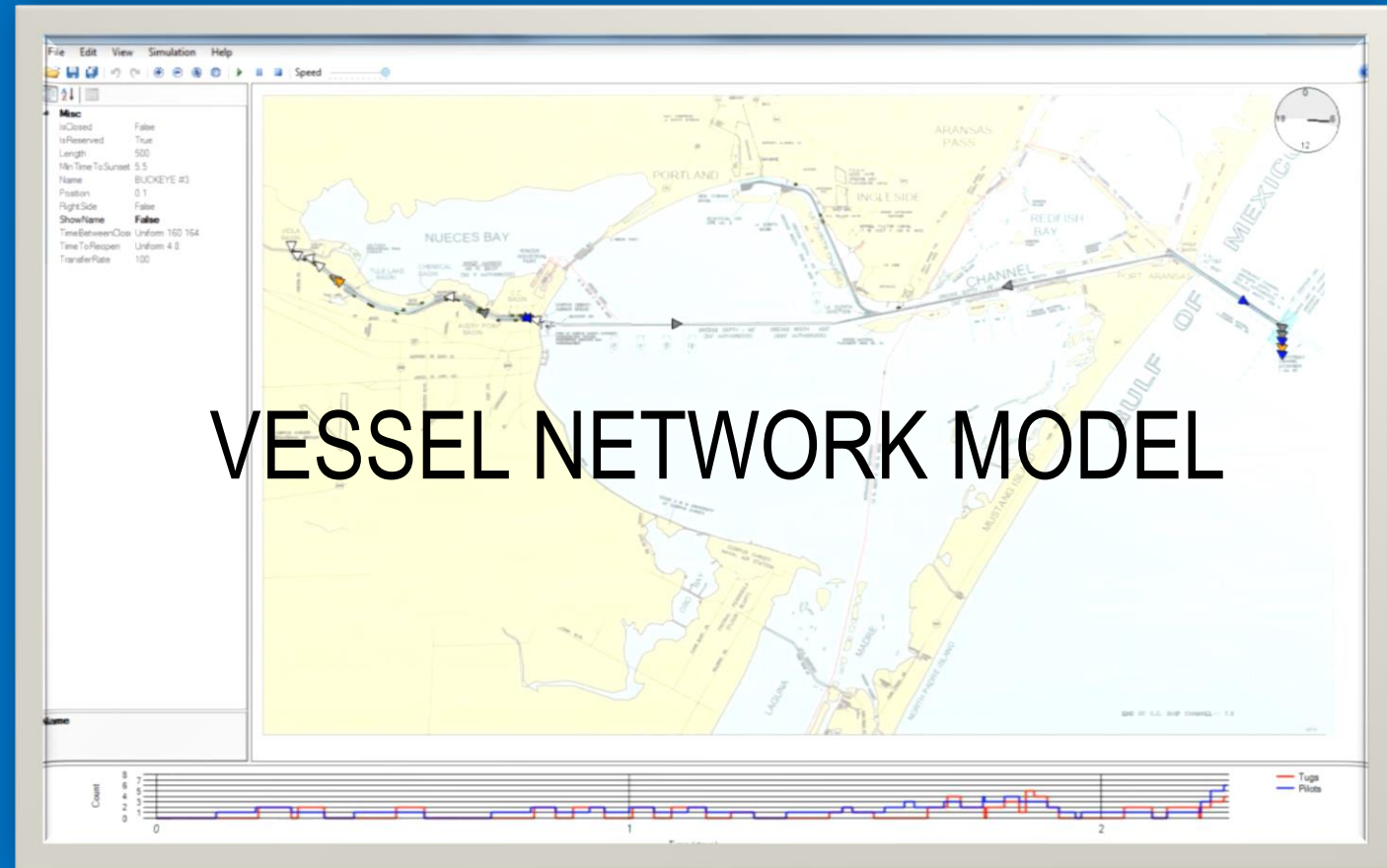**American Association of Port Authorities**

Port Corpus Christi Ship Channel and Waterways Planning and Design using Simulation

Presented by: Vijay Agrawal, PE

- Industry Trends
- Case Study
  - Data Needs
  - Analysis Techniques
  - Results
- Benefits of simulation modeling

VESSEL NETWORK MODEL

1

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U.S. Waterway System in 2017

- 2.4 Billion Short Tons of U.S. Waterborne Traffic
- 600 Billion Ton-miles of Cargo movement
- 230 Million Cubic Yards of Dredging
- $1.4 Billion Spent in channel New Work & Maintenance (123 contracts)
- Approximately 100,000 Ship Calls per Year

- AAPA Survey: $130 Billion shortfall in federal funding over the next five years in land- and waterside infrastructure
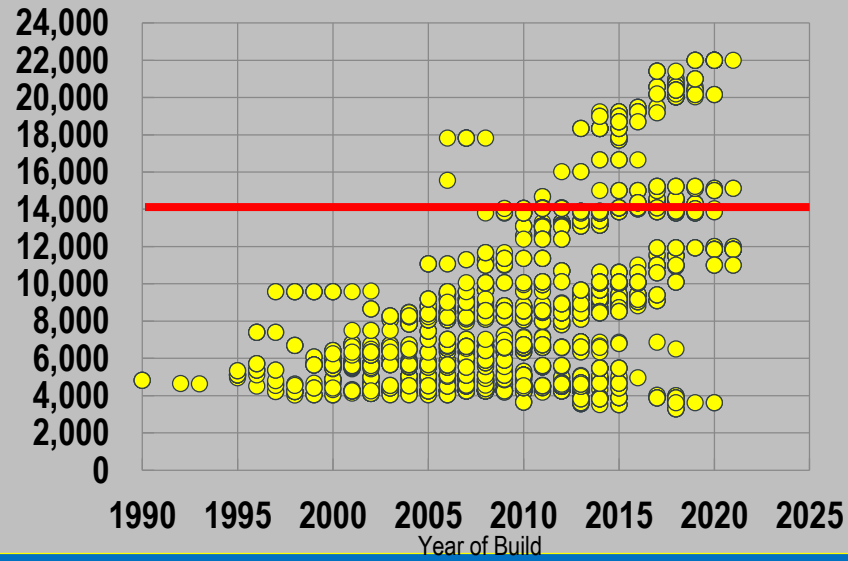
The U.S. Waterway System

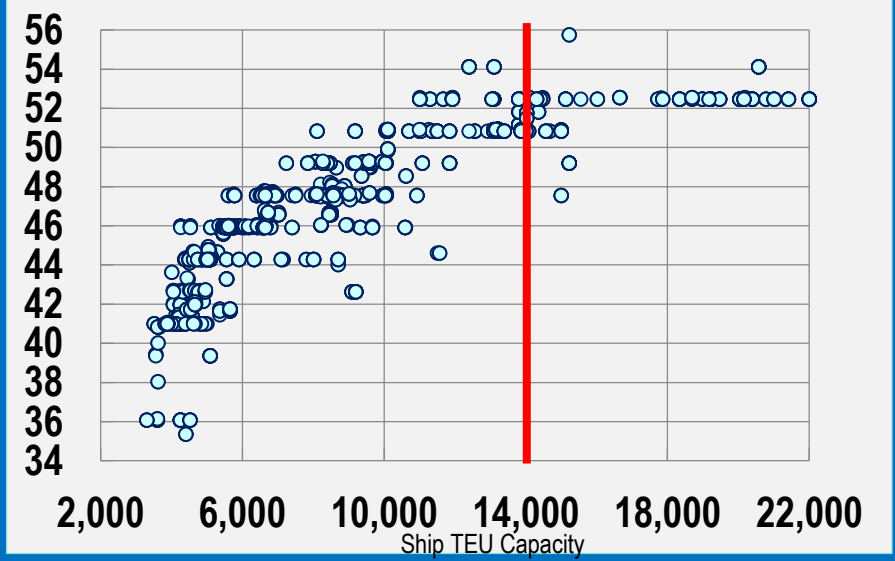2017 Transportation Facts & Information

Navigation and Civil Works
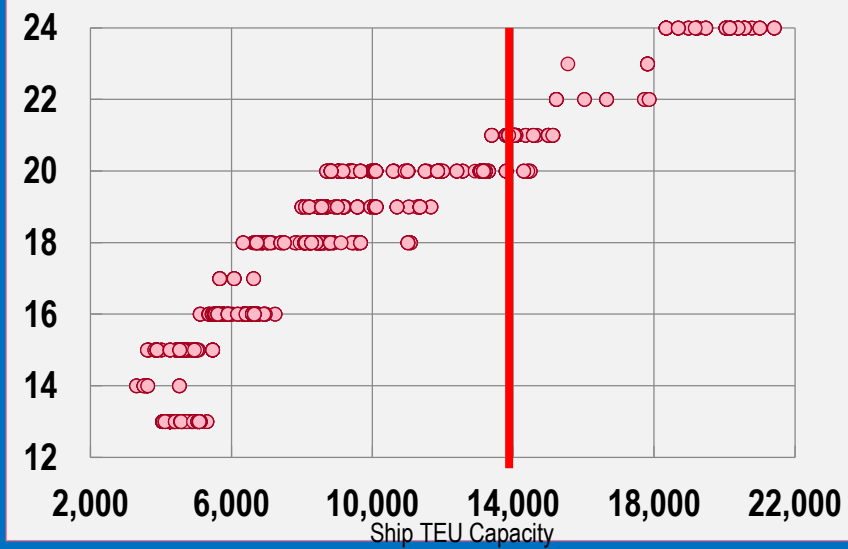Decision Support Center
U.S. Army Corps of Engineers

