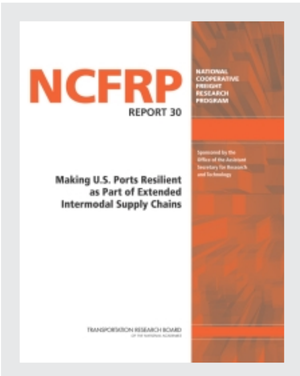


Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains

DETAILS

99 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-37518-4 | DOI 10.17226/23428

AUTHORS

Southworth, Frank; Hayes, Jolene; McLeod, Shannon; and Anne Strauss-Wieder

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 30

Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains

Frank Southworth
Georgia Institute of Technology
Atlanta, GA

Jolene Hayes
Shannon McLeod
Parsons Brinckerhoff, Inc.
Norfolk, VA

Anne Strauss-Wieder
A. Strauss-Wieder, Inc.
Westfield, NJ

Subscriber Categories
Freight Transportation • Marine Transportation • Terminals and Facilities

Research sponsored by the Office of the Assistant Secretary for Research and Technology

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2014
www.TRB.org

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Office of the Assistant Secretary for Research and Technology under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between the Research and Innovative Technology Administration, which is now the Office of the Assistant Secretary for Research and Technology, and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

Program guidance is provided by an Oversight Committee comprised of a representative cross section of freight stakeholders appointed by the National Research Council of The National Academies. The NCFRP Oversight Committee meets annually to formulate the research program by identifying the highest priority projects and defining funding levels and expected products. Research problem statements recommending research needs for consideration by the Oversight Committee are solicited annually, but may be submitted to TRB at any time. Each selected project is assigned to a panel, appointed by TRB, which provides technical guidance and counsel throughout the life of the project. Heavy emphasis is placed on including members representing the intended users of the research products.

The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.

NCFRP REPORT 30

Project NCFRP-37
ISSN 1947-5659
ISBN 978-0-309-28423-3
Library of Congress Control Number 2014944444

NOTICE

The project that is the subject of this report was a part of the National Cooperative Freight Research Program, conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council.

The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

The opinions and conclusions expressed or implied in this report are those of the researchers who performed the research and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors.

The Transportation Research Board of the National Academies, the National Research Council, and the sponsors of the National Cooperative Freight Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of the report.

Published reports of the

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at:

http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. C. D. Mote, Jr., is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. C. D. Mote, Jr., are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

COOPERATIVE RESEARCH PROGRAMS

CRP STAFF FOR NCFRP REPORT 30

Christopher W. Jenks, *Director, Cooperative Research Programs*
William C. Rogers, *Senior Program Officer*
Charlotte Thomas, *Senior Program Assistant*
Eileen P. Delaney, *Director of Publications*
Hilary Freer, *Senior Editor*

NCFRP PROJECT 37 PANEL
Freight Research Projects

Thomas H. Wakeman, III, *Stevens Institute of Technology, Hoboken, NJ* (Chair)
James M. Dwyer, *Maryland Port Administration, Baltimore, MD*
Jeff Lillycrop, *U.S. Army Corps of Engineers*
Jon S. Meyer, *Baltimore, MD*
Annie Protopapas, *Texas A&M Transportation Institute, College Station, TX*
Roberta E. Weisbrod, *Sustainable Ports, Brooklyn, NY*
W. Scott Brotemarkle, *TRB Liaison*

AUTHOR ACKNOWLEDGMENTS

The report's authors would like to thank the many individuals who gave their time and shared their expertise during the many telephone and in-person discussions held with members of the research team. The level of cooperation received was excellent throughout. No opinions expressed by the authors of this report are to be ascribed to specific individuals or companies.

FOREWORD

By William C. Rogers
Staff Officer
Transportation Research Board

NCFRP Report 30: Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains builds on *NCHRP Report 732: Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System* to provide a set of high-level guidelines, illustrated by two case studies, that will help seaport authorities (as well as state DOTs in which such ports are located) to minimize lost throughput capacity resulting from a major disruption. The report focuses on identifying and elaborating on the steps needed to coordinate freight movements through ports in times of severe stress on existing operating infrastructures and services whether being stressed because of damage to port facilities, to the highway, rail, and waterway routes leading into and out of the port, or because of the need to handle additional cargo volumes due to port disruptions elsewhere. The catchall term used for such efforts is port resiliency—the ability of a port to withstand and bounce back from a serious threat to its ability to process freight in an efficient, cost-effective manner.

How resilient a port is depends on many different factors. From a purely physical processing standpoint, resilience means ensuring that freight gets into, is suitably processed by, and gets out of the port as expeditiously as possible. Given the considerable expense of providing redundant cargo handling capacity, a key to effective disruption response and subsequent recovery is to identify the primary steps in the cargo moving, manifesting, and storage processes involved; who is in charge of each processing step; who and which agencies need to be kept informed of progress; and who will have a decision-making role in changing operating rules and procedures when a disruption occurs.

Under NCFRP Project 37, the Georgia Institute of Technology was asked to (1) review the literature on past disruption events, with an emphasis on specific actions that helped to limit the extent or duration of a disruption; (2) conduct expert interviews (with seaport operators, truck, rail, and ocean vessel carriers) to obtain their views on current levels of port resiliency, as well as on the most effective means of increasing resiliency and speeding recovery should a disruption occur; (3) conduct two in-depth case studies of recent port disruptions, Superstorm Sandy's impacts on the major East Coast ports and the extended lock closures along the Columbia River System in the Pacific Northwest; and (4) develop high-level guidelines suitable for public-sector decisionmakers who might become involved in a disruption recovery event.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

CHAPTER 1

Introduction

1.1 Project Background and Purpose

The research reported in this document addresses the issue of how seaports respond to, and recover from, major disruptions to the movement of cargo through their facilities. As key nodes in the nation's freight supply chains and the points at which most of the nation's imports enter and exports leave the nation's shores, seaports represent an essential resource in the cost-effective operation of the U.S. economy. Recent highly disruptive natural events such as Hurricanes Irene and Katrina, and Superstorm Sandy, have shown the costs to society of extreme coastal weather events. And due to their coastal locations, seaports are often among the most severely impacted of built infrastructures.

The specific objective of this research project is to develop a set of high-level guidelines, informed by expert opinions and illustrated by example case studies. These guidelines are intended to help the seaport authorities and regional transportation agencies in which such ports are located minimize the extent and duration of lost cargo throughput resulting from such disruptions. Whether a natural or manmade event (such as a terrorist attack or labor strike), the goal is to bring the seaport's freight movement system back to its prior operating level before costly and protracted delays can occur—whether stressed because of damage to cargo handling and warehousing facilities within the port; to the highway, rail, waterway, and pipeline routes leading into and out of the port; or because of the need to handle additional cargo volumes due to port disruptions or surges in cargo demands elsewhere. The term used in this report for such efforts is *port resilience*—the ability of a seaport to withstand and bounce back quickly from a serious threat to its ability to process freight in an efficient and cost-effective manner.

This report offers insights from a wide range of experts on how public and private agencies can help seaports recover quickly from a sudden partial or complete loss of cargo handling capacity in the future. Recent studies have shown that delays in the recovery of port operations can have significant economic, as well as social costs, and can upset arrangements to move freight at distances far removed from the impacted port, on both the landside and waterside of the interrupted product supply chains. This report recognizes these broader supply chain impacts of port closures, as well as the highly concentrated nature of much of the freight moving into and out of the United States through a relatively small number of large port complexes. In particular, this research seeks to codify and turn into useful action items many of the lessons learned from a series of damaging coastal weather events, and from the greater attention now being given to possible terrorist actions since the events of 11 September 2001.

Two key challenges to doing so are (1) the considerable complexity and large number of independently motivated actors, or agents, involved in moving much of the freight through the nation's ports; and (2) the considerable variety of ways in which U.S. ports are organized in terms of ownership, organizational oversight, and physical and legal responsibilities for goods moved.

This said, significant commonalities across port operations suggest that lessons learned from each disruptive event provide value to other ports that may face future disruptions to services. The value of such lessons is reflected in the constant updates to port emergency preparations and recovery plans, as port authorities aim to decrease recovery time from disruptive events.

This report demonstrates that considerable ingenuity has been used in finding timely solutions to recent disruptions in seaport operations. The report also identifies areas that require additional consideration, analysis, and action as U.S. ports prepare for a future in which the movement of traded goods will have an increasingly important role in regional and national economies.

1.2 Report Organization

This report describes the methods used, information gained, and findings obtained from the following:

- **Chapter 2, Literature Review**—A review of the recent seaport disruption and resiliency literature.
- **Chapter 3, Interviews with Supply Chain Experts**—A summary of findings from a series of teleconference-based interviews with experts from around the United States who have had experience in responding to, and recovering from, supply chain disruptions to seaports.
- **Chapter 4, Case Study: Response to and Recovery from Superstorm Sandy**—A summary and set of lessons learned from on-site and telephone interviews with experts at different stages of the freight supply chain who were involved in responding to the major East Coast ports disruptions resulting from the November 2012 extreme weather event known as Superstorm Sandy.
- **Chapter 5, Case Study: Columbia River Closure**—A summary and set of lessons learned from on-site and telephone interviews with supply chain experts faced with the port disruptions resulting from extended closure of locks along the Columbia River System in the Pacific Northwest.
- **Chapter 6, Synthesis of Findings**—A summary of major issues raised, solutions proposed and implemented, and lessons learned from the materials summarized in Chapters 2 through 5, leading to a set of high-level rules of thumb that public agency responders might consider when preparing for, as well as responding to and recovering from, future cargo-impacting disruptions involving U.S. seaports.

After completing an initial literature review in early 2013, the subsequent three rounds of expert interviews were used not only to add much needed insight into actual practice, but also to update the literature review on the basis of additional issues and materials identified.

CHAPTER 2

Literature Review

Ports' complexities exacerbate the difficulty of taking adequate steps to deal with possible natural disasters. Ports are often sprawling enterprises, and each port is unique.

—GAO 2007, p. 1

2.1 Content and Organization

This chapter provides a review of the literature on both the nature of, and responses to, significant disruptions to the movement of freight through U.S. ports. For the purposes of this study, the following definitions are used:

- **Ports** are defined as deep-draft coastal facilities and terminals capable of handling both international and domestic marine cargo.
- **Disruption** is defined as any significant loss of a port's regular cargo handling capacity.

Since the formation of the United States, ports have been the gateways to international commerce and trade. In 2012, U.S. waterborne trade amounted to over 2.1 billion metric tons, including over 1.3 billion tons in foreign trades that were valued at over $1.78 trillion (MARAD, 2013), making efficient port operations one of the keys to U.S. economic health. Significant disruptions to port operations can prove very costly. Port disruptions not only affect those freight businesses directly involved in maritime operations, disruptions also can affect the broader regional economies and industrial sectors they support (Abt Associates, 2003; Hall, 2004; Gordon et al., 2005; CBO, 2006; Park et al., 2008; National Infrastructure Simulation and Analysis Center [NISAC]/National Incident Management Systems and Advanced Technology [NIMSAT], 2011). Therefore, dealing efficiently with such disruptions should be a high priority for all levels of government.

The focus of the review is on the actions required to recover and maintain a port's cargo throughput following a disruption. The goal is *continuity of port business activity*, and the phrase most often used for measuring how well such efforts succeed is *port resilience*—the ability of a port to provide and maintain an acceptable level of service, notably a steady freight volume throughput, when disruptive forces are imposed on it (Rice and Caniato, 2003; Sheffi, 2005; GAO, 2010; Berle et al., 2011a, b; TISP, 2011; NAS, 2012).

In keeping with the broader aims of the overall research project, the main product of the review is a list of issues and subsequent actions that need to be addressed to enhance port resiliency, including prior preventative actions, actions geared to immediate impact response, and actions geared to rapid post-incident recovery. A consistent finding from the literature was the need to draw on expert opinions on how to proactively plan for port resilience, as well as the identification of the many different types of stakeholders involved in port planning and operations.

Section 2.2 discusses the many different causes and characteristics of past port disruptions, how these events relate to the way U.S. ports are operated, and which public and private-sector organizations are usually involved in port response and recovery activities. With this background, the recent literature on port disruption events was searched for specific examples of past response and recovery problems (Section 2.3), and for specific actions as well as broader approaches that have been proposed for limiting the negative consequences of future occurrences (Section 2.4). Section 2.5 summarizes the review's key findings, with an eye to developing a set of high-level response and recovery guidelines that can help decisionmakers focus on the important issues involved in a major port disruption event. The review does not recommend specific response or recovery actions.

2.2 Nature of the Challenge

The review of port resiliency is made within the context of the following unique challenges involved with maritime operations:

Ports Are Complex Physical, Transactional, and Institutional Entities

As described in *NCHRP Report 732* (GTRC et al., 2012), building on RAND Corporation Inc.'s (2005) treatment of supply chains, international goods movement involves a three-tiered structure (note: terms are slightly modified here):

- **Physical/logistics layer**—includes physical transportation systems and entities such as truck, rail, and ocean carriers, etc.;
- **Transactional/informational layer**—procures and distributes goods and is primarily driven by information flow (e.g., customer, retailer, foreign supplier); and
- **Regulatory/oversight layer**—provides the policy framework for both commerce and security, and enforces rules of behavior through standards, fines, and duties.

High-level port operations associated with each of these different activity layers are listed in Figure 2.1.

A port's continuing success in moving freight depends on effective coordination of the many aspects of port operations, each involving people, technology, information, and both physical and financial resources. As a result, ports are subject to a variety of vulnerabilities associated with human actions (e.g., industry disputes, terrorist attacks, operator mistakes), technological failures (e.g., computer networks, control systems, vessel and dock equipment, etc.), natural disasters (e.g., hydrologic, geologic/seismic, atmospheric hazards), and organizational failures (e.g., excessive bureaucracy, poor interagency coordination, poor training).

VESSEL ACTIVITIES	TERMINAL ACTIVITIES	TRANSACTION ACTIVITIES	INLAND MOVEMENT ACTIVITIES
Pilotage, Tugs, Provisions, Fuel, Crew, Shore Leave, etc.	Crane Operation, Stevedoring, Yard Handling, Cargo Manipulation, Inspections, etc.	Banking, Insurance, Data Processing, Freight Forwarding, Customhouse Brokerage, etc.	Trucking, Rail, Barge and/or Pipeline

Source: New York Shipping Association, The Economic Impact of the New York-New Jersey Port/Maritime Industry, 2010, p.14. (prepared by A. Strauss-Wieder, Inc.).

Figure 2.1. Components of port operations.

Ports Are Multiple Stakeholder Operations

An ICF International assessment of climate change impacts on transportation and infrastructure in the Central Gulf Coast region noted that ports present unique institutional as well as physical challenges, stating "the mix of privately owned/operated facilities, publicly owned/operated facilities, and publicly owned-privately operated facilities creates a unique mix when compared with other transportation infrastructure" (2011, p. 53).

Table 2.1 lists the most common types of participating organizations identified in recent literature, and summarizes their principal (but not always *only*) roles with respect to port disruptions. Each stakeholder group has its own set of priorities and constraints that come to the fore whenever a port has difficulty moving cargo. How these various stakeholders interact with each other varies from port to port. A port may be operated by a state, county, municipality, private corporation, or some combination of these agencies. Although the number and make-up of the stakeholders involved in port operations varies a good deal, in general they include the port authorities themselves; private-sector operators doing business within the port; local, state, and federal government agencies; and information sharing and planning forums, often made up of representatives from both the public and private sectors (GAO, 2007; GAO, 2012b). With a great deal of today's freight being scheduled by freight brokers, including some large third-party logistics (3PL) agencies, port and terminal authorities must deal with these brokers as well as the freight carriers operating within their boundaries. The more "freight agents" involved, the more involved transactional issues are likely to become, and the greater the need for increased coordination, communication, and planning throughout a product's supply chain.

Disruptive events trigger government participation at a number of different levels. When a major disruption to a port's cargo operations occurs, federal, state, and local government agencies often become involved. Some of this involvement is mandated by law. Usually, local and state authorities take the lead in responding to emergencies, with federal agency support provided when needed, and especially when local resources become strained or when an event causes problems that go well beyond a port's physical boundaries. In most instances, however, the working relationships among local, state, and federal agencies differs in practice according to the way that local and state authorities approach the issue of port planning.

The level of federal involvement in international freight transportation systems increased significantly after the terrorist attacks of 11 September 2001, the damaging Gulf Coast hurricane season of 2005, and the impacts of Superstorm Sandy in 2012. Although the events of 11 September 2001 spurred considerable efforts to tighten port security, notably through pre-event preparedness, the severe weather events of 2005 and 2012 further focused attention not only on incident preparedness, but also on response and recovery.

Several Government Agencies May Become Involved

Knowledge of the laws and regulations that apply to different levels of government involvement need to be clear to all parties included in a major port disruption event. Through legislation and presidential directives, the Department of Homeland Security (DHS) is the primary federal organization responsible for preparing the nation for terrorist attacks and for major natural disasters. Homeland Security Presidential Directives 5 and 8 require DHS to establish a National Preparedness System with a single, comprehensive ("all-hazards") approach to managing emergency events, whether the result of terrorist attacks or large-scale natural or accidental disasters. This federal role is currently governed by the National Response Framework (NRF), which became effective on March 22, 2008, and supports the National Incident Management System (NIMS). Since 2003, Homeland Security Presidential Directive 5 (HSPD-5) has required all federal departments and agencies to adopt NIMS as a condition for state, tribal, and local governments

Table 2.1. Organizations commonly involved in U.S. port operations and planning.

Stakeholder Organizations	Principal Roles (Freight)
A. Physical/ Logistical Asset Utilization	
Port Authorities	Cargo loading/unloading, storage and throughput.
Terminal Operators	Cargo sorting, re-packaging, storage and throughput. Ensuring labor, chassis and container availability.
Port Labor Force (Stevedores, Crane Operators, etc.)	Cargo sorting, loading/unloading, storage and inter-modal transfer.
Maritime Vessel Operators Shipping Lines	Cargo pickup and delivery.
Inland Freight Carriers Trucking Firms, Railroads, Pipelines, Barge Operators	Cargo pickup from and delivery to the port. Intermodal transfers of cargo within the port.
Local, State and Federal Governments Including USCG (Captain of the Port), USACE, State and Federal DOT(s)	Ensuring main channel operation and safe debris removal. Ensuring highway, rail, inland water and pipeline access and egress capacity.
Local Utility Companies Electricity, gas, water, waste management	Ensuring the needed power and water supplies to the port.
Local Fire and Police Departments and Local Hospitals	First responders to port disruption incidents.
B. Communications & Information Flows	
Port Authorities	Cyber scheduling of cargo and equipment assets and fees, and tracking of cargo throughout and port equipment usage.
Freight Brokers (inc. 3PLs) **Freight Carriers** **Freight Shippers**	Supply chain cyber-transactions: inventory control, cargo manifesting, cargo and transportation asset matching, cargo and transportation equipment matching. Banking (fees). Insurance (damage, on-time delivery).
Terminal Operators	Cargo handling and storage and portservice contracts and fees, inventory monitoring.
C. Regulations	
Port Authorities Organizations, who may own, lease and/or operate none, some, or all of the port's cargo terminals, docks, cranes, offices and other equipment and services.	Safe, secure, efficient and environmentally sound port operations.
Local and State Governments State DOTs, OEMs, OHSs, Police, Fire, Water Supply Authorities, etc.	Monitoring port safety and security regulations and records. Freeing up financial resources in times of stress. Applying hazardous materials incident rules and regulations.
Federal Government DHS (FEMA, USCG, CBP, ICE, etc.), DOC (inc. NOAA), DOE, DOJ, DOD (notably USACE, USN), USDA, etc. as nature of incident/nature of cargo impacted warrants. (e.g., Federal relief assistance provided under the Stafford Act)	Port command and control during contingencies (USCG Captain of the Port). Port safety and security regulations and recordings. Freeing up additional financial and resources in times of crisis. Applying hazardous materials incident rules and regulations.
Labor Unions	Ensuring appropriate working conditions and hours of operation for port work force.
Port Advisory Panels/Planning Councils Multiple stakeholder local/state/federal government & public/private sector agency organizations with different start-up histories	Pre-planning and development of incident management protocols and training exercises. Evolution of stakeholder inter-agency coordination & communications roles, responsibilities and protocols.
Maritime and Ground/Intermodal Trade Associations (e.g., Amer. Assocn. of Port Authorities, Amer. Assocn. of State Highway and Transportation Officials)	Member supporting information gathering and sharing and member issues identification, training and advocacy.

to receive federal preparedness assistance. NIMS (DHS, 2008; see also http://www.fema.gov/about-national-incident-management-system) offers a consistent nationwide approach for governments, the private-sector, and nongovernment organizations to work together to prepare for, respond to, and recover from, domestic incidents, regardless of cause, size, or complexity.

Under Presidential Policy Directive 8 (PPD-8, March 30, 2011), and much of the federal legislation for port security, especially that contained in the 2002 Maritime Transportation Security Act (including requiring a national security plan, area security plans, and facility and vessel security plans) and in the 2006 Security and Accountability for Every Port Act (SAFE Port Act), a particularly damaging or widespread incident also may involve some or all of the following agencies:

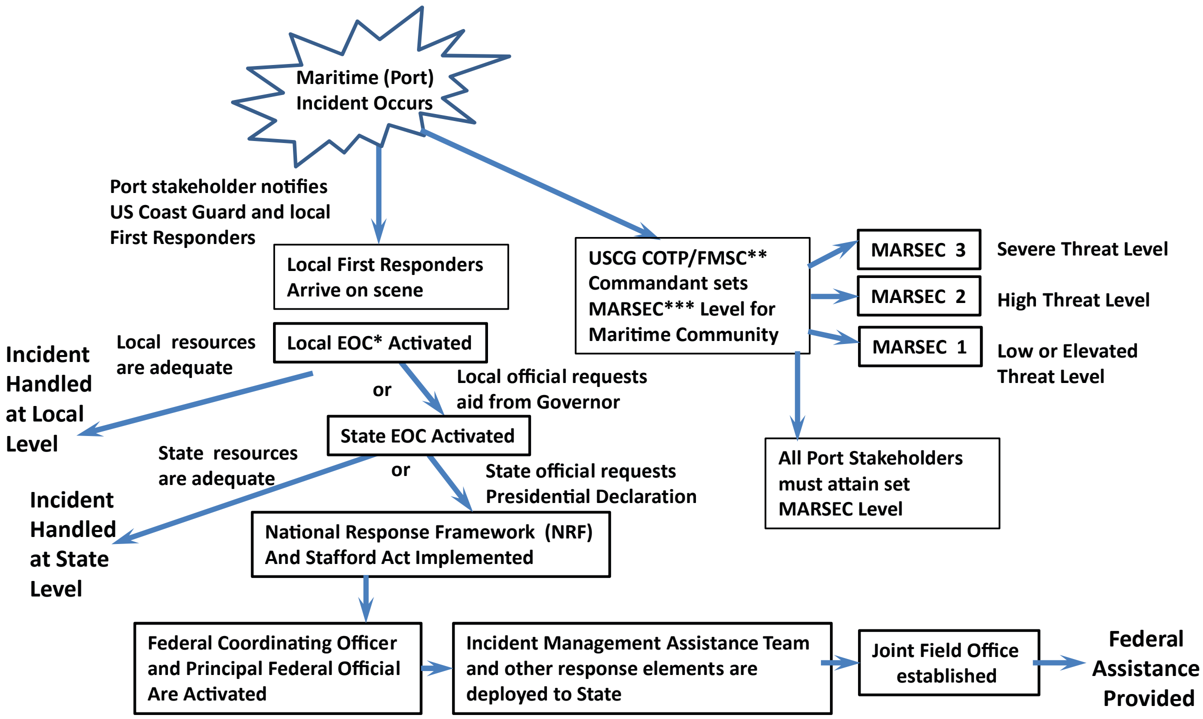
- State and local departments of transportation (DOTs), other branches of FEMA and its regional offices, U.S. Customs and Border Protection (CBP), and U.S. Coast Guard (USCG) within DHS;
- U.S. Army Corps of Engineers (USACE) and Department of the Navy (DON) within the Department of Defense (DOD);
- Maritime Administration (MARAD) within U.S.DOT;
- Federal Bureau of Investigation (FBI) within the Department of Justice (DOJ); and
- National Oceanic and Atmospheric Administration (NOAA) within the U.S. Department of Commerce (DOC).

Disruptions involving hazardous materials (hazmat) releases can pose some unique problems. *HMCRP Report 9* (Ranous, 2012) addresses these issues in depth from the local community response and recovery perspective. The National Weather Service (NWS) is a component of NOAA. An Operating Unit of DOC, NOAA has become involved in disruption preparedness, particularly after Hurricane Katrina. For example, prior to Superstorm Sandy, it was NWS that briefed agencies and advised them of the projected storm surges and other conditions that led to decisions to close harbors and terminals (ASW Inc., 2013).

In most instances, however, it is the port authority and its local emergency response and law enforcement agencies that prepare and begin the response to an incident, with subsequent assistance from federal agencies when needed. Within DHS, the USCG is responsible for the maritime environment and the safety and security of ports, including recovery after an incident, and the USCG's Captain of the Port (COTP) has command responsibility during a major port disruption. The Coast Guard Authorization Act of 2010 calls for Area Maritime Security (AMS) Plans to establish response and recovery protocols to prepare for, respond to, mitigate against, and recover from, a transportation security incident (TSI). Developed with input from other government and private agencies, these plans serve as the primary means of identifying and coordinating USCG procedures related to prevention, protection, security response, and maritime-transportation service recovery (GAO, 2012a). Which agencies and levels of government become involved in incident response depends on the severity of the disruption. Figure 2.2 shows this tiered response, passing from local to state to federal assistance as the severity of the incident and the resources needed to respond to it increases.

One of the first steps in achieving compliance with NIMS is development of a systematic tool used for the command, control, and coordination of emergency response known as an incident command system (ICS, see http://www.fema.gov/incident-command-system#item3). ICS ideally allows different agencies to work together using common terminology and operating procedures for controlling personnel, facilities, equipment, and communications associated with an incident. ICS responsibilities include the following:

- **Command**—providing on-scene management and control authority,
- **Operations**—directing incident tactical operations,
- **Planning**—preparing an Incident Action Plan and maintaining situation and resources status,



*EOC = Emergency Operations Center **COTP/FMSC Commandant = Captain of The Port/Federal Maritime Security Coordinator
***MARSEC = MARitime SECurity
Source: Adapted from USCG, 2009, p. 63

Figure 2.2. Different levels of government involvement associated with different levels of incident severity.

- **Logistics**—providing services and support to the incident,
- **Finance and Administration**—tracking incident costs and accounts for reimbursements, and
- **Intelligence**—providing analysis and sharing of information during the incident.

USCG is actively involved in what it terms Marine Transportation System (MTS) Recovery Planning. MTS plans require, among other things, an inventory of what the U.S. military often terms essential elements of information (EEIs) representing the critical items of information or intelligence required to plan and execute an operation such as a response to a port disruption event (see DOA, 1993, for an example list of port EEIs; for additional details on the roles played by the USCG during port contingencies, see USCG, 2008, 2009 and Young 2009a, b).

Understanding Ports Means Understanding Supply Chains

Ports are not stand-alone facilities. Rather, they are integral components of many of the nation's most important commodity supply chains. At the same time, ports represent some of the most important nodes in the nation's multimodal transportation network. As such, their operations both influence and depend heavily upon the landside (highway, rail, pipeline, inland barge) and deep-water transportation networks accessing them (see Figure 2.3), and on the efficiency of the intermodal transfers that take place within or in close proximity to the port itself. Efficient operation of these inland modes is also essential to port resiliency.

For example, in the aftermath of Superstorm Sandy, barges and rail freight options were used to transport cargo from vessels offloaded at alternative ports, back to customers in the New York-New Jersey region (ASW Inc., 2013; and see Chapter 4).

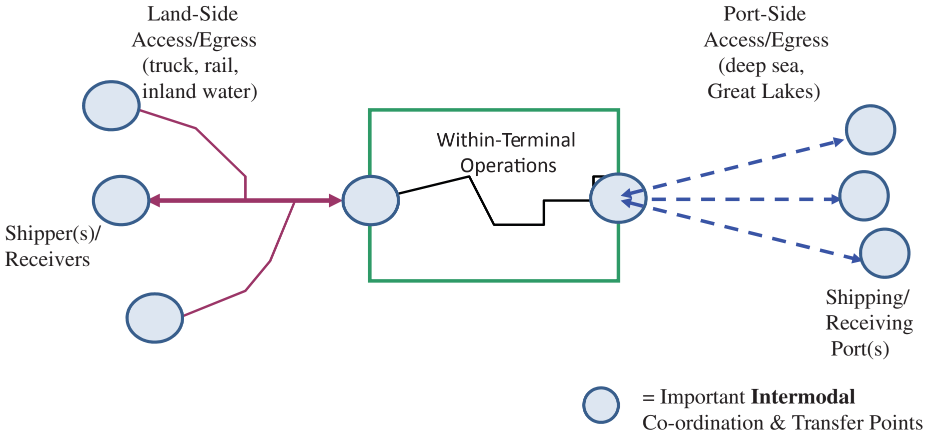


Figure 2.3. The port as an intermodal connector in product supply chains.

The National Strategy for Global Supply Chain Security (Washington, D.C., Jan. 23, 2012, http://www.whitehouse.gov/the-press-office/2012/01/25/fact-sheet-national-strategy-global-supply chain-security) articulates the federal government's policy for strengthening the global supply chain, focusing on the assets and infrastructure by which goods are moved, as well as supporting communications infrastructure and systems (GAO, 2012b). As noted in *NCHRP Report 732* (GTRC et al., 2012), supply chain disruptions have defining characteristics including

- Geographic scope;
- Facilities disrupted;
- Modes impacted;
- Commodities and characteristics of the shipments disrupted (e.g., time sensitivity, temperature controlled, seasonality, etc.); and
- Likely timeframe needed for service resumption.

These same factors affect port resiliency. Berle et al. (2011a, b), for example, identify a number of common "failure modes" in maritime transportation, from loss of entire port services, to the loss of one or more terminals, and the loss of individual intermodal connections (e.g., truck-water, rail-water), navigable waterways, and shipping vessels—all of which can cause serious and costly delays to port operations.

However, understanding the physical components of such supply chains is only one aspect of port resilience. For example, if one or more ports are affected by a disruption, what efforts must be undertaken to divert vessels to neighboring ports? The ways in which different types of freight will be able to move through neighboring ports also depends on numerous business-specific factors, such as the financial and regulatory options available to a shipper or carrier, as well as on the urgency attached to specific types of cargo delivery.

An All-Hazards Approach to Contingency Planning

Although no two port disruption events are identical, and no two ports operate in exactly the same manner, sufficient similarities exist in port operations to draw useful lessons from the most common types of cargo handling disruptions. In particular, federal response to emergencies such as port disruptions has evolved since 2001 into an all-hazards approach that adopts the premise that at a suitably high level of decision making there are a common set of actions or decisions to be made that apply to a wide range of seaport disruption events (FEMA, 1996; GAO, 2007).

The past three decades have seen U.S. port disruptions come in many different forms and severity levels, occasioned by various manmade and natural causes, and with a wide range of physical and economic impacts on the ports and on their wider trading areas. These include the multi-port and protracted disruptions listed in Table 2.2.

This port disruption history also includes many other, less widespread but often costly, disruptions to freight movement through individual ports or port terminals. For example, in looking through the Major Hazard Incident Data Service database (MHIDAS, 2002), Darbra and Casal (2004) found 471 hazmat-related "seaport accidents" reported in 95 countries from 1900 to 2002, including 399 seaport-based accidents since 1981. Over half of these accidents involved some form of chemical release, followed in frequency by fires (29 percent) and explosions (17 percent). More than 56 percent of the accidents occurred during transport (mainly involving ships, but also some truck- and rail-related incidents). Incidents during loading/unloading operations, warehousing, and storage accounted for over 30 percent of total occurrences. External causes, involved in 17 percent of accidents, included high winds, sabotage, and fire. Human factors were attributed to 16 percent of accidents.

Where a disruption is either geographically widespread, such as the West Coast seaports shutdown of 2002 (Hall, 2004), or of long duration, such as the post-hurricane season recovery

Table 2.2. U.S. seaport disruption events.

Type of Disruption	Event	Year	Seaports Affected
Natural disasters			
Hurricane	Katrina	2005	Gulfport, MS; Miami, FL; Mobile, AL; Morgan City, LA; New Orleans, LA; Pascagoula, MS
Hurricane	Rita	2005	Freeport, TX; Houston, TX; Miami,FL; Morgan City, LA; New Orleans, LA; Port Arthur,TX
Hurricane	Ike	2008	Port Arthur/Beaumont,TX; Freeport, TX; Galveston,TX; Houston,TX; Texas City,TX
Hurricane	Irene	2011	East Coast ports including Wilmington and Morehead City, NC; Norfolk,VA; Baltimore, MD; Philadelphia, PA; Newark, NJ; and New York City, NY.
Superstorm	Sandy	2012	Northeast coast ports, including Norfolk,VA; Baltimore, MD; Newark, NJ; and New York City, NY.
Earthquake	Nisqually	2001	Tacoma, WA
Earthquake	Loma Prieta	1989	Richmond and Oakland, CA
Labor disputes			
Lockout	West Coast	2002	29 West Coast ports, including Los Angeles, Long Beach, Oakland and San Diego, CA; Portland, OR; and Seattle and Tacoma, WA.
Strike	San Pedro Bay	2012	Los Angeles and Long Beach, CA

Note: The list shown in this table does not include all major hurricane events over the past three decades, many of which might have caused similar levels of port disruption had their paths been a little different.

of a number of Gulf Coast ports in 2005 (Grenzeback and Lukmann, 2009), and/or involves a significant port cargo hub as in Superstorm Sandy (ASW Inc., 2013), freight movements must be considered in a broader regional, national, or international network context. In such instances, sudden shifts in goods movements across two or more terminals may place undue strain on a port's cargo handling services, representing yet one more form of disruption to normal port operating conditions. Port congestion levels may become especially high should such diversions occur during seasonal traffic peaks. For example, a major disruption to cargo throughput during late summer and fall peaking of ship traffic at the Los Angeles and Long Beach seaports could prove especially troublesome (CBO, 2006).

