Measuring Port Resilience

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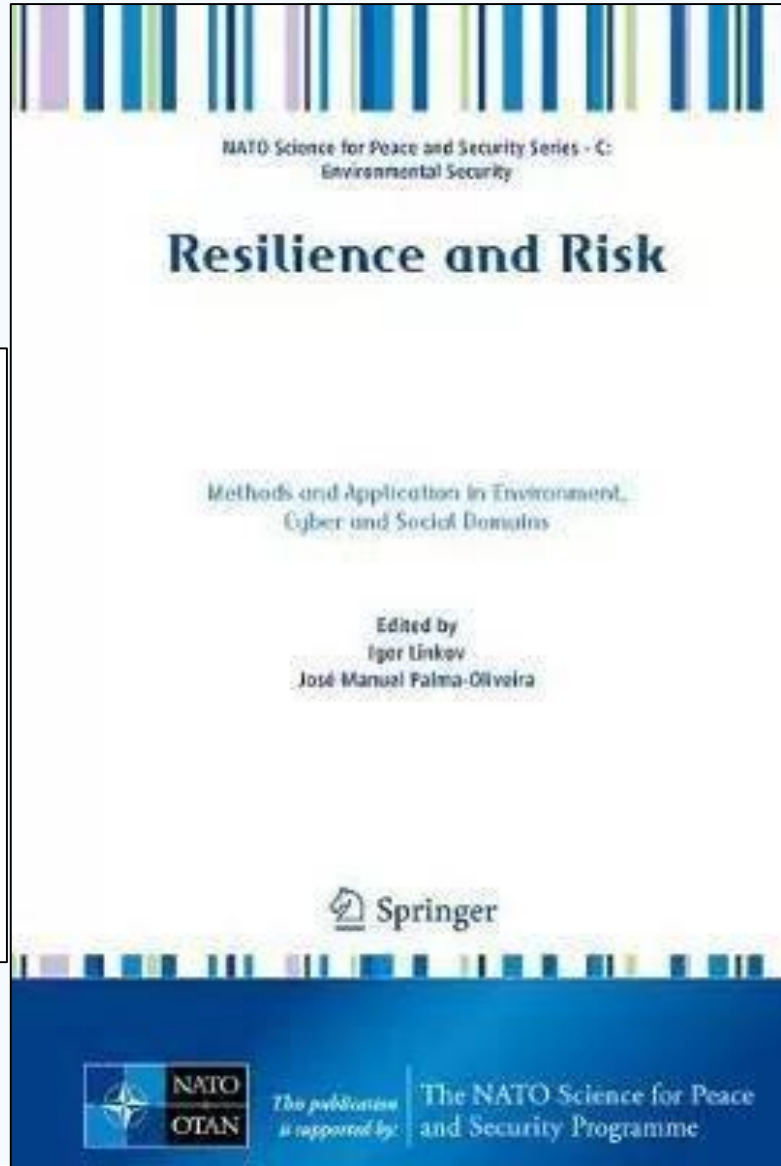
How to Measure Port Resilience?

Seaport Climate Vulnerability Assessment at the Multi-Port Scale: A Review of Approaches

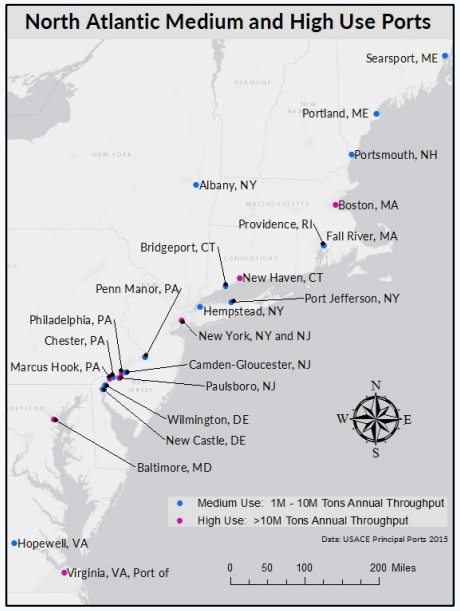
- Most CCVA for ports to date has been limited to the *single-port* scale
- Most *multi-port* assessments stop short of comparative CCVA or focus on other concepts (e.g., performance)
  - **Indicator-based**, data-driven approach allows for intra-port comparisons



McIntosh, R. D., and A. Becker, 2017: Seaport Climate Vulnerability Assessment at the Multi-port Scale: A Review of Approaches. *Resilience and Risk: Methods and Application in Environment, Cyber and Social Domains, I. Linkov, and J. M. Palma-Oliveira, Eds., Springer Netherlands, 205-224.*

Can We Develop Indicators?

