Climate change and ports: Qualitative analysis of consequences, plans, and requirements

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Agenda

• Brief background on ports and climate impacts
• Climate adaptation survey results
• Toward developing a lexicon –
  – Consequences
  – Strategies
• Conclusions
Seaport characteristics

• Economic engines at every scale
  o 80-90% of world freight moves by ship
  o Jobs, critical resources, facilitate trade of goods and energy
  o Profit centers for countless private firms

• Dependent on specific locations
  o Deep water, protective harbors, multi-modal connections

• Highly vulnerable locations
  o Often estuaries or river deltas that provide ecosystem services
  o Prone to flooding, storm surge, and SLR

• Complex decision-making systems
  o Overlapping jurisdictions, public/private nature,
Scenarios of concern to ports

- Sea levels to rise 0.75 – 1.9 meters by 2100
  +/- regional differences
- Doubling of Cat 4 and 5 tropical storms
  Ocean storm tracks shifting
- Inland flooding

Today’s 100-year flood = 2100’s 3-year flood (NYC)?

(Rhamstorf 2007; Bender, Knutson et al. 2010; NRC 2010; IPCC 2007, Lin et al. 2012)
What are ports doing now?

- 350 IAPH/AAPA members
- Survey Monkey
- Designed/Pretested with IAPH/AAPA
- 30 Questions
- Distributed Summer 2009
- 93 Usable Responses

Survey respondents concerned, but felt uninformed

Impacts of climate change is something that needs to be addressed by the port community.

I feel sufficiently informed about how climate change will impact my port operations.

N = 93
Ports are building infrastructure, but design standards do not include climate change.

**Plans for new construction in the next 10 years***

*16% of these are also building storm protections*
Concern for sea level rise

58% of ports feel they would have a problem

39% of ports feel they would have a problem

12% of ports feel they already have a problem

**Expected life of infrastructure (50-100 years+)**

*Figure 4. Global mean sea level rise curves for the 2013 NCA. Curves using a historic rate of 1.8 mm/year and a start year of 1992.*

*Chart Source: Vermeer M, Rahmstorf S. PNAS 2009, 106:21527-21532*
The path to action

What are the physical changes?

What are the direct impacts of these changes?

What are the consequences of these impacts and for whom?

What strategies can be implemented?

Which actors must take responsibility for implementation and on what timeline?
Impacts mostly understood, but what of consequences of impacts?

**Table 1. Climate Change Impacts on Port and Hinterland port infrastructure and operations**

<table>
<thead>
<tr>
<th>Climatic Factor</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rising sea levels</td>
<td>▲ corrosion rate and degradation of materials designed for particular range of sea level conditions.</td>
</tr>
<tr>
<td>Change in wind conditions and higher waves</td>
<td>Effects on offshore loading and unloading operations. Change in overtopping and threat to stability of breakwaters.</td>
</tr>
<tr>
<td>Erosion or accretion of beaches protecting port structures</td>
<td>Risks for safety of such structures and ▲probability of flooding.</td>
</tr>
<tr>
<td>Changes in storm duration and/or frequency</td>
<td>▼regularity of ports, ▲downtime and requirements for more storage capacity at container terminals for use in times of closure. ▲construction and maintenance costs at ports and facilities.</td>
</tr>
</tbody>
</table>

*UNECE, 2011. “Climate Change and International Transport Networks: Overview of Main Concerns and Considerations;” Table 1.*
The path to action

What are the physical changes?

What are the direct impacts of these changes?

What are the consequences of these impacts and for whom?

What strategies can be implemented?