Port Resilience Requires Multi-Stage Contingency Planning and Implementation

Much of the post 9/11 literature on port disruptions focuses on port security issues, with increasing attention given to the broader issue of maritime-transportation involved product supply chains. Most of the specific actions recommended in the literature for mitigating the effects of a disruption fall into the following three categories:

1. Prior actions geared to avoiding or limiting a disruption's impacts (**preparedness**);
2. Actions geared to dealing with the immediate impacts of the disruption (**response**); and
3. Actions geared to getting the port back up and running again as soon as possible (**recovery** and, eventually, **resumption** of pre-incident operating levels).

Collectively, these three sets of actions seek to increase a port's resilience to threats through greater planning, redundancy, and flexibility. Planning was evident in the preparation for Superstorm Sandy (see Chapter 4 of this report)—although the anticipated landfall location and severity of impacts were not known until the day before, notifications to New York-New Jersey port tenants began several days earlier following the USCG Sector New York Hurricane/Severe Weather Plan, and the Port Authority of New York and New Jersey's Emergency Operations Plan (ASW Inc., 2013). Pre-event planning also was a key ingredient in the response to the Columbia River lock outage (see Chapter 5 of this report).

Redundancy refers to any duplication of systems necessary for accommodating throughput during, or immediately following, a port disruption. This includes redundancy in a variety of port assets in addition to transportation and cargo handling equipment. For example, a number of the 17 ports interviewed by the U.S. Government Accounting Office (GAO, 2007) reported purchasing back-up phone systems and power generators, creating alternative administrative sites, and developing alternative storage for computer information in case of emergencies. Most of this redundancy is the result of actions taken by port authorities prior to a disruption.

Flexibility, in contrast, entails redeploying existing cargo handling capacity in an effective manner. For example, normal operating practices and working hours may need to be changed in the interim. Flexibility was evident in the recovery from Superstorm Sandy—the freight railroads repositioned equipment away from the storm's path to locations where the assets could then be used to move cargo that had been diverted to Baltimore and Norfolk. Vessels docked at alternative terminals within the New York-New Jersey Harbor, as marine terminals became operational in different timeframes. Private terminal operators and labor worked throughout the weekend after the storm to handle backlogged vessels and cargo after the New York-New Jersey port was reopened (ASW Inc., 2013).

Such changes, in turn, require the necessary authority and willingness to do so, as well as the ability to inform those involved of the changes being implemented. Recognizing that actions taken during the immediate response and short-term recovery stages of an incident will go better if based on well-established and well-exercised prior event planning and training. Most studies reviewed suggest that ports and their local authorities engage in a number of these pre-event activities. Response actions then seek to limit any further damage to the port once an incident occurs, allowing for recovery to begin by fixing, replacing, or redeploying available port operating assets.

Planning and Resource Allocation Should Be Consistent with the Nature and Severity of a Disruption

Although the literature identified a number of port security and contingency response activities that have value to most types of incidents, the flexibility to adopt an all-hazards approach to deal with different types of events also is important. In particular, the physical extent and severity of the damage inflicted, the duration of the disruption to cargo movement, and the length of time between the disruption occurring and the time port authorities are made aware of the threat (see Table 2.3) can affect both how and how well a port complex can respond.

Not all port disruptions involve the entire port complex, and although the physical effects of some events may last for weeks, in other cases they are over in a few days. Public agency responses should be scaled accordingly, and planning for a range of different levels of event severity, as well as event type, makes good sense. Early assessment of event severity therefore is a very useful step in the incident identification and response process.

Port Disruptions Often Increase the Danger to People as Well as Cargo

Many types of port disruption involve danger to people as well as to cargo, and planning for such emergencies necessarily prioritizes human life and safety. Actions that protect port workers

Table 2.3. Causes and classes of disruptions to port operations.

Events with Little or No Prior Warning	*Events with Some Prior Warning*
Hazardous Materials Accidents:	**Severe Weather Events:**
Chemical Spills	Hurricanes
Oil Spills	Tsunamis
Gas Leaks	Floods
Fires	Tornadoes
Acts of Terror/Sabotage/Human Error:	Snow/Ice build-up
Explosions	Earthquakes
Chemical, radiological or biological releases (inc. Dirty Bombs)	**Labor Shortages:**
Fires	Port Lockouts
Cyber attacks on computer systems	Labor Strikes
Vessel sinkings	Work to Rule Slowdowns
Channel blockages	Epidemics (e.g., Avian Flu)
Power systems sabotage	
Train derailments	
Unanticipated equipment (truck, chassis, container, etc.) shortages	
Severe Weather Events:	
Port access route closures (e.g., due to rockslides, flash flooding, etc.)	

Source: Based on Kidby, 2008

and visitors draw on resources and set priorities that need to be recognized in pre-event planning activities as well as in the immediate response and recovery phases following an incident. For example, based on the severity of the impending storm, the Port Authority of New York and New Jersey ordered all of the maritime terminals closed to all but essential personnel the night before Sandy hit the coast, and ordered all remaining personnel and security off port facilities by the evening of the day of the storm, prior to the first anticipated storm surge. As a result, no personnel were lost during the storm (ASW Inc., 2013).

Much less dramatic but potentially protracted events (such as a port labor strike) also place a burden on maintaining safe operations during abnormal working conditions. Therefore, while the focus in this review is on issues and actions needed to keep the freight moving through a port, these actions are always subject to human health and safety concerns and to the regulations governing safe cargo handling and equipment operating practices, including potential exposure to hazardous materials.

2.3 Issues Raised by Past Port Disruptions

This section focuses on responses given by experts to port security, port resilience, or post-disruption incidence response surveys, or via panels and workshops convened to discuss these issues and typically involving a wide range of stakeholder groups. In particular, this section draws on the findings reported by Allen et al. (2003), Hultin et al. (2004), CBO (2006), Hudgins (2006), USCG (2006), Zegart et al. (2006), GAO (2007), Rice and Trepte (2010) and Berle et al. (2011a, b), as well as those reported by government agency reviews of the main elements incorporated in specific port preparedness, incident response, and recovery plans (e.g., GAO, 2012a). As a set, these sources associate the following issues with port disruptions:

- Loss of shipboard and intermodal cargo handling equipment;
- Loss of terminal/port access/egress routes;
- Loss of terminal storage space;
- Loss of navigable channel clearances (channel depths);
- Loss of navigation support vessels;
- Damage to port servicing truck, rail, inland barge, or pipeline assets;
- Loss of on-dock storage space;
- Loss/damage to within and outside port communications;
- Loss/damage to cargo/container/vessel tracking/security systems;
- Utility (power and/or water) system failures;
- Loss/lack of waste and debris removal assets;
- Lack of availability of transportation fuels;
- Lack of availability of financial resources;
- Lack of availability of labor; and
- Uncertainty/lack of coordination among responding agencies.

For example, CBO's (2006) look at container port disruptions identifies the following physical components as key aspects of port throughput capacity:

- Channel depth (a ship size restriction);
- Number of berths (number of ships processed at one time);
- Capacity of container loading/unloading equipment (cranes, etc.);
- On-dock storage space and equipment for moving containers to local terminals (or to storage and distribution centers farther inland);
- Intermodal connections for loading containers on trucks or rail cars;
- Truck fleet and railcar capacity; and
- Skilled labor, in order to fully utilize cranes for loading and unloading tasks, etc.

Loss of on-dock storage space was noted as a potentially expensive bottleneck. As the stacks of containers on a dock grow, the process of sorting, locating, and moving individual containers to specific terminals can "quickly bog down."

Sufficient truck and rail capacity must be available to carry these containers away. Constraints on rail capacity are considered to have contributed to a slowdown in the distribution of U.S. imports in late 2004 (CBO, 2005). Structural damage to buildings and piers, and silting and debris clogging key waterways were two significant problems reported to the GAO's (2007) survey of seaports impacted by the 2005 hurricanes in the Gulf of Mexico, as well as Superstorm Sandy (ASW Inc., 2013). Port authorities also reported difficulties restoring power, water, and other utilities.

Proposing a supply-chain-based business continuity plan for dealing with maritime system disruption, Berle et al. (2011a) carried out 16 semi-structured interviews with terminal operators, port authorities, and the USCG in selected ports in California, Texas, New York, New Jersey, and Panama; also drawing on empirical evidence from two MIT Center for Transportation and Logistics (CTL) surveys, as follows:

- From the MIT CTL Port Resilience Project—some 525 respondents, including shippers, port authorities, and terminal operators provided insight into disruptions in the port environment (Rice et al., 2010).
- From the 2010 MIT CTL Global Risk Survey—involving 2,400 supply chain respondents worldwide (Arntzen, 2011) who were asked about the importance of failure modes on major supply chain disruptions. In responding to questions about importance and frequency of failures, the loss of materials supply and interruptions to internal operations topped the list of concerns. Loss of communication was rated as the third most important failure mode. Financial flows (access to capital resources and liquidity of cash) and labor availability were also mentioned, if with less frequency.

Based on these responses, the authors identify the following six "failure modes" associated with maritime-transportation supply chains: "loss of capacity to supply, financial flows, transportation, communication, internal operations/capacity and human resources." Under each of these modes, they identify failures in the supply chain associated specifically with the loss of functionality at ports, at terminals, at intermodal connections, in navigable waterways, and in vessels (Berle et al., 2011a, Table 3; Rice and Caniato, 2003; Berle et al., 2011b).

Capacity to supply refers to the availability of a wide range of different physical assets that support port and terminal activity, including infrastructure; spaces to maneuver in; utilities such as electricity, water and waste treatment; fuel; availability of navigational support and safety vessels; navigable channels and dredging equipment; heavy lift equipment; and the fleet of cargo vessels themselves. *Transportation* refers to the ability to move goods and people within and through a port, a terminal, an intermodal connection and a navigable waterway, as well as the ability maneuver the maritime vessels themselves. This requires trucks and trains, as well as tugs, lifts, stackers, gantry cranes, chassis, and other port/terminal/navigable channel maintenance vehicles and vessels. *Internal operations/capacity* refers to the ability to efficiently and safely position, load/unload, process, and document a large volume of goods movements associated with storage, maritime vessels, and ground transportation modes by ensuring sufficient berthing, storage and transloading space, loading gear, pumping capacity, bridge and channel clearances, etc. Problems with *financial flows* are associated with loss of liquidity (i.e., running out of cash) while credit tightens, and customer payments arrive late. Among their findings, Berle et al. (2011a) conclude that "while stakeholders in the [maritime transportation] industry have a solid focus on frequent operational risks, there is a lack of awareness of vulnerabilities, as well as methods for addressing and planning for low-frequency high-impact disruption scenarios," and that "supply chain stakeholders in general are focused on prevention and frequencies rather than preparing to respond after incidents have occurred."

Hudgins (2006) reports the results of splitting members of the American Association of Port Authorities (AAPA) Security Committee into four groups, and asking each group to develop a list of their top areas of concern with respect to emergency preparedness. Common to all four groups were concerns over the following:

- Communications (e.g., phone lists for personnel recalls);
- Port access control (e.g., letters of authorization);
- Port re-entry procedures (e.g., re-entry passes); and
- Providing safe accommodations for essential personnel.

In looking specifically for ways that local agencies could improve their terrorism response plans at the Los Angeles and Long Beach ports complex, Allen et al. (2003) conducted more than six dozen interviews with elected officials, agency leaders, private stakeholders, and first responders. Their study identified three broad policy problems that may hinder efficient and effective emergency response as follows:

1. Inaccessibility of the port complex—Poor vehicle access may prevent first responders from reaching the facility and assisting victims;
2. Oversight and coordination—Local political decisionmakers do not sufficiently oversee emergency response planning and key stakeholders are absent from the planning process; and
3. Incompatible communication systems—Differences in radio technologies prevent agencies from communicating during a response and from coordinating emergency response efforts.

All three issues are identified in other studies.

Port Access Issues

Bringing additional labor into the port to deal with a disruption to cargo movement, whether this involves longshoremen, law enforcement, fire prevention, hazmat teams, vessel/vehicle repair, or debris removal crews, requires adequate pre-planning as well as agreements between labor unions and port management. It is also important that port and emergency response officials understand the potential dangers associated with bringing labor from outside or from other parts of a port to deal with fires or incidents that may involve exposures to hazardous materials (Ranous, 2012). Poor labor credentialing has been a problem on occasion. Truck drivers entering a port must have a Transportation Worker Identification Credential (TWIC) card, and most U.S. ports also have their own local registration system for drivers. In some cases (e.g., Gulfport during Katrina, Houston during Rita), U.S. port officials and laborers who might have speeded up a port's recovery had difficulty re-entering a Gulf seaport after the 2005 hurricanes because they lacked the credentials required by local police and other emergency management officials (GAO, 2007).

Where the use of labor during contingencies is concerned, inevitably there are legal and liability issues. The Infrastructure Security Partnership (TISP, 2011, p. 30) provides the following list of workforce policy issues: "compensation, prolonged absences, social isolation, and removal of potentially contagious employees, safe workplace rules, flexible payroll issues, contractual issues, information from/coordination with regulators; privacy issues; ethical issues; union-related issues; liability associated with vaccine distribution and administering."

Need for Oversight and Coordination among Responding Agencies

During a port disruption event, a good deal of importance attaches to the actions of key decisionmakers. This means identifying these people and their roles prior to a disruptive event. Mansouri et al. (2009) point out that these decisionmakers need to have a clear understanding about sources of uncertainty and possible consequences of unprotected vulnerabilities that threaten the port system if they are to respond to incidents in a timely and efficient manner.

The topic of interagency coordination is one addressed repeatedly in post-9/11 literature, which recognizes that the complexity of modern port operations has become a major cause of difficulty in implementing effective port security and incident response protocols (Hecker, 2002; Harrald et al., 2004; DOJ, 2006; Robinson, 2006; Barnes and Oloruntoba, 2009; Lane, 2009; GAO, 2012b). Command and control is often fragmented by the legal jurisdiction of the different federal, state, and local government agencies and the often overlapping nature of their responsibilities. For example, the Port of New York and New Jersey is the owner of its port facilities, but it lacks control over the movement of cargo, people, and trucks on the property. "In most ports, the Port Authority operates the port. Here they are just the landlord and act as a facilitator. Terminal operators here are major players" (Hultin et al., 2004, p. 18).

Providing supporting evidence, a GAO (2005a) analysis of 85 USCG exercises to test aspects of the Coast Guard's terrorism response plans revealed four common problem areas:

- Communication problems among different agencies,
- Inadequate and uncoordinated resources,
- A lack of knowledge or training in the incident command structure, and
- A lack of knowledge about who has jurisdictional authority.

A subsequent GAO (2007) study, drawing on the experiences of officials and other stakeholders at 17 of the U.S. seaports impacted by Hurricanes Katrina, Rita, and Wilma in 2005 reported that some port authorities had difficulty accessing both federal and regional FEMA and MARAD resources in their recovery efforts and also ran into problems with filling out the appropriate forms for disaster relief aid. Similar concerns are expressed by Zegart et al. (2006). In interviews with stakeholders associated with the Ports of Los Angeles and Long Beach, several port security officials expressed concern that ambiguities in federal and state guidelines, coupled with natural bureaucratic rivalries, posed a risk of coordination breakdowns during incident response.

Several U.S. seaports have responded to these interagency coordination and communication issues. During the post-2005 hurricane season in the Gulf, the Port of Mobile formed a task force that includes the following:

- Port authority police chief;
- Harbormaster;
- Environmental, health, and safety manager;
- A member of the county emergency management agency; and
- Representatives of the port's rail, cargo, intermodal, and development divisions.

At the Port of Houston, the USCG used its authority to mandate the creation of port coordination teams that include all port stakeholders, with team composition changing to match the nature of the threat. "For security threats, the teams are organized geographically and do not require that the entire port close down, thereby appropriately matching resources to the threat being faced. For natural disasters, the teams are organized functionally because of the more dispersed nature of the threat" (GAO, 2007).

More recent site visits to the ports of Tacoma, Oakland, Houston, Mobile, Gulf Port, Miami, and Savannah by GAO (2012b, p. 1) found that "efforts to incorporate resilience into these programs and assessments were evolving. . . . However, we also found that program management could be strengthened. We recommended that [the Office of Infrastructure Protection], IP, develop performance measures to assess the extent to which asset owners and operators are taking actions to resolve resilience gaps, and also update guidance for its Protective Security Advisors (PSA), who serve as liaisons between DHS and security stakeholders—to include asset owners and operators—in local communities." Ensuring continued and sustained stakeholder enthusiasm and momentum post-incident is an important topic here (TISP, 2011, p. 34).

Need for Compatibility in Real-Time Communications Technologies

Real-time communications are essential to rapid and effective response during a disruption. Coordination between responsible and responding parties is otherwise severely compromised. For example, differences in radio technologies can prevent agencies from communicating during emergency response efforts (see Allen et al., 2003, who identified this as an issue at the Los Angeles/Long Beach port complex). The same comment applies to computer software and the databases it accesses, including both front-line and back-up systems that may be called upon to preserve commercial trading as well as security and safety data. Noting a trend in recent years for many trading firms to coordinate their activities both internally and externally via multi-enterprise supply chains, Carbone and De Martino (2003) refer to such activity as integrated supply chain management (SCM). Where ports are concerned, this means coordinating the movement of products between suppliers, carriers, distributors, and customers and their various brokers. The goal is to get all of these stakeholders to use a "common platform of logistics transactions and information systems" as they apply to cargo moving through a port.

A loss of access to skilled labor can result from an inability to contact the workers needed. During an emergency, getting the necessary responders to the port complex may prove challenging. For example, Allen et al. (2003) and Zegart et al. (2006) noted that between the Los Angeles Port Police, Port of Long Beach Harbor Patrol, Los Angeles Fire Department, Long Beach Fire Department, and USCG, only about 100 sworn law enforcement officers and firefighters were on duty at the port during a typical shift, and that a significant port disruption incident would require considerable additional manpower to be drawn in from, in this case, a rather large, surrounding county. According to GAO (2007), a significant number of the port authorities impacted by the 2005 hurricane season reported problems caused by extensive telephone outages and limited cell phone reception. "For example, one port [Mobile] was without services for 2 to 4 weeks following Hurricane Katrina." This loss of communications led, among other problems, to difficulties in contacting those port personnel who had been forced to abandon their homes during the hurricane. Superstorm Sandy also identified that insufficient fuel supplies combined with significantly damaged transit systems can hinder the ability of labor to commute to port terminals (ASW Inc., 2013). Rao et al. (2007) provides an overview of IT benefits and opportunities associated with disaster management.

Need for a Back-Up in Case of Cyber System Failures

Modern information technology (IT) goes well beyond direct person-to-person communications, and includes a growing list of technologies that can help to identify and subsequently respond to an impending threat (including sensor technologies, identification and authentication technologies, screening technologies, surveillance technologies, anti-tamper technologies, and tracking and inspection technologies [Stowksy, 2006]). IT also includes the day-to-day cargo manifesting and tracking systems used by supply chain participants. The more port authorities become dependent on these automated/semi-automated systems, the greater the potential impacts from a temporary loss in communications/computer power/database access due to incident-induced damage or disruption. Resilience through redundancy, in the form of back-up IT systems can be very expensive, but may be a necessity in today's business world. Superstorm Sandy demonstrated the need for such resiliency during the prolonged power and communication grid disruptions following the storm combined with loss of port offices. A scan of the Internet also reveals the response to the superstorm demonstrated the usefulness and effectiveness of social media (e.g., LinkedIn, ConstantContact, Facebook, and Twitter), which was used by both public and private organizations to disseminate information, conditions, and needs (ASW Inc., 2013). Brodeau and Graubart (2011) provide an extensive review of cyber resiliency issues.

2.4 Promising Practices and Possible Planning Frameworks

Bringing the different aspects of the port resiliency and business continuity problem together represents a significant challenge for the individuals and agencies involved. A port authority and its supporting state and local emergency response agencies must be able to utilize the port's physical/logistical assets (its channels, docks, cranes, ships, trucks, railcars, etc.), transactional/informational assets (communications systems, computer systems, fuel, water, waste and power control systems, etc.) and its oversight/institutional systems (port emergency points of contact, first responder and other contingency plan protocols and notification systems, command and control procedures, roles and responsibilities) to act effectively prior to, during, and for some time after whenever a significant disruption to cargo movement occurs. Where necessary, additional assets may be requested via federal government sources, creating the need for additional interagency coordination and cooperation.

Figure 2.4 summarizes this idea, representing a port as a complex intermodal node within the nation's multimodal transportation network—one that draws on a range of institutional responses that need to be communicated via an increasingly sophisticated set of information gathering and processing technologies, into a set of physical actions that cause cargo to pass through the port.

A long list of port assets may be impacted or otherwise involved. Table 2.4 provides a sample port asset sensitivity to threat matrix that includes the principal physical/logistical assets discussed in Section 2.3, and the most commonly reported types of physical asset disruption, (from collapsed buildings and flooding to fires and explosions, hazmat releases, backups in truck or railcar traffic within or leading into or out of the port complex; power, fuel and labor shortages;

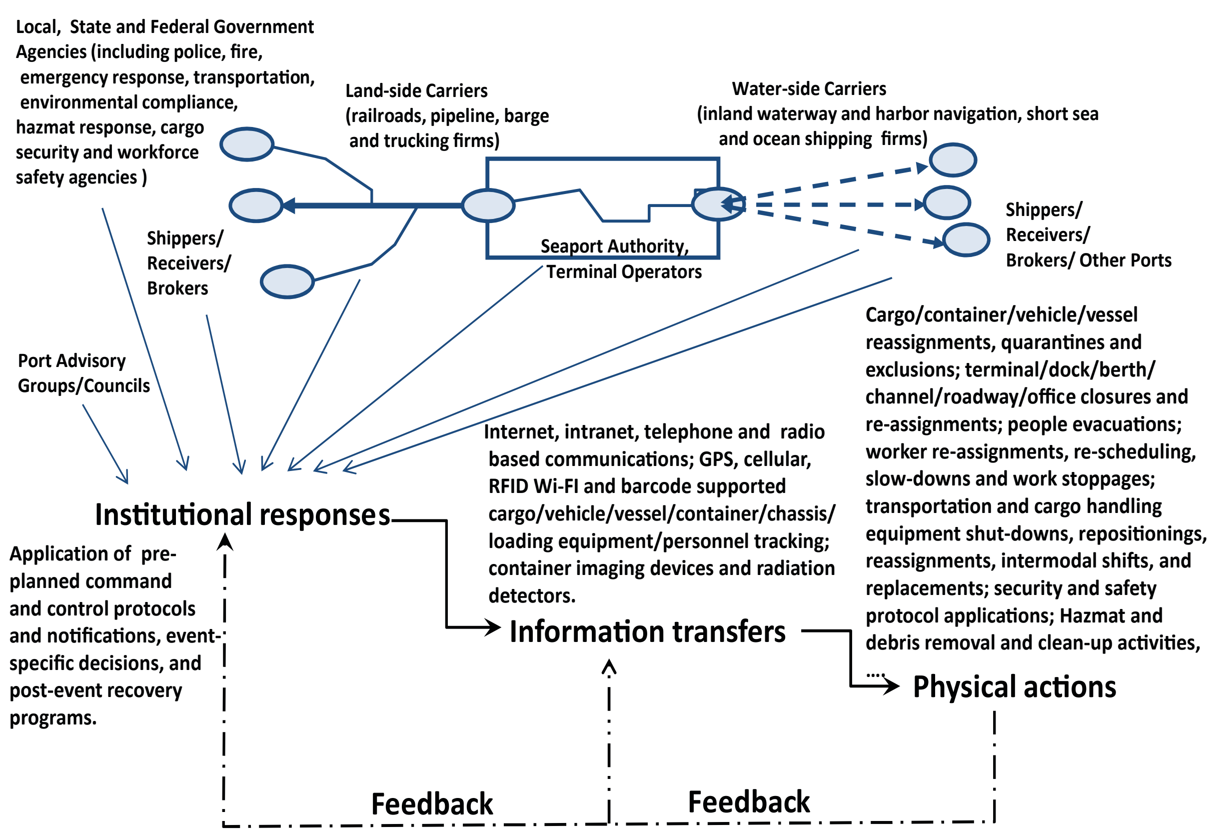


Figure 2.4. Agents and activities associated with a port-based supply chain disruption.

Table 2.4. Example high-level asset sensitivity to threat matrix.

	Causes of Disruptions: Hurricanes/High Winds, Tsunamis, Heavy Storms, Earthquakes, Terrorism, Vandalism, Work Accidents, Labor Disputes, Epidemics, Re-directed Freight (from Other Port Closures), Snow/Ice Storms, Very Low Temperatures										
	Physical Characteristics of Disruptions										
Assets Affected:	Collapsed & Damaged Structures*	Flooding	Land Subsidence	Explosions	Fires	Hazmat Exposures	Truck, Rail and/or Water Traffic Back-Ups	Power Outages	Breaks in the Fuel Supply	Workforce Slowdowns & Stoppages	Cyber Failures**
Within Port Buildings:											
Terminal Storage Areas											
Terminal Load/Unload Areas											
Terminal Approach Areas											
Port Offices											
Outside Port Buildings:											
Consolidation/Distribn. Centers											
Temporary Cargo Storage Areas											
Transport Modes:											
Rail:											
Load/Unload Points											
Outside Port Tracks											
Within Port Tracks											
Trains (Engines, Railcars)											
Highway:											
Load/Unload Points											
Port Gates											
Port Approach Roads											
Within Port Roads											
Trucks											
Water:											
Docks/Berths											
Main Channel											
Side Channels											
Ships											
Barges & Tows											
Navigation Support Vessels											
Debris Removal Vessels											
Dredging Equipment											
Pipelines:											
Oil/gas pipelines											
Oil/gas storage tanks											
Cargo Handling Equipment:											
Conveyors											
Cranes											
Forklifts											
Pallettes											
Containers:											
Boxes (TEUs, FEUs)											
Chassis											
Port Security System:											
Equipment Tracking Systems											
Motion Sensors											
Early Warning Systems											
Power/Utility Systems:											
Port Lighting											
Heating/Cooling Equip.											
Water											
Waste Disposal Equip.											
Hazmat Containment Equip.											
Communication Systems:											
Computers/ Internet (Intranets)											
Telephones											
Back-Up Systems (e.g., Radios)											
Port Employees:											
Port Labor											
Port Management											

* including buildings, roads, bridges, tracks and waterways; **including computer and electronic communication, including workforce assignment, cargo billing and cargo tracking system outages.

cyber breakdowns). Past causes of such asset breakdowns are also shown (e.g., severe weather, sabotage, etc.), once again reflecting an all-hazards approach. Similar sensitivity matrices might be developed for the transactional/informational and oversight layers discussed in Section 2.2.

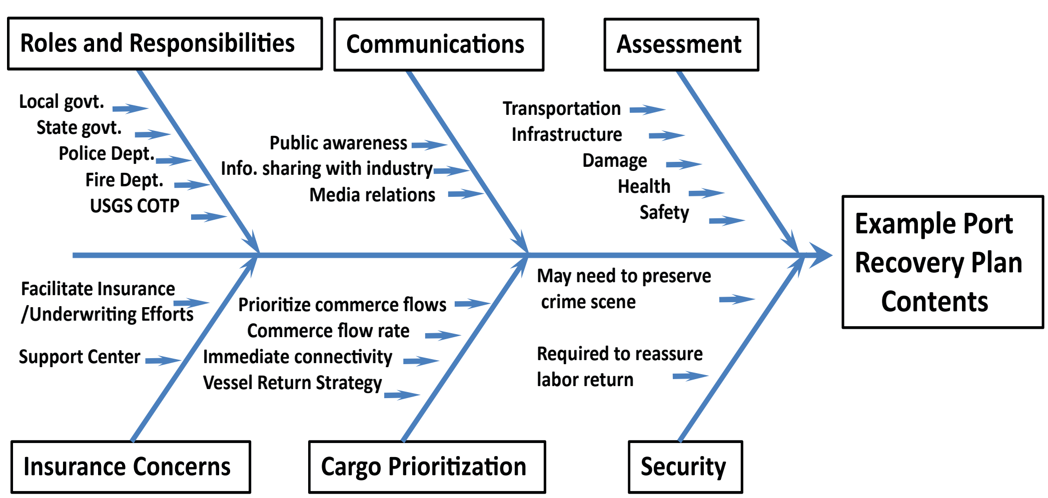
The rest of this section looks at some recent efforts to identify actions that need to be taken and planned for to mitigate the effects of port disruptions, and tries to put these actions into a broad order of priority. Whether seen as components of an action plan or more generally as a framework from which to develop such a plan, each of these studies offers useful insights into the disaster pre-planning, response, and recovery process. In particular, the discussion draws on the findings reported by Allen et al. (2003), Breaux (2006), Eldridge (2006), Perrone (2006), GAO (2007), Pate et al. (2007), Mansourri et al. (2009), USCG (2009), ICF International and PB Americas (2011), Loh and Thai (2012), and Ranous (2012).

It is useful to begin with the detailed Marine Transportation System (MTS) Recovery Plan produced by the USCG Commander for Long Island Sound (USCG, 2009). This report provides a series of detailed Emergency Recovery Decision Matrices (USCG, 2009, pp. 70–75) under the following headings:

- Traffic Management during an MTS Recovery Port Evacuation,
- Mass Evacuation of People from the Port area during MTS Recovery,
- The Challenges of Controlling Vessel Traffic during a Port Evacuation in MTS Recovery,
- Coordination of Emergency Services during a Port Evacuation in MTS Recovery, and
- SAFE Port Operations.

A series of fishbone diagrams is used to illustrate the main issues and their connections under each of these headings. Stepping back a little from these details, Figure 2.5 illustrates six main topics and associated issues recommended for consideration during the preparation of a port recovery plan—to which two additional issues could be added—fuel supply and debris removal, as most recently evidenced by the 2012 to 2013 aftermath of Superstorm Sandy.

Roles and responsibilities should be clearly identified for port stakeholders under the Incident Command System (ICS). Any incident requiring the closure of a port would be run utilizing the ICS, preferably using a unified command structure that brings together all of the incident commanders of the major organizations involved in the incident.



Source: Based on USCG, 2009, p. 74

Figure 2.5. High-level issues associated with port recovery planning.

Communications among responders, port stakeholders, media, and the public has been identified as a consistent problem and one that must be addressed in any operational plan. "Just as important, a clear, accurate, and unified message must be presented to the public, media, and most importantly to the port stakeholders" (USCG 2009, p. 75). It is also seen as the responsibility of the unified command to convey to the port workers that it is truly safe to begin recovery.

Assessments are needed to determine the suitability of the port to restart any of the operations that were shut down by the incident. Typically, these would include assessment of the condition of the transportation assets in the port, its infrastructure, as well as health, safety, and damage assessments. The report recommends the use of thresholds to determine when people and businesses can resume operations, and the development of contact checklists for use by assessment teams.

Cargo prioritization rules are needed, and an acceptable cargo flow rate possibly targeted. Who should make cargo priority decisions? What roles will the government (local, state, federal) play in this process? How will labor availability affect such planning?

Security issues are looked at from two perspectives: how does security affect the actual recovery process, and what is the need to preserve a crime scene? The question of what needs to be in place for the security aspects of the port to be reactivated should also be added. For example, after Superstorm Sandy, security fencing and gates had to be repaired prior to the resumption of port operations.

Given the considerable uncertainty and complexity surrounding what have become multi-agency port security operations, Pate et al. (2007), when reporting to the DOJ, used a case study methodology to look for successful security practices associated with terrorist events. Selecting 17 U.S. seaports (San Diego, Los Angeles, and Long Beach, California; Jacksonville, Tampa, Fort Lauderdale, and Miami, Florida; New Orleans, Louisiana; Houston, Galveston, and Texas City, Texas; Charleston, South Carolina; Savannah, Georgia; Port of Virginia, Virginia; Boston, Massachusetts; Seattle and Tacoma, Washington), and with a particular focus on the use of inter-governmental and public-private agency partnerships, a number of promising practices based on the expert opinions of port personnel were identified. The study considered each port's preparedness for, response to, and recovery capabilities after a potential terrorist attack. Specifically, ports were asked to describe their plans to mitigate the effects of a potential attack, to assure continuity of port operations, and to expedite the recovery of maritime infrastructure.

As part of a port's preparedness, three important practices were identified: training, field exercises, and the use of models, simulations, and games. Site visits also identified a number of promising incident response practices, with many of the ports visited using an ICS to deal with the uncertainty and fast collaborative/multi-agency actions required when responding to an attack. Under this system, the agency chosen to oversee emergency operations depends on the nature and location of the event. In particular, it highlights the idea of a unified command approach in which agency managers share decision-making responsibility within a group, while individual agencies maintain operational control over their own assets and personnel. The authors note that "such a system allows agencies to adapt to changing situations by avoiding a rigid organizational structure, but it hinges on informal trust, cooperation, and institutional knowledge about which agency leads under what circumstances" (Pate et al., 2007, p. 14). Seattle's Marine Terrorism Response (MTR) Project, Boston's Maritime Incident Resources Training Partnership (MIRT), and the local participation in the DHS-developed Port Security Exercise Training Program (PortSTEP) are referred to as good examples of incident response preparedness. Emphasizing the need for response exercises, training courses, and a strong team response, the authors cite promising multi-agency, team-based responses in the ports of Boston, Massachusetts; Charleston, South Carolina; Houston, Texas; and Port of Virginia, Virginia that help to coordinate firefighters and hazmat response, establish information centers for collating and distributing emergency information to port stakeholders, and use public-private partnerships to provide specialized equipment to handle certain types of emergencies (e.g., since the 9/11 attacks, FEMA has been directing grants to fund civilian Community Emergency Response Team programs in all 50 states to educate people about preparedness for disasters and train them in basic disaster response skills).

In considering port recovery actions, Pate et al. (2007) concluded that compared to the other four areas already discussed (i.e., port awareness, prevention, preparedness, and response to an attack), "we did not learn about very many promising practices in the area of recovery on our site visits." Exceptions here included recovery implementation planning in Galveston/Houston, Texas; Los Angeles, California; and Seattle, Washington. In the Houston/Galveston area, officials established Port Coordination Centers (PCCs) to inform and advise on port operational and infrastructure needs, including security concerns that arise in the case of an emergency. These centers can convene functionally in the case of a natural disaster, or geographically in the case of a security incident (another aspect of an all-hazards approach). Each PCC "designates a liaison officer to a regional Port Coordination Team (PCT) in order to establish shipping priorities, manage the flow of vessel movements, preserve safety and security, and implement established emergency protocols. The PCT's role is to disseminate information concerning the nature of the threat, implement protective strategies, continue communication to update the strategies, and reopen the port in an orderly manner" (Pate et al., 2007, p. 16).

