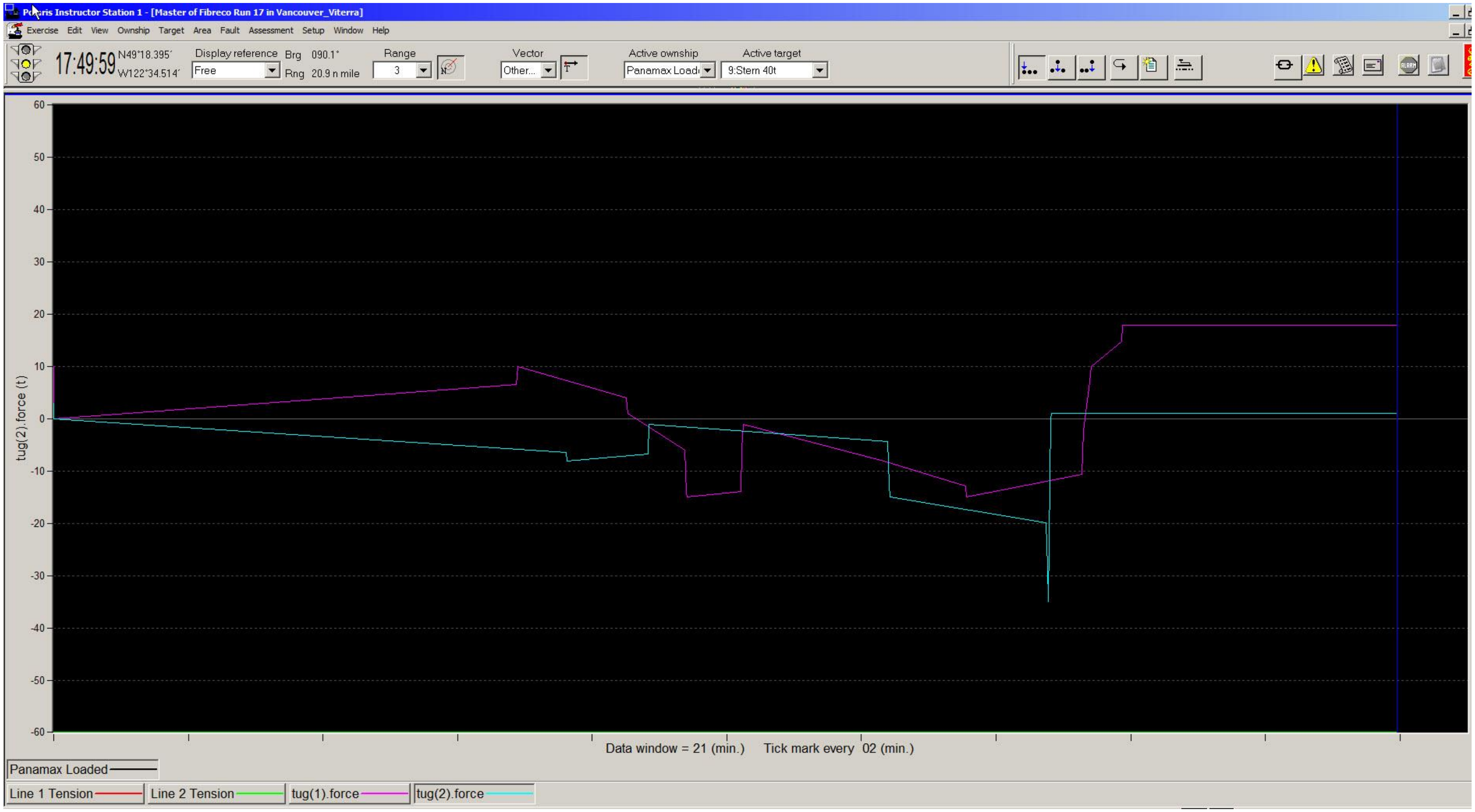
Range: 3/8

Vector: Other...