Expert Evaluation of Open-Data Indicators of Seaport Vulnerability to Climate and Extreme Weather Impacts for U.S. North Atlantic



Study Area:

22 Ports of the US North Atlantic

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Expert evaluation of open-data indicators of seaport vulnerability to climate and extreme weather impacts for U.S. North Atlantic ports

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ABSTRACT

When comparing vulnerabilities of multiple disparate systems, indicator-based vulnerability assessment (IBVA) methods can yield standardized metrics, allowing for high-level analysis to identify areas or systems of concern. Identification of indicators is often a first step in the development of coastal vulnerability indices (CVI). To advance IBVA for the seaport sector, researchers investigated the sufficiency of and elicited expert-evaluation of publicly available open-data to serve as indicators of climate and extreme-weather vulnerability for 22 major seaports in the North East United States, addressing the question: How sufficient is the current state of data reporting for and about the seaport sector to develop expert-supported vulnerability indicators for a regional sample of ports? Researchers developed a framework for expert-evaluation of candidate indicators that can be replicated to develop indicators in other sectors and for other purposes. Researchers first identified candidate indicators from the climate change vulnerability assessment (CCVA) and seaport-studies literature and vetted them for data-availability for the sample ports. Candidate indicators were then evaluated by experts via a mind-mapping exercise, and finally via a visual analogue scale (VAS) measurement instrument. Researchers developed a VAS instrument to elicit expert perception of the magnitude and direction of correlation between candidate indicators and each of the three dimensions of vulnerability that have become standard in the CCVA literature, e.g., exposure, sensitivity, and adaptive capacity. For candidate indicators selected from currently available open data sources, port-expert respondents found notably stronger correlation with the exposure and sensitivity of a port than with the adaptive capacity. Results suggest that more open reporting and sharing of port-specific data within the maritime transportation sector will be necessary before IBVA will become feasible for seaports.

1. Introduction

1.1. Indicator-based assessments

Indicators are "measurable, observable quantities that serve as proxies for an aspect of a system that cannot itself be directly, adequately measured" (Gallopin, 1997; Hinkel, 2011; McIntosh and Becker, 2017). Indicator-based assessment methods are employed when concepts to be measured are theoretical and not directly quantifiable. While the concepts of resilience and vulnerability are not directly measurable, such concepts may be operationalized by "mapping them to functions of observable variables called indicators" (Gallopin, 1997; Hinkel, 2011; McIntosh and Becker, 2017). When comparing vulnerabilities of multiple disparate systems, indicator-based vulnerability assessment (IBVA) methods can yield standardized metrics, allowing for high-level analysis to identify areas or systems of concern. The comparative assessment of coastal vulnerability often leads to the development of coastal vulnerability indices (CVI), and the identification of indicators is commonly a first step in the development of CVI. Indicators are often combined into multidimensional tools known as indicator-based composite indices that synthesize multiple indicators into a single composite indicator that can represent a relative value of a theoretical concept (Dedeke, 2013; McIntosh and Becker, 2017). Such indicator-based composite indices are meant to yield a high-level overview of the relative values of a concept of interest, e.g., vulnerability, and as such, are more suited to high-level identification of relative outliers than to in-depth analyses of the concept of interest. To advance IBVA for the seaport sector, researchers investigated the sufficiency and elicited expert-evaluation of publicly available open-data, generally collected for other purposes, to serve as indicators of climate

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Refining Candidate Indicators

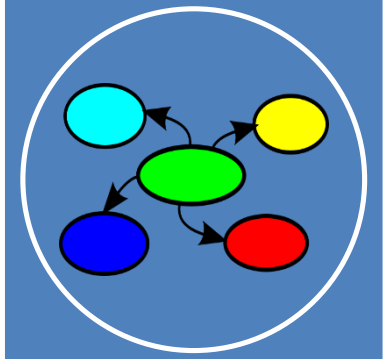
Literature Review

- Start with definition of Vulnerability (IPCC)
- Sought indicators of *exposure*, *sensitivity*, *adaptive capacity* for ports