Pate et al. (2007) highlights the use of consequence management (CM) by a number of ports. CM involves a formal process for the restoration function after a catastrophe. Based on their discussions with port officials, the authors recommend, "ports should consider adopting a consequence management awareness/training program and a certification process for all levels of response, to avoid disparate approaches that could inhibit communication and coordination. Second, it is important to identify, train, and mentor individuals within organizations on consequence management. Third, ports should develop a tiered continuum of response." Noting that local responders will have to carry the burden of the immediate response, and drawing on an article about CM by Seiple (1997), modified slightly here, it was suggested that ports make use of the following actions:

- Establish coordination mechanisms to oversee the entire immediate response,
- Plan for the use of federal assets to augment the existing response,
- Examine the role of the military's reserves as needed in a tiered response between the first responders and the arrival of federal help,
- Plan for surge capacities that will be needed for different types of response,
- Develop plans for tactical coordination at the incident,
- Develop evacuation plans,
- Decide who will handle the information campaign,
- Plan for the role of medical facilities, and
- Ensure that local fire and police departments are prepared to work together.

A clear lesson from the literature is the need for sound pre-incident planning or preparedness as it is referred to above. This was a theme for a number of presentations by port officials at a 2006 AAPA Emergency Preparation and Response Seminar in Portland, Oregon (see http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762), that looked at different aspects of port response and recovery planning. In planning to deal with the financial, administrative, and personnel issues associated with a disruptive event, Eldridge (2006) emphasizes coverage of the 5Ms—money, manpower, machines, materials, and methods; while McDonough (2006) lists the following steps in recovery planning for container, Ro-Ro, and non-petroleum bulk vessel operations (through New York):

1. Return labor to the port;
2. Complete work on berthed vessels;

3. Prepare berthed vessels for departure;
4. Move outbound vessels in order of Vessel Management Plan (VMP) inbound berth requirements;
5. Move inbound/priority vessels to berths;
6. Rotate all vessels in accordance with VMP until backlog eliminated;
7. Return to normal operations, reposition surge equipment; and
8. Draft the after-action report.

Where VMP refers to a Vessel Management Plan, it is based on the following information:

- A list of vessels, inbound and outbound;
- The order of arrival for inbound vessels;
- The designated berths for inbound vessels;
- The loading status for outbound vessels;
- Required intraport movements;
- A listing of priority cargos, inbound and outbound;
- The required tugs, pilots, and bunker vessels;
- The required number of gangs, mechanics, etc.;
- As well as a detailed inventory (vessel frequency requirements; berth availability; terminal capacity; equipment availability and capacity; productivity (vessel and field); estimated cargo/vessel clearance times; off-terminal empty storage capacity; intermodal capacity and road/rail access issues; labor assets; and labor skills inventory) of port or terminal cargo processing assets.

Perrone (2006), reflecting on experience with security issues at the Port of Long Beach, identifies the following program management tasks associated with regional business and government continuity planning during significant port disruption events:

- Damage and safety assessments;
- Structural inspections;
- Mitigation and construction activities;
- Personnel availability;
- Business processes, vendors, suppliers;
- Utilities restoration;
- Land and water transportation restoration; and
- Prioritized restoration of business and government.

Perrone also offers a view of business continuity after a disruption event as the outcome of four largely parallel processes: emergency management (people evacuations and recovery of facilities), crisis management (corporate and local command, control, communication, and collaboration), business resumption planning (involving both people and business processes), and IT disaster recovery planning (leading to the availability of a working IT system).

Mansourri et al. (2009) propose a three-stage risk management (RM) approach to increase port resilience based on (1) assessing vulnerabilities, (2) devising resilience strategies, and (3) valuing alternative investment strategies. Assessing vulnerabilities includes identifying critical risks, selecting one or more of these risks for further attention, and creating a probability-based risk profile for each of the risks (disruptions) identified. Devising resilience strategies for these risks then involves brainstorming response strategies among stakeholders and identifying the costs associated with each strategy. Under devising resilience strategies, the authors distinguish between identifying resiliency barriers to external shocks, notably the creation of redundancy, such as the provision of extra wharfs, and developing Resiliency Contingencies applied to the support of internal port operating practices, such as the use of more effective container tracking systems. A third stage (of less immediate interest to the present paper) then involves using formal decision analysis tools such as Decision Tree Analysis and Options Analysis to place a cost and value on these different response strategies.

Prioritizing Response and Recovery Actions

Following Hurricane Katrina, the USCG conducted efforts to identify additional recovery-related elements and incorporate them within its AMS Plans, to help ensure a consistent approach to MTS recovery and trade resumption. AMS Plan guidance provides general priorities for waterway/port area recovery, which are intended to be used as an initial planning guide and adjusted as needed for individual port areas, as follows (GAO, 2012a, p. 9):

1. Major transportation routes needed for first response and emergency services including evacuation routes, tunnels, bridges, and key waterways;
2. Main shipping channels critical for homeland security and homeland defense operations;
3. Port areas and channels critical for military traffic or out-loads;
4. Main shipping channels critical to major commercial operations;
5. Other maritime infrastructure, operations, and structures critical to the operation of the port/waterway identified by the AMS assessment;
6. Secondary bridges and tunnels;
7. Secondary commercial waterways; and
8. Public/recreational waterways.

The federal Security and Accountability for Every Port Act of 2006 (the "SAFE Port Act") also required that AMS Plans include a Salvage Response Plan that identifies available equipment and other resources necessary for clearing waterways, to enable resumption of port commerce "as quickly as possible following a TSI."

The Infrastructure Security Partnership publishes a regional disaster resilience (RDR) guide to developing an action plan, in the form of a roadmap that describes "a step-by-step process that can be customized to develop a cross-sector, multi-jurisdiction strategy to improve capabilities to deal with any major incident or disaster" (TISP, 2011). Although not port focused, the guide targets, and suggests prioritizing, actions by local and state officials (among others), while promoting an all-hazards approach that emphasizes information sharing, public-private-sector partnering, and multi-jurisdictional collaborations. As part of a high-level, 14-focus area guide to resiliency planning, Focus Area 8 addresses the following continuity of operations and business priority issues:

- Pre-event preparedness, mitigation (remote siting, back-up systems and built-in redundancies, preservation of vital records, etc.);
- Identify operational challenges associated with loss of services/damage to assets;
- Ensure essential staff, including technical experts and general workforce;
- Ensure access to information and situational awareness;
- Address challenges for small and medium businesses;
- Identify essential operations and business activities;
- Assess potential disruptions to operational and business services, including logistics, suppliers, customers, availability of truck drivers, warehouses, etc.;
- Set up business liaison with Emergency Operations Center;
- Address administrative, budget issues;
- Address workforce policy issues (compensation, absences, isolation, and removal of potentially contagious employees, safe workplace rules, flexible payroll issues, etc.);
- Assist small businesses for contingency planning/continuity of operations;
- Involve businesses in unconventional threat preparedness activities;
- Notify and provide employee information;

- Train employees; and
- Test continuity plans and procedures.

These issues overlap with issues dealing with ensuring resiliency in energy, transportation, cyber security and information systems, and water and waste water, and supporting medical and healthcare systems.

ICF International and PB Americas' (2011) assessment of the impacts of climate change and variability on port assets in 61 marine terminals in Mobile County, Alabama, led them to suggest the following criteria be used to prioritize the criticality of the county's marine network assets:

- Socioeconomic
  – Part of national and international commerce systems
  – Important multimodal linkages
  – Functions as community connection
  – No system redundancy
  – Serves (Mobile area) economic centers
- Operational
  – Use of, and demand for, a facility
  – Port capacity
  – Port cargo value
  – Operations
  – Channel berth and depth
  – Maximum vessel size
- Health and Safety
  – Identified in evacuation plans
  – Component of disaster relief and recovery plan
  – Identified hazardous materials transfer point
  – Component of national defense system
  – Provides materials to health facilities

2.5 Summary

Based on the literature reviewed, disaster planning and the actions that result from it involve solutions that include a combination of physical/logistical, informational/transactional, and regulatory actions. They also involve significant investments of financial, physical, and manpower resources in each of the three stages of pre-event preparedness, incident response, and port recovery. Actions taken during each of these stages, while generic at a reasonably high level of abstraction, need to be tailored to a particular port event based on the following specifics:

- The type (cause) of the disruption
  – Natural disaster (hurricane/tsunami/severe storm/earthquake)
  – Labor strike (port, railroad, or trucking industry strike)
  – Terrorist acts (bombing, arson, or sabotage)
- The speed of onset and severity of the disruption
  – Geographic extent—from a single terminal or port connector to an entire seaport or region
  – Extent of prior warning
  – Likely economic (trade) impact
  – Duration—from loss of operations lasting a few days to many weeks
  – Seasonality—whether the disruption occurs during a peak shipping season
- The classes and volumes of freight to be moved
  – Container freight
  – Break bulk cargo

  - Dry bulk
  - Liquid bulk (petroleum and non-petroleum)
  - Special freight
  - Roll on-roll off
  - Military cargo
- The modes of transportation affected and involved in cargo transfers
  - Water (deep sea, intra-coastal, Great Lakes, inland)
  - Truck
  - Rail
  - Pipeline
  - Air cargo
- The institutional (public/private sector) nature of a port's operations
  - Command and control authority during contingencies (who decides, lines of command and communication, use of prepared action plans)
  - Asset ownership (terminals, land, vessels, intermodal equipment and facilities, cargo, communication and IT systems, etc.)
  - Control over asset utilization (navigation, loading/unloading, cargo screening, cargo storage, utilities, and water supply, etc.)
  - Port (longshoremen, management, etc.) and local authority (fire, police, medical, etc.) labor and their availability and work arrangements
  - Financial resources (availability and authority to use)
  - Legal and insurance issues as they affect workers, responders, cargo, equipment, and facilities
- The involvement of local, regional, and federal government
  - Safety compliance
  - Environmental compliance
  - Security compliance
  - Credentialing
  - Cargo clearance and inspection
- The response of freight shippers, carriers, and brokers to the disruption, and notably with respect to extent, timing, and duration of cargo rerouting and diversion to other ports.

The challenge is to capture the practicalities implied by the many different dimensions of a port disruption event, in both an orderly and repeatable manner. The extent to which this is feasible will determine the level of abstraction, and therefore ultimate usefulness, of any high-level "rules of thumb" for responding to port disruption and recovery (see Chapter 6).

2.6 Literature Review References

AAPA (2009) *Emergency Preparedness & Continuity of Operations Planning Manual for Best Practices.* AAPA. http://www.aapa-ports.org/Issues/IssueDetail.cfm?itemnumber=1161 Accessed 1/24/2013.

Abt Associates (2003) *The Economic Impact of Nuclear Terrorist Attacks on Freight Transport Systems in an Age of Seaport Vulnerability*. DTRS57-03-P080130. Report prepared for U.S. DOT/RSPA/Volpe National Transportation Center, Cambridge, MA.

Allen II, W. T., Clampitt, A., Hipp, M. and Jacobson, S. (2003) *Port Security Applied Policy Project: Recommendations to Improve Emergency Response Capabilities at the Port of Los Angeles and the Port of Long Beach.* University of California, Los Angeles, CA. http://www.belfercenter.hks.harvard.edu/files/psapp_042103.pdf Accessed 1/23/2013.

Arntzen, B. (2011) "Global Differences in Supply Chain Attitudes," in *Global SCALE Risk Initiative.* Massachusetts Institute of Technology, Center for Transportation and Logistics: Cambridge, MA.

ASW, Inc. (2013) *Superstorm Sandy: Framing the Discussion of a Supply Chain Disruption and Transportation Outlooks.* A. Strauss-Wieder Inc. FHWA Talking Freight Seminar, January 23, 2013.

ASW, Inc. (2010) *Economic Impact of the New York-New Jersey Port/Maritime Industry*, Prepared by A. Strauss-Wieder, Inc. for the New York Shipping Association.

Barnes, P. and Oloruntoba, R. (2009) "Assurance of Security in Maritime Supply Chains: Conceptual Issues of Vulnerability and Crisis Management." *Journal of International Management 11:*519–540.

Bassan, S. (2007) "Evaluating Seaport Operation and Capacity Analysis—Preliminary Methodology." *Maritime Policy and Management 34(1):*3–19.

Berle, O., Rice, J. B., and Asbjørnslett, B. E. (2011a) "Failure Modes in the Maritime Transportation System—A Functional Approach to Throughput Vulnerability." *Maritime Policy and Management 38(6):*605–632.

Berle, O., Asbjørnslett, B. E., and Rice, J. B. (2011b) "Formal Vulnerability Assessment of a Maritime Transportation System." *Reliability Engineering and System Safety 96:*696–705.

Breaux, D. (2006) *Preparation through Planning. Port Operations and Facilities.* AAPA Emergency Preparation and Response Seminar, Portland, Oregon. http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762 Accessed 2/1/2013.

Brodeau, J. and Graubart, R. (2011) Cyber Resiliency Engineering Framework. MITRE Corporation. Document Number MTR110237. Bedford, MA.

Carbone, V. and De Martino, M. (2003) "Changing Role of Ports in Supply-Chain Management: An Empirical Analysis." *Maritime Policy Management 30(4):* 305–320.

CBO (2006) *The Economic Costs of Disruptions in Container Shipments.* Congressional Budget Office U.S. Congress, Washington, D.C. (March 29, 2006).

CBO (2005) *Freight Rail Transportation: A Review of the 2004 Experience.* Congressional Budget Office, U.S. Congress, Washington, D.C. (May 2005).

Chopra, S. and Sodhi, M. (2004) "Managing Risk to Avoid Supply-Chain Breakdown," *MIT Sloan Management Review 46(1):*53–61.

CSR (2009) *Port Security. Year One Report.* Center for Secure and Resilient Maritime Commerce, Stevens Institute of Technology. Hoboken, New Jersey.

Darbra, R.-M. and Casal, J. (2004) "Historical Analysis of Accidents at Seaports," *Safety Science 42:*85–98.

DHS (2008) National Incident Management System. U.S. DHS. Washington, D.C. December 2008.

DOA (1993) Army Water Transport Operations. FM50-55. Appendix D. Department of the Army, Washington, D.C. 30 September 1993. http://www.globalsecurity.org/military/library/policy/army/fm/55-50/ Accessed 2/6/2013.

DOJ (2006) The Federal Bureau of Investigation's Efforts to Protect the Nation's Seaports. Audit Report 06-26. U.S. DOJ, Washington, D.C.

Eldridge, M. (2006) "Have you Covered Your 5Ms?" AAPA Emergency Preparation and Response Seminar, Portland, Oregon. http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762 Accessed 2/1/2013.

Farris II, M. T. (2008) Are You Prepared for a Devastating Port Strike in 2008? *Transportation Journal 47*, No. 1: 43–53.

FEMA (1996) Guide for All-Hazard Emergency Operations Planning. State and Local Guide (SLG) 101. U.S. FEMA, Washington, D.C.

Flynn, S. R. (2008) "Mahan Revisited: Why Resilient Commercial Seaports are a National Security Imperative," Keynote Presentation, Transportation Research Board, Marine Board Maritime Disaster Workshop, Beckman Center, University of California, Irvine, CA. September 4, 2008.

GAO (2012a) *Maritime Security: Coast Guard Efforts to Address Port Recovery and Salvage Response.* U.S. Government Accounting Office. GAO-12-494R. Washington, D.C.

GAO (2012b) *Critical Infrastructure Protection. An Implementation Strategy Could Advance DHS's Coordination of Resilience Efforts across Ports and Other Infrastructure.* U.S. Government Accounting Office, GAO-13-11. Washington, D.C.

GAO (2010) *Update to National Infrastructure Protection Plan Includes Increased Emphasis on Risk Management and Resilience.* U.S. Government Accounting Office, GAO-10-296. Washington, D.C.

GAO (2007) *Port Risk Management. Additional Federal Guidance Would Aid Ports in Disaster Planning and Recovery.* U.S. Government Accounting Office, GAO-07-412. Washington, D.C.

GAO (2005a) *Homeland Security: Process for Reporting Lessons Learned from Seaport Exercises Needs Further Attention*, Government Accounting Office, GAO-05-170, Washington, D.C.

GAO (2005b) *Homeland Security. DHS' Efforts to Enhance First Responders' All-Hazards Capabilities Continue to Evolve.* Government Accounting Office, GAO-05-652, Washington, D.C.

Gordon, P., Moore II, J., Richardson, H., and Pan, Q. (2005) *The Economic Impact of a Terrorist Attack on the Twin Ports of Los Angeles-Long Beach.* Report 05-012. Center for Risk and Economic Analysis of Terrorism Events, University of Southern California, Los Angeles.

Grenzeback, L. R. and Lukmann, A. T. (2009) Case Study of the Transportation Sector's Response to and Recovery from Hurricanes Katrina and Rita. Report prepared for the Transportation Research Board, Washington, D.C.

GTRC et al. (2012) *NCHRP Report 732: Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System.* Georgia Tech Research Corporation, A. Strauss-Wieder, Inc. and PB Americas, Inc. Prepared for the Transportation Research Board, Washington, D.C.

Hale, T. and Moberg, C. R. (2005) "Improving Supply Chain Disaster Preparedness: A Decision Process for Secure Site Location." *International Journal of Physical Distribution & Logistics Management 35(3):*197–207.

Hall, P. V. (2004). "We'd Have To Sink the Ships" Impact Studies and the 2002 West Coast Port Lockout. *Economic Development Quarterly, Vol. 18, No. 4:*354–367

Harrald, J. R., et al. (2004) A Framework for Sustainable Port Security. *Journal of Homeland Security and Emergency Management 1(2):*1–13.

Hecker, J. Z. (2002) *Port Security: Nation Faces Formidable Challenges in Making New Initiatives Successful.* U.S. General Accounting Office. Washington, D.C. August 1.

Hudgins, H. (2006) *Emergency Preparation through Planning: Security.* AAPA Emergency Preparation and Response Seminar, Portland, Oregon. http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762 Accessed 2/1/2013.

Hultin, J. M., Pen Nitti, M., Ullman, H., and Stevens, L. A. (2004) *Securing the Port of New York and New Jersey, Network-Centric Operations Applied to the Campaign against Terrorism.* Report by the Stevens Institute of Technology. Hoboken, NJ.

ICF International and PB Americas (2011) "Task 1: Assessing Infrastructure for Criticality in Mobile, AL." *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: The Gulf Coast Study, Phase 2.* FHWA-HEP-11-029.

Kidby, M. F. (2008) Hazards to Navigation: How to Manage the Removal/Disposal of Debris. Maritime Disaster Workshop. U.S. Army Corps of Engineers. September 4–5.

Lambert, D. M. (2001) "The Supply Chain Management and Logistics Controversy." In Brewer, A., Button, K., and Hensher, D. A. (eds.) *Handbook of Logistics and Supply Chain Management, Volume 2.* Pergamon: 99–125.

Lambert, D. M., Stock, J. R., and Ellram, L. M. (1998) *Fundamentals of Logistics Management.* McGraw Hill, New York.

Lane (2009) *U.S. Seaport Security: Critical Challenge for Department of Homeland Security.* Strategy Research Project 02-04-2009. U.S. Army War College, Carlisle Barracks, PA.

Leamer, E. E. and Thornberg, C. (2006) "Ports, Trade, and Terrorism: Balancing the Catastrophic and the Chronic." In Haveman, J. D. and Shatz, H. J. (eds) *Protecting the Nation's Seaports: Balancing Security and Cost.* Public Policy Institute of California, San Francisco. www.ppic.org/content/pubs/report/R_606JHR.pdf

Loh, H. S. and Thai, V. V. (2012) The Role of Ports in Supply Chain Disruption Management. 2012 International Forum on Shipping, Ports and Airports. Hong Kong, China. 27–30 May, 2102. http://www.icms.polyu.edu.hk/ifspa2012/Papers/M09.pdf Accessed 12/10/2013.

Mahrouz, A. and Arisha, A. (2009) "Seaport Management Aspects and Perspectives: An Overview." Proceedings of the 12th Annual Irish Academy of Management Conference, Galway-Mayo Institute of Technology, Galway, Ireland, September 2–4, 2009.

Mansouri, M., Mostashari, A., and Nilchiani, R. (2009) "A Decision Analysis Framework for Resilience Strategies in Maritime Infrastructure and Transportation Systems." 3rd Annual IEEE International Systems Conference, Vancouver, Canada.

MARAD (2013) U.S. Water Transportation Statistical Snapshot 2011. Released 11/06/2013 http://www.marad.dot.gov/library_landing_page/data_and_statistics/Data_and_Statistics.htm

McDonough, F. (2006) *From Rubble to Recovery.* AAPA Emergency Preparation and Response Seminar, Portland, Oregon. http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762 Accessed 2/1/2013.

MHIDAS (2002) Major Hazard Incident Data Service, OHS_ROM, Reference Manual. http://w3.cetem.gov.br/infomimet/vercadastro1_en.asp?count=131 Accessed 1/25/2013.

NAS (2012) *Disaster Resilience: A National Imperative.* The National Academies. Washington, D.C.

NFPA (2010) *NFPA 1600, Standard on Disaster/Emergency Management and Business Continuity Programs.* National Fire Prevention Association. Quincy, MA.

NISAC/NIMSAT (2011) *Louisiana Highway 1/Port Fourchon Study.* National Infrastructure Simulation and Analysis Center (NISAC) and the National Incident Management Systems and Advanced Technology (NIMSAT) Institute, University of Louisiana, Lafayette. http://www.la1coalition.org/

Park, J., Gordon, P., Moore II, J. E., and Richardson, H. W. (2008) "State-by-State Economic Impacts of the 2002 Shutdown of the Los Angeles–Long Beach Ports." *Growth and Change 39:*548–572.

Pate, A., Taylor, B., and Kubu, B. (2007) *Protecting America's Ports: Promising Practices.* Report submitted to Police Executive Research Forum to the National Institute of Justice, U.S. DOJ, Washington, D.C.

Perrone, C. (2006) "Business Continuity: Port Environment. COOP–Continuity of Operations Planning." AAPA. Emergency Preparation and Response Seminar, Portland, Oregon. http://www.aapa-ports.org/Programs/PastDetail.cfm?itemnumber=762 Accessed 1/22/2013.

Pruitt, K., Richard, F., and Stephen, P. (2004) "Modeling Homeland Security." *Journal of Defense Modeling and Simulation 1(4)*:185–198.

RAND Corporation (2005) Assessing Container Security—A Framework for Measuring Performance of the Global Supply Chain. Rand Corporation Infrastructure Safety and Environment.

Ranous, R. A. (2012) *HMCRP Report 9: A Compendium of Best Practices and Lessons Learned for Improving Local Community Recovery from Disastrous Hazardous Materials Transportation Incidents.* Transportation Research Board, Washington, D.C.

Rao, R. R., Eisenberg, J., and Schmitt, T. (eds) *Improving Disaster Management: The Role of IT in Mitigation, Preparedness, Recovery, and Response.* National Research Council Press. Washington, D.C. http://www.nap.edu/catalog.php?record_id=11824 Accessed 12/30/2013.

Rice Jr., J. B. (2009) Keeping the Economy Moving through Port Resilience. CTL Webinar. MIT Center for Transportation and Logistics. http://video.mit.edu/watch/webinar-mit-port-reslience-project-4816/ Accessed 1/22/2013.

Rice Jr., J. B. and Trepte, K. (2010) "Port Disruption Survey" in *Port Resilience Project.* Massachusetts Institute of Technology, Center for Transportation and Logistics: Cambridge, MA.

Rice Jr., J. B. and Caniato, F. (2003) "Building a Secure and Resilient Supply Network." *Supply Chain Management Review 7(5):*22–30.

Robinson, T. (2006) *Overview of the Department of Homeland Security Port Maritime Activities & the Port Security Grant Program.* Preparedness Directorate, Office of Grants and Training. U.S. DHS, Washington, D.C.

Rowan, E., Evans, C., Riley-Gilbert, M., Hyman, R., and Kafalenos, R. (2012) "Assessing the Sensitivity of Transportation Assets to Extreme Weather Events and Climate Change." Transportation Research Board, 2013 Annual Meeting paper, Washington, D.C.

Seiple, C. (1997) "Domestic Response to Weapons of Mass Destruction." *Parameters*, Autumn 1997: 119–34.

Sheffi, Y. (2005) *The Resilient Enterprise—Overcoming Vulnerability for Competitive Advantage.* MIT Press, Cambridge, MA.

Stowksy, J. (2006) "Chapter 5: Harnessing A Trojan Horse: Aligning Security Investments with Commercial Trajectories in Cargo Container Shipping." In *Protecting the Nation's Seaports: Balancing Security and Cost*, Haveman, J. D. and Shatz, H. J. (eds.). Public Policy Institute of California, San Francisco.

TISP (2011) *Regional Disaster Resilience: A Guide for Developing an Action Plan, 2011 Edition.* The Infrastructure Security Partnership.

USCG (2009) Commander, USCG Sector Long Island Sound Marine Transportation System Recovery Plan. U.S. Coast Guard, DHS. New Haven, CT. April 2009.

USCG (2008) Maritime Transportation System (MTS) Recovery. State of the Coast Guard Address. http://www.rrt1.nrt.org/production/nrt/rrt1.nsf/Resources/rt1Presentations_September2008/$File/MTS%20Recovery%20Overview.Sep08.pdf. Accessed 12/2/2013.

USCG (2006) *National Maritime Recovery Symposium Report.* U.S. Coast Guard. Maritime Institute of Technology and Graduate Studies, Linthicum, Maryland.

Young, W. (2009a) Literature Review: Marine Transportation System Recovery. Preparing for, Responding to, and Recovering from Disasters Study Group. U.S. Coast Guard.

Young, W. (2009b) Information Paper: Marine Transportation System Recovery Current State of Preparedness Practice. Preparing for, Responding to, and Recovering from Disasters Study Group. U.S. Coast Guard.

Zegart, A. B., Hipp, M. C., and Jacobson, S. K. (2006) "Chapter 6: Governance Challenges in Port Security: A Case Study of Emergency Response Capabilities at the Ports of Los Angeles and Long Beach." In *Protecting the Nation's Seaports: Balancing Security and Cost*, Haveman, J. D. and Shatz, H. J., (eds.). Public Policy Institute of California, San Francisco.

CHAPTER 3

Interviews with Supply Chain Experts

Our operational capabilities also include developing a national capacity for Marine Transportation System recovery. The nation needs a coordinated, integrated approach to planning for and responding to major disruptions in our marine transportation system, the lifeblood of America's economy.

—Adm. Thad Allen, *2007 State of the Coast Guard Address* (USCG, 2008)

3.1 Introduction

This chapter describes the results of a series of expert interviews drawing on different roles in moving freight through U.S. seaports. Individual interviews were conducted with more than 20 experts responsible for different activities within seaport-inclusive freight supply chains. The interviews are intended to supplement and make further contributions to the discussion of U.S. ports' resiliency in times of major cargo movement disruptions, adding to the information presented in previous research studies involving the activities of government entities serving in various oversight/regulatory roles.

The interviews, drawn primarily from private industry, included key executives at seaports, beneficial cargo owners (BCOs), 3PLs, shipping agencies, railroads, trucking and warehousing companies, and trade organizations. See Appendix 3A for a list of sample questions and a complete list of participating organizations. In keeping with the supply chain focus of the research, these interviews also focused on three pieces of the business continuity puzzle, all of which need to fit together to ensure effective cargo throughput. The components are as follows:

- Shipping/shipping channel,
- Port operations, and
- Landside, intermodal freight processing.

The interviews included questions on identifying port resiliency steps, with port resiliency defined as the ability of a coastal seaport to provide and maintain an acceptable level of service, notably a steady freight volume throughput, when disruptive forces impose upon it. These steps primarily involve coordinating freight movements through ports in times of severe stress on existing operating infrastructures and services—whether being stressed because of damage to port facilities or to the highway, rail, and waterway routes leading into and out of the port; from stoppages of work or port closures due to other disruptive events; or because of the need to handle additional cargo volumes due to port disruptions elsewhere. The research team asked the executives interviewed to specifically consider the following three aspects of the supply chain:

- Transactions and information flow,
- Physical/logistical infrastructure that supports the movement of goods, and
- Regulatory/government agency involvement.

Additionally, respondents were asked to provide insight regarding how quickly private industry alters business practices based on lessons learned from events such as the 2002 West Coast Lockout, Hurricanes Katrina and Ike, and Superstorm Sandy. This dynamic and competitive industry is found to be remarkably collaborative and connected during times of major distress, as demonstrated in the following summary of the key points that emerged from the discussions.

3.2 Differences in Types of Port Disruptions

The respondents identified two key differences in types of port disruptions, making a distinction between natural disasters and manmade disruptions (e.g., labor disputes, security threats, technological emergencies). It was also noted that (1) the geographic impact of an event and (2) the probability of a disruption occurring considerably affected the respondents' ability to plan and subsequently react to it. For example, looming storms are monitored as they near a port, and plans for moving cargo in and out are coordinated between the vessel operators, the USCG, and the ports, in addition to many other participants. In contrast, manmade disruptions can be less predictable and may impact more than a single port. For example, the 2013 computer/information system issues at Maher Terminals—one of the largest terminals at the Port of New York and New Jersey—generated ripples through the other terminals in the immediate region, as well as affected several other East Coast ports. Within the Port of New York and New Jersey, other terminals were asked by carriers to handle their vessels in addition to their regular customers. Vessel, terminal, and inland operations were affected, leading to at least one carrier, Hapag Lloyd, asking their customers to switch cargo routing to alternative East Coast ports (Bonney, 2013).

Labor disputes can impact port resiliency and business continuity planning. Following the 2002 International Longshore and Warehouse Union (ILWU) West Coast Lockout, BCOs proactively revised their strategies and operating plans for importing goods by diversifying and creating redundancy. For example, many major retailers that prior to 2002, had relied on one or two distribution centers, decided to develop redundancy in their system by constructing facilities near all four corners of the country (NW, SW, SE, NE), a strategy dubbed "the four corners approach." Additionally, they began purchasing the same item from more than one supplier located in different parts of the world. BCOs also have altered the way they do business to minimize impacts caused by labor disputes and, in so doing, made themselves more resilient to other port disruptions that have occurred in the past decade.

3.3 Communications and the Flow of Information

Communicating and maintaining the flow of logistics information throughout the supply chain—from truckers to suppliers to carriers to key federal agencies—was considered by the executives interviewed to be the single most important element to returning operations to normal following a port disruption. The ability to maintain the flow of information before, during, and after a port disruption directly affects recovery time. The amount of warning time and the belief that the event will actually occur also contributes to resiliency. Respondents impacted by both manmade and natural disasters indicated that knowledge of whether an event would occur and when it would happen resulted in different response approaches. For example, an imminent hurricane prompts early communication about potential physical damage that could disrupt communication capabilities, whereas a terrorist attack would not. Due to these differences, those respondents were asked to provide lessons learned for both types of disruptions. The communication and coordination process was delineated into three time periods: before, during, and after a major port disruption.

Before the Disruption

Before a natural disaster, the USCG utilizes Marine Transportation System Recovery Units (MTSRUs), often consisting of existing port coordination teams that typically include the National Weather Service, port staff, vessel operators, terminal operators, tug boat operators, railroads, emergency responders, CBP, MARAD, USACE, utility operators, shipping agents, and many others. Decisions, such as where to move assets, when to close the port, and how to prioritize cargo flows before and immediately following the resumption of operations, often begin as soon as a major storm becomes known. Communication between ports also may begin at this point, as with Superstorm Sandy, which resulted in the diversion of 57 ships to alternative ports along the U.S. East Coast. Shipping agents, the primary conduit for communications between carriers, shippers, regulatory agencies, and the USCG, played a significant role in this process. In the case of Superstorm Sandy, the vessel diversion planning involved the Port of New York and New Jersey communicating with other East Coast ports, such as the Virginia Port Authority. Other major players in the communication and coordination of the diversions may include USCG, CBP, tug operators, terminal operators, trucking companies, and the shipping agents representing carriers and BCOs.

At one large port, port employees may get an email or a reverse 9-1-1 call when an event occurs (in this case, to about 6,000 people in a matter of seconds) that provides status updates about access impacts and requests that recipients acknowledge receipt of the message. Port employees also carry a card with instructions on what to do in case of such notifications. Regular testing can ensure that when an event occurs, all employees will receive status updates and emergency response instructions. The ports interviewed indicated that they maintain contact information for all staff, and test emergency blast emails and reverse 9-1-1 calls to all listed telephone numbers (office, home, work cellular, and personal cellular). Quarterly testing is often conducted and failed contact attempts are identified. When a failed attempt occurs, Risk Management staff contact the employee and request updated contact information.

In addition to regular test calls, Hurricane Katrina prompted regular drills to ensure that first responders understand the communication and Emergency Operation Center (EOC) protocols. Participants typically include USCG, USACE, FEMA, MARAD, USDOD, CBP, FBI, local fire and police, various port authority staff, tug boat operators, marine terminal operators, railroad operators, and others. Interview participants commented that ports need a designated and suitably trained and knowledgeable (certified) emergency manager who plans for, receives stakeholder calls, coordinates activities, and monitors disruptive events. Some participants also recommended the comingling of the port's executive director, public affairs officer, and emergency manager in the EOC. One port respondent suggested the need for at least two table-top exercises each year. These exercises require a significant amount of planning to carry off. A full-day exercise that includes testing of the various communication channels between stakeholders may require 3 to 4 months of planning.

Early preparation may allow for dissemination of satellite phones to key personnel, protection of back-up power sources, and use of two-way radios, as well as deployment of USDOD vessels with satellite communication capabilities and direct lines of communication to key government officials, including the president. One respondent suggested ensuring that back-up copies (hard and electronic) of the emergency operation procedures and recovery plans and any other critical documents (such as manifests) are stored offsite prior to an event, since the information could become inaccessible due to flooding, road closures, etc. during and after a disruption.

This respondent described the idea of an emergency backpack containing a laptop loaded with all critical plans and information.

During the Disruption

Communication during port disruptions occurs at two different levels: operational and public information. Clear, constant, and consistent transmission of operational information reduces the impact of an event. In this regard, the USCG facilitates regular conference calls with all private and public participants and implements response plans, including daily calls, when a disruption occurs. Maintaining communication capabilities during an emergency requires appropriate technological capabilities and an adopted process. Many respondents stated that technological capabilities have been greatly expanded through investments in satellite telephones and two-way radios.

During Hurricane Katrina and for several days after, MARAD vessels and other vessels at the Port of New Orleans equipped with satellite communication and two-way radios provided the sole source of communication between emergency responders and the outside world, including the White House and DOD. This allowed the federal government to understand the needs on the ground and quickly deploy the appropriate resources—in the case of Hurricane Katrina this included the deployment of highly skilled SWAT teams.

