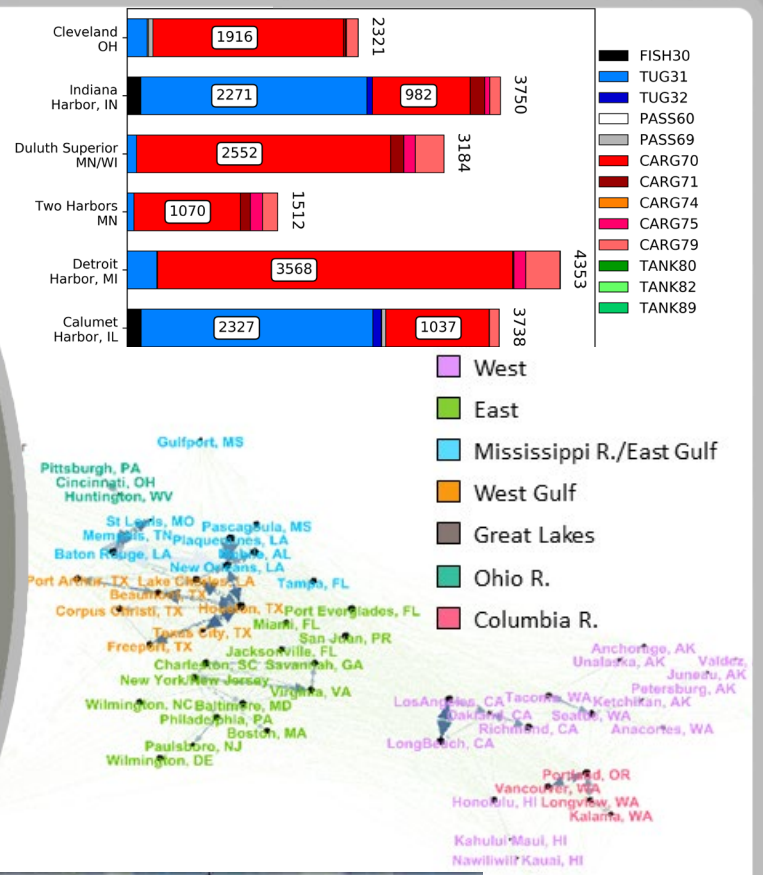
MODERNIZING NAVIGATION INFRASTRUCTURE MANAGEMENT USING AIS DATA: PORT CONNECTIVITY AND UNDERKEEL CLEARANCE IN THE SOUTH ATLANTIC DIVISION



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US Army Corps of Engineers

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U.S. Maritime Transportation

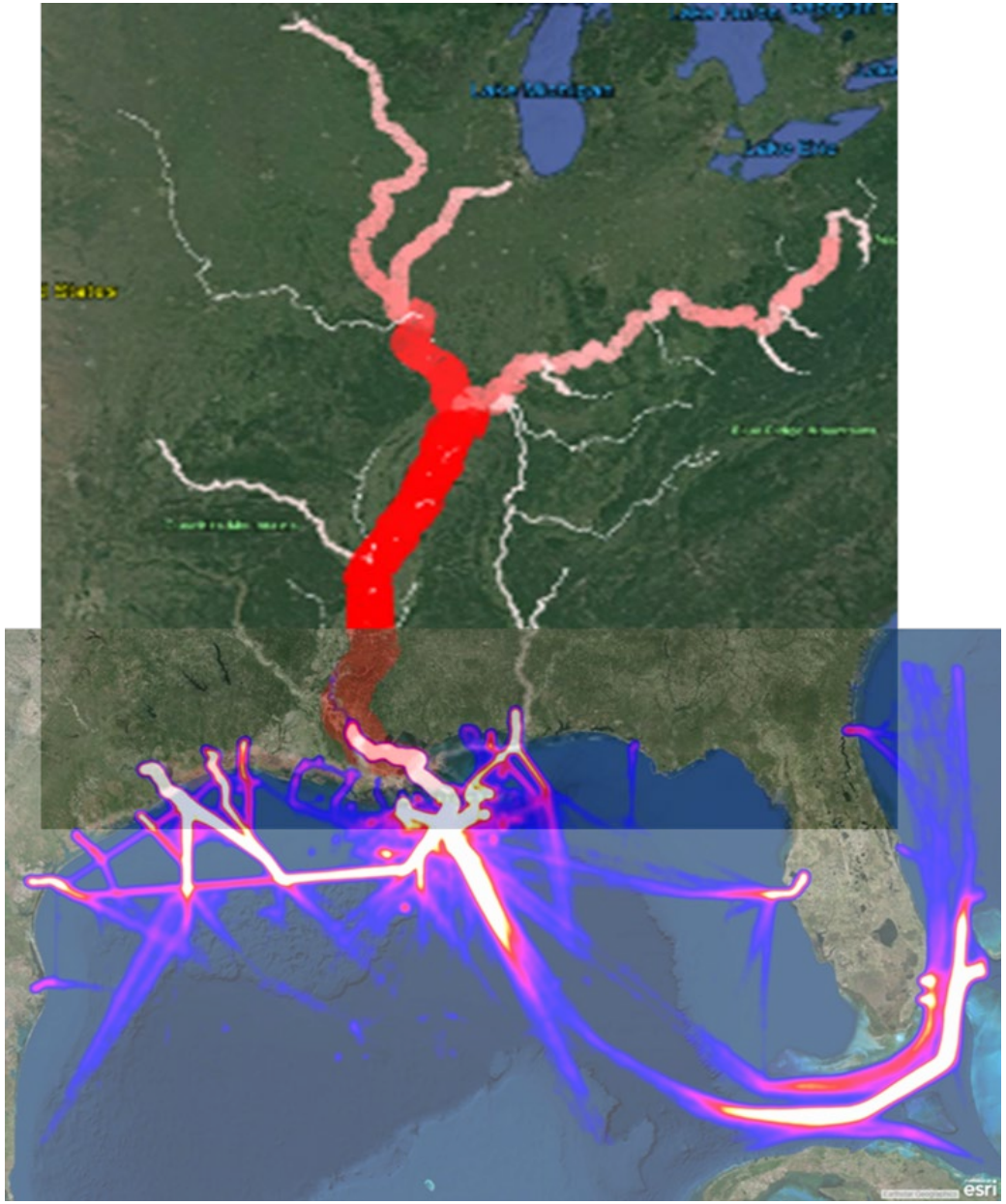
- The U.S. maritime transportation system (MTS) - pillar of the national supply chain (90% of imports/exports).
- $4.6 trillion in economic activity every year.
- Operators/regulators charged with making it more efficient and resilient
- USACE is one of these agencies.
  - Maintain 25,000 mi. of navigable waterways.
  - ~ $1 billion annually on dredging.
- Vulnerable to wide range of disruptions.
  - This has been in the news…
- Demands continue to increase.
  - Ships getting larger.
  - Channels required to be deeper and wider.

