Accommodating Larger Vessels: Ship Maneuverability and Channel Depth;

A discussion of vessel motion in shallow water and future research needs.

PANELISTS:

Paul Amos: President, Columbia River Pilots.

Larry Daggett: Vice President, Waterway Simulation Technology. Previously with Army Corps ERDC labs.

Dan Jordan: Columbia River Bar Pilot, currently involved in a study of vessel dynamics on the Columbia River Bar.

Mike Morris: Houston Ship Channel Pilot.

Eric Burnette: Sr. Waterways Planner, Port of Portland, Oregon (moderator).

ORDER OF PRESENTATION:

1. Introduction of panelists.

2. Trends driving the discussion of vessel motion in shallow water.

1. Presentation on basic squat and under-keel definitions and concepts.

2. Very brief audience Q & A on key definitions and concepts.

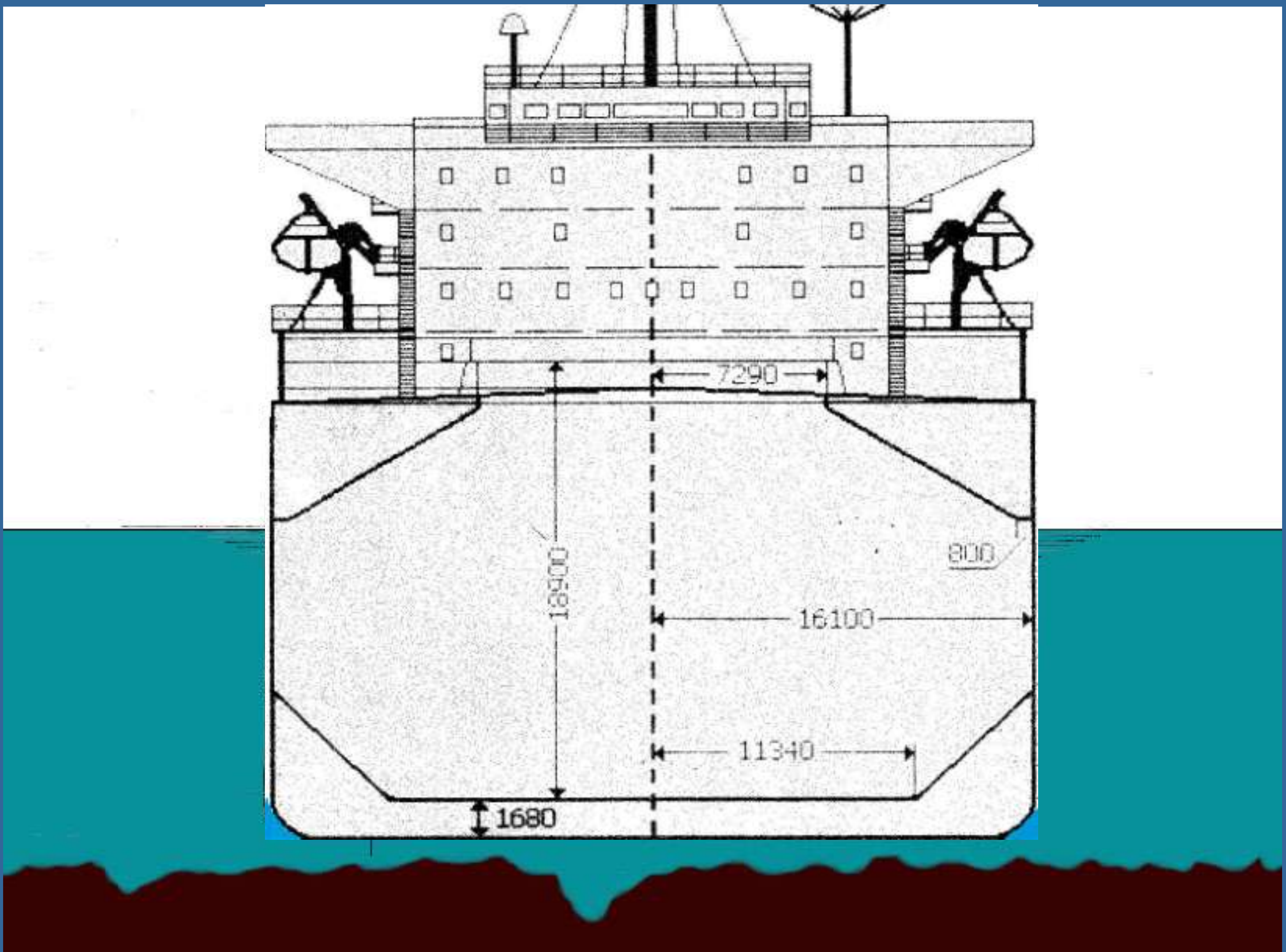
1. Moderated discussion between panelists.

1. Audience Q & A.

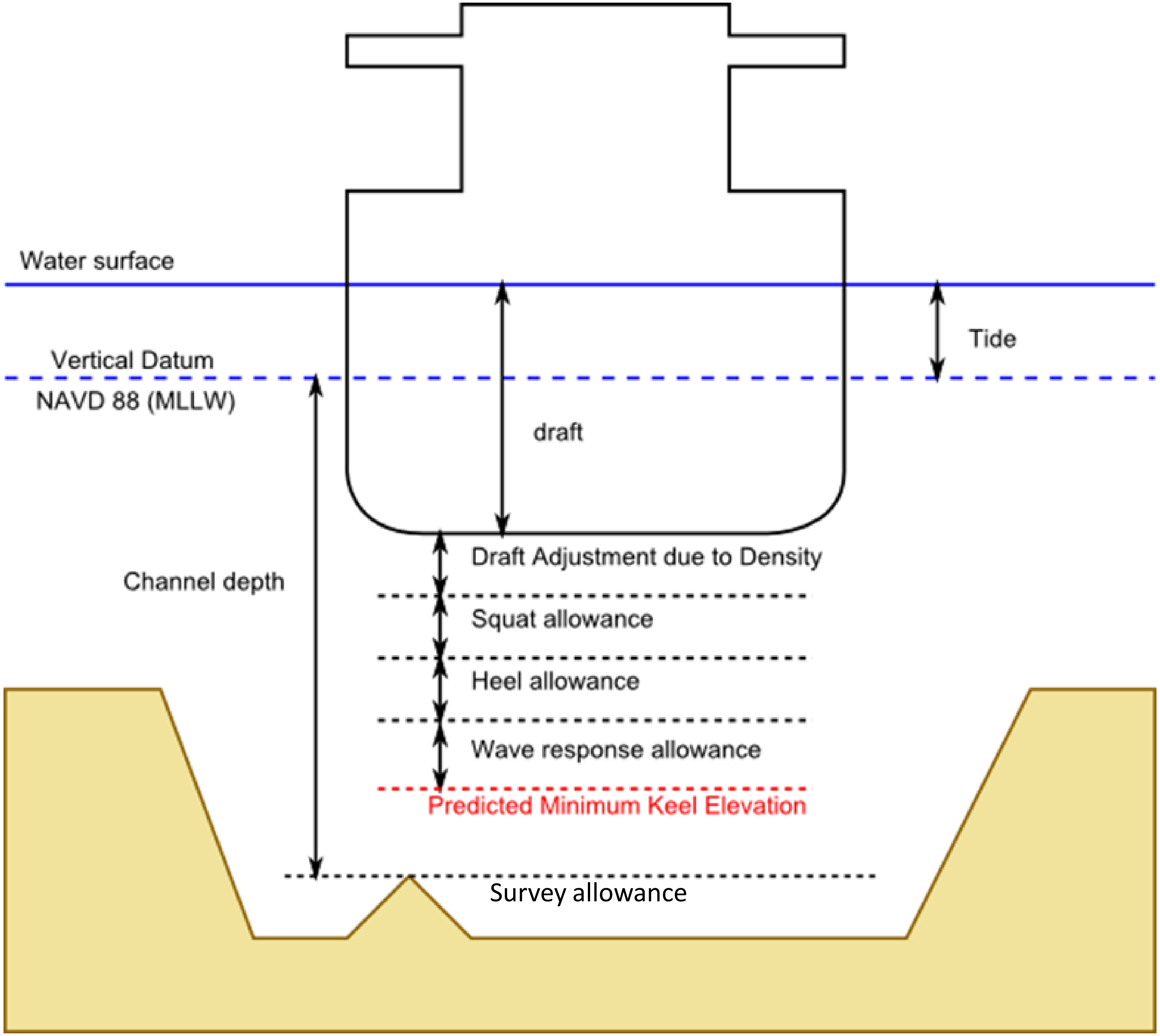
An operational view of **Vessel Motions**