Since 2005, to provide similar support, the DOD has worked closely with ports when hurricanes are approaching. Many interview participants reported that they have invested in satellite phones and disseminate them to key personnel prior to an anticipated natural disaster. In addition, many respondents have invested in cellular telephones with out-of-state area codes and two-way radios. Ports also have implemented IT redundancy. Several respondents, in both the private and public sectors, reported that they now have servers in two or three locations with at least one server residing in another state. Similarly, out-of-area call centers and administrative office spaces have been identified in recent plans.

Clear communication with the media has proven successful in providing the public with regular status updates (good examples include Hurricanes Katrina, Superstorm Sandy, and the 2002 Lockout) as well as preventing or reducing speculation. Regular media updates provide information to all stakeholders and facilitate the recovery process.

Additionally, providing regular updates to the media and trade associations representing cargo owners, shippers, and carriers has been strengthened over the past decade. However, whereas communication has been strengthened with most supply chain participants, many respondents identified two areas of improvement: (1) port access for workers and truck drivers, and (2) contacting and coordinating with private companies outside a port's jurisdiction that have been impacted by the disruption.

Many respondents indicated that it was difficult to access the port during and immediately following a natural disaster due to emergency road closures and security protocols at a port. For example, in the case of Hurricane Katrina, all roadways were converted to one-way out. Hence, workers and truck drivers destined for the Port of New Orleans were denied entry by local law enforcement. Respondents involved in other Gulf and East Coast hurricanes described similar problems. Most recently, TWIC requirements have hindered recovery efforts in the Port of New York and New Jersey because there are not enough TWIC holders to escort recovery workers. Overall, respondents pointed to a need to improve communication and coordination with local, state, and federal agencies. Implementation of a system that provides placards to drivers and recovery workers was suggested by multiple respondents.

Some interview participants commented on the difficulty of contacting private terminals and companies that are impacted by the closure of the main shipping channel due to a natural disaster. In the cases of Hurricanes Ike and Katrina, respondents described a concerted effort by the entire port community to pull together, citing cases of private tug operators working with port staff and other government agencies to traverse the port waters in order to investigate damage and reach private port users who had no means of communication. Hurricane Rita prompted the development of a list of port users in the path of the storm. This list aided recovery efforts after Sandy; however, some of the information had not been updated in over a year. The use of this data during Sandy prompted changes to the maintenance of the data.

After the Disruption

Following a port disruption, communication can prove difficult, particularly if power is lost. Communication and coordination efforts have greatly improved since Hurricane Katrina. The Port of New Orleans provided a detailed account of lessons learned that has contributed to the development of emergency preparedness and business continuity plans at most large U.S. ports. For example, since Hurricane Katrina, U.S. DOD's naval vessels equipped with satellite phone systems have served as a hub of communication when all other sources have been unavailable due to power outages and damage to cellular telephone facilities.

Respondents generally agreed that communication directly correlates with recovery time and business resumption after a port disruption. Port closures result in major congestion at the gates, vessel queuing in harbors, backlogs at warehousing transloading facilities, and manufacturing production stoppages (caused by lack of material to manufacture or lack of storage room for manufactured goods). These bottlenecks further result in significant costs to businesses that have goods stored on the docks and cannot find a drayage firm to pick them up due to high demand, impacts to vessel schedules, a lack of ability to maintain supplies at retailers due to just-in-time inventory practices, etc. Port disruptions can cause small and large companies to go out of business, and place undue burden on many others, such as the Ports of Oakland, Seattle, and Tacoma that lost customers to other ports (including Prince Rupert in Canada) during the 2002 West Coast Lockout.

Some interview participants remarked that certain decisionmakers did not understand the vital role that ports played in recovery efforts, such as supplying gas and other necessities to the impacted communities. One respondent suggested port and logistics training for first responders and other stakeholders (e.g., electrical companies) prior to an event to foster collaboration and provide an understanding of the importance of resuming cargo flow after a disruption.

Respondents also suggested better coordination and communication among all parties to discuss opportunities for improving efficiencies after a major port disruption. Processing queued vessels and extending gate operating hours were considered particularly important after a port disruption to quickly dissolve the backlog.

The interviews found that port disruptions that close several ports on one coast for more than a week result in significant queuing of vessels. When a hurricane closes a port for 10 days, vessel operators may skip the impacted port to maintain their schedule or divert to another port. However, during the 2002 West Coast Lockout, vessels destined for multiple ports along the West Coast, most of which called to the Ports of Los Angeles-Long Beach first, had no option but to drop anchor along the coast. One respondent with a terminal in South America opted to divert to that port and off-load goods in order to remain on schedule, but this respondent stated that they were one of the few operators with this option available. As a result, a vessel queue extending 20 miles south of Los Angeles-Long Beach ensued. Eliminating the queue required close coordination with vessel operators, terminal operators, shippers, and many others. Respondents indicated that USCG led the process, much like they have in other regions of the country following a natural disaster. Respondents stated that all participants cooperated and disputes over prioritization rarely occurred.

One respondent suggested that a Recovery Advisory Unit could be developed to support effective communication between the key stakeholders who need to determine the prioritization of vessels in a queue based on factors such as national security and perishable goods. Extending gate hours to 24/7 operations immediately following the reopening of a port was discussed as another option that could reduce impacts on the overall supply chain. Communicating the extension of gate hours could be achieved through media broadcasts.

Lessons Learned

- Educate decisionmakers involved in the recovery on the vital role that ports have in ensuring necessary supplies are available after a disruption.
- Maintain back-up copies of important documents in both electronic and hardcopy formats.
- Regularly test reverse 9-1-1 calls and verify/update employee contact numbers.
- Ensure USCG has current contact information for a list of port users involved in emergency planning and quarterly emergency preparedness and recovery drills.
- Contact and collaborate with private companies that use impacted shipping channel(s) prior to a disruptive event.
- Invest in satellite and two-way radios, as well as out-of-area cellular telephones; regularly practice the plan for disseminating equipment and establishing a communication tree.
- Identify multiple, alternative EOC locations where emergency correspondences can be exchanged by affected parties.
- Develop an access plan and a communication protocol with input from police, first responders, industry, etc., to ensure that truck drivers moving cargo or carrying FEMA supplies can access the port after a natural disaster.
- Develop a media plan for processing press releases; use press releases to communicate economic resiliency, attract labor, and provide regular status updates (needs and progress).
- Consider establishing Regional Operations Centers to share information between ports and port users.
- Develop a Recovery Advisory Unit to prioritize vessel processing.
- Extend gate hours following a port disruption and communicate with media to ensure truckers and other stakeholders are aware of change in terminal operation.

3.4 Physical Infrastructure

Respondents described how past physical disruptions have impacted the power supply, safe passage of ships, trains, and trucks; and access to water and sewer, as well as labor actions that have restricted access to goods on ships, in marine terminals, or in warehouses.

Power Generation

Many interview respondents remarked that they have begun to re-evaluate their emergency preparedness and recovery plans and incorporate new features for ensuring that power generation is either maintained or quickly recovers following a major disruption to power lines or to the electricity grid. Loss of regional grid-based power supply can become a "single point of failure" issue in some ports (note: no power means no fuel pumps working). During Superstorm Sandy and Hurricanes Ike and Katrina, respondents identified damage to back-up generators that were stored in low-lying areas and the inability to utilize solar power during outages to the grid. Respondents also mentioned the lack of access to fuel for generators that survived the storms, as well as access to vehicles for priority personnel. One respondent lost both personal automobiles and could not locate a rental car within 800 miles. All respondents mentioned the importance of power at ports, and some port authorities have begun to discuss options such as reversing cold ironing capabilities (the practice of providing shore power to a ship so the ship may shut down primary and secondary combustion engines while in port) to allow vessels to power the marine terminals.

One possible option suggested for consideration involved drawing power from nuclear powered Navy ships (or submarines). However, the process of how exactly to tap into this ship power safely and to the satisfaction of the power companies has yet to be solved. Although drawing power from Navy ships is considered technically feasible, it was suggested that a port would need at least the following four things to happen first:

- Identify power supply components and capabilities,
- Identify power supply necessary to operate port,
- Develop physical cut-off mechanism and operational protocol to ensure port-generated electricity does not access and damage the grid, and
- Coordinate with DOD/Navy personnel to investigate feasibility of tapping into nuclear power supply on vessels.

Not all power losses need to be widespread to be costly. An example was cited of a damaged power line leading to a 3-day partial port closure. In this case, key recovery aspects included access to back-up generators and communication.

Lessons Learned

- Ensuring power is crucial for recovery and business continuity.
- Locate generators above flood levels.
- Store fuel for generators and priority personnel vehicles.
- Encourage port personnel to top-off personal vehicles and store vehicles outside of potential flooding areas.
- Investigate alternatives for accessing solar power and reversing cold ironing during extended grid outages.

Channels/Harbors

The USCG and USACE work closely to identify and repair damage to the channels and quickly clear waterways after storms and other events that result in obstructions to safe passage of vessels. The two agencies coordinate directly with industry, ports, and other regulatory agencies to provide information necessary for prioritizing ship movements immediately following reopening. Channels and harbors have typically recovered quickly (within 2–3 days) following a major hurricane. However, damage to wharfs in some major storms has caused disruptions of several months in rare instances. Private companies tend to cooperate when a channel is blocked. All parties share the common goal of reopening it as quickly as possible. An example was cited of using nearby barges to remove obstruction material and providing a “barracks barge” to allow workers to stay on site overnight in order to stay close to the blockage they were working to remove.

Lessons Learned

USCG collaborative efforts prepare industry and public agencies for port disruptions through information sharing, providing input on emergency operations and recovery plans, and facilitating regular exercises/drills.

Terminals

For marine terminals located in low-lying areas, respondents described preparedness and recovery plans based on personal experiences, as well as the experiences of others. Many of the respondents have incorporated lessons learned from Ike, Katrina, and Sandy into their planning efforts. USCG and NOAA coordinate with vessel operators and terminal operators to protect against cargo losses on the docks by adjusting vessel schedules, either slow sailing or increasing speed. Accordingly, the railroads and drayage drivers must respond to these schedule changes. Additionally, respondents identified damage to terminal equipment as a significant issue. Salt water is particularly troublesome for battery-operated terminal and warehouse equipment.

Lessons Learned

- Identify alternative, higher ground locations for storing terminal and warehouse equipment (which may, however, increase cargo loading costs).
- Identify temporary, higher ground storage locations for cargo.
- Extend gate hours of operations and coordinate with truck companies and railroads in advance of a disruption (if known event) to facilitate moving cargo off terminals.

Temporary Housing and Office Space

Hurricane Katrina prompted the thinking of many ports and other key agencies to go beyond emergency preparedness to business recovery/continuity planning. During Hurricane Katrina, entire sections of New Orleans became uninhabitable. The Port of New Orleans implemented a detailed emergency preparation plan upon first reports from the NWS that New Orleans could be impacted and had fully implemented their plan in advance of the storm; however, the port did not have a recovery plan. Housing workers to repair the port proved to be a significant challenge. Even key personnel were forced to vacate, prompting the Executive Branch of the federal government to implement a plan to use USDOD vessels. Within a few days, Port of New Orleans staff had set up administrative functions in Atlanta, Georgia, and some top-level staff returned to the port and lived on the USDOD vessels during recovery. Another Louisiana port, Port Tangipahoa, located 25 miles north of New Orleans, provided temporary administrative space. During the recovery effort, on-site portable buildings, USDOD vessels, cruise vessels, and other temporary housing provided shelter for port workers and first responders.

Lessons Learned

- Prepare and constantly update a recovery plan that includes temporary housing for first responders and key personnel.
- Identify long-term temporary office space.
- Develop back-up systems for all business functions, in particular, information systems and servers, call centers, and payroll functions (most public and private entities have one or more back-up servers with at least one located in another state).

Railroad Facilities

The Class I railroads have experience with a variety of disruptions along their facilities. Therefore, they have plans in place to expeditiously react to service disruptions, including derailments, inclement weather, port disruptions, labor disputes, etc. One Class I railroad noted that it had contracts throughout the country to address disruptions quickly and minimize revenue losses. For example, after Hurricane Katrina, reconstruction of the collapsed rail bridge over Lake Pontchartrain was expedited by having existing contracts with construction companies in the region, leading to a resumption of bridge operations just 12 days after it had collapsed.

The freight railroads make provisions for hurricane season. They identify safe storage locations, particularly in areas of the country where their rail yards reside in low-lying areas. During both

Hurricane Katrina and Superstorm Sandy, the freight railroads moved as much equipment as possible to higher ground. For equipment that could not be moved, the railroads took significant steps to protect assets, such as removing engines from locomotives. Freight railroad representatives described damage to public rail assets and the need for public agencies to emulate the freight railroads' plans.

When labor disputes arise, the railroads work closely with customers to move up delivery schedules or identify alternative routes. During the 2002 West Coast Lockout, a lack of railcars proved to be a difficult problem due to the sheer volume of goods that had accumulated at the West Coast ports over the 10-day duration. The railroads indicated that changes to shipping resulting from labor disputes are led by their customers. The railroads provide service options and accommodate the changes but generally do not play a role in prompting the changes.

Lessons Learned

- Disruptions to passenger rail systems impact freight railroads. Damaged equipment on the tracks causes recovery delays. Respondents suggested that public agencies should develop asset protection plans and identify funding to implement the plans in advance of an imminent storm. This would not only benefit resiliency, it would also reduce recovery costs.
- Railcar shortages following a major disruption have prompted some shippers to consider operational changes to avoid delays in receiving cargo (e.g., early delivery and rerouting of goods to warehouse/distribution centers not impacted by the disruption).

Trucking/Warehousing

A limited number of port drayage drivers coupled with limited driver hours of operation resulted in significant delays in moving cargo in and out of the West Coast ports after the 2002 West Coast Lockout. Respondents indicated that bottlenecks at the gates and inside the marine terminals resulted in turn times of three to four hours per transaction. The ports provided storage fee relief for goods on the docks during the Lockout, but on the first day after the Lockout, storage fees went into effect. With major delays at the gates and a lack of drivers, trucks, and chassis to move the containers, respondents of some small warehousing companies stated that they nearly went out of business. One such respondent decided to purchase trucks and provide drayage services to mitigate the impacts of future port disruptions on his warehousing business.

Following Hurricane Katrina, an overall shortage of port industry workers quickly became a barrier to supply chain resiliency. Nearly all residents with the ability to vacate the region had done so. The Port of New Orleans utilized media releases to solicit truck drivers from across the country to come and help. As drivers began to arrive, the port realized the need for housing them and worked with the federal government to locate temporary housing.

Trucks generally waited at sites located some way from the impacted port until it reopened. (If a shipping channel is officially "closed" insurance picks up some delay costs. If not, carriers usually shoulder the added cost burden and so the landside carriers want to be ready to start work as soon as the port's channel is declared open.) Similar to the railroads, the trucking industry participants stated that they are "nimble," meaning they can quickly respond to changing market needs. The experience from recent events, such as hurricanes and labor disputes, exemplifies this point in that drivers have reacted quickly to rerouting requests. However, respondents in California indicated that a labor disruption similar to that in 2002 would be more impactful today because of the Clean Truck Program and the California Air Resource Board's stringent truck emissions standards, both of which have resulted in fewer overall trucks in the system.

Lessons Learned

- Marine terminal storage fees should be revisited. Respondents suggested a longer grace period following a disruption coupled with a reduced sliding scale storage rate schedule commensurate with the backlog of goods.
- Respondents throughout the supply chain suggested (quite emphatically) longer gate hours following a major port disruption until the backlog is resolved.
- Utilize media to solicit truck drivers before and after event.
- Move chassis to higher ground out of the danger/any flooded areas.

Water/Sewer

During the Hurricane Katrina recovery, water and sewer service disruptions created significant impacts to the entire region. Use of the vessels at port helped to mitigate the impacts by providing workers with appropriate facilities so that they could repair the damage to the water and sewer lines.

The importance of water and sewer to business continuity is not limited to major disasters. One respondent described a water main issue that resulted in loss of water to marine terminals which, in turn, led to longshoremen refusing to work. Business continuity planning based on the Hurricane Katrina experiences mitigated the impact of this particular event because the port's plan contained an emergency response for such an event. Within hours of the water disruption, the port provided portable restrooms and water facilities to all impacted port facilities and work on the docks resumed. The communication protocol and response planning activities aided in the swift response.

Lessons Learned

- Maintain a list of vendors and contractors that can quickly respond to water and sewer disruptions, and if feasible, maintain on-call contracts to ensure quick response to emergencies.
- Collaborate with port water/sewer users and incorporate their needs into the emergency response plan.
- Maintain and regularly verify an emergency contact list of terminal operators and other port water/sewer users.

3.5 Regulatory Issues

Respondents discussed various regulatory issues that could be considered to either avoid a port disruption or recover from one more quickly, as follows:

- Adjacent track rules,
- Credentialing,
- Weight restrictions,
- Truck driver operating hours, and
- Adequate regulatory agency staffing and responsiveness.

Adjacent Track Rules

Two respondents referred to the adjacent track rule as a lesson learned for other ports to consider in preventing a potential disruptive event in the future. This rule restricts labor from working on a track adjacent to a track with an active train. This rule evolved from a tragic accident that resulted in the death of a worker. In all but a few terminals at the Ports of Long Beach and Los Angeles, this rule has been expanded from the adjacent track to an entire terminal so whenever a train enters or exits a terminal, all labor stops work.

Credentialing

In the case of Superstorm Sandy, truck drivers tasked either with collecting cargo that was diverted to other East Coast ports or with trucking it to the Port of New York and New Jersey experienced credentialing issues. All drivers entering a port must have a TWIC card, but most ports also have their own registration system for drivers. Ports typically have a process for handling new long-haul drivers from outside of the area, but this process was developed to handle relatively few drivers per day and may involve fees (e.g., for the port-specific credential and, in some cases, a port-specific RFID tag. Respondents suggested improving communication between ports when cargo is diverted and sharing truck driver registration data during these events. Similarly, recovery workers without a TWIC card must be accompanied by a TWIC cardholder. During a major cleanup effort, such as Superstorm Sandy, this may cause delays in the recovery process because of the lack of available TWIC cardholders.

Weight Restrictions

Respondents stated that truck weight restrictions are waived for trucks delivering FEMA relief supplies, and suggested similar relief for certain commodities to off-set impacts to the supply chain.

Truck Driver Operating Hours

Some respondents suggested allowing drivers to exceed the maximum allowable hours of driving for drayage drivers following a major disruption. One respondent described drivers sitting idle for 3 or more hours at marine terminals after a major port disruption. This respondent suggested that the driver fatigue concern not apply when a truck is idle. A few respondents stated that truck driver hours of operation are not restricted for FEMA supplies or for certain agricultural products and suggested that temporary relief from this regulation be applied for a set time following a major port disruption.

Adequate Regulatory Agency Staffing and Responsiveness

Respondents described backlog and unnecessary marine terminal storage charges that occurred due to a lack of regulatory staff available to conduct inspections at ports handling diverted vessels. For example, some of the respondents noted CBP had adequate staffing but identified U.S. Department of Agriculture staffing shortages at the Virginia Port Authority when Superstorm Sandy resulted in the diversion of several ships, and U.S. Environmental Protection Agency staffing shortages at the Port of New York and New Jersey related to off-loading petroleum. Respondents suggested that these agencies identify a means for quickly determining staffing needs, develop emergency deployment plans, and participate in port disruption drills conducted regularly by ports throughout the country.

Lessons Learned

- Develop a mechanism for sharing truck driver registration information between ports during major port disruptions, or simplify/automate the registration process to speed up the processing of diverted cargo.
- Review truck weight restriction rules and heavy weight corridors; identify scenarios that may warrant temporary relief from regulations and implementation of short-term heavy weight corridors.
- Review truck driver hours of operations and identify scenarios that may warrant relief from regulations.

- Include all regulatory agencies involved in goods movement through ports in the emergency preparedness and recovery planning exercises conducted at ports throughout the country.

Respondents in general indicated that preparedness and recovery/business continuity planning has greatly improved over the past 10 years. A common theme echoed throughout the interviews is that the USCG provides significant support, particularly when the ports carry out emergency drills. Respondents indicated the need to continue to share information and experiences from major port disruptions locally, regionally, nationally, and internationally. They also mentioned repeatedly, the importance of communication and information sharing before, during, and after a port disruption.

3.6 References

Bonney, J. (2013) "Maher Says It's 'Turned the Corner' at NY-NJ," *Journal of Commerce*, July 30, 2013.

USCG (2008) Maritime Transportation System (MTS) Recovery. State of the Coast Guard Address. http://www.rrt1.nrt.org/production/nrt/rrt1.nsf/Resources/rt1Presentations_September2008/$File/MTS%20Recovery%20Overview.Sep08.pdf. Accessed 12/2/2013.

Appendix 3A: Interview Guide 1

Represented Participants

- Port of Long Beach,
- Port of New Orleans,
- Port of Houston,
- Three U.S. Class I railroads,
- APL,
- Moran Shipping Agency, Inc.,
- Horizon Lines,
- Maersk Sealand,
- World Shipping Council,
- Chamber of Shipping Americas,
- National Retail Federation,
- Kroger,
- UPS,
- Golden State Logistics,
- TTSI,
- ATRI,
- NFI Industries,
- AET Inc., Limited, and
- Coppersmith.

Sample Questionnaire

Key Questions

1. What disruptive events have occurred in the past at a U.S. *[your]* port most impacted your company's operations and/or services you provide? *[Question could also apply to their experience at previous companies]*
2. How did the disruptive event(s) impact _____ *[company/port]* and for how long?
3. What were some of the biggest surprises from the disruptive event(s) that you faced? How did it influence your reactions?

Plans and Strategies

1. What plans or strategies previously put in place by your company were helpful in responding to the disruption(s)?
2. What aspects of the recovery effort were not in your plans or strategies that should be considered in the future?

Coordination/Communication and Decision Making

1. Who were the most important individuals (roles) involved in responding to the disruption(s)?
2. How did you coordinate with external partners and governmental agencies (e.g., FEMA, DHS)?
3. How did you communicate with your customers?
4. What do you consider the strengths of your organization with respect to coordination and communication during and after the event(s)?
5. Would you improve your communication and coordination process for future situations? If so, how?
6. Would you change the decision-making process? If so, how?

Continuity of Operations and Service

In considering how to maintain service and cargo flow in times of disruption:

1. What are the most important considerations?
2. What are the major challenges or obstacles?
3. What would you do differently to enhance freight movement and service for future disruptive event(s)?

Big Picture

Based on the actions taken during and after the disruptive event(s):

1. What were the steps that were "done well"?
2. What were the "lessons learned"?
3. Are there any overall "improvements" that you would suggest?

Conclusion

1. Are there any other individuals or organizations in the private industry that you think we should contact with respect to port resiliency and the extended intermodal supply chain?

CHAPTER 4

Case Study: Response to and Recovery from Superstorm Sandy

4.1 Introduction

Superstorm Sandy was a multi-state weather event in October 2012 that resulted in significant physical damage to the Port of New York and New Jersey, the largest port on the U.S. East Coast. Sandy also affected nearly all elements in the supply chain—ports, airports, railroads, trucking firms, and warehouses/distribution centers. The situation was further complicated because Superstorm Sandy occurred during the peak shipment week of the year.

While the physical devastation was largely centered in the New York–New Jersey area, the effects of the storm and its impact on the supply chain were experienced by ports, freight transportation suppliers, and shippers/receivers along the entire U.S. East Coast and further inland. Massive power outages affected communications, repairs, and resumption of service. Emergency supplies needed to move. Alternative routes and modes were pressed into service. Federal and state regulations pertaining to certain aspects of goods movement needed to be addressed, were sometimes waived, and sometimes affected modal options.

Nevertheless, the preparation for, immediate response to, and long-term actions resulting from Superstorm Sandy, as discussed in this case study, illustrate the following:

- All three layers of supply chain considerations—physical operations, information and communication flows, and regulatory activities—can be affected by disruptions and can play key roles in the immediate response and speed of business resumption.
- Ongoing high-level public-private groups consisting of key port community organizations that have direct roles in operations, disruption response, and other issues, can expedite business recovery.
- The availability of electrical power and other utilities is essential to recovery and business resumption.
- A major port closure can negatively affect the operations at alternative ports by generating unanticipated surges in vessel and cargo operations at those locations.
- *Modal flexing*—the ability of alternative freight modes to assist in response and business continuity—is essential.
- Facility recovery requires balancing immediate needs versus more time-consuming equipment repairs.

This case study, which focuses on a major port disruption involving containerized cargo movements, includes the following:

- A description of Superstorm Sandy, including characterizing the storm within the supply chain disruption characteristics identified in *Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System* (GTRC, 2012, pp. 30–32).

- A discussion of the topographies of import and export maritime cargo movement affected by disruptions.
- Overviews of preparations, impacts on port operations and responses, and business resumption.
- A summary of the lessons learned and actions being taken or considered.

The following organizations interviewed for this case study reflect the range of public and private organizations involved in port operations.

- Federal agencies: USCG and CBP.
- Port agencies: The Port Authority of New York and New Jersey, the Virginia Port Authority, and the Maryland Port Authority.
- Maritime terminal operators: Global Marine Terminal, APM Terminal, Virginal International Terminals LLC, and the New York Shipping Association (which represents the terminal operators and provides labor for port operations).
- Railroads: Norfolk Southern and CSX Railroads.
- Trucking and Drayage Companies: International Motor Freight and Cross Port Transport.
- Barge Operator: Columbia Coastal.
- Container Lines: Maersk and Hapag Lloyd.

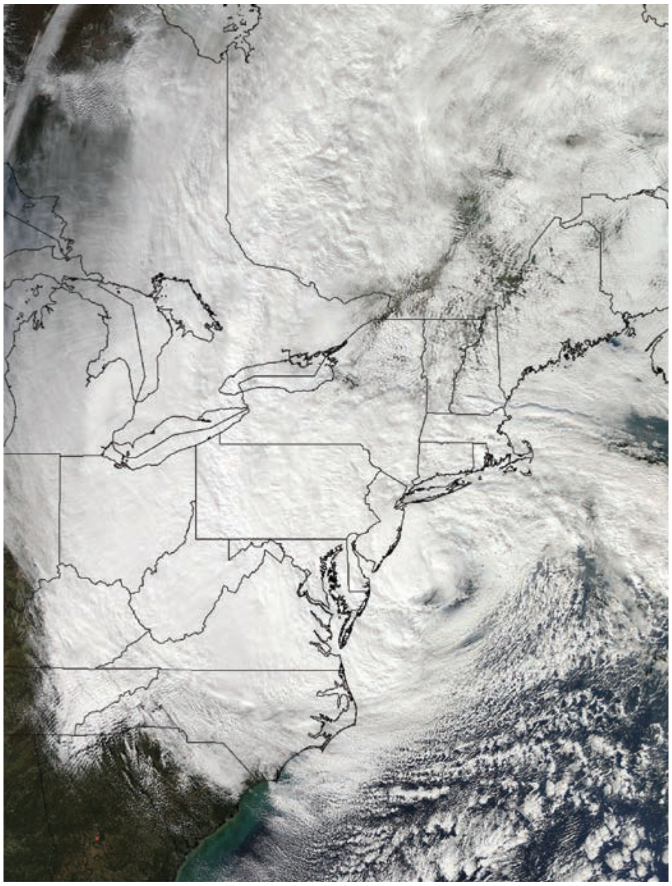
Additionally, three major retailers with large distribution centers provided material used in this case study. The discussion guides used to frame the interviews are provided in Appendix 4A of this report.

4.2 Description of Superstorm Sandy

This section provides a timeline of the superstorm (Figure 4.1) and provides a context for the port-related supply chain discussions that follow in the case study. According to Accuweather (http://www.accuweather.com/en/weather-news/timeline-of-events-surrounding/2665639), "Sandy was the strongest hurricane on record to strike the United States north of North Carolina." This section focuses on the general storm; the timelines and actions specific to ports are described separately in a later section of this case study.

Sandy's reported timeline (http://www.fema.gov/hurricane-sandy-timeline, http://newswatch.nationalgeographic.com/2012/11/02/a-timeline-of-hurricane-sandys-path-of-destruction/, http://www.accuweather.com/en/weather-news/timeline-of-events-surrounding/2665639, http://www.cnn.com/2013/07/13/world/americas/hurricane-sandy-fast-facts), is as follows:

- Monday, October 22, NOAA's NWS officially designates Tropical Depression 18 as Tropical Storm Sandy. The storm formed in the southern Caribbean Sea off the coast of Nicaragua. The maximum winds are 40 mph.
- Tuesday, October 23, NWS issues advisories for a Tropical Storm Watch for portions of south Florida and the Florida Keys.
- Wednesday, October 24, The storm, now a Category 1 hurricane, moves northward across the Caribbean and crosses Jamaica with winds of 80 mph and generates 20 inches of rain on Hispaniola. More than 50 people die in the flooding and mudslides in Haiti. Hurricane Sandy is now monitored by the FEMA regional office in Atlanta. NWS storm warnings extend to southeastern Florida.
- Thursday, October 25, Hurricane Sandy is located in the eastern Caribbean Sea with maximum sustained winds of 105 mph. FEMA is now in close coordination with state emergency management partners in Florida and the potentially affected states in the Southeast, Mid-Atlantic, and New England. The American Red Cross takes preparatory steps as far north as New York.
- Friday, October 26, Sandy strengthens as it moves from Jamaica to Cuba and strikes the historic City of Santiago de Cuba with winds of about 110 mph, only 1 mph below the status



Source: NASA

Figure 4.1. Superstorm Sandy on October 29, 2012.

of a major Category 3 hurricane. New York; Maryland; Washington, D.C.; Pennsylvania; and North Carolina declare states of emergency. The governor of Maine signs a limited emergency declaration allowing power crews from other states and/or Canada to help Maine prepare for Sandy. FEMA deploys Incident Management Assistance Teams to Connecticut, Delaware, New York, New Jersey, Massachusetts, New Hampshire, Pennsylvania, and Vermont, as well as liaison officers to EOCs in multiple states. In addition to Florida, the NWS issues Tropical Storm Watches for coastal areas in South Carolina and parts of North Carolina from the Savannah River (which delineates the border of Georgia and South Carolina) northward to Oregon Inlet, North Carolina, including Pamlico Sound. USCG issues warnings, closes several ports, and sets specific conditions for operations in storm conditions as far north as the Port of Baltimore. The U.S. National Guard positions more than 61,000 personnel along the East Coast and coordinates with local authorities in preparation for Sandy's landfall. The Federal Aviation Administration, U.S. Department of Energy, U.S. Department of Agriculture, and U.S. Geological Service also are engaged. Additional federal agencies engage as the storm progresses.

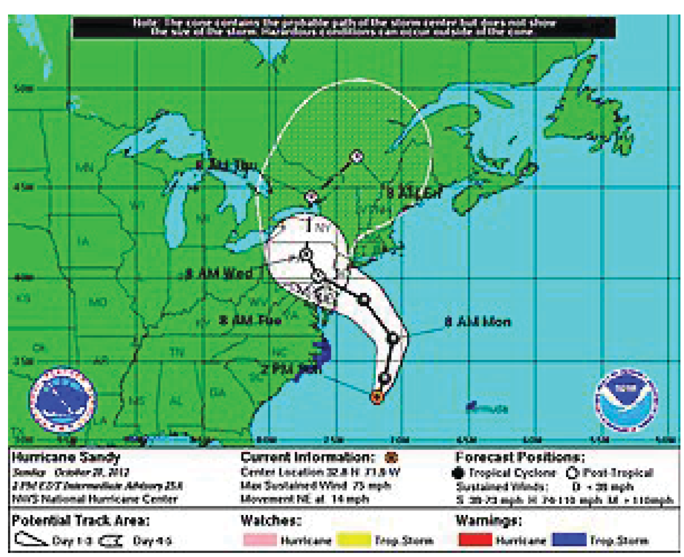
- Saturday, October 27, Sandy moves away from the Bahamas and makes a turn to the northeast off the coast of Florida. The storm briefly weakens to a tropical depression, but quickly re-intensifies into a Category 1 hurricane. New Jersey, Connecticut, and Massachusetts declare states of emergency. New Jersey Governor Chris Christie orders residents living in the barrier islands from Sandy Hook south to Cape May to evacuate. Amtrak cancels several of its runs that originate or end at East Coast stations. FEMA activates the National Response Coordination

Center (NRCC), a multi-agency center based at FEMA headquarters in Washington, D.C. The NRCC provides overall coordination of the federal response by bringing together federal departments and agencies to assist in the preparations for, and response to, disasters. Medical teams and support supplies are mobilized. American Red Cross chapters are mobilized. New York City Mayor Bloomberg tells New Yorkers in a pre-storm press conference to prepare for the arrival of Sandy by staying indoors and avoiding low-lying areas.

- Sunday, October 28, Sandy continues moving northeast on a track that takes it parallel to the coasts of Georgia, South Carolina, and North Carolina. The storm's center stays well offshore as it approaches the coast of North Carolina. The storm sends powerful waves onto North Carolina's Outer Banks, washing out NC Highway 12 in several locations. An unusual configuration of weather factors converges, with meteorologists warning that the storm will likely become a powerful, hybrid superstorm as it churns northward. A high-pressure cold front to Sandy's north is anticipated to force the storm to start turning to the northwest toward major cities such as Baltimore, Washington, Philadelphia, and New York (Figure 4.2). In addition, the full moon is anticipated to make Sandy's storm surge—expected to be 11 to 12 feet in some places—even higher as it makes landfall. Sandy has expanded into a massive storm with winds covering about 1,000 miles. Keith Blackwell, a meteorologist at the University of South Alabama's Coastal Weather Research Center in Mobile, tells *National Geographic News*, "It's so strong and so large, Normally protected areas like New York Harbor and Long Island are seeing the worst-case scenario."

  The local actions reported by CNN and others are as follows:

  – New York's Metropolitan Transportation Authority suspends subway and commuter rail services at 7:00 p.m. Bus services are suspended at 9:00 p.m.
  – USACE mobilizes planning and response teams (PRTs) and other resources to support temporary power generator requirements.
  – New York City Mayor Michael Bloomberg orders evacuations in low-lying areas of the city and public school closures.
  – Rhode Island declares a state of emergency.
  – President Barack Obama declares a state of emergency in Connecticut; Washington, D.C.; Delaware; Maryland; Massachusetts; New York; New Jersey; and Rhode Island.