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MIGHTY SHIPS
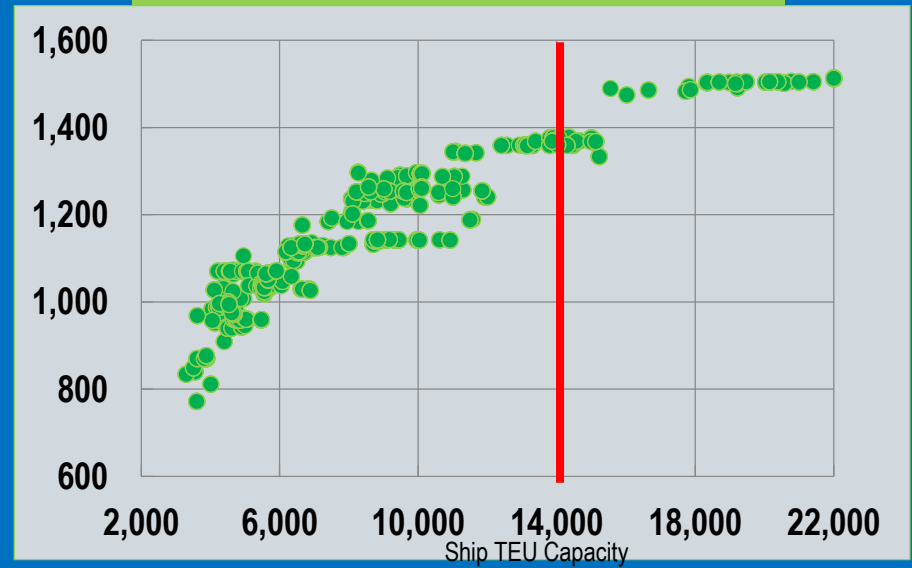
Source: 2018 Fairplay Data

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Tidal Impacts on Draft and Air Draft

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Air Draft vs Tidal Variation, Lion's Gate Bridge Example

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Impact of Weather on Vessel Operating Rules

- Ports may occasionally close, or operate with more restricted rules
- Two-way channels may become one-way in fog or high wind conditions
- More tugs may be required in some conditions
- Weather probability will vary with seasons

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Ships Need Pilots and Tugs to Move

- Location for Pilot on/off?
- Number of tugs per vessel?
- Total port-wide pilot/tug capacity?
- Will lack of pilots or tugs affect port capacity?
- Is work schedule 24/7?
- What total time required to move ships to each neighborhood?

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Vessel Passing rules

- What gap required between ships?
- Fixed gap or % of ship beam?
- What gap between ship and shore?
- Same for night vs day?
- Same in all weather?
- Dependent on ship cargo?
- Dependent on # tugs used?
- How closely can ships follow each other when moving in the same direction?

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Daylight vs Night Navigation

- In some harbors, some vessels can only move during daylight
- Harbor capacity changes for summer vs winter as daylight expands
- Larger ships tend to have more restrictive rules
- Investment in navigation aids can perhaps change rules
- Vessels with restricted rules want to have terminals close to the open sea

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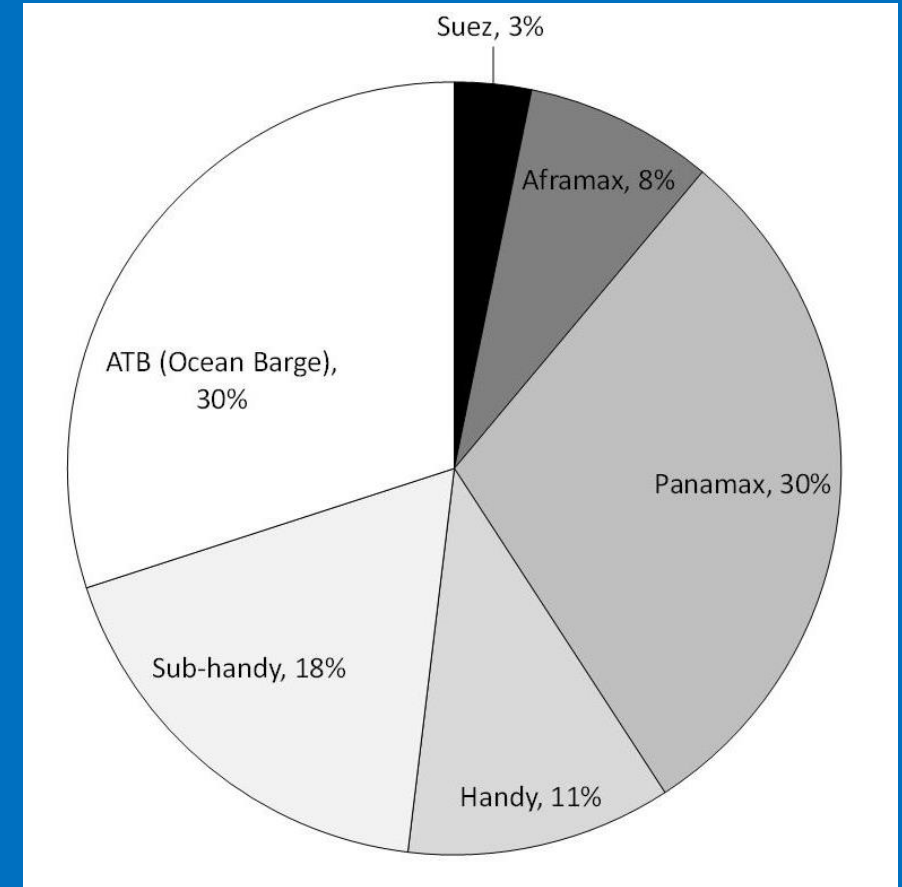# Port of Corpus Christi has more than 45 Individual Terminals / Docks