Squat / Sinkage
Heel / Roll
Pitch / Wave Response

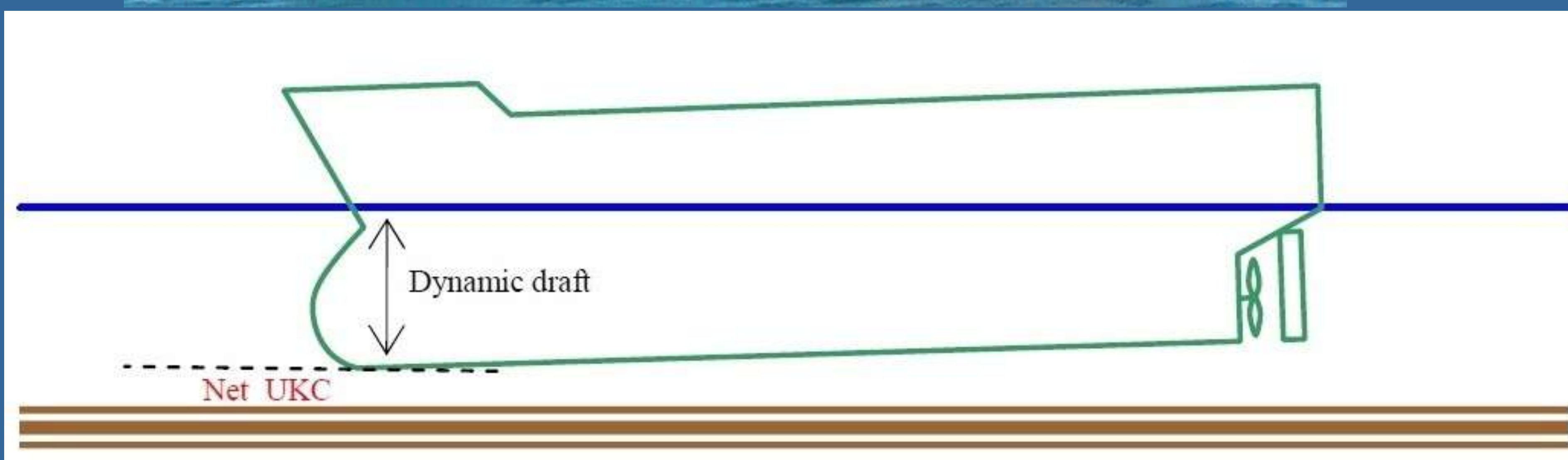
Real Scale in Calm Water



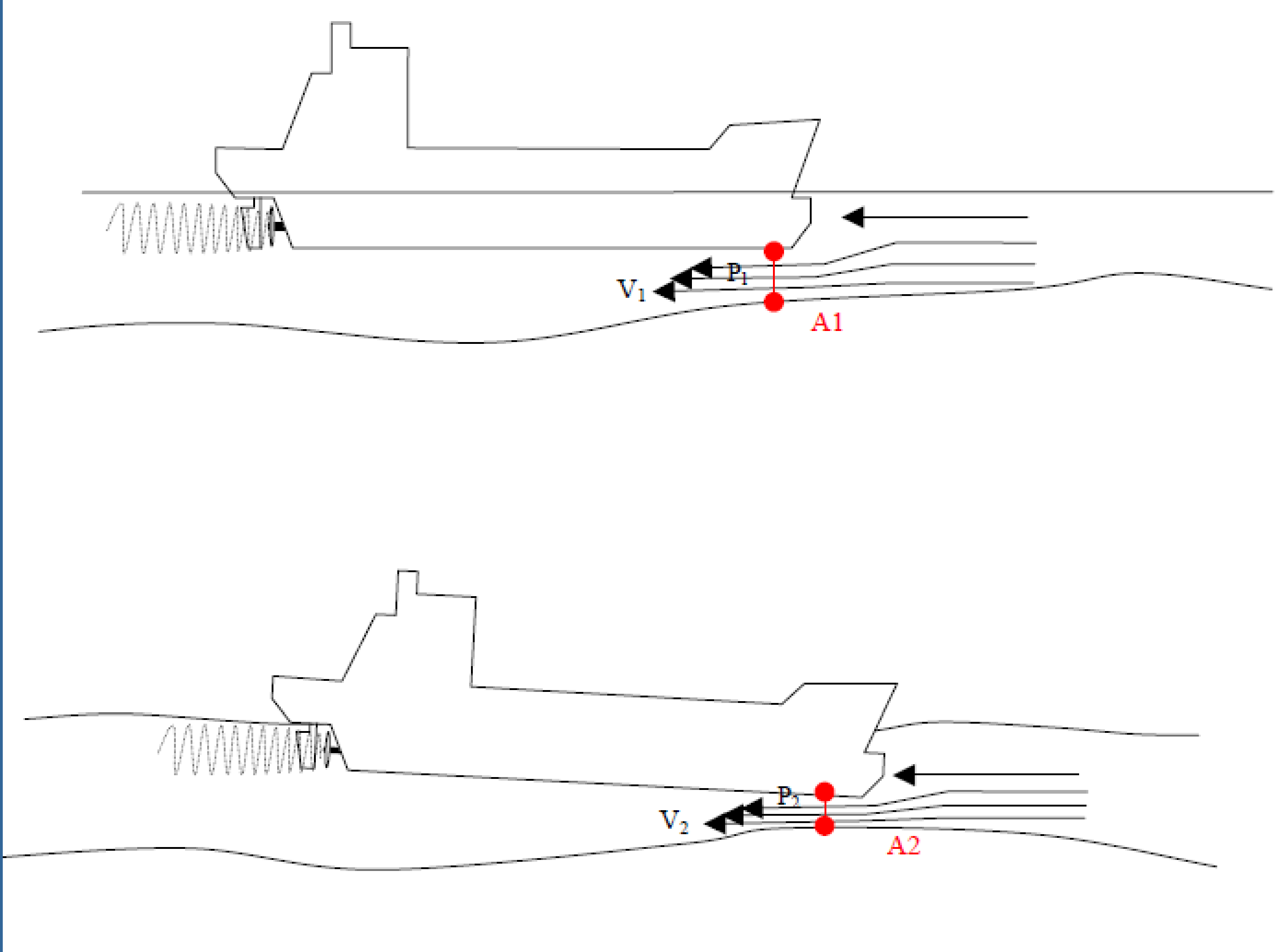
Components of Under Keel Clearance



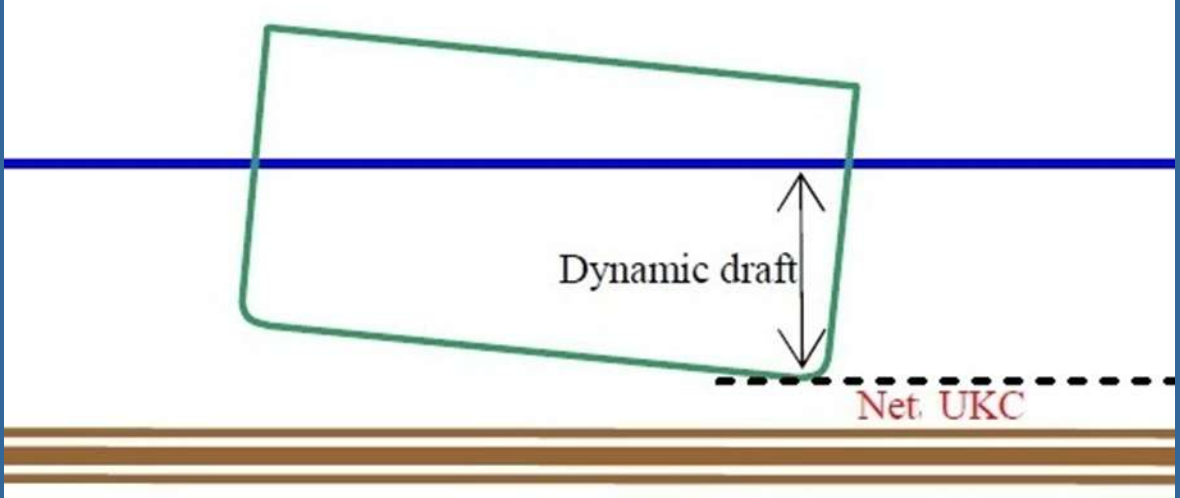
Squat / Sinkage



Squat changes with speed and bottom contours



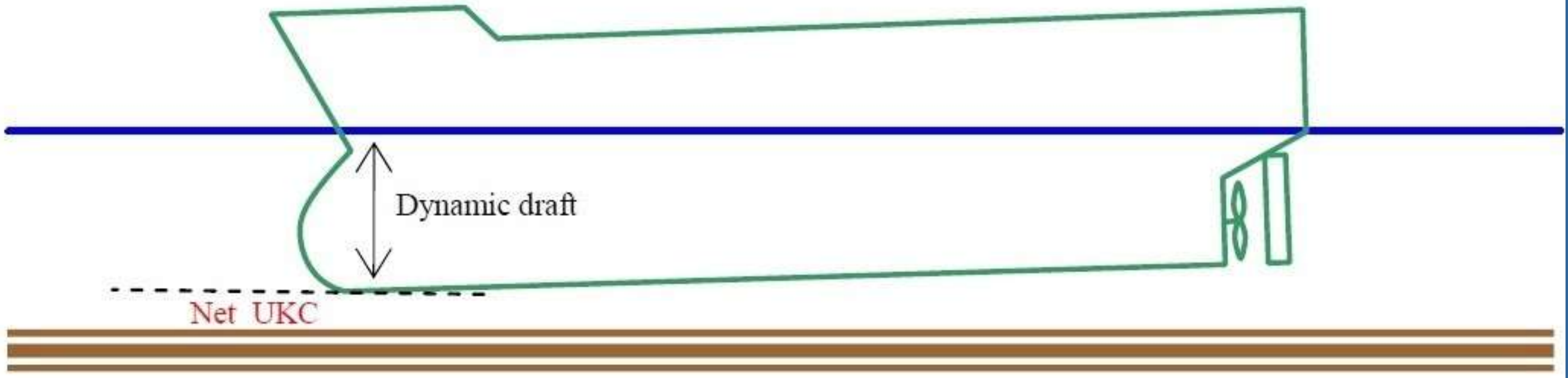
Roll / Heel



Increase of Draft due to List

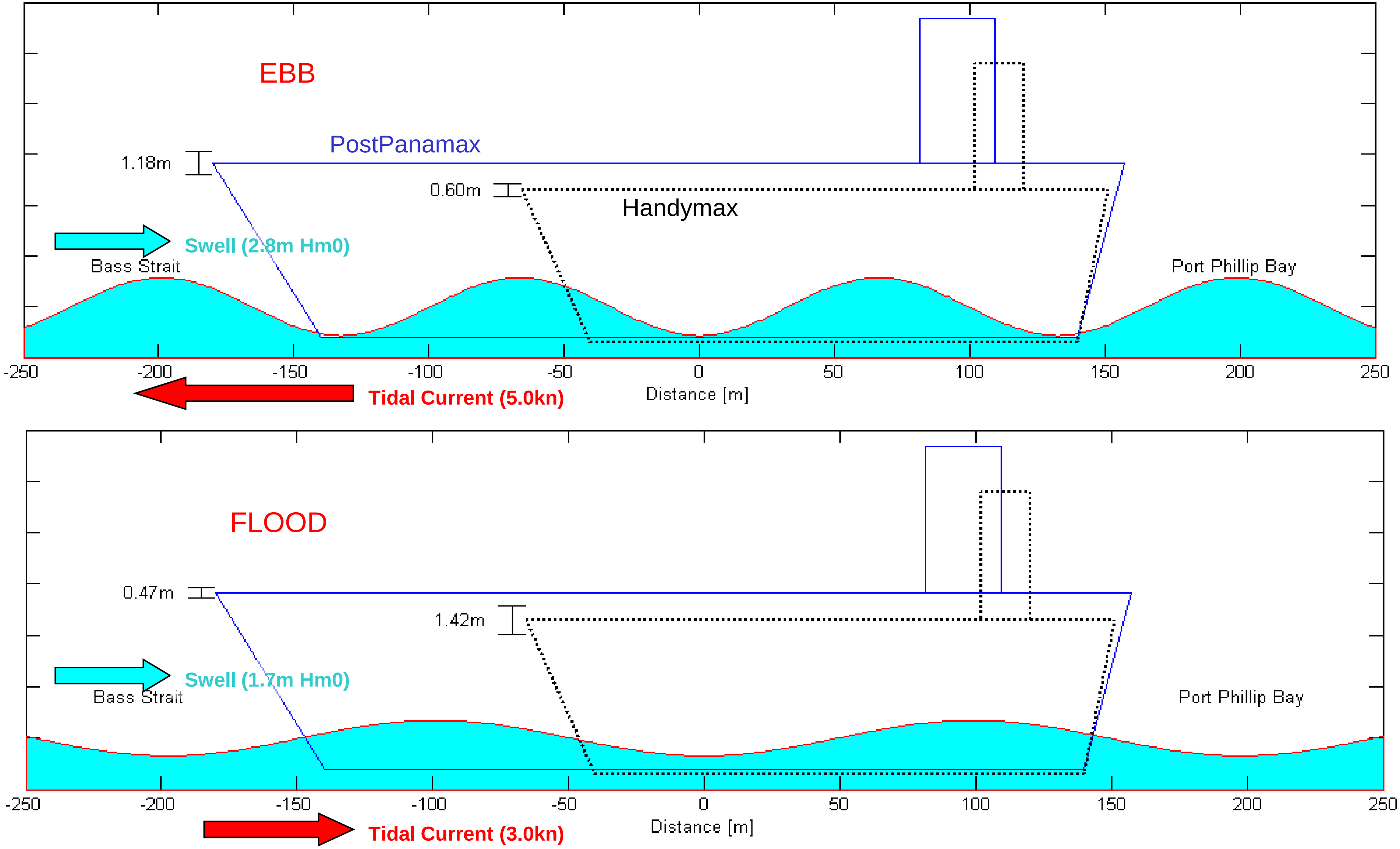
Beam	1º	2º	3º
60’	0.52’	1.05’	1.57’
80’	0.70’	1.40’	2.09’
100’	0.87’	1.75’	2.62’
110’	0.96’	1.92’	2.88’
120’	1.05’	2.09’	3.14’
140’	1.22’	2.44’	3.66’
160’	1.40’	2.79’	4.19’’

Wave Response

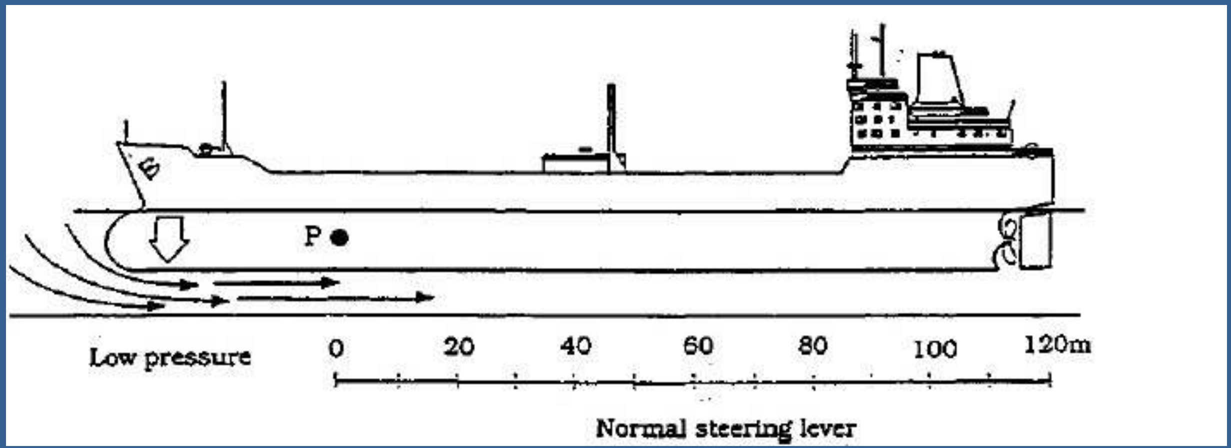


Wave Response

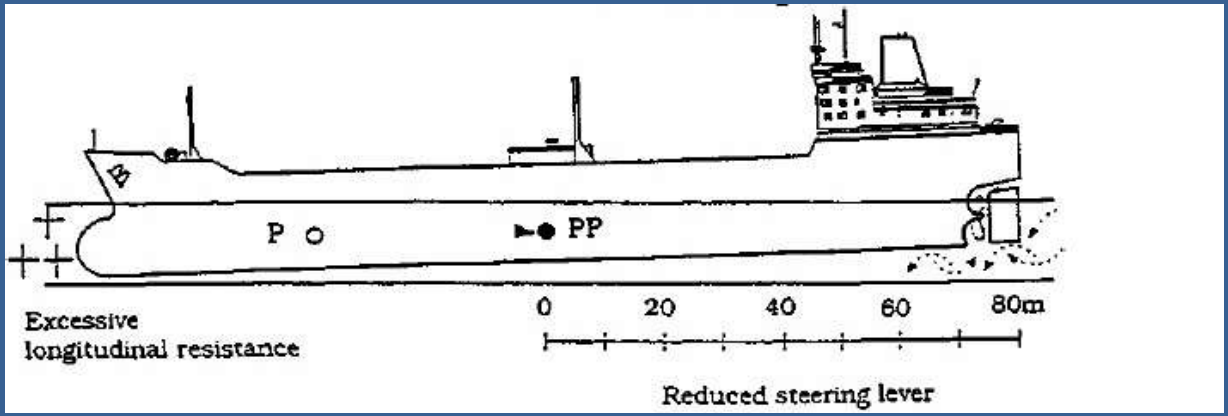
Offshore Swell height = 2m, period = 14 seconds