Source: National Hurricane Center

Figure 4.2. Superstorm Sandy's track as of October 28, 2012.

  - The Broadway League cancels all Broadway performances for Sunday and Monday nights.
  - The Port Authority of New York and New Jersey suspends all PATH train service at midnight until further notice.
  - Airlines cancel flights, Amtrak cancels service. Airports are closed in the area.
  - The Southeastern Pennsylvania Transportation Authority, New Jersey Transit, and the New York Metropolitan Transportation Authority suspend all services.
- Monday, October 29, Sandy makes its expected sharp turn toward the northwest on a path for the coast of New Jersey. The storm also starts interacting with the other weather systems, gaining energy in the process. The storm results in heavy snow in the Appalachian Mountains of Virginia, West Virginia, and North Carolina. The center of the storm makes landfall near Atlantic City, New Jersey. The storm is no longer considered a hurricane but is now classified as a post-tropical nor'easter. But the storm's unusual path from the southeast makes its storm surge much worse for New Jersey and New York. The New York Harbor receives the surge and high winds. The surge is worsened because the full moon has added about a foot to the surge and Sandy arrives at high tide. Meteorologist Tim Morrin of the NWS's New York office tells *National Geographic News* that the surge—nearly 14 feet—is a new record for a storm surge in the harbor. The previous record of just over 10 feet was set in 1960 when Hurricane Donna passed just offshore. The surge tops the Battery seawall in Lower Manhattan and floods parts of the city's subway system. The surge also floods the Hugh Carey Tunnel, which links Lower Manhattan and Brooklyn, as well as the PATH system. Winds, rain, and flooding impact New Jersey and New York throughout the night and through three cycles of high and low tides.
- Tuesday, October 30, Sandy moves away from New York. As the day progresses, Sandy weakens as it moves inland over Pennsylvania. President Obama declared major disasters for Connecticut, New Jersey, and New York, making disaster assistance available to those in the heaviest hit areas affected by the storm.

In the end, the impact of Superstorm Sandy was historic. As reported in *USA Today* (http://www.usatoday.com/story/news/nation/2013/10/29/sandy-anniversary-facts-devastation/3305985/), Sandy

- Was responsible for an estimated $65 billion in damage in the United States, second only to Hurricane Katrina.
- Caused some 8.5 million customers to lose electrical power in a multi-state area.
- Was a "once in 700-year event" creating the first time that a storm took a sharp turn to the west and hit New Jersey.
- Led to the retirement of the name *Sandy*, which only occurs if a storm is so deadly or damaging that the use of the name is considered insensitive.

4.3 Characterizing Superstorm Sandy's Disruption of the Supply Chain

Superstorm Sandy was devastating. The superstorm's impact on supply chains was equally disruptive. Supply chain disruptions are characterized in the following terms:

- The extent of the geographic area affected,
- The freight modes and facilities affected,
- The characteristics of the cargo affected, and
- The length of time needed to resume activity at the affected freight facilities.

Superstorm Sandy's disruptions to the supply chain, with a specific focus on containerized port operations, are described in the rest of this section.

Geographic Area Affected

Superstorm Sandy was a multi-state event that affected the entire U.S. East Coast, as well as areas inland as the weather event traveled north. Several ports were put on heightened alert or closed as Sandy moved north, including ports in North Carolina, Virginia, and Maryland. However, physical damage, if any, was limited in these areas.

The most significant physical damage to ports handling containerized cargo occurred in the New York–New Jersey region (Figure 4.3). Six terminals, all under the control of the Port Authority of New York and New Jersey, which operates as their landlord, and each operated by private entities, are located within the area. All were affected and sustained significant damage. The terminals included the following:

- APM and Maher Terminals in Elizabeth, New Jersey;
- Port Newark Container Terminal in Newark, New Jersey;
- Global Marine Terminal in Jersey City, New Jersey;
- New York Container Terminal on Staten Island, New York; and
- Red Hook Container Terminal in Brooklyn, New York.

The Port of New York and New Jersey is the largest container port on the North American East Coast and the third largest in the United States (after the Ports of Los Angeles and Long Beach). The port is a major international trade gateway. Collectively, in 2012, the six container terminals within the port handled over 5.5 million 20-foot equivalent units (TEUs) translating into over 3.2 million containers (of, generally, 40-foot and 20-foot lengths).

Freight Modes and Facilities Affected

All freight modes and facilities were affected by Superstorm Sandy, particularly in the New York–New Jersey region. The port industry is defined as any activity directly related to the movement of waterborne cargo. The system involves the following three elements:

- The waterways and channels used by vessels;
- The terminals through which the maritime cargo flows; and

Source: http://www.panynj.gov/port/containerized-cargo.html

Figure 4.3. Container terminals in the Port of New York and New Jersey.

- The inland and domestic movements of international maritime cargo, including barge, truck, rail, pipeline, and—sometimes—air cargo.

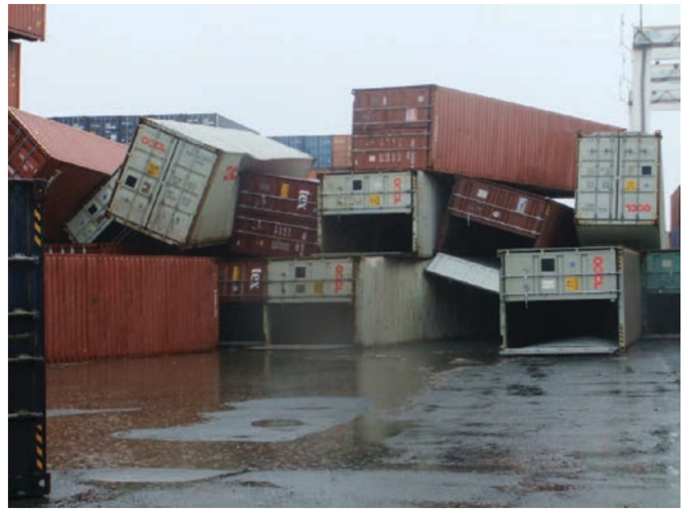
Trucks, railroads, domestic barges, and air cargo carriers also can act as alternative transportation options to facilitate business recovery when port infrastructure and operations are affected. All of these forms of freight conveyance were affected, particularly in the New York–New Jersey area, as follows:

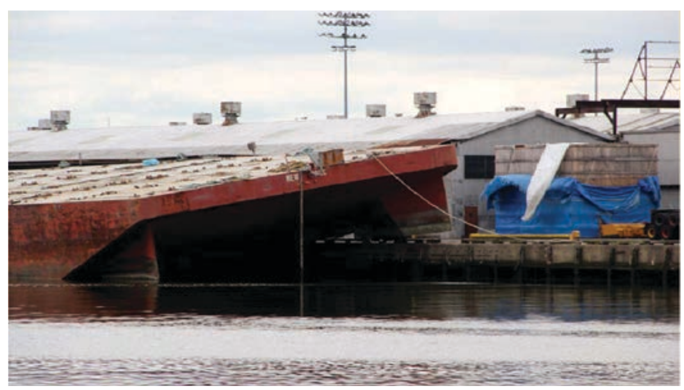
- The waterways were affected by floating debris, potential changes in channel depth and damage to navigation aids.
- The terminals sustained damage to equipment, buildings, and paved areas. Electrical power was lost. Surging salt water damage was widespread.
- Trucking firms directly serving the port/providing drayage service sustained losses of tractors and other equipment. In addition, roadways were damaged, blocked, or washed away. Fuel and chassis shortages impeded truck operations.
- The major Class I railroads serving the Port of New York and New Jersey moved equipment prior to the superstorm but still sustained damages to on-dock rail yards. In addition, the CSX Kearny Yard in Essex County—eventually used for the shuttle trains returning diverted cargo to the region—was flooded with more than 4 feet of water, with damage to equipment.
- Newark Liberty International and John F. Kennedy International Airports—the two regional airports that handle the majority of air cargo—sustained damages and were closed (though for a shorter time than the port facilities).

New Jersey is also a major warehousing and distribution center node, with over 940 million square feet of industrial property. Major warehouses and distribution centers throughout the region that receive import shipments were significantly affected. Buildings lost electrical power and needed to rely on generators for up to 2 weeks at significant cost. Although some of the distribution centers have large solar panel arrays on their roofs, these solar systems feed into the regional electrical grid and do not serve the buildings directly. Trucking firms faced the same challenges as described for the port areas.

Characteristics of the Containerized Cargo Affected

Containerized cargo typically consists of a wide range of products, particularly for retail markets. According to the *Journal of Commerce* (see http://www.joc.com/international-trade-news/trade-data/united-states-trade-data/top-100-importers-2012_20130524.html), the top 10 importers via ocean container transport include Wal-Mart, Target, Home Depot, Dole Food, Lowe's, Sears Holdings, the LG Group, Heineken USA, and Philips Electronics North America.





As described by one major retailer, Superstorm Sandy occurred during the peak intake week of the year—the week when warehouses and distribution centers are stocking fully for the holiday season. As such, the containerized shipments affected by the superstorm were time sensitive, in peak season, and generally comprised of higher value products than at other times of the year. An interviewee characterized the situation, saying "This was Christmas season. Everyone was in a rush. The customers wanted cargo to move immediately and not stop because one port was shut down. These diversions were unwelcome."

Length of Recovery Period

For the purposes of this case study, the length of the recovery period is defined as the length of time that was needed to return the majority of the Port of New York–New Jersey's container terminals to operation, even though significant repairs were still under way. Under this definition, the port was closed for nearly 1 week. Although the terminals were reopened and handling vessel operations, the import containers diverted to other ports took varying lengths of time, sometimes beyond this 1-week period, to be moved to their original U.S. destination.

4.4 Topographies of Import and Export Containerized Cargo Operations

Another approach to understanding the impact of Superstorm Sandy on ports and supply chains is to identify how the elements of import and export containerized cargo operations were affected. Of the over 5.5 million TEUs handled by the Port of New York and New Jersey in 2012, over 2.7 million TEUs, or 50 percent, were loaded import containers. Figure 4.4 summarizes the topography of import container movements and diversions based on industry knowledge, along with the research and interviews conducted for this project.

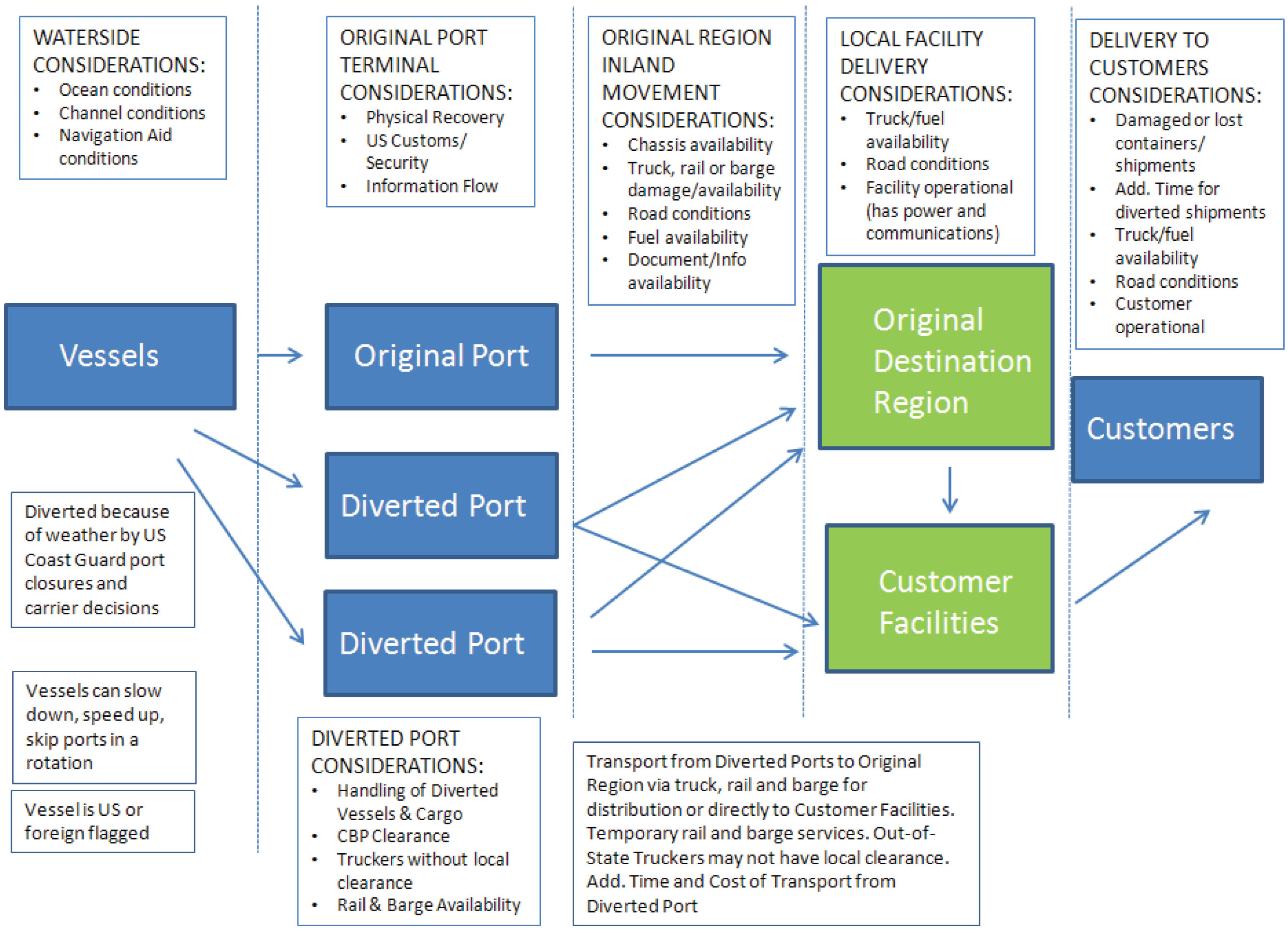
Vessel Operations

Vessel operations are scheduled and monitored by carrier operations personnel who assess the conditions at the ports of call and at sea, along with the options available.

The Merchant Marine Act of 1920, commonly referred to as the Jones Act, requires that goods and passengers transported solely between U.S. ports must be done on vessels made and staffed in the United States (referred to as "flagging" of the vessels). Foreign-flagged vessels can transport passengers and cargo on rotations that include at least one overseas port but cannot move cargo and passengers between two or more U.S. ports; the origin and destination of a shipment carried on a foreign-flagged vessel must include an overseas port.

As weather and ocean conditions during Superstorm Sandy deteriorated and the USCG closed ports on the U.S. East Coast, ocean carrier operations staff considered their options. These options included keeping going, slowing down, or speeding up vessels to work around the worst elements of the vast superstorm, as well as whether to skip one or more East Coast ports that were typically part of the vessels' scheduled rotations.

As a result of these conditions, as well as the week-long closure of the Port of New York and New Jersey, vessels with import containers offloaded shipments at alternative locations along the East Coast. The Port Authority of New York and New Jersey estimates that 57 vessels, including 15,000 containers and 9,000 vehicles, were diverted to other U.S. East Coast ports as a result of Superstorm Sandy (PANYNJ, 2012).



Source: A. Strauss-Wieder, Inc.

Figure 4.4. Topography of import container operations and diversions.

Port and Terminal Considerations

To resume the flow of imported cargo, the "original" impacted port must focus on immediate recovery and restarting of operations. As discussed in this case study, this effort involves addressing physical damage, information flows (in terms of coordinating recovery and the information needed for resuming cargo movement), and meeting agency requirements, particularly security and cargo inspection.

The issues are equally as complex for alternate ports handling the diverted cargo and vessels. These ports must balance the handling of cargo from their regular customers with the surge in diverted vessels and cargo. The considerations for "diverted ports" include having sufficient equipment and labor to handle the additional loads, information regarding how the diverted cargo will be moved inland to customers (availability of barge, rail, and/or truck options), and the physical capacity to store the containers at the port until these movements occur. The speed at which decisions are made regarding these movements, as well as obtaining sufficient equipment and CBP clearance, contributes to determining how long the diverted cargo must be stored at the diverted port.

Federal agencies, such as CBP, also must deal with reassigning at least some of the shipments from the original customs district to the district where the diverted port is located so the cargo can be cleared to be moved inland. Otherwise, the cargo must travel "in bond" in the original customs district for clearance. Import cargo also must satisfy CBP requirements.

Most of the containerized cargo diverted by Superstorm Sandy was handled by the Virginia Port Authority. The Ports of Baltimore, Halifax, and Philadelphia also handled some diverted vessels and cargo. According to the interviews, Baltimore handled approximately 2,800 containers, and Virginia Port Authority handled some 8,000 to 10,000 diverted containers.

Inland Movement Considerations

At the original port of call where the physical damage occurred, the restarting of cargo operations is also dependent on the availability of inland modal connections. The considerations regarding inland movement vary by mode and include the following:

- Truck movements are dependent on access and regional roadways to be open; having sufficient tractors, chassis, fuel, and drivers to handle the movements; and having the data systems operational for gate clearances and needed cargo information. Trucking companies are also dependent on the inland customer's location, such as a warehouse or distribution center, being operational (i.e., recovered from any damage; is accessible; and has power, data systems, and personnel) and accepting deliveries.
- Rail movements are similarly dependent on on-dock, near-dock, and other rail yards on the system being operational and rail lines being clear for train movements. Sufficient locomotives, fuel, labor, and intermodal equipment (including the equipment for the loading and unloading of trains) are needed.
- Barge movements are dependent on the waterways being certified for operation; the facility where the barge is calling being operational; sufficient equipment, labor, and fuel being available; and the conditions at the location where the barge is calling.

Over 80 percent of the cargo at the Port of New York and New Jersey moves inland via truck, a reflection of the region's population density and as a major North American distribution center node. Most of the remaining shipments move inland through the ExpressRail yards located at the Port.

Many of the trucking firms serving the Port of New York and New Jersey suffered significant losses of tractors. Some trucking firms worked closely with their suppliers to secure replacement tractors as quickly as possible. Others, including owner operators, did not have such business relationships and capital to recover quickly.

The ExpressRail yards at the port experienced surges in salt water, with sand, fencing, and other debris deposited on track, and power out for controls and signals. In general, the damage to the rail infrastructure was characterized by the interviewees as less severe than the trucking damages. Much of the rail infrastructure is located further from the wharfs, and the Class I railroads had moved equipment out of the area prior to the storm.

A different set of inland movement considerations confront the ports handling the diverted vessels and cargo. The Jones Act, as previously discussed, does not permit diverted cargo that is offloaded at one U.S. port to then be picked up by another foreign flag vessel to be moved to the original port. A U.S.-port-to-U.S.-port move must be done by a U.S.-flagged vessel, such as a U.S.-flagged coastal container barge, or moved by rail or truck, generally after clearing CBP. Diverted containers needed a permit from CBP to transfer within the original port, an in-bond transfer between ports, or an entry release/clearance by CBP prior to inland movement.

The resiliency and flexibility of the U.S. multimodal freight system thus becomes a consideration in the ability to move cargo from the diverted ports to customers, as do existing contractual arrangements among carriers and transportation providers. The distance between the diverted port and the location of the customer's U.S. facility is a consideration.

Based on the interviews, in general, if the distance is under a half-day's drive, then trucks can become an option where timely movement of the diverted loads can justify the additional trucking costs. The trucks picking up this cargo must have the credentials to call on the terminals at the diverted port.

Movements by barge and rail offer more cost-effective solutions for large-scale transport of diverted cargo to customers. Barge movements offer the opportunity to move the containers in bond to the original port for clearance. Based on the interviews, movement of diverted containers via rail required the containers to have cleared U.S. Customs. Movements by barge and rail are also dependent on the availability of these options at the diverted ports.

Such "modal flexing" was crucial to handling the cargo diverted by Superstorm Sandy. For example

- CSX created special rail shuttles between Norfolk, Virginia, and Kearny Yard in New Jersey, and qualified crews moved diverted containers to customers in the New York–New Jersey region. Most of the containers diverted to Norfolk were handled via these trains after each container was cleared by CBP. Diverted containers that were destined to locations further inland could be handled by the existing CSX and Norfolk Southern trains at Norfolk after clearing CBP.
- Columbia Coastal similarly sent special barges to Virginia to bring containers back to the Port of New York and New Jersey. The company's existing barge service between Baltimore and New Jersey handled containers diverted to Maryland.
- Cargo diverted to Philadelphia destined to the New York–New Jersey area could be picked up by truck, given the shorter distance.

Considerations at Customer Locations

Customers had to handle a wide range of supply chain issues due to the port disruptions, including

- Damage to the container contents—The surge in salt water enveloped many containers at the Port of New York and New Jersey. The high winds also toppled stored containers. Both situations resulted in damaged contents that needed to be replaced quickly given the urgent demands of peak season.
- Increased waits for containers—If the containers were at the original port, the customer had to wait for the port to reopen to obtain the containers. Resumption of business service at the port, including information systems, equipment shortages and clearing CBP, and arranging truck delivery, increased the amount of time needed to obtain the containers. Where containers had been diverted, customers had to wait while these containers were located and arrangements made for their delivery from the diverted port. In addition, the party responsible for the container's transportation to the customer (which can be either the supplier or the customer) was also responsible for any additional costs associated with the move from a distant location.
- Truckers serving the warehouse—When fuel is in short supply, arrangements may need to be made to ensure that trucks have sufficient fuel to operate. Some customers, as well as trucking firms, arranged for tank trucks to be available on site to service trucks and their own labor force.
- Conditions at buildings—If electrical power was out at the buildings, then generators were needed to power equipment and the warehouse information management systems that are crucial for material flows and facility operations. In addition, customers had to take care of

their labor force, including making sure those workers had access to fuel and supplies for their homes. Any damage to buildings and access roads had to be repaired sufficiently to restart operations.
- Conditions at their customers' buildings—In some cases, when retail stores being served by the warehouses were not open, product had to be held at the distribution center. In other cases, where supplies were urgently needed for response and recovery, customers had to dispatch their own trucks to pick up supplies as they became available at the warehouse.

The organizations interviewed for the case study primarily focused on the movement of import containers. However, one interviewee did note a decision point unique to export containers—whether to hold the product at the domestic origin or reroute the shipments based on the anticipated resumption of business operations.

The next several sections of the case study detail the preparations for, impacts of, and responses to Superstorm Sandy.

4.5 Superstorm Sandy Preparations

The preparations for the superstorm reflect the vast geographic area and freight modes affected, as well as the uncertainties regarding the storm's path and potential impact. All elements in the topography prepared for the event, with preparations occurring on the physical, information/communications, and regulatory levels.

Preparations by Public Agencies

Numerous public agencies at the federal, state, and local levels prepared for Superstorm Sandy. Decisions and levels of preparation varied based on location and intensified as the path and attributes of Sandy became more apparent. For example, the path of Sandy is clearly evident in the port conditions set by the USCG as the weather event proceeded up the East Coast. The initial USCG announcements focused on the Florida area. As Sandy's path proceeded, on October 26, the USCG set Hampton Roads (Virginia) and the Port of Baltimore on port condition "Whiskey" (http://www.fema.gov/hurricane-sandy-timeline), a port readiness condition indicating that hurricane force winds are possible within 72 hours (http://www.nrlmry.navy.mil/port_studies/tr8203nc/miami/text/sect3.htm). On October 27, the USCG set port condition "X-Ray" for the Port of Philadelphia, meaning that gale force winds were expected within 48 hours (http://www.uscgnews.com/go/doc/4007/1591207/). Philadelphia moved to condition "Yankee" (gale force winds possible within 24 hours) the next day (see http://www.uscgnews.com/go/doc/4007/1591215/) and to "Zulu" (gale force winds within 12 hours) on October 29 (http://www.uscgnews.com/go/doc/4007/1591223/). On October 28, this condition was raised to "Zulu" for Baltimore and Virginia (http://www.uscgnews.com/go/doc/4007/1591327/). The USCG opened all ports from Philadelphia to North Carolina on November 1 (http://www.uscgnews.com/go/doc/4007/1594499/).

In the New York area, the captain of the Port of New York and New Jersey provided advanced notice on Saturday, October 28, that the port would be closed effective by mid-Sunday afternoon. The USCG set condition "Yankee" for the Port of New York and New Jersey on the same day, and made the following requirements (http://www.uscgnews.com/go/doc/4007/1591335/):

- Commercial deep-draft vessels greater than 500 gross tons are not authorized to remain in port alongside a pier after 6 p.m., today.
- All vessels must be out of Bay Ridge, Stapleton, and Gravesend Bay Anchorage Grounds by 6 p.m., today.

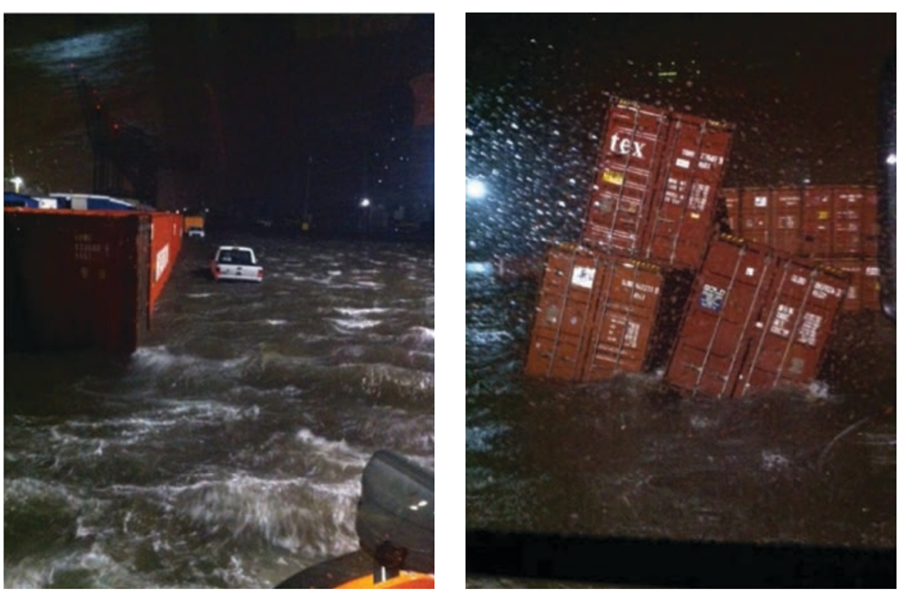
- Only one barge per commercial mooring buoy, with a tug in the vicinity, is authorized after 6 p.m., today.
- After the hurricane has passed, all facilities must fill out a post-storm assessment survey.

The USCG set condition “Zulu” and closed the Port of New York and New Jersey on October 29 (http://www.uscgnews.com/go/doc/4007/1591571/). Ultimately, ports from Virginia to Boston were closed.

The following timeline of actions by the Port Authority of New York and New Jersey (PANYNJ, 2012) shows the initial monitoring of conditions, with significant ramping up of actions as it became evident, on the day before the Superstorm Sandy hit, that the New York–New Jersey region would be at the epicenter of the weather event:

- Notification to port authority tenants began Thursday, October 25 (following USCG Sector NY Hurricane/Severe Weather Plan and Port Authority’s Emergency Operations Plan).
- The Port Authority EOC is activated on Oct. 28. The October 28 National Weather Service briefing indicated surge of 6’-11” above normal high tide. Based on emerging conditions, the port authority decides to close the maritime terminals to all but essential personnel by 23:59 hours. All vessels were required to be at “safe harbor” (not at the berths) or out to sea by 18:00 hours.
- Monday, Oct. 29, 12:00 hours, the agency orders all tenant personnel and port authority contract security off the port; port authority and staff, including the port authority police department are vacated at 19:15 hours (just prior to the anticipated surge).
- Monday, Oct 29, 20:00 hours, the agency notes that NOAA has reported water levels at the Battery and Bergen Point at 9’-10” above MHW; winds at 80 to 90 mph; surge 13–14 feet. These metrics are far greater and more sustained than the conditions experienced during Irene the year before.

Several interviewees noted that it was at 11:00 a.m. on Sunday—the day before the superstorm—that it became certain that Sandy would hit the New York–New Jersey region with devastating winds and storm surges.



Source: New York Container Terminal

Figure 4.5. Conditions at New York Container Terminal during the Storm: White Caps in the Middle of the Terminal.

Physical Preparations

The organizations interviewed for this case study summarized the preparations undertaken by each of the freight transportation modes and facilities for Sandy as follows:

- **Ocean Carriers**—Each carrier's operations center tracked the superstorm along the U.S. East Coast, determining whether the vessels should continue as planned, slow down, speed up, or perform other actions. One carrier had more than 15 vessels in the area potentially affected by Sandy. In addition, following USCG-set port conditions, work on vessels docked at ports had to cease and vessels needed to be put out to sea.
- **Barge Operators**—In addition to securing their equipment, Columbia Coastal, the major domestic coastwise intermodal barge service provider, began making preparations for providing port-to-port service to handle diverted containers.
- **Terminal Operators**—Similarly, following USCG-set port conditions, work on vessels was suspended. In addition, with high winds anticipated, container stacks had to be lowered; with more containers placed at ground level. One interviewee noted that the availability of labor on a Sunday to move the containers was an issue. Positioning more containers on the ground addressed wind concerns but increased the number of containers inundated by Sandy's unusually high and sustained salt water surges. Terminal operators also secured equipment, moving equipment where possible to the highest location available. Hurricane strappings on the large container cranes were secured. Following USCG and port authority orders, all personnel were evacuated as Sandy approached the port. At offices within the port, computers and other equipment were placed on top of desks and elevated in case of flooding (see Figure 4.5).
- **Trucking Firms**—Trucking firms similarly secured their tractors and other equipment, as well as placed computer and other equipment on desktops in case of flooding. Many trucking companies are located proximate to the port in areas that had not previously flooded in storms.
- **Freight Railroads**—Norfolk Southern and CSX, the two national Class I railroads that handle the majority of the rail cargo at the Port of New York and New Jersey and serve other ports along the East Coast, moved their equipment out of the Port of New York and New Jersey as well as repositioned their equipment and personnel along the East Coast. The railroads applied lessons from previous severe weather events such as Katrina. The railroads followed three procedures:
  - Stop all inbound trains before they arrive in the affected area. CSX stopped inbound trains in Syracuse and in northwestern Ohio.
  - Evacuate as much equipment as possible from the affected area.
  - Move all equipment that cannot be evacuated to the highest ground available.

  The railroads also began preparations for special intermodal rail shuttle service to handle diverted containers.
- **Warehouse Operators**—Warehouse and distribution center (DC) operators followed their individual plans for severe weather events. In one example, a DC operator with an emergency generator ensured that the fuel tank to support it was filled. Other DC operators proceeded with securing back-up generators from suppliers. These generators are quite large and expensive to rent. However, electrical power is required to operate warehouse information management systems, as well as the conveyors and other equipment in the building.

All businesses made efforts to ensure that their personnel were safe and their facilities secured. Some major companies that had experienced large disruptive events previously also maintained emergency supplies for their personnel; for example, containers were preloaded with generators, water, and other supplies for personnel and their families, and were quickly dispatched to affected locations.

Communications and Information Flow

The Maritime Transportation Security Act of 2002 (MTSA), among other provisions, requires the establishment of committees at each port that include the public agencies and private organizations to focus on securing each location. MTSA also required that the National Maritime Transportation Security Plan include a procedure for restoring cargo flow following a national transportation security incident (USCG, 2008). Such committees proved highly useful in the resumption of activities following such events as Katrina. The SAFE Port Act of 2006 similarly required protocols for the resumption of trade.

As a result, the USCG (USCG, 2008) established the Marine Transportation System Recovery Unit (MTSRU). In addition to a national-level MTSRU, regional-level MTSRUs were created to manage area events. According to the USCG, "The District MTSRU will consider regional impacts of the incident and work to coordinate or prioritize regional recovery efforts in support of the overall national effort to facilitate the rapid resumption of commerce. District MTSRU staff also provide the linkages and coordination with the Joint Field Office (JFO), if a JFO is established. These MTSRUs will also provide the necessary capability to handle large-scale, broad geography and multiple-incident events" (USCG, 2008). As one interviewee described it, the goal of the MTSRU is to provide a holistic coordinating approach and collective informed decisions for reopening the waterways. Superstorm Sandy was the most significant activation of MTS since Katrina.

The MTSRU in the Port of New York and New Jersey is a public-private coordination group that meets regularly. The group includes "anyone with a significant footprint in the water." The members include the Port Authority of New York and New Jersey, the New York City Economic Development Corporation (which manages waterfront properties in the city), major refineries, tug and barge operators, the Staten Island ferry, all of the terminal operators, the New York Shipping Association, the pilots' organization, and other maritime operators in the port. The public agencies include the port authority, CBP, and the USCG. The procedures and working relationships established through the MTSRU, according to the interviews, were instrumental in the port's expedited return to service after Superstorm Sandy.

The MTSRU does not currently include rail or truck organizations. However, the Port Authority of New York and New Jersey maintains e-mail, web, and other links with these stakeholders. The New Jersey Motor Truck Association issued numerous email blasts to their members regarding road, weather, and fuel conditions, as well as permit and regulation changes and suspensions. In addition to the MTSRU, the port authority held conference calls. The agency also notified more than 10,000 organizations by e-mail through its e-Alerts system and by fax. The port authority sent out two or more daily reports on port conditions. In the supply chain, information systems also included real-time tracking of shipments. Accordingly, the location of inbound shipments could be monitored.

4.6 Superstorm Sandy's Impacts on Port Operations

The Port of New York and New Jersey received the brunt of Superstorm Sandy's impact. The other major container ports on the U.S. East Coast reopened quickly and sustained minimal damage. As noted by the interviewees, "By the time the storm hit, the full port was evacuated and secured. This was our best decision. There was no loss of life, no injuries, and no theft." All aspects of the import container topography were immediately impacted, affected by physical damage, power outages, communication outages, and damage to employee homes.

Physical Damage

The damage to the Port of New York and New Jersey was extensive and all operations halted. The facilities had no electric power, which is increasingly crucial as ports move toward using electrically powered equipment instead of diesel-powered equipment.