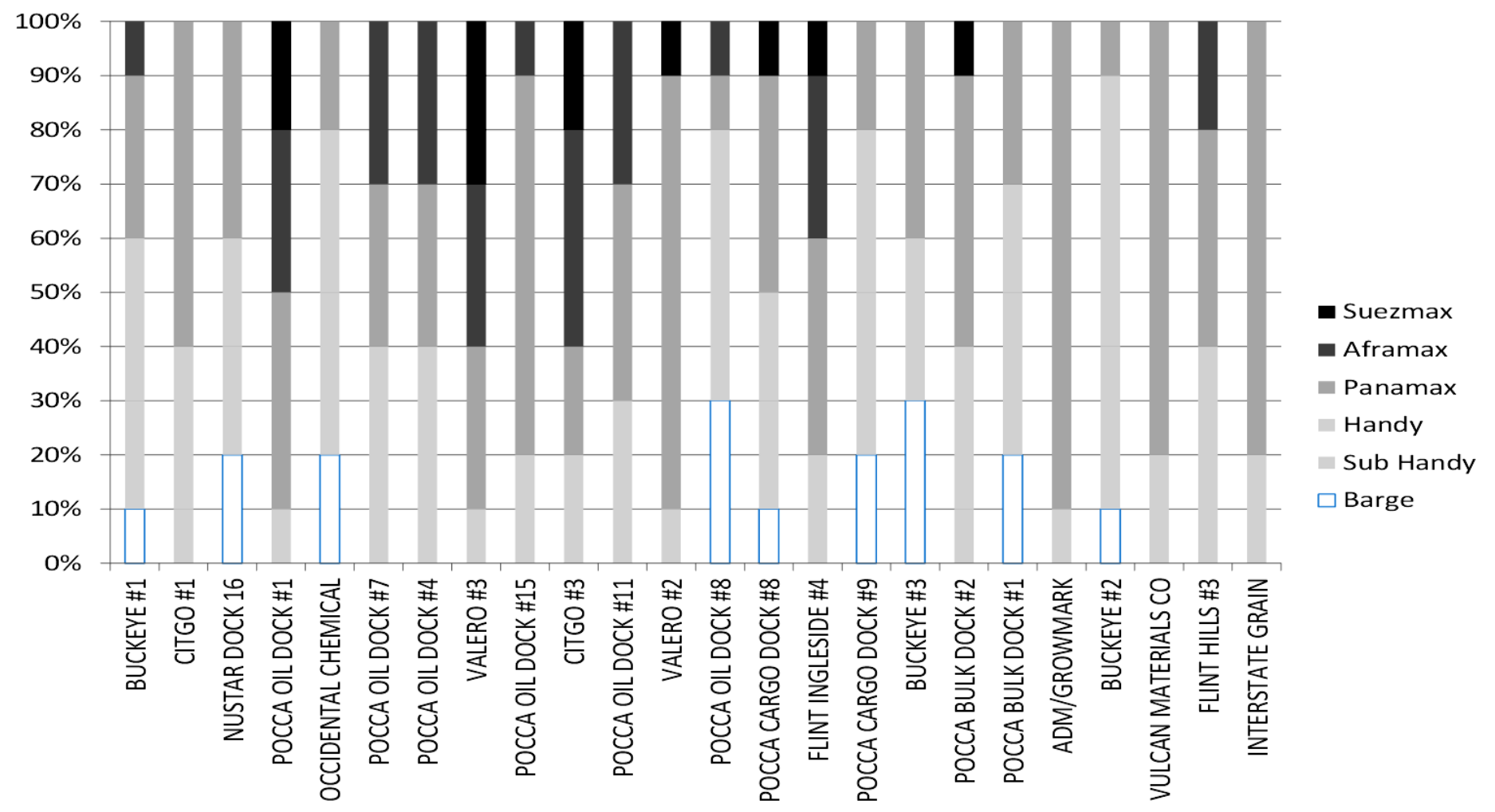# Increasing Number of Ship Arrivals at Port of Corpus Christi
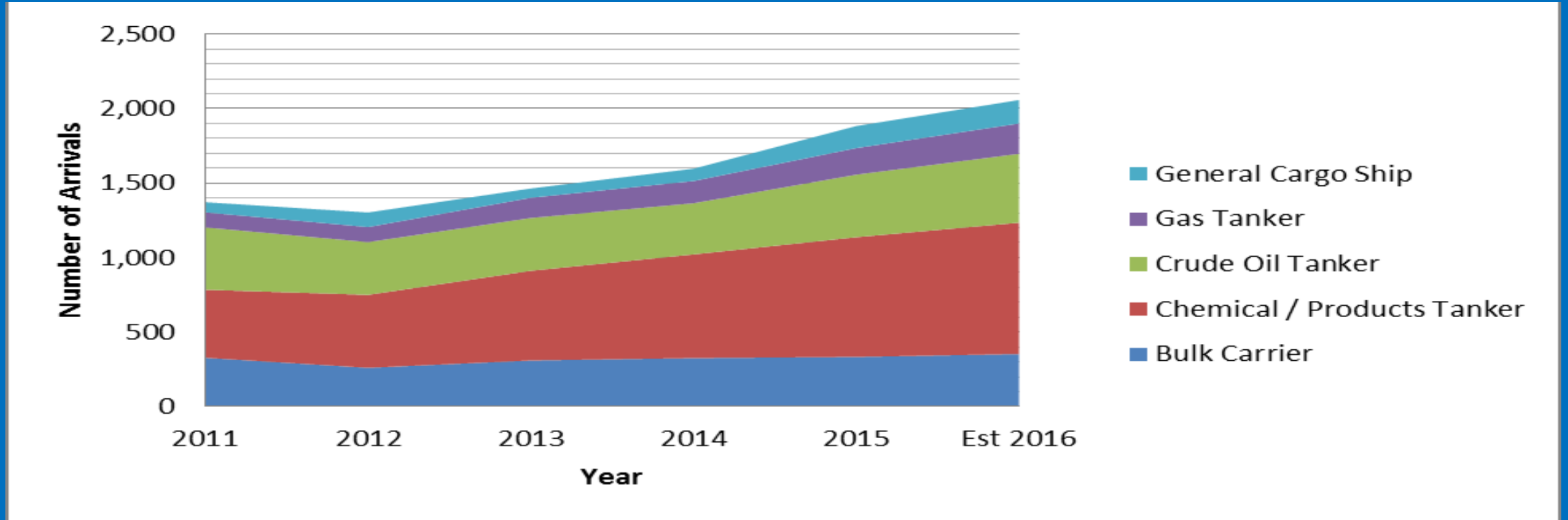
Corpus Christi Ship Channel Snapshot of Activity in 2015

- 5,425 pilot events
- 4,849 ship movements (some with more than one pilot)
- 115% ratio of peak/mean week
- 54 ship moves per peak week
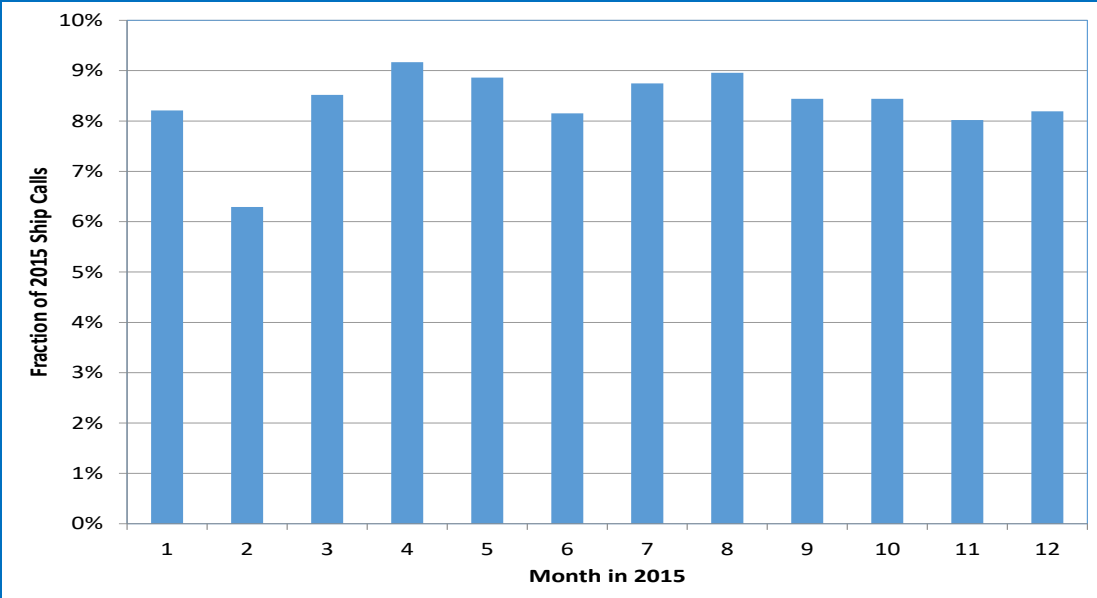- 8 ship moves per mean day, peak week

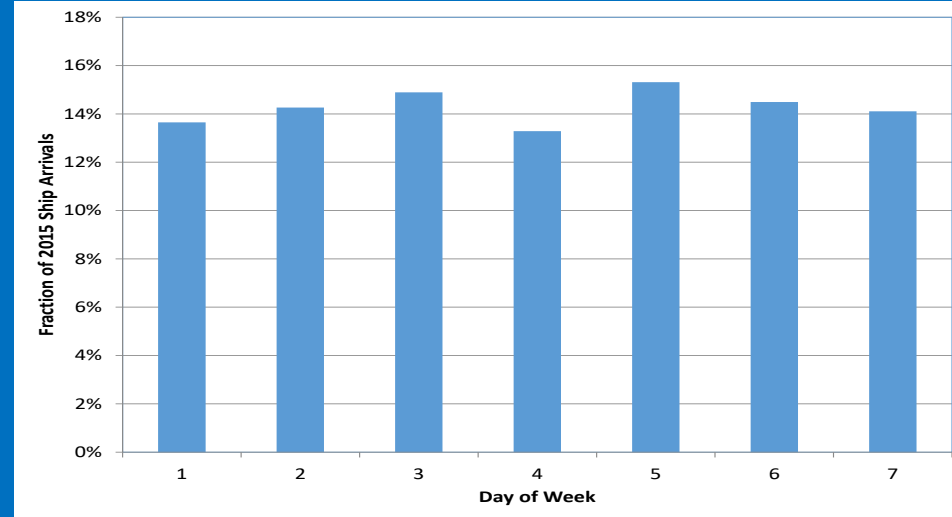Port-Wide Vessel Mix

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Ship Size Mix by Destination