Effects of Squat on Vessel Maneuverability

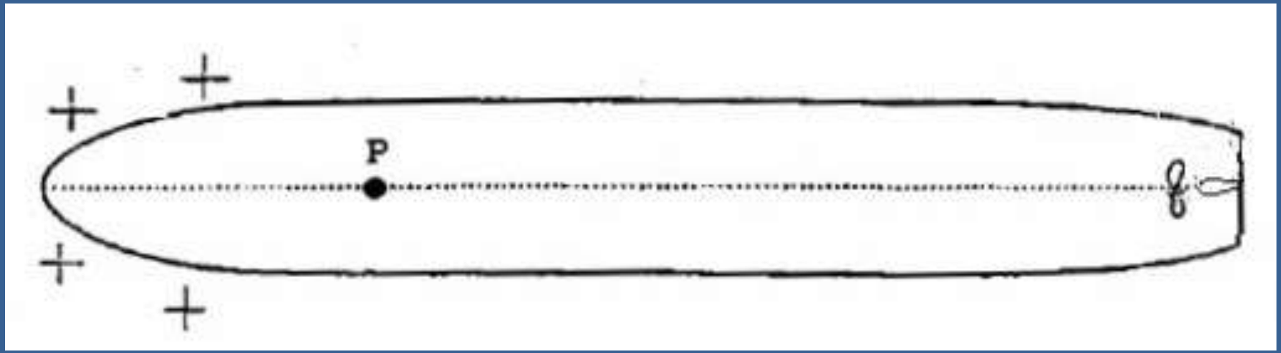


Directionally Stable with Pivot Point forward

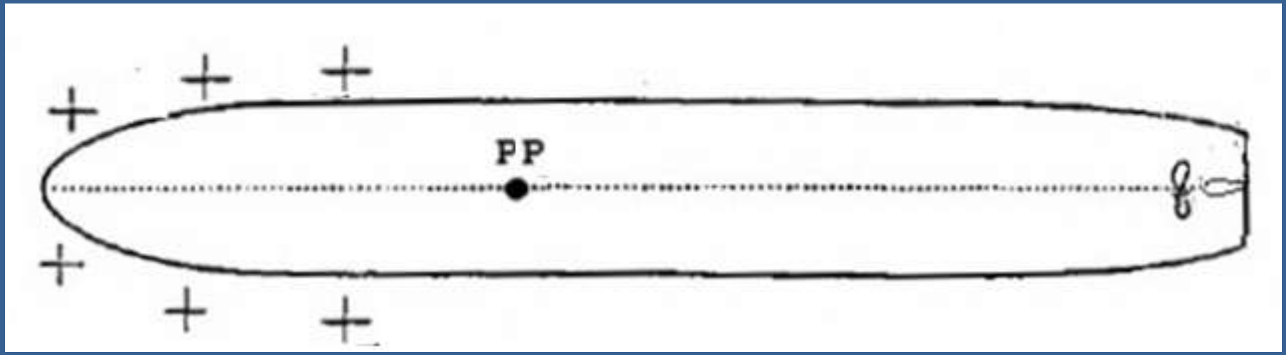


Directionally Unstable with Pivot Point aft

Effects of Squat on Vessel Maneuverability

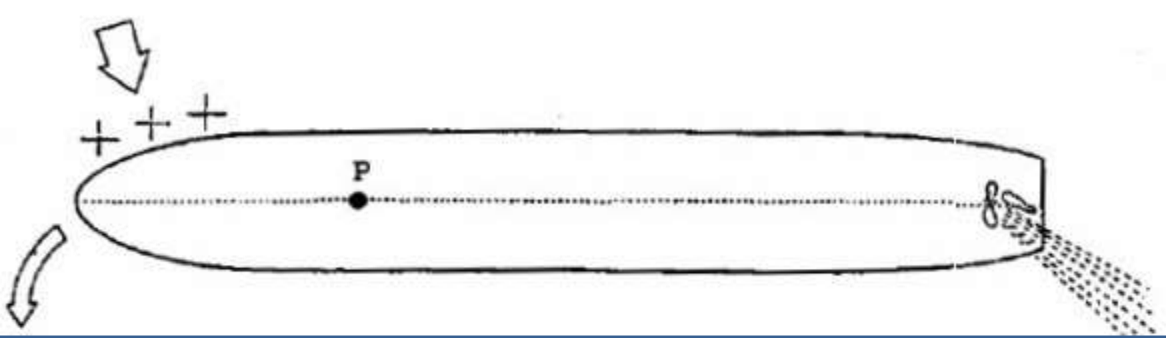


Normal Bow Pressure with Pivot Point forward

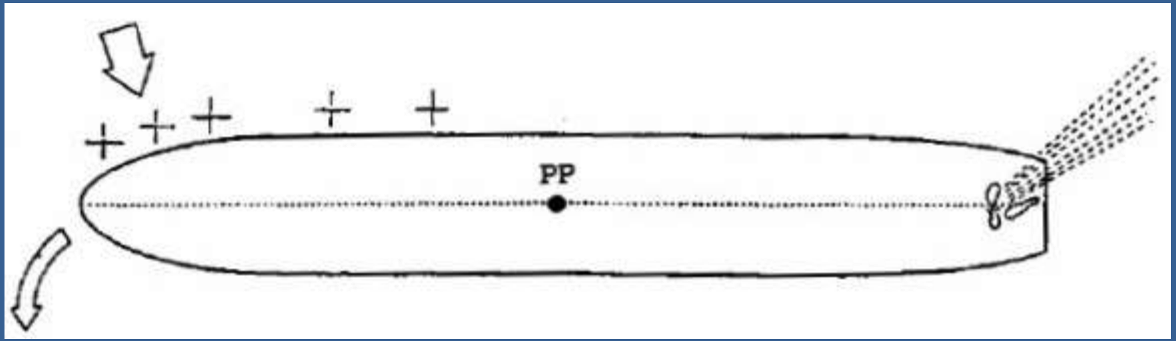


Increased Bow Pressure with Pivot Point aft

Effects of Squat on Vessel Maneuverability



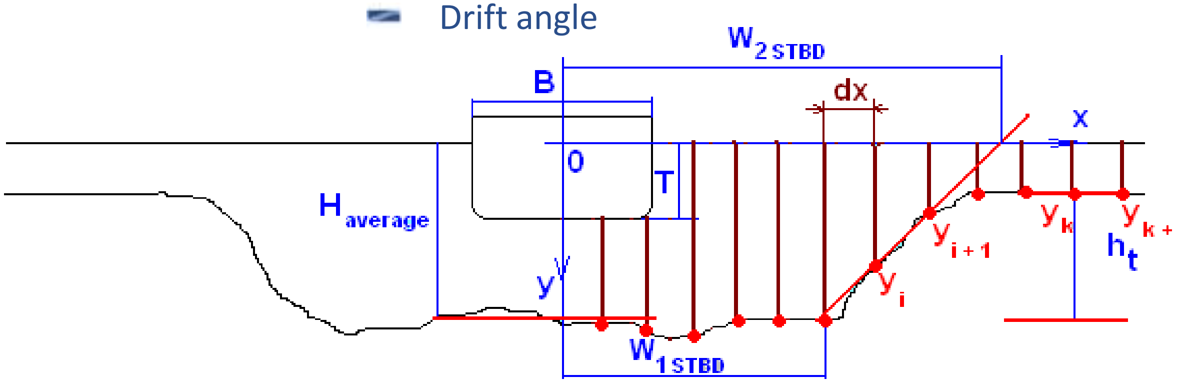
Normal turning forces



Increased bow pressure and shortened steering lever make turns difficult to control

Parameters used in Squat modeling and simulation predictions are as following:

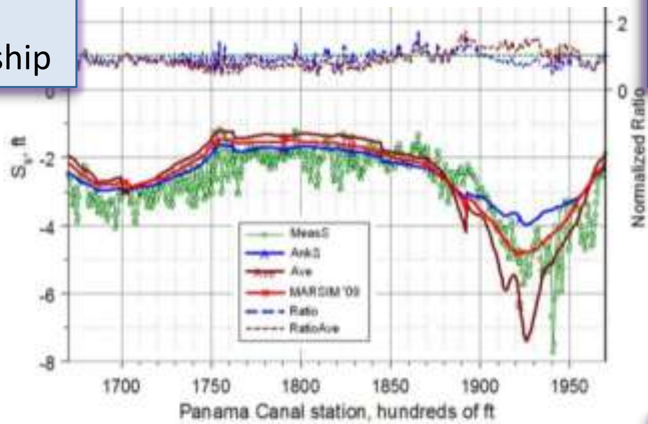
- Fore Draft
- Aft Draft
- Ship Breadth
- Length Between Perpendiculars
- Length in Waterline
- Block Coefficient $C_b = \frac{V}{L_{pp}BT}$
- Mid-Frame Coefficient
- Volumetric Displacement
- Number of Propellers
- Bulb Type
- Type of Stern
- Transom stern width
- Metacentric height
- Gravity center
- Ship speed
- Yaw rate
- Type of bottom soil
- Channel Type: Unrestricted channel, Restricted channel (with flooded banks), Canal (with surface piercing banks)
- Depth of water ($H_{average}$)
- Width of the channel (W) $W_{effective} = \left[\frac{7.04}{C_B^{0.85}}\right] B$
- Flooded bank height (h_t)
- Channel cross-sectional area from the longitudinal symmetry plane of the ship to STBD (S_{STBD})
- Channel cross-sectional area from the longitudinal symmetry plane of the ship to PORT (S_{PORT})
- Drift angle



