Module 6: Beyond the Automatic Identification System Analysis Package (AISAP)

Engineer Research and Development Center

http://ais-portal.usace.army.mil/

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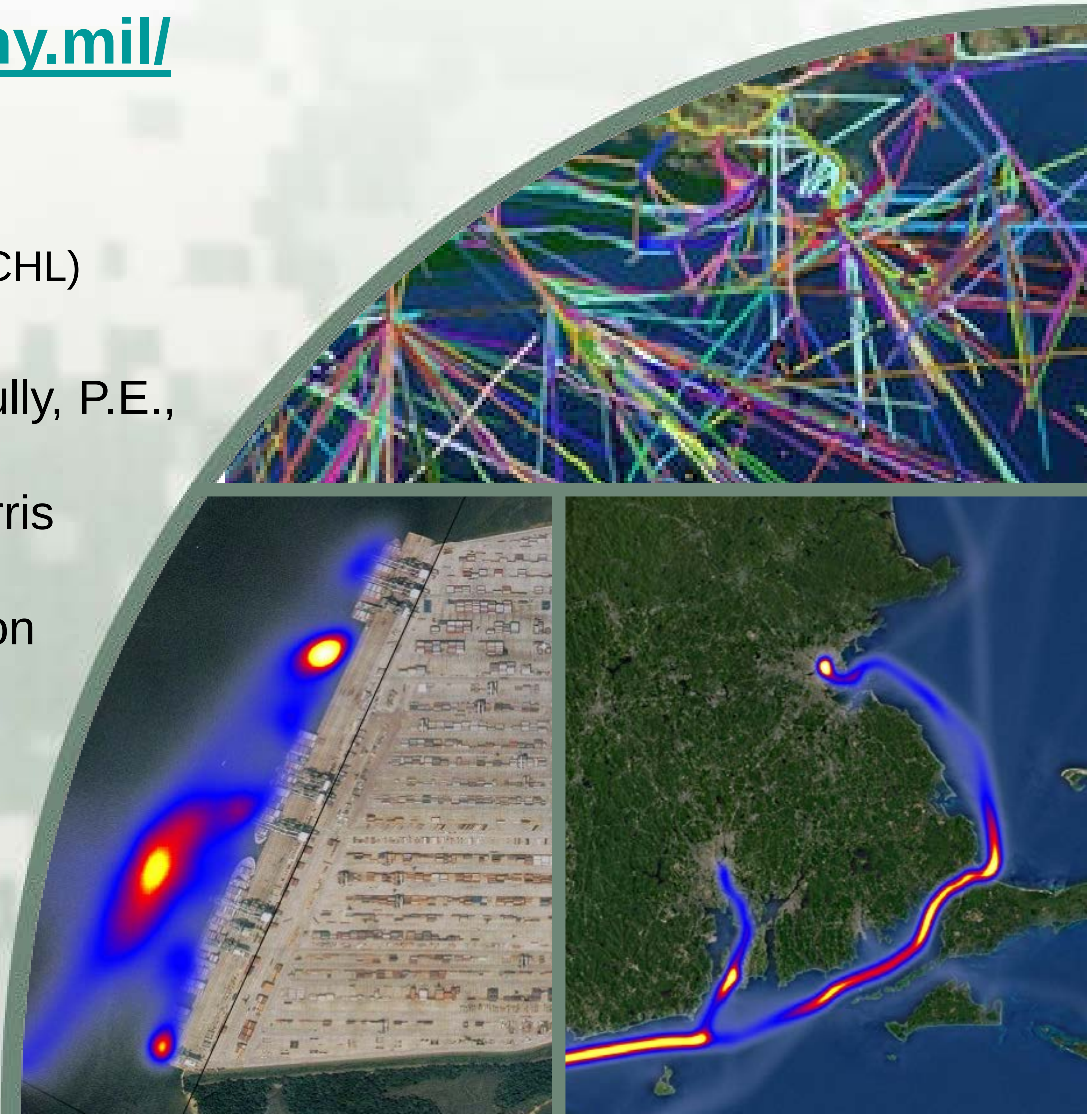
AISAP User Workshop
SWD – Dallas, TX
31 AUG 2016



US Army Corps of Engineers

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COASTAL & HYDRAULICS LABORATORY

NAVSYS Navigation Systems Research Program

Outline

1. Tidal Analysis
2. Arrival Process Mining
3. Underkeel Clearance
4. Dredging Influence
5. Waterway Travel Time Statistical Profiles
6. Coastal Applications

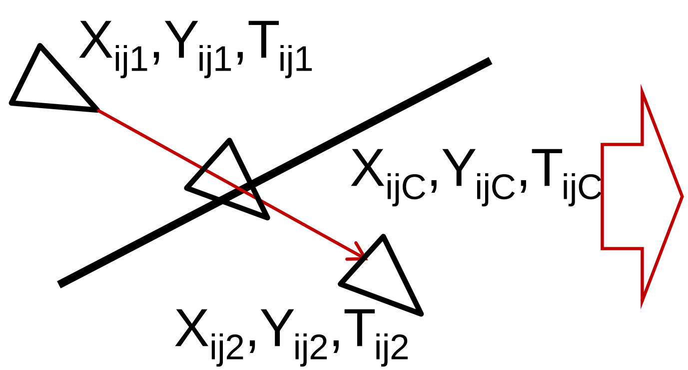
Tidal Analysis

- AIS data used to describe “Tidal Dependence” of a port entrance.
- Method to compare ports in terms of reliance on tide

Assign Tidal Elevation

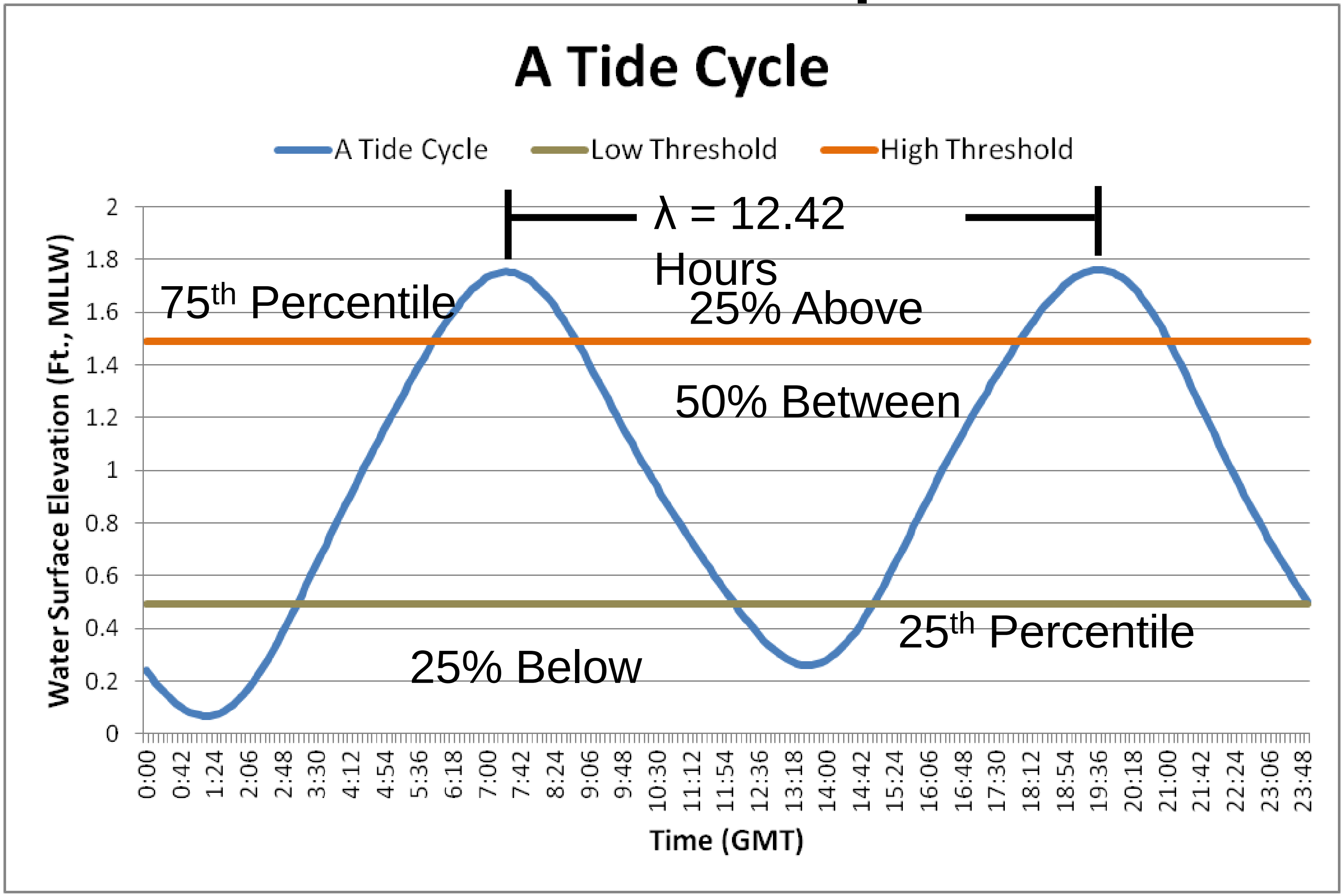
- Determine the time vessels cross a reference
- Use the time of crossing to interpolate an elevation from tidal (prediction) record.

ssing time and elevation.