A Busy Port with Vessels Coming in Every Day

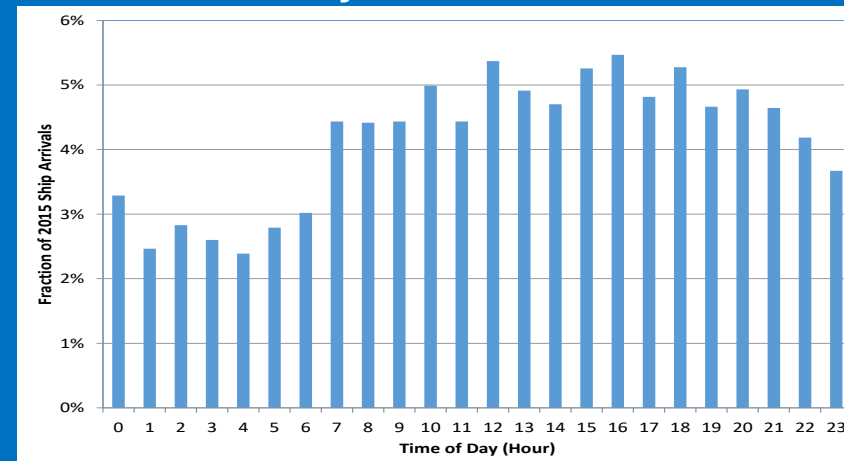Monthly Arrival Pattern

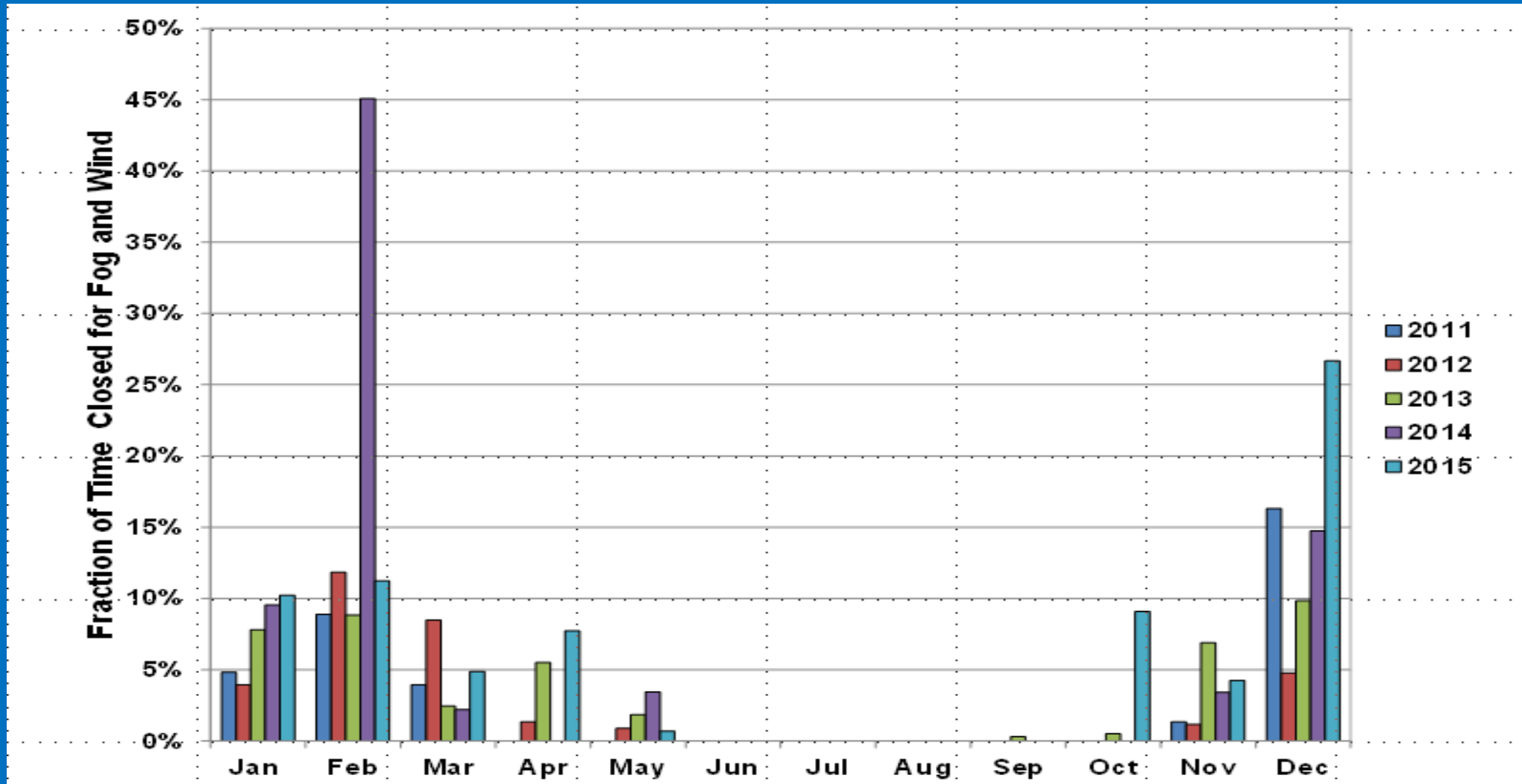Day of Week Arrival Pattern
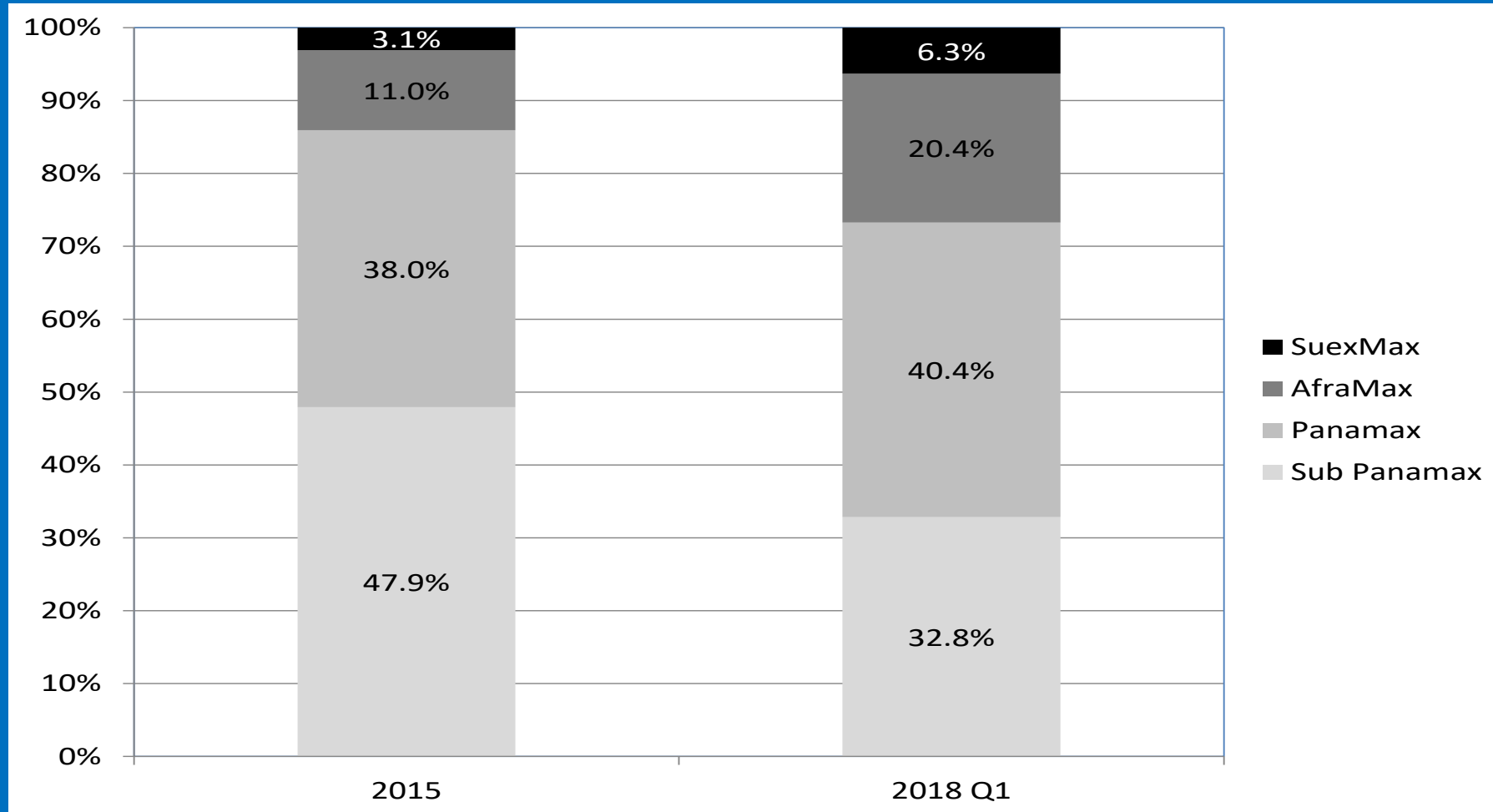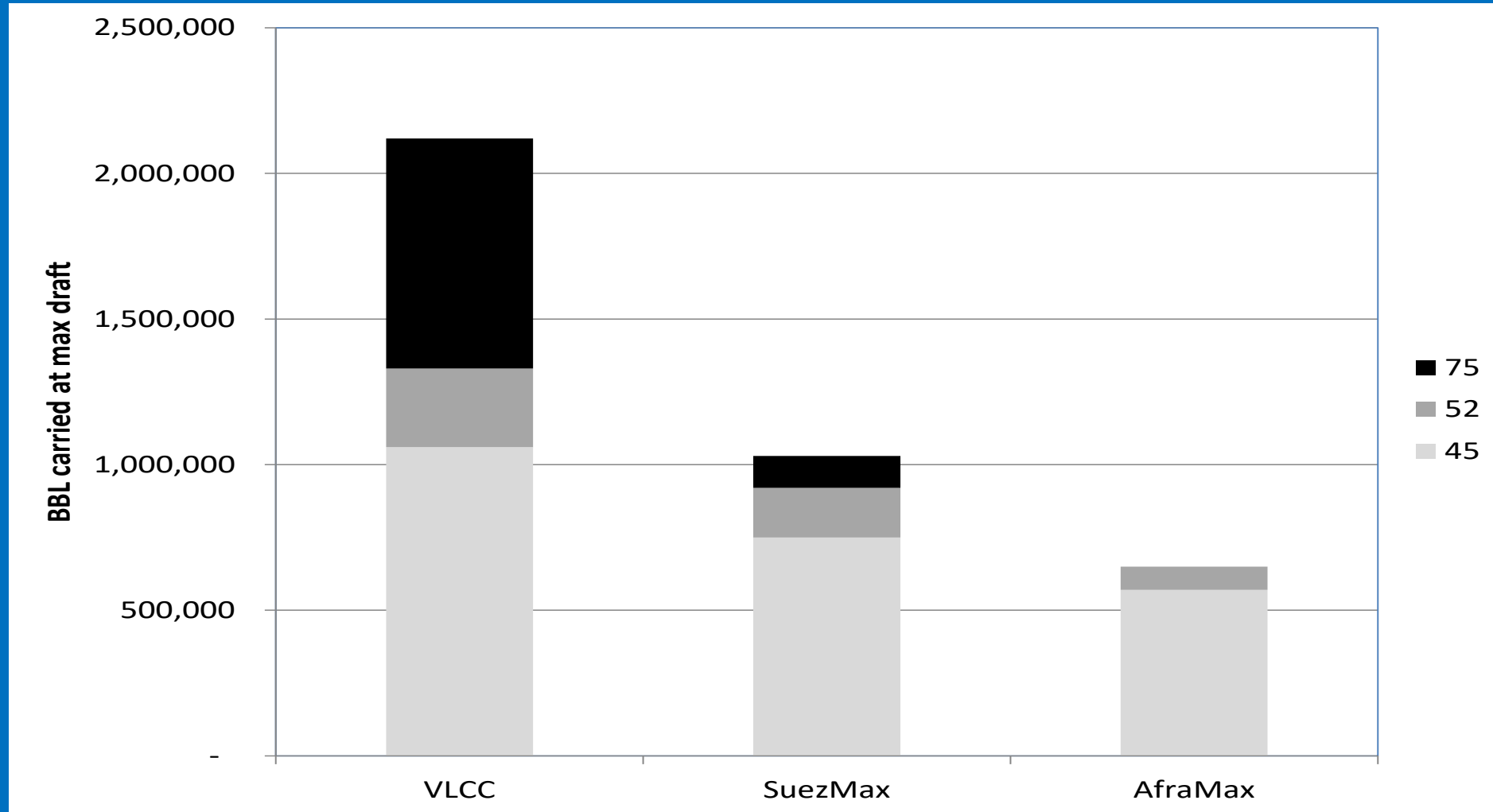
Hourly Arrival Pattern