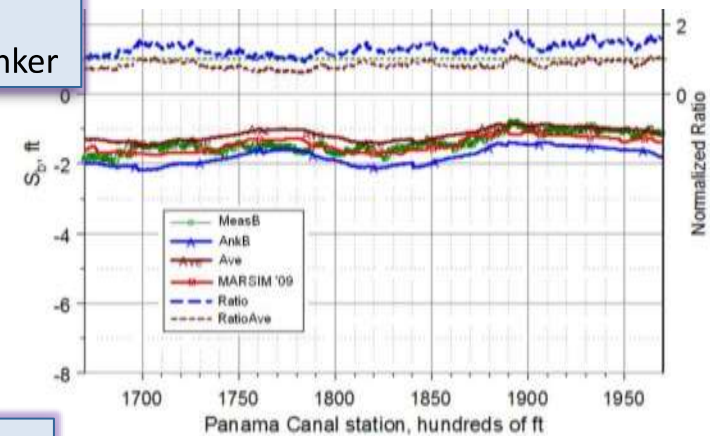
PANAMA CANAL SQUAT PREDICTIONS VS. SEA-TRIALS MEASUREMENTS

Average bow or stern squat predictions to the measured DGPS values for ships

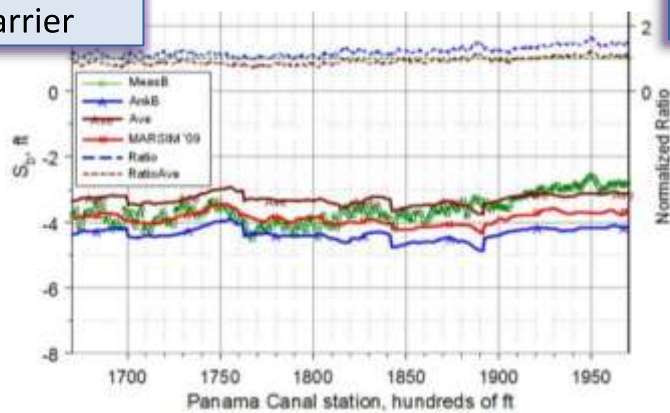
Majestic Maersk
Panamax containership



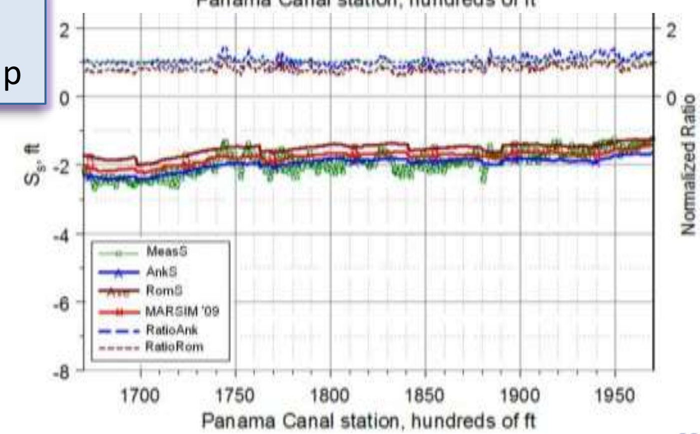
Elbe
Panamax tanker



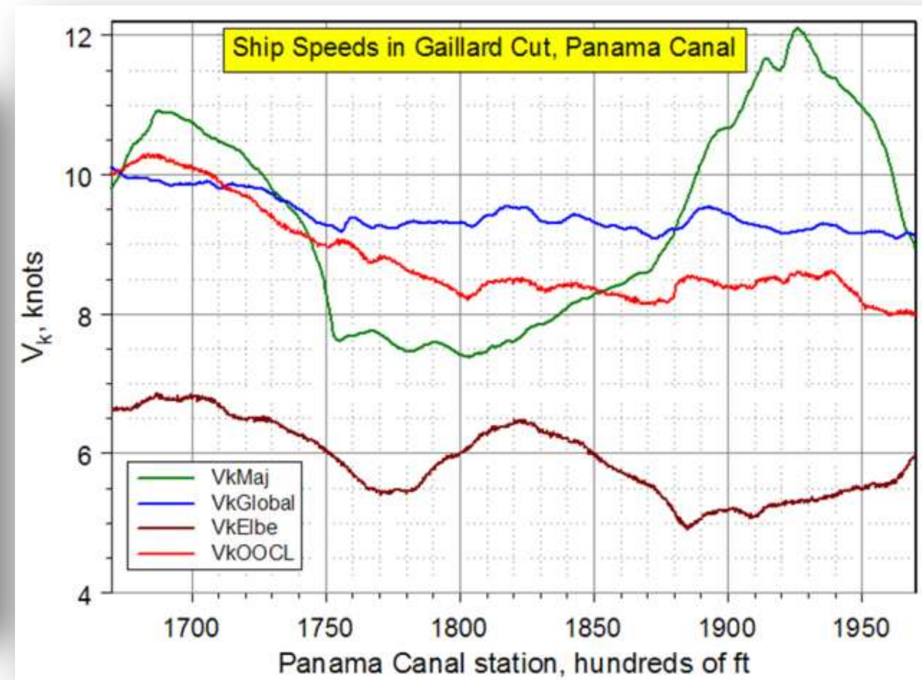
Global Challenger
Panamax bulk carrier



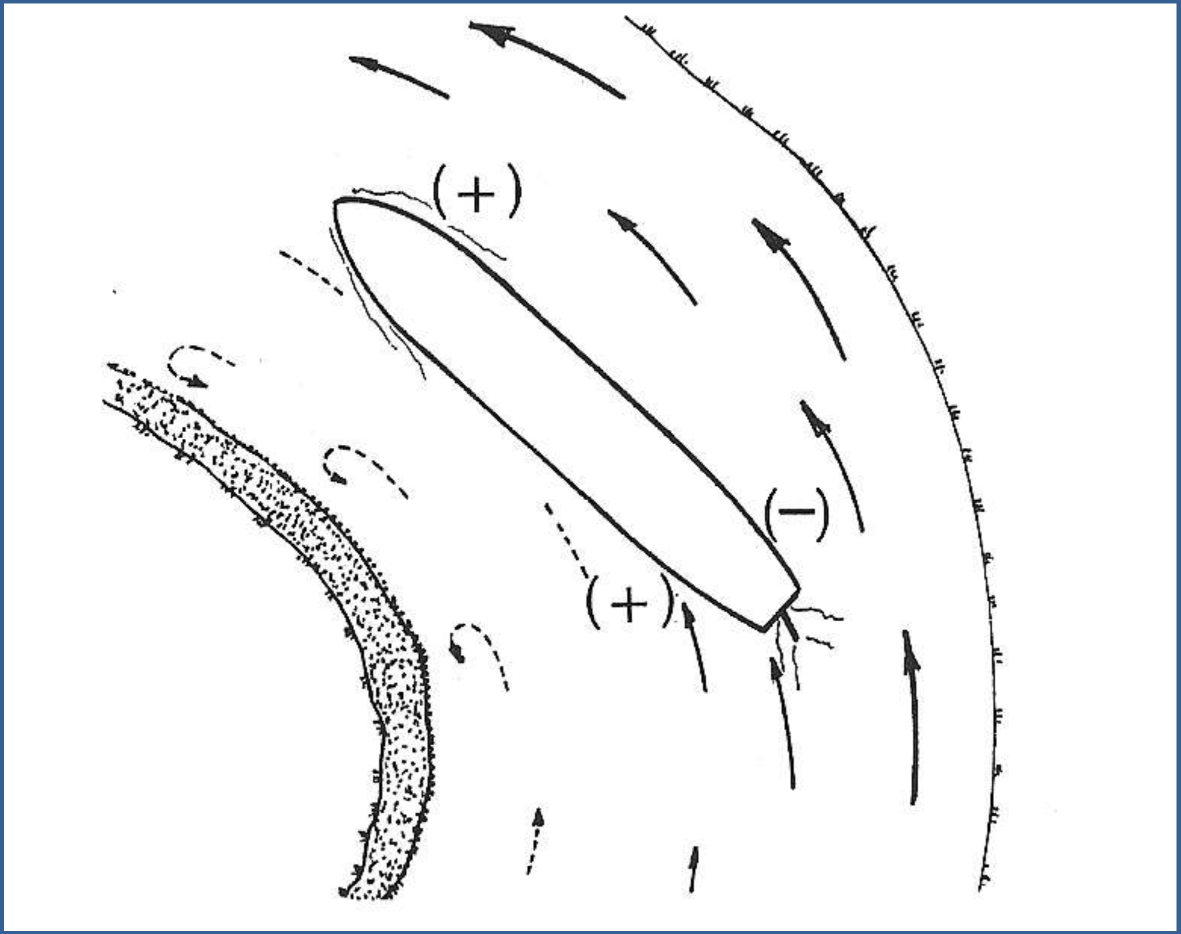
OOCL Fair
containership



PANAMA CANAL SQUAT PREDICTIONS VS. SEA-TRIALS MEASUREMENTS

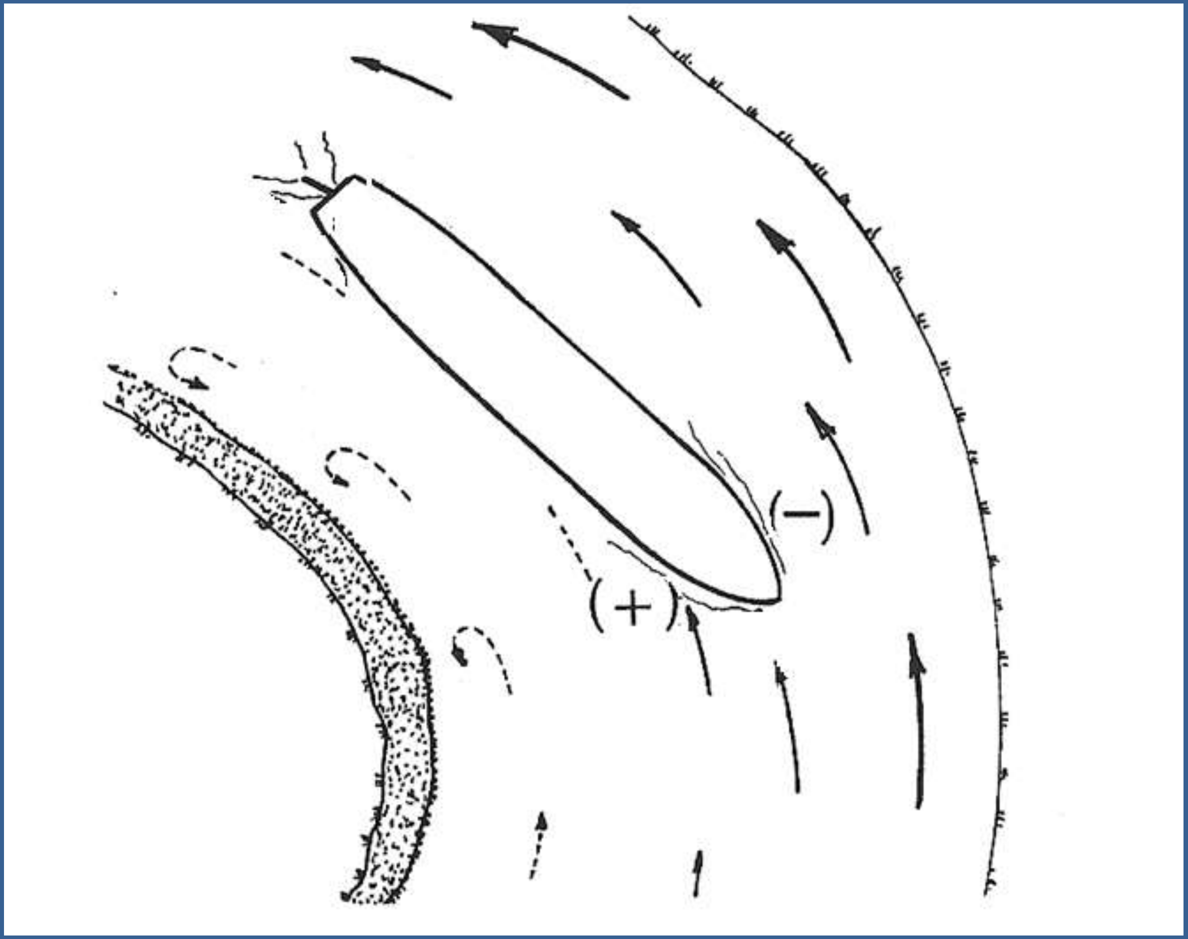


Effects of Current on Vessel Maneuverability



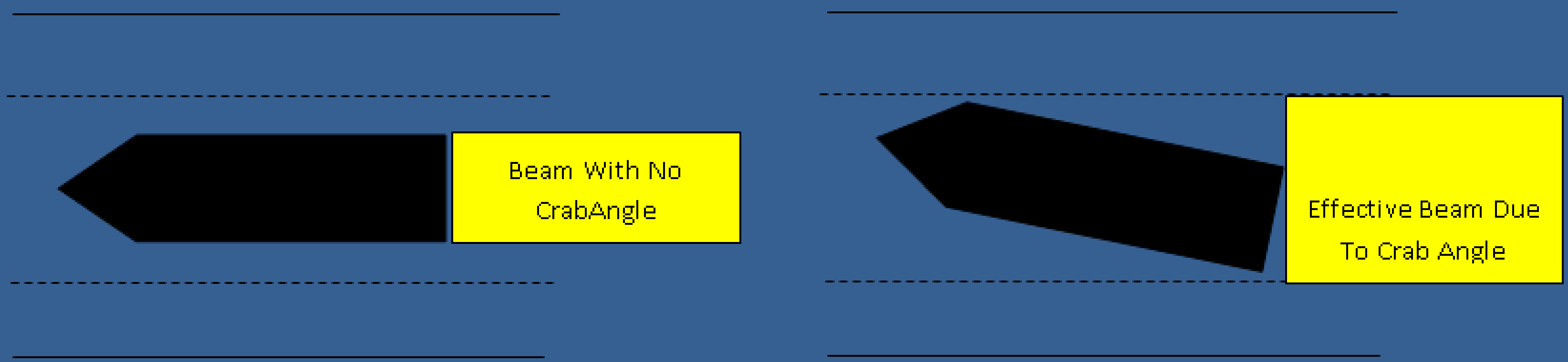
A following current can increase the rate of turn