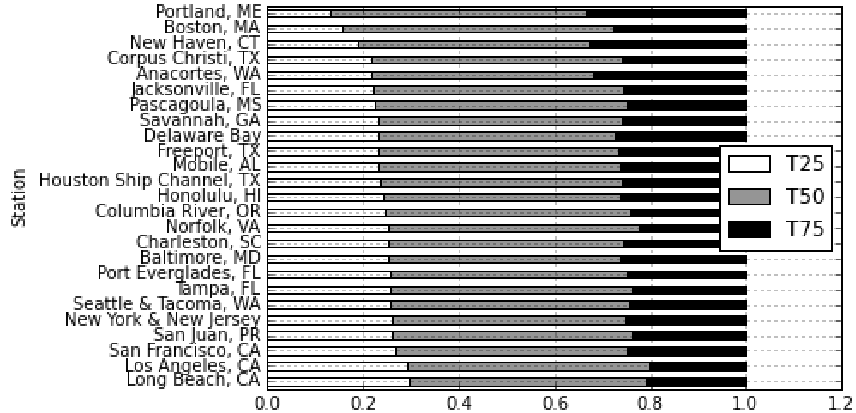
Time	Elev.
T_{ij1}	Z_{j1}
T_{ijC}	Z_{jC}
T_{ij2}	Z_{j2}

Measure Tidal Dependence

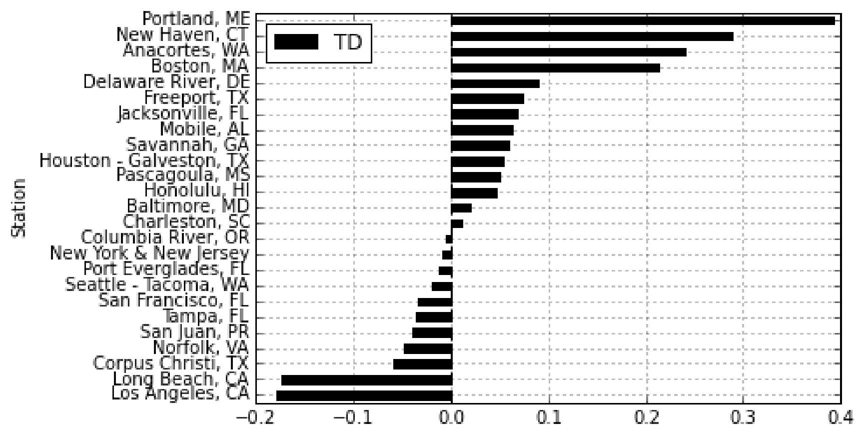


Traffic Classification

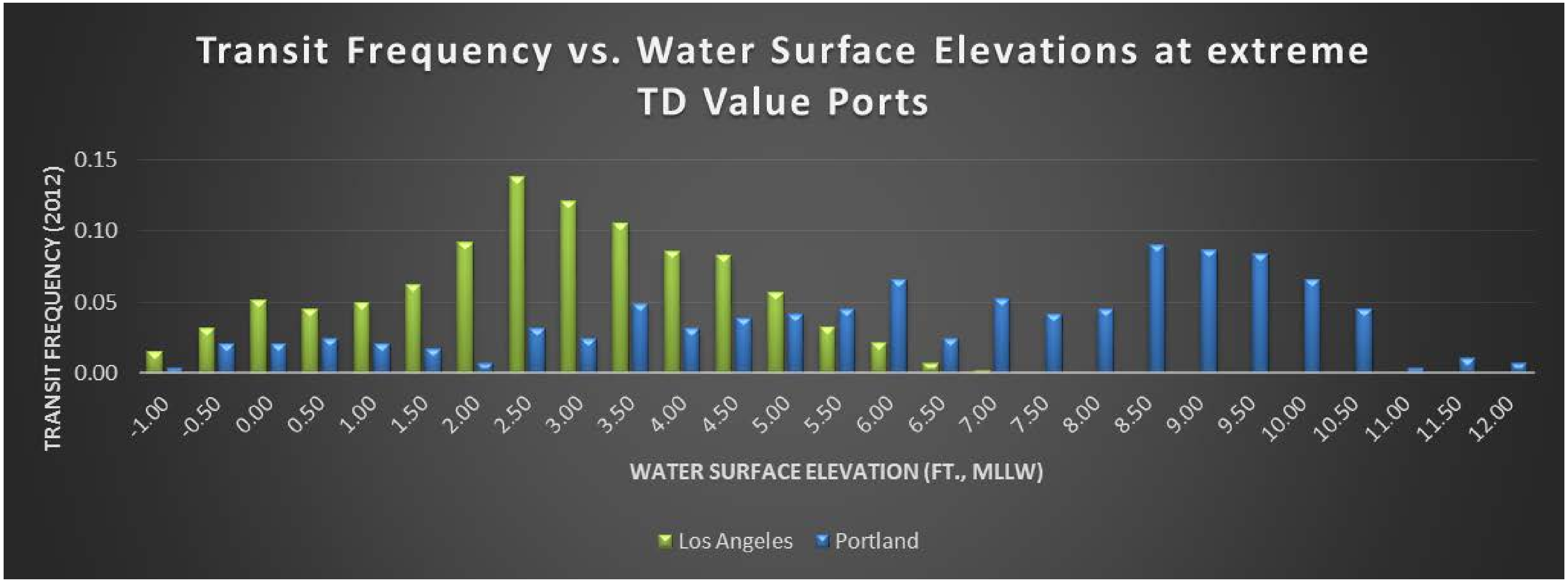
Average vessel traffic distribution 2012-2014