PORT CORPUS CHRISTI®

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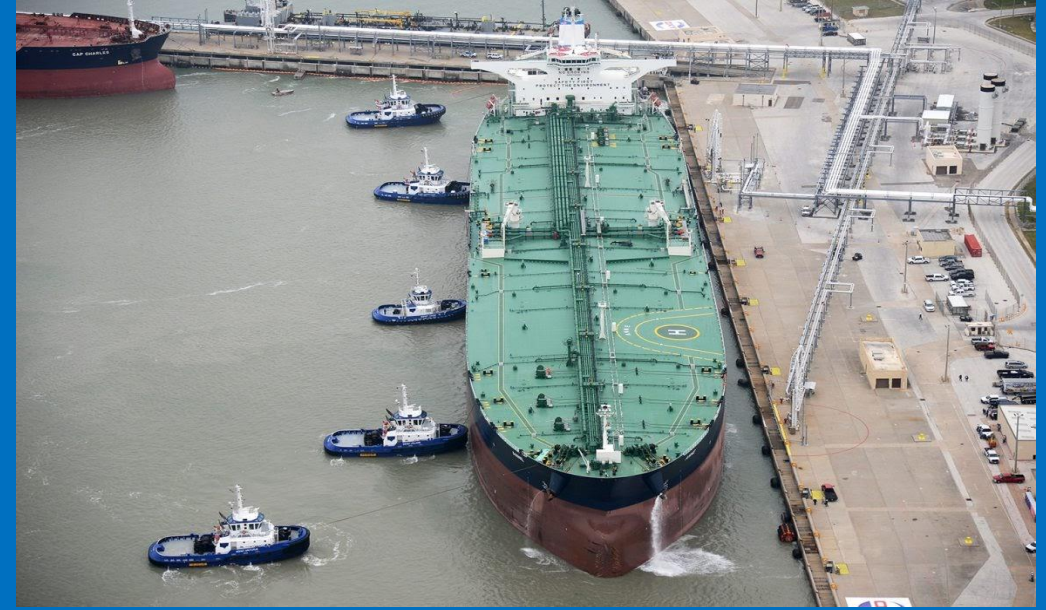# Weather (fog+wind) Closure By Month 2011-2015, Corpus Christi

AECOM

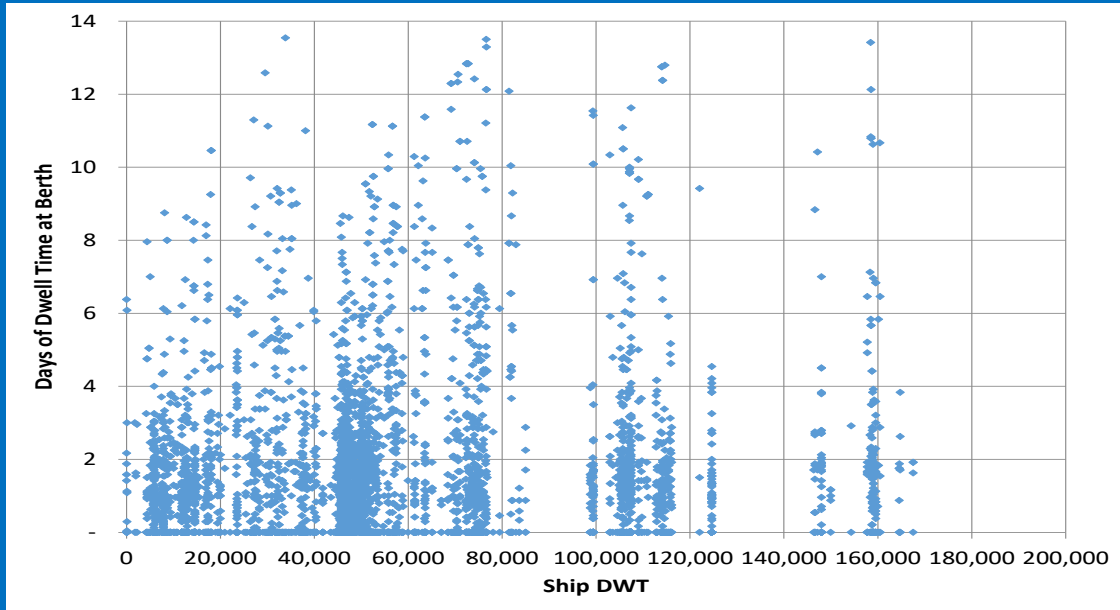# Port Users are Rapidly Shifting to Larger Vessels

Draft vs Cargo Capacity

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Several Additional Tug Boats required for VLCC Docking