Effects of Current on Vessel Maneuverability



An opposing current can decrease the rate of turn

Swept Path



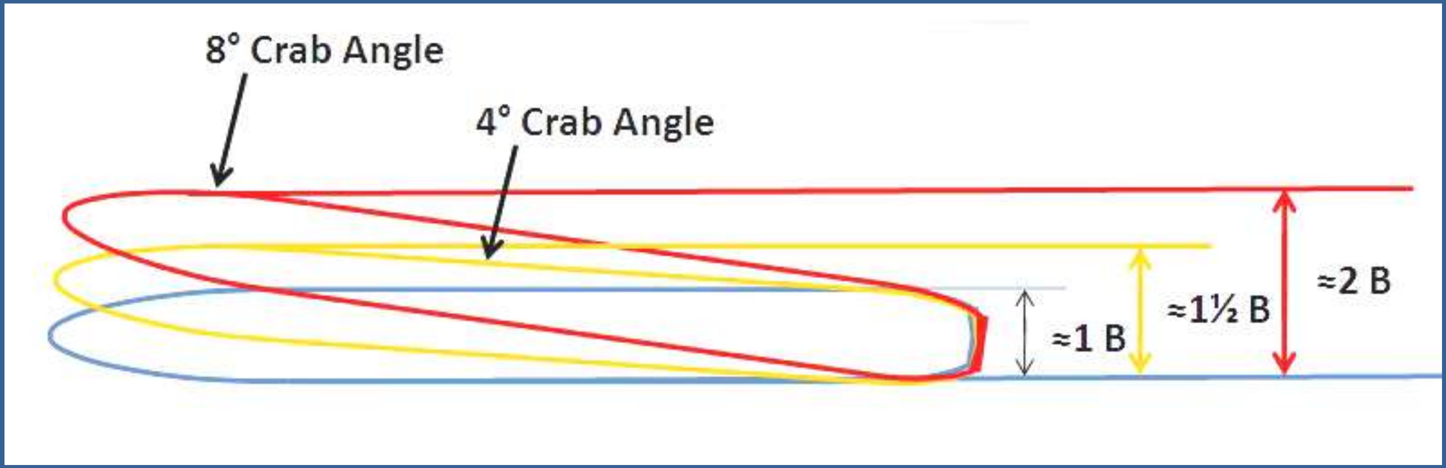
Examples

600’ x 106’ (Handy-max) with 1° leeway will have a 116.4’ actual beam width

800’ x 142’ (Afro-max) with 3° leeway will have a 183.7’ actual beam width

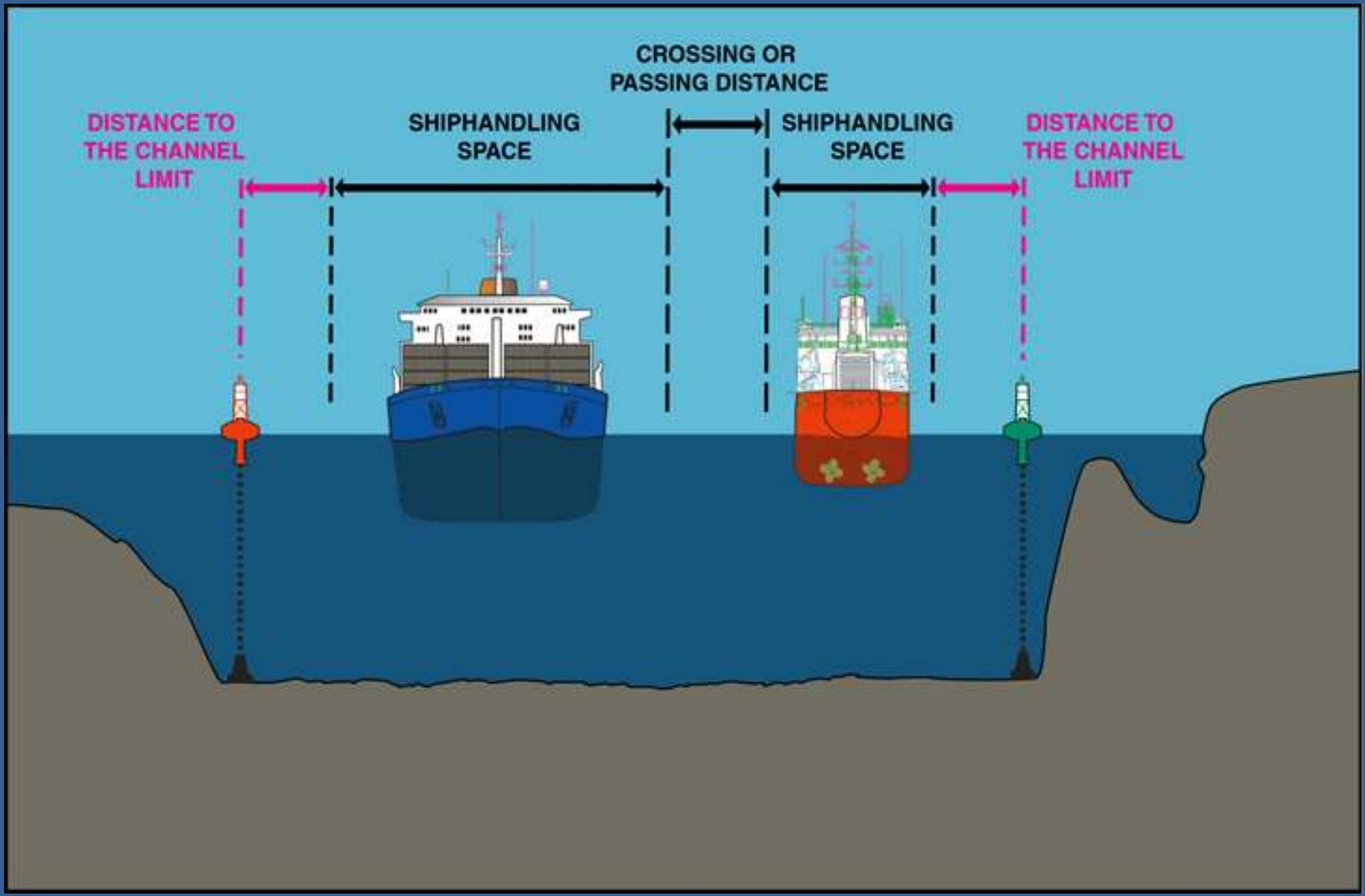
1100’ x 141’ (Container) with 4° leeway will have a 217.4’ actual beam width