108 Candidate Indicators

Check Data Availability for Study Area Ports

48 Candidate Indicators



Mind Map Exercise

9 Federal experts from CMTS RIAT evaluated indicators for correlation

34 Candidate Indicators

1. Start with definition of climate-vulnerability
   - Identified 108 candidate indicators from literature
2. Eliminated those without a source of data for at least 16 of the 22 sample ports
3. Mind map exercise:

CMTS
U.S. Committee on the Marine Transportation System

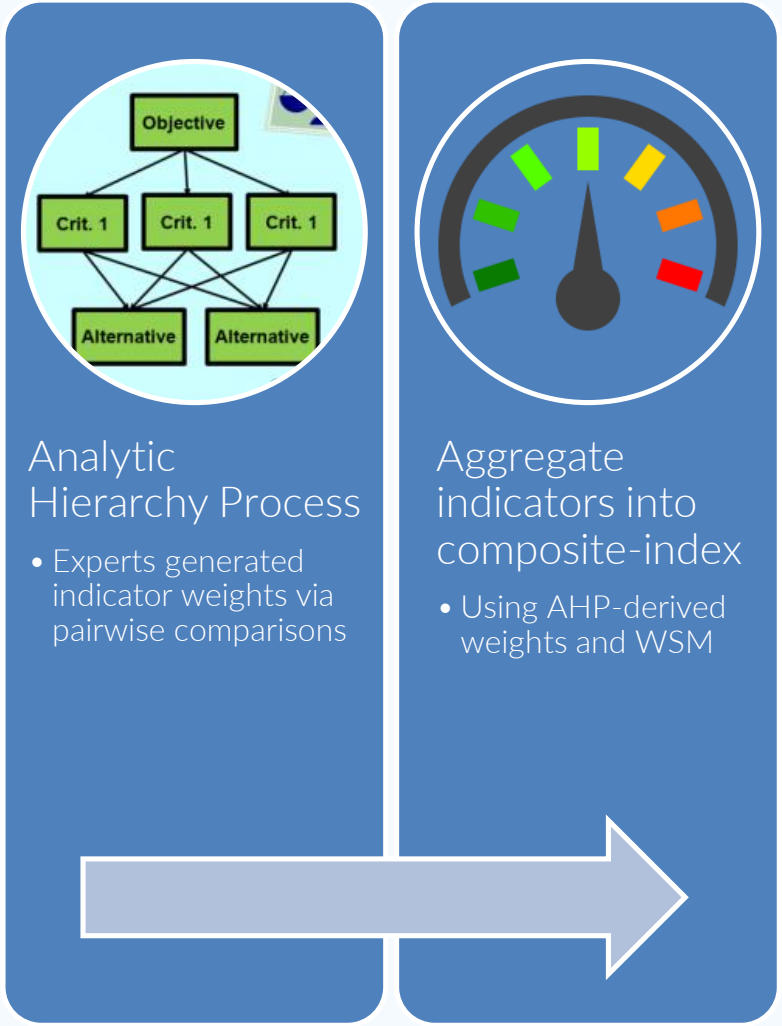
Expert Evaluation of Open-Data Indicators

Key Findings:

- Open-data can be developed into expert-supported indicators of seaport climate ***exposure*** and ***sensitivity***
- Relatively little expert-perceived correlation between open-data and a port's ***adaptive capacity***
- Overall higher levels of expert-perceived correlation for *place-based* indicators than *port-specific* indicators

Photo: Savannah Pilots

Can We Model Port Resilience?



Design:

1. Applied AHP to generate weights for top-rated indicators
2. Aggregated indicators into prototype composite-index using weighted sum model