Which actors must take responsibility for implementation and on what timeline?
Consequences of storm impacts to port communities: Improving understanding through qualitative analysis

- “Seaport decision-making system” as unit of analysis
- Two highly-vulnerable US ports
  - Gulfport (Mississippi) and Providence (Rhode Island)
- Interviews of 57 key decision makers
- Focus on extreme storm scenarios - not climate change
Ports Within 50km of Tropical Storm Tracks 1960-2010

- Gulfport
- Providence

- Green dots: Ports Within 50km
- Orange lines: Tropical Storm Tracks
Six categories of storm consequences
(272 mentions – 96 unique items)

- Debris
- Direct damages to port
- Business consequences
- Local and regional consequences external to port
- Damage to intermodal system and supply chain
- Environmental consequences

Frequency mentioned

- Gulfport
- Providence
Example 1: Debris

One respondent described shipping containers literally surfing down the faces of waves. Containers “went flying into neighborhoods, breaking up houses that may have been repairable from flooding alone, but instead were just pulverized.”

Specifics:
- Chickens and pork products from port washed up and rotting throughout city
- Containers from port scattered all over city
- Debris causing damage to structures on the port
- Debris in the channel impacting navigation
- Floating casino business carried away
- General debris
- Marine debris
- Rail cars ended up in ship berths
- Tree debris
Example 2: Regional impacts

Regional Consequences

- Other regional consequences
- Public sector consequences

“The average salary at the Port is about 70 or 80 thousand dollars a year. Some folks have high school diplomas and some probably don’t have high school diplomas. But they are middle class taxpayers. And when you pull that kind of money out of your economy, it can have a drastic impact. From an economic standpoint, it’s devastating.”

- Treatment plant issues
- Employment issues
  - Lost jobs, housing for relief workers, overtime pay, workers stranded at port, fluctuations in labor pool
- Public sector impacts
  - Cost of cleanup, local economy suffers, military reserve forces recalled for duty

- New business can also result from catastrophic event
- Delays in commerce and cleanup due to loss of capacity of port
Direct impacts
- Damage to intermodal system
- Debris
- Direct Damages to Port

Private sector consequences
- Supply chain interruption
- Consequences to port business

Public sector consequences
- Social/cultural consequence
- Local/regional economy consequences
- Environmental consequences

Major storm impacts and consequences
## Port resilience-building strategies

(125 unique strategies mentioned)

<table>
<thead>
<tr>
<th>Type of strategy</th>
<th>Time horizon</th>
<th># of strategies mentioned</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity building</td>
<td>Ongoing</td>
<td>46</td>
<td>Vulnerability assessments, climate commissions, improve forecasting, collaborate between agencies, map flood-prone areas, streamline permitting process, hire more staff…</td>
</tr>
<tr>
<td>Risk Reduction</td>
<td>Long</td>
<td>39</td>
<td>Breakwaters, storm barriers, elevate land, move port, create seasonal facilities, harden structures, incentivize resilience building, restore barrier islands…</td>
</tr>
<tr>
<td>Risk management</td>
<td>Medium</td>
<td>37</td>
<td>Emergency drills, port evacuations, business continuity plans, secure equipment in place, conduct emergency drills, shut down the waterway…</td>
</tr>
<tr>
<td>Risk transfer</td>
<td>Short</td>
<td>3</td>
<td>Increase insurance coverage, disaster relief, adjust insurance premiums incrementally…</td>
</tr>
</tbody>
</table>
Port resilience strategies and likely candidates to take the lead on implementation

- Risk Transfer
- Risk reduction
- Risk management
- Capacity building

<table>
<thead>
<tr>
<th>Broad category</th>
<th>Federal agencies</th>
<th>Local agencies</th>
<th>Multiple actors</th>
<th>Multiple actors</th>
<th>Port</th>
<th>State agencies</th>
<th>State agencies</th>
<th>State agencies</th>
<th>State agencies</th>
<th>State agencies</th>
<th>Private firms</th>
<th>Private firms</th>
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</thead>
</table>

# of unique strategies
Conclusions

• Many actors - Public, private, public/private
• Difficult to quantify true consequences
• Impacts/consequences can occur out of the career or lifetime of decision makers
• Not always clear responsibility
• Next steps: strategies, timetables, and implementation responsibility
Many thanks to:
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Providence and Gulfport RDS Mental Models