1100’ x 141’ (Container) with 8° leeway will have a 292.7’ actual beam width



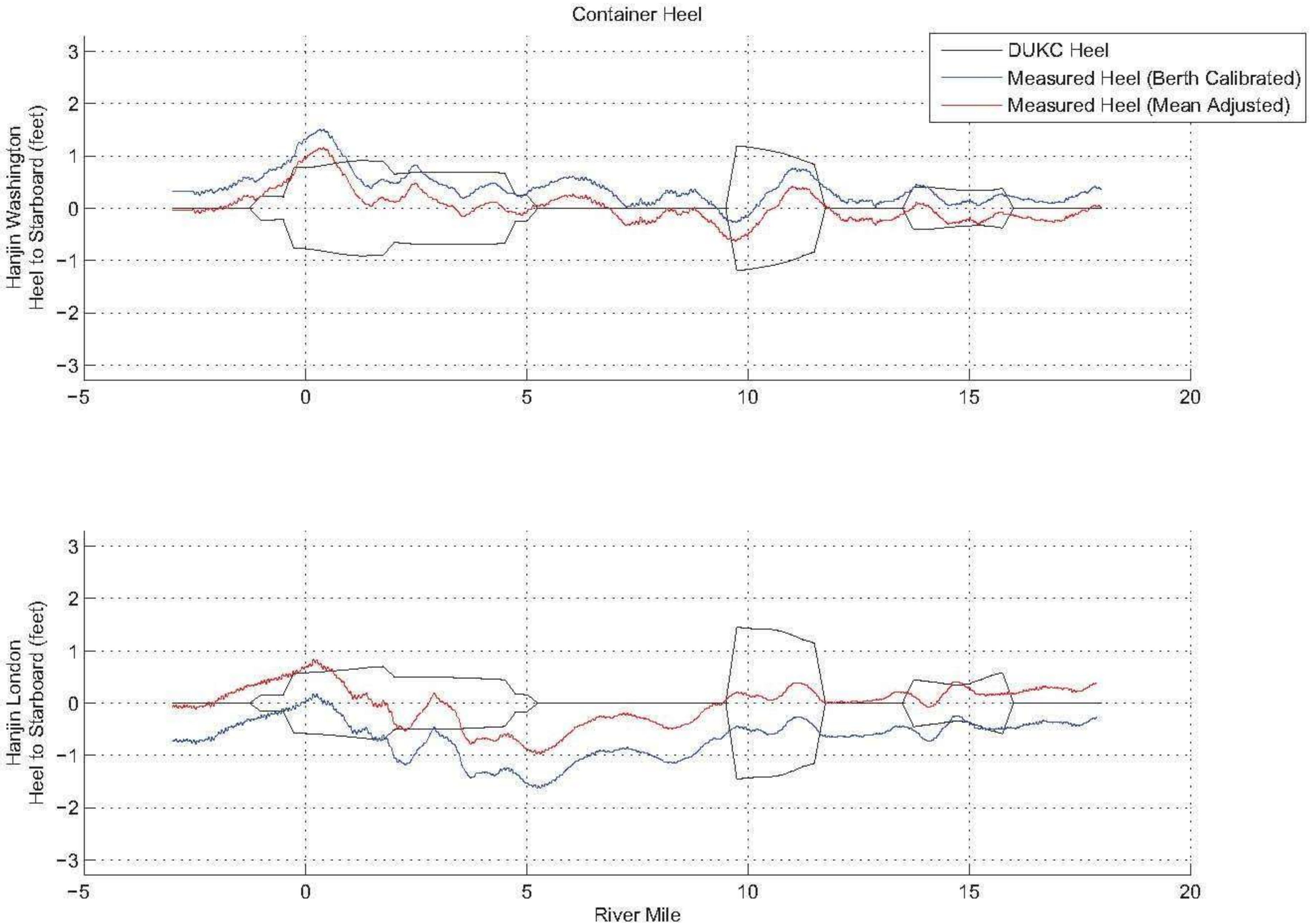
Rule of Thumb

Safe Channel Width



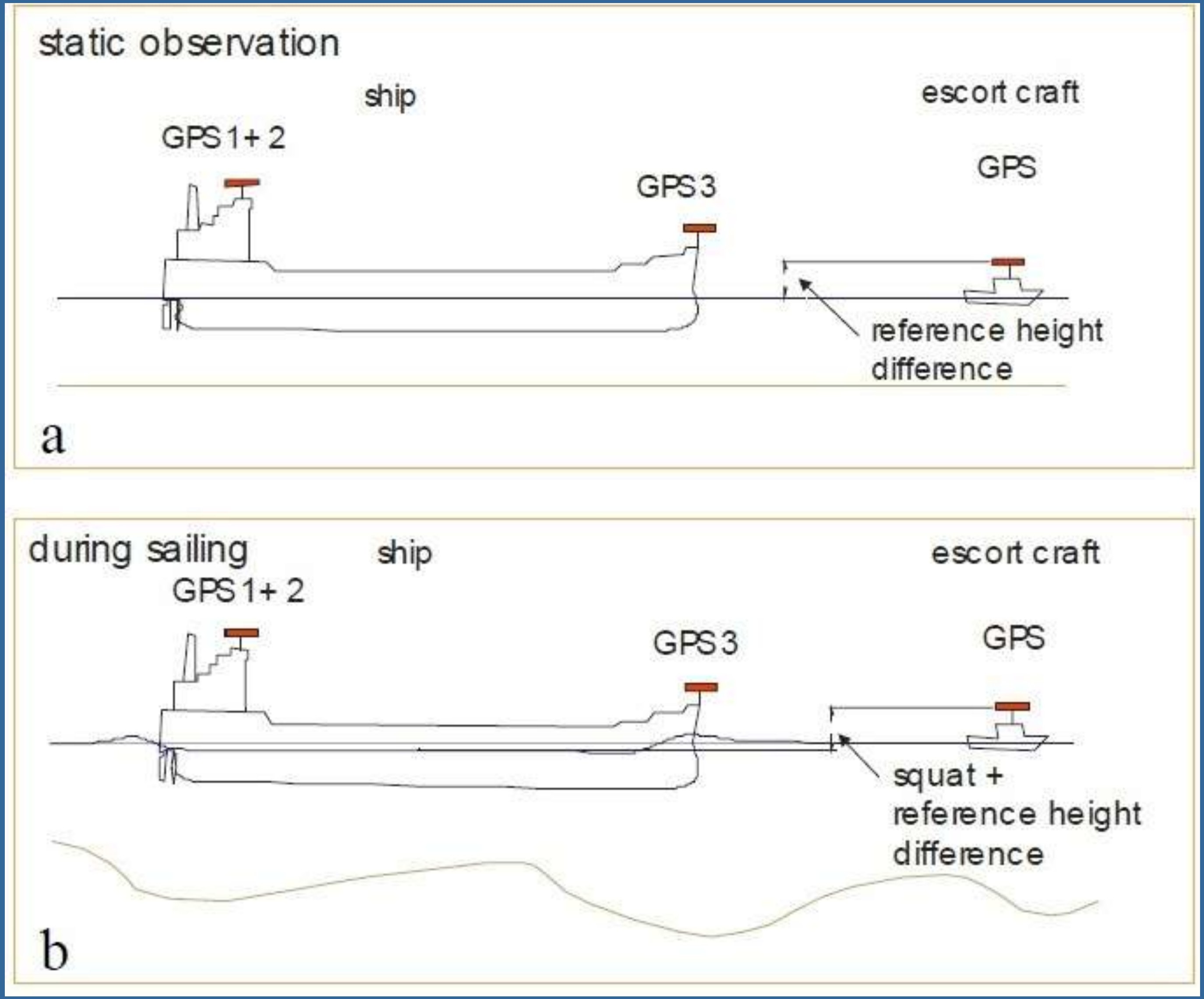
Safer Ports

don’t come about by accident

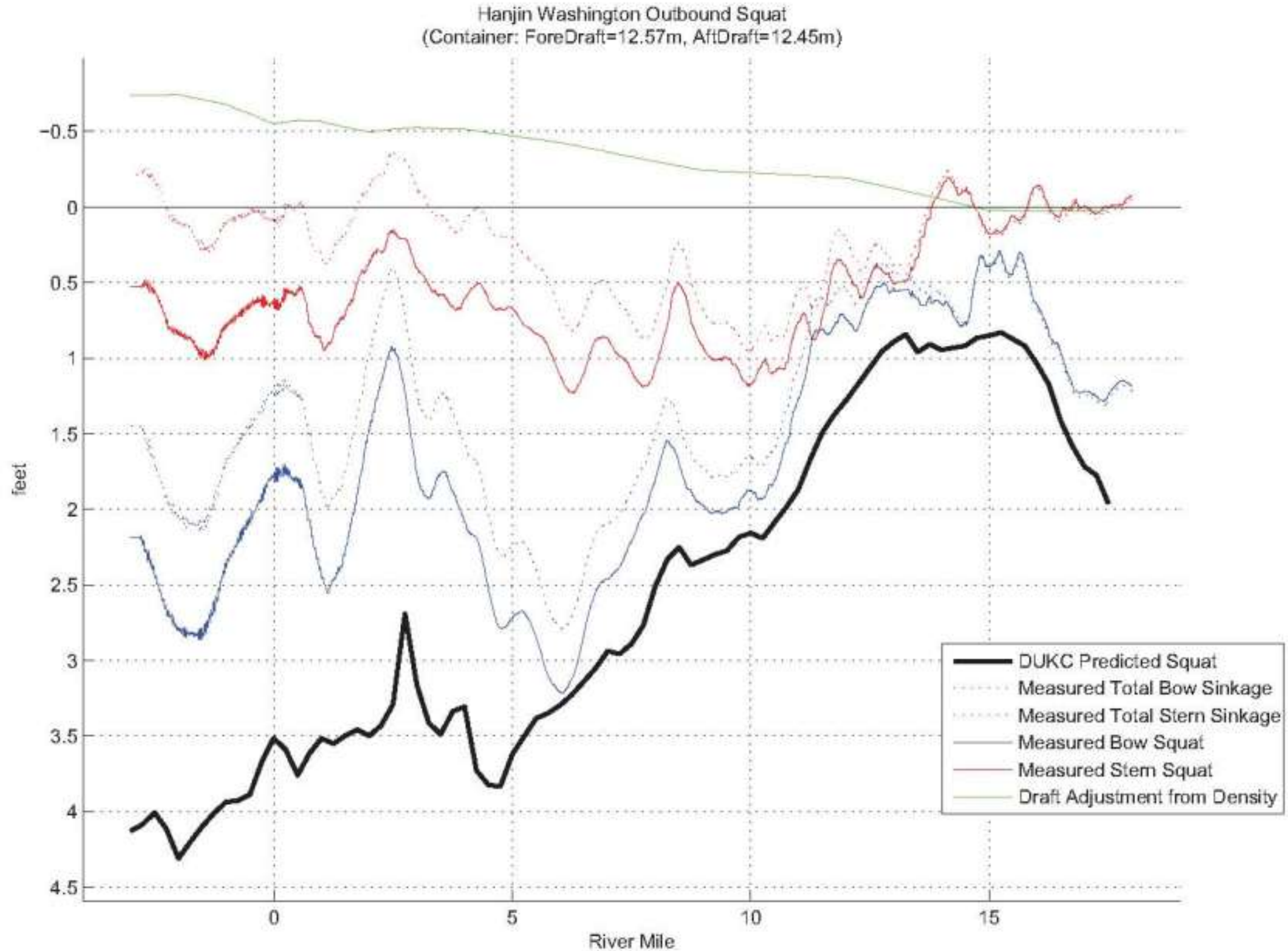


Container Heel
DUKC Heel
Measured Heel (Berth Calibrated)
Measured Heel (Mean Adjusted)
Hanjin Washington
Heel to Starboard (feet)
3
2
1
0
−1
−2
−3
−5
0
5
10
15
20
Hanjin London
Heel to Starboard (feet)
River Mile

Vessel Motion Analysis

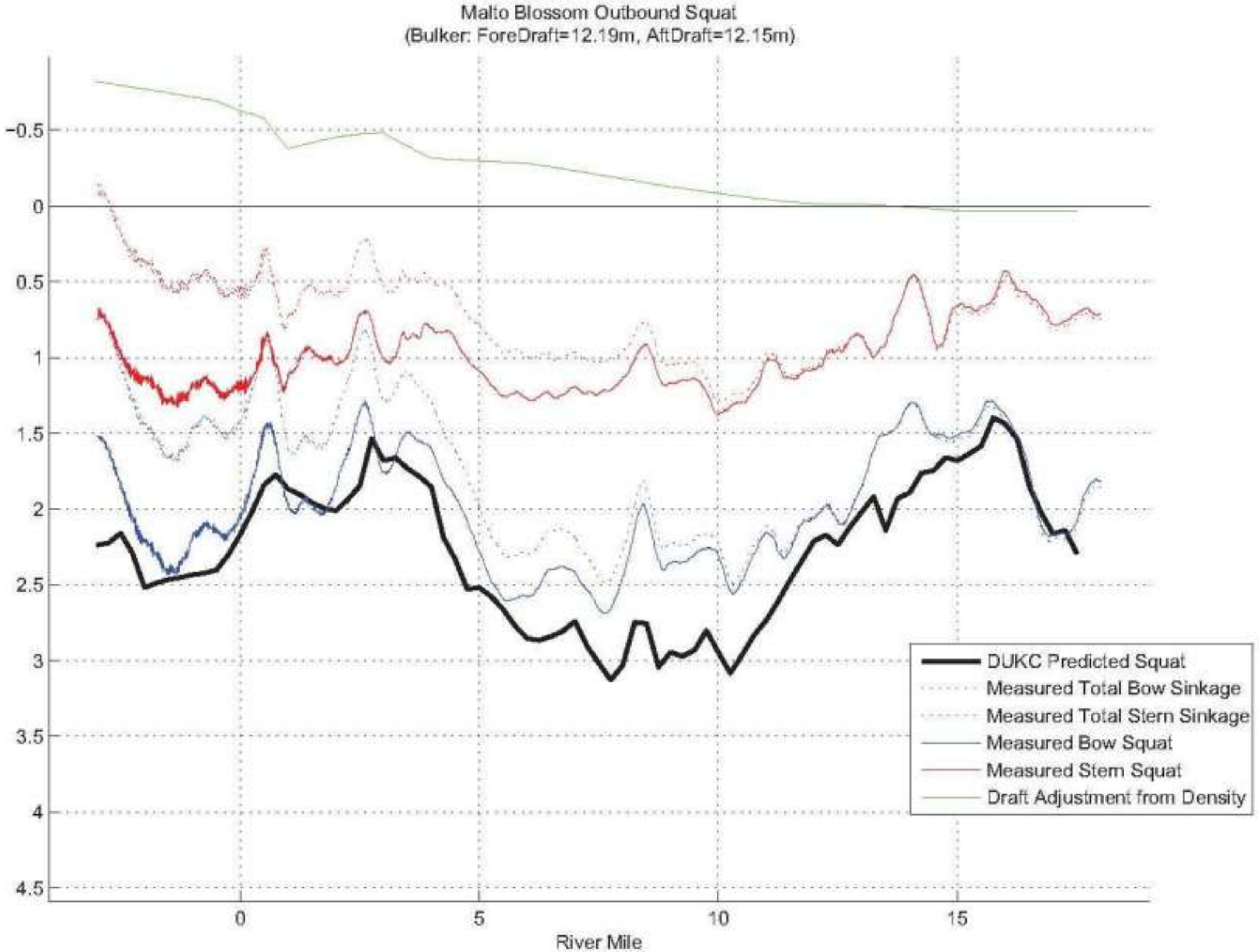


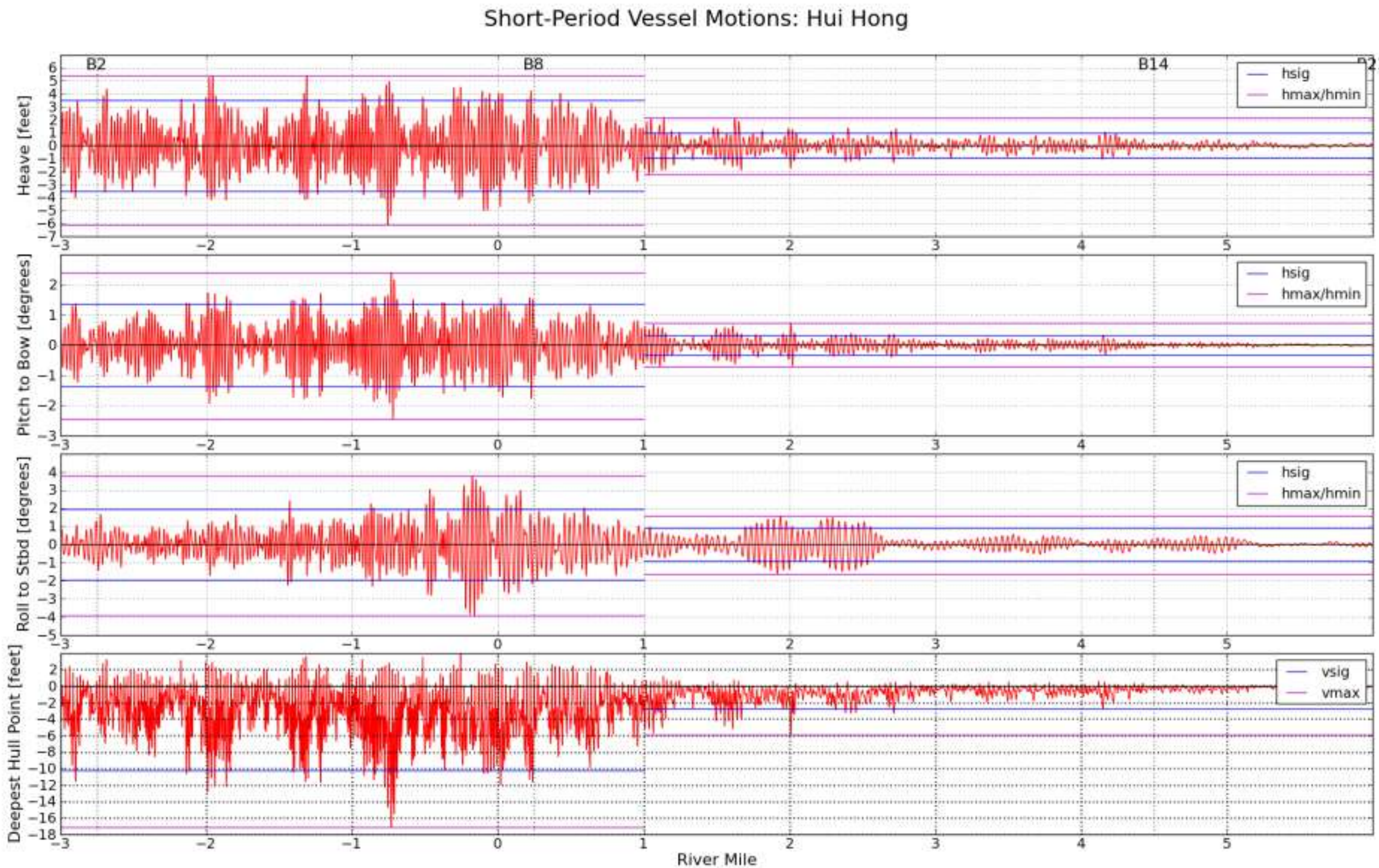
Squat: Hanjin Washington Outbound



FSVMA

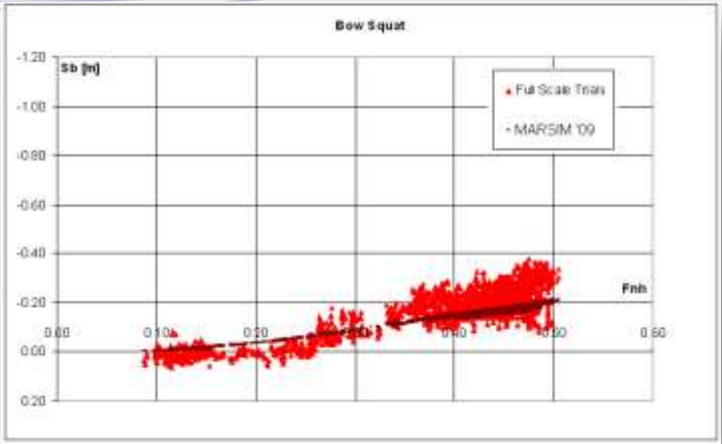
Fig. A-11

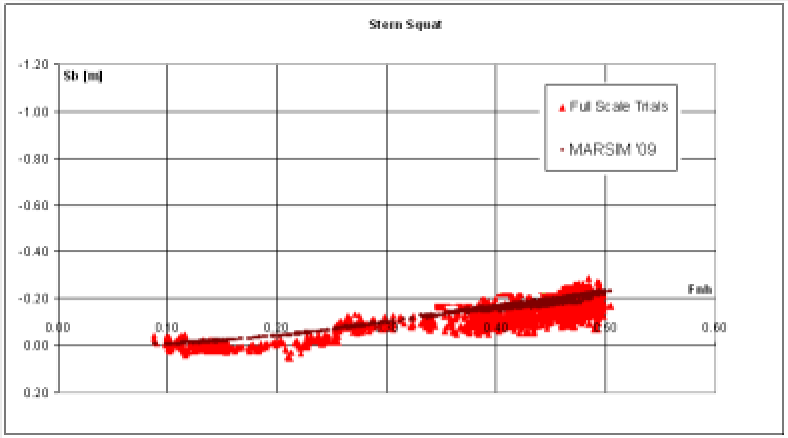

Malto Blossom Outbound Squat
(Bulker: ForeDraft=12.19m, AftDraft=12.15m)
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
5
10
15
River Mile
DUKC Predicted Squat
Measured Total Bow Sinkage
Measured Total Stern Sinkage
Measured Bow Squat
Measured Stern Squat
Draft Adjustment from Density