TD = (T_{75} -T_{25}) / T_{50}



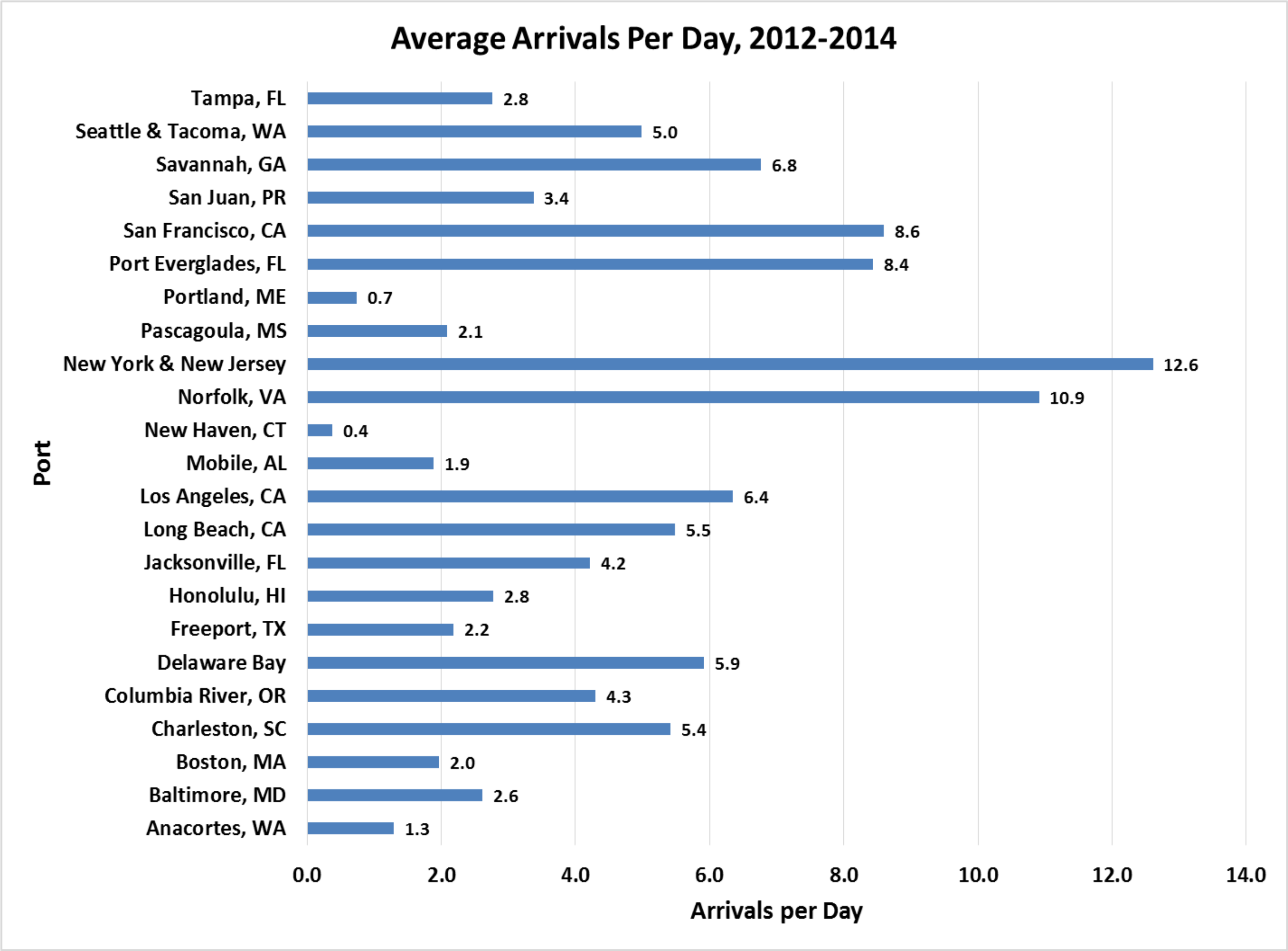
Tide Distribution of Extreme TD Ports



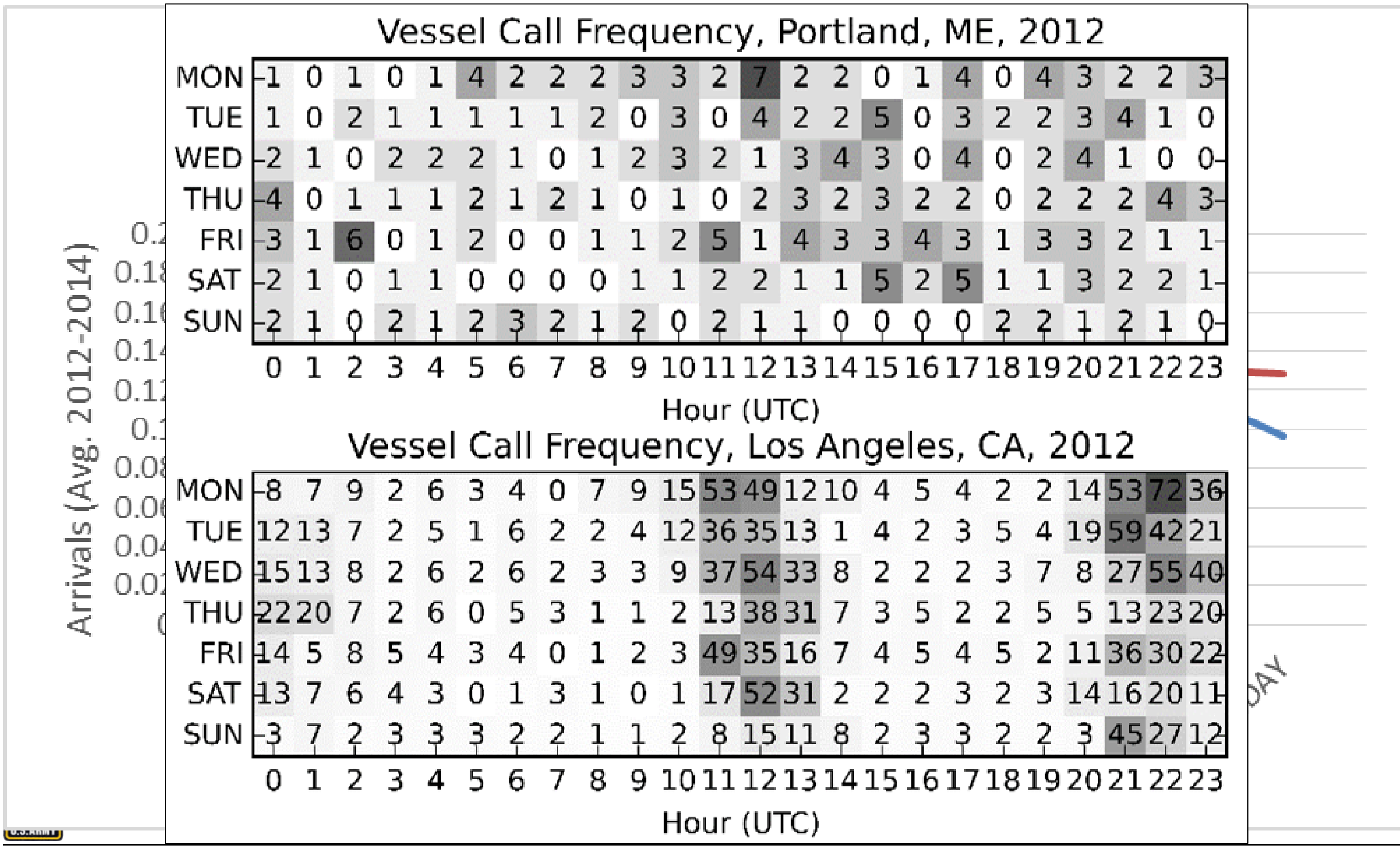
Arrival Process Mining

- Descriptive traffic measures extracted from reach-level AIS data
- Input to Planning Feasibility Studies
- Arrival rate
- Interarrival time
- Arrival Frequency

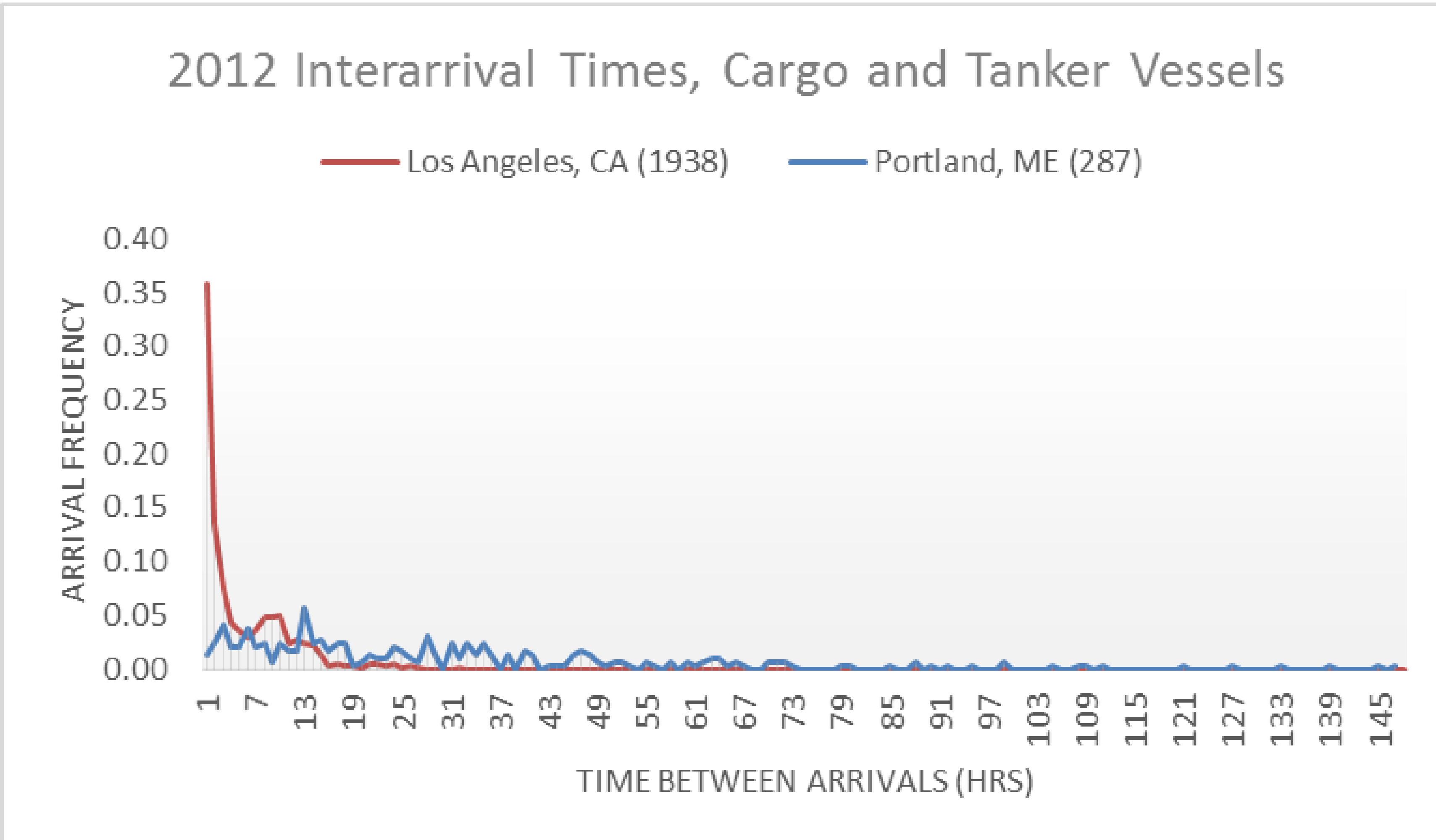
Arrival Rate



Arrival Frequency



Arrival Rate

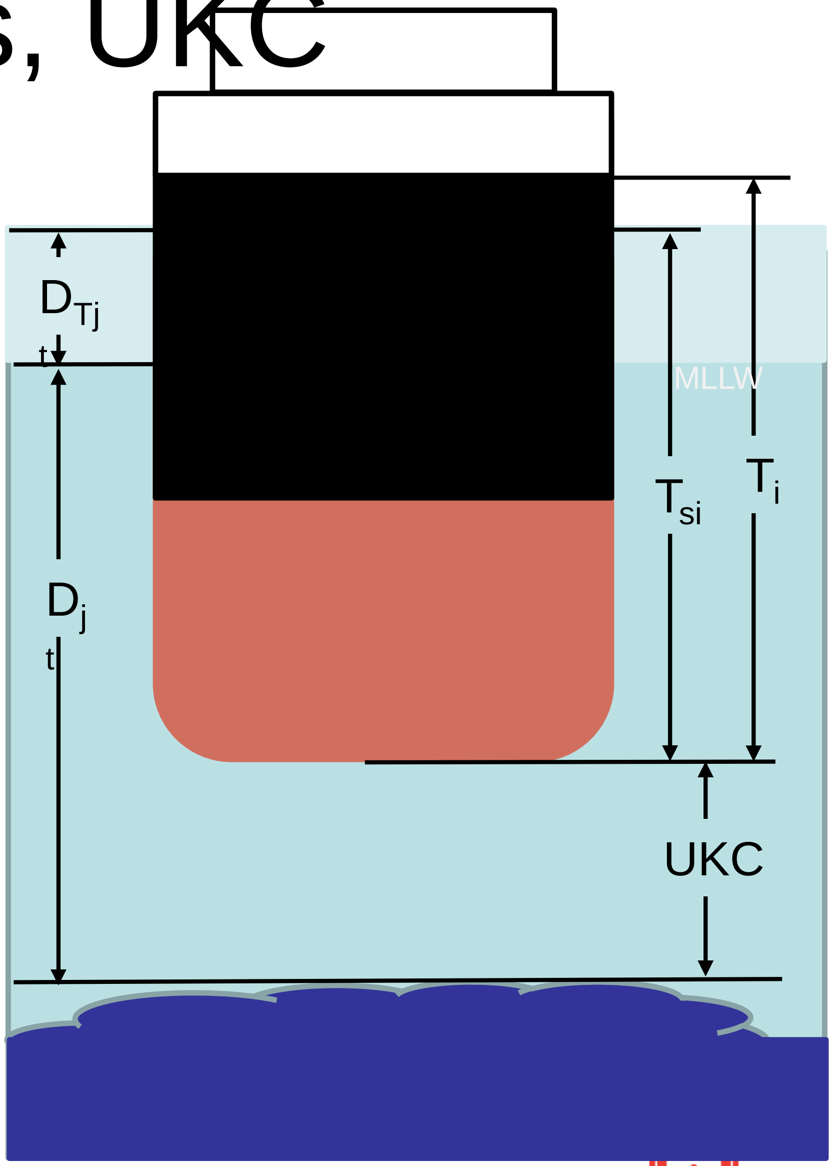


Underkeel Clearance

- Dredging supports navigation by creating adequate keel space
- USACE tracks controlling depth via CCS
- AIS tracks vessel time of arrival, which gives time index for water level
- AIS has draft which can be validated with authoritative information
- Estimating UKC can tell where we're over dredging.