Active ownship: Panamax Loadi

Active target: 9:Stern 40t

Figure A34: Applied Tug Forces – Simulation Run 17



Polaris Instructor Station 1 - [Master of Fibreco Run 17 in Vancouver_Viterra]

17:49:59 N49°18.395′ W122°34.514′

Display reference: Free

Brg 090.1°

Rng 20.9 n mile

Range: 3

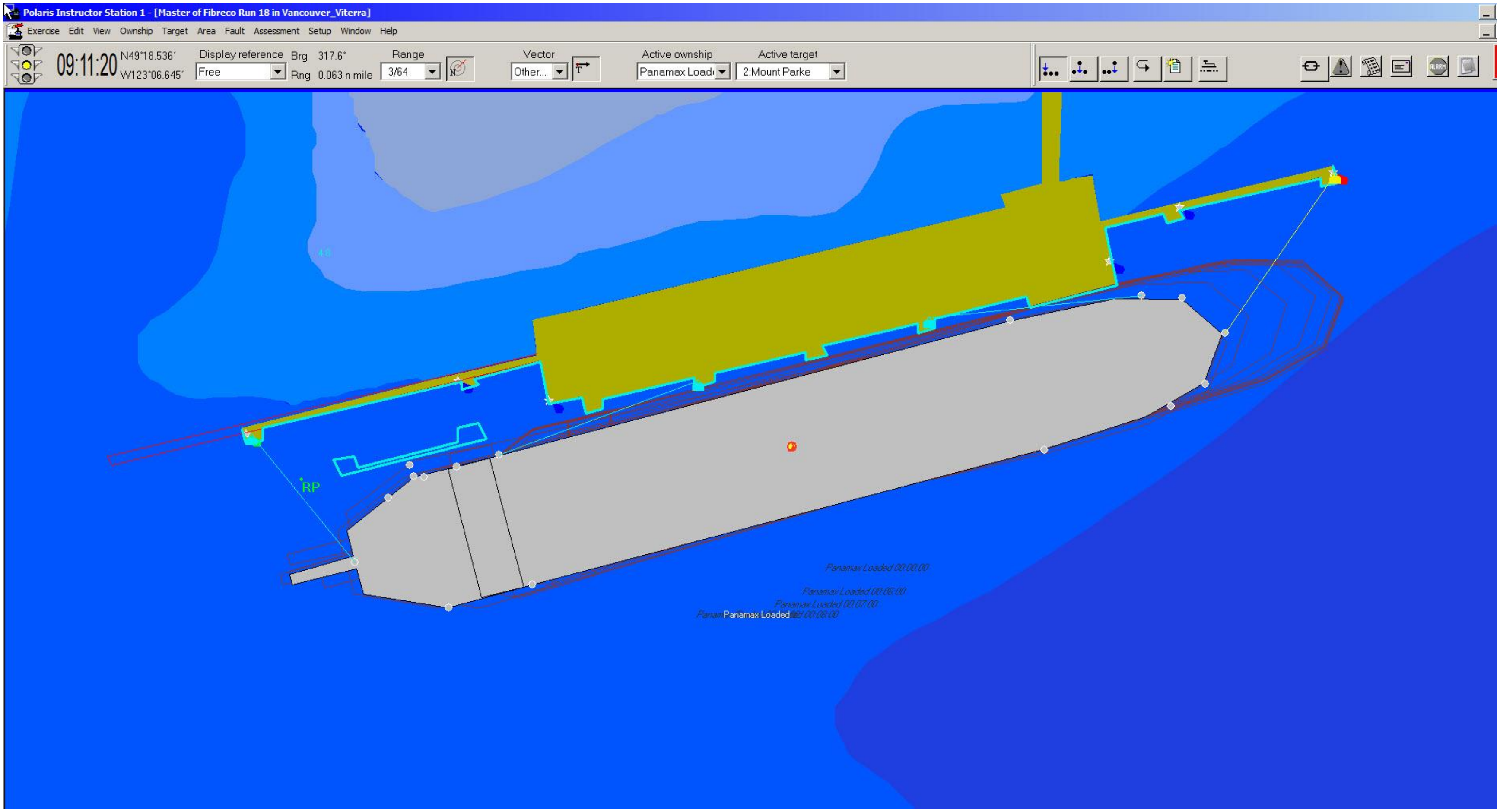
Vector: Other...

Active ownship: Panamax Loadi

Active target: 9:Stern 40t

Data window = 21 (min.) Tick mark every 02 (min.)