Congestion at LA/LB . Image courtesy of westeroverseas.com

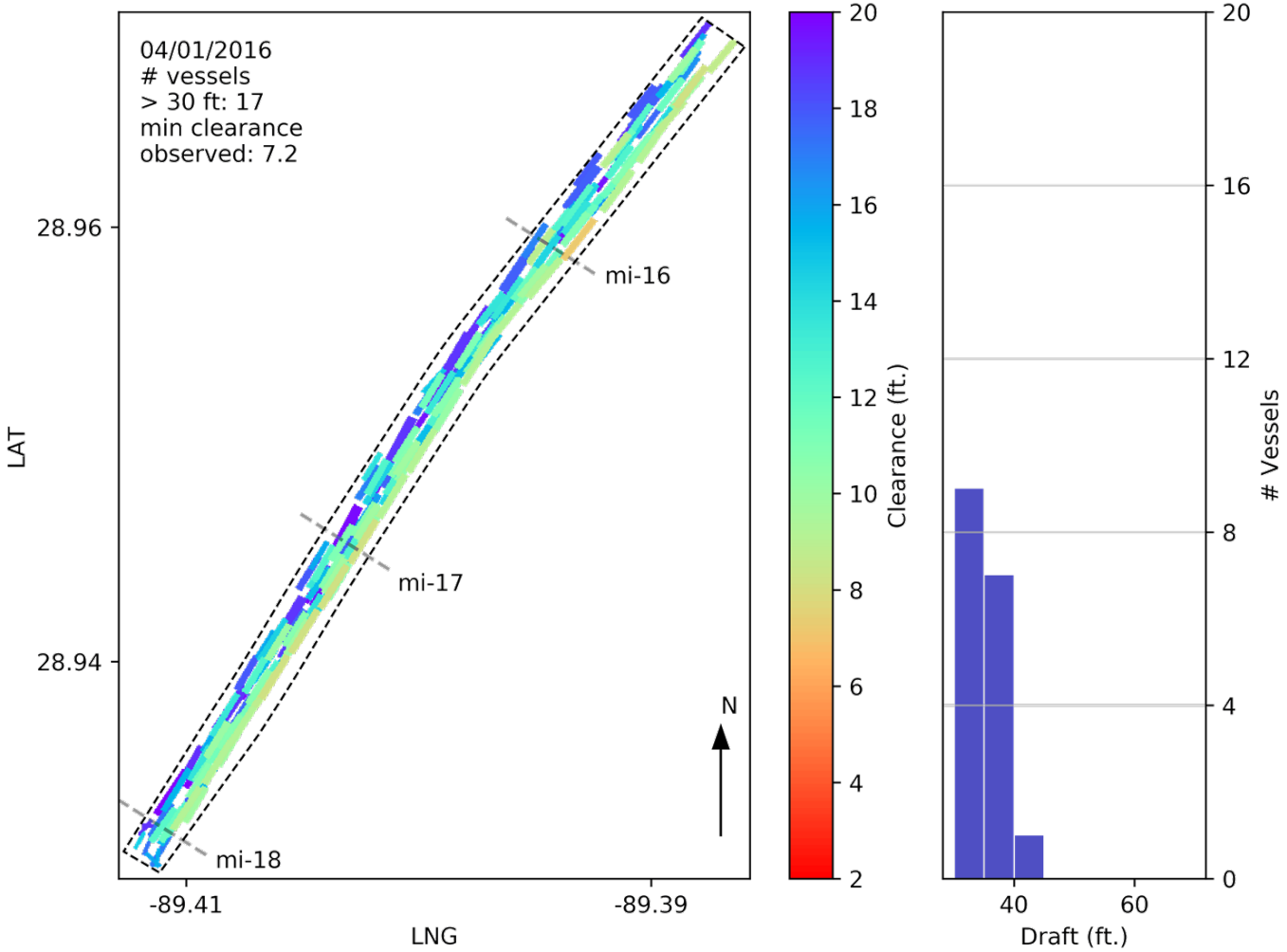
Evergreen's Ever Given blocking Suez Canal. Image courtesy of bbc.com.

The Problem of Money

- Can’t maintain all channels to authorized depth at current funding levels.
- Ensure good stewardship of USACE dredging dollars – “most bang for the buck”.
- USACE prioritizes maintenance projects based on total tonnage.
  - Prefers to maintain the original authorized design.
- USACE allocates maintenance funding based on:
  - the criticality of a port – tonnage.
  - channel usage - projected by channel design prior to construction/deepening.
  - Impacted navigation - shoaling frequency.
- Historical approach used best information available at the time.
- More tools available now.