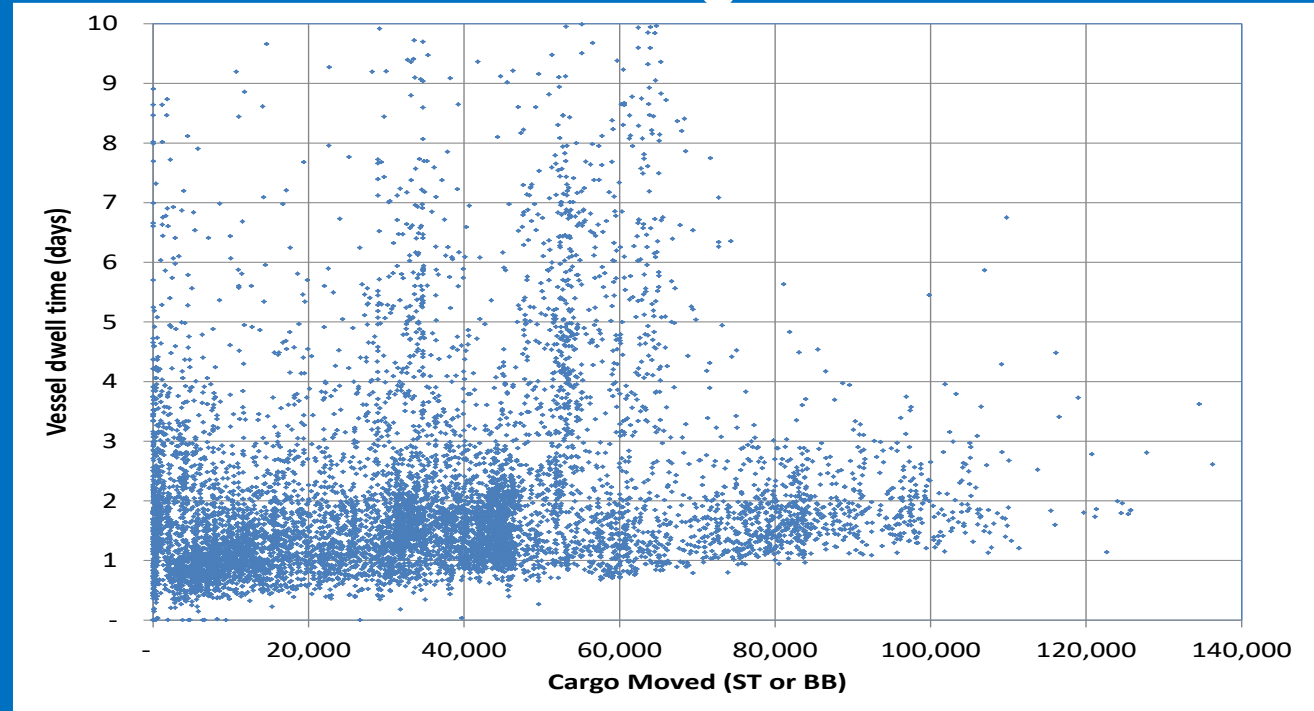
PORT**CORPUS CHRISTI**®

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Bigger Vessels Take Longer to Load/Unload

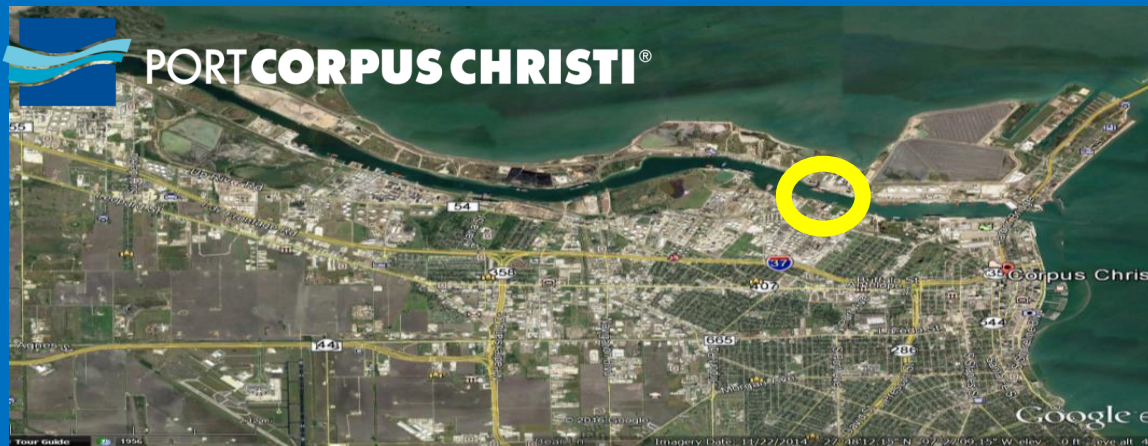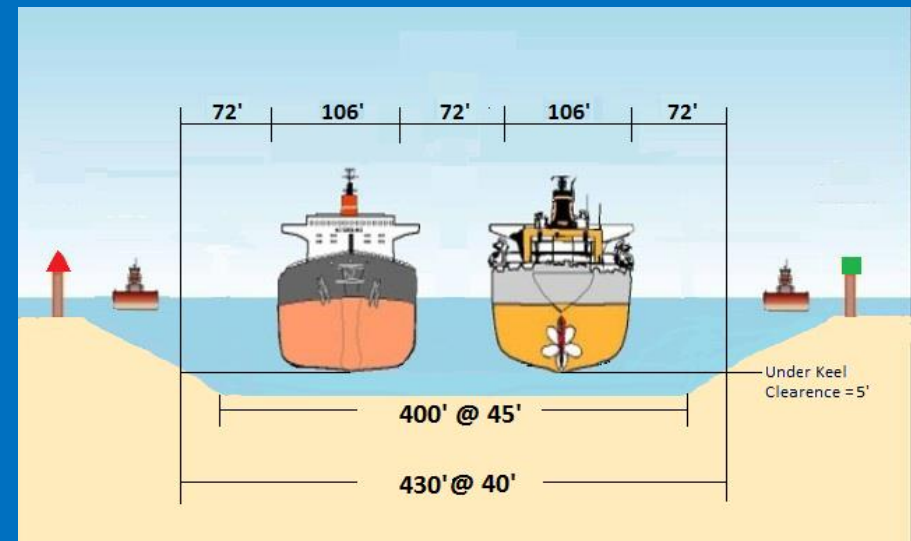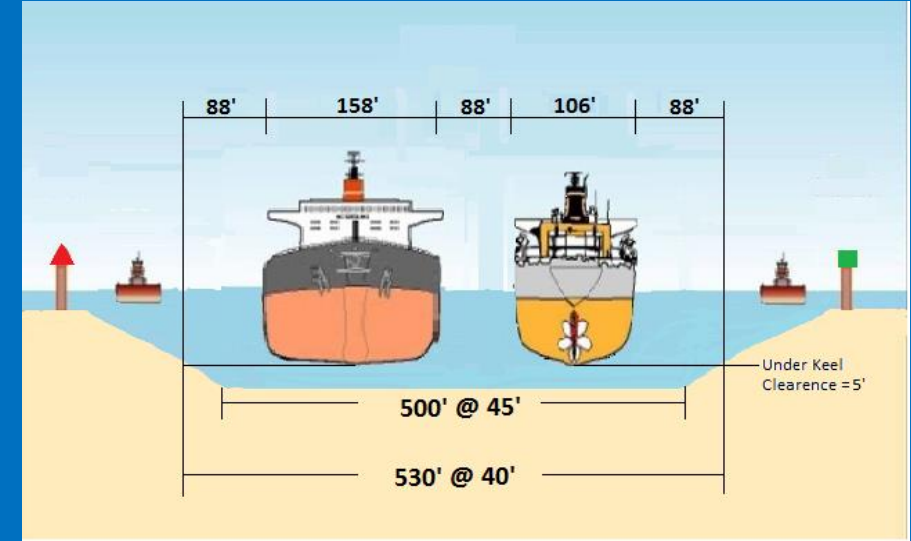
Dwell Time vs Ship Size

Dwell Time vs Cargo Transfer Size

Corpus Christi Ship Channel Vessel Beam Restrictions

- Cut A @ 500' wide - 265' of total beam
- Cut B @ 400' wide - 215' of total beam
- Citgo/ADM, 357' of total beam for berths+channel
- La Quinta Channel is one way only regardless of size

Operating Rules Vary by Vessel Class

- VLCC and LNGC vessels cannot meet/pass any other vessel types regardless of channel width

| Rule	VLCC	LNGC	Suezmax	Aframax	Panamax	Handy	Sub-handy	ATB (Ocean Barge)
Tugs inbound	5	4	3	2.5	2	2	2	1
Tugs outbound	5	4	3	2.5	2	1.5	1	1
Pilots @ day	3	2	2	1.5	1.5	1	1	1
Pilots @ night	NA	NA	NA	2	1.5	1	1	1
Typical beam (ft.)	200	154	158	138	106	90	75	75
Daylight only Y/N	Y	Y	Y	Y for 40.9'+	N	N	N	N

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Variables to Adjust to Achieve Calibration