Figure A35: Track Plot Simulation Run 18



Polaris Instructor Station 1 - [Master of Fibreco Run 18 in Vancouver_Viterra]

09:11:20 N49°18.536´ W123°06.645´

Display reference: Free

Brg 317.6°

Rng 0.063 n mile

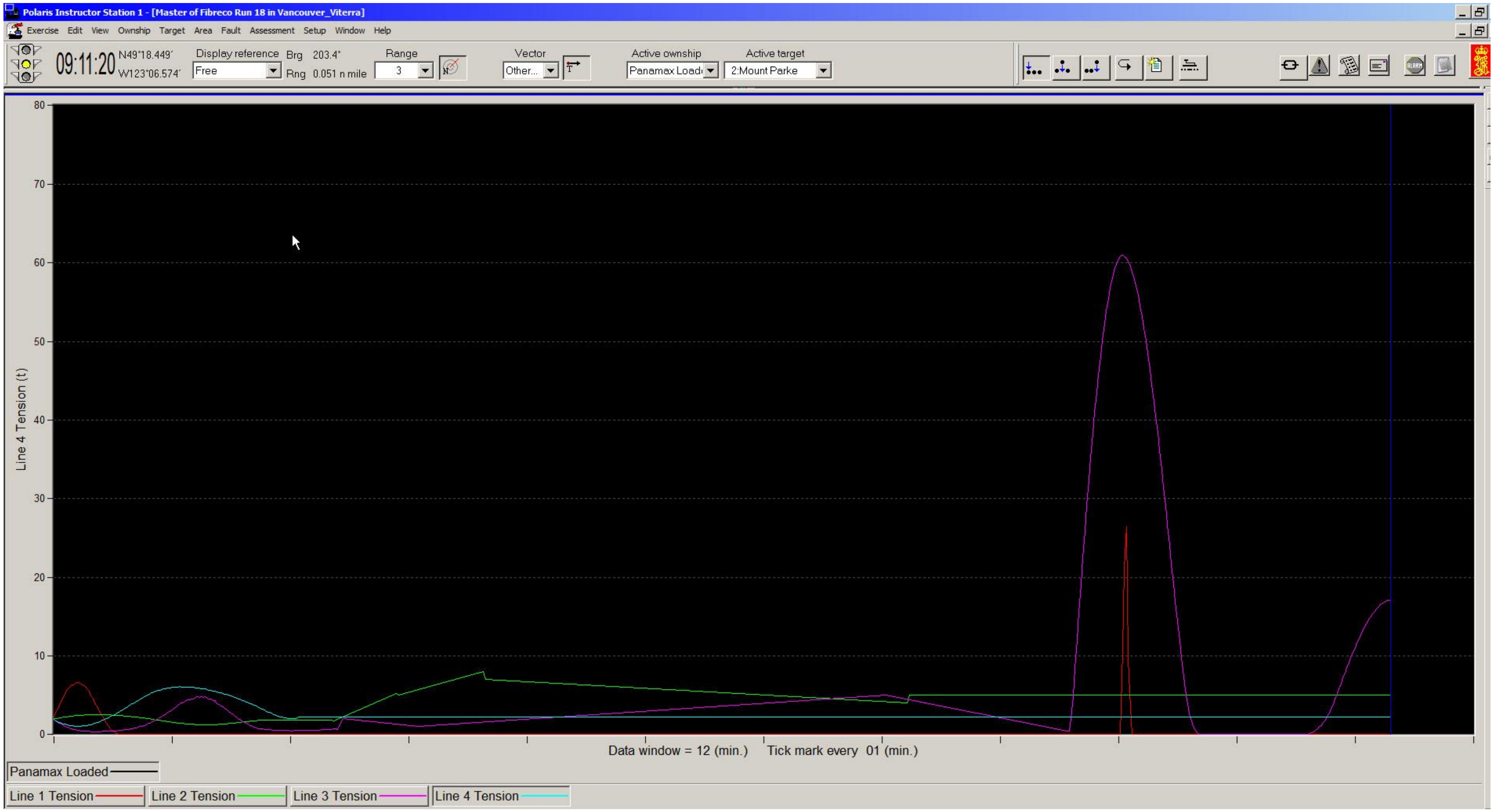
Range: 3/64

Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

Figure A36: Mooring Lines Tension – Simulation Run 18



Polaris Instructor Station 1 - [Master of Fibreco Run 18 in Vancouver_Viterra]