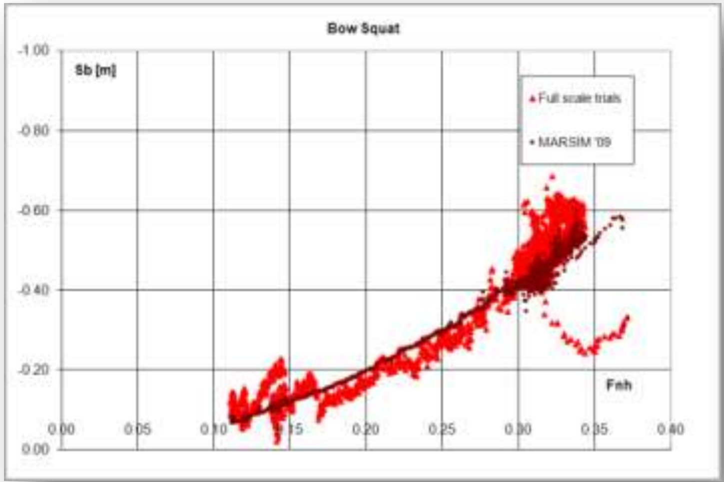
Short-Period Vessel Motions: Hui Hong
B2
B8
B14
B21
hsig
hmax/hmin
vsig
vmax
Heave [feet]
Pitch to Bow [degrees]
Roll to Stbd [degrees]
Deepest Hull Point [feet]
River Mile

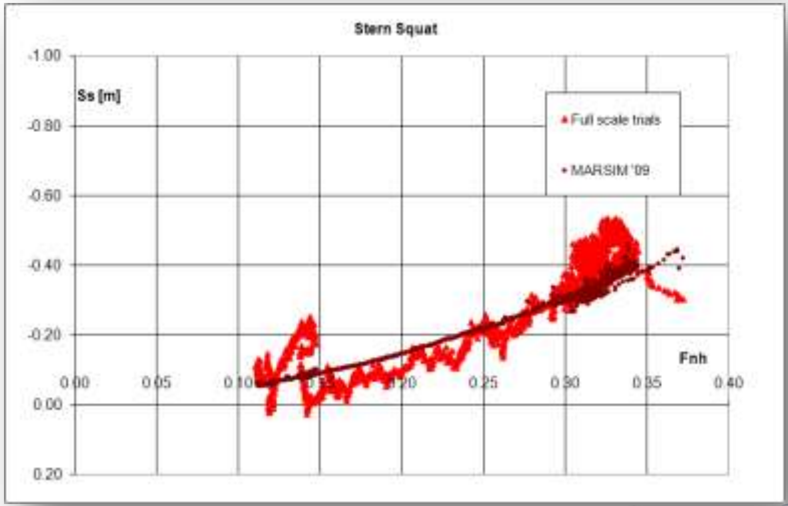
MODELING OF SQUAT IN RESTRICTED CHANNELS





Salty Laker “John B.Arid” vs Fnh (Depth Froude Number)



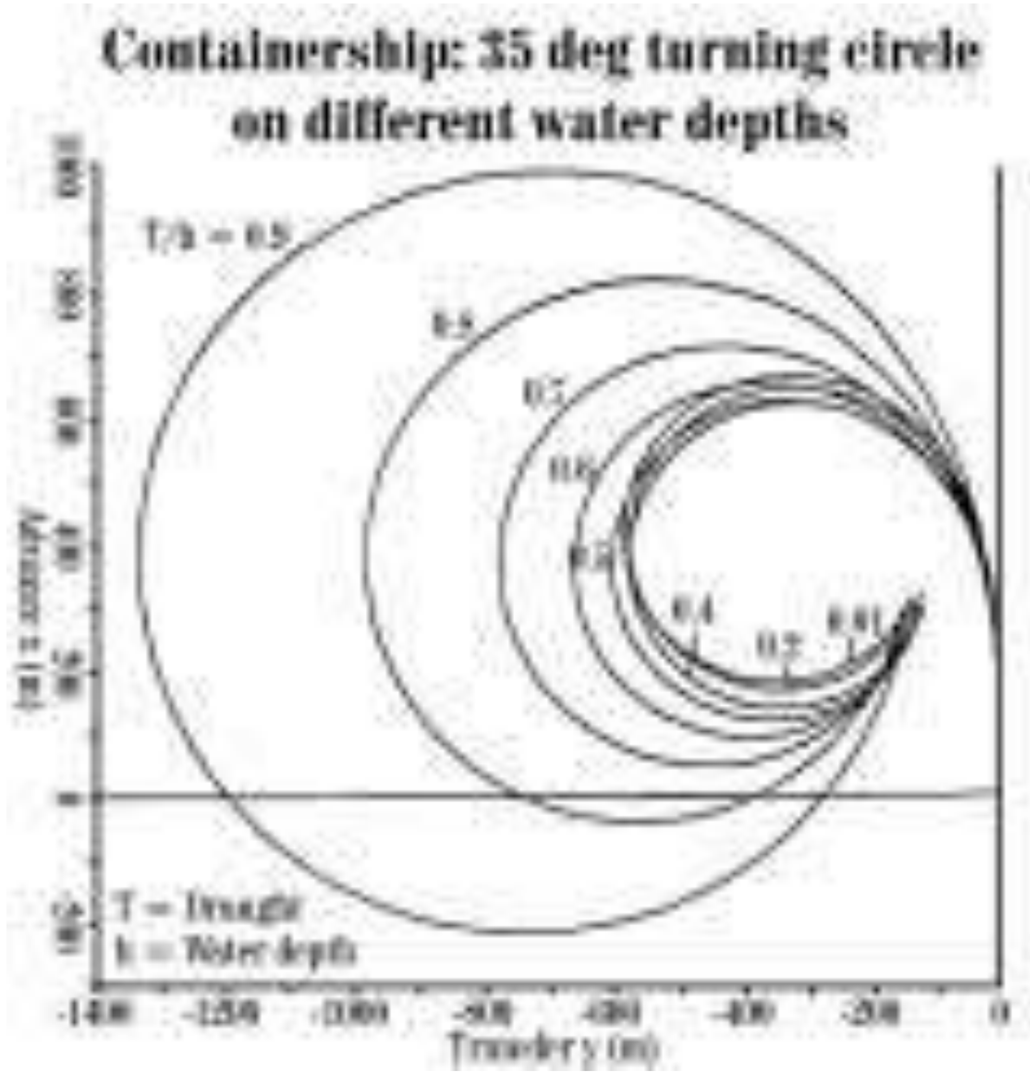


m/v Algoville vs. Fnh (Depth Froude Number)