- Business impacts
  - Direct damages to port
  - Debris
  - Environmental impacts
  - Local and regional impacts external to port
  - Damage to intermodal system and supply chain

Gulfport
Providence
1. Policies (includes insurance, design standards, zoning)

- Federal – E.g., Incentivize resilience, commission studies
- Local – Create regional mitigation plans, consider resilience in local comp plans
- State – Create SLR policies, enhance building codes, create cleanup agreements
- Port – Mandatory evacuations, build resilience into ops/maintenance
- Private/insurance – Adjust premiums incrementally, conduct insurance inspections
2. Process (includes coordination, commissions, outreach, education)

- Collaborations
- Increase staffing
- Improve informational flows
- Increase planning horizons
- Shift in thinking toward prioritization of resilience
3. Construction and design

• Construct/modify ON port lands
  – Elevate structures, elevate port lands, harden structures...

• Construct/modify OFF port lands
  – Breakwaters, flood barriers, move the port...
4. Practice (current and potential)

- Drills and re-event trainings
- Post-storm actions
- Storm preparations

5. Plans and planning efforts

- Data storage plans
- Emergency response and recovery plans
- Work to ID funding streams
6. Research (inc. risk assessment, forecasting, projections)

- Damage assessments
- Risk/vulnerability assessments
- Improve forecasting abilities
- Map flood-prone areas
- Utilize gaming, simulations, and scenarios
- Partner with academic institutions and NGOs
What do decision makers perceive as strategies to build resilience?
What are the barriers to implementing resilience measures?

- Lack of leadership
- Lack of expertise
- Politics
- Scientific understanding
- Fatalism
- Communication
- Technological and engineering
- Attitudes, values, motivations
- Understanding of the issues
- A : Adaptation options and process
- Resources and funding
- Institutional governance issues

* After Moser and Ekstrom 20120
Extra Slides Below

- All tropical cyclones: $141.6 billion (45.6%)
- Tornadoes: $82.4 billion (26.5%)
- Total: $310.7 billion

- Utility service disruption: $0.2 billion (0.1%)
- Water damage: $0.4 billion (0.1%)
- Civil disorders: $1.1 billion (0.4%)
- Fire: $8.1 billion (2.6%)
- Wind/Hail/Flood: $9.9 billion (3.2%)
- Earthquakes: $19.5 billion (6.3%)
- Terrorism: $22.9 billion (7.4%)
- Winter storms: $24.4 billion (7.9%)
The port decision-making system

- Port authority
- Customers, state regulators, city planners, insurers
- US Army Corps, FEMA, Federal regulators
Six categories of resilience strategies
(125 unique items)

- Practice (current and potential)
- Constructions and design
- Policies (including insurance, design standards, zoning)
- Process (including coordination, commissions, ...)
- Research (inc. risk assessment, forecasting...)

Categories:
- Academia/NonProfit
- Public - Local
- Public - Federal
- Public - State
- Port
Strategies to build resilience

- Capacity Building
- Risk Reduction
- Risk Management
- Risk Transfer
Gulfport’s plan to elevate to 25 feet.
Providence, RI: Achilles heal of the Northeast
Direct damages to port
- Buildings and structures
- Docks and berthing areas
- Equipment
- Freight and cargo
- Land areas
- Utilities

Local and regional impacts
- Public sector impacts
- Employment losses
- Damage to ancillary services

Environmental impacts
- Coastal land damages
- Hazards to human health
- Ecosystem damages
- Waterway contamination

Debris
- Originating at port (off-port or on-port consequences)
- Originating off port (on-port consequences)
- General

Damages to intermodal system
- Road and rail
- Supply chain
- Navigation system

Business impacts
- Business continuity
- Difficulty in planning/development
- Employee and staffing issues
- Increased costs
- Insurance problems
- Loss of port functionality
- Operational burdens