09:11:20 N49°18.449′ W123°06.574′

Display reference: Free

Brg 203.4°

Rng 0.051 n mile

Range: 3

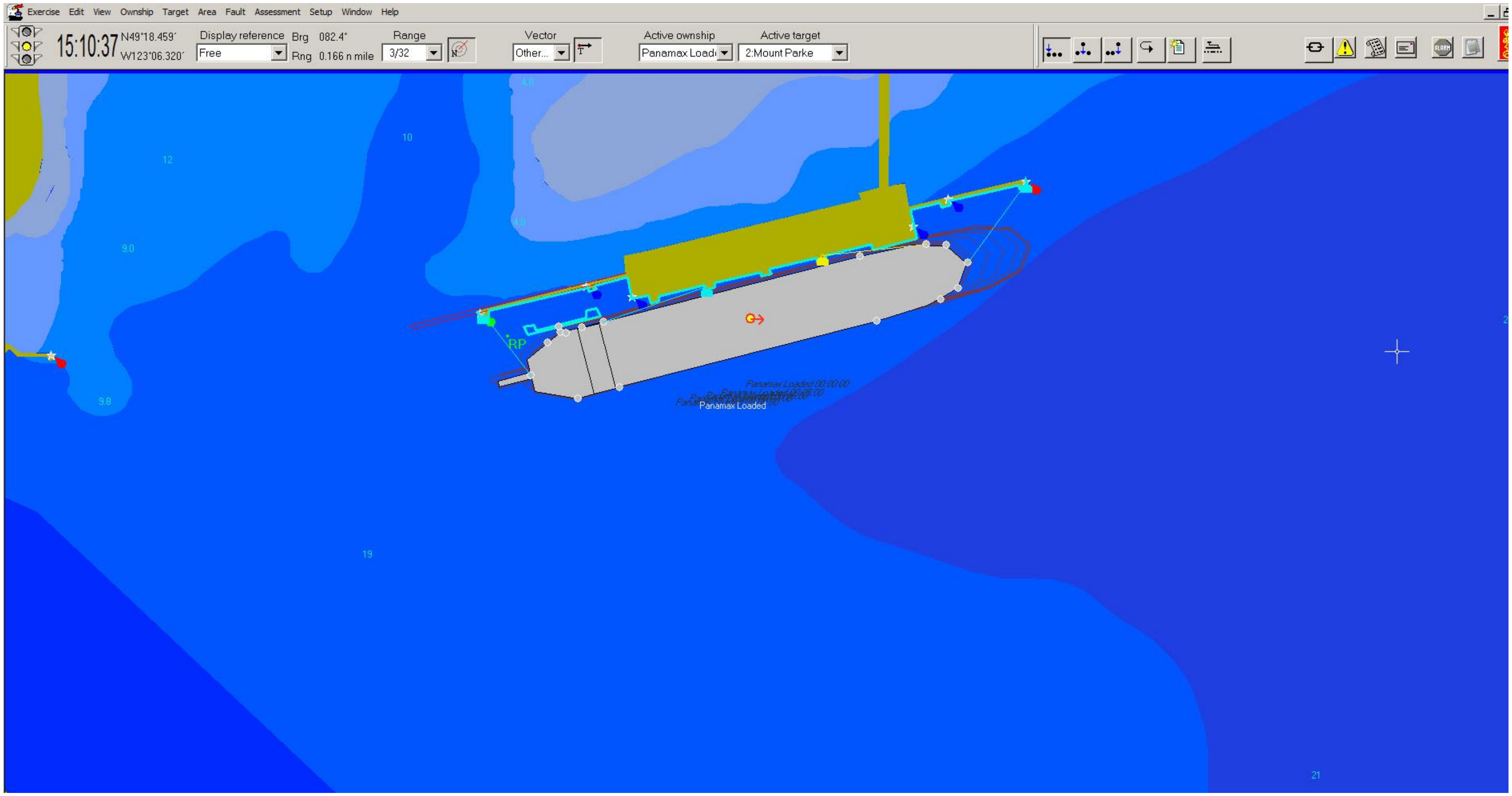
Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

Data window = 12 (min.) Tick mark every 01 (min.)