Parameters, UKC

- Vessel Arrival times in each reach from AIS
- Estimate T_i from AIS
- Estimate T_{si} from ship specific sailing records or by ship type.
- Interpret D_{Tjt} from NOAA tide data using arrival time.
- Estimate D_{jt} by linear interpolation of channel condition record at arrival time.
- UKC components can be estimated from AIS data or applied deterministically.
- Result is a distribution of UKC_{ijt}



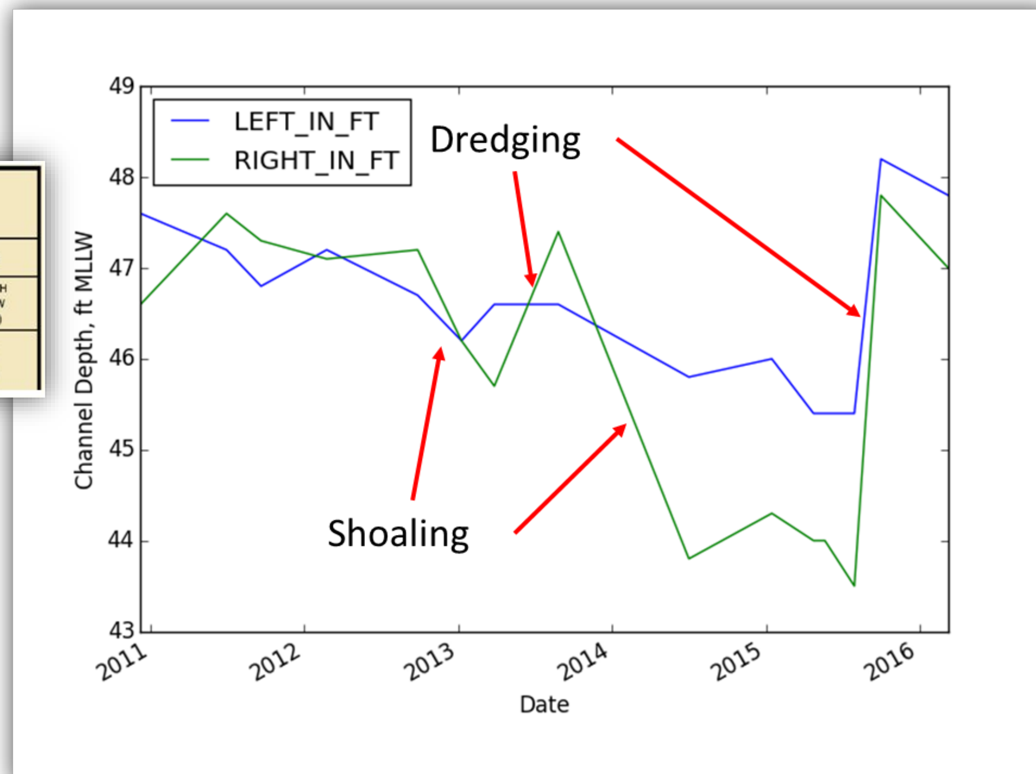
Available Channel Depth

- eHydro data used in channel condition maps and reports
- Maps and reports are communicated to NOAA and local pilots
- Time series of channel condition reports provides a history of channel bottom elevation

BALTIMORE HARBOR CHANNEL DEPTHS

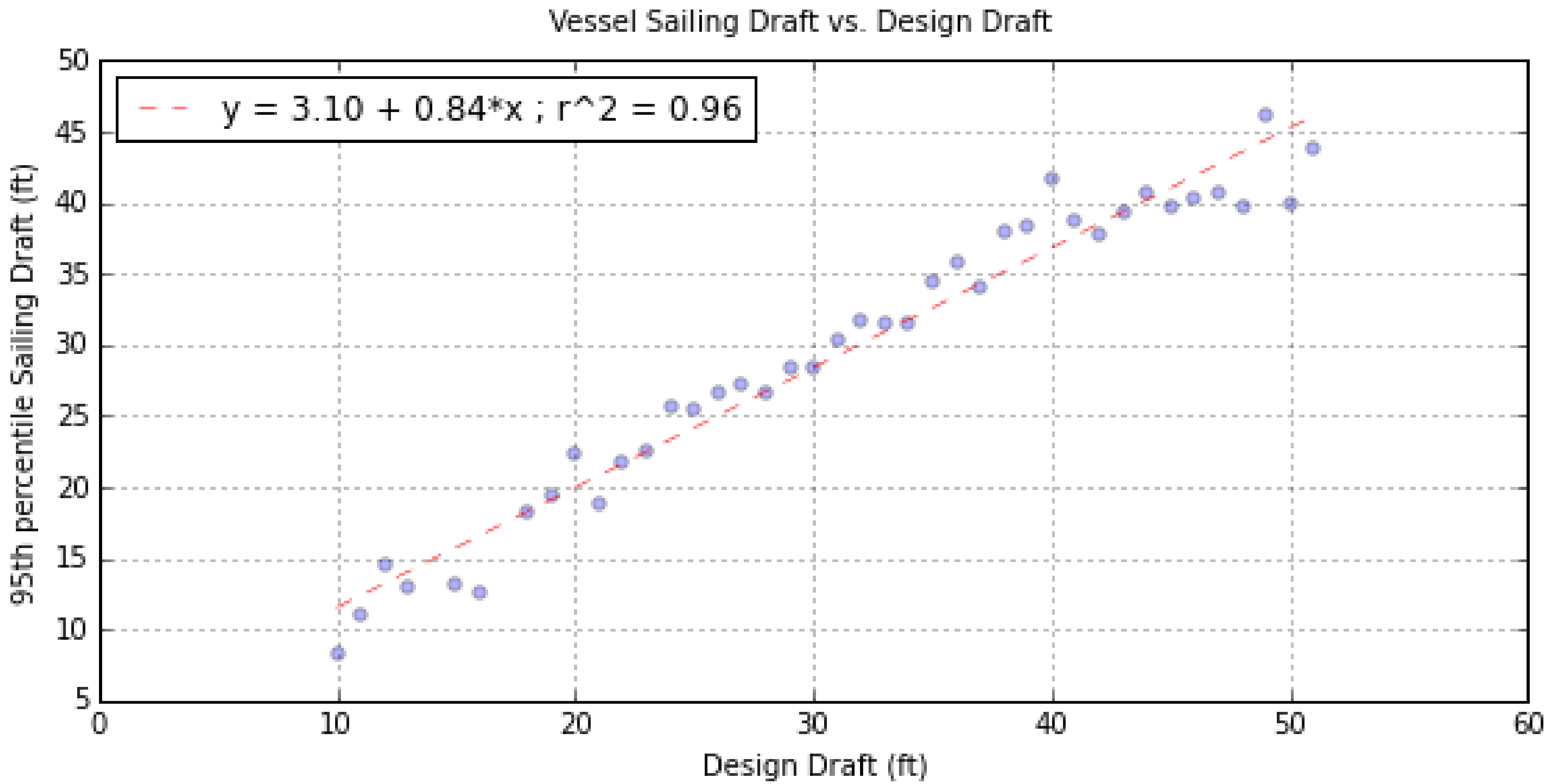
TABULATED FROM SURVEYS BY THE CORPS OF ENGINEERS - SURVEYS TO AUG 1998

CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOWER LOW WATER (MLLW)						PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	LEFT INSIDE QUARTER	RIGHT INSIDE QUARTER	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH (NAUT. MILES)	DEPTH MLLW (FEET)
BREWERTON CHANNEL	A47.5	50.9	50.5	A46.6	6-98	700	3.06	50
BREWERTON ANGLE	46.3	49.2	48.6	46.2	6-98	700-1450	0.79	50
FORT MCHENRY CHANNEL	A46.5	50.2	49.6	48.4	6-98	700	3.77	50



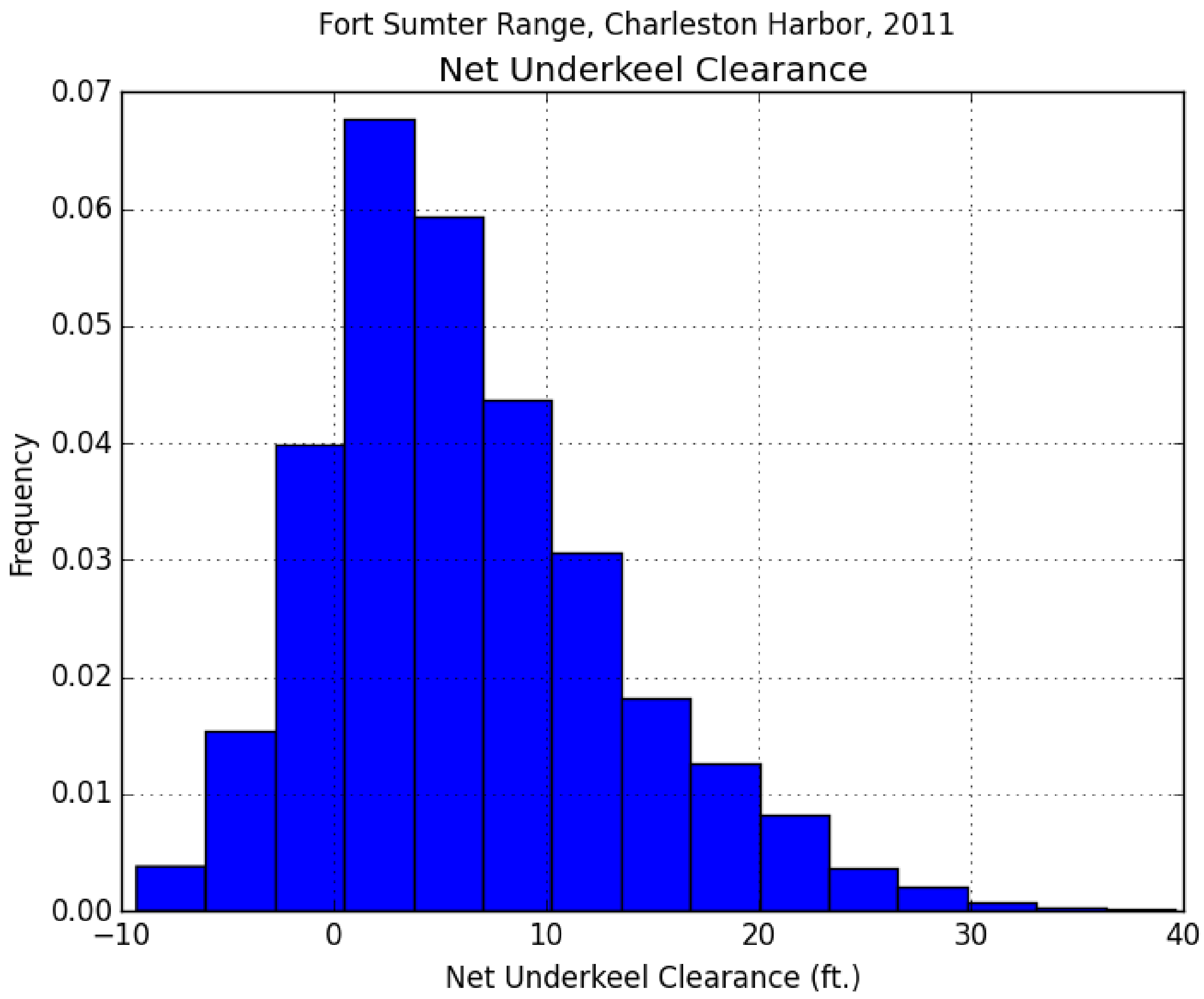
Vessel Draft

Pilotd Vessels, Charleston, SC, 2011



Nominal Design Draft (ft.)

Reach Net UKC



Reach Performance

Daniel Island Bend
failed: 0.0
total: 1301.0
reliability: 1.0
unique: 246
squat, mean, std: 0.797 0.245
KM, mean, std: 1.83 0.245
$119,988
* * * * * * * * * * * * * * * *

Daniel Island Reach
failed: 17.0
total: 1299.0
reliability: 0.9869
unique:246
squat, mean, std: 0.854 0.26
KM, mean, std: 1.89 0.26
$839,114
* * * * * * * * * * * * * * * *

Drum Island Reach
failed: 8.0
total: 1505.0
reliability: 0.9947
unique: 338
squat, mean, std: 0.787 0.239
KM, mean, std: 1.56 0.242
$240,403
* * * * * * * * * * * * * * * *

Fort Sumter Range
failed: 658.0
total: 3931.0
reliability: 0.8326
unique: 699
squat, mean, std: 2.03 0.643
KM, mean, std: 4.81 0.65
$2,074,169
* * * * * * * * * * * * * * * *

Hog Island Reach
failed: 175.0
total: 3262.0
reliability: 0.9464
unique: 700
squat, mean, std: 1.14 0.33
KM, mean, std: 1.91 0.327
$432,383
* * * * * * * * * * * * * * * *

Myers Bend
failed: 8.0
total: 1505.0
reliability: 0.9947
unique: 338
squat, mean, std: 0.801 0.286
KM, mean, std: 1.57 0.288
$54,078
* * * * * * * * * * * * * * * *

Navy Yard Reach
failed: 5.0
total: 1276.0
reliability: 0.9961
unique: 217
squat, mean, std: 0.83 0.407
KM, mean, std: 1.87 0.407
$91,557
* * * * * * * * * * * * * * * *

Port Terminal Reach
failed: 0.0
total: 688.0
reliability: 1.0
unique: 176
squat, mean, std: 0.308 0.298
KM, mean, std: 1.28 0.298
$61,525
* * * * * * * * * * * * * * * *

Shipyard River
failed: 1.0
total: 36.0
reliability: 0.9722
unique: 10
squat, mean, std: 0.296 0.288
KM, mean, std: 1.48 0.288
$830,842
* * * * * * * * * * * * * * * *

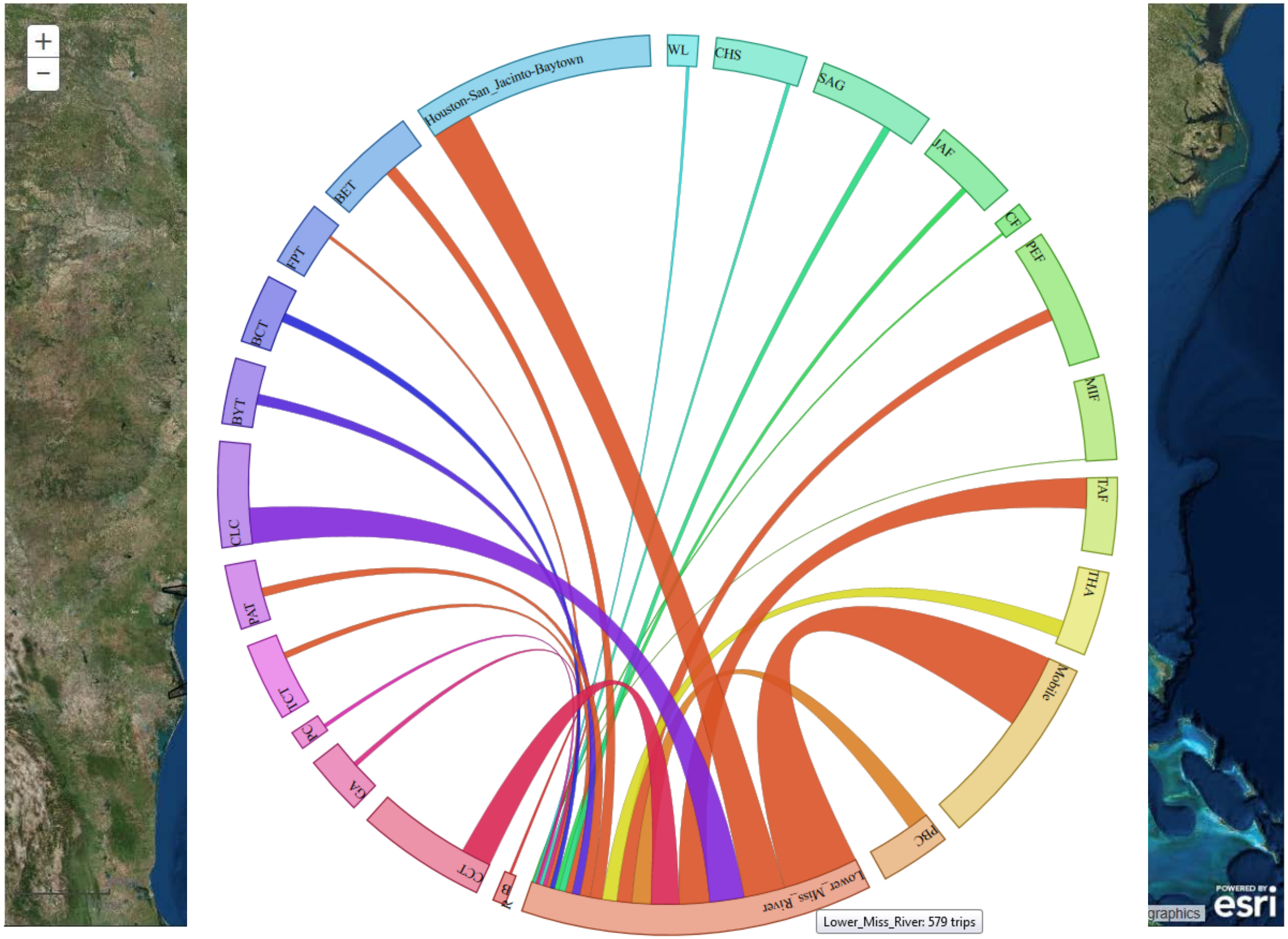
Tidewater Reach
failed: 21.0
total: 257.0
reliability: 0.9183
unique: 46
squat, mean, std: 0.213 0.0928
KM, mean, std: 0.833 0.0928
$195,742
* * * * * * * * * * * * * * * *

Town Creek Lower and Columbust St. Turn Basin
failed: 1.0
total: 88.0
reliability: 0.9886
unique: 58
squat, mean, std: 0.735 4.6
KM, mean, std: 1.36 4.6
$123,659
* * * * * * * * * * * * * * * *

Wando Lower Reach
failed: 145.0
total: 1756.0
reliability: 0.9174
unique: 214
squat, mean, std: 0.949 0.35
KM, mean, std: 1.57 0.35
$244,654
* * * * * * * * * * * * * * * *

Port Interconnectivity

Trips Between Ports, 2014



Waterway Travel Time Statistical Profiles

Study Objective: Create a statistical profile of waterway system travel times by analyzing vessel position reports

Potential Applications

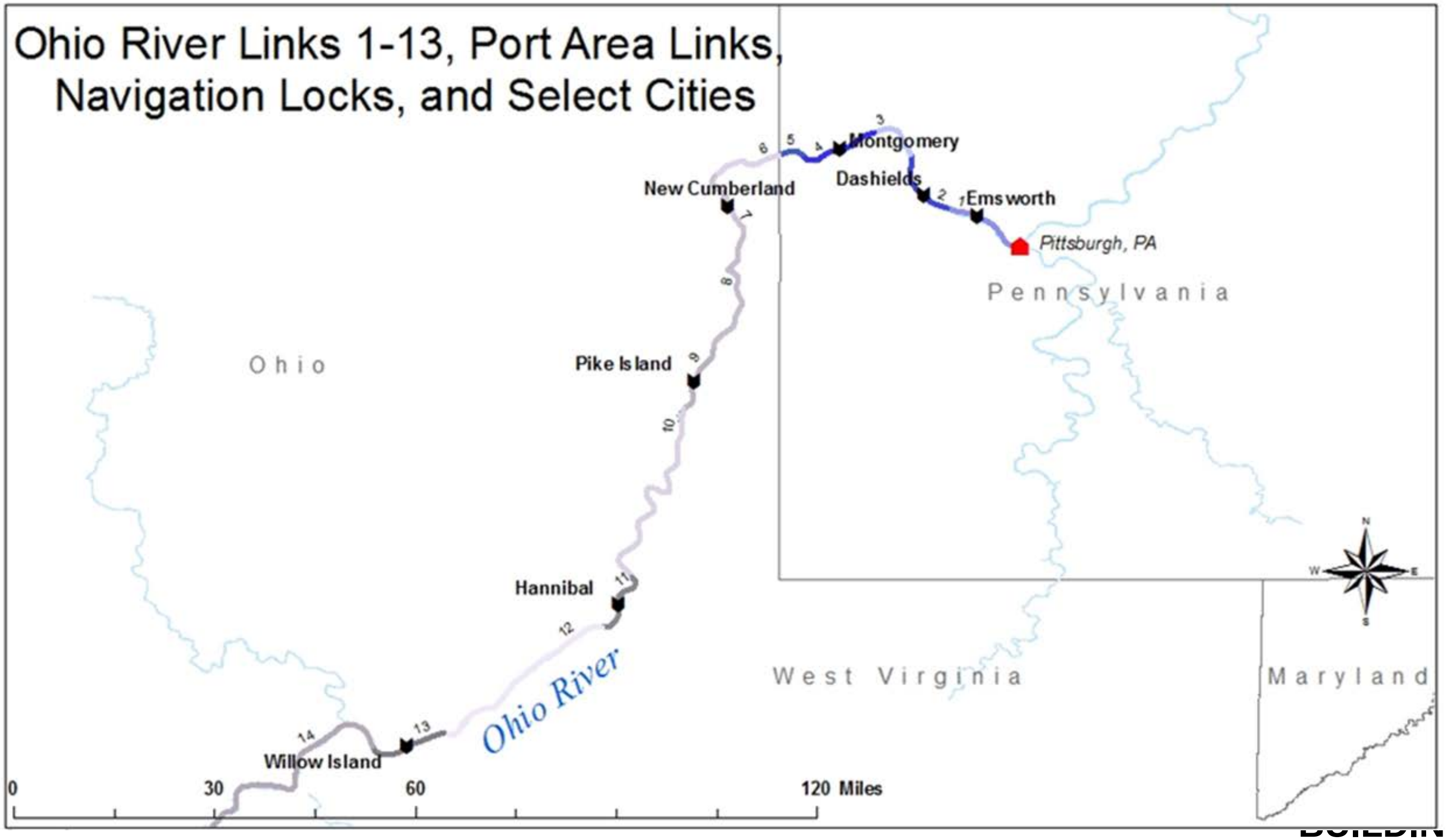
- Measure Marine Transportation System (MTS) performance
- Quantity system resiliency (withstand, recover)
- Locate system bottlenecks and areas with most critical needs
- Compare performance pre and post operations and maintenance
- Voyage planning, River Information Services (RIS)

Dewatered lock

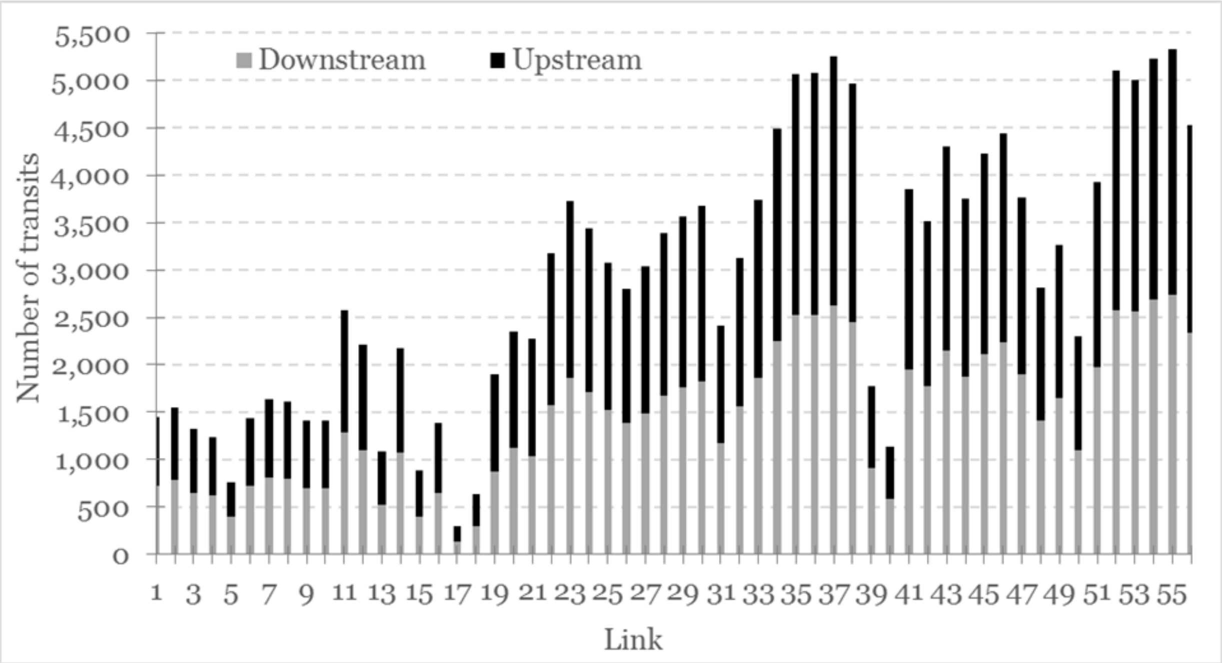
Sample Case Study: Ohio River Travel Time Atlas

Objective: Develop a statistical profile of waterway travel times between origins and destinations.

- Waterway segmented into shorter links DEFINED BY THE USER:
  - Isolates travel behavior
  - Increases sample size

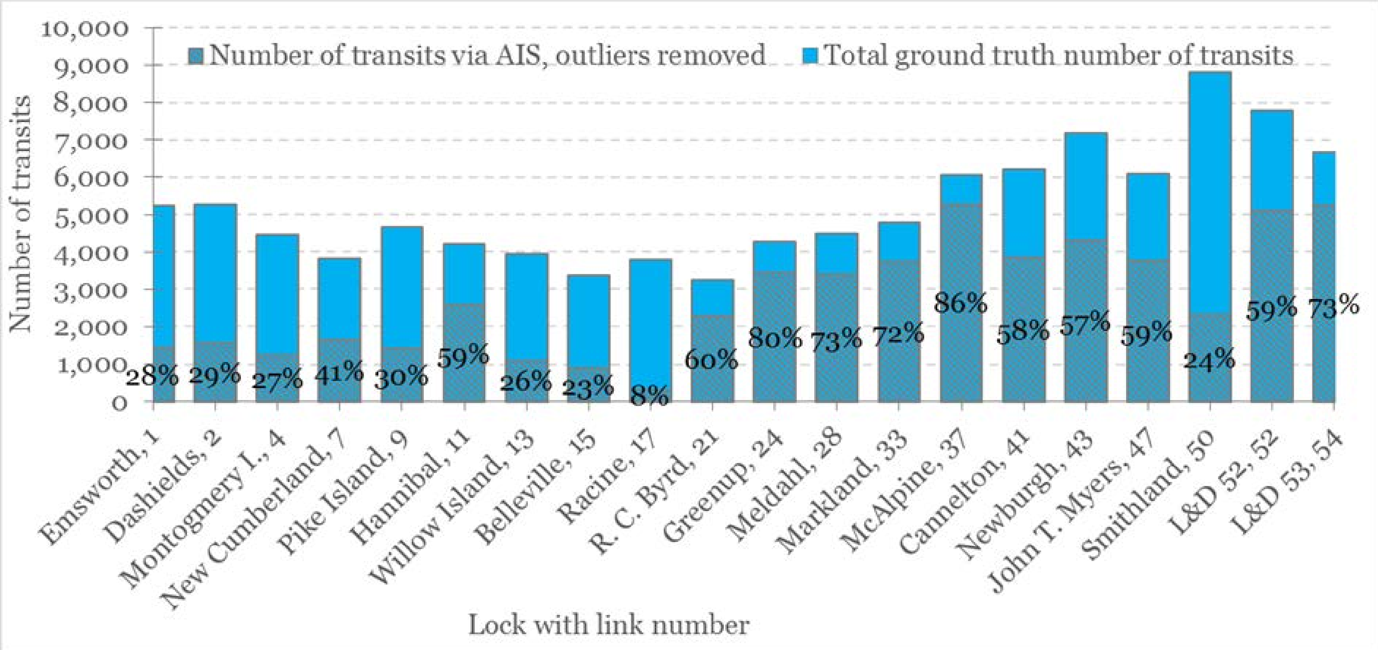


Case Study Results: Waterway Usage



Ohio River link number of transits by direction of travel, 2014

Ohio River number of transits via AIS and ground truth, 2014.