$$A_i^{WSM-score} = \sum_{j=1}^{n} w_j p_{ij}, for\ i = 1, 2, 3 \ldots, m.$$

Weight of indicator I_j

Vulnerability score of port A_i

Performance of port A_i in terms of indicator I_j

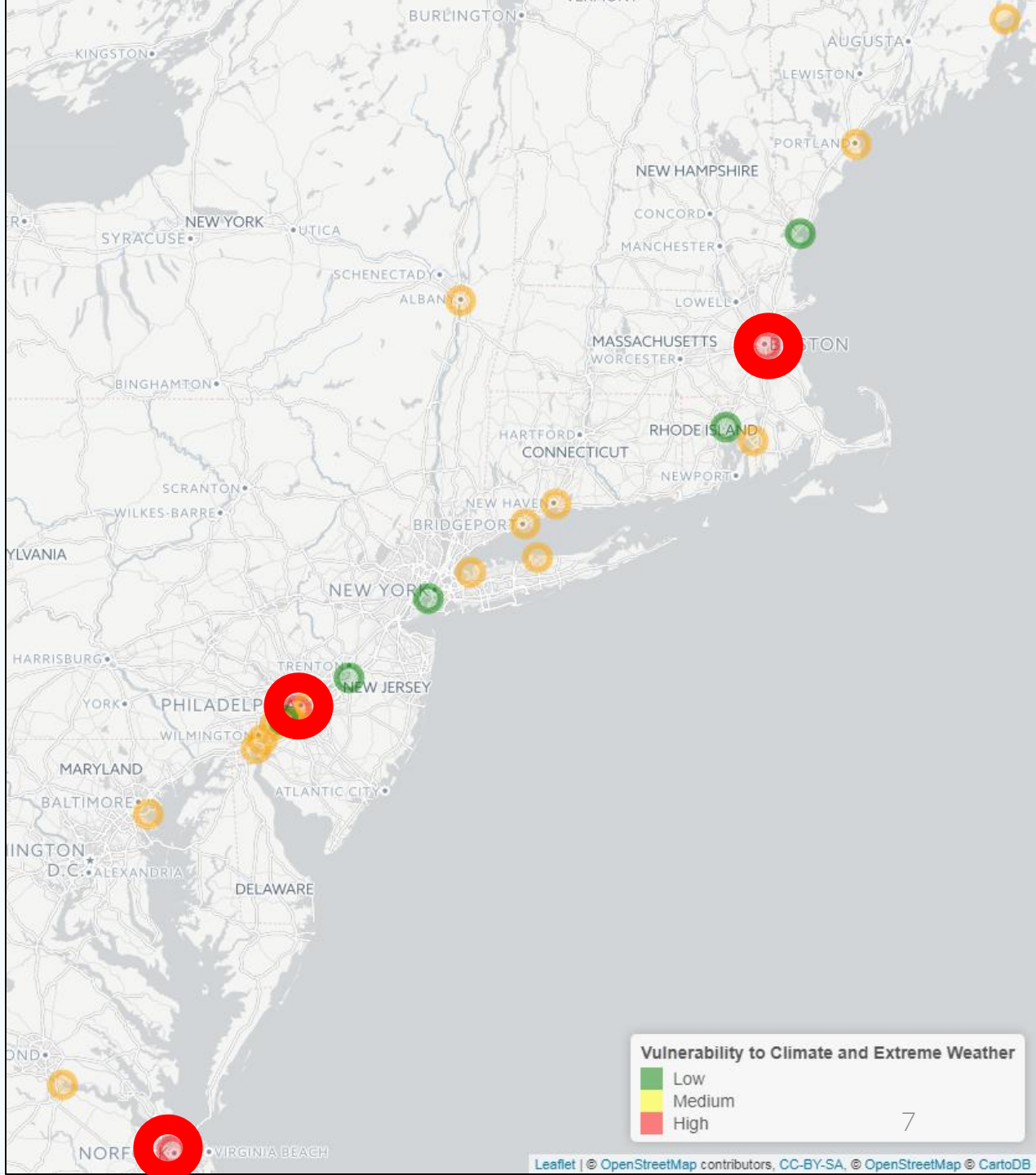
Model Results

Aggregate indicators into composite-index

- Using AHP-derived weights and WSM

Potential hot-spots of vulnerability:

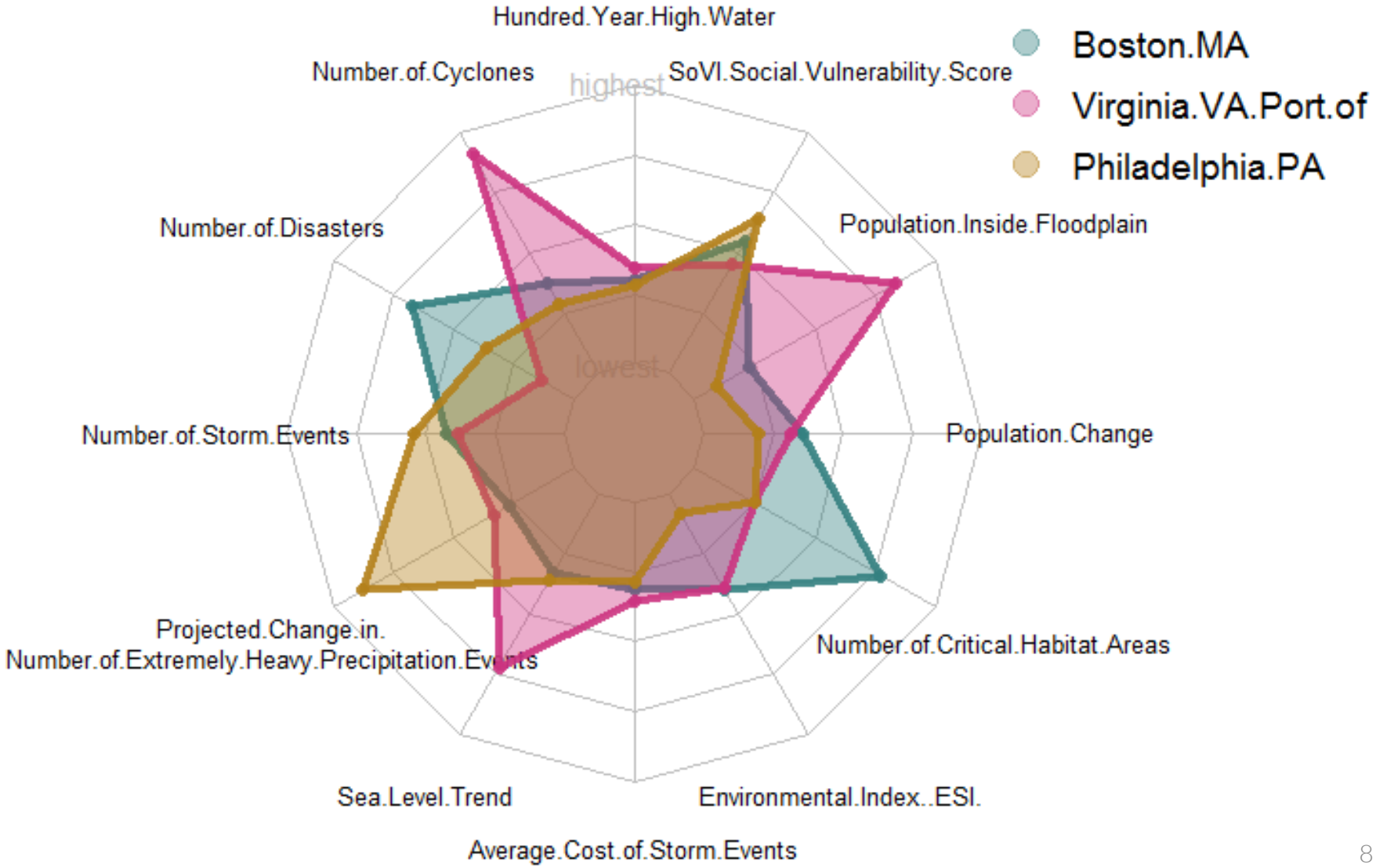
- Port of Boston
- Port of Philadelphia
- Port of Virginia



Boston vs Virginia vs Philadelphia

Visualize individual indicators

- Disaggregated sub structure



Validating Model Results

How do model results compare to experts' subjective port vulnerability rankings?

Model matched #1, and 3 out of top 4 most vulnerable ports

Port	Experts' Rank	Port	Model Rank
Virginia.VA.Port.of	1	Virginia.VA.Port.of	1
New.York.NY.and.NJ	2	Boston.MA	2
Boston.MA	3	Philadelphia.PA	3
New.Haven.CT	4	New.Haven.CT	4
Baltimore.MD	5	Port.Jefferson.NY	5
Providence.RI	6	Portland.ME	6
Portland.ME	7	Hopewell.VA	7
Portsmouth.NH	8	Fall.River.MA	8
Philadelphia.PA	9	Camden-Gloucester.NJ	9
Hempstead.NY	10	Baltimore.MD	10

Photo: E. Mclean

Limitations

- Results sensitive to value-judgements:
  - How to delimit each port?
  - How to compile indicator data?
    - Max value or average value?
- Reproducibility limited by expert subjectivity
- Lack of indicators of adaptive capacity

Photo: E. Mclean

Recommendations

- Focus effort on assessing adaptive capacity
  - Experts weight a/c high in importance
  - Yet, a/c lacks representation in data
- Investigate what types of bespoke data might be synthesized into new additional indicators
- Compliment theoretical study with investigation of *empirical* impacts of climate/weather on seaports