Figure A37: Track Plot Simulation Run 19



15:10:37 N49°18.459′ W123°06.320′

Display reference: Free

Brg 082.4°

Rng 0.166 n mile

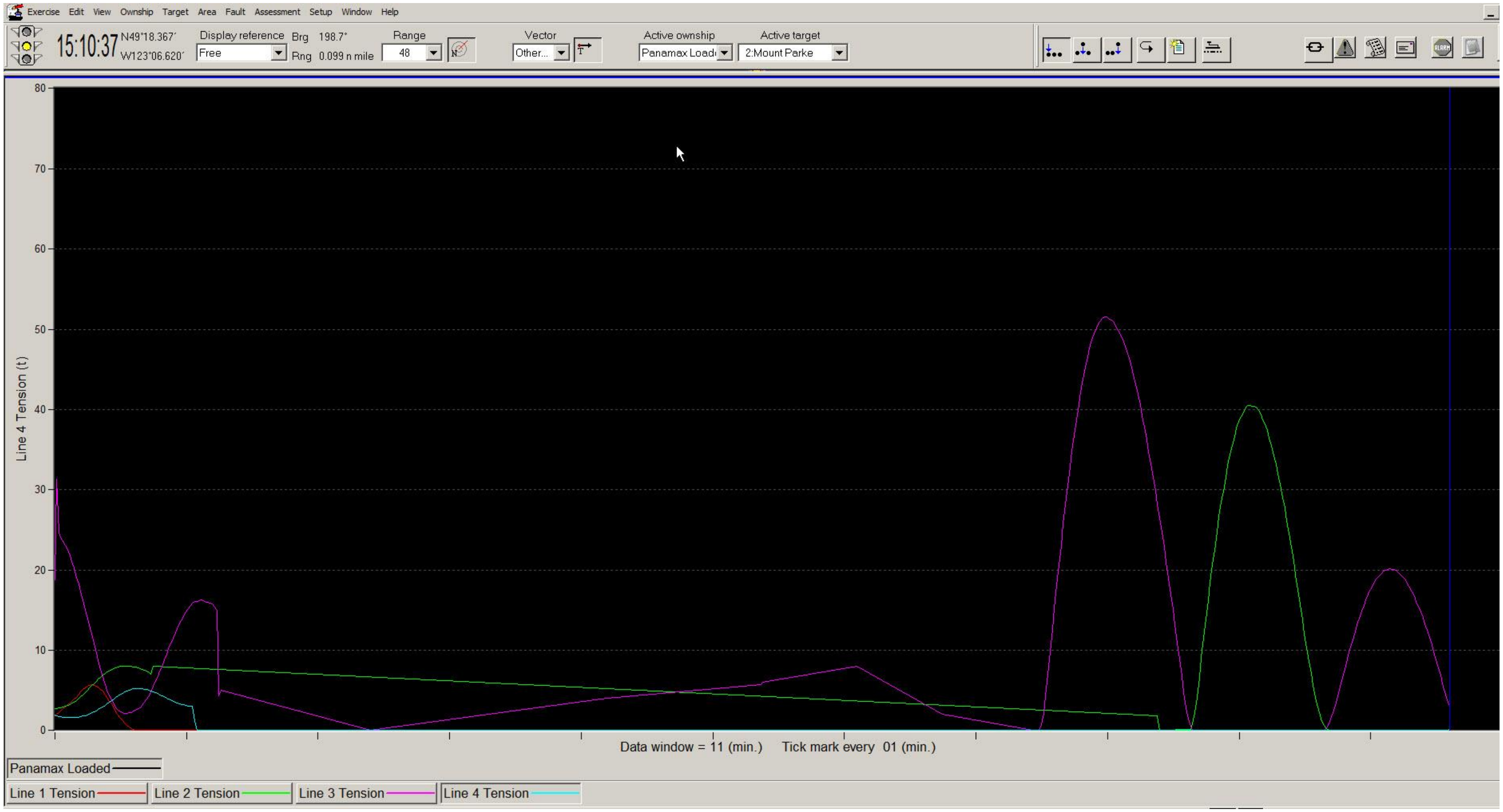
Range: 3/32

Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

Figure A38: Mooring Lines Tension – Simulation Run 19



15:10:37 N49°18.367′ W123°06.620′

Display reference: Free

Brg 198.7°

Rng 0.099 n mile

Range: 48

Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

Data window = 11 (min.) Tick mark every 01 (min.)