Case Study Results: Average Travel Time and Standard Deviation

Ohio R. Link Annual Average and Standard Deviation of Travel Time, 2014

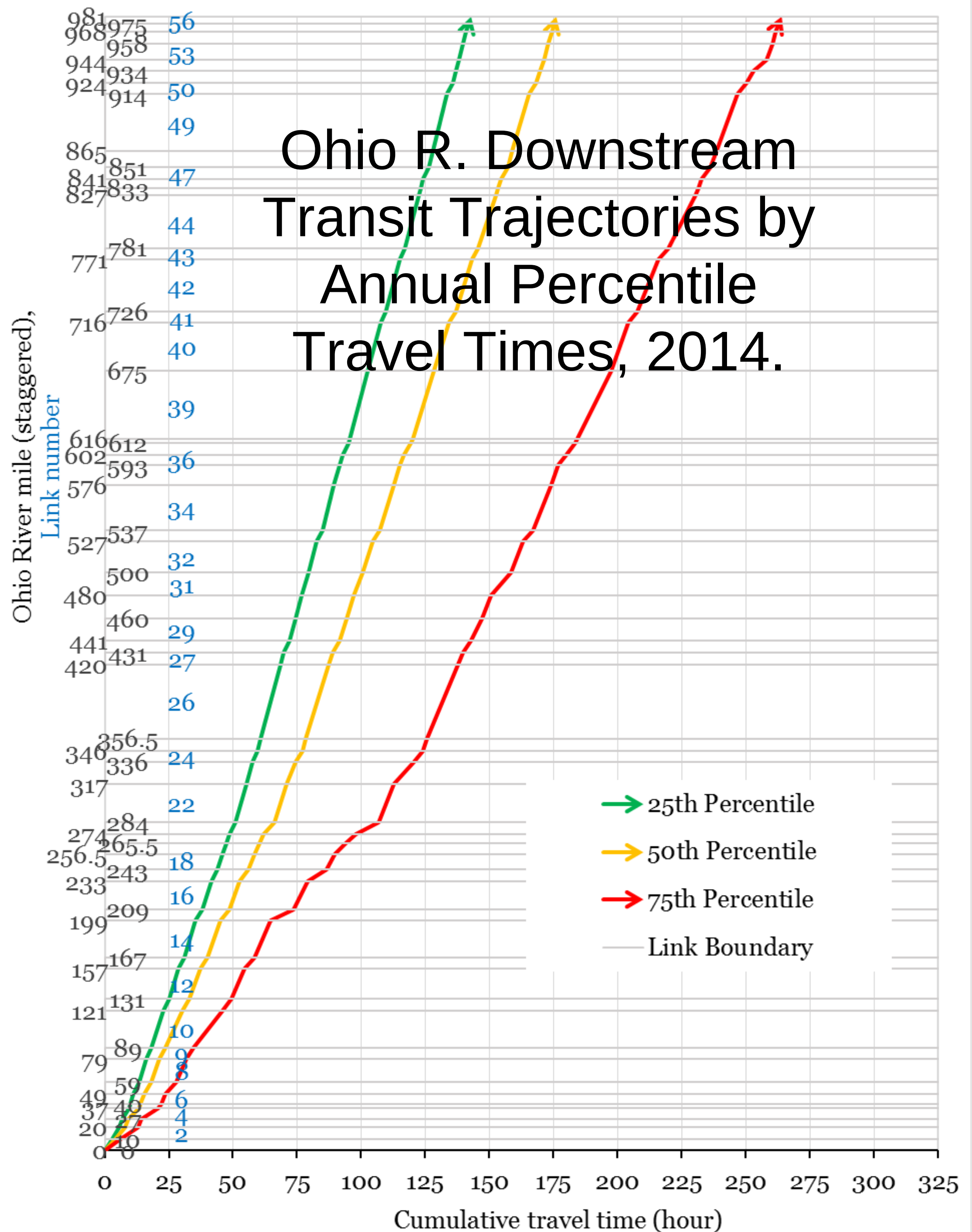
The cell shading (conditional formatting) highlights the lowest relative values in green and the highest in red.

Direction of Travel	Downstream		Upstream	
Link	Average Travel Time	Standard Deviation of Travel Time	Average Travel Time	Standard Deviation of Travel Time
1	4.97	3.93	5.54	4.91
2	7.30	9.39	7.65	9.36
3	1.53	1.37	1.99	1.33
4	5.87	7.36	6.33	6.73
5	1.06	0.95	1.15	0.80
6	1.91	1.37	2.48	1.55
7	5.65	9.21	5.12	7.38
8	3.93	3.21	5.59	3.26
9	3.03	2.86	3.78	5.06
10	9.19	7.57	9.05	6.78
11	3.56	3.50	4.41	5.91
12	4.69	3.38	5.55	2.86
13	5.92	11.35	6.58	12.32
14	6.02	4.07	8.17	4.44
15	13.17	19.66	12.49	18.90
16	6.35	6.57	6.61	4.29
17	12.74	19.52	10.08	15.39
18	3.30	3.15	3.93	2.49
19	3.19	2.88	3.12	2.39
20	2.86	2.46	3.33	2.62
21	8.52	11.68	6.95	8.37
22	5.40	3.46	8.92	4.28
23	5.62	4.43	5.50	4.05
24	3.08	2.22	3.49	2.38
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Case Study Results: Percentile Travel Times for a Waterway by Link

Travel times estimated as the amount of time for a vessel to travel from one end of the link to the other.

Future study:
Categorize by environmental conditions and/or vessel characteristics.



Case Study Results: O-D Percentile Travel Times

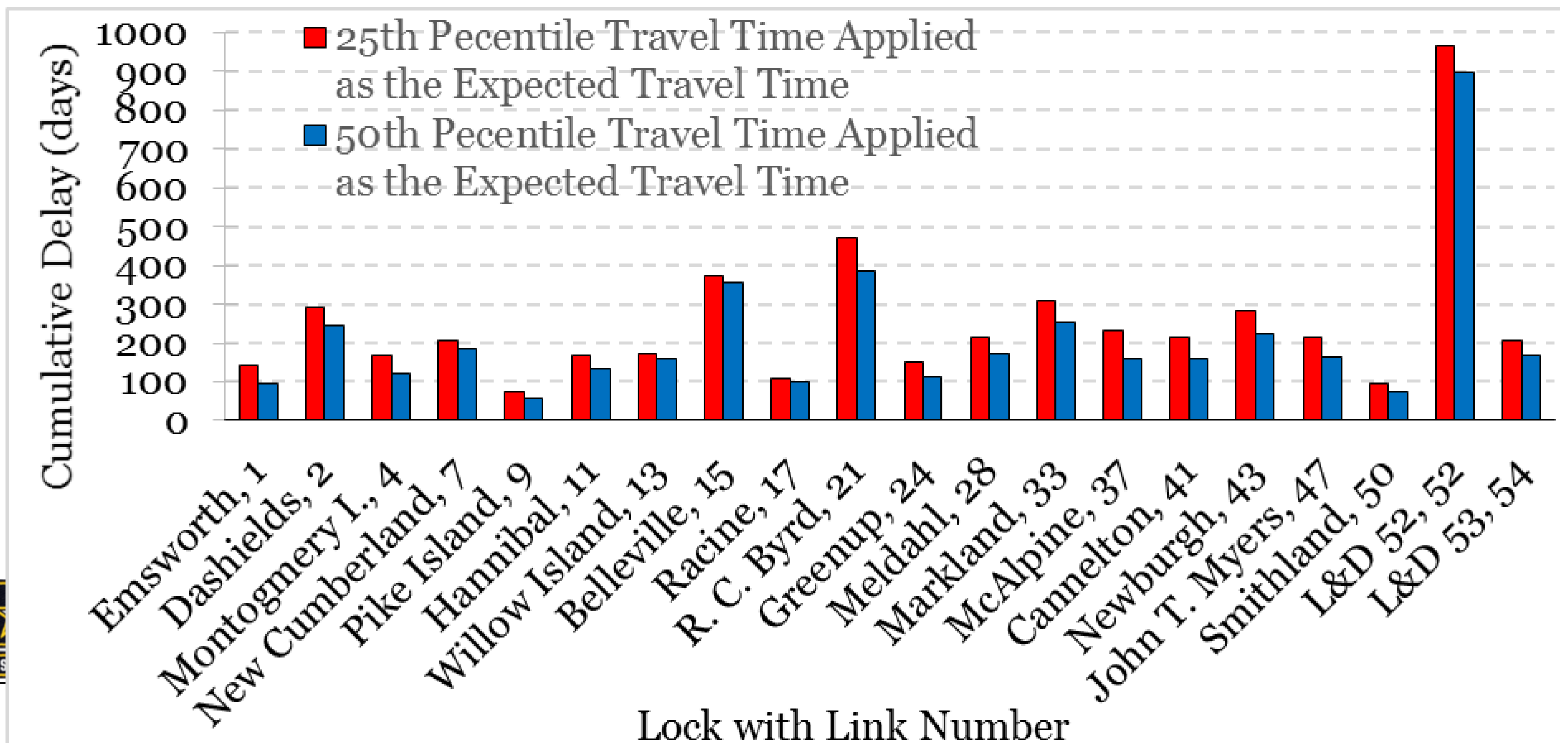
Destination / Origin (Ohio River Mile)	Ohio River Upstream End / Pittsburgh Upstream Boundary (0)	Pittsburgh Downstream Boundary (40)	Huntington Tri-State Upstream Boundary (256.5)	Huntington Tri-State Downstream / Cincinnati Upstream Boundary (356.5)	Cincinnati Downstream Boundary (576)	Louisville Upstream Boundary (593)	Louisville Downstream Boundary (616)	Mount Vernon Upstream Boundary (827)	Mount Vernon Downstream Boundary (833)	Ohio River Downstream End (981)
Ohio River Upstream End / Pittsburgh Upstream Boundary (0)		9.9 14.0 21.9	46.1 58.5 89.8	60.9 78.4 125.6	93.1 122.2 187.0	95.1 124.5 189.7	99.2 129.4 197.2	126.2 162.0 243.4	127.0 162.9 244.6	146.3 185.6 276.9
Pittsburgh Downstream Boundary (40)	12.1 16.3 23.2		36.2 44.5 67.9	51.0 64.4 103.8	83.2 108.2 165.1	85.2 110.5 167.8	89.3 115.4 175.3	116.3 148.0 221.5	117.1 148.9 222.7	136.4 171.6 255.1
Huntington Tri-State Upstream Boundary (256.5)	57.3 71.7 97.6	45.1 55.4 74.4		14.8 19.9 35.9	47.1 63.7 97.2	49.1 66.0 99.9	53.1 70.9 107.4	80.1 103.5 153.6	80.9 104.4 154.8	100.2 127.1 187.1

Ohio R. Annual Percentile Travel Times between O-Ds (hours), 2014

Case Study Results: Link Travel Time Delay

- Link travel time delay: travel time over the expected travel time
- Expected travel time proxy: annual 25th or 50th percentile travel time
- Cumulative delay is the sum of the delay of each individual transit experiences – dependent on both traffic volume and delay per vessel
- Different definition of delay than the USACE Lock Performance Monitoring System (LPMS). The two approaches provide different information and both provide meaningful results.