- Ship speed
- Mix of ship sizes
- Pilot/tug deadhead time
- Ship dwell time at berth
- Berth availability (tankage constraints)
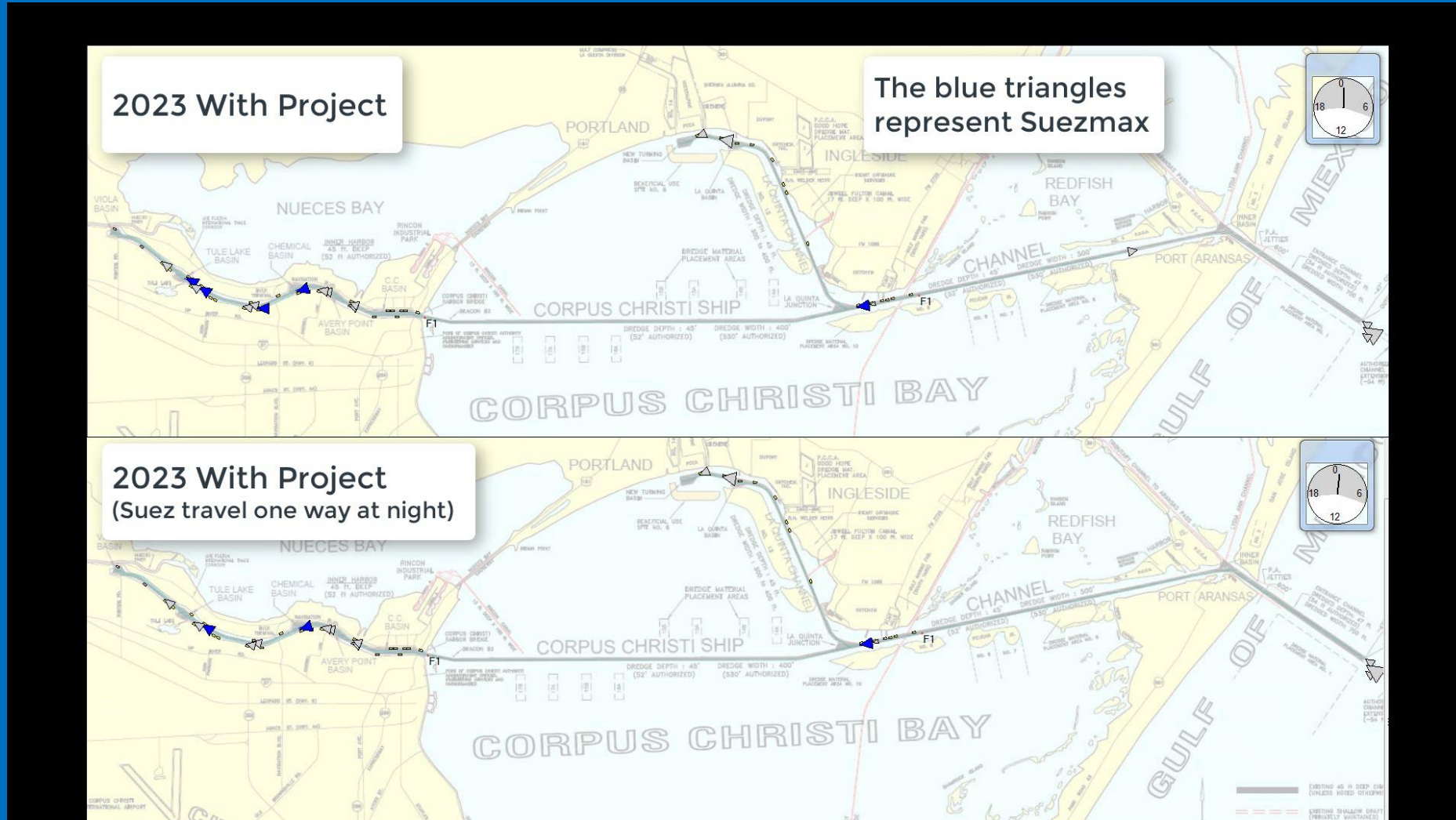- Port-wide shutdown time (fog etc.)
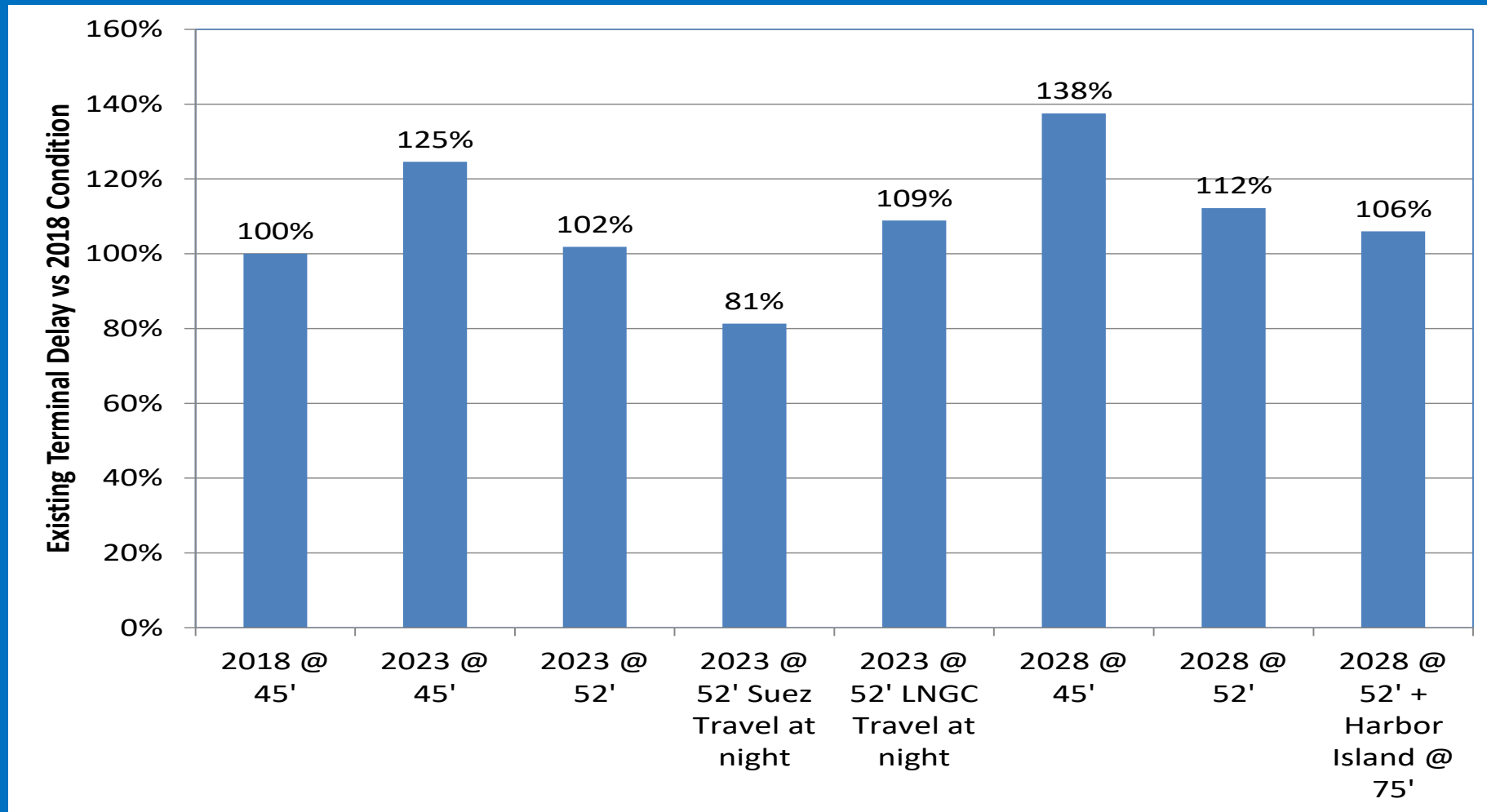
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AECOM Vessel Network Model (VNM)
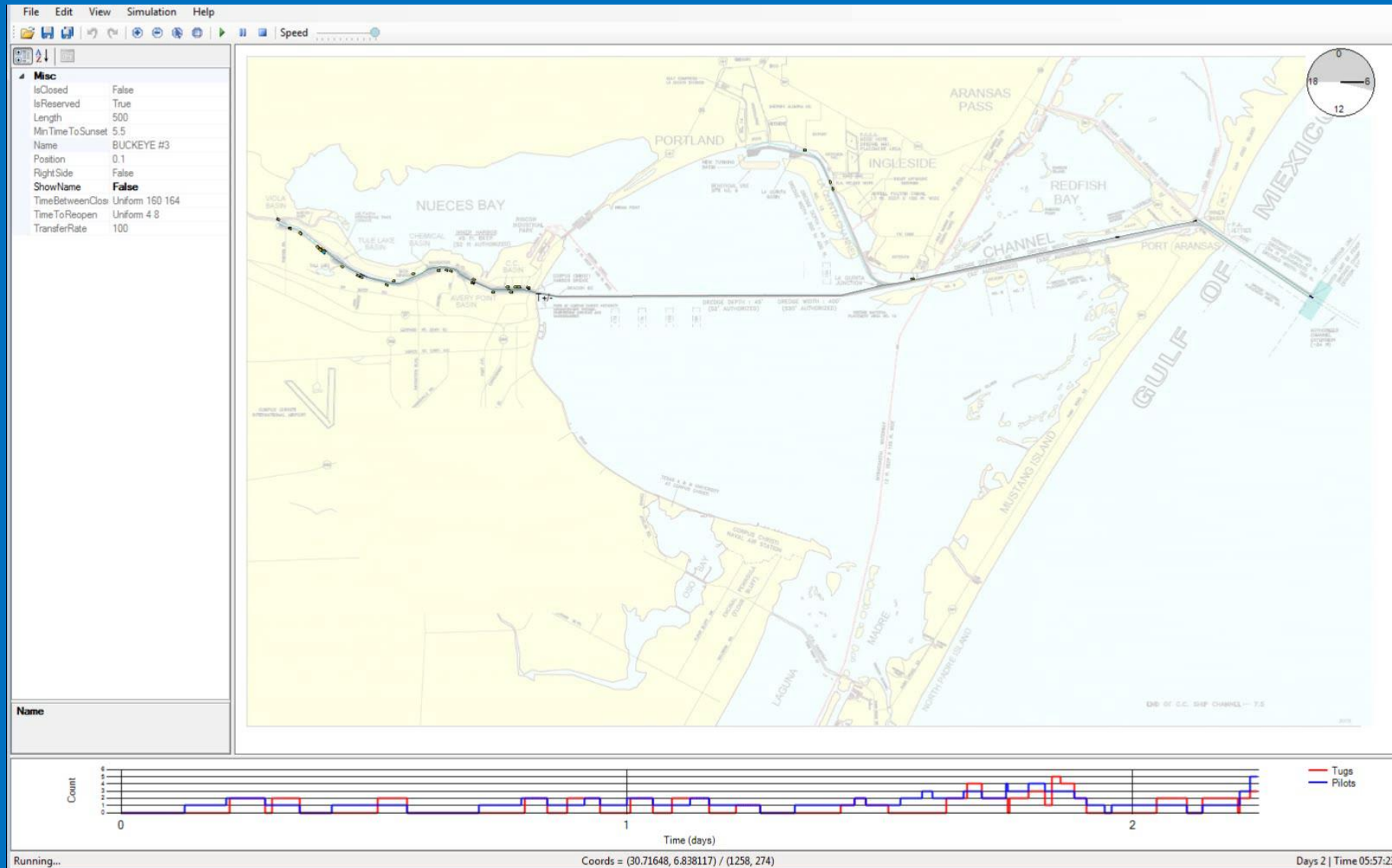
Optimize and Prioritize Dredging Requirements
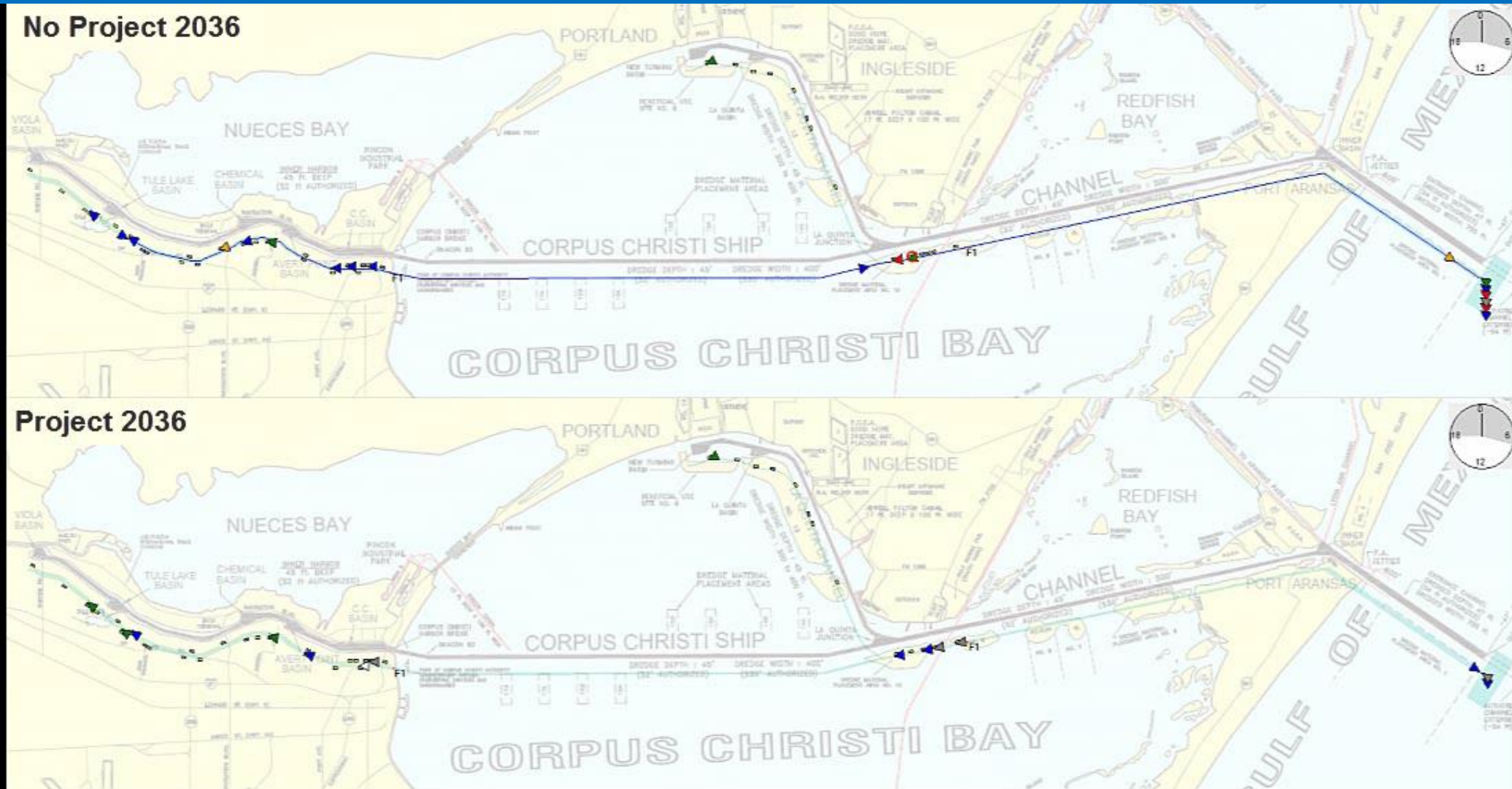
Optimize Piloting Rules