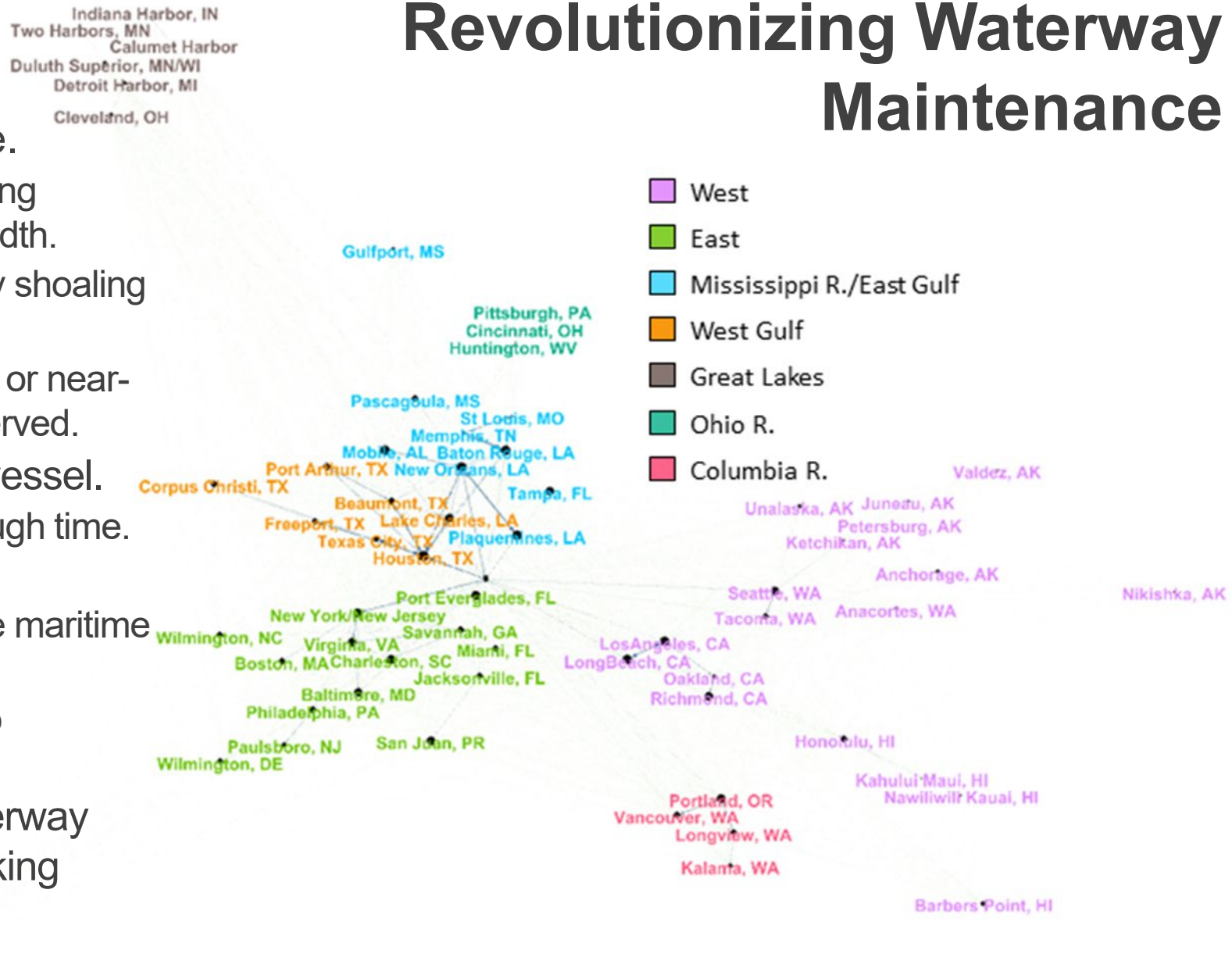
The New Stuff

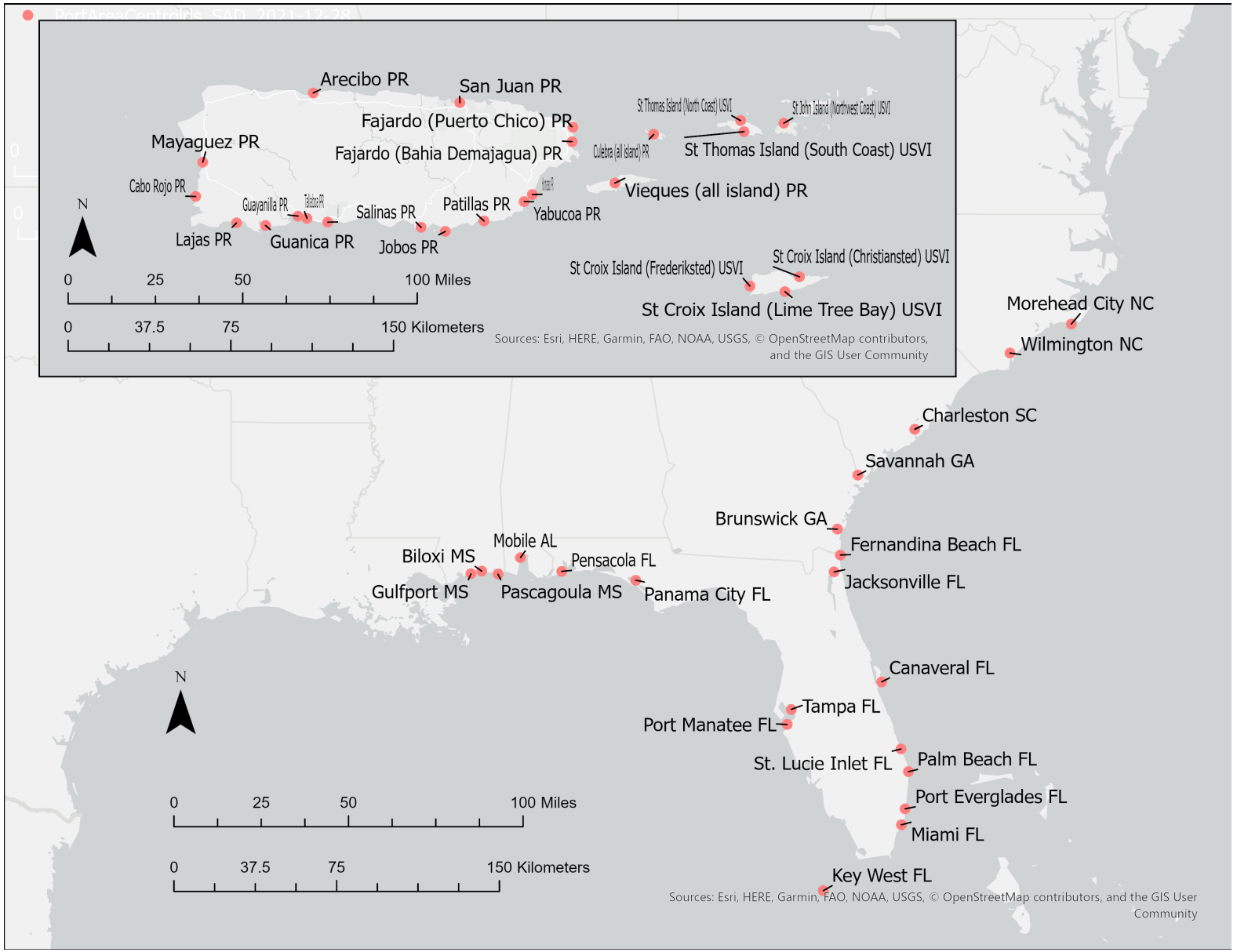


- Marine vessel Automatic Identification System (AIS).
  - Spatio-temporal record of commercial vessels.
  - Useful for variety of waterway maintenance issues.
- Bathymetry - eHydro survey data.
- WL data - NOAA tide stations.
- Vessel draft – Foreign Vessel Entrances & Clearances (IWR 2018).
- For entire U.S. we know:
  - Who, what, when, where for ships.
  - Available depth.
  - How deep ships are drafting.

Revolutionizing Waterway Maintenance

- Calculate the underkeel clearance.
  - Directly measures how ships are using USACE services – channel depth/width.
  - Where are vessels not obstructed by shoaling due to vessel draft or shoal location.
  - Where minimal underkeel clearance or near-miss keel strikes are frequently observed.
- Map of the shipping route of every vessel.
  - Volume of traffic by vessel type through time.
  - Connectivity between all U.S. Ports.
  - Resilience of the regional/nationwide maritime traffic system.
  - Which waterways are most critical to supporting economy.
- How <u>important</u> is it to keep this waterway open and <u>how much</u> are vessels taking advantage of our dredging.





South Atlantic Division Study P1

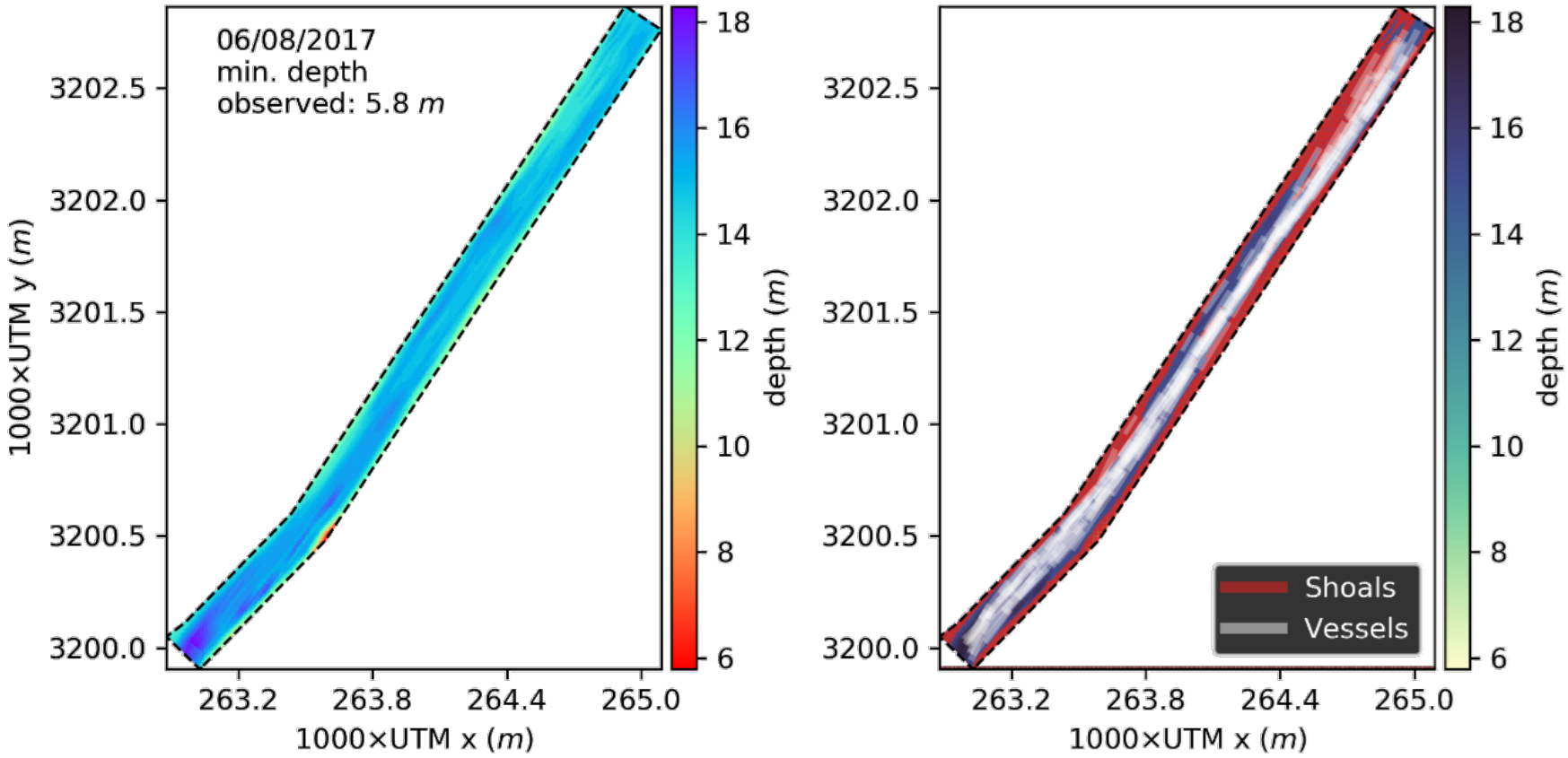
Port Connectivity:

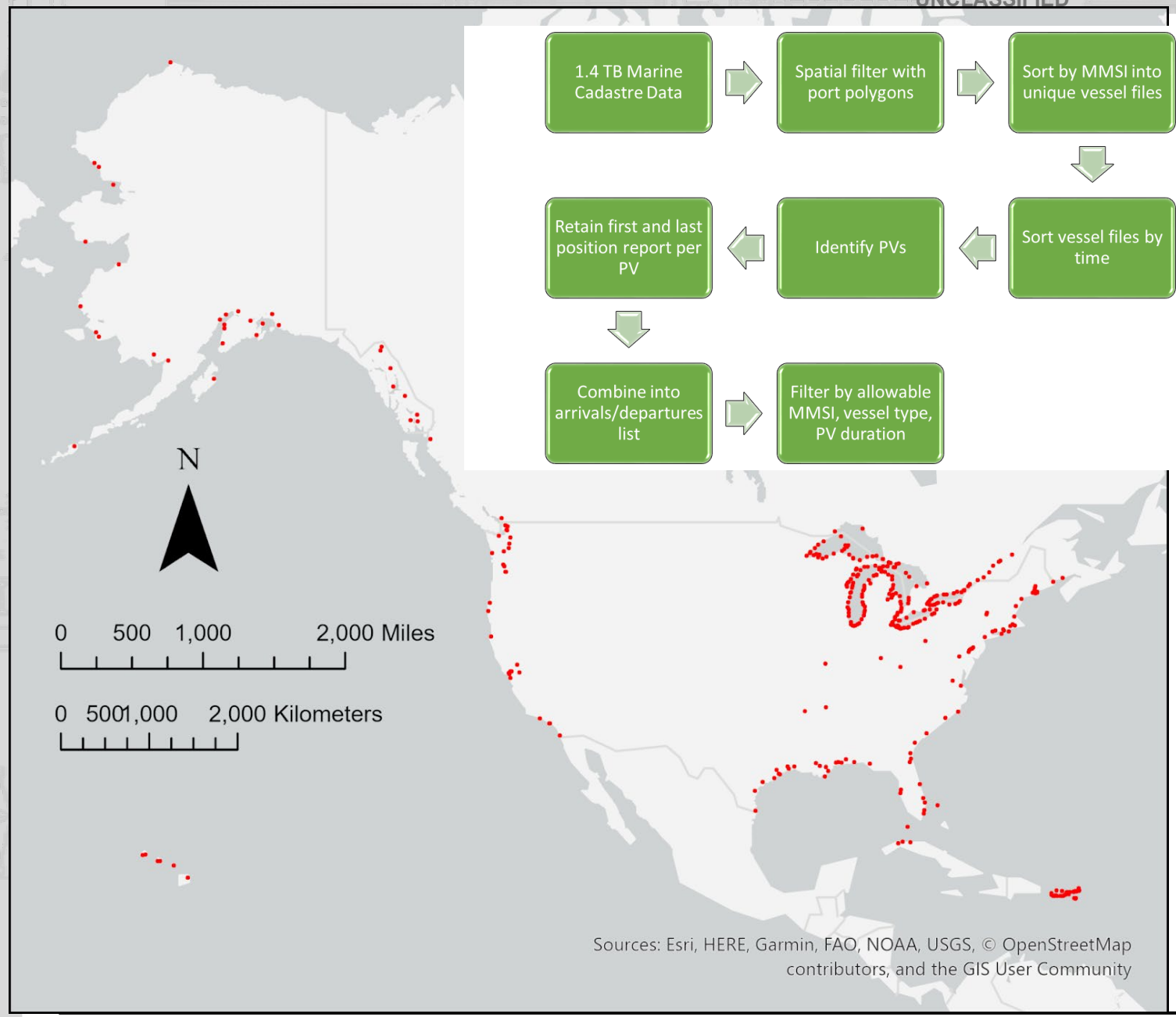
- Making improvements to AIS-derived port network description.
- Compare criticality of SAD ports estimated by tonnage and PageRank.
- Determine if AIS-derived vessel volume is proxy for tonnage.

South Atlantic Division Study P2

Underkeel Clearance:

- Compute underkeel clearance for channel reaches for ports of:
  - Mobile, AL
  - Savannah, GA
  - Tampa Bay, FL
  - Pascagoula, MS
  - Charleston, SC
  - Port Everglades, FL
  - Jacksonville, FL
  - San Juan, PR
  - Miami, FL
  - Wilmington, NC
  - Brunswick, GA
  - Palm Beach, FL
  - Canaveral, FL





Port Network

- Resilience for DHS
- First version:
  - 2015-2018
  - 62 U.S. Ports
- Updated:
  - 2009-2020
  - 385 North American Ports
  - International Transits
  - Weigh by vessel volume
- PageRank vs. Tonnage vs. Volume
- Is volume reasonable proxy for tonnage?

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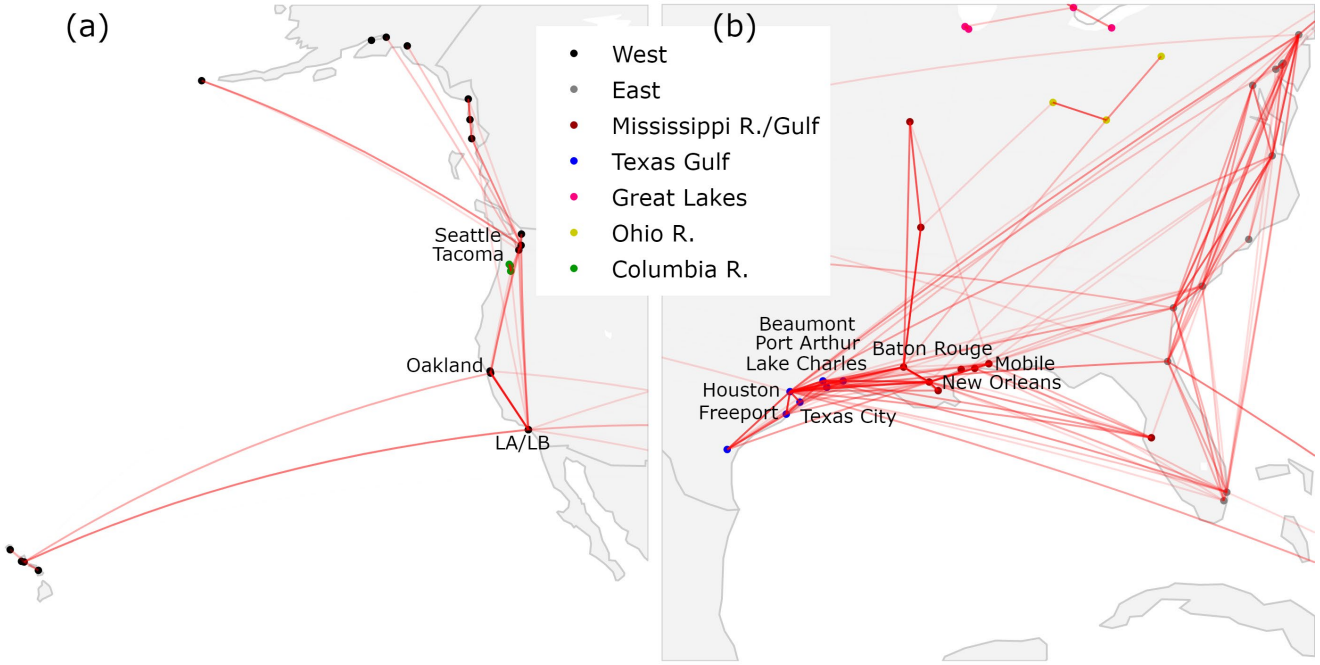
ook like?

Port	# Arrivals (Rank)	PageRank Score $\times 10^{-2}$ (Rank)	Community
Houston, TX	40,405 (**1**)	6.40 (**1**)	West Gulf
New Orleans, LA	36,382 (**2**)	5.77 (**2**)	Mississippi R./East Gulf
Baton Rouge, LA	28,670 (**3**)	4.50 (**3**)	Mississippi R./East Gulf
Beaumont, TX	16,607 (**4**)	2.68 (**8**)	West Gulf
Lake Charles, LA	14,123 (**6**)	2.27 (**12**)	West Gulf
Los Angeles, CA	11,829 (**7**)	3.16 (**5**)	West
Long Beach, CA	11,211 (**9**)	2.99 (**7**)	West
Port Arthur, TX	11,026 (**10**)	1.81 (**18**)	West Gulf
Texas City, TX	9,212 (**14**)	1.58 (**26**)	West Gulf
Oakland, CA	8,986 (**15**)	2.61 (**10**)	West
Freeport, TX	8,498 (**17**)	1.48 (**32**)	West Gulf
Mobile, AL	7,663 (**18**)	1.47 (**33**)	Mississippi R./East Gulf
Seattle, WA	7,416 (**19**)	3.24 (**4**)	West
Tacoma, WA	5,770 (**27**)	2.35 (**11**)	West

What is PageRank?

- Measurement of network centrality.
- Web search optimization – Page et al. 1999.
- Quantify port “importance” to network traffic flow.
- Arrivals to Volumes.



- PageRank vs. traffic discrepancy.
  - Port Rank Tonnage vs. Volume vs. PageRank
  - Why?

Port	PageRank Score $\times 10^{-2}$ (Rank)	Tonnage Million Short Tons (Rank)
Duluth Superior, MN/WI	3.5 (1)	167 (21)
New York/New Jersey	2.6 (**2**)	673 (**3**)
Houston, TX	2.6 (**3**)	1,302 (**2**)
Detroit Harbor, MI	2.2 (4)	69 (42)
Port of South Louisiana	1.9 (**5**)	1,309 (**1**)
Burns Harbor, IN	1.6 (6)	44 (55)
New Orleans, LA	1.6 (**7**)	460 (**5**)
Virginia, VA	1.5 (**8**)	313 (**10**)
Long Beach, CA	1.5 (**9**)	409 (**7**)
Savannah, GA	1.5 (10)	195 (17)
Oakland, CA	1.4 (11)	95 (34)
Los Angeles, CA	1.3 (**12**)	319 (**9**)

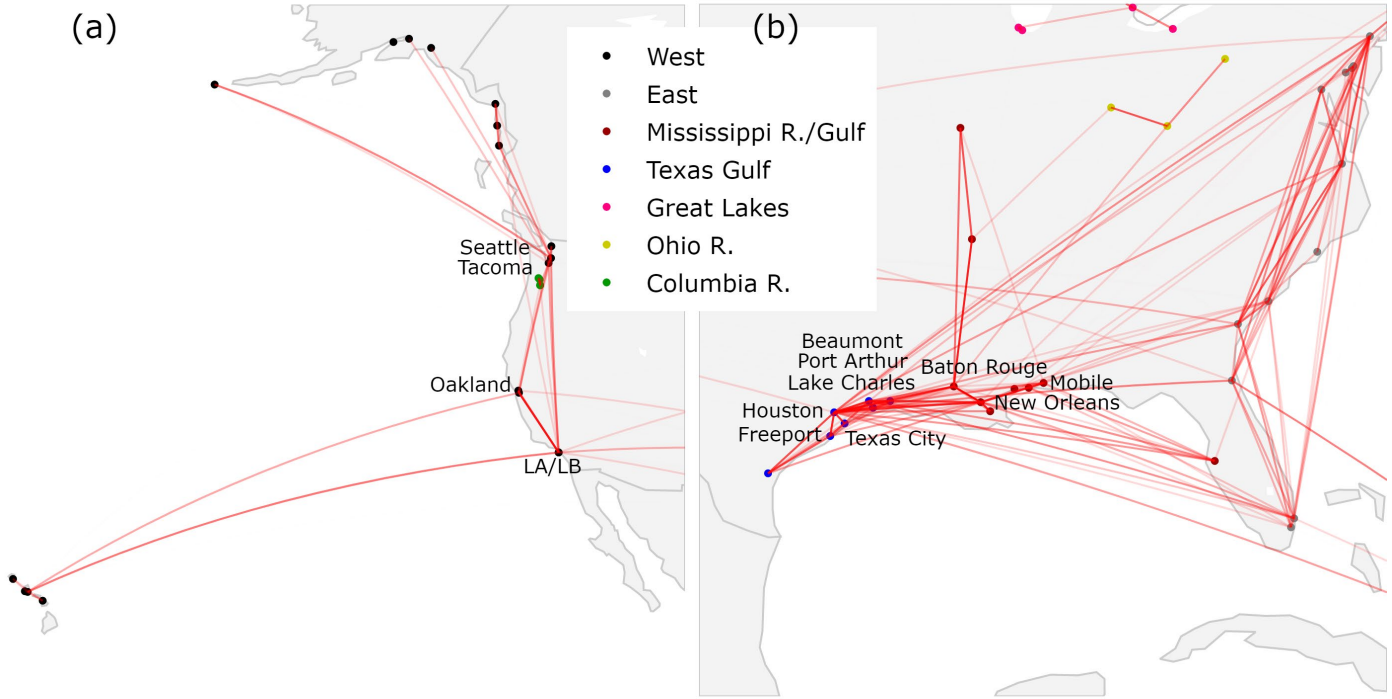
PageRank Lessons

- Two Harbors, MN is number 13…
- Something weird going on w/ Great Lakes.
- Marin was using data for Great Lakes, Caribbean Study.
- 202 ports are Great Lakes.
- Minimum node value if ANY amount of traffic.

PageRank v. Tonnage

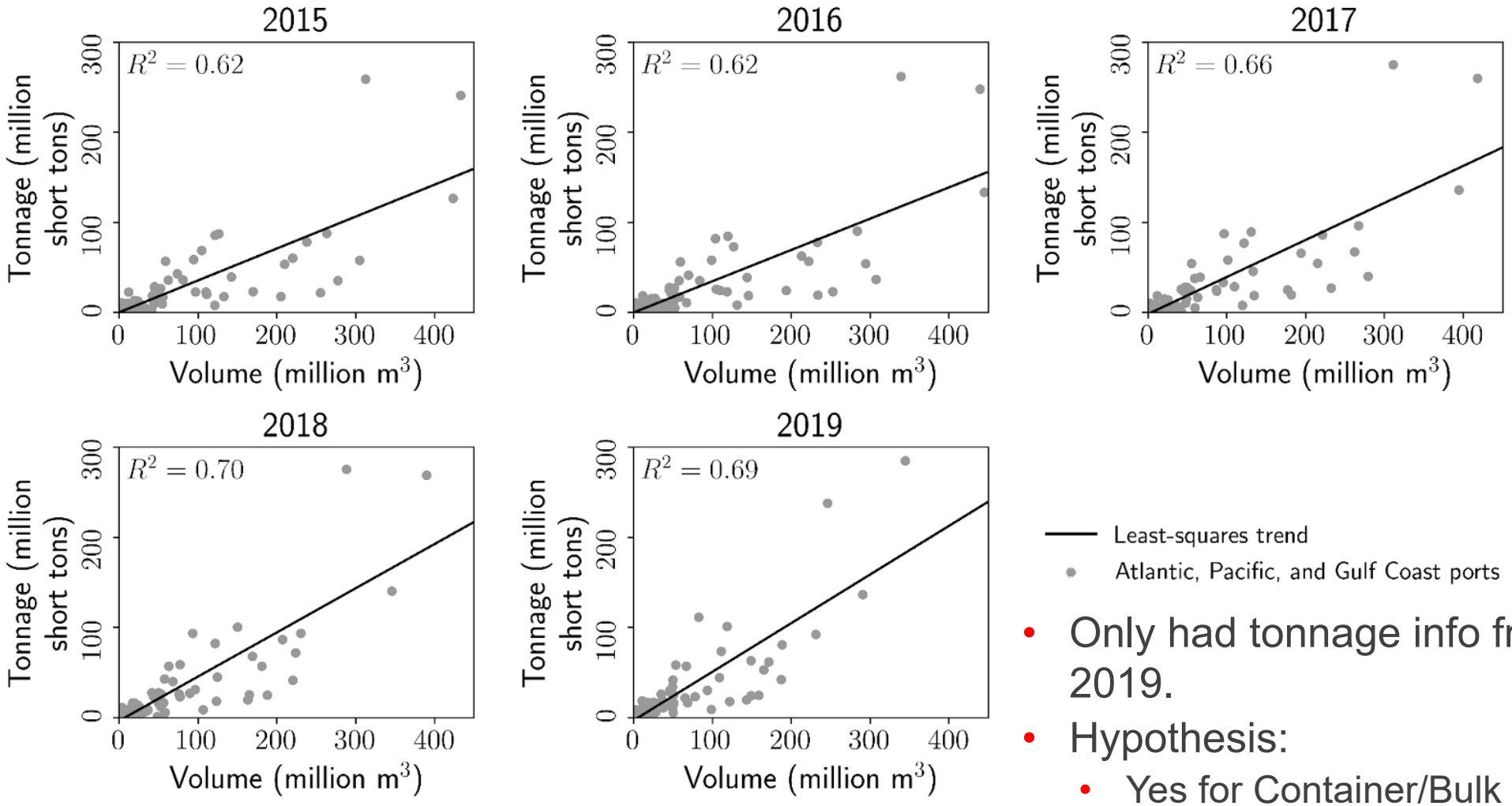
Port	PageRank Score $\times 10^{-2}$ (Rank)	Tonnage Million Short Tons (Rank)
Houston, TX	3.0 (**1**)	1,302 (**2**)
New York/New Jersey	2.7 (**2**)	673 (**3**)
Port of South Louisiana	2.2 (**3**)	1,309 (**1**)
Duluth Superior MN/WI	2.2 (**4**)	167 (**21**)
New Orleans, LA	1.8 (**5**)	460 (**5**)
Long Beach, CA	1.7 (**6**)	409 (**7**)
Savannah, GA	1.7 (**7**)	195 (**17**)
Virginia, VA	1.7 (**8**)	313 (**10**)
Oakland, CA	1.6 (**9**)	95 (**34**)
Los Angeles, CA	1.5 (**10**)	319 (**9**)
Plaquemines, LA	1.5 (**11**)	274 (**13**)
Charleston, SC	1.4 (**12**)	121 (**26**)

- Set minimum port size.



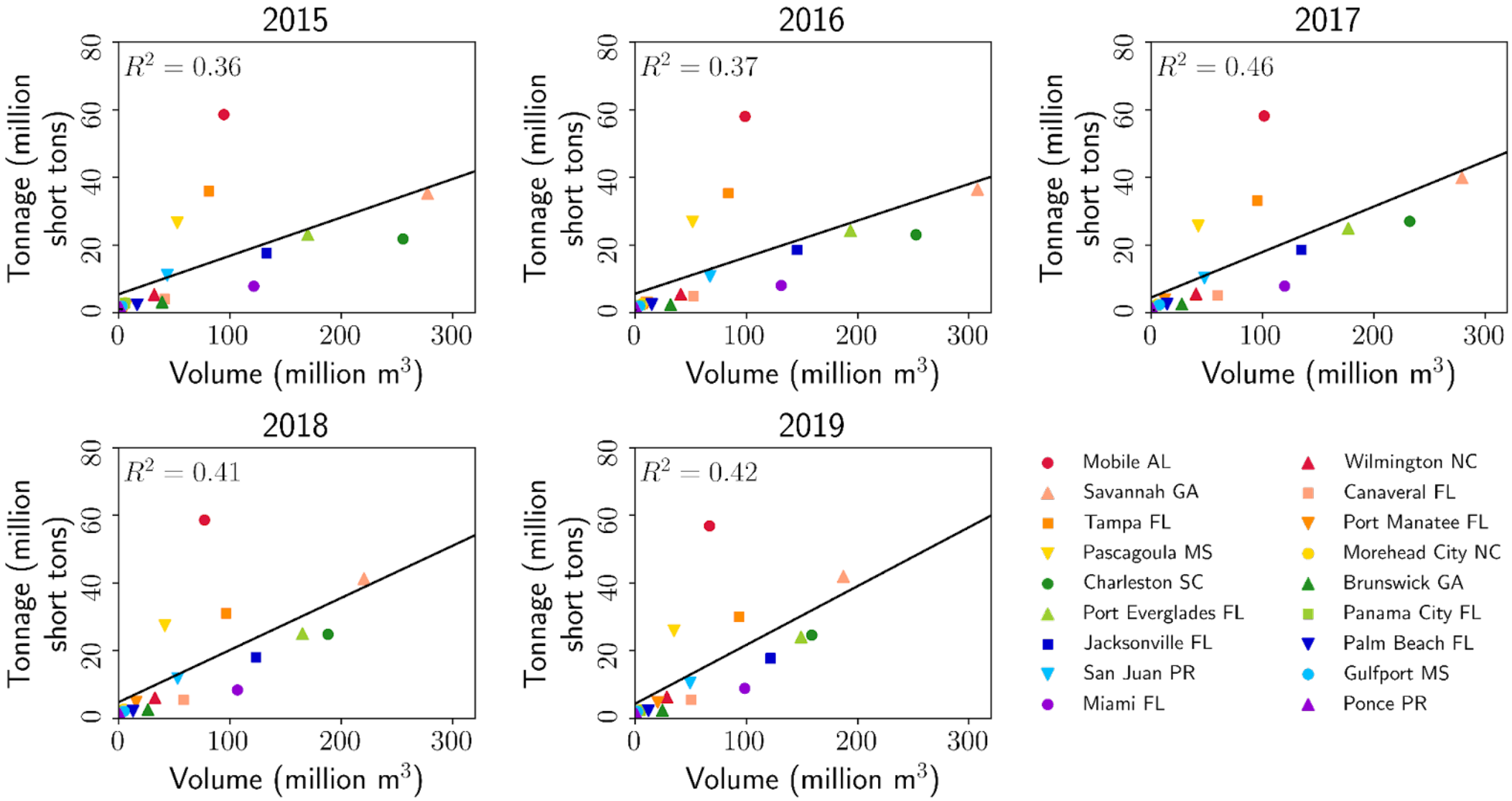
- Why is Duluth Superior still high?
  - Hub for all Great Lakes.
  - Great Lakes are isolated from wider network.
- Effect of including International Transits?

Is Volume a Reasonable Proxy for Tonnage

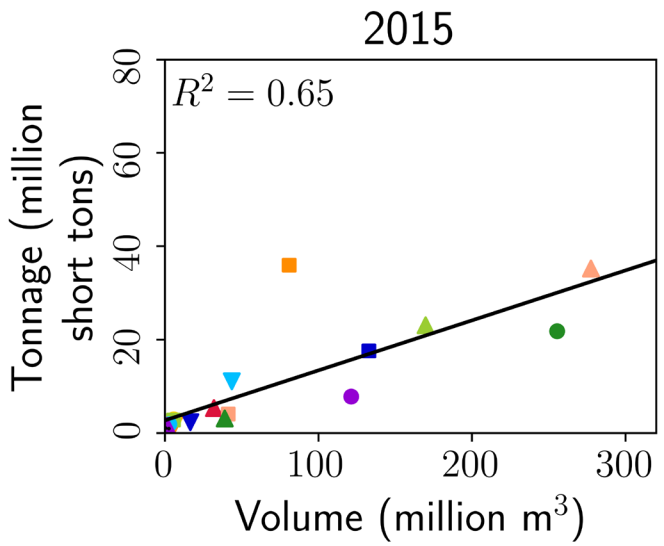


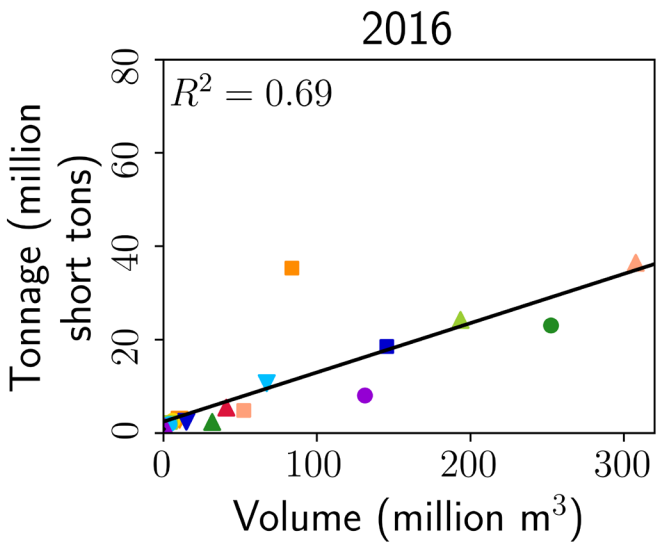
- Only had tonnage info from IWR for 2015 – 2019.
- Hypothesis:
  - Yes for Container/Bulk Carrier/Tanker ports.
  - No for tug traffic ports.

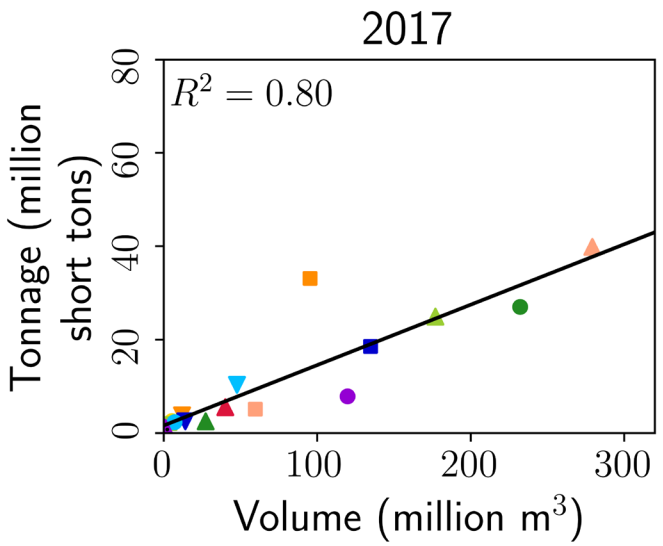
Is Volume a Reasonable Proxy for Tonnage - SAD

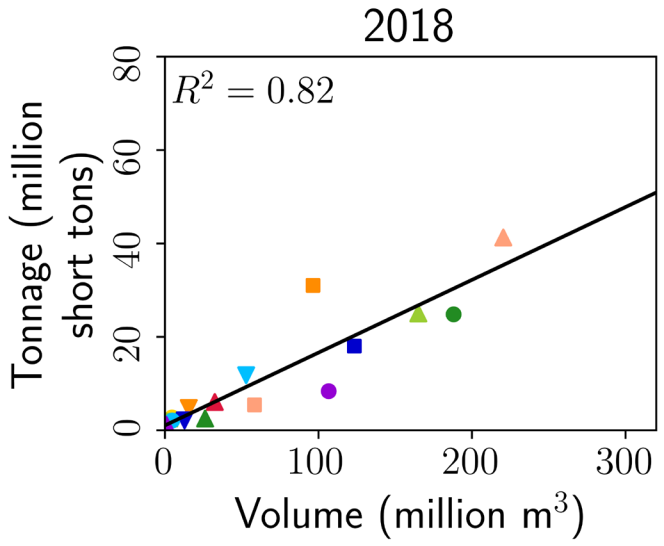


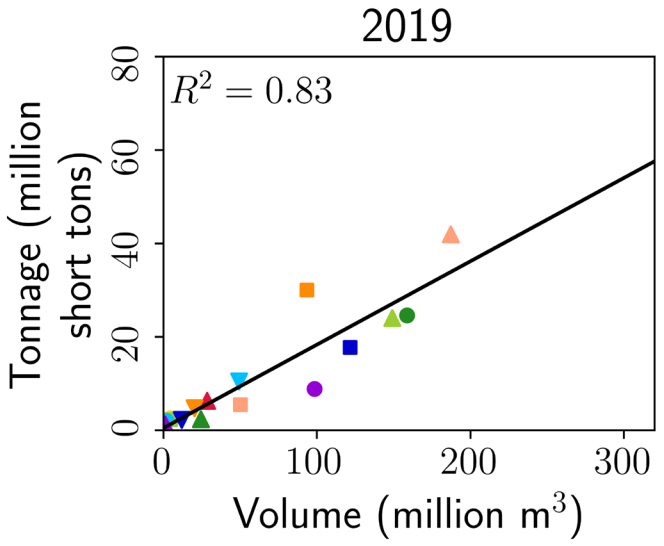
Is Volume a Reasonable Proxy for Tonnage - SAD











- Mobile, AL & Pascagoula, MS…

Other Uses for Port Connectivity

- PageRank can identify hubs:
  - Most helpful for waterway maintenance.
  - Support not supplant tonnage.
  - LA/LB issues show that can't just use another port.
- Volume as proxy:
  - Useful within certain limitations.
- Other uses for Connectivity Data:
  - Regional traffic studies.
  - Look at vessel traffic in wake of disruption at high resolution – e.g. hurricanes.
  - Determine which ports can possibly take disrupted cargo.
  - Estimate available capacity at ports.
  - With polygon tweaks we can monitor port traffic; transit time, vessel passing, time at dock, time at anchor.

On to Underkeel Clearance

- Mobile, AL
- Savannah, GA
- Tampa Bay, FL
- Pascagoula, MS
- Charleston, SC
- Port Everglades, FL
- Jacksonville, FL
- San Juan, PR
- Miami, FL
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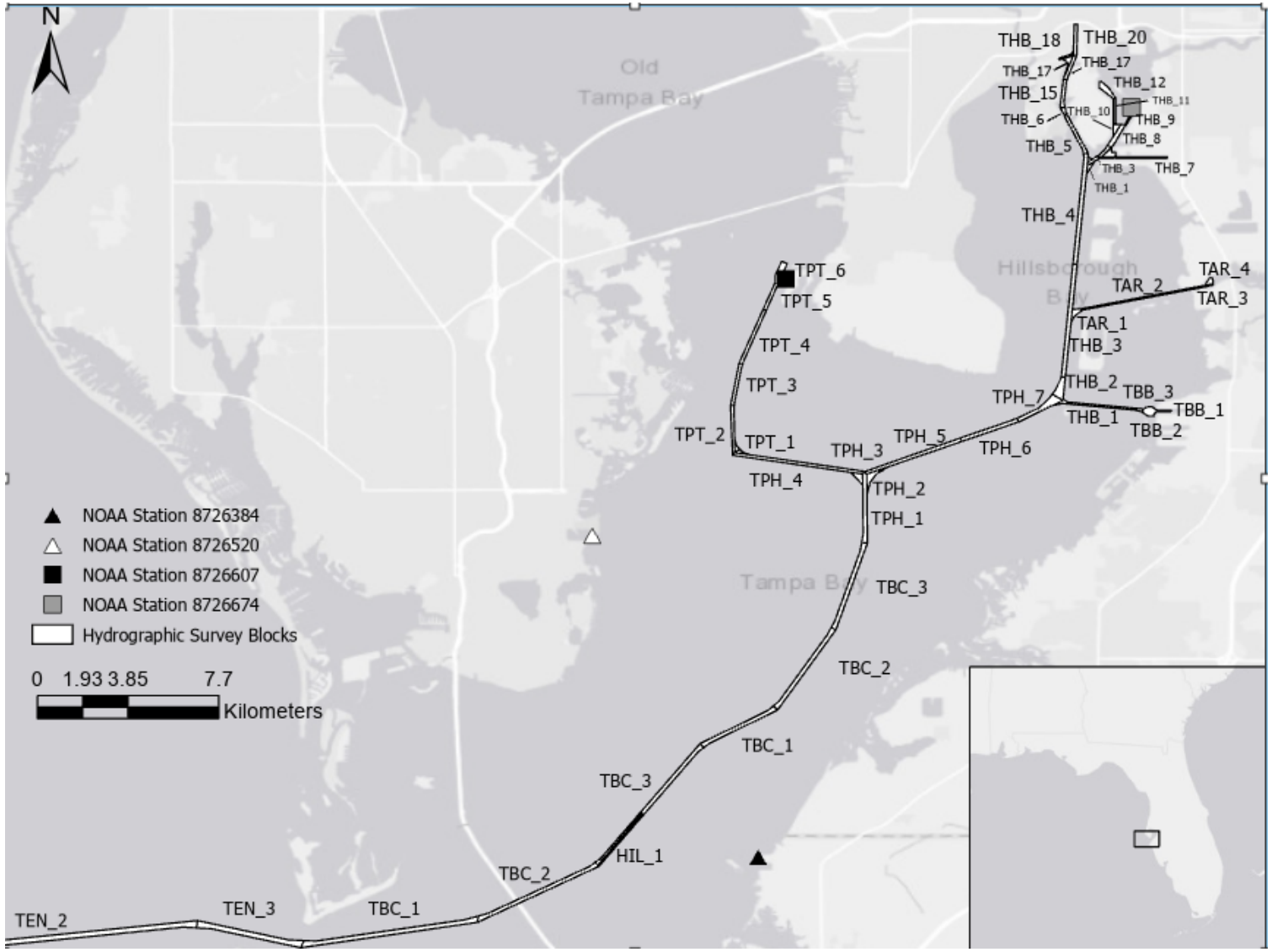
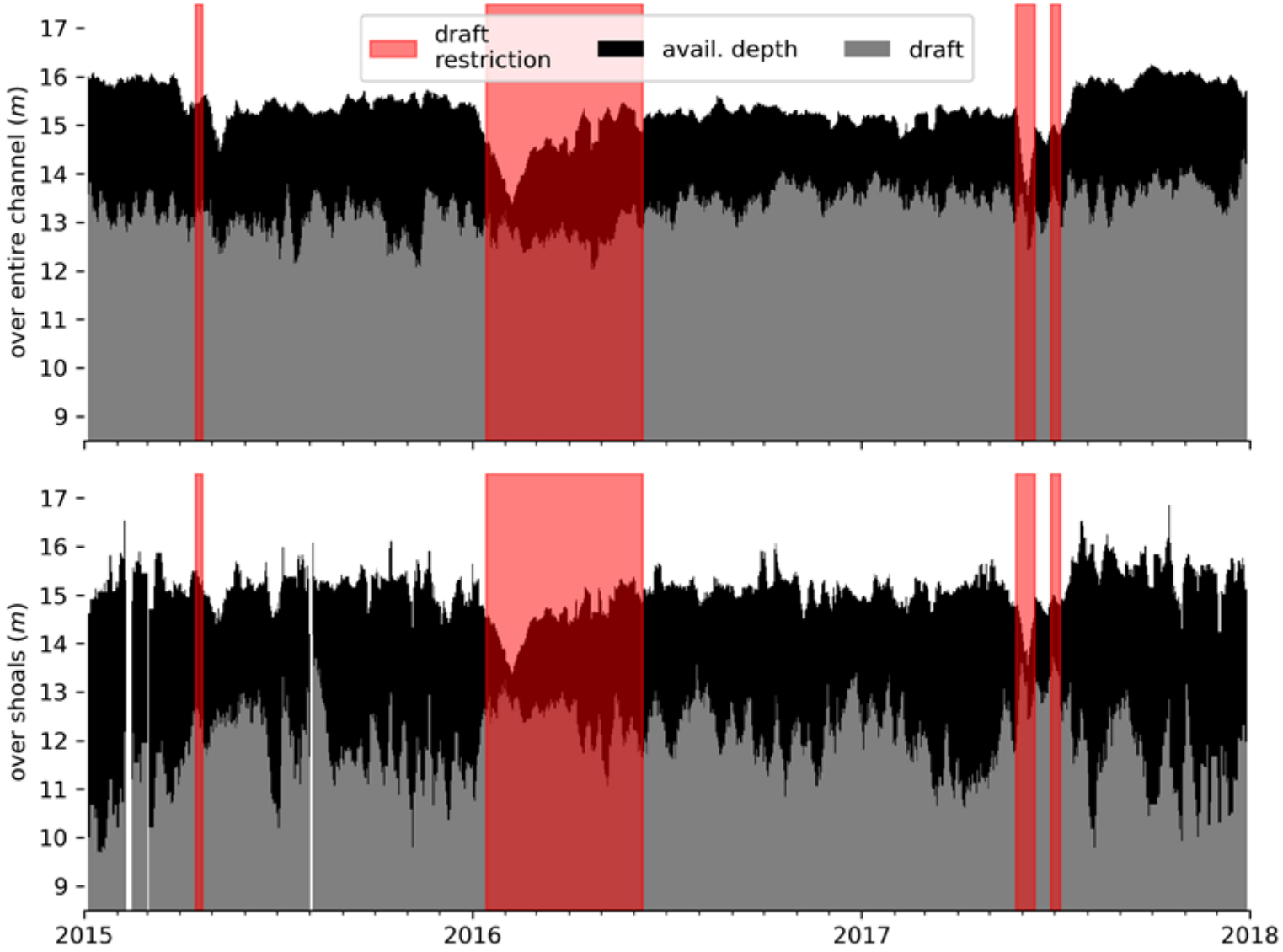


Underkeel as a Metric

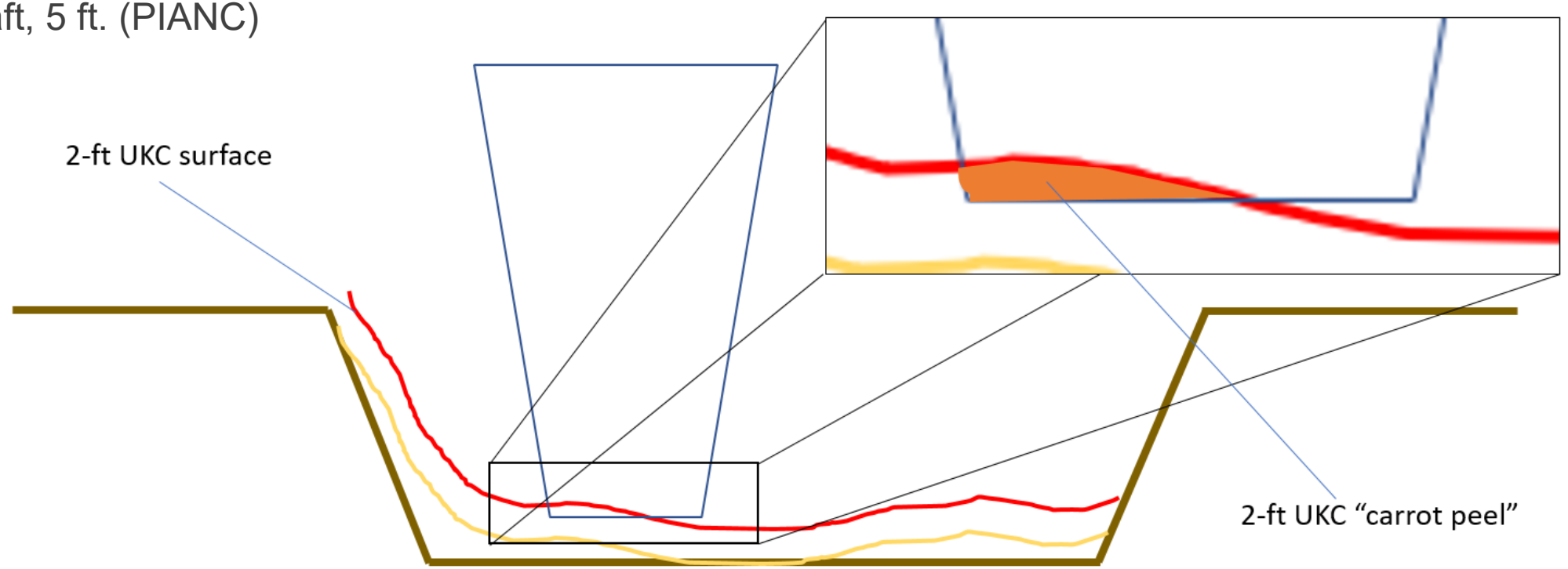
- Minimum underkeel clearance in SW Pass.
- Explains temporal trends within reaches.
- NOT as easy to compare between ports.
- Extreme-value oriented.
- Vulnerable to errors in the data.

Available channel depth in terms minimum observed UKC and draft of vessel incurring minimum UKC over the entire channel (above) and over shoals (below).



"Carrot Slicing"

- Want single number to compare across reaches.
- Inspiration from ship domain violations.
  - Not very many collisions.
  - Compare "close calls".
- "Carrot Slicing" – per Ned.
- Artificially raise the bed up XX ft.
  - Quantify volume of vessel that encroaches.
  - 2 ft., 5% draft, 5 ft. (PIANC)
- Need to:
  - Interpolate between reports.
  - Normalize by long axis.



Questions?