Panamax Loaded

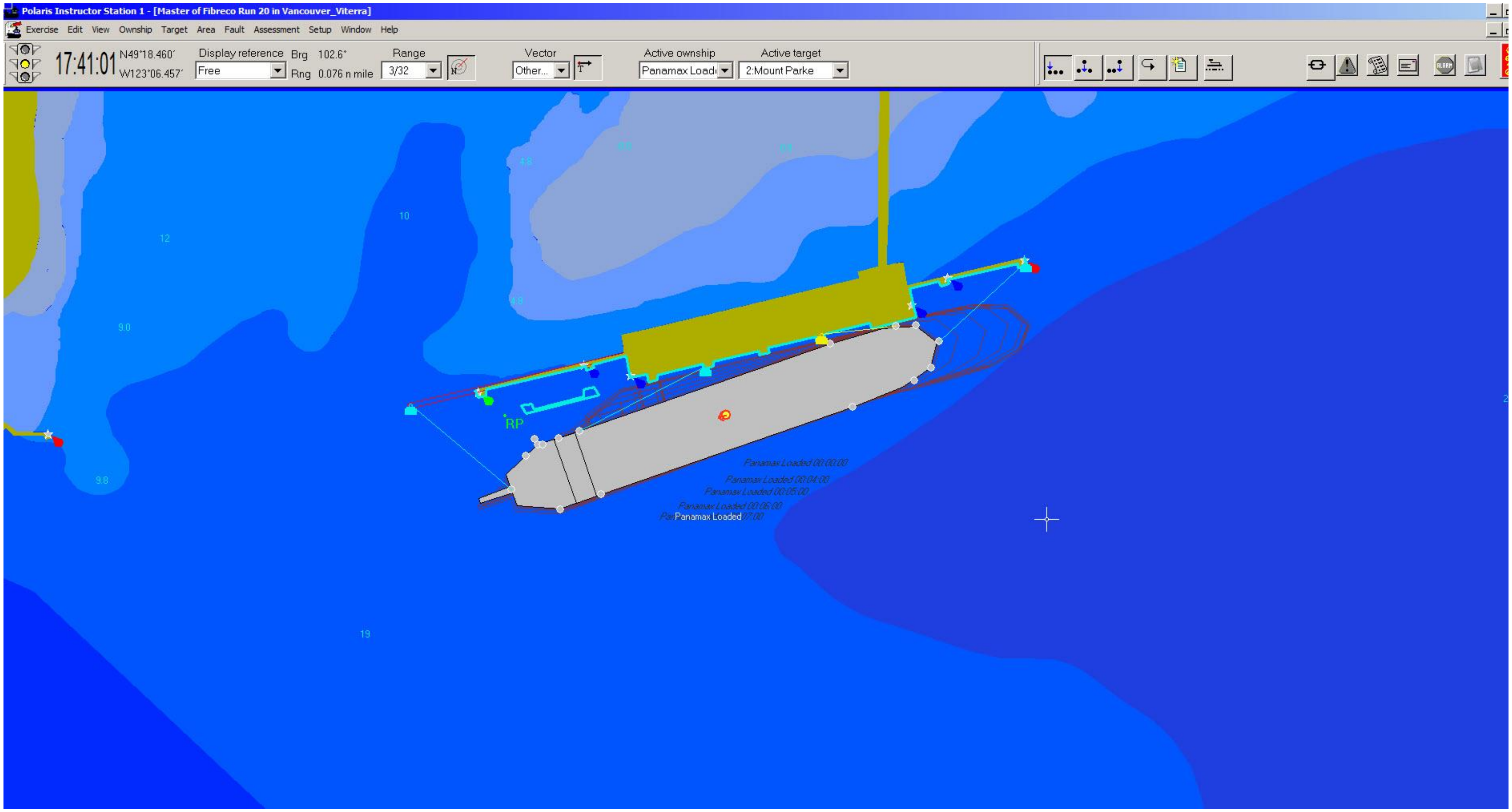
Line 1 Tension

Line 2 Tension

Line 3 Tension

Line 4 Tension

Figure A39: Track Plot Simulation Run 20



Polaris Instructor Station 1 - [Master of Fibreco Run 20 in Vancouver_Viterra]