The damages, which began to be identified and addressed the day after the storm, included the following (PANYNJ, 2012):

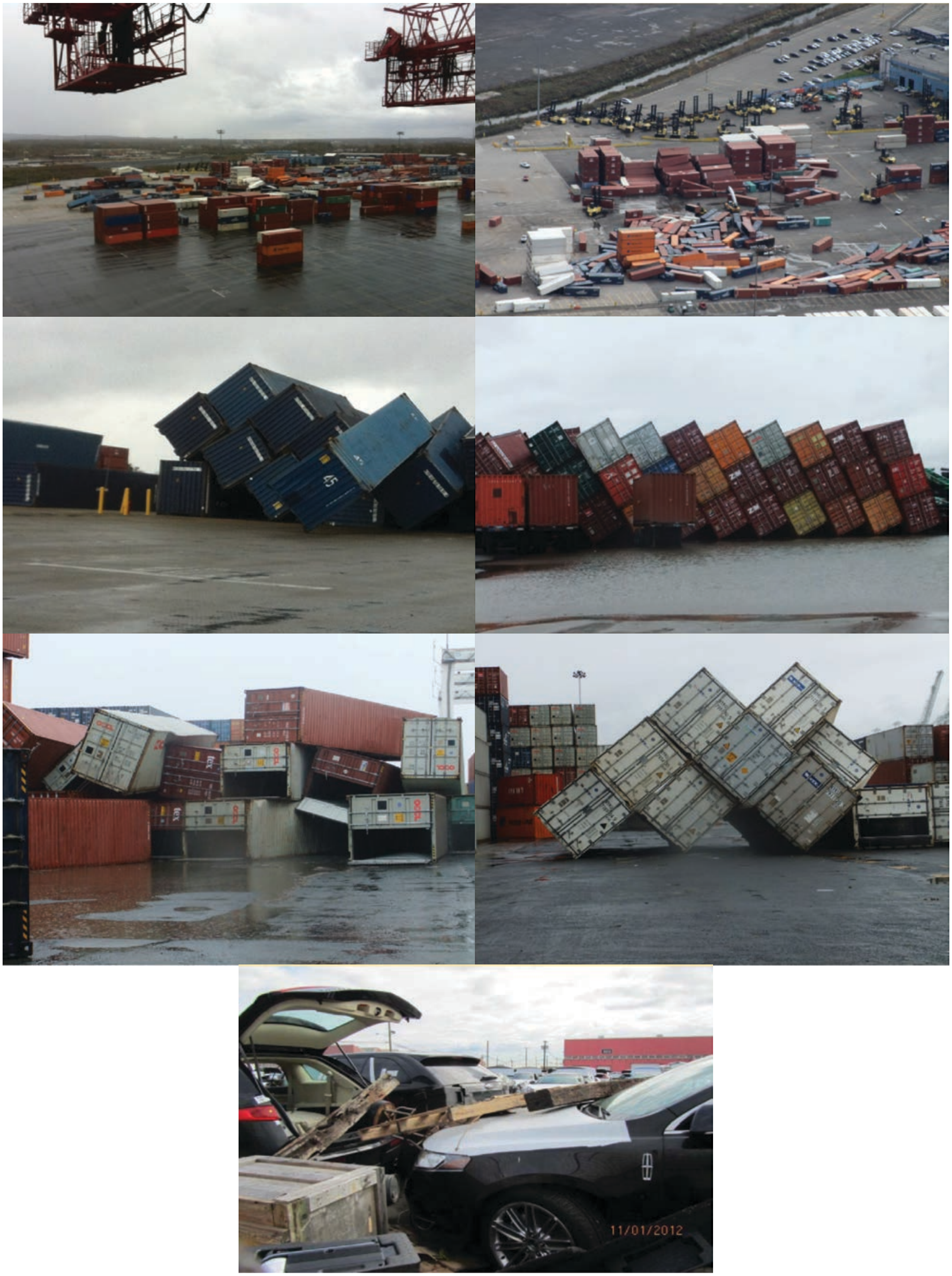
- Flooding (water level in buildings was between 3 to 5 feet);
- Damage to utilities—general commercial power, motors, controllers;
- Damage to sewage/fire pump motors and controllers;
- Loss of rail relays and switches;
- Destruction of security fencing and guard booths;
- Damage to cranes and cargo handling equipment;
- Debris in roadways, channels, and berths;
- Road and rail track damage;
- Toppled container stacks and loss of containers (containers in waterways, on rail lines, etc.); and
- Loss of autos from flooding and fire.

Containers and other debris were in the waterways. Shoaling and potential hazards to navigation had to be identified and addressed, as well as ensuring that all navigation aids were operational. The surge of salt water during Superstorm Sandy was aggressive, affecting areas that had never experienced flooding prior to the event. As shown in Figures 4.6 through 4.10, the rise in water was rapid and fueled by both the wind and tides. The first floor of the port authority's administration building was flooded, as were buildings in other areas of the port used by terminals, trucking firms, and other businesses. The flooding also deposited sand and debris throughout the port (including the on-dock rail yards), as well as damaged the required security fencing.

Although many container stacks were lowered in accordance with preparation for a wind event, interviewees noted that the surging water still floated up the stacks and caused many to fall over.

In addition to the damage to the security fencing and gates, the Radiation Portal Monitors maintained by the CBP, which screen all import containers leaving the port, were flooded and damaged. All perimeters and security measures had to be in good working order and meet CBP needs prior to restarting terminal operations. The large container cranes survived Sandy with the hurricane strapping. However, the engines that power the cranes located at the base of each structure were submerged in salt water. Salt water damage to this equipment had to be addressed. Yard equipment, essential to terminal operations, also sustained damage that came primarily from salt water submersion.

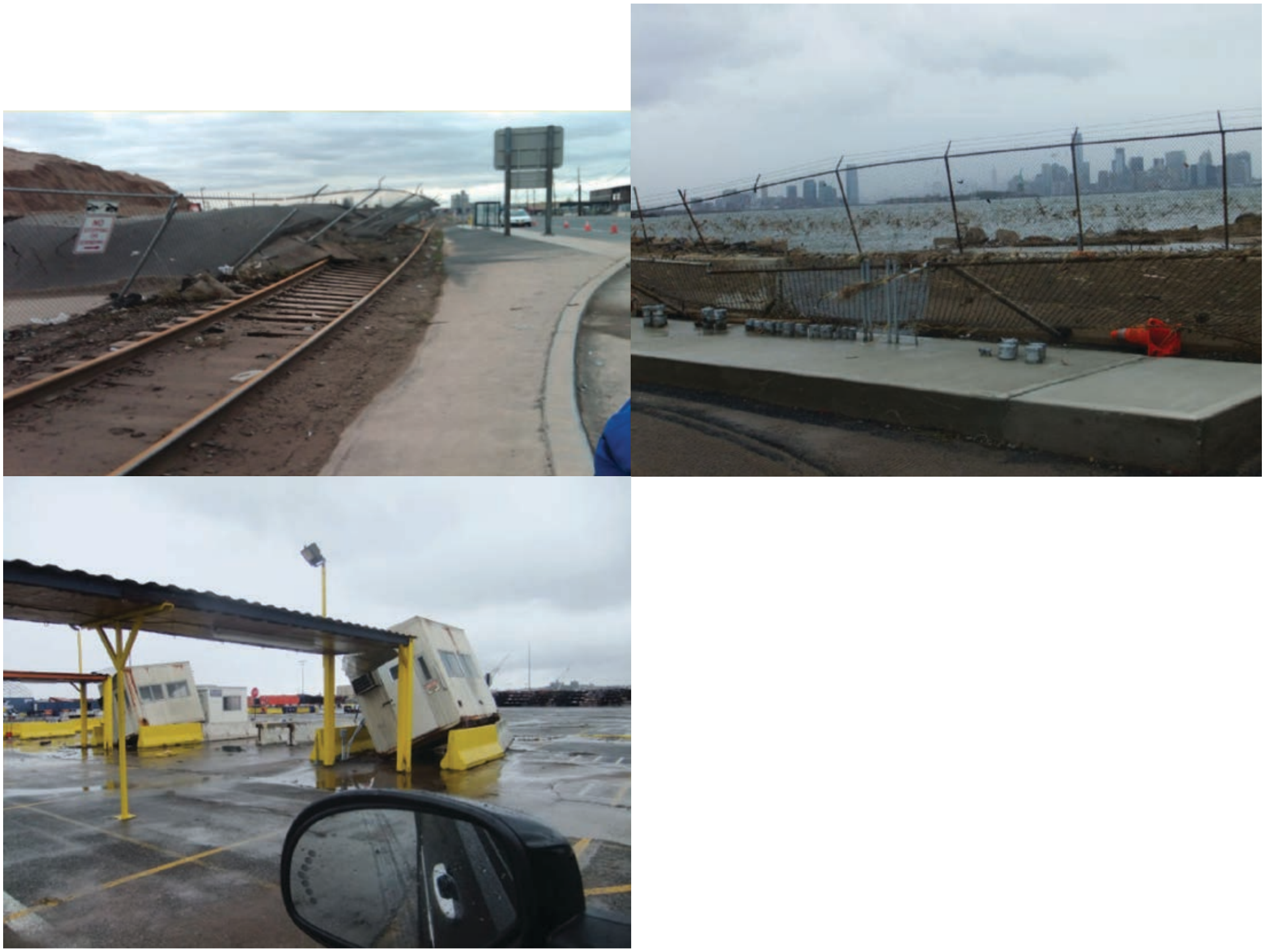
Containerized cargo was not the only type of cargo affected at the port. The Port of New York and New Jersey is one of the largest auto import and export locations in the United States. It is generally an industry practice to store vehicles at ports either prior to delivery to dealerships or in preparation for export. Thousands of new vehicles stored at the Port of New York and New Jersey were flooded and destroyed. The engines of some electrical vehicles burned as a result of their exposure to salt water. Some interviewees noted the odd site of seeing fires in the middle of flooded areas.



Source: Port Authority of New York and New Jersey, Terminal Operators

Figure 4.6. Superstorm damage at the Port of New York and New Jersey.

Figure 4.7. Flooding at port terminal buildings and damage to security fencing.



Source: Port Authority of New York and New Jersey, Terminal Operators

Figure 4.7. (Continued).

The CSX Kearny Yard, a major regional rail facility used for intermodal rail service, was flooded by 4 feet of water, lost power, and suffered major damage to the container chassis at the facility. While not currently used for container operations, Greenville Yard, which is the New Jersey terminal for the rail car float between New York and New Jersey, as well as local carload rail, was completely destroyed. At Greenville, the float bridge was destroyed and one of the rail car float barges broke in half and sank at the terminal. The rail rights of way (located further inland) generally used for freight movement had minimal and, in some cases, no damage. The Norfolk Southern intermodal yards in the region (Croxton and ERail) were not affected as severely as the CSX Kearny Yard.

Trucking companies that provide drayage service to the port's terminals sustained damage to tractors and offices. The most affected trucking firms were located at the port, as well as in low-lying areas in the vicinity of the port. Trucking firms also needed to contend with damaged roads, non-functioning traffic signals, and detours, as well as fuel shortages throughout the New York–New Jersey region. Determinations had to be made as to whether customers' facilities were open and available to accept deliveries or pick ups.

Note: Barge shown is the Red Hook Barge at/on Berth Six in New Jersey.
Source: Port Authority of New York and New Jersey, Terminal Operators

Figure 4.8. Damage to container barges, roadways and drayage trucks.

Source: A. Strauss-Wieder, Inc.

Figure 4.9. Greenville car float prior to Superstorm Sandy.

Source: Port Authority of New York and New Jersey
Note: Float bridges destroyed. Rail Car float barge broken in half and sunk.

Figure 4.10. Greenville rail car float after Superstorm Sandy.

In addition to the damage to equipment, the port's chassis pools were severely affected through submersion in salt water. The availability of chassis was crucial to resuming operations at the port. Major distribution centers located in New Jersey suffered power outages. Trucking companies suffered loss of equipment from the surge flooding, blocked and damaged roads, and fuel shortages. In addition to damages to container operations, the sea-level petro-chemical complexes and freight operations were affected.

Impacts on Communications and Information Flows

Superstorm Sandy caused power outages in a multi-state area. The port facilities in the New York–New Jersey region, as well as key freight infrastructure, such as the CSX Kearny Yard, were without power. Although utility repair crews had already been mustered from around the country (and more would be called in), the extent of the damage and the many critical infrastructure elements and facilities needing power restoration required the port to "compete" with other recovery priorities in the region. The area power companies were part of the MTSRU and were located with the port authority at the agency's EOC. The utilities understandably could not focus solely on the port because of the extensive geographic scope and severity of the damage from the storm.

Power outages took electrically powered cell towers and communications hubs offline. Computer systems were offline. In addition, the salt water surges inundated first-floor and ground-level computer rooms and utility areas. Downed trees and utility poles severed fiber and copper communications lines. As one interviewee noted, "We had no power or street lights. Clean-up operations could only be done during daylight."

Critical data and systems were not immediately available (even when back-up sites were available, there was no power to access the Internet). Paper copies and maps came into use in some organizations.

However, the MTSRU and the port authority, along with other agencies, arranged daily conference calls at set times. Knowing when a conference call was to take place enabled individuals to call in, sometimes from cell phones powered by car engines. The port authority held regularly scheduled conference calls twice each day. Two thousand additional people subscribed to the agency's messaging and "e-Alerts" in the 12 hours prior to Sandy's landfall in the New York–New Jersey region. As noted previously, messages were sent to such entities as BCOs and carriers at least twice daily.

Impact on Public Agencies

Public agencies were similarly affected by the damage and power outages. A wide regional response was underway by multiple agencies. Within that context, those public agencies with specific regulatory responsibilities involving port operations began mandated processes. The port authority's administration building at the maritime terminals was flooded; the agency set up a command center at Newark Liberty International Airport, which is adjacent to the port, immediately after Superstorm Sandy passed, and set up a Mobile Command Center at the port by the end of the first day after the Sandy. The agency was able to reoccupy their Administration Building at the port, despite the damage, on the second day after Superstorm Sandy.

4.7 Superstorm Sandy Port-Related Business Recovery

The topography of import containers is particularly evident in the ways in which the supply chain recovered from the superstorm, along with the issues and considerations faced by the different elements in the topography. One set of issues affected the New York–New Jersey's port facilities, which suffered significant physical damage. A completely different, but equally disruptive, set of issues affected the ports handling the diverted vessels and cargo.

The Port of New York and New Jersey was largely reopened for business in 1 week, a remarkable achievement given the extent of the physical damage. The timeline leading to the full reopening of the container terminals was documented by the Port Authority of New York and New Jersey (2012) as follows:

- Tuesday, October 30 (day after the superstorm)—Assessment, response, recovery, and restoration begins;
- Friday, November 2—USCG re-opens port to deep-draft commercial traffic and *Brilliance of the Seas*, a cruise vessel, is the first to arrive at Pennsylvania's Cape Liberty facilities;
- Saturday, November 3—Power restored at Elizabeth, New Jersey, the location of the two largest container terminals (Maher and APM);
- Sunday, November 4—Maher and APM work five vessels;
- Monday, November 5—Truck gates at all container terminals open for business; and
- Monday and Tuesday, November 5 and 6—All remaining container terminals work their first vessels.

The port agency also reported that 57 vessels of all types were diverted to other U.S. East Coast ports. The diverted containers were estimated at 15,000. Separately, about 9,000 autos were diverted. Outside of the New York–New Jersey region, various freight modes and diverted ports worked together to handle the diverted shipments. As several interviewees noted, the diverted containers disrupted cargo flows and congested maritime terminals along the entire U.S. East Coast.

Physical Flow Recovery in the New York–New Jersey Region

All physical elements of the supply chain within the New York–New Jersey region began recovery and preparation for resumption of operations in parallel as soon as access to the facilities became available. Work was limited to daylight hours until power was restored.

- **Waterways**—USCG had to ascertain that channels were navigable and clear of marine debris and underwater obstructions to ensure the safe passage of vessels. At first light on Tuesday morning as the storm was still passing through, the USCG and Sandy Hook Pilots conducted a visual waterway assessment using Sandy Hook Pilot vessels. Immediately following the storm, NOAA and the Army Corps of Engineers commenced a detailed underwater channel survey to identify any underwater obstructions. NOAA and USACE completed the main channel and approach to port surveys within 3 days after Sandy had passed through and continued to survey lesser trafficked areas the week following the storm. As a result of the storm surge, there were at least 50 off-station Federal Aids to Navigation, several marine debris fields throughout the waterways, and over 20 shipping containers in adjacent channels, all which needed to be put back on station or safely removed before the USCG could permit deep-draft vessels to transit the waterways.
- **Maritime Terminals**—As soon as permitted by the port authority, each of the terminals had the personnel who could travel to the facility begin inventorying and addressing the damage. The first order of business was the removal of the debris. Equipment and engines submerged in salt water needed to be pulled, cleaned, and serviced prior to use, including the container cranes. Knowing that vessels were waiting to call and that the port was in peak season, the terminal operators weighed making immediate repairs that may require additional work in the future or taking additional time to service equipment. Given the situation, the terminals generally pursued the safe immediate return of equipment to service and began plans for long-term repairs and replacements. Interviewees noted that replacement equipment was brought in from all around the country. Engine motors and electrical equipment had to be cleaned,

flushed and, in some cases, baked. Interviewees noted that spare parts had been stored on pallets on the floor and were subject to flooding.

Additionally, some equipment was beyond repair and had to be stored for insurance purposes. Interviewees described the "graveyards of destroyed equipment." New equipment was acquired, where possible, through vendors. Debris was removed from the terminals, containers were restacked or relocated as damaged, and damaged buildings were attended to. Experts at other ports in other parts of the United States that have encountered similar problems (such as after Katrina) were consulted. Security fencing and gates damaged by the superstorm were replaced in order to meet USCG, CBP, and other federal requirements, and were reviewed by the USCG. Interviewees noted that common sense approaches were used to bring the security measures back online. CBP examined and replaced the radiation detectors with the assistance of the U.S. Department of Energy. Replacement of the detectors, which had to be operational before the port could reopen, required parts to be flown in from elsewhere in the United States and installed.

Terminal operators also identified and developed lists of the containers exposed to water. It was noted that quite a few containers were damaged by the storm surge. Customers were notified but were not permitted to open the damaged containers at the port. Terminal operators were concerned that damaged loads would be abandoned. Customers needed to pick up the damaged containers and examine the contents elsewhere. This decision was reflected in the damaged shipments and containers later seen in the yards of distribution centers awaiting insurance decisions.

- **Rail Yards**—At the port and the CSX Kearny Yard, debris needed to be removed and the tracks cleared for operation. Generators were used to restore some systems. The railroads were generally in the best condition after the superstorm. Once the rail yards at the port and elsewhere were operational, the railroads "metered" the traffic into them, building back up to full service.
- **Trucking Firms**—Damaged equipment was inventoried and stored for insurance claims. Vendors were contacted to obtain replacement equipment. Some trucking companies that had tanker trucks in their fleet arranged to have them filled with fuel for use by their trucks and personnel. A shortage of trucks for draying port containers also ensued with the loss of equipment. The chassis pools, generally operated by third parties, sustained substantial damage. Each chassis had to be inspected, repaired, and made road ready—a process that took several hours for each chassis—before being used to haul containers. Chassis shortages were reported for months following the superstorm. Trucking firms located in flooded areas also had to deal with damage to offices and computer equipment.
- **Distribution Centers**—The first order of business for buildings without power was securing and powering up generators. Power was needed for restoration of operations. Personnel needed to be contacted and staffing decisions made. The location of inbound shipments had to be ascertained from transportation providers. Additionally, as containers began to arrive, damage to contents from the salt water surge was ascertained. Damaged shipments and containers had to be stored at the distribution center for insurance claims, a process that took months to complete.

Physical Flow Recovery Outside the New York–New Jersey Region

The interviews undertaken for this case study clearly demonstrated the strength of having a multimodal freight system, as well as the challenges faced. As previously noted, Columbia Coastal and the two railroads, CSX and Norfolk Southern, began repositioning equipment and qualifying crews for special container barges and shuttle trains. The Port of Virginia received the bulk of the diverted shipments, handling over 7,000 containers.

The impacts included

- **Virginia Port Authority**—With vessels and thousands of containers diverted to the port, agency and terminal staff quickly had to ascertain how to handle the additional workload and the stowing of diverted containers. Decisions for the inland movement of diverted containers were made with the additional costs incurred by the shippers via their contracts. Although the majority of the diverted containers destined for the region were handled by CSX's special shuttle trains, some of the diverted containers were moved back to the New York–New Jersey region "in bond" via the Columbia Coastal barge. The surge in containers and the need for additional paperwork caused delays in the supply chains. Problems with the disposition of the diverted containers caused disruptions to port operations and delayed shipment actions. Some container lines made arrangements directly with the railroads and barge companies (billing their customers at cost for the additional transportation charges), and some comingling of diverted containers with other containers at the port adversely impacted terminal operations. Some customers, caught in the midst of their peak season, added to the complexity of the situation by sending requests for release of specific containers. Interviewees reported delays ranging from days to weeks to receive some of the diverted containers.
- **Rail at the Port of Virginia**—CSX, through existing contracts with the carriers that had diverted the majority of the vessels and containers to Virginia, handled most of the rail movements back to the New York–New Jersey region into their Kearny Yard. Where diverted import containers were destined to locations outside the New York–New Jersey area, Norfolk Southern and CSX accommodated these shipments per their existing contracts with carriers on their regularly scheduled trains to the Midwest, once the containers had CBP clearance. CSX handled 5,300 of the diverted containers, with about a third of these containers destined for the Midwest. The remainder had to be moved back to the New York–New Jersey region. Although Norfolk Southern has existing doublestack service between Norfolk and New Jersey, CSX, which had the existing carrier contracts with the affected lines, did not have a "port-to-port" service; CSX had to create the service and then work with the shipping lines to put together a recovery train service. Empty doublestack equipment had to be brought to Norfolk, along with train crews from around the country. Once containers were cleared by CBP, the shipments were brought by truck to a local rail ramp outside of the port; both on-dock and off-dock rail facilities had to be used to handle the surge in containers. The required X-raying of containers was a constraint; there were not enough machines on hand to handle the increased rail volumes. The first few trains were brought into Kearny Yard. Once the on-dock ExpressRail facilities were operational, the special shuttle trains used those facilities.
- **Coastal Barge at Norfolk**—Columbia Coastal moved from 2,500 to 3,000 containers in bond on their barges. Three special dedicated barges were arranged, with each capable of hauling from 300 to 400 units.
- **Port of Baltimore**—Baltimore experienced a smaller surge in diverted containers but was also impacted by the additional unexpected activity. The port received about 2,800 diverted containers and about 8,000 diverted vehicles. These arrived on vessels in their regular rotations; no diverted cargo vessels were handled. The port had space at its terminal to stack the containers separate from the main stacks while decisions were made and paperwork processed. The diverted containers were moved back to the New York–New Jersey region via the existing Columbia Coastal barge, existing CSX trains to Philadelphia (where they were then trucked to customers), and by truck. New York trucks coming to the Port of Baltimore had to be entered into the port's eModal system and obtain clearance before they could pick up containers. Information and regulatory issues included how the containers would be processed and how the cargo manifests would be handled by federal agencies, as well as chassis availability. The Port of Baltimore is primarily a truck port, with 90 percent of its cargo handled by trucks. Chassis imbalances developed as equipment used to move cargo to the New York–New Jersey

area was not returned. The port estimated that it took approximately 2 weeks to return to normal operation after the superstorm due to the surge in diverted cargo.

Communications and Information Flows

At least four ongoing daily conference calls were scheduled during the recovery efforts—two were conducted by the USCG, one by the port authority, and one by the New York Shipping Association (NYSA). The strong relationships built through the MTSRU were instrumental in the relatively quick recovery of the Port of New York and New Jersey. As one interviewee noted, "This was why we were so successful with Sandy. Everyone was working together. The level of trust and cooperation was a strength of this area." As one example, the USCG's fuel piers were physically destroyed, and their vessel needed to be fueled to undertake the waterways inspection. A private terminal operator on the MTSRU heard of the need and instructed his terminal personnel to fuel the vessel from the tank at their facility. The pilots had federal agency personnel join them on their inspection vessels so that the navigation aids could be checked more quickly.

Information flows were crucial to ensuring sufficient personnel at facilities. NYSA was responsible for ordering the labor for the port terminals. At times working with cell phones and paper records, NYSA worked with labor to ensure staffing as needed for the terminals. Although labor negotiations along the U.S. East Coast were underway at the time, interviewees noted that labor and management worked closely together to reopen the port as quickly as possible. As noted, five vessels were worked on the first weekend once some terminals reopened.

At some distribution centers, power outages disabled the personnel systems, making it difficult to contact staff as to whether to come to the building and managing whom was in the building. In the aftermath of Superstorm Sandy, back-up personnel systems were set up at sister facilities elsewhere in the United States. Information flows were crucial to business recovery. Some trucking companies lost their computer systems and access to back-up systems. Paper records were destroyed by flooding. For them, the first order of business was contacting their customers and vendors. Customers were contacted to ascertain their condition and ability to receive/pick up shipments. Customers needed to be kept informed as to port conditions and the location of their shipments. In some cases, customers had to be informed that their shipments had been damaged or destroyed. Vendors needed to be contacted to obtain replacement equipment and supplies. One company noted that its approach was to internally develop strategies and then quickly communicate the solutions to its customers. It noted that the quicker it knew the situation and options, the better it could develop strategies and communicate with its customers.

Regulatory and Public Agency Roles in the Recovery

Daily coordination among the responsible agencies occurred. CBP had to be able to conduct any necessary inspections and radiation screening of import cargo coming into the terminals before the port could be reopened. The waterways had to be inspected. DHS rented a 747 to bring the replacement radiation detectors to the New York–New Jersey region.

PSE&G, the major power utility in the area of the maritime terminals in New Jersey, had a staff member imbedded with port authority staff to serve as the point person. While competing with other pressing needs for power restoration, the two organizations coordinated on the details of restoring electricity to the terminals, the installation of generators, and other issues. PSE&G also had a command post at the airport and housed maintenance staff at hotels near the airport. Although port agencies and carriers indicated that they pursued obtaining a Jones Act waiver for diverted containers (similar to the waiver authorized by federal authorities for fuel movements) no such waiver was approved. As a result, diverted containers had to be moved using specially implemented services by private entities, including U.S.-flagged barges, container rail shuttles, and private trucks.

In Virginia, CBP added staff and worked around the clock to revise paperwork, recode shipments, and hand-refile documentation in order to clear the surge in diverted containers. Adjusting bills of lading so that shipments could clear in Virginia was considered by interviewees to be a complex and time-consuming task, often involving manual work for individual shipments.

4.8 Lessons Learned

The key lessons that emerged from Superstorm Sandy include the following:

Physical/Logistical

- Prepare for the unexpected. As one interviewee noted, "The predictive maps indicated that large portions [of the port] would be dry. We clearly were not prepared for the surges." Another noted that "All of the hurricane plans considered wind events."
- Electrical power is crucial, even more today as ports move toward more environmentally sustainable equipment and increased reliance on automated information systems through the port and supply chain processes. As one interviewee noted, "Power was such a critical problem here." Another interviewee noted that "Power was outside of our control." Moving forward, proactive engagement with the area's power providers, as well as procurement of emergency generators and investigations of micro-grid technologies were mentioned as next steps.
- Balancing resiliency and maintenance costs should be considered. Moving traffic-light controls, pumps, and generators to higher elevations also means increased use of bucket trucks and the building of higher walkways for servicing.
- Modal flexing is a requirement for port and supply chain disruptions. The ability of modes to offer alternative services and routings was shown to be essential in resuming business operations after Superstorm Sandy.

Informational/Communications

- Information technologies are integral to port and supply chain systems. Without power, these systems cannot operate. As one interviewee noted, "There is no more 'manual.' We cannot go back to paper. Everything is now integrated."
- Communication is key—communication and coordination among public agencies, among public and private organizations, and along the entire supply chain. Communications with customers were crucial: Where were their shipments and in what condition? Several interviewees noted that it was important "to get information out to the customers quickly and ahead of questions."
- Establishing relationships is also key. Mandated committees, such as the MTSRU, clearly facilitate recovery. Networks of vendors helped get replacement parts and equipment.

Regulatory/Oversight

- Common sense solutions can expedite recovery. The interviewees noted how public agencies worked with private organizations to find acceptable short-term solutions in such areas as securing perimeters to allow reopening of facilities.
- Superstorm Sandy illustrated that storm-related vessel and cargo surges can be just as disruptive to supply chains and freight movement as port closures. Logistics plans and protocols should be considered to handle surges of diverted shipments.

- A temporary waiver of the Jones Act, similar to the waiver authorized for fuel movements, potentially would have provided a cost-effective means for handling diverted containers. One interviewee noted that a Jones Act waiver could have been an incredible relief valve. Several interviewees noted that with a Jones Act waiver, the diverted containers offloaded by one vessel in a rotation could have been picked up by the next vessel in the rotation for delivery to the original port. The interviewees noted that this approach would have facilitated planning and handling of the diverted containers, as well as significantly reduced the need for alternative modes and the time-consuming paperwork for CBP clearing of the containers at the diverted ports.
- Similarly, CBP systems and procedures required intensive, and often manual, interventions to handle diverted containers. Interviewees noted the hard work of CBP staff but also noted the need to consider developing protocols for handling diverted shipments in the future.

As one interviewee summed up the overall objective, "We all serve the customer. Look for the best solution for the customer." Superstorm Sandy uniquely hit during the peak season of customer demand. The response of ports and the supply chain has to be considered within that context.

4.9 References

Georgia Tech Research Corporation, Parsons Brinckerhoff, and A. Strauss-Wieder, Inc. *NCHRP Report 732: Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System*, 2012, pp 30–32.

National Geographic News, http://newswatch.nationalgeographic.com/2012/11/02/a-timeline-of-hurricane-sandys-path-of-destruction/

Port Authority of New York and New Jersey, NAIOP briefing, November 30, 2012.

USCG, U.S. Coast Guard Commandant Instruction 16000.28, February 18, 2008, http://www.uscg.mil/directives/ci/16000-16999/CI_16000_28.pdf

Appendix 4A: Interview Guide 2

Interview Guide Used for Public Agencies

Note that a similar form was used to guide discussions with private organizations.

Introduction

Superstorm Sandy struck the U.S. East Coast during one of the most critical weeks in the peak shipping season. We are assessing the impacts, recovery, supply chain and facility changes, and the lessons learned from this event as a key element of a project for the National Cooperative Freight Research Program (NCFRP). NCFRP is part of the Transportation Research Board and the National Academy of Sciences. A description of our project can be found at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3493

The results of our work will be released in a report to inform discussions of the supply chain and port disruptions throughout the United States. As we all know, keeping goods moving is important, particularly after a disruption. The information you provide in our discussion will help us to identify and elaborate on the steps needed to coordinate and continue freight movements through ports in times of severe stress.

Our individual discussion is confidential. We will keep the information you give us confidential. No quotes or information will be attributed to an individual person or organization.

We are also looking at three aspects of the supply chain: the physical movement of goods, information flows, and regulatory/governmental agency involvement.

Background on Your Agency

- Please describe your agency's role and responsibilities in port preparations, decision points, immediate response, and business continuity/recovery.
- What public agencies and private-sector organizations does your agency interface directly with in these activities?
- What is your agency's geographical scope of responsibility? As a follow up, does your agency coordinate with ports being used for diverted vessels?

Coordination and Communication

- How do you coordinate with partner governmental agencies (e.g., FEMA, DHS)?
- How do you coordinate with private-sector shippers and transportation providers?
- What do you consider the strengths of your organization with respect to coordination and communication before, during, and after the event(s)?
- How would you improve your communication and coordination process for future situations?

Continuity of Operations and Service

In considering how to maintain service and cargo flow in times of disruption:

- What are the most important considerations (physical, information flows, and regulatory)?
- What are the major challenges or obstacles (physical, information flows, and regulatory)?

Sandy

Let's talk about the Superstorm Sandy event:

- Preparations
- Impacts on your facilities and operations
- Immediate response and business continuity
- Lessons learned
- Anticipated changes in facilities and operations

Next Steps

- What other organizations and individuals should we talk with regarding Sandy and port resiliency?
- Is there any other information that you would like to share with us at this time?

Thank you! We will share the draft case study with you, as well as send you the final report once published by the National Academy.

CHAPTER 5

Case Study: Columbia River Closure

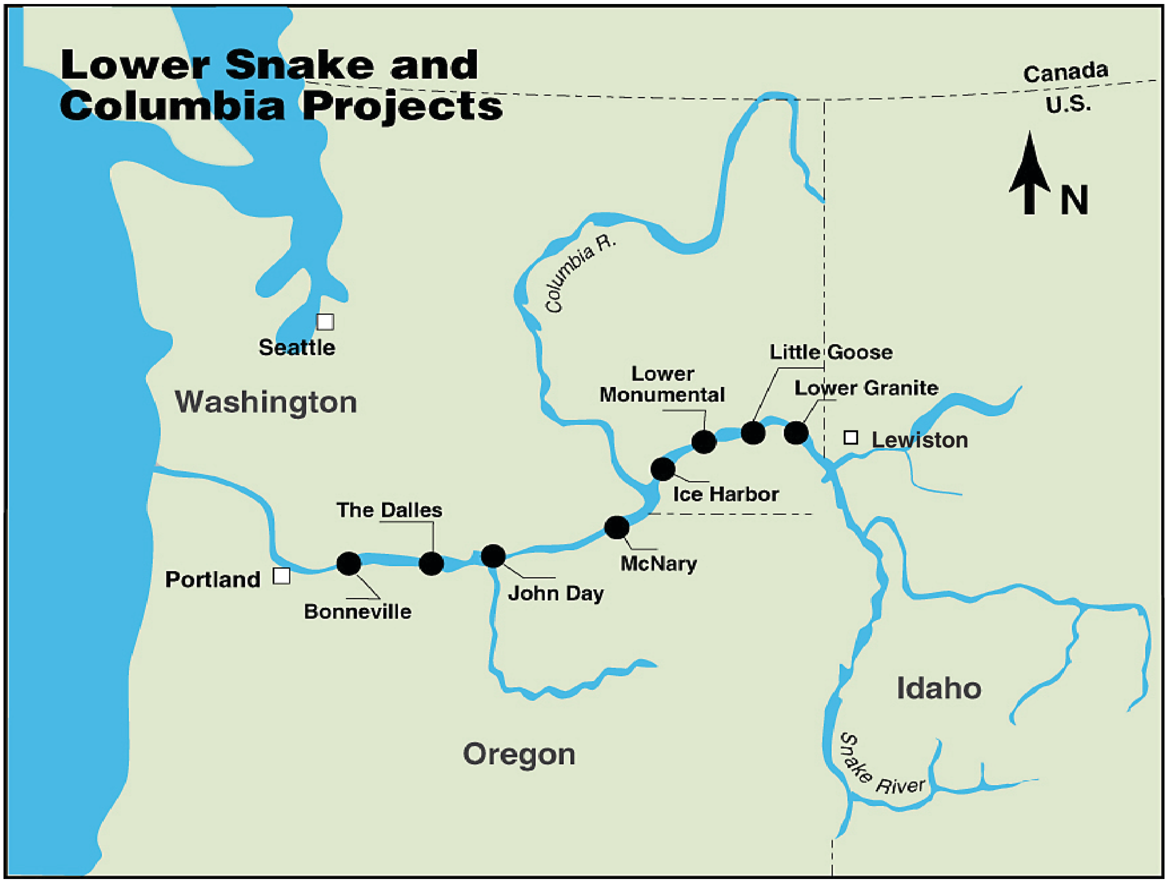
5.1 Introduction

This chapter describes activities involved in planning for, responding to, and recovering from an anticipated and protracted river closure event that affected a number of marine ports along the Columbia-Snake River system in the Pacific Northwest. As such, it offers a case study of how a series of small and large ports and their supply chain partners dealt with the event, and provides a number of lessons learned from the experience. The study differs from the Superstorm Sandy case study in Chapter 4 of this report by addressing an event that had a good deal of pre-planning associated with it, and one that also dealt with numerous bulk (notably agricultural commodities), versus containerized, cargo movement issues. And as with the Superstorm Sandy case study, the selected disruption event allowed for perspectives on the closure and its recovery to be elicited from experts at a number of different ports along the river system.