Photo: E. Mclean

Muchas Gracias
Fa'afetai Lava
Thank You

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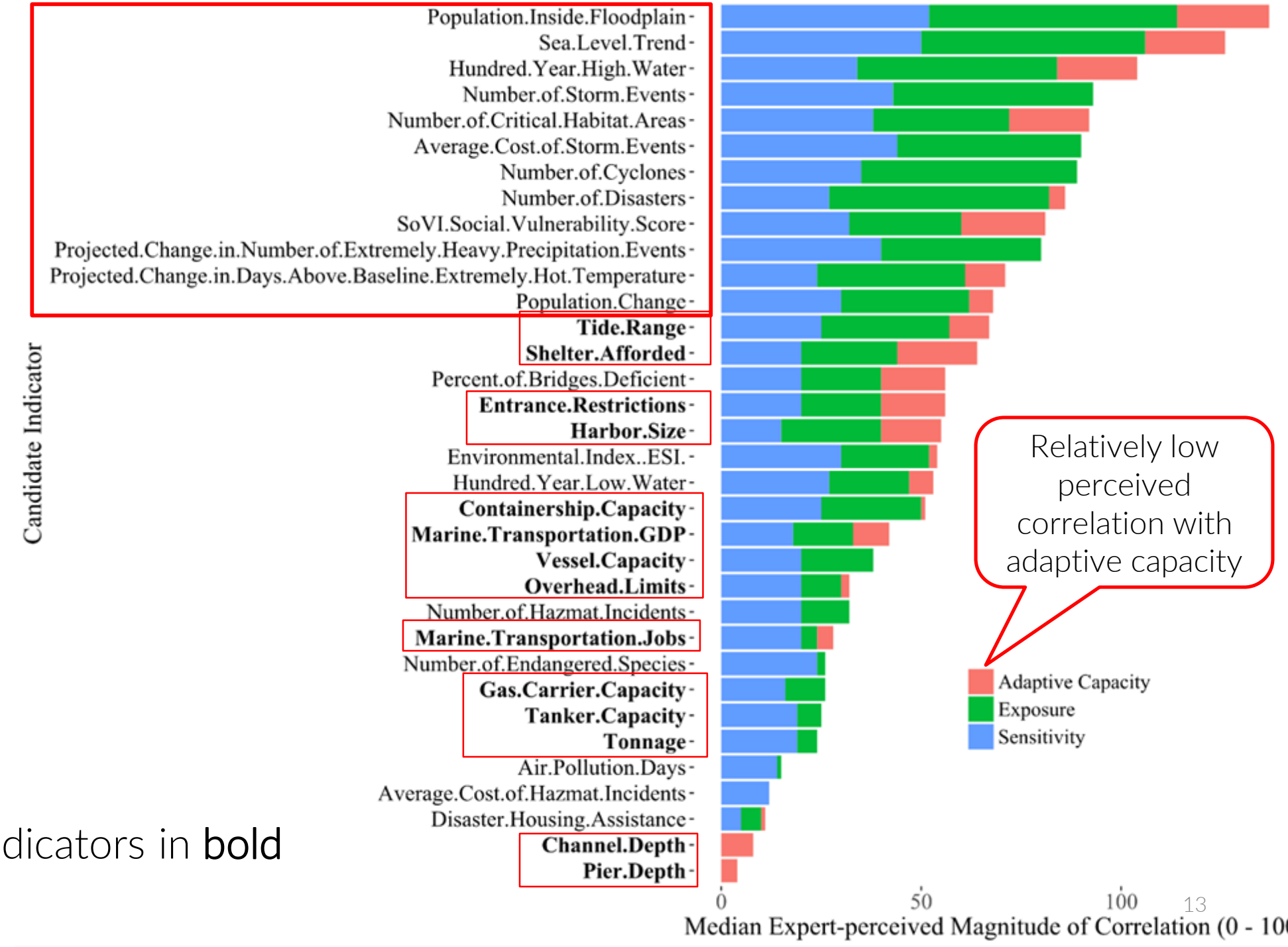
Results

34 Candidate indicators of seaport vulnerability to climate and extreme-weather:

Sorted by median expert-perceived magnitude of correlation with the three components of vulnerability

Port-Specific indicators in **bold**



Definitions

- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2014)

- **Sensitivity**: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli (IPCC 2001)

- **Adaptive Capacity**: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC 2014)