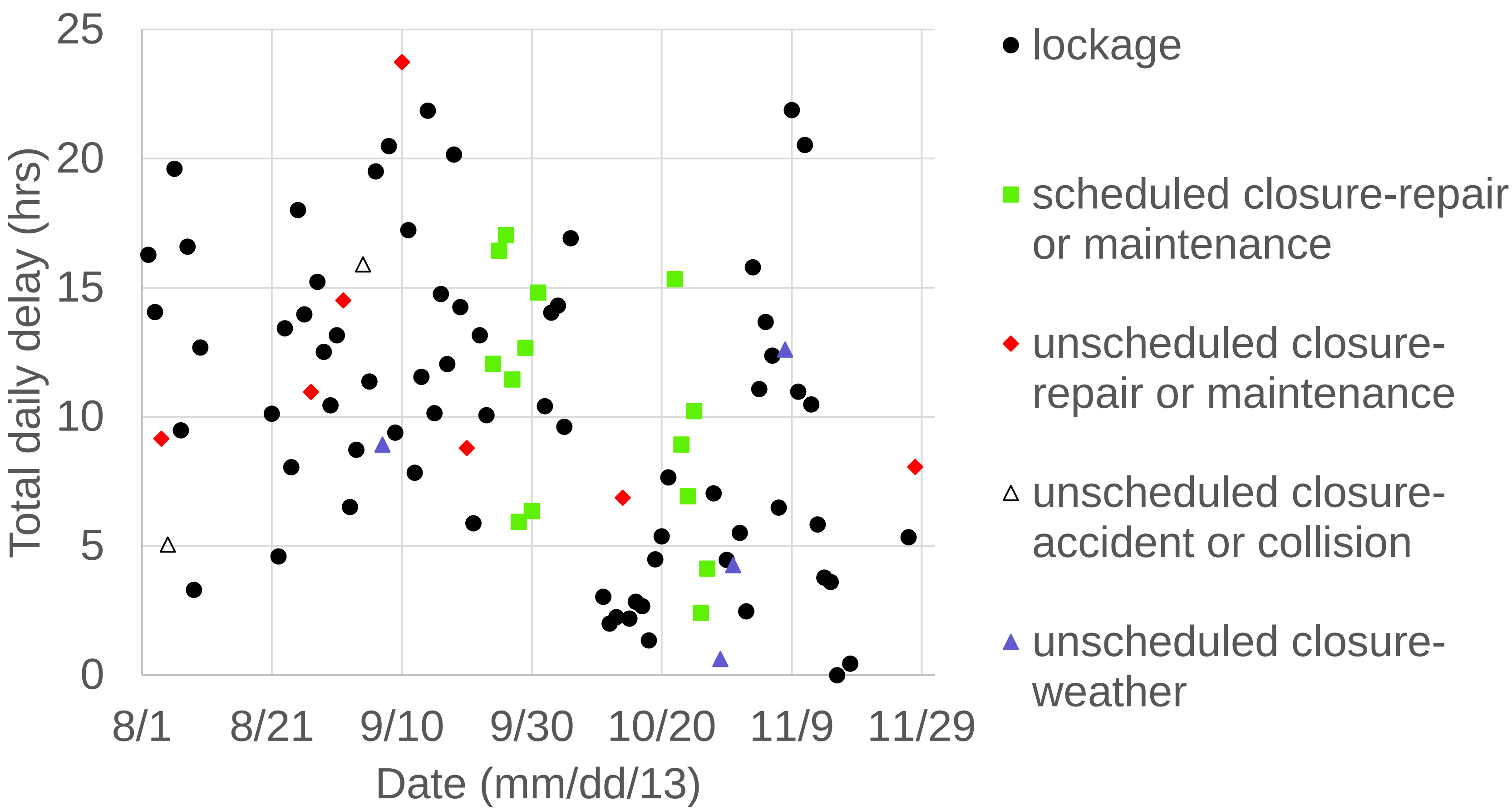
Ohio River 2014 Cumulative Delay



Case Study Results:

Delay by Event for L&D 52 in 2013

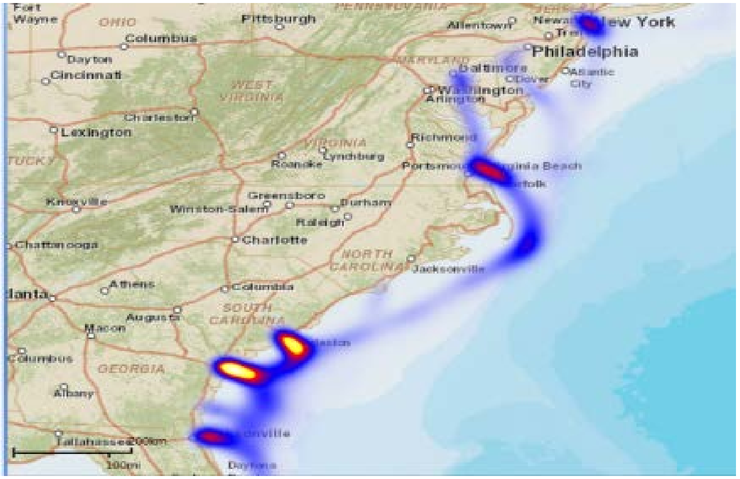
- Analyze AIS data to estimate link delay
- Apply LPMS records to determine lockage closure events by type

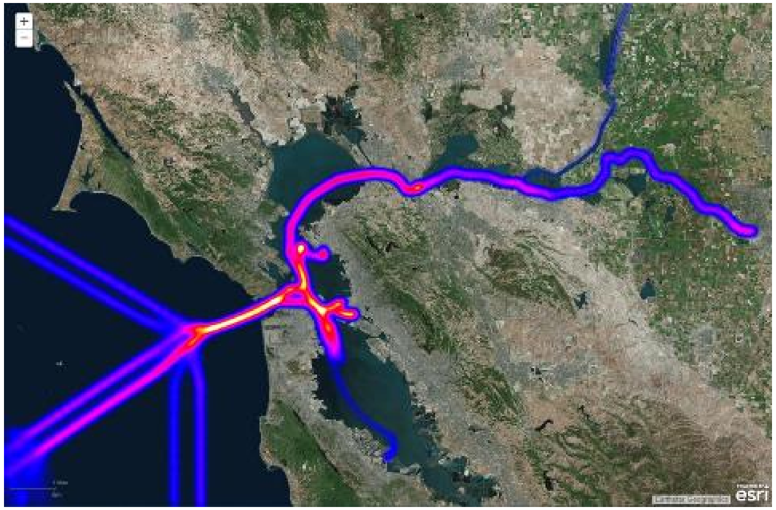


AIS Data Coastal Ports Applications

Derived coastal information:

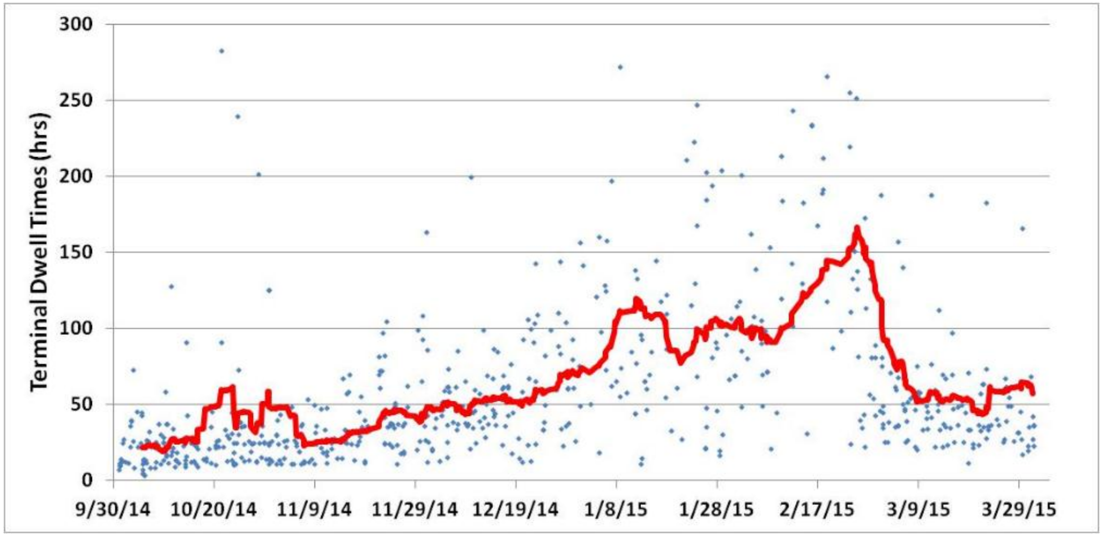
- Travel times within navigation channels
- Dwell times at anchorages
- Port Connectivity/ Systems Analysis
  - Cascading effects from “isolated” project events
  - Identification of critical network components
  - System decision making



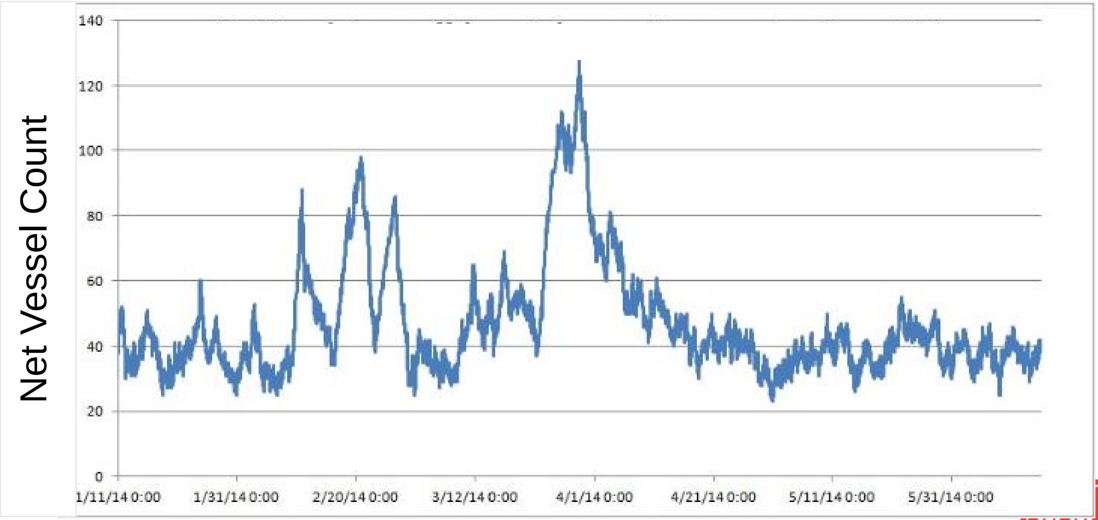


Costal Navigation Resiliency Analysis Examples – Quantifying the Effects of Events

Terminal dwell times during the West Coast slow down



Number of vessels waiting to enter Galveston Bay with queuing caused by fog and a vessel accident



Takeaway

- This is just a fraction of what we've already thought of…