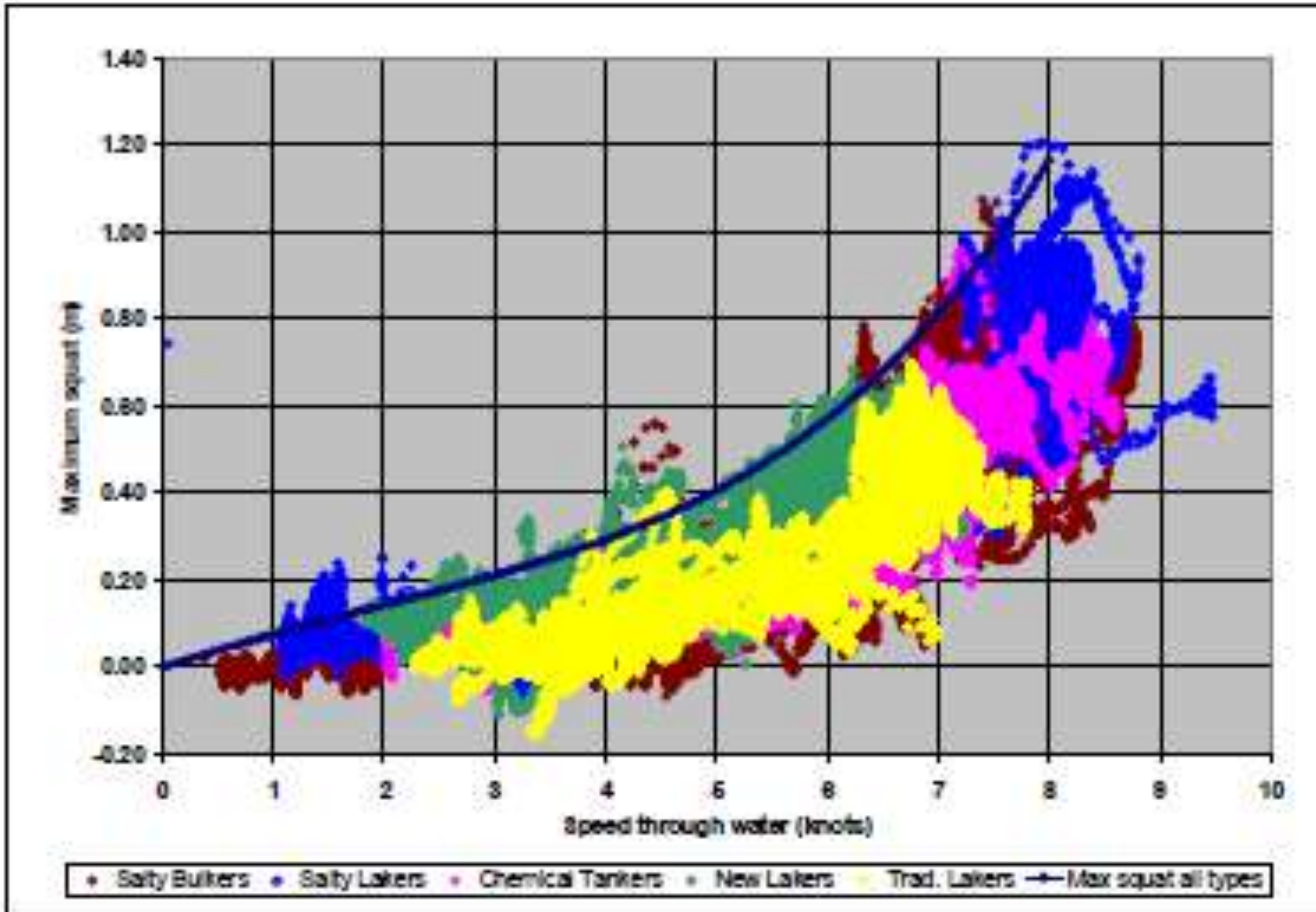
TRANSAS
SETS THE STANDARD

WST
Waterway Simulation Technology

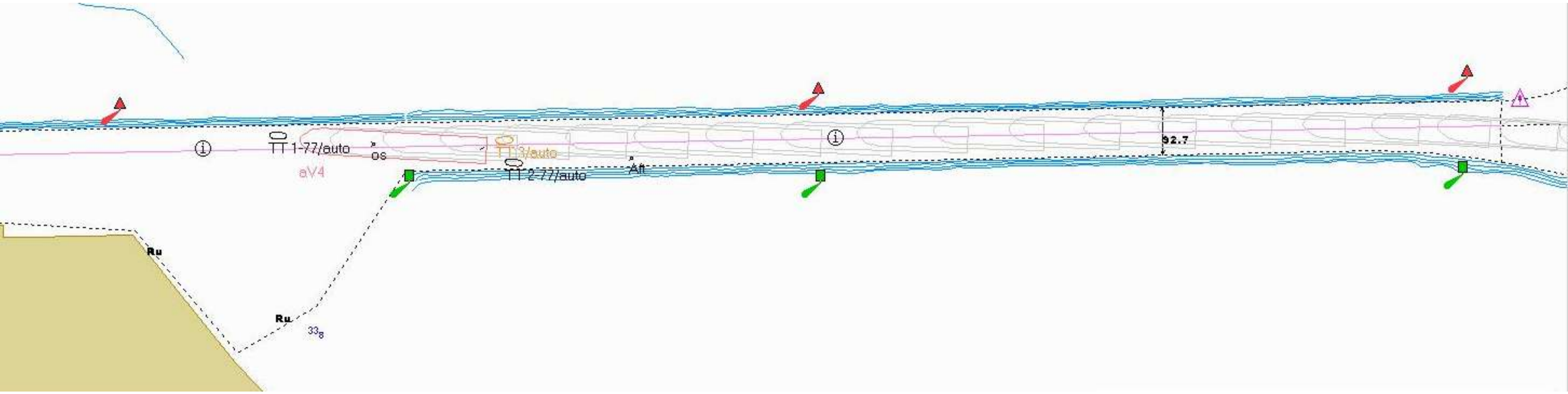
Low UKC Effects on Turning



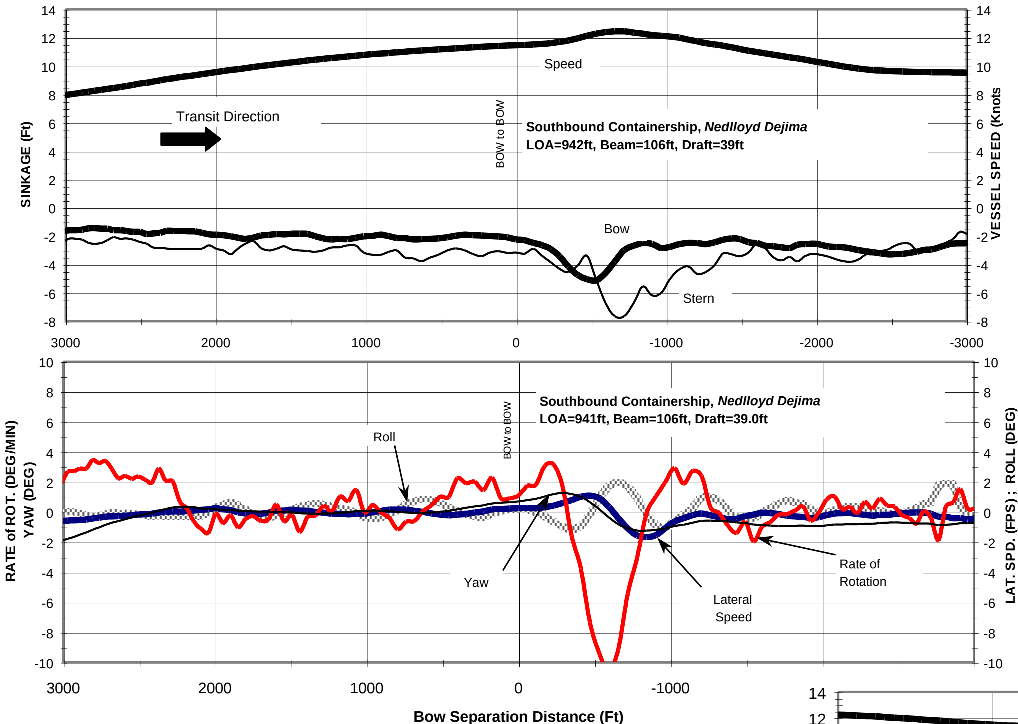
Measured Squat Values & Prediction Equation - All Ship Types



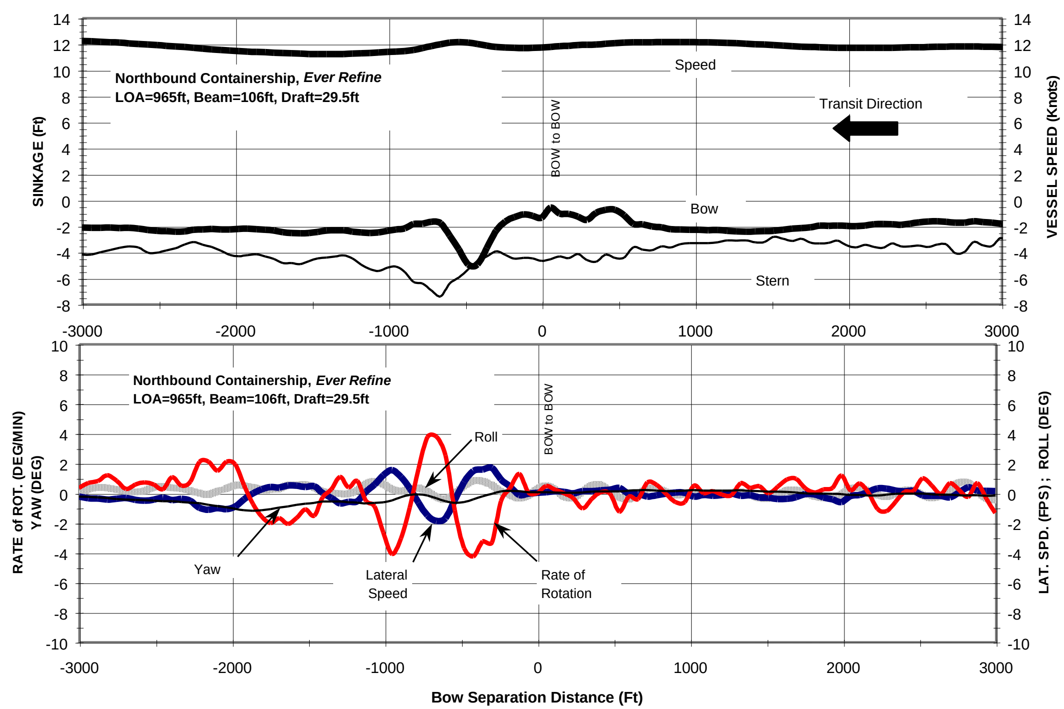
Control with Tug Assistance



Passing in Bas Obispo Reach Panama Canal



At High Speed and Close Quarters



What Else is on the Bottom?

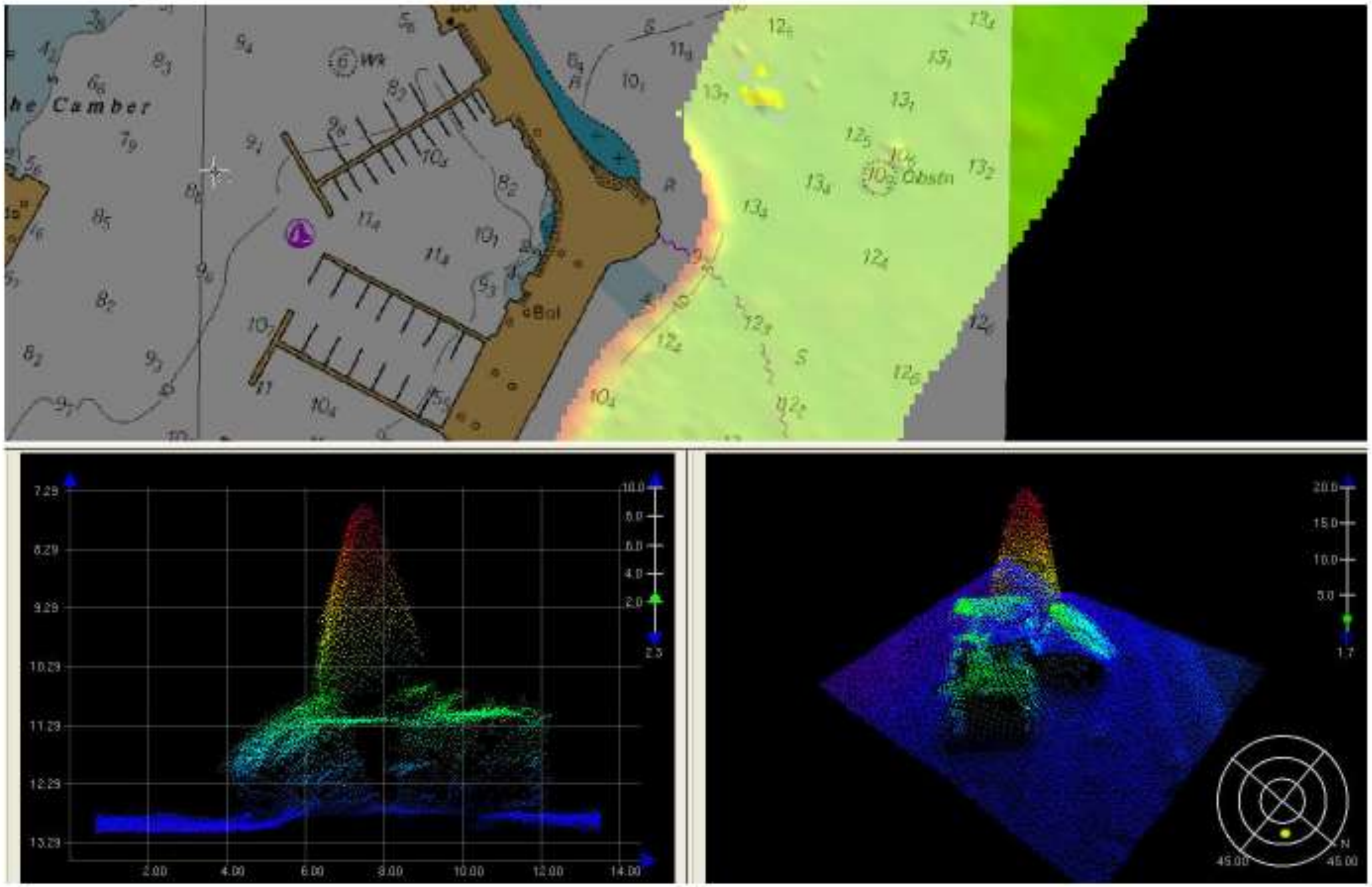
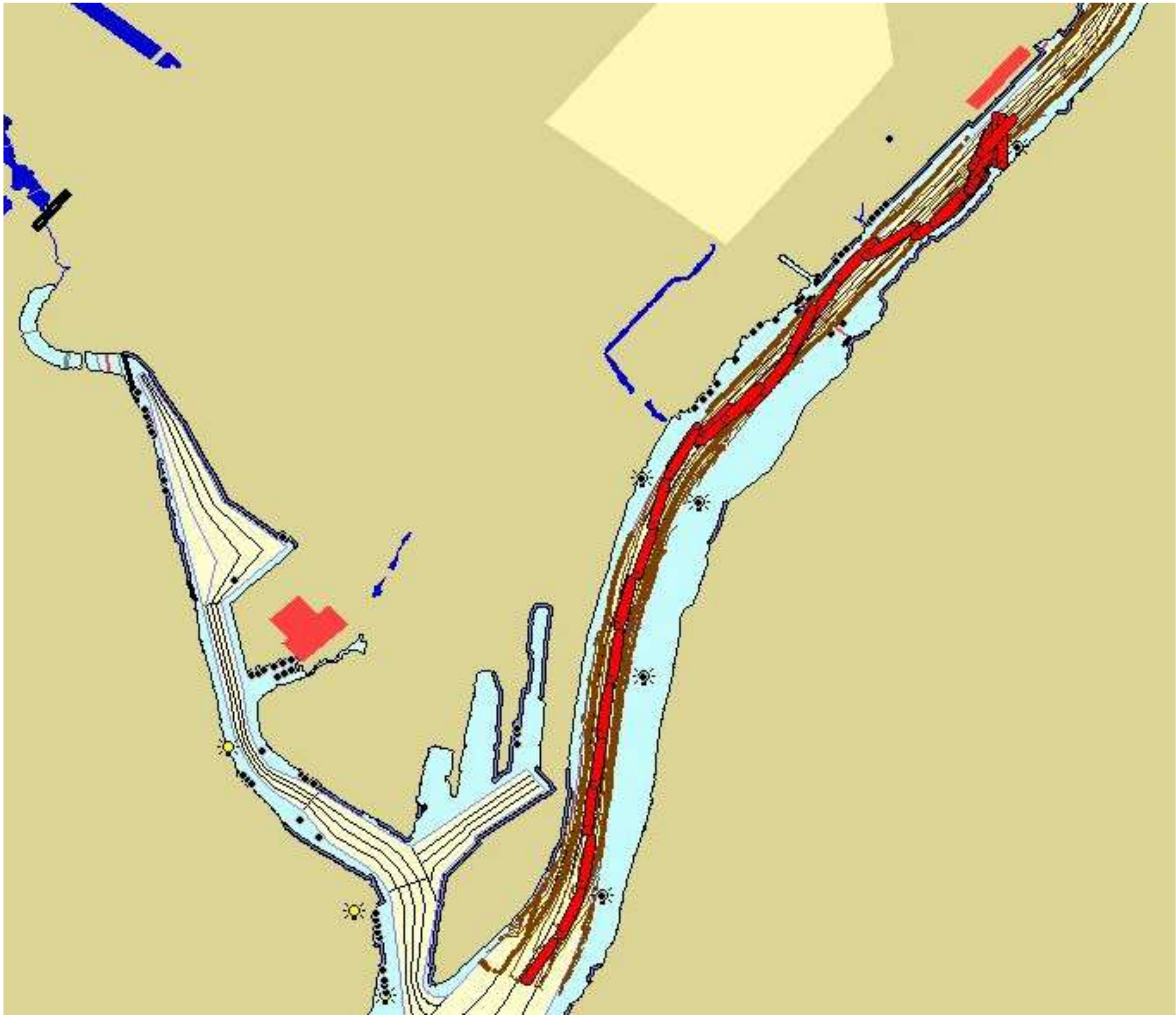


Fig 20 : Possibly sunken buoy

How Important in Understanding Bank Suction?



VMAX UKC Upbound 9/16/2002
LOA=333.49m,B=70m,T=10.99m