Sample Modeling Results

Ship Channel and Waterways Planning and Design using Simulation

- Channel Capacity
- Phasing of Capital Dredging
- Phasing of Maintenance Dredging
- Congestion Mitigation Planning
- Lay berth or in-harbor anchorage options
- Convoy options
- Identify Landside capacity issues for key terminals
- Detailed analysis of pilot and tug resources
- Reverse lightering

VESSEL NETWORK MODEL
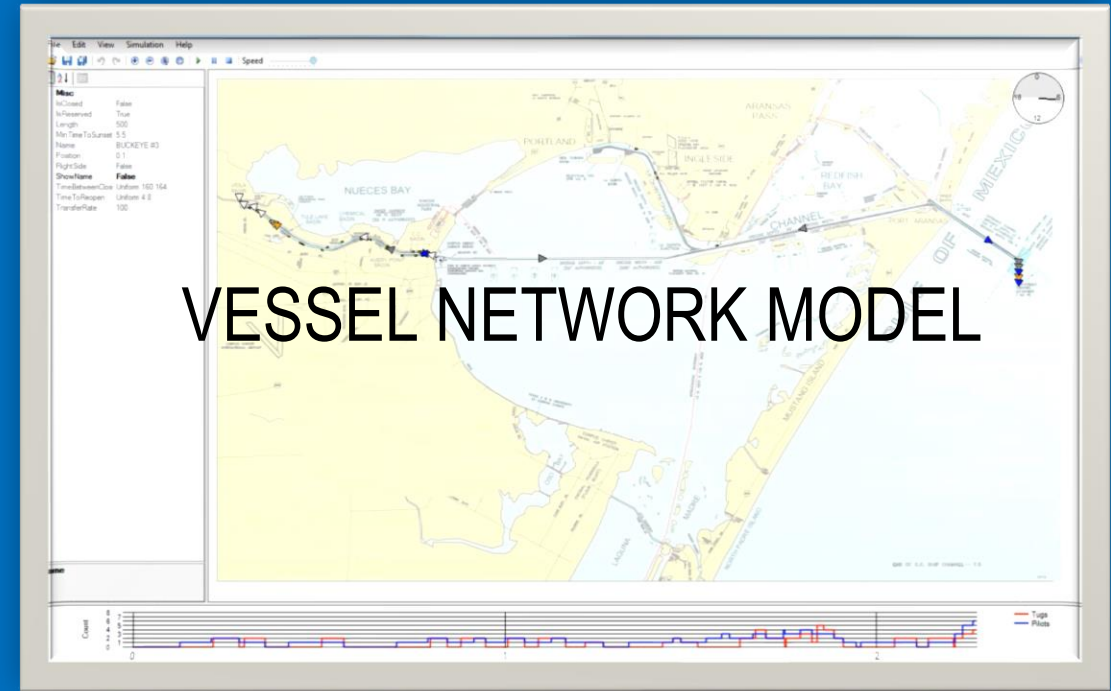
Thank you for your attention!

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