The Columbia-Snake River System

The Columbia and Snake Rivers have been used for trade and subsistence for thousands of years, and for power generation since the 1800s. The Columbia, the largest river in the Pacific Northwest, begins in Canada in the Rocky Mountains and passes through Washington before emptying into the Pacific Ocean near Astoria, Oregon. The 1,243-mile Columbia River is joined by its largest tributary, the 1,078-mile Snake River near the tri-cities region of Washington State, just west of Idaho (Kammerer, 1990). The Columbia-Snake River system today consists of a deep-draft navigation channel and an inland navigation channel. The 105-mile (waterway lengths are provided in statute miles), 43-foot deep channel runs along the lower Columbia River from Portland/Vancouver to the Pacific Ocean (Pacific Northwest Waterways Association, nd). About 44 million tons of cargo moved along this channel in 2011 (USACE, 2011). The 360-mile, 14-foot deep inland channel from Portland/Vancouver to Lewiston, Idaho, includes eight dams with navigation locks on the Columbia and Snake Rivers, as shown in Figure 5.1.

In the 1960s and 1970s, USACE built four dams and locks on the lower Snake River to facilitate shipping and produce hydroelectricity (BST Associates, 2003). The lower Columbia River has likewise been dammed for navigation and hydropower beginning with the Bonneville Dam, which was authorized by Franklin D. Roosevelt in 1933 and completed in 1937. The original lock was subsequently replaced in 1993 to match the size of the locks at the other seven projects on the Columbia-Snake River system. Three additional dams with navigation locks were constructed on the Columbia River, including McNary (1954), The Dalles (1957), and John Day (1971). Thus, a 465-mile shipping channel through locks and reservoirs for heavy barges exists from the Pacific Ocean to Lewiston, Idaho (Bird, 1989).



Source: USACE Portland District

Figure 5.1. Locks and dams along the Columbia-Snake River system.

The USACE (nd) Waterborne Commerce Statistics Center indicates that about 8 million tons of cargo is barged annually (2010–2012) through the Bonneville Dam. Most of the barge traffic originating at small ports on the Snake River is transported to deep-water ports on the lower Columbia River. The Columbia-Snake River system includes five deep-water, marine cargo ports downriver of Bonneville Dam and 19 shallow-water ports with marine cargo facilities upriver of Bonneville Dam as listed in Table 5.1.

The inland navigation channel accommodates barges carrying twice the weight as those traveling on the shallower Mississippi River. Agricultural products from producers in Washington, Oregon, and Idaho are among the main goods transported by barge on the Snake and Columbia rivers. The river system supports the highest export of wheat and barley in the United States, the highest export of paper, forest, and mineral bulk products on the West Coast, and the highest import of autos on the West Coast (Center for Economic Development, Education and Research, 2005). The system also provides petroleum to eastern Washington and eastern Oregon via barge since no pipeline exists between refineries near Portland and a pipeline in Lewiston, Idaho. The economic value of this transportation link is apparent from the commerce that flows up and down the system.

The river system also hosts many species of fish, which migrate between fresh and saltwater environments, the most common species being salmon. Installation of the dams and locks impacted the migration of fish, prompting close observation by federal and state agencies, tribal authorities, and environmental groups. Over the past few decades, USACE has closely

74 Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains

Table 5.1. Columbia-Snake River system marine cargo ports.

Deep-water Ports	Waterway	State
Astoria	Columbia River	Oregon
Longview	Columbia River	Washington
Kalama	Columbia River	Washington
Vancouver	Columbia River	Washington
Portland	Columbia River	Oregon
Shallow-water Ports	**Waterway**	**State**
Camas-Washougal	Columbia River	Washington
Skamania	Columbia River	Washington
Cascade Locks	Columbia River	Oregon
Hood River	Columbia River	Oregon
Klickitat	Columbia River	Washington
The Dalles	Columbia River	Oregon
Arlington	Columbia River	Oregon
Morrow	Columbia River	Oregon
Umatilla	Columbia River	Oregon
Benton	Columbia River	Washington
Kennewick	Columbia River	Washington
Pasco	Columbia River	Washington
Walla Walla	Snake River	Washington
Columbia	Snake River	Washington
Central Ferry	Snake River	Washington
Almota	Snake River	Washington
Wilma	Snake River	Washington
Clarkston	Snake River	Washington
Lewiston	Snake River	Idaho

Source: PB Analysis based on USACE Navigation Data Center U.S. Waterway Data—Port and Waterway Facilities, the Pacific Northwest Waterways Association and individual port websites coordinated with resource agencies to design and construct improvements to mitigate impacts of the dams on fish populations. For example, installation of fish slides and other fish passage improvements have allowed fish to traverse dams more easily, resulting in the trend toward recovery of many of the fish populations. All of these aspects—trade, power generation, and environmental impacts—must be considered in the planning and timing of the 2- to 3-week maintenance closures of the locks each year, as was true for the orchestrated 14-week closure that occurred in 2010–2011.

The Columbia-Snake River System Rehabilitation Project

The Columbia-Snake River Extended Navigation Lock Closure Project in 2010–2011 arose out of a series of inspection reports in the mid 2000s that documented the need to replace aging lock gates and repair other components, including the following:

- The Dalles Navigation Lock downstream gate (completed 1957),
- Lower Monumental Navigation Lock downstream gate and other components (completed 1969),
- John Day Navigation Lock (completed 1971),
- Lower Granite upstream and downstream gates, and
- Ice Harbor downstream gate.

The decision to expedite the replacement of aging infrastructure occurred following an emergency shutdown of The Dalles Navigation Lock in 2009 that resulted in the discovery of significant deterioration. USACE determined that repairs (Figure 5.2) could only sustain the navigation for the short term, and that full replacement of the customized lock gates needed to happen as soon as possible. Due to the long lead time with designing and constructing these massive lock gates (12 months minimum), USACE initiated in-house design of replacement locks for The Dalles, Lower Monumental, and John Day.

In order to repair these aging locks, the entire river system north of the Bonneville Dam was closed to navigation for 14 weeks, thus eliminating barge transportation on much of the inland Columbia River and all of the Snake River.

Figure 5.2. The Dalles Lock repair, 2009.

The Disruption Event

On December 10, 2010, the USACE closed the Columbia and Snake Rivers to barge traffic to repair aging locks and dams along the river system. The system remained closed for major repairs through March 24, 2011. Prior to the event, a shutdown of this length was unprecedented in the United States; however, similar shutdowns in other U.S. regions may become more common as infrastructure ages. The Columbia-Snake River system operates with only one lock at each of its eight dams situated along a 465-mile waterway connecting the Pacific Ocean to Lewiston, Idaho. Many other systems have two locks at each dam, allowing for continuation of operations through one lock while the neighboring lock undergoes repair. Along this system, each lock is unique; therefore, fabrication of large replacement parts requires customization that typically takes a year. Irreparable failure of one of these locks would result in significant economic losses for the region and a high risk of permanent diversion to other gateways.

Due to the unprecedented nature of this closure, USACE initiated a planning effort that involved early communication with all affected river users and close coordination with other local, state, and federal agencies. The closure of the system impacted producers, ports, grain elevators, barge operators, petroleum providers and users, solid waste disposal activities, and many others. This case study describes the responses received from more than a dozen in-depth interviews (sample questions and participating organizations appear in Appendix 5A) with industry experts to identify measures that were taken to improve the region's trade resiliency to the disruption to waterborne commerce. The case study describes preparations taken prior to the river closure, discusses the subsequent impacts to key stakeholders, and summarizes lessons learned from the disruption event within the following three overarching themes identified in previous chapters of this report:

- Physical infrastructure that supports the movement of goods,
- Logistics and information flow, and
- Regulatory/government agency involvement.

5.2 Columbia-Snake River Closure Impacts

This case study began with an extensive review of the prior research conducted by Washington State University's Freight Policy Transportation Institute (FPTI) on this event, which included economic and environmental analysis, as well as industry interviews. FPTI closely observed changes to trade flows and fuel prices before, during, and after the extended lock closure with the intention of documenting the preparations of shippers, river carriers, government entities, ports, and communities prior to the extended lock outage and capturing the economic impacts based on a comparison of trade flows (Simmons and Casavant, 2011b). Their research involved analysis of trade statistics and surveys completed by industry representatives. The USACE Waterborne Commerce Statistics Center provided commodity data, and it also provided lock operational data from their Lock Performance Monitoring System (LPMS) for the locks owned or operated by USACE. Some of the study findings (Simmons and Casavant, 2011c) are as follows:

- Below The Dalles Lock and Dam, a total of 377,000 tons were shipped downriver between December 10, 2010 and March 24, 2011.
- Tonnage shipped downriver during the lock outage decreased by 79 percent when compared to an average tonnage of 1.8 million tons for the previous three winters.
- Commodities with the largest volume of downriver shipments included wheat; forest products, lumber, logs and woodchips; sand, gravel, and stone products; and primary non-ferrous metallic products.

- Wheat comprised 62 percent, or 233,500 tons, of the total 377,000 tons moving downriver from the lock outage; normally these movements make up at least 75 percent of shipments flowing through the entire lock system.
- Approximately 10,500 tons were shipped upriver between December 10, 2010 and March 24, 2011 through Bonneville to The Dalles area—down from 608,500 tons.
- Southern Washington firms experienced a 95 percent decrease in wheat shipments.
- Eastern Oregon firms experienced a decline in shipments of 20 percent.
- Northern and Southern Idaho experienced declines in shipments of 86 percent and 32 percent, respectively.
- Most wheat firms in the Pacific Northwest moved the majority of their product, an average of 68.5 percent, by rail during the lock outage, as compared to 29 percent during a typical winter.
- Eastern Oregon and Southern Washington firms employed trucking services to transport wheat from December 2010 to March 2010, about 40 to 75 percent of shipments, respectively.
- On average, truck-barge rates were at least 36 cents per bushel less than rail and truck during the lock outage, as compared to at least 10 cents per bushel less during the typical year.

Overall, most of the region fully recovered from the event with only moderate economic losses. Those hardest hit by the event included grain elevators, ports, barge lines, and some of the producers. The following sections describe ways in which these groups mitigated the impacts of the closure, as well as provide strategies to enhance resiliency for future disruptions based on lessons learned from this event.

5.3 Columbia-Snake River Closure Preparations and Response and Recovery Efforts

The University of Washington's FPTI studies discussed many of the preparation activities that led up to the closure, and the economic results of the closure. Incorporating and building on that information, this case study focuses on what preparations and response and recovery efforts were essential in improving resiliency of the industry upon the conclusion of the closure, and how the experience from this event might inform other regions that may experience similar planned navigation channel shutdowns in the future. Specifically, and using the private and public agency discussion guides reproduced in Appendix 5A, a series of in-person and telephone interviews were conducted with experts with first-hand knowledge of the extended lock closure event. These included interviewees at three of the impacted ports, three grain elevators (one upriver and two overseas exports), one grain producer, two barge operators, USACE, USCG, and a trade association representing several water-dependent industries, including ports, producers, terminal operators, and barge and tug operators. In speaking with many of the impacted industries, the following three components that best mitigated industry and economic impacts repeatedly rose to the top:

1. Physical/logistical preparation given the advanced warning,
2. Constant and consistent communication and coordination, and
3. Regulatory and public agency involvement and government aid.

Physical/Logistical Preparation

Advanced warning mitigated many of the impacts that the industry would have experienced under an emergency, long-term closure. By communicating with stakeholders 18 months in advance, the industry responded by budgeting for more annual expenses, selling some commodities early, constructing more storage space, purchasing trucks, and identifying alternative transport options, such as different routes or transportation modes.

Producers

Producers indicated that the risk associated with storing product, namely insect and heat damage, and the cost of carry (4 percent per bushel, including 2 percent for storage and 2 percent for interest) were lower than the risk of higher costs associated with shipping via truck or rail (Simmons and Casavant, 2011a). Increased demand for truck and rail resulted in higher costs than during normal operations. From the producers' standpoint, knowing the additional costs at least a year in advance was helpful.

The wheat industry performed better than anticipated this year due to extenuating circumstances, including the drought in Russia and subsequent export ban, severe flooding in Australia that degraded the quality of the wheat, and a below-average year for Canadian wheat. This lack of quality supply caused an increase in the demand for U.S. wheat (Simmons and Casavant, 2011b).

The forestry industry increased movements prior to December 2010 to build up inventories. From July to December, forest product shipment volumes moving downriver were consistently about 75 percent above 2007–2009 averages. The forestry industry suggests it took this route of action in order to satisfy customers' orders and inventories prior to the lock outage instead of foregoing all commerce that would usually ship from December to March (Simmons and Casavant, 2011d).

The fertilizer industry focuses on two peak times of year, including one from March through May that coincides with planting schedules. Any possibility of delays to the extended lock closure could have significantly impacted the fertilizer industry. Communication of the schedule and regular status updates eased the concerns of the industry.

Preparations, Impacts, and Industry Responses

- Coordinated alternative purchasing schedules with customers to line-up the purchase of railed and trucked products during the closure and the purchase of barged products immediately before and after the closure.
- The barge lines increased tariff by 7.5 percent just 6 months prior to the closure to off-set anticipated revenue losses that would occur during the shutdown; producers were not prepared for this significant cost increase and suggested a 12-month warning would have been very helpful.
- Truck shortages impacted some producers that did not own trucks; some producers have begun to explore options for purchasing trucks since another closure is anticipated to occur in 2017–2018.

Grain Elevators (Upriver Elevators and Downriver Deep-Water Export Elevators)

The Columbia-Snake River system consists of 27 grain elevators. Only two of them have access to rail. The grain elevators communicated regularly with the Pacific Northwest Waterways Association (PNWA), a trade association representing several water-dependent industries in the region, and with their producers, to plan for the closure. They also communicated regularly with the U.S. Wheat Association, which communicated the information to overseas customers throughout Asia. Armed with the schedule well in advance, they employed mitigation measures similar to those used by producers, including constructing more storage, budgeting ahead, and adjusting purchasing schedules. Another measure included increasing the storage tariff from 2.5 cents to 5 cents per bushel stored beyond 20 days. They communicated this planned measure with the producers a year before it went into effect so that the producers could plan accordingly. This measure encouraged turnover of the grain in advance of the closure, thus allowing more space to store product during the closure. Also, the grain elevators scheduled two to three barges per day 5 weeks in advance of the reopening, instead of the standard practice of scheduling barges as needed. As they correctly anticipated, the barge lines could not keep up with the demand so over-scheduling proved to be quite beneficial.

Although two grain elevators had access to rail, during the extended closure, the cost of rail along with reliability issues resulted in lower than anticipated rail utilization. As quoted by FPTI (Simmons and Casavant, 2011c), "Rail performance was terrible. Cars were 10 days early in December and over 30 days late by the end of February and continuing through March."

In general, the grain elevators found rail to be unreliable and the risk of delay too high. Maintaining the ability to satisfy customers was worth the higher transportation costs associated with trucking product rather than using trains.

Preparations, Impacts, and Industry Responses

- Barge lines staged empty barges at key grain elevators for additional "as needed" storage—they were utilized toward the end of the closure.
- The closure was scheduled within the "fish window," which avoided harvest time.
- Those with access moved more by rail, doubling the overall cost of moving goods during the closure, but preventing the loss of customers; overall a 30–40 percent cost increase mitigated the risk of losing customers to other countries, such as Canada and Europe.
- Cost of rail space during the closure was three times higher than the shippers and ports had projected, at a cost of approximately $800 above tariff according to one of the exporters interviewed.
- Russian export restrictions in place during the closure were thought to play a significant role in the willingness of customers to alter purchasing schedules.
- Low interest rates significantly reduced projected carrying costs.
- Grain companies took advantage of the closures to perform maintenance and rehabilitation activities; this ensured retention of employees and prevented loss of equipment availability during work times.
- Many of the grain elevators and producers incorrectly assumed that vessel schedules would adjust in anticipation of the closure—they did not. This prevented much of the product from being shipped out in October, which created congestion at the locks and a shortage of barges in the weeks leading up to the closure.

Barge Operators

USACE and the PNWA communicated frequently with the barge operators to prepare for the closure, and the barge operators communicated regularly with the grain elevators and the deep export elevators, such as EGT, United Grain, and Columbia Grain. Since barge transportation, for the most part, was halted for the 4 months of the extended lock outage, advanced planning and communication played a significant role in employee retention efforts and, subsequently, in the overall supply chain resiliency of the region. In speaking with the two largest barge operators, the extended closure meant revenue loss and the potential for losing well-trained and certified operators. In speaking with one of the barge operating companies, the average cost to hire and train a skilled operator is $40,000. For this reason, the 18-month warning prompted the following actions by the two companies interviewed for this case study.

- Staff retention efforts that
  - Informed staff and encouraged them to accumulate vacation time and work overtime 1 year in advance of the closure;
  - Provided staff with information about how to obtain low-interest loans from their retirement accounts;
  - Initiated early discussions with the state unemployment office to reduce wait time for their employees to receive benefits;
  - Encouraged and funded required staff certification programs, continuing education, and advanced degrees; and

  - Allowed staff to seek temporary employment during the closure while maintaining their current medical benefits.
- Focused on repairs to vessels and facilities (one firm repaired 25 percent of its fleet).
- Utilized staff and equipment in other ways (luckily, an unusual tidal surge that occurred during the closure required use of tug boats to stabilize ships at dock; this extra work created a "no revenue loss" situation for one of the barge operators).

Quoting FPTI (Simmons and Casavant, 2011d), "Two barge lines continued to ship forest products, paper, and wheat on the lower Columbia River, below the Bonneville Lock and dam. These lines also performed harbor work in this area. According to a barge line representative, harbor work is "switching grain, petroleum, freight, or container barges into or out of a marine facility to allow loading or discharging. This work also included shifting barges, or moving barges in and out of storage locations or maintenance facilities, which allowed boat crews and barge employees to continue to work and remain busy. Upriver barging tugs that were idle due to the lock outage were called into service to handle the large cargo volumes in the Portland area. These two barge lines were surprised by the volume transported on the lower Columbia River during the lock outage and the consequential need for their services. These extra services helped dampen the revenue and job loss of the interruption of service on much of the Columbia and all of the Snake Rivers."

Most barge companies temporarily laid-off or reduced the hours of a significant number of their employees during the closure. Some barge companies offered job sharing, others provided education reimbursement, but all of them continued to pay benefit packages during the extended lock outage. As a result of these efforts, all of the firms interviewed successfully retained 100 percent of their employees.

Ports

All of the ports worked closely together to retain business, but only the deep-water ports of Portland, Vancouver, Kalama, and Longview had the resources to subsidize transportation costs. The Port of Portland coordinated closely with the Ports of Lewiston and Morrow, as well as other upriver ports in advance of the extended closure. In addition to assisting with altering shipment schedules and developing alternative storage options during the outage, the Port of Portland took steps to retain shippers by off-setting their costs of shipping via rail and truck transportation while barging was unavailable. The Port of Portland paid carriers $400 per container (regardless of size) for rail and truck shipments from Lewiston, Idaho, and $250 per container for rail or truck shipments from Umatilla and Boardman, Oregon. The Port of Portland set aside $800,000 for this transportation subsidy. Less than half of the allotted subsidy was used by industry because of a shift in the purchasing schedules, and the program resulted in no loss of Port of Portland business.

Upriver ports faced the significant challenge of remaining relevant during and after the closure. Unlike the larger downriver export ports, like the Port of Portland, the smaller upriver ports did not have the financial resources to subsidize transportation costs during the extended closure. As a result, the Port of Lewiston, for example, remains down by 20 percent in 2013 from its 2009 volumes. Some shippers apparently found alternative gateways with competitive rates during the closure and have not returned.

Preparations, Impacts, and Industry Responses

- Upgraded container storage and improved port facilities;
- Port of Portland provided subsidies to patrons (industries and shippers) to mitigate truck and rail cost increases:
  - Provided $250 per unit (any size container) for products shipped from Umatilla, Oregon and Boardman, Oregon;
  - Provided $400 per unit (any size container) for products shipped from Lewiston, Idaho;

- Updated patrons and shippers on the status of the lock outage;
- Participated in USACE teleconferences; and
- Provided storage for some products halted by the extended lock outage.

Petroleum

For this case study, the following information was extracted from an FPTI report (Simmons and Casavant, 2011d) because none of the petroleum companies responded to requests to discuss the outage—a challenge that the FPTI researchers also encountered.

Energy continuity, particularly for heating during the winter months, became a concern for the eastern side of the region, including the cities of Spokane, Yakima, and the tri-cities, which relies primarily on barged petroleum from refineries near Seattle. No pipeline exists between the refineries and this region. In preparation, storage facilities in the eastern Washington/Oregon and northern Idaho regions were maximized prior to the outage. Truck and rail transport supplemented demand during the closure, and Tidewater filled and docked six barges of petroleum at Pasco prior to the closure. Initial plans for reversing the flows of two pipelines, one between Pasco, Washington and Utah, and another between Spokane, Washington and Montana, did not occur due to lack of availability.

The FPTI researchers (Simmons and Casavant, 2011c) contacted the Washington State Department of Commerce (WSDOC) and the Oregon Department of Energy (ODE) to identify actions taken by both states and suppliers to ensure energy continuity during the extended closure.

Preparations, Impacts, and Industry Responses

- Released situation reports warning residents of fuel price increases, shortages, and availability of fuel from alternative sources.
- Provided weekly and monthly reports of gasoline and diesel prices around the Pacific Northwest and updates on fuel deliveries. Responded to public/media questions, comments, and complaints surrounding fuel impacts related to the extended lock outage.
- Petroleum companies shipped more than half of their product by tanker truck during the lock outage, and less than half by rail (60 and 40 percent, respectively).

No significant impacts to petroleum supplies occurred because of the amount of lead time and warning provided by USACE to the industry and these state entities. The ODE and WSDOC worked closely with the industry to ensure winter energy demands would be met without resulting in significant cost increases to consumers. The extended closure did not result in reported fuel shortages, price gouging, or price hikes. Burlington Northern Santa Fe Railway (BNSF), a Class I railroad, transported fuels from Anacortes, Washington (a town north of Seattle) to a transfer point, presumably at Pasco, Washington. The fuels were then interchanged from BNSF to another smaller rail system and hauled to Lewiston for dispersion by tanker truck. According to WSDE, Union Pacific Railway (UP) also added additional tanker railcars to handle fuel loads from Portland to Spokane, Washington (Simmons and Casavant, 2011d).

Rail Companies

In contrast to barge companies, which lost business for the majority of the lock outage, rail lines experienced an increase in cargo loads during the lock outage. Some of the rail operators coordinated with customers and producers to identify anticipated demand for rail transport during the extended closure. The railroads carried more cargo by repositioning rail cars and staff, as well as increasing days of operation. The railroads operated an average of 1.5 additional trains per week during the outage. Each additional train hauled 110 railcars, the equivalent of 440 trucks, which helped alleviate roadway congestion. The majority of these additional trains moved from east to west and carried wheat, forest products, barley, paper, peas, and lentils.

Additional trains moving upriver (from west to east) moved empty containers, petroleum, diesel, and fertilizer (Simmons and Casavant, 2011d).

In addition to moving extra cargo, rail companies experienced increased costs due to fuel and labor to provide additional days of service to those industries and ports in need. One railroad line in eastern Washington shuttled empty containers for the Port of Lewiston, which involved constant contact with the Port and the ability to be flexible with train schedules. Employees of rail lines faced long shifts, large train loads, and overtime hours (Simmons and Casavant, 2011d).

Information Flows and Coordination

USACE Communication/Project Management

Early on, USACE Northwest Division identified the importance to the overall economic health of the region of reopening the river system on time. With the end in mind, USACE assigned a project manager to each of the dams and a single point of contact (project liaison) to oversee all of the projects and feed information internally and externally. The project liaison was in daily communication with each of the project managers and regularly hosted coordination meetings with the project managers of the concurrent replacement projects. The project liaison reported information to the USACE northwestern division chief of project management and the division's congressional liaison.

The information provided by the project liaison to the division heads ensured that all information flow to USACE Headquarters and the media funneled through the top levels, thus providing a buffer to the individual project managers. By relieving them of media duty, the project managers were able to focus on construction activities and meeting the committed schedule. The project managers planned for the movement of equipment and oversized replacement pieces via barge to minimize over-the-road impacts, developed plans for inclement weather events, and accelerated preparatory work at the three dams receiving new locks by adding Sunday shifts.

The project liaison also compiled information from the project managers and provided status updates to the industry during monthly teleconferences held on the first Tuesday of every month. Furthermore, USACE posted progress reports on its website, and announced delays and/or revisions in construction and opening dates via email, telephone, and website postings. In addition, the project liaison coordinated and organized several tours for industry, elected officials, and the public to view construction and rehabilitation to demonstrate the importance of the major lock repairs to the Pacific Northwest's economy.

Regulatory and Public Agency Involvement

USACE

The Army Corps of Engineers' Northwestern Division's Portland and Walla Walla Districts maintain the navigation locks along the Columbia and Snake Rivers. The division and the two districts coordinate maintenance, inspections, and repair activities to minimize disruptions to navigation. Together, they initiate a communication process with various river users prior to annual 2–3 week maintenance and inspection closures. In 2009, when the extent of the damage at The Dalles was discovered, the two districts immediately began working together to develop the work program, identify funding needs, and develop a coordination/communication structure.

During interviews conducted for this case study with USACE, the ports, and several industry leaders, it became clear that the structure and role of USACE accounted for much of the success of the closure, in particular, their 18-month advanced warning and detailed schedule. USACE coordinated closely with PNWA, which represents river-supported industries, such as ports, producers, terminal operators, and barge and tug operators, to reach out to industries that would be impacted by the closure. USACE coordinated with PNWA along with several of the ports and other entities on lobbying efforts to ensure funding became available and the closure met the announced schedule. In addition, USACE coordinated with environmental agencies to time the closure during a period when impacts to fish habitat would be minimal. USACE shared this information with the trade industry, and the trade industry utilized this information to coordinate alternative purchase schedules with foreign buyers.

Pacific Northwest Waterways Association (PNWA)

PNWA played an active role in communicating to members of Congress the importance of the river to the national economy, coordinating information prior to the closure, and providing regular communication to its members. PNWA and industry partners regularly visit Washington, D.C. to explain the importance of the Columbia-Snake River system to the Nation's export of grain and Idaho and Utah's access to petroleum.

In the years prior to 2009, PNWA had been coordinating with the Portland and Walla Walla Districts to understand which navigation lock components were most in need of repair or replacement. As soon as the extent of damage and repair work became known in 2009, PNWA began coordinating funding needs and lobbying efforts with USACE, its members, and other trade organizations, such as the U.S. Wheat Association. PNWA also began participating in USACE weekly status teleconference calls prior to and during the closure. Throughout the closure, PNWA collaborated with USACE and played a significant role in the flow of information to all levels of government and their members.

Washington State Department of Employment Security

The states of Oregon and Washington worked closely with industries that would be temporarily laying-off much of their staff during the extended closure. The State of Washington Department of Employment Security proactively assisted Tidewater in identifying all employees that would temporarily be unemployed and pre-registering them for unemployment assistance. Tidewater employees began receiving benefits the first week they were unemployed. In addition, the State of Washington relieved these temporarily unemployed beneficiaries.

5.4 Lessons Learned and Actions Taken

The FPTI reports, including industry surveys, coupled with this study's interviews of major stakeholders, provide a number of actions that can help to minimize impacts of a long-term closure of a primary freight waterway on port operations and their associated supply chains. These best practices and lessons learned fall into three primary categories, including (1) information flows and coordination, (2) physical infrastructure, and (3) regulatory and public agency involvement.

Information Flows and Coordination

USACE acted as the central point of contact and also developed a structure that led to the successful preparation and completion of the lock replacements and repairs. This included identifying a single point of contact within USACE that coordinated with the USACE Portland and Walla Walla Districts and the Northwestern Division Headquarters, coordinated regular calls with industry representatives, coordinated tours of the construction projects, and coordinated all press releases and public communications. In summary, best practices included the following.

USACE

- Allowed the on-site lead engineer to focus on constructing the project on time and within budget; minimized administrative and media duties by funneling status updates to a single USACE point of contact;
- Initiated design of lock replacements in advance of acquiring funding and communicated "shovel-ready" status of the project to congressional representatives, which resulted in receiving ARRA funds;
- Initiated resource agency and high-level industry input about the best time to close the system 2 years prior to the closure to minimize impacts to fish runs and trade;
- Initiated industry communication, including start and end dates of the extended closure, 18 months in advance;
- Established weekly status update conference calls with the industry;
- Notified stakeholders about project status and progress, as well as any potential schedule changes;
- Prepared regular press releases; and
- Provided regular status reports to USACE Headquarters in Washington, D.C.

Advocacy Groups

- Continued to voice support for the rehabilitation of the extended lock outage that would enhance reliability of the navigation and delivery system;
- Participated in USACE teleconferences;
- Updated wheat elevators, buyers in international markets, exporters, and other stakeholders on lock rehabilitation preparation and progress;
- Continued communication with wheat exporters, grain commissions, and elevator managers; fielded comments and complaints regarding alternative modes of transportation and the need for the river system;
- Conducted conferences for its members justifying the importance of the lock outage;
- Suggested alternative means of transportation to its members; and
- Spoke to the public and press about the significance of the outage.

Industry

- Focused on employee retention plans, including maintaining benefits, coordinating with the state in advance to ensure employees could immediately obtain unemployment benefits, providing education reimbursement, providing more opportunities for overtime in advance of the closure, allowing employees to obtain temporary employment while maintaining benefits, etc.;
- Communicated with their employees 12 months in advance of the closure;
- Participated in USACE and PNWA coordination calls;
- Focused Washington, D.C. lobbying efforts on obtaining funding;
- Communicated with their customers 12–18 months prior to the closure and identified preparation and business continuity plans; and
- Moved goods in advance to the extent possible by working with buyers to adjust purchase schedules.

Physical Infrastructure

Infrastructure relevant to a major inland waterway consists primarily of the navigation channel and navigation locks, and the associated ports, railways, and roadways that support waterborne commerce. All pieces work together as a system. When planning for a significant disruption of a primary navigation artery, such as the 14-week extended closure, one must understand the entire system in order to identify strategies to support supply chain resiliency. In the case of the Columbia-Snake River system, the infrastructure includes 8 navigation locks, 27 grain elevators, and 24 ports with marine cargo facilities (19 upriver of Bonneville Dam). USACE and PNWA worked closely together to announce the upcoming closure and coordinate preparation activities. The following identifies steps that were taken to assist water-dependent users.

USACE

- Planned the extended lock outage around salmon runs and heavy cargo months;
- Moved accessories, lock gate equipment, and other necessary supplies for the extended lock outage by barge transportation as to not clog major highways or railways;
- Developed traffic management plans for staging construction equipment and components; and
- Accelerated prep work for the three locks that were receiving new gates (see Figure 5.3) so that repairs and replacements could stay on, or ahead of, schedule (e.g., added Sunday shifts).

Ports, Grain Terminal, and Producers

- Upgraded storage capacity,
- Purchased trucks,
- Improved and/or rehabilitated facilities, and
- Repaired equipment.

Railroads

- Repositioned railcars and engines, and
- Increased hours of operations.

Regulatory and Public Agency Involvement

Several concurrent events created the perfect scenario for the expedient repairs to occur. The availability of ARRA funds and the project "readiness" allowed the project to capitalize on a

Figure 5.3. Manufacturing gates.

unique revenue source that became available after the most recent economic recession. Significant support at the federal level for projects that strengthen export activities also helped attract funding.

USACE

- Developed an implementation plan, including early initiation of engineering design, industry collaboration to lobby for funding, and an overall communication and implementation strategy;
- Coordinated and collaborated with resource agencies such as U.S. Fish and Wildlife, early on to identify the least impactful time to close the locks;
- Coordinated and collaborated with several federal, state, and local agencies in advance to identify who would be impacted and how best to minimize impacts—in particular, business retention; and
- Developed response plans for bad weather, unexpected delays in construction, and traffic impacts.

Possible Considerations for the Future

- Low interest rates significantly reduced projected carrying costs; consider subsidies for the industry, in particular, producers who bear most of the additional transportation costs.
- Rail tariff rates were much higher than normal due to increased demand and the costs associated with repositioning equipment; potential for government assistance.
- Increase the availability of trucks to producers through a program such as the Ports of Long Beach/Los Angeles Clean Truck Program.
- Require 12-month advance warning of tariff increases above a minimum threshold to prevent undue hardships to producers.

5.5 References

Bird, P. (1989) "Navigation on the Columbia-Snake River System." *Transportation Research Circular* 350: 55–59. Transportation Research Board, Washington, D.C.

BST Associates (2003) *Lower Snake River Transportation Study Final Report: American Rivers.* p 13. June 2003.

Center for Economic Development and Research (CEDER) (2005) *Columbia/Snake River System and Oregon Coastal Cargo Ports Marine Transportation System Study.* Prepared by Parsons Brinckerhoff, BST Associates, and Pacific Northwest Waterways Association. June 2005.

Kammerer, J. C. (1990) Water Fact Sheet. Open File Report 87-242. United States Geological Survey, Department of the Interior. http://pubs.usgs.gov/of/1987/ofr87-242/pdf/ofr87242.pdf May 1990.

