PORTFOLIO SCALE VESSEL ANALYSIS
COASTAL NAVIGATION PROJECT MANAGEMENT

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BLUF

Identify methods to measure interactions between vessel traffic and infrastructure using archival AIS data to better inform and align management of coastal navigation projects with levels of use at *portfolio scale*.
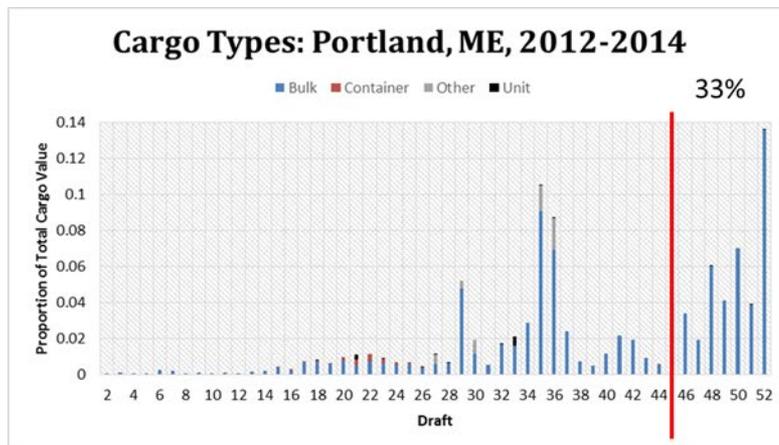
USACE measures but doesn't control.
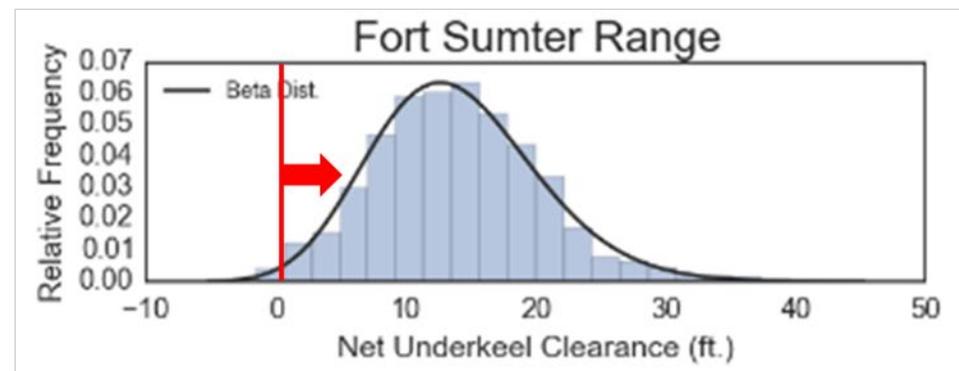


USACE controls but doesn't measure.

Research Drivers & Goals

- **USACE navigation project metrics are insufficient to drive gains in performance of the coastal navigation system.**
  - *Cargo throughput* **is beyond USACE control.**
  - **Channel** *controlling depth* **is under-informative.**
- **Infrastructure maintenance is assumed but rarely demonstrated to improve vessel performance.**
  - **USACE lacks the ability to measure vessel performance directly.**
  - **Evidence that investments benefit users is lacking.**
- **GOALS:**
  - **Augment subjective, qualitative navigation structure performance metric (OCA), and proxy project maintenance prioritization metrics (tonnage, value).**
  - **Cast structure performance in terms of vessel activity for navigation structures.**
  - **Formulate management metrics at "portfolio scale".**

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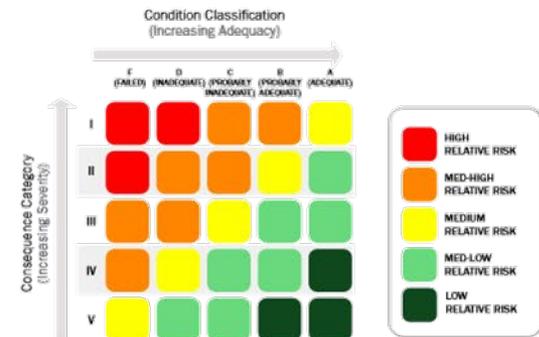
Given 10M vessel transits, what can be said about traffic near 1k coastal structures?

■ **Measurable ∩ Meaningful**
- **Number and types of vessels**
- **Number of transits per vessel & type**
- **Timing of transits, seasonality**
- **Proximity to structure**
- *Use trends*
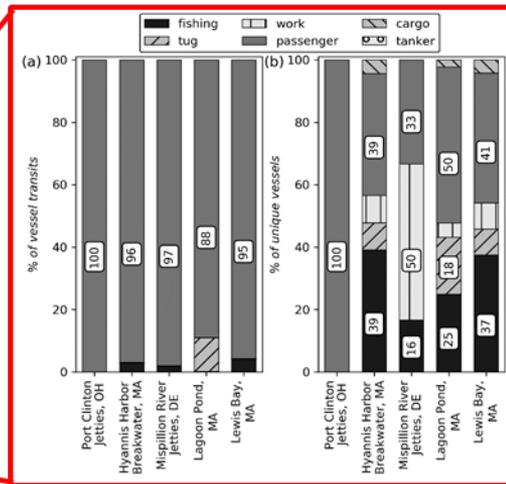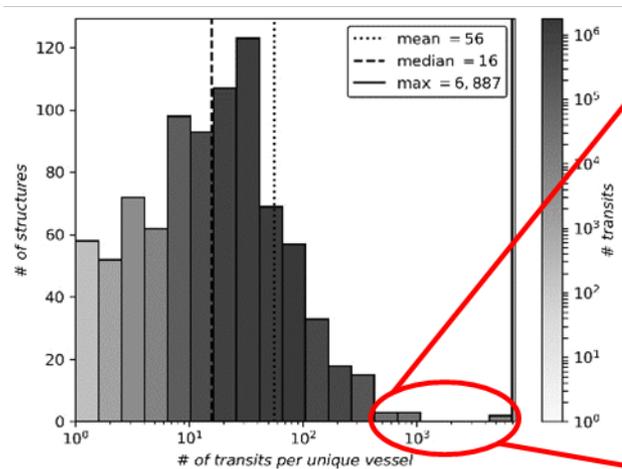
Grays Harbor N. Jetty
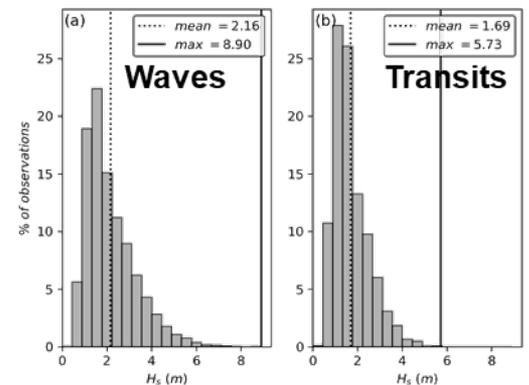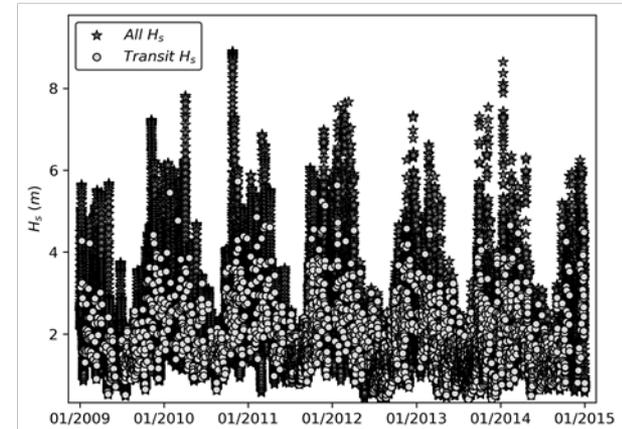
Who uses it and how much?

Under what conditions?

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How do we find interesting structures?

- **Information Entropy**
  - **Entropy = $\sum [P(k) * ln(P(k))]$**
  - **Maximum entropy: Even distribution across categories**
 - **Minimum entropy: Distribution focused in fewer categories**
- **Average trip per user = Total/Unique**
  - **Indicates frequent trips relative to the user base**

Port Everglades Harbor North Jetty, Florida
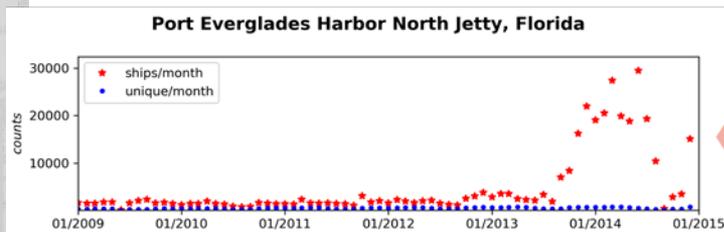
Yearly Entropy = 1.328 Total/Unique = 47.5
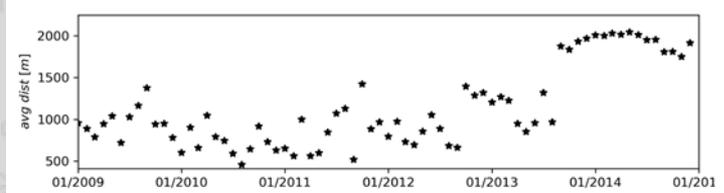
Total/Unique = 16366/28 = 584.5

Mispillion River North Jetty, Delaware
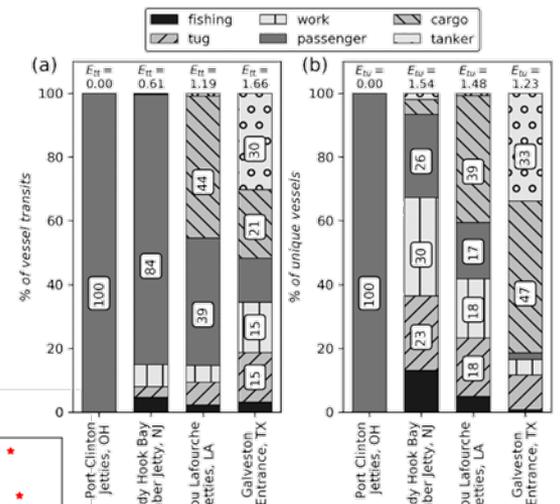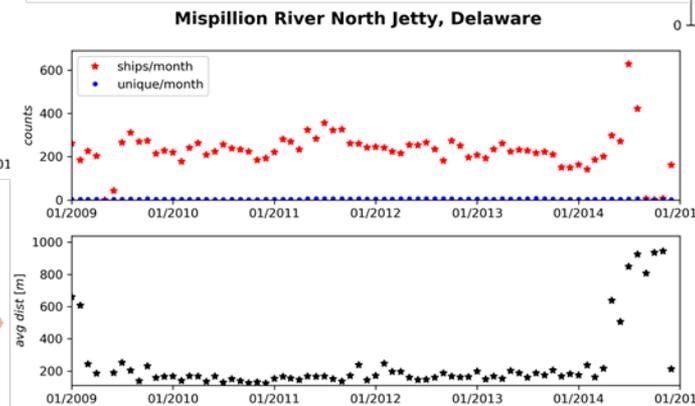
Vessel Clearance Analysis

- **AIS provides enough information to resolve vessel footprint**
  - Augmenting AIS can resolve vessel sail draft
- **eHydro provides bathy elevation**
- **CSAT provides shoaling rate**
- **NOAA gages provide water level**
- **Channel Framework links input**
- **Enables characterization of navigation channels in terms of 3D vessel clearance while navigating, not channel depth.**
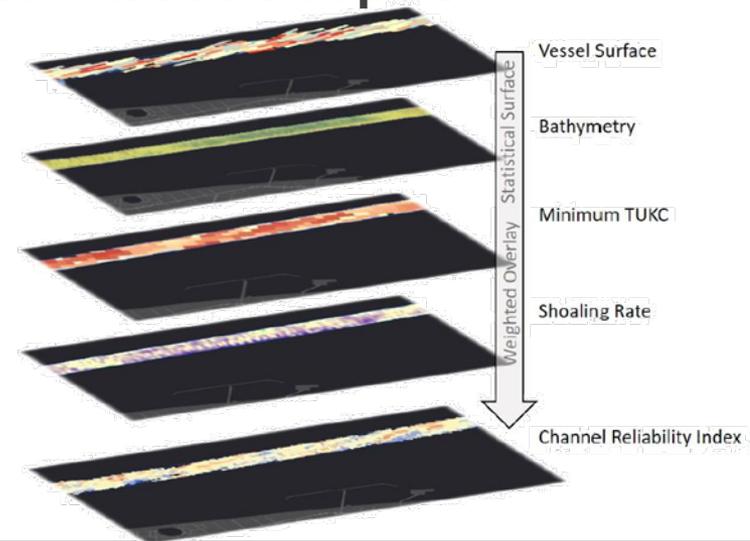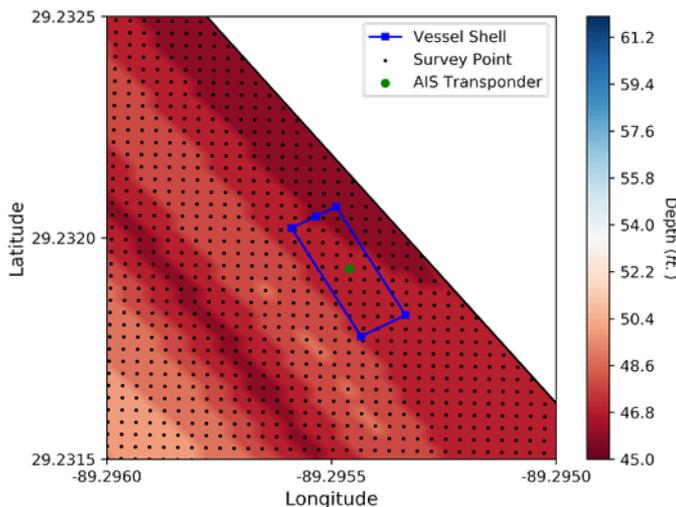
Vessel Clearance Analysis

MC AIS Positions
Data Validation:(MMSI, Time, Lat, Lng).
Time Conversion
UTM zone tagging.
Data collation to SQL db.

AIS Spatial Filtering
Assign AIS positions to CF reach
Retain matched data as SQL .db

Channel Framework
Dissolve Polygons
Buffer polygons by 1k ft.

RIS AIS Particulars
Data Validation:(MMSI, Time, Lat, Lng).

Dimension Vessels
Hash position data into detailed vessel dimensions

WCSC Ent. & Clear.
Data Validation:(MMSI, Time, Lat, Lng).

Build Vessel Shell
Resolve vessel footprint and best estimate of sailing draft

NOAA WL Records
Build list of gages (verified & prediction)
Assign gages to CF reach
Epoch time conversion
Drop repeated data ???

Estimate Water Level @ Transit
Index tide record with CF ID for each AIS data point

Estimate Elevation @ Transit
Index survey record with CF ID
Use KD-Tree to determine nearest survey node to each AIS Position
Interpolate elevation @ transit

eHydro Surveys
Data validation
Assign surveys to CF reaches
Convert to common datum (WGS84)
Data filtering

Compute Clearance Mertics
Underkeel = Water Level – Bathy El. – Eff. Draft
Channel Side = minimum distance between unbuffered CF boundary & Shell

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Align measurement with management

- **Identify metrics relevant to desired objective**
- **Score projects**
- **Partition projects into management groups**
- **Develop management tactics to advance objective**

Level of Functionality	TABLE F-10 Coastal Navigation Structures Functional Condition Rating (FCR) Table
Full -- A	No notable impact, project performing as designed.
Sufficient – B	(1) Infrequent or periodic limitations on navigability, or (2) minor/periodic increases in dredge quantity
Reduced -- C	(1) Less than 10% of the time, design vessels cannot navigate or operate within authorized limits; (2) O&M dredging requirements in the Entrance and Bar Channel have increased less than 10%, as compared to the long-term average annual rate.
Severely Degraded -- D	(1) 10-20% of the time, design vessels cannot navigate or operate within authorized limits; (2) O&M dredging requirements in the Entrance and Bar Channel have increased 10-20%, as compared to the long-term average annual rate.
Completely Degraded -- F	(1)-20-40% of the time, design vessels cannot navigate or operate within authorized limits; (2) O&M dredging requirements in the Entrance and Bar Channel have increased 20-40%, as compared to the long-term average annual rate.

- Fishing vessels, low traffic volume
- Tow and Work vessels, moderate traffic volume
- Passenger vessels, moderate traffic volume
- Seasonal cargo vessels, moderate traffic volume
- Cargo and Tanker vessels, high traffic volume
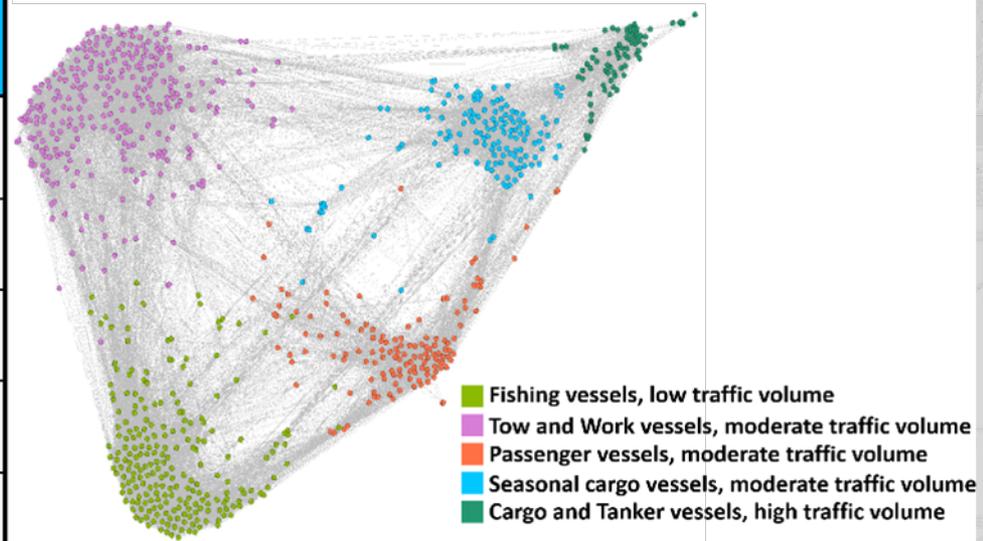
Budget EC Structure Functionality Guidance:
-No way to measure navigability
-Shoaling may be unrelated to structures and does not categorically impede navigation

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Summary

In 2019:

- **Identified vessel performance metrics, used them to describe and group infrastructure for management purposes**
- **Developed a portfolio-scale framework for estimating clearances (underkeel, channel side) of archival vessels in transit data.**
- **TN: Assessing Jetty Effectiveness via Statistical Analysis of AIS Data**
- **JA: Mining Marine Vessel AIS Data to Inform Coastal Structure Management (ASCE Waterways, accepted 7/3)**

Next Steps:

- **Need to refine how vessel clearance measurements can be meaningfully communicated & formulated for management.**
- **Need input from field to further develop structure load/resistance metrics:**
  - **Incident Hs/Design Hs**
  - **Repair/Dredge $ index**
  - **Traffic count-wave loading similarity**

Port Clinton Harbor East Jetty, OH

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