17:41:01 N49°18.460′ W123°06.457′

Display reference: Free

Brg 102.6°

Rng 0.076 n mile

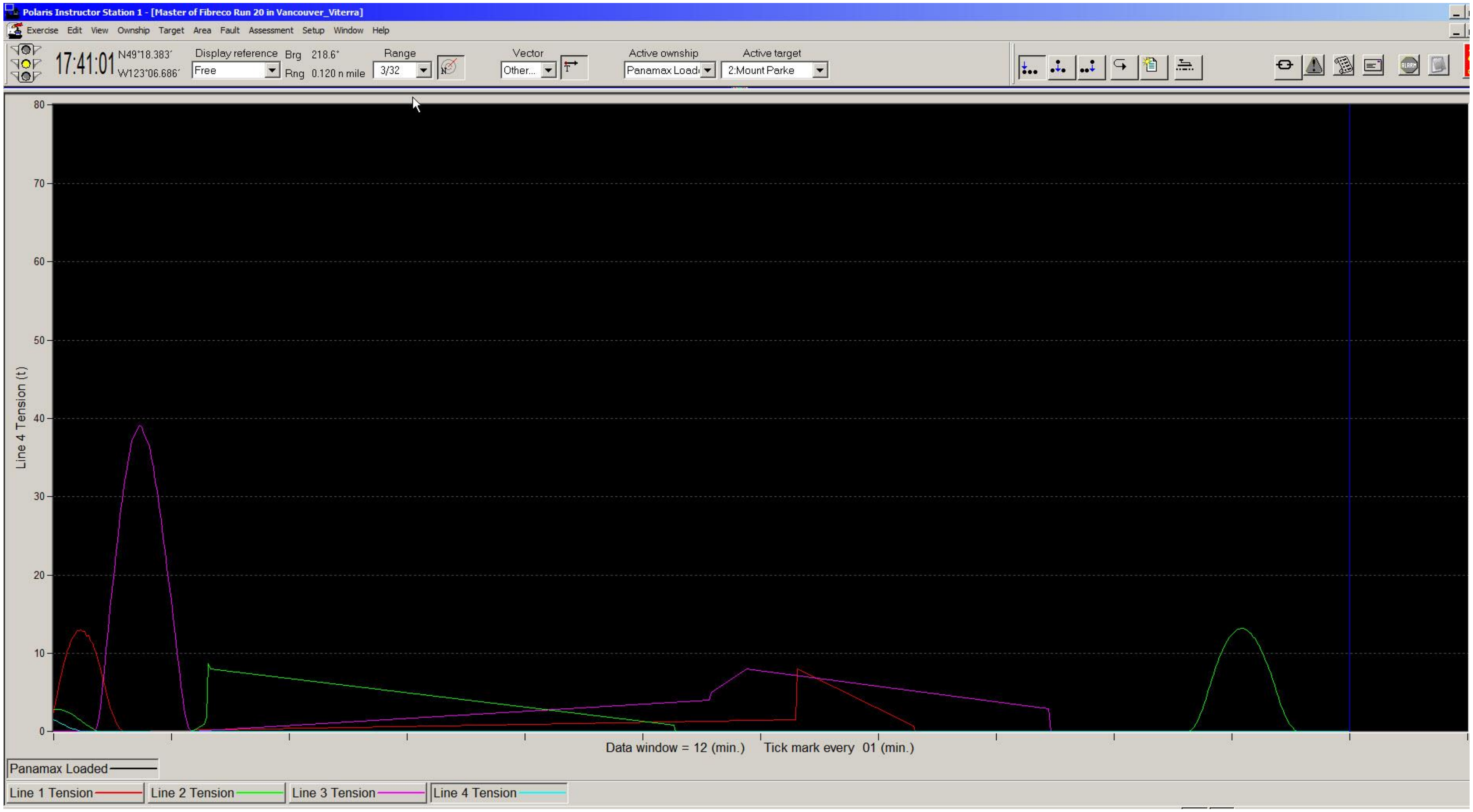
Range: 3/32

Vector: Other...

Active ownship: Panamax Load

Active target: 2:Mount Parke

Figure A40: Mooring Lines Tension – Simulation Run 20



Polaris Instructor Station 1 - [Master of Fibreco Run 20 in Vancouver_Viterra]

17:41:01 N49°18.383′ W123°06.686′

Display reference: Free

Brg 218.6°

Rng 0.120 n mile

Range: 3/32

Vector: Other...

Active ownship: Panamax Loadı

Active target: 2:Mount Parke

Data window = 12 (min.)   Tick mark every 01 (min.)