Pacific Northwest Waterways Association "Columbia Snake River System Facts," http://www.pnwa.net/new/Articles/CSRSFactSheet.pdf.

Simmons, S. and Casavant, K. (2010) *Historical Waterborne Commerce on the Columbia-Snake River System: Commodity Movements Up and Down River, 1991–2010.* FPTI Research Report #1. FPTI, Washington State University. Pullman, WA.

Simmons, S. and Casavant, K. (2011a) *Industry Preparations for the Columbia-Snake River Extended Lock Outage.* FPTI Research Report #2 Freight Policy Transportation Institute, Washington State University. Pullman, WA.

Simmons, S. and Casavant, K. (2011b) *Industry Reactions to the Columbia-Snake River Extended Lock Outage, December 2010–March 2011.* FPTI Research Report #9. FPTI, Washington State University. Pullman, WA.

Simmons, S. and Casavant, K. (2011c) *Return to the River: Columbia-Snake River Extended Lock Outage, April–June 2011.* FPTI Research Report #10. FPTI, Washington State University. Pullman, WA.

Simmons, S. and Casavant, K. (2011d) *Economic and Environmental Impacts of the Columbia-Snake River Extended Lock Outage.* FPTI Research Report #12. FPTI, Washington State University. Pullman, WA. August 2011.

USACE Waterborne Commerce Statistics Center, "2011 Waterborne Commerce of the U.S. Waterways and Harbors on the Pacific Coast," http://www.navigationdatacenter.us/wcsc/wcsc.htm.

USACE Waterborne Commerce Statistics Center, "Locks by Waterway, Tons Locked by Commodity Group," http://www.navigationdatacenter.us/lpms/cy2012comweb.htm.

Appendix 5A: Interview Guide 3

Represented Participants

- Port of Portland;
- Port of Morrow;
- Port of Lewiston;
- United Grain;
- Columbia Grain;
- Shaver Transportation Company (barge operator);
- Tidewater Barge;
- Pacific Northwest Waterways Association;
- USACE (Portland Division, Portland District, and Walla Walla District);
- Lewis-Clark Terminal (grain elevator);
- United States Coast Guard; and
- D & G Farms (Idaho wheat grower).

Sample Questionnaire:

Private-Sector Shippers Discussion Guide

Note that a similar form was used to guide discussions with public organizations.

Introduction

Port disruptions, such as those caused by natural disasters, labor disputes, and other man-made events, impact the entire supply chain. We are assessing the impacts, recovery, supply chain and facility changes, and the lessons learned from these events as a key element of a project for the NCFRP. As part of this study, the scheduled closure of the Columbia River has been identified as one of two in-depth case studies to investigate. NCFRP is part of the Transportation Research Board and the National Academy of Science. A description of our project can be found at http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3493

The results of our work will be released in a report to inform discussions of the supply chain and port disruptions throughout the United States, including the recent Superstorm Sandy impacts on the Port of New York and New Jersey and the Columbia River locks repair impacts. As we all know, keeping goods moving is important, particularly after a disruption. Your experience in the planned closure of the Columbia River to ocean-going vessels will help us to identify and elaborate on the steps needed to coordinate and continue freight movements through ports in times of severe stress.

Our individual discussion is confidential. We will keep the information you give us confidential. No quotes or information will be attributed to an individual person or organization.

We are also looking at three aspects of the supply chain—the physical movement of goods, information flows, and regulatory/governmental agency involvement.

Background on Your Organization

- Please describe your use of the supply chain and your involvement with cargo moving through port facilities.
- What public agencies and private-sector organizations do you interface directly with in these activities?
- How do disruptions at a port affect your operations?
- How do you prepare, respond to, and ensure business continuity/recovery when supply chain disruptions occur, particularly disruptions involving one or more ports?

- What is your facility's geographic coverage? Do you interface with facilities in other geographic areas?

Coordination and Communication

- How do you coordinate with governmental agencies (e.g., FEMA, DHS, port agencies, and roadway authorities)?
- How do you coordinate with transportation providers, your suppliers, and your customers?
- What do you consider the strengths of your organization with respect to coordination and communication before, during, and after a port disruption?
- How would you improve your communication and coordination process for future situations?

Continuity of Operations and Service

In considering how to maintain service and cargo flow in times of disruption:

- What are the most important considerations (physical, information flows, and regulatory)?
- What are the major challenges or obstacles (physical, information flows, and regulatory)?

Columbia River Closure

Let's talk about the Columbia River Closure event:

- Preparations;
- Impacts on your facilities and operations;
- Immediate response, business continuity, and recovery;
- Lessons learned;
- Anticipated changes in facilities and operations.

Next Steps

- What other organizations and individuals should we talk with regarding the Columbia River closure and supply chain resiliency?
- Is there any other information that you would like to share with us at this time?

Thank you! We will share the draft case study with you, as well as send you the final report once published by the National Academy.

CHAPTER 6

Synthesis of Findings

6.1 Introduction

This chapter of the report draws from the material presented in previous chapters to synthesize a series of high-level rules of thumb that could help public agencies respond to significant disruptions to a seaport's cargo throughput activities.

The multi-stakeholder complexity associated with seaport disruptions, as well as the dynamic—and often unique—nature of the situation in the immediate response stage, make the development of specific action plans a significant challenge. One is reminded of the military maxim, "All plans are great until the first shot is fired." Yet, even though the unexpected often occurs, the two case studies in this report support the value of pre-planning and plan-based exercising of both logistical and informational protocols, as ways to mitigate some of the worst effects of a disruption to a port's operations. The case studies also suggest that regulatory protocols could be useful in recovering from future disruptive events.

Once an event takes place, the practicalities of the situation appear to dictate an immediate response phase, leading into a more protracted recovery effort. The initial goal is to resume port operations as soon as possible, although a return to pre-disruptive operational status may take longer to achieve.

This present study focuses on one aspect of a broad objective of port recovery, getting cargo throughput back to pre-event levels within the port as quickly as possible and using, as required, multiple modes and multiple ports to achieve this goal. The literature on this topic indicates that this task is a business continuity challenge, with the implied need to keep the additional costs of freight loss, damage, and delay to a minimum. Doing so in some more extreme cases of port disruption, such as that resulting from Superstorm Sandy (Chapter 4) has to be accomplished in the context of much broader safety and damage issues, and also in the context of simultaneous impacts on multiple adjacent seaports. And as with all transportation-system-related actions, the safety of people must come first.

The specific actions recommended in the literature for mitigating the effects of a disruption cover three distinct phases associated with any disruption event, as follows:

1. Prior actions geared to avoiding or limiting a disruption's impacts (preparedness);
2. Actions geared to dealing with the immediate impacts of the disruption (response); and
3. Actions geared to getting the port back up and running again as soon as possible (recovery, and eventually resumption, of pre-incident operating levels).

Collectively, these three sets of actions seek to increase a port's resilience to threats through greater pre-planning and plan exercising, asset redundancy, and flexibility in the use of existing assets (see Chapter 2 for details). Although the focus of this present research has been on the second and third actions in this sequence, it is clear that the success of any actions taken will depend, in many instances, on the effectiveness of prior planning, which requires the establishment of effective working arrangements between both the public agencies and private-sector stakeholders involved. Such arrangements were demonstrated in recent disruptions by the roles played by MTSRUs and in the multimodal movement of diverted cargos.

The research also demonstrated that delays in recovery can occur when such arrangements are not fully in place. One example was the need to arrange for and use U.S.-flagged vessels or alternative modes when there was no Jones Act exemption provision for the handling of diverted containers after Superstorm Sandy. With a Jones Act exemption, some of the organizations interviewed noted that the diverted containers would have been handled by the next vessels in the rotation, as is apparently done in Europe and Asia. Instead, alternative arrangements had to be made and these additional costs were passed on to the BCOs.

Based on the many expert interviews carried out by the project team, it is also clear that disruptions to cargo movement at our nation's seaports represent costly delays to product supply chains. That is, ports are key supply chain nodes whose functionality is dependent on the efficiency of not only within-port cargo handling activities, but also on the upstream and downstream efficiency with which freight comes into, and subsequently moves beyond, the port complex.

The more significant the disruption, the greater the pressure placed on both landside and waterside transportation modes to respond. As the precursor study to this present report demonstrates (Georgia Tech Research Corporation, et al., 2012), if protracted outside-the-port mode shifts are required, the economic costs to shippers, carriers, and customers of returning to pre-disruption conditions can be significant. Therefore, port disruptions need to be viewed in this context of broader network supply chain impacts, and all supply chain stakeholders impacted need to be kept up to date on the status of port-inclusive cargo movements. Where multiple ports are impacted, either directly (e.g., by widespread bad weather) or indirectly (by being asked to handle a short-notice surge in demands to handle cargo diverted from adjacent ports), the supply chain adjustments require considerable cooperation.

6.2 Influences of Prior Warning and Severity of Port Disruptions

As noted in Chapter 2 of this report and confirmed by the study's expert interviews, the evidence from past disruptions to seaport activities clearly indicates that the character of resilience enhancing activities can be significantly influenced by stakeholders' awareness of the nature, timing, and severity of a forthcoming disruption. In cases of severe and geographically widespread disruptions, such as Superstorm Sandy, there is a need to plan for, and execute, some significant cargo diversions on both the waterside and landside activities associated with cargo deliveries. On the landside, modal flexibility is an important asset, one that means being able to shift from one mode to another (e.g., from truck to rail or barge, or vice versa) as conditions dictate. On the waterside of port operations, the ability to re-direct inbound shipping to other ports also requires knowledge of both container and non-container cargo handling capabilities at adjacent ports—which themselves also may be under duress. Throughout all of this temporary (if sometimes protracted) coping activity, it is also clear that a significant break at any point within the multimodal landside-within port-waterside connections discussed in Chapter 2 can have costly negative consequences on a stakeholder's entire supply chain. Treating ports as key nodes in trade-based supply chains therefore seems to warrant further attention and to offer a productive perspective to adopt in seeking greater freight system resiliency. And even when both the timing and nature of a cargo-handling disruption to port activities is anticipated with a high degree of confidence, as in the Columbia River case study described in Chapter 5, unanticipated events may occur, and return to pre-event operating conditions can still be difficult and costly. A third type of disruption, not covered by a case study in this report, involves an event for which little or no prior warning is possible, such as sudden chemical spill or a terrorist attack, and which may create an immediate level of confusion that adds uncertainties in responding to issues of humanitarian logistics as well as commercial supply chains. In the Columbia River and New York–New Jersey port disruptions described in Chapters 4 and 5, some degree of prior warning (if not of the exact nature and true severity of the event in the Sandy case) was available. As noted by one of this project's panelists, human emotions will play a far greater role in the nature of stakeholder response and resilience activities because of the heightened fear and uncertainty associated with an entirely unanticipated disruption.

With these thoughts in mind, the following observations are presented as a high-level framework from which to consider the key points identified by the project. These rules of thumb are arranged around the report's three major themes

1. Actions dealing with utilization of physical and logistical assets;
2. Actions to ensure adequate and timely communication of critical information; and
3. Actions that address and, where necessary, seek temporary waivers to, prevailing government regulations.

6.3 Protecting and Using Physical/Logistical Assets

Identify the type and potential severity of the supply chain disruption, and the level of resources needed to deal with it, including its

- Geographic scope,
- Facilities disrupted,
- Modes impacted,
- Commodities and characteristics of the shipments disrupted, and
- Likely timeframe needed for service resumption.

Know the current condition, location, and available cargo handling capability of the port's major physical assets, and determine the safety of these assets, including

- Seagoing vessels;
- Landside modes (truck, rail, barge) serving the port and associated equipment;
- Indoor and outdoor storage and dock capacities;
- Cargo including full and empty containers;
- Cargo handling equipment (cranes, forklifts, etc.);
- Channel clearing vessels and equipment;
- Size of the normal and temporary, event-activated labor force (by job type); and
- Water, fuel, and power supply.

Identify the need to move port assets to safer locations—terminal equipment, containers, IT equipment, rail and truck equipment, and even vessels may need to be moved off site given sufficient forewarning of an event.

Identify, as early as possible, any anticipated cargo handling shortfalls and the key logistical options available for responding to the situation.

- Identify regulatory options to support cargo handling (e.g., Jones Act, size/weight, and other temporary regulatory exemptions);
- Identify the options for landside mode-shifting (or "mode flexing") with respect to cargo types and their inland origins (outgoing) and destinations (incoming);

- Quantify all available cargo handling resources and explore willingness of stakeholders to share resources during response and recovery periods;
- Identify the current condition, location, and availability of cargo handling capacity at ports suitable for cargo diversions, again with respect to cargo types and their inland origins (outgoing) and destinations (incoming), and recognizing:
  - Size of diversions expected (e.g., number of vessels and containers diverted);
  - Timing of diversions and expected vessel arrival times at alternative port; and
  - Potential impacts on, and limitations imposed by, alternative landside (truck, rail, barge) as well as oceanside, modal options at the alternative port

6.4 Maintaining Frequent Communications and Information Flow

Monitor and maintain the workings of the port's real-time communications technologies

- This includes communications between port management; emergency responders; port labor; local, regional, and federal enforcement and planning agencies; port supply chain stakeholders (carriers, shippers, receivers, brokers); the media; and (as warranted by event extent and severity) the public at large.
- Employ, as needed, the redundancy offered by alternative communication technologies (GPS, cellular phones, land lines, online Internet and Intranet websites, and in some cases paper copies). Each can become essential to an effective recovery as well as response phase in cases of severe or widespread disruption events. Note that some of these IT assets may have been moved offsite for safety reasons (see 6.3) or functions may be running through back-up data and communication systems.
- Establish daily conference call arrangements for disruption situations.

Maintain regular, two-way communications with all stakeholders—report regularly on status of port and terminal operations, damages and current and potential delays to cargo movement, as well as any proposals or plans to handle such delays. Consider using all forms of available communication necessary, including hard copy. The ability of carriers and shippers of cargo, or their agents, to quickly assess freight delivery problems, identify supply chain alternatives, and communicate this information with their customers significantly impacts supply chain resilience. Early communication with customers minimizes economic costs and supports business retention.

Monitor and maintain the condition of the port's data, computer, and telecommunications online and back-up systems in case of cyber system failures—resilience through redundancy, in the form of back-up information (data storage and retrieval, rapid communication) technology systems is becoming/has become a necessity in today's business world.

6.5 Dealing with Regulatory Compliance Issues

Determine the institutional and regulatory context of the event with respect to

- Port operational command and emergency response authority;
- Control over within-port asset utilization;
- Public/private-sector asset ownership;
- Financial resources/availability and authority to use; and
- Legal and insurance issues with respect to labor credentialing, cargo inspection, and clearance, safety, security and environmental compliance.

Understand both specific agency and specific individual roles and responsibilities—Know who to contact on specific issues, from the role of the USCG's Captain of the Port to that of other federal, state, and local government agencies, port officials, vessel and intermodal inland freight carriers, terminal operators, etc. In particular, who makes the key port operating decisions, and who sets response priorities? Also, how and when do such priorities change during the immediate response phase, in the immediate post-response period, and during the subsequent port recovery phase?

Understand and seek temporary waivers to appropriate cargo, labor, and fuel regulations as port operating conditions change—Monitor and seek modifications to a port's personnel access conditions, as needed, for effective labor notification, credentialing, and limitations on exposure.

- Labor credentialing associated with port entry, re-entry and (if needed) on-site or near site temporary housing;
- Labor safety, including roles assigned to workers and first responders unfamiliar with a specific port's operations; and
- Other workforce policy issues (see TSIP, 2011, and Section 2.4 of this report).

Monitor and seek modifications to a port's electrical and fuel supply systems, as needed for effective power generation for buildings, vehicles, and cargo handling equipment.

Monitor and seek temporary modifications to a port's cargo, intermodal, and vessel handling rules and regulations, as deemed necessary. This applies to cargos being diverted to ports that are asked to handle a sudden surge in the demand for its freight handling capabilities due to a major disruption at another port.

6.6 Example Port Disruption Rules of Thumb Table

Table 6.1 presents a sample rules of thumb template. The table is used here to demonstrate the type of high-level incident response activities that the interviews suggest are required of port preparedness and response leading up to, during, and both immediately after and during any long-term incident recovery period. Entries in the table are organized around the physical, informational, and regulatory dimensions of the problem. They are based on the use of a centralized, EOC approach to incident response that brings together the various public and private stakeholders involved. The specific make-up and operating authorities of such an EOC will vary on a case-by-case basis, but the general concept of an "all hazards" and multi-stakeholder-informed approach to the problem seems valid.

6.7 Possible Next Steps

Based on the research undertaken for this study, the following may merit further investigation:

- Identify and assess the challenges associated with handing surges in diverted vessels and shipments in response to a significant single- or multiple-port disruption event. This includes:
  - Existing and potential roles of regulatory, physical, and information flows to expedite handling of diverted containers; and
  - Mode shifts or other means of gaining flexibility in post-disruption modal transportation services, notably on the inland movement of cargo to and from affected ports.
- Articulate and provide rules of thumb for balancing resiliency/system infrastructure hardening with the potential increases in the cost of maintenance.
- Identify the interactions among humanitarian, recovery, and revenue cargo logistics, notably during no-notification disruption events.

Table 6.1. Sample rules of thumb.

	A. Physical/Logistical Asset Utilization			
	1. Before Disruption (Pre-Planning)	2. During Disruption (Response Phase)	3. After Disruption (Recovery Phase)	
			Immediate Response	Longer Term Recovery
Emergency Operations Center	Establish and regularly exercise a multi-stakeholder group EOC.Train all port staff on response procedures and regularly update staff telephone contact information. Include power utilities and inland modes in planning.	Activate first responders and notfy stakeholder groups. Identify staffing needs, call-in appropriate first responders and law enforcement agencies along with key port personnel.	Coordinate and track progress of contingency response plans associated with emergency responders and affected stakeholders.	Determine and report on when conditions within the port have come back to normal and respond to requests from stakeholders for assistance in the interim.
Workforce/ Responders	Develop a port response and recovery plan, including a temporary housing plan, with input from police, first responders, industry, etc. to ensure that truck drivers, barge, ship and railroad workers moving cargo or carrying FEMA supplies can access the port when needed, and when safe to do so; and that both port workers and emergency responders are aware of and trained in safety issues when clearing debris and handling containers and cargo. Encourage individuals to top-off personal vehicles with fuel and store vehicles outside potential disruption area.	Inform port labor force of port conditions and whether to stay home, or travel to port as usual/via designated emergency routes. Contact first responders, including any medically trained personnel deemed ncessary on-site. If applicable, utilize reverse 9-1-1 for port staff. Arrange on-site housing as needed for critical staff.	Establish report-to-work areas and temporary housing and medical treatment locations, as needed for first responders and key personnel. Monitor port access for port personnel and responders and seek modifications to protocols as needed for effective response efforts, while maintaining port security. Consider needs of the families of on-site workers (provide provisions so that on-site staff can focus on work, knowing families taken care of).	Coordinate with labor unions regarding labor needed, working hours and locations.
Power & Fuel Supply	Identify location and condition of power supply components and capabilities necessary to operate the port. Store fuel for generators and priority personnel vehicles. Locate generators above flood levels. Investigate alternatives for accessing/bringing emergency power to the port (e.g., use of solar power; possibility of reversing cold ironing during extended grid outages). Consider micro-grid technologies.	Utilize EOC and stakeholders to identify power outages. Notify local power company of loss of and immediate needs for power to port facilities. Immediately repair or replace power equipment as conditions permit.	Ensure continuity or quick recovery of power supply to port operations. Identify liquid fuel needs, location of resources, and best available shipment mode/route. Provide fuel to key personnel vehicles. Consider using shipboard power to assist in port operations where feasible.	Re-establish and where necessary add robustness to the port's existing power supply, including the addition of possible alternative sources of power to the port.
Water Supply	Maintain a list of vendors and contractors that can quickly respond to water and sewer disruptions, and if feasible, maintain on-call contracts to ensure quick response to emergencies. Collaborate with port water/sewer users and incorporate their needs into the emergency response plan. Maintain and regularly verify an emergency contact list of terminal operators and other port water/sewer users.	Identify, and if feasible quickly repair, any losses of water supply, especially losses that may hamper the immediate response phase.	Ensure continuity or quick recovery of water supply to port operations	Re-establish and where necessary add robustness to the port's existing water supply,
Cargo Handling Equipment	Prepare for bad weather to impact equipment access/utilization: Move chassis to higher ground out of the danger/any flooded areas. Stabilize cranes and protect other cargo loading equipment (e.g., fork-lifts) against high winds, water damage, or other threats as needed. Stabilize/protect container stacks. Maintain list of parts and repair vendors, with locations of off-site parts and supplies. Identify locations of closest back-ups and coordinate potential asset sharing arrangements and responses.	Coordinate with port stakeholders to identify equipment damage and inmmediate needs. Monitor and quickly repair/replace faulty/damaged equipment where feasible. Stabilize/protect container stacks	Seek temporary replacements/resource sharing arrangements for damaged equipment. Stabilize/protect container stacks. Coordinate with other ports/entities to seek temporary replacements/resource sharing arrangements for damaged equipment.	Replace damaged equipment on a priority basis.

A. Physical/Logistical Asset Utilization (continued)				
	1. Before Disruption (Pre-Planning)	2. During Disruption (Response Phase)	3. After Disruption (Recovery Phase)	
			Immediate Response	Longer Term Recovery
Terminal Activities	Consider operational changes to facilitate moving cargo off terminal and/or limiting the amount of cargo arriving at the terminal prior to a known event. Examples include early delivery and re-routing of goods to warehouse/distribution centers not impacted by the disruption. Identify safer (e.g., higher ground) cargo storage locations. Establish procedures for securing equipment and personnel prior to a known event. Stabilize/protect cargo such as container stacks. Establish evacuation and recovery plans for unanticipated events.	Monitor cargo handling and storage space assets. Coordinate appropriate response with port operators for the specific event as impacts become better known. Stabilize/protect cargo.	Coordinate with port operators to establish working condition of port terminals and warehouses. Quantify damage to facilities, including terminals, roadways, railways, warehouses, etc. Stabilize/protect cargo. Identify costs, and if necessary, initiate funding aid requests through FEMA and other available resources. Arrange for additional labor to assist with cargo movements, if needed. Consider extending gate hours of operation. Clear debris and repair damaged structures/cargo storage areas.	Establish working condition of terminals with their owners/operators. If necessary, clear debris and repair damaged structures/cargo storage areas, roadways, railways, etc. Collaborate with terminal operators and labor to establish emergency working procedures necessary for business continuity.
Channels & Docks	Implement MTSRU and Coast Guard coordination with port working group on equipment and steps for channel and waterways inspections. Identify equipment, personnel, and alternative resources. Establish rules for communicating disruptive event specifics with both at-dock and at-sea vessel operators. Implement response plan.	Identify any channel blockages or restrictions on dockside vessel use and notify all impacted stakeholders through established communication protocol. Close impacted channels and/or docks and clear blockage	Provide status updates on channel blockages or restrictions on dockside vessel use. Continue to clear channel and on-dock debris and repair navigational aids. Channel and berth dredging may be needed to address a storm-related siltation.	Schedule and process vessels utilizing a pre-planned yet dynamic prioritization system capable of revising priority queues as needed until recovery is complete. Continue channel dredging as needed.
Vessels	Establish a Recovery Advisory Unit to prioritize vessel processing and storage berths during a disruption, and for handling containers originally destined for another port (surge planning due to cargo diversions). Consistently monitor status of disruption, and if necessary, alter delivery options (i.e., divert to another port, speed up or slow down to avoid disruption, etc.)	Consistently monitor anchored vessels, and where necessary, assist at-risk vessels with loading, unloading, and securing cargo. All vessels moved from berths and secured by carriers per rules and regulations established for port operations.	Continue to monitor conditions of vessels at port. Implement and monitor vessel arrival/departure prioitization plan. Once the USCG declares the port to be reopened, establish the priority order for vessel calls or diversions to alternative ports. Carriers are responsible for vessel decisions.	Maintain or modify vessel arrival/departure prioritization plan during recovery period, as needed.
Landside Intermodal	Establish procedures for securing and/or repositioning equipment and personnel prior to a known event, including potential services and shuttles to/from alternative ports. Establish evacuation and recovery plans for unanticipated events. Coordinate with landside operators (truck/rail/barge) to develop cargo diversion plan for potential shift of services to/from alternative ports. Develop and maintain a list of on-call contractors capable of quickly repairing damaged infrastructure.	Identify affected personnel, cargo handling and storage space, and inland transportation (truck, rail, barge, pipeline) assets at the port. Monitor conditions of off-terminal roadways and railways. If the disruption causes vessel diversions, coordinate with intermodal industry to respond.	Assist stakeholders in searching for alternative transportation options, including potentially shared truck/rail/barge assets. Coordinate with public agencies to prioritize roadway repairs and identify funding needs. Monitor railway facility repairs.	Continue diverted container services as needed and fully re-establish inland connections. Determine long term capital investments needed to restore and further harden inland connection facilities.
Port Security	Implement security plan and review existing condition of port boundary/fences utilizing port surveillance devices and field checks by security personnel. Check, and if necessary, repair inoperable surveillance devices.	Secure port facilities and personnel. Establish perimeter security when port is closed. Continuously monitor working condition of surveillance equipment.	Repair major gaps in port boundaries/fences and damage to port surveillance devices. Maintain a careful watch on port assets for safety reasons, and to prevent theft. Provide access to port workers/personnel and truck drivers aiding in recovery efforts. Possibly assist with port traffic until traffic signals repaired.	Ensure that port boundary/fences and port surveillance devices are in pre-event working condition (or better).

(*continued on next page*)

Table 6.1. (Continued).

B. Communications & Information Flows				
	1. Before Disruption (Pre-Planning)	2. During Disruption (Response Phase)	3. After Disruption (Recovery Phase)	
			Immediate Response	Longer Term Recovery
Emergency Operations Center	Ensure EOC has up-to-date stakeholder contact information for terminal operators, labor unions, law enforcement agencies, etc. involved in emergency planning and emergency preparedness and recovery drills. Contact and collaborate with private companies that use impacted shipping channels prior to anticipated disruptions. Identify alternative EOC locations where emergency correspondences can be exchanged by affected parties if need arises. Develop an access plan and communication protocol with input from law enforcement agencies, first responders, industry, etc. to ensure that truckers moving cargo or carrying FEMA supplies can access the port after a natural disaster. Maintain back-up copies of important documents in both electronic and hardcopy formats. Develop media plan for processing press releases.	Contact first responders and law enforcement agencies as needed, along with key port personnel. Assist private sector stakeholders in searching for potentially shared/loaned cargo loading and transportation assets. Maintain back-up copies of important documents in both electronic and hardcopy formats.	Inform/solicit input from regulatory agencies about ongoing response activities. Maintain real time contacts. Assist private sector stakeholders with recovery needs, such as searching for potentially shared/loaned cargo loading and transportation assets. Use press releases to communicate regular port operational status updates. Keep a record of lessons learned.	Continue to update and solicit input from all stakeholders about on-going recovery activities. Assist stakeholders in searching for needed, including loaned assets. Update lessons learned.
Terminal Activities	Develop an emergency preparedness and recovery plan. Establish off-site back up locations for communications and information systems, along with procedures for continual operations during and after disruptions. Train terminal staff/workers or provide detailed information about the terminal's emergency plans to workers or their representatives. Maintain a list of employee contact information. Coordinate terminal response plans with labor unions.	Provide status updates to impacted port operators via the EOC and established port communication protocol.	Engage in conference calls with other organizations to expedite recovery efforts. Coordinate with labor for workforce needs. Engage in calls with suppliers and repair organizations as needed. Provide detailed information to carriers regarding conditions at and around terminals.	Track status of private port and terminal operators and their needs for asset/financial assistance.
Vessels	Coordinate information between vessel and terminal operators to protect against cargo losses (e.g., by adjusting vessel schedules to avoid event, diverting, etc.). Before a pending natural disaster, continuously monitor weather and coordinate with USCG to secure vessels.	Monitor vessel status and media reports on an event status.	Monitor and update vessel priority queue as needed. Determine availability of at-dock berths and whether specific vessels should be re-docked, delayed entry, or diverted to another port. Provide regular status updates to regulatory agencies responsible for inspections to allow them to identify and provide resource needs. During major events that disrupt vessel loading and unloading, coordinate with USCG and industry to prioritize vessel calls.	Check vessel priority queue and location of available dock-side vessel loading/unloading points.
Landside Intermodal	Communicate with key landside operators via established stakeholder coordination process, including railroad and trucking operators. Utilize media to solicit truck drivers before the event.	Provide regular status updates to all impacted intermodal operators, including obstructions, damage, and closures.	Provide regular status updates to key stakeholders. Communicate with media to ensure truckers and other stakeholders are aware of any changes in gate hours and other terminal operations impacting them. Utilize media to solicit truck drivers after the event. Inform railroads and drayage truckers of potential schedule changes. Communicate via industry organizations, port groups, and social media to ensure truckers, railroads, and other stakeholders are aware of any changes in gate hours and other terminal operations impacting them. Possibly utilize media to solicit truck drivers after the event. Inform railroads and drayage truckers of potential schedule changes.	Inform carriers of resumption of normal operations or of any delays/changes in these conditions that may affect them.

C. Regulations				
	1. Before Disruption (Pre-Planning)	**2. During Disruption (Response Phase)**	**3. After Disruption (Recovery Phase)**	
			Immediate Response	**Longer Term Recovery**
Emergency Operations Center	Coordinate and collaborate with federal, state, and local agencies in advance to identify who may be impacted and how best to minimize impacts. Transmit any USCG condition-of-the-port messages to potentially affected stakeholders. Include all relevant regulatory agencies in any emergency preparedness activities. Identify the agencies and individuals to be contacted for regulatory waivers or exemptions. Establish draft language and requirements for such waivers and exemptions prior to potential events.	Transmit Captain of The Port directions to activate contingency plans.	Inform regulatory agencies about ongoing issues that require their attention. Identify the need for additional security/law enforcement/emergency response actions and notifications. Request waivers and/or exemptions to transport of fuel and/or diverted cargo as need identified.	Include all regulatory agencies involved in goods movement through the port in appropriate recovery planning activities. Track any significant inland supply chain based modal shifts (e.g., truck to rail or vice versa). Add additional port partners as needed to coordinating group.
Vessels	Coordinate information between vessel and terminal operators to protect against cargo losses (e.g., by adjusting vessel schedules to avoid event, diverting, etc.). If vessel diversion to a nearby port is anticipated, develop plan for avoiding access impacts due to regulatory processes/procedures.	Apply both national and international regulations to ship operations while in port during the event. Communicate and coordinate with regulatory agencies to begin identifying recovery needs.	Apply both national and international regulations to ship operations while in port immediately after the event. Follow regulatory agency guidance regarding reopening of ports and waivers/exemptions for diverted cargo.	Apply both national and international regulations to ship operations while in port after the event. Identify any regulations or regulatory processes that could be altered to improve recovery.
Landside Intermodal	Where needed, consider regulatory actions needed to establish temporary barge and rail shuttle services, as well as truck driver credentialing at alternative ports. Coordinate with regulatory agencies to identify potential access impacts that existing regulations (e.g., TWIC, port truck registration, etc.) might create. Review truck weight restriction rules; identify scenarios that may warrant temporary relief from regulations in specific port access and egress corridors. Avoid repair delays to public infrastructure by minimizing contracting time (e.g., maintain a list of on-call contractors).	Follow established regulations regarding modal operations during disruptions. Establish temporary truck driver credentialing requirements to fit short-term port needs.	For disruptions that create significant backlog, consider temporarily lifting the restriction on truck driver hours of operations and initiating temporary truck driver credentialing requirements to fit short-term port needs. Consider implementing temporary modification of truck weight restriction rules on specific port access and egress corridors. Work with regulatory agencies as needed to clear diverted cargo for inland movement from alternative ports (if cargo is not traveling "in bond.)"	Review rail, barge and pipeline operating procedures for possible avoidable cargo handling delays. Monitor recovery and determine when to end temporary regulatory relief of port access, hours of operation rules, and/or vehicle weight restrictions.
Port Security	Implement pre-planned law enforcement procedures to protect port cargo and facilities from damage or theft. Coordinate with regulatory agencies and terminal operators. Coordinate with CBP to develop protocols to handle potentially diverted shipments.	Use law enforcement to clear at-risk port areas and facilitate access by first responders.	Maintain a careful watch on port assets for safety reasons, and to prevent theft. Work with ports and transportation providers on temporary driver credentialing and shuttle services as needed. Coordinate with CBP to expeditiously handle diverted cargo.	Maintain necessary port security patrols and protocols, applying any lessons learned.

98 Making U.S. Ports Resilient as Part of Extended Intermodal Supply Chains

- Examine the benefits of, and models for, extending stakeholder participation to include inland transportation modes, and how different types of disruption events might benefit from different response team configurations.
- On a methodological note, and given the complexities involved, the use of an agent-based micro-simulation tool suggests itself as one means of exploring alternative multi-stakeholder, supply-chain-oriented response and recovery scenarios.

6.8 References

Georgia Tech Research Corporation, Parsons Brinckerhoff and A. Strauss-Wieder, Inc. (2012) *NCHRP Report 732: Methodologies to Estimate the Economic Impacts of Disruptions to the Goods Movement System.* Transportation Research Board, Washington, D.C. http://www.accuweather.com/en/weather-news/timeline-of-events-surrounding/2665639

Abbreviations

3PL	Third-Party Logistics
AAPA	American Association of Port Authorities
AMS	Area Maritime Security (usually refers to USCG AMS Plans)
BCO	Beneficial Cargo Owner
CBP	Customs and Border Protection
CM	Consequence Management
COTP	Captain of the Port
DHS	Department of Homeland Security
DOC	Department of Commerce
DOJ	Department of Justice
DON	Department of the Navy
DOT	Department of Transportation
EEI	Essential Element of Information
EOC	Emergency Operation Center
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
ICS	Incident Command System
ILWU	International Longshore and Warehouse Union
IT	Information Technology
MARAD	Maritime Administration
MTS	Marine Transportation System
MTSRU	Marine Transportation System Recovery Unit
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NRCC	National Response Coordination Center
NRF	National Response Framework
NWS	National Weather Service
OEM	Original Equipment Manufacturer
PCC	Port Coordination Center
PCT	Port Coordination Team
RM	Risk Management
Ro-Ro	Roll-On-Roll-Off (vessel designed to carry wheeled cargo—e.g., automobiles—that is driven on and off the vessel on its own wheels)
TSI	Transportation Security Incident
TWIC	Transportation Worker Identification Credential
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation