U.S. Army Corps of Engineers
Charleston District

APPENDIX C

CHARLESTON HARBOR POST 45
CHARLESTON, SOUTH CAROLINA

Economics

May 2015

Charleston Harbor Post 45

Appendix C: Economics

Charleston, South Carolina

May 26, 2015

U.S. Army Corps of Engineers
Charleston District
South Atlantic Division

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List of Acronyms

AAEQ – Average Annual Equivalent

ACP - Panama Canal Authority

ARRA – American Recovery and Reinvestment Act

BLT – Bulk Loading Tool

CA – Central America

CAR – Caribbean

CDF – Cumulative Distribution Functions

CLT- Container Loading Tool

CSPS – Container Shipping Planning Service

CST – Columbus Street Terminal

CY – Calendar Year

DC – Distribution Centers

DWT – Deadweight Tonne

ECSA – East Coast South America

ECUS – East Coast United States

EJ – Environmental Justice

ETTC – Estimate Total Trip Cargo

FCC – Fully Cellular Container

FE – Far East

FUSRAP – Formally Utilized Sites Remedial Action Program

FY – Fiscal Year

GDP – Gross Domestic Product

GI – Global Insight

GRP – Gross Regional Product

HMST – HarborSym Modeling Suite of Tools

IMF – International Monetary Fund

IMO – International Maritime Organization

ISC – Indian Sub-Continent

ISCME – Indian Sub- Continent Middle East

IWR – Institute for Water Resources

LAUS – Local Area Unemployment Statistics

LBP – Lower Boundary Points

LFA – Loading Factor Analysis

LOA – Lengths Overall

LPC – Local Purchase Coefficient

LR – Lloyd's Register

LSE – Lloyd's Shipping Economist

MED – Mediterranean

MSA – Metropolitan Statistical Area

MSI – Maritime Strategies, Inc

MXSLLD – Maximum Summer Loadline Draught

NAAQS – National Ambient Air Quality Standards

NAICS – North American Industry Classification System

NBT – New Navy Base Terminal

NCT – North Charleston Terminal

NED – National Economic Development

NEUR – Northern Europe

NOMPEAS – National Navigation Operations and Maintenance Performance Evaluation And Assessment System

OD – Origin-to-Destination

OECD - Organization for Economic Co-operation and Development

PDT – Project Delivery Team

PEN – Pendulum

PPX – Post Panamax Generation I

PPX II – Post Panamax Generation II

PPX III – Post Panamax Generation III

SUPER PPX – Super Post Panamax

PX - Panamax

QCEW – Quarterly Census of Employment and Wages

RECONS – Regional Economic System

RED – Regional Economic Development

RORO – Roll on/Roll off

SCSPA – South Carolina State Ports Authority

SHEP – Savannah Harbor Expansion Project

SNAME – Society of Naval Architects and Marine Engineers

SPX - Subpanamax

TEU – Twenty-Foot Equivalent Unit

TPI – Tons Per Inch Immersion

TSP – Tentatively Selected Plan

UKC – Underkeel Clearance

UNCTAD – United Nations Conference on Trade and Development

UPT – Union Pier Terminal

USACE – United States Army Corps of Engineers

VT - Veterans Terminal

WCSA - -West Coast South America

WWT – Wando Welch Terminal

XB – Extreme Breadth

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Charleston Harbor Post 45 Economic Evaluation

1.0 Introduction

This document presents the economic evaluations performed for the Charleston Harbor deepening and widening project, also known as the Charleston Harbor Post 45. The current federally authorized channel depth of Charleston Harbor is 45 feet. In May of 2011, the U.S. Army Corps of Engineers (USACE) Charleston District was approved by the Office of Management and Budget to begin the multi-year feasibility study to determine if deepening Charleston Harbor is both economically beneficial and environmentally acceptable to the nation. The Charleston USACE District together with the Deep Draft Navigation Planning Center of Expertise performed the economic analyses contained within this document in support of the feasibility study.

1.1 Study Purpose and Scope

The purpose of this study is to evaluate problems and opportunities for improved navigation efficiency in Charleston Harbor and identify the plan that best satisfies the environmental, economic, and engineering criteria. The scope of this feasibility study involves analysis of existing conditions and requirements, identifying opportunities for improvement, preparing economic analyses of alternatives, identifying environmental impacts, and analyzing the National Economic Development (NED) plan.

Potential navigation improvements include deepening and widening of navigational channels, turning basin expansion, and expanded channel wideners. The purpose of these potential improvements is to increase the efficiency of cargo vessel operations on Post-Panamax vessels, which are already calling on the Port of Charleston and are projected to call on the port with increased frequency in the future. This study identifies and evaluates alternatives that will:

- Accommodate recent and anticipated future growth in containerized cargo and containership traffic;
- Improve the efficiency of operations for containerships within the Charleston Harbor Navigation Project;
- Allow larger and more efficient container ships to use the Port; and
- Reduce vessel congestion in the Wando and Cooper Rivers.

1.2 Document Layout

Section 2 details the existing conditions at Charleston Harbor. Section 3 examines future without and with project conditions and includes an evaluation and description of forecast trade, terminal expansions, and the vessel fleet and operations at the harbor. Section 4 presents the transportation cost savings benefit analysis. In Section 5, sensitivities to the forecast are explored. Section 6 examines the multi-port analysis while Section 7 describes the socioeconomics of Charleston and the surrounding region.

2.0 Existing Conditions

The existing conditions are defined in this report as the project conditions that exist today (2011) plus any changes that are expected to occur prior to project year one, anticipated in 2022. The Charleston Harbor 45-foot project was designed to serve Panamax container vessels and similar size container vessels limited to a draft of about 42 feet. When the most recent harbor improvements were authorized in 1996, sub-Panamax and Panamax vessels made up about 80 percent of the container capacity in the world fleet and new-build vessels, and all of the fleet calling Charleston. Since then, larger Post Panamax and Super Post Panamax classes of vessels are making up increasing percentages of new-build vessels and the world fleet.

The South Atlantic Region is one of the fastest growing parts of the Country. Five South Atlantic states (North Carolina, South Carolina, Georgia, Alabama and Tennessee) and North Florida have been designated as the Piedmont Atlantic Mega-region, as shown in Figure 1. The population of this Mega-region in 2000 was 34 million people (over 12 percent of the total U.S. population), and it is expected to grow to over 57 million by 2050 (approximately 13.5 percent of the total U.S. population).[1] Much of this growth is occurring in a crescent-shaped area of economic activity from Raleigh-Durham, NC, to Birmingham, AL, and includes Charlotte, NC, and Atlanta, GA. This region is growing faster than the surrounding areas and much faster than the U.S. as a whole.

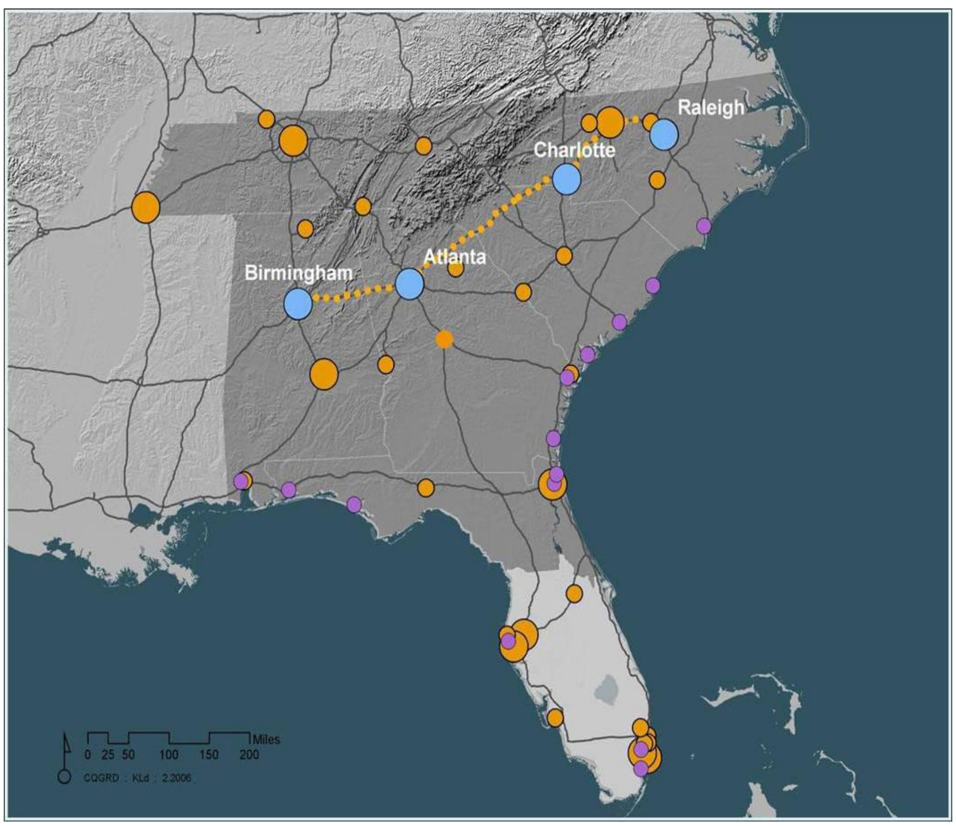

Figure 1: Piedmont Atlantic Mega Region

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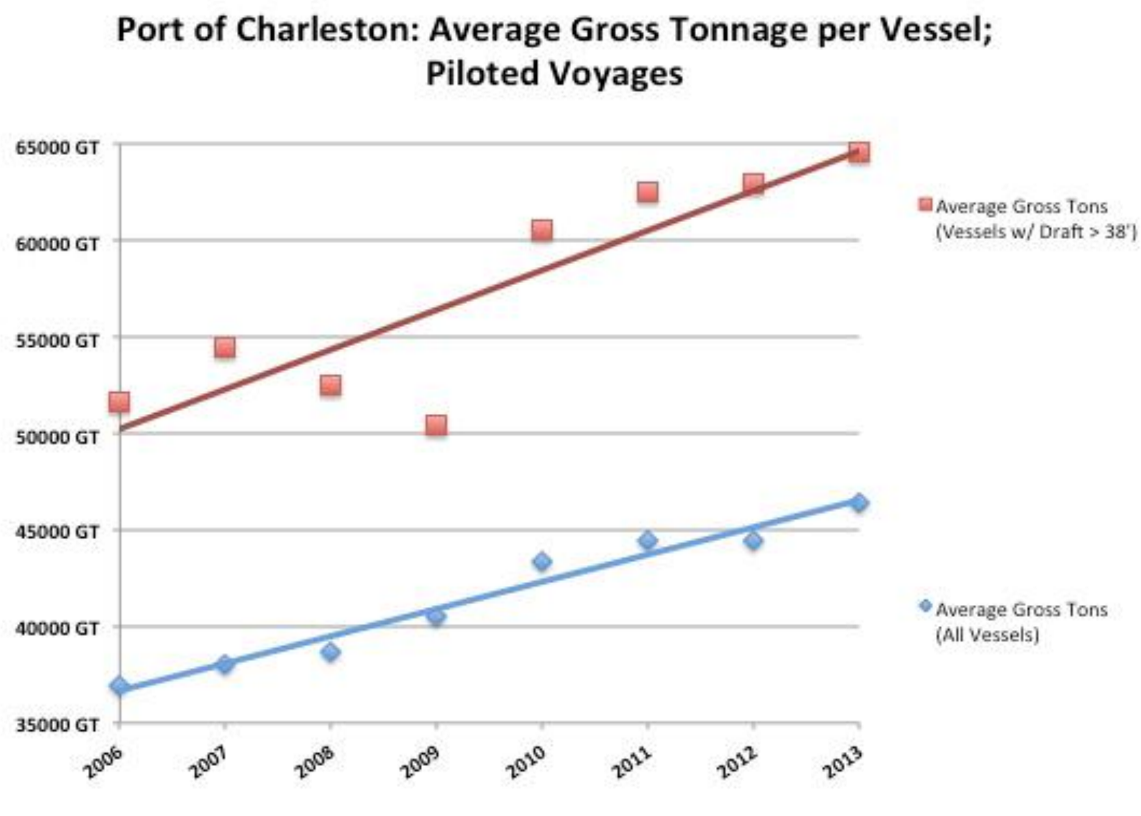
[1] Georgia Institute of Technology, Center for Quality Growth and Regional Development. Emerging Mega Regions: Studying the Southeastern United States, January 2006.

Over the years, containerized cargo has taken over a large proportion of the worldwide general cargo trade. This is due to the containerized trade allowing shipper to move cargo with less cost, added security, and makes landside transportation more efficient. A 2001 Society of Naval Architects and Marine Engineers (SNAME) paper reported that 70 percent of all cargo was being shipped in containers and projected that by 2010, 90 percent of general cargo would be containerized.[2,3] As newly-built containerships are introduced into worldwide waterborne trade, it is expected that a growing share of these new ships will be Post-Panamax vessels as shippers continue to realize economies of scale when delivering goods. These larger ships will be deployed in response to increases in container cargo volume, as well as from pressure to transport goods at a faster rate and with lower slot costs (the cost of shipping a single container).

Both long-term and short-term data acquired from the local ship pilots indicates steady increases in the size of container ships calling on Charleston and has been a noted trend in other south east US ports as well, as shown in Figure 2. Monthly data trends show a steady increase in ship size in the months following the worst of the recession, beginning in 2009.[4]



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[2] Payer, Hans G. Technological and Economic Implications of Mega-Container Carriers, SNAME Transactions, Vol. 109, 2001, pp. 101-120.

[3] While this projection appears to not have come true, most likely due to the current worldwide recession, there is still an upward trend in the percentage of cargo that is shipped in containers.

[4] Charleston Branch Pilot Association Data for 2009 and 2010

Figure 2: Piloted Vessels Annual Average Gross Tonnage from 2006 to 2013

New ships built to take advantage of the Panama Canal improvements (approximately 1,400 feet long, 180 feet wide, and 60 feet deep) are already sailing to the U.S. Charleston is one of the U.S. ports capable of handling PPX I and PPX II vessels now, but is restricted to use of tide when loaded to design draft. Vessels greater than 8,000 TEUs (Twenty-foot Equivalent Units) began calling at Charleston Harbor in 2010. From January through June 2014, fifty vessel calls to the Port of Charleston have had more than 8,000 TEUs in capacity (six of those calls were vessels with a capacity greater than 9,000 TEUs). Draft and tide constraints cause light loading and transit delays, resulting in higher transportation costs or diversions to less appropriate ports.

2.1 Economic Study Area (Hinterland) and Regional Distribution Centers

The Charleston Harbor hinterland includes the South Atlantic, Southeast, Gulf, and Midwest regions. Except for relatively small portions of traffic to Ohio and the U.S. Central region (AR, OK, KS, NE, SD, ND), the states included in the "all other" category represent markets where the South Carolina State Ports Authority (SCSPA) has not historically competed for container traffic. Figure 3 shows the container market hinterland divided into geographic regions that represent how container shipping lines, importers and exporters tend to route their container cargo**.**

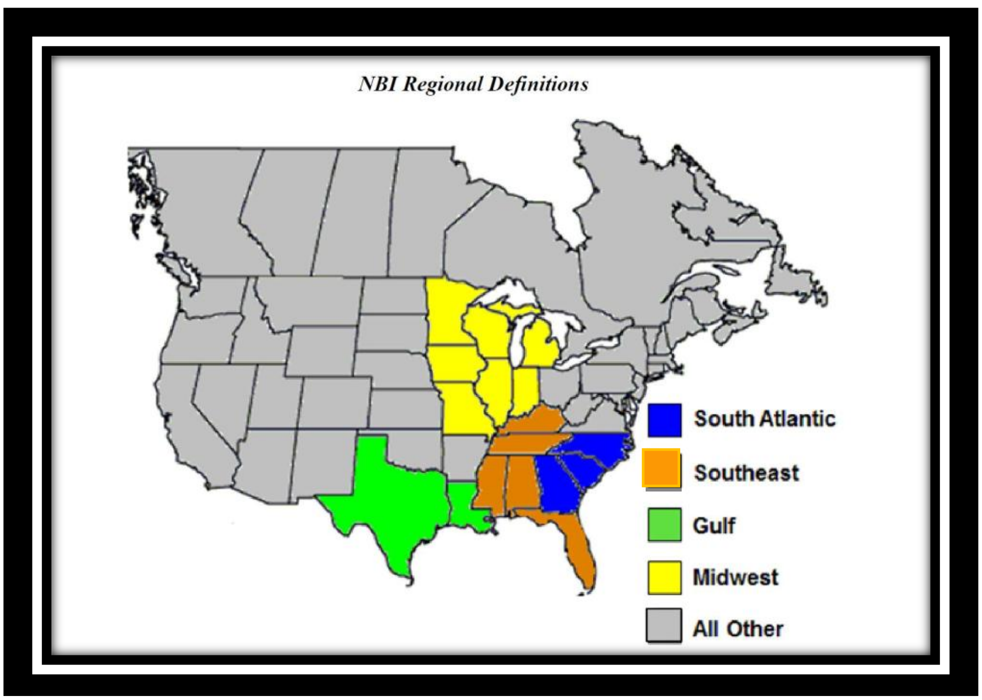


Figure 3: Geographic Segmentation of Charleston Harbor Hinterland
Source: Norbridge (NBI)

The South Atlantic and Southeast regions accounted for an estimated average 84 percent of the Port's loaded container traffic throughput during calendar years (CY) 2008 through 2010. The remainder of the Port's loaded container traffic, on average, moved via three regions, i.e., the Midwest (8 percent), Gulf (4 percent), and All Other (4 percent) regions respectively. The All Other Region includes seven states.

The Port serves an extensive regional geography, with more than 20,000 companies in two dozen states using the Port of Charleston to access overseas suppliers and buyers. As noted above, the South Atlantic and Southeast regions account for the majority of all South Carolina State Ports Authority (SCSPA) container traffic. According to the Bureau of Economic Analysis, the Southeast/South Atlantic region was the fastest growing regional U.S. economy east of the Rockies (in terms of Gross Domestic Product (GDP)) between 2000 and 2010. The SCSPA's position as a key container port gateway to this region will drive anticipated, above average market growth. Figure 4 shows GDP growth by region between 2000 and 2010.

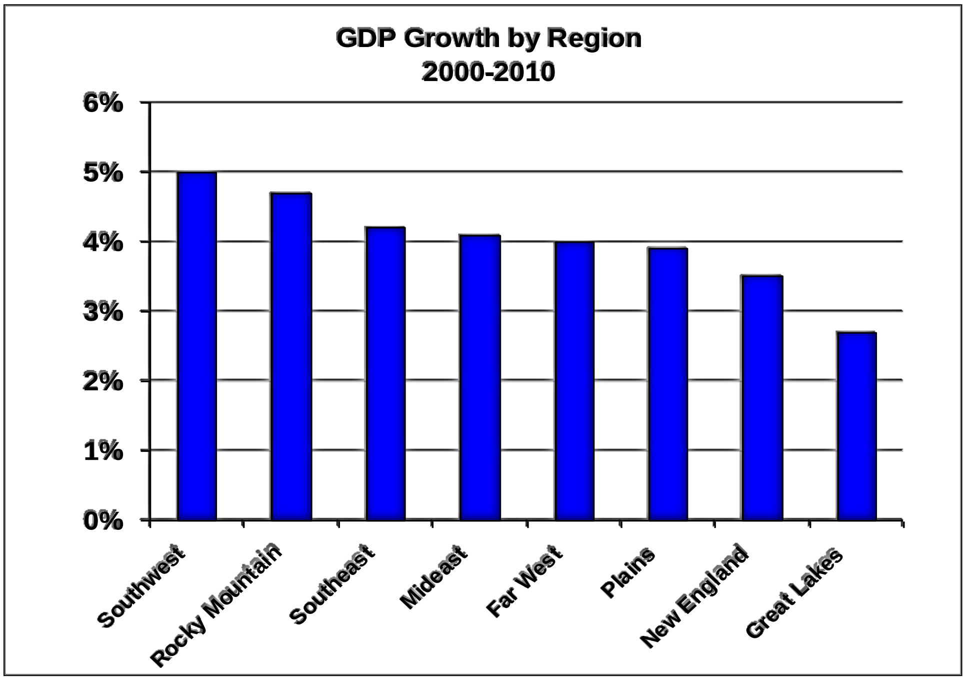


Figure 4: GDP Growth by Region
Source: BEA Note: Compound annual growth rate

The Port serves a diverse customer base, both geographically and industrially. The Port's container customer base includes global and North American centric manufacturers and retailers such as Toyota, Michelin, Lowes, Target, and Furniture Brands International. Figure 5 presents a representative cross section of container customers. The Port's container cargo base is also highly diversified in terms of import and export commodities. The Port's containerized cargo base includes import automotive parts and components, apparel, retail goods, and home furnishings.

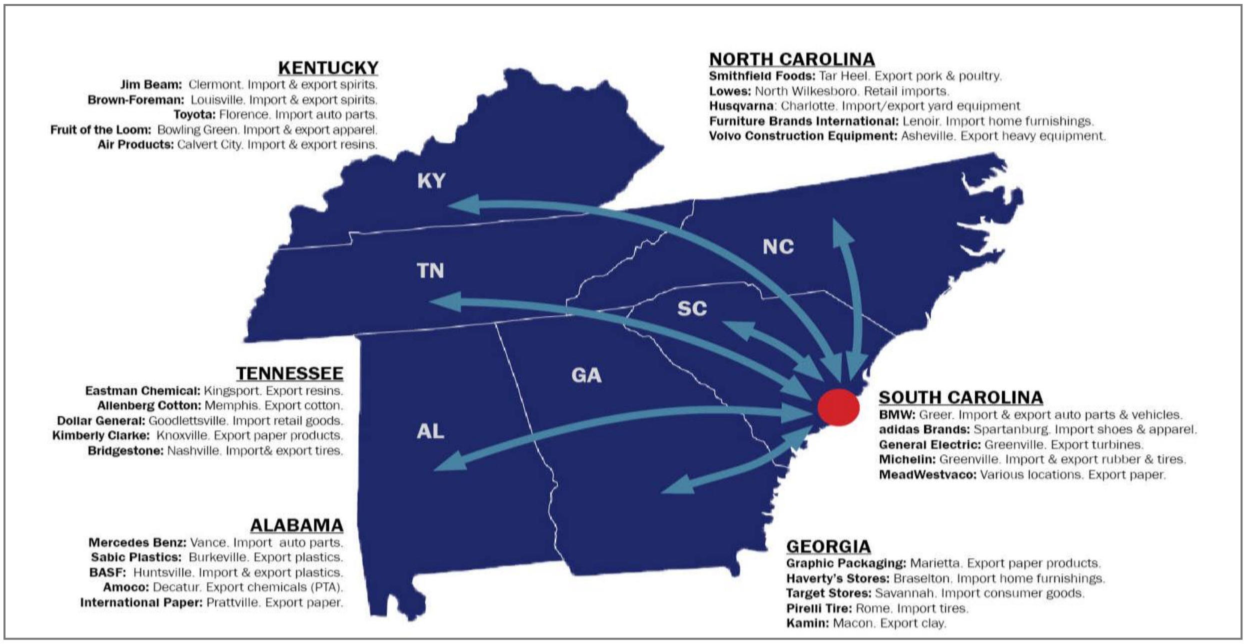


Figure 5: Port of Charleston Representative Container Customers
Source: SCSPA

Export container commodities include chemicals, paper, plastic, and heavy lift items. According to the SCSPA the 20 top export and import commodities make up 63 percent of container exports and 50 percent of container imports, respectively. Tables 1 and 2 present Charleston top 20 export and import commodities.

Table 1: Top 20 Charleston Container Export Commodities (Based on Tonnage)

	Total Exports	100%
Rank	Total Top 20	63%
1	Paper & Paperboard, Incl. Waste	19%
2	Wood Pulp	8%
3	Auto Parts	4%
4	Logs & Lumber	3%
5	Fabrics including Raw Cotton	3%
6	General Cargo, Misc	3%
7	Synthetic Resins, NSPF	2%
8	Mixed Metal Scrap	2%
9	Unclassifiable Chemicals	2%
10	Poultry, Chiefly Fresh & Frozen	2%
11	Auto & Truck Tire &Tubes	2%
12	Foam Waste & Scrap	2%
13	Machinery Misc, Cassette Players	2%
14	Automobiles	2%
15	Grapefruit & Lemons	1%
16	Lawn & Garden Equipment	1%
17	Plastic Products, MISC	1%
18	Furniture	1%
19	Medical Equip & Supplies	1%
20	Plasticizers	1%

Source: SCSPA

Table 2: Top 20 Charleston Container Import Commodities (Based on Tonnage)

Rank	Total Imports	100%
	Total Top 20	50%
1	Furniture	7%
2	Auto Parts	6%
3	Sheets, Towels & Blankets	5%
4	Fabrics Incl. Raw Cotton	3%
5	Auto & Truck Tires & Tubes	3%
6	General Cargo, Misc	3%
7	Menswear	3%
8	Apparel, Misc	2%
9	Women's & Infant Ware	2%
10	Paper & Paperboard, Incl Waste	2%
11	Household Goods	2%
12	Foot ware	2%
13	Yarns, Misc.	2%
14	Plastic Products, Misc	1%
15	Staple Fibers	1%
16	Machinery Parts, Misc	1%
17	Logs & Lumber	1%
18	Medical Equip & Supplies	1%
19	Hardware, Misc	1%
20	Engines, Motors, & Parts	1%

Source: SCSPA

2.1.1 Distribution Centers Development

Distribution Centers (DC) are an integral component of importers and exporters international supply chains. They not only provide the warehousing space necessary for storing the goods received from/delivered to the Port, but in a current business environment characterized by hub-and-spoke supply chains and "last-minute" orders, they oftentimes serve as central nodes in a company's regional or national logistics network and allow for value-added services such as consolidation/deconsolidation, cross-docking, and transloading (removing contents of international marine containers and repackaging in 53' domestic containers to create economies of scale for domestic delivery). Consequently, DC locations can influence importers', exporters', and container shipping lines cargo routing and port selection decisions.

The Port is benefiting from significant growth in South Carolina's DC industry. South Carolina is generally recognized as offering a business friendly climate, is benefiting from a growing industrial customer base and provides companies with access to skilled labor. The construction of the 1.2 million square foot Boeing 787 Dreamliner facility, which opened in the summer of 2011, and where the first 787 Dreamliner began production in 2012, is a salient example of South Carolina's attractive business environment. In early 2013, Boeing announced that an IT Center of Excellence and an Engineering Design Center will both be established in South Carolina. As part of the engineering strategy, Boeing is building a new facility in South Carolina which will design and assemble the 737 MAX engine inlets. Assembly is scheduled to begin in the new facility in mid-2015.

Currently, some of the nation's leading industrial developers have plans to install more than 20 million square feet of Class A industrial buildings in proximity to the Port. These DC developments are easily accessible via I-26, the main interstate artery serving the Port. Many of the developments are national in scope.

2.1.2 Maritime Businesses

A database of major port users and port service providers was obtained from the SCSPA. Port service providers facilitate the movement of imports/exports to and from port facilities for companies that ship or receive raw materials, component parts, and products. These firms are engaged in providing services such as freight forwarding, shipping agent services and customs house brokering. There are hundreds of transportation companies that facilitate trade in the Port of Charleston. These businesses include the SCSPA and its 470 employees; 36 steam lines; 5 stevedores and hundreds of longshoremen; 149 truck lines; 2 Class I railroads; 2 tug companies; 52 customs house brokers and freight forwardness; docking and harbor pilots; and hundreds of other firms.

2.1.3 Cargo Profile

In Fiscal Year (FY) 2011, the SCSPA served 1,729 ships and barges at its seaport terminals in Charleston and Georgetown. In the Port of Charleston, the SCSPA handled 1.38 million TEUs, up 8 percent from the previous fiscal year. The SCSPA's Charleston breakbulk cargo totaled 715,134 tons. Top commodities across Charleston docks include agricultural products, consumer goods, machinery, metals, vehicles, chemicals, and clay products. Georgetown, a dedicated breakbulk and bulk facility, handled 276,570 tons of cargo in FY11.

Table 3: Top Ten U.S. Seaport Districts in Dollar Value of All Goods Handled CY 2012 (Million $)

"Exports" are FAS value of U.S. exports of domestic PORT DISTRICT	Imports (6)	Exports (1)	TOTAL
LA/Long Beach	$320,326.5	$79,329.3	$399,655.8
Houston/Galveston	$132,735.5	$117,104.8	$249,840.3
New York/New Jersey	$153,553.5	$57,015.0	$210,568.5
New Orleans	$90,952.5	$64,194.8	$155,146.8
Seattle/Tacoma	$69,890.1	$25,747.5	$95,637.6
Savannah	$55,895.9	$37,094.3	$92,990.2
San Francisco/Oakland	$46,402.9	$23,485.5	$69,888.4
CHARLESTON	**$40,233.3**	**$23,411.5**	**$63,644.8**
Norfolk/Hampton Roads	$35,744.2	$27,502.8	$63,247.0
Baltimore	$32,081.4	$21,878.9	$53,960.3

Source: Obtained from SCSPC Port of Charleston website, source listed as U.S. Census Bureau Trade Data Branch report FT920, Tables 1 & 6 and foreign merchandise by district of export "Imports" are CIF & Customs value of U.S. general imports by district of unlading.

Steel, petroleum coke, and wood briquettes are top cargoes. Although shippers in two dozen states use Charleston to access foreign customers and suppliers, 45 percent of SCSPA tonnage and about a third of containers are related to South Carolina firms. North Europe and Asia are the SCSPA's top markets, combining for 54 percent of total volume, but more than 150 nations are served directly from SCSPA docks.

2.1.4 Cargo Value

Table 3 above presents the top ten U.S. seaport districts in dollar value of goods handled in Calendar Year (CY) 2012. As shown in Table 3, the Charleston Customs district ranks as the eighth largest dollar value of international shipments, with cargo valued at more than $63.6 billion in 2012.

In FY 2013, the SCSPA served 1,839 vessels and barges at its seaport terminals in Charleston and Georgetown. In the Port of Charleston, the SCSPA handled 1.56 million TEUs, or 20-ft equivalent units, up 8.9 percent from the previous fiscal year. The SCSPA's Charleston breakbulk cargo totaled 723,420 tons. Top commodities across docks include agricultural products, consumer goods, machinery, metals, vehicles, chemicals and clay products.

2.2 Facilities and Infrastructure

There are five terminals in the Port of Charleston and a sixth terminal has been permitted. Three of the five existing terminals handle containers, and two are break bulk terminals handling conventional breakbulk, roll-on/roll-off, heavy-lift, and project cargoes. The SCSPA plans, designs, constructs, and operates the container gantry cranes and cargo storage yards at most of its marine terminal facilities. The five facilities are shown within Figure 6 and described below.

Figure 6: Charleston Harbor and SCSPA Terminal Facilities

The SCSPA's five Port of Charleston marine terminals are:

- Union Pier Terminal (UPT) - 19.5 miles from the sea buoy
- Columbus Street Terminal (CST) - 20 miles from the sea buoy
- Wando Welch Terminal (WWT) - 22 miles from the sea buoy
- Veterans Terminal (VT) - 24 miles from the sea buoy
- North Charleston Terminal (NCT) - 28 to 29 miles from the sea buoy

2.2.1 The Union Pier Terminal

The Union Pier Terminal (UPT) in the Port of Charleston is dedicated to breakbulk and roll-on/roll-off (RORO) cargoes. Recently redesigned, its four berths are a total of 753 meterslong and are served by 63.3 thousand square meters of sprinkler-protected transit shed. Warehouses and dockside open areas are served by multiple rail lines, and all warehouses have covered rail access. This also the current location of the cruise vessel calls. The terminal is located 19.5 miles from the sea buoy and has easy access to Interstate 26.

2.2.2 The Columbus Street Terminal

In February 2011, CST's use transitioned from container and project cargo/heavy lift operations to Roll on/Roll off, breakbulk, and project cargo/heavy lift operations. CST retains its container handling capability and can be transitioned back to container operations if and when required. With a total of over one kilometer of continuous berthing space, the terminal includes over 31 hectares of open storage and almost eight hectares of sprinkler-protected warehouses that offer covered rail access. With ship-side rail service and an on-terminal rail yard, this Port of Charleston terminal has easy access to Interstate 26. It is located approximately 20 miles from the sea buoy.

2.2.3 The Wando Welch Terminal

The Port of Charleston's Wando Welch Terminal (WWT) is recognized around the world for its productivity and innovative design. It is the port's biggest terminal in both size and volume. With 348.8 meters of berthing space, the terminal is served by ten container cranes (six super post-Panamax and four post-Panamax). The terminal offers over 98 hectares of container storage space and an 18,600 square meter container freight station. In addition to having a fumigation area, a maintenance facility, and administrative and meeting buildings, the terminal contains inspection facilities for U.S. Customs and the U.S. Department of Agriculture. It is located approximately 22 miles from the sea buoy and is also near the Interstate 526 highway interchange.

2.2.4 The Veterans Terminal

The Veterans Terminal (VT) in the Port of Charleston is a 44.5-hectare dedicated bulk, breakbulk, roll-on/roll-off, and project cargo terminal on the Cooper River. The terminal is 1.5 miles from Interstate 26. The terminal has capacity for outside storage and covered sprinkler-protected warehouses. It has three piers with a total of almost 1,600 meters of berthing space. The VT is located 24 miles from the sea buoy.

2.2.5 The North Charleston Terminal

The North Charleston Terminal (NCT) is a modern container terminal in Port Charleston with an on-terminal rail yard direct access to Interstate highways 26 and 526. Dedicated to containerized cargoes, the terminal has three berths totaling nearly one-half of a mile. It also has 52.5 hectares of open storage and an over 36,000 square meter Container Freight Station. Just outside the terminal gates is an 8,500 square meter leased warehouse space. The terminal is served by intermodal rail and also has capacity for handling breakbulk and roll-on/roll-off cargoes. The terminal is about 28 to 29 miles from the sea buoy.

2.3 Container Services

According to the Waterborne Commerce Statistics Center, In 2013, the SCSPA was the ninth largest U.S. container port in terms of TEU throughput. SCSPA's container business has traditionally served Southeast importers and exporters. It also serves customers in the Midwest and along the Gulf Coast. Its major trade lanes include Asia, Northern Europe, the Mediterranean, Mideast, India Subcontinent, and the East Coast of South America. Its customer base includes 17 of the global 20 carriers and consortia. The SCSPA's container business, like the North American container industry, experienced a significant decline as a result of the 2008 to 2009 economic recession. The Port of Charleston total TEU throughput for CY2001 to CY2013 is shown in Figure 7.

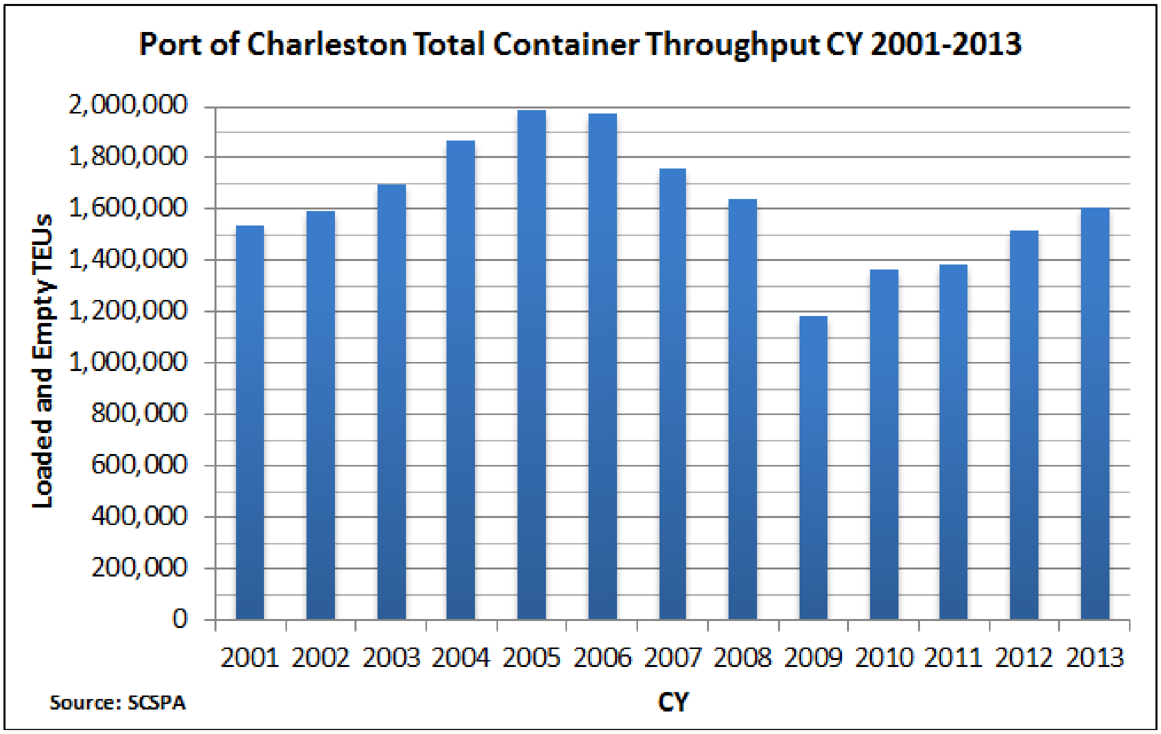


Figure 7: Port of Charleston Total Container Throughput CY2001 to CY2013

As shown in Figure 7, container traffic peaked in 2005 to 2006, declined to a low of 1.1 million TEUs in 2009 and recovered to 1.6 million TEUs in 2013.

2.3.1 Existing Container Terminals and Capabilities

As discussed earlier the SCSPA's container business is primarily handled at the WWT and NCT. The terminals have a throughput capacity of approximately 2.8 million TEUs. The SCSPA retains a container handling capability at CST, though currently the terminal does not handle container cargo. The SCSPA is also in the process of constructing the new Navy Base Terminal (NBT) on the south end of the former Charleston Naval Shipyard. The NBT is anticipated to be capable of handling approximately 1.4 million TEUs annually, increasing the total annual Port capacity to 4.2 million TEUs. This terminal is anticipated to come online by 2019. Table 4 provides an overview of the infrastructure and container handling equipment associated with the WWT, NCT, and CST facilities. It is important to note that the SCSPA container berth at NCT and the CST berths are capable of being deepened to nearly 60 feet without structural modification or reinforcing.

Table 4: Port of Charleston Container Terminal Infrastructure and Equipment Overview

	Wando Welch	North Charleston	Columbus Street
Gross Terminal Acres	693	201	155
Project Depth (MLW)	45 feet	45 feet	45 feet
Berth Length	3,800 feet	2,460 feet	2,700 feet
Ship-Shore Gantry Cranes	2 ZPMC Super Post-Panamax 4 Paceco/Hyundai Super Post-Panamax 3 Morris Post-Panamax 2 Paceco/Hyundai Super Post-Panamax (process of being relocated to WWT from CST)	2 ZPMC Super Post-Panamax 4 IHI Post-Panamax	2 Paceco/Espana Super Post-Panamax 1 IHI Post-Panamax
Gantry Cranes	30	10	3
Top-lifters	19	12	NA
Maximum Airdraft at Mean High Water	186 feet (Grace Memorial Bridge)	155 feet (Don Holt Bridge)	None
Rail Service	None	CSXT & NS	CSXT & NS

Source: SCSPA

2.3.2 Carriers and Trade Lanes

According to a report by SCSPA, on average, 23 scheduled weekly container services have called to the Port over the past four years. Sixteen of these services have typically called at the WWT. Major lines and consortia calling WWT include Maersk, MSC, and the New World Alliance. Seven of the regularly scheduled services calling the Port call at the NCT. Major lines and consortia calling NCT include Evergreen, Zim, the CKYH, and Grand Alliance consortia. Table 5 provides a summary of the Port's container services by trade lane between 2008 and 2011.

Table 5: Port of Charleston Container Services by Trade Lane 2008 to 2011

	2008	2009	2010	2011
Asia	4	4	6	7
Indian Subcontinent / Middle East	2	3	2	2
North Europe	7	7	6	7
Asia-Europe Pendulum	3	3	1	1
South America	3	4	4	4
Caribbean / Central America	1	-	1	-
Mediterranean	2	1	1	1
Africa	1	1	1	1
Total	**23**	**23**	**22**	**23**

Source: SCPA; Norbridge Analysis

The number of services calling the Port and the trade lane distribution of these services has been relatively consistent since 2008. This stability reflects the combined effects of decreased volumes associated with the 2008 to 2009 recession and the effect it has had on vessel services. Despite these trends, Asian services nearly doubled, increasing from 4 in 2008 to 7 in 2011. The Port's ability to handle large containerships is a major factor underlying the increase in Asian services.

2.3.3 TEU Weight per Container

A model created by Institute for Water Resources (IWR) called National Navigation Operations and Maintenance Performance Evaluation and Assessment System (NOMPEAS) was used to estimate the average weight per TEU (box plus cargo) for trade lanes. NOMPEAS data provides the total TEUs and average weight per TEU on each call by International Maritime Organization (IMO)/Month/Year. The NOMPEAS model uses a combination of data sources, including Waterborne Commerce and Lloyd-Fairplay to develop this information.

The NOMPEAS data were linked to the SCSPA Container Detail Database by IMO/Month/Year. The Container Detail Database includes a Service Code for each vessel call that relates to a trade route that services Charleston Harbor. Each service code was assigned to one of the ten trade lanes developed for the analysis based on world regions. The vessel calls were then separated into 10 trade lanes. The SCSPA Container Detail Database contains the TEU data by vessel call for each vessel loaded/empty by import/export transported through the harbor. Each vessel was linked to the NOMPEAS average weight per TEU data using IMO/Month/Year. It was assumed that each empty TEU weighed 2 tonnes. The remaining tonnage on each trade lane and the total number of TEUs on the trade lane was used to calculate an average weight per TEU for the trade lane. Results are shown in Table 6.

Table 6: Average Weight per Loaded TEU by Trade Lane

Trade Lane	World Region	Average Weight per Loaded TEU
FE ECUS NEUR	Far East - East Coast U.S. - Northern Europe	8.2
ISCME	Indian Sub-Continent - Middle East	8.6
MED	Mediterranean	8.9
NEUR	Northern Europe	8.2
FE ECUS Panama	Far East - East Coast U.S. - Panama	8.2
FE ECUS Suez	Far East - East Coast U.S. - Suez Canal	8.7
Africa	African Continent	9.5
ECSA	East Coast South America	9.8
WCSA	West Coast South America	10
Carr CA	Caribbean - Central America	7.5

2.4 Historical Commerce

Figure 8 shows the historical total commerce at Charleston Harbor as reported to the Waterborne Commerce of the U.S. The squares depict total commodity shipments for each year from 1990 to 2012. As illustrated, total commerce has varied over time with substantial growth from 1990 to 2006. There was a precipitous 40 percent decline from 2006 to 2009. Since 2009, commodity tonnage has rebounded by 21 percent. The long-term trend for identified commerce is represented by the straight line.

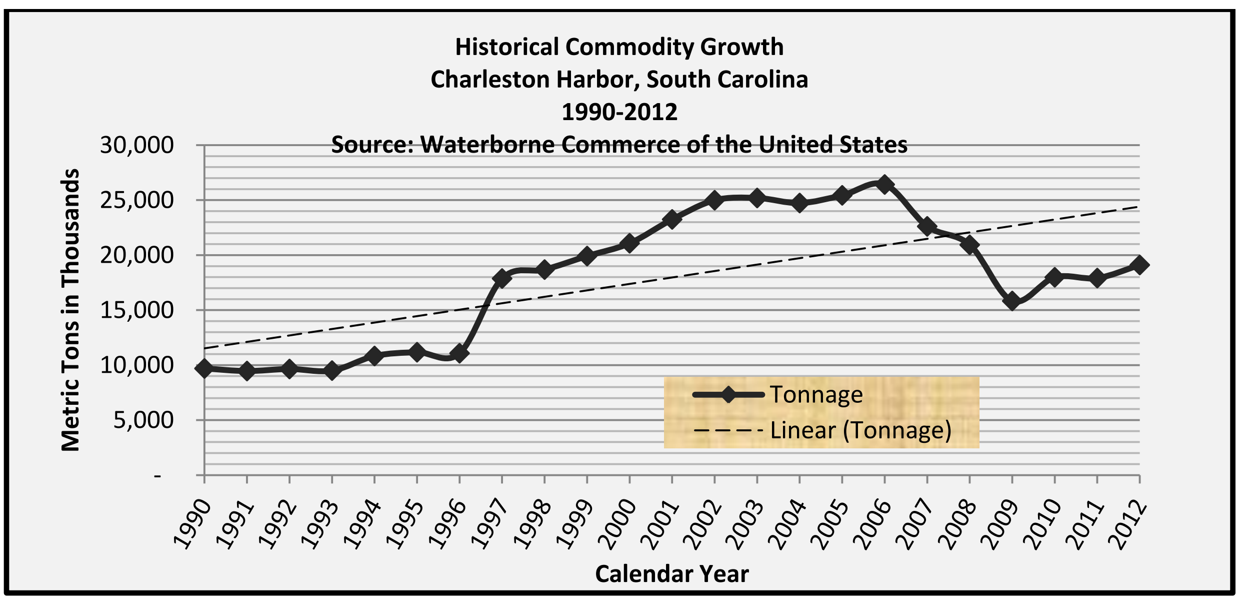


Figure 8: Charleston Harbor Historical Commerce – All Commerce (Metric Tons)

SCSPA reported data[5] in Figure 9 illustrates the number of loaded export and import TEUs at Charleston Harbor grew from 1994 to 2005. As indicated in Figure 9, export TEUs grew by an average of 5 percent annually from 1994 to 2005. From 2005 to 2009, export TEUs decreased by 7 percent annually. Export TEUs then rebounded to grow by 7 percent annually from 2009 to 2013. From 1994 to 2005, loaded import TEUs grew annually by 12 percent, on average, and fell by 13 percent from 2005 to 2009; then rebounded by 7 percent from 2009 to 2013. By 2013, SCSPA reported that 640,897 loaded TEUs were exported and 660,533 loaded TEUs were imported.

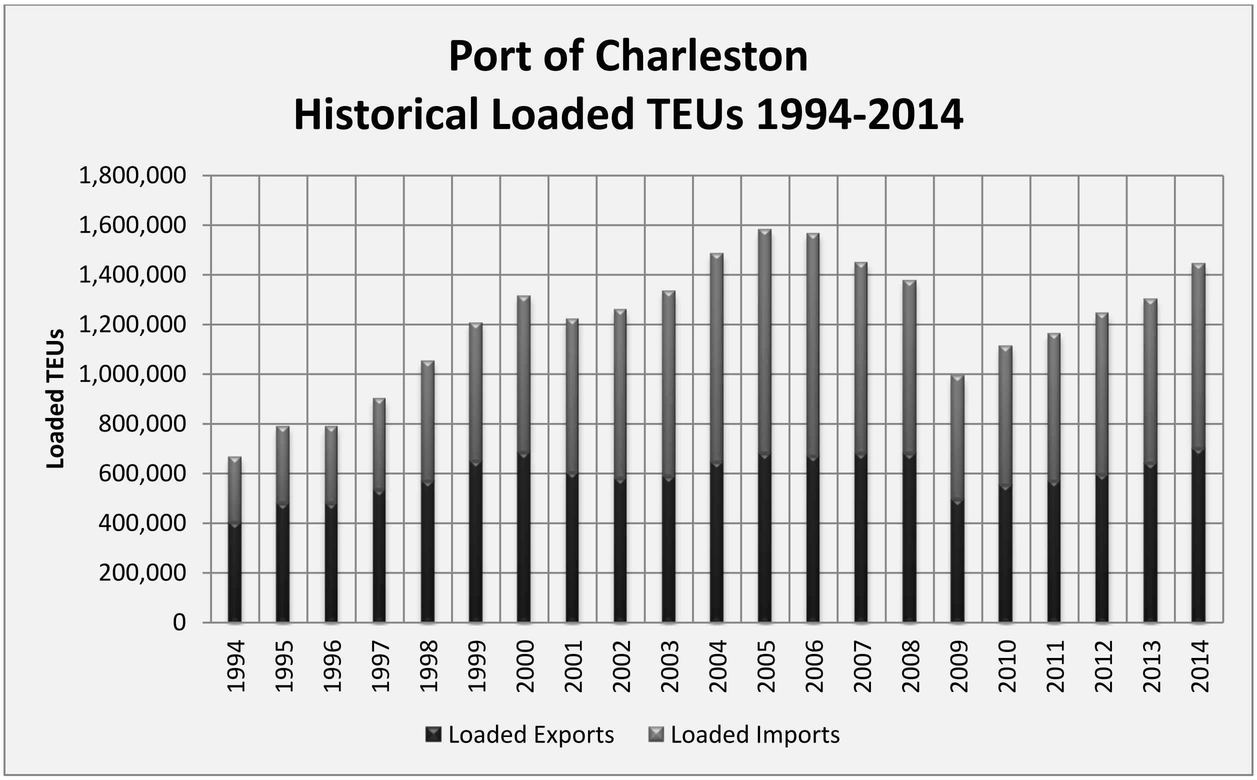


Figure 9: Charleston Harbor Historical Loaded TEUs 1994 to 2014

2.5 Existing Fleet

Data for container fleet was obtained from Charleston Branch Pilot's log and the Lloyds Fairplay database. The two datasets were combined using the IMO, a unique vessel identification number. From 2008 to 2011 a variety of different container ships called to the Port of Charleston. These ships are classified as sub-Panamax, Panamax, Post Panamax Generation 1, and Post Panamax Generation II, depending on their capacity. The vessels are distinguished based on physical and operation characteristics, including lengths overall (LOA), design draft, beam, speed, and TEU capacity. It is common practice to separate the containership fleet in TEU bands or classes to analyze supply within the industry. However, due to the evolution of vessel design over time, these TEU bands do not always neatly correspond to a breakdown of the fleet by dimensions such as beam or draft. Accordingly,

[5] SCSPA reported TEU volumes for exports and imports starting from 1994.

breakdowns in terms of beam and draft straddle different classes. For instance, within the 3,900 to 5,200 TEU band, which is generally regarded as the Panamax range, a number of ships fall within that category yet have beams that are too large to pass safely through the current Panama Canal, despite what their class name may suggest. Conversely, there are many Panamax vessels in the world fleet that fit easily through the Panamax Canal while carrying large volumes of TEUs. To minimize the overlap for this analysis, the beam band or range was used to distinguish container vessels into four classes as shown in Table 7 below.

Table 7: Vessel Size Class Definitions

	Vessel Size	Charleston Container Fleet by Year			
Vessel Class	**Beam Range**	**2011**	**2010**	**2009**	**2008**
Sub-Panamax	<99	110	104	117	260
Panamax	>99.001 - <110	980	919	1057	1053
PPX1	>110 - <135	141	158	97	111
PPX2	>135 - <152	62	37		

2.5.1 Average Ship Gross Tonnage

According to Charleston Branch Pilots' (harbor pilots) data, the average cargo ship size in the Port of Charleston has grown by 28 percent through the previous eight years, from 2005 through 2013. As shown in Table 8 below, the average ship in 2005 was about 36,000 gross tons, and in 2013 the average ship had increased to 46,000 gross tons.

Table 8: Average Ship Gross Tonnage by Year (2005 to 2013)

Year	Average Gross Tonnage
2005	36,139
2006	37,619
2007	38,785
2008	39,209
2009	40,100
2010	44,311
2011	44,911
2012	44,925
2013	46,100

As vessels gross tonnage grows, so does vessel design draft, length, beam, and height (air draft). Each of these vessel characteristics is critical to navigation safety and port capability. Turning basins are particularly critical to a port's ship handling capabilities. Turning basins must be situated where ships can access them without air draft restrictions, and must have sufficient width and depth to safely handle longer, wider, and deeper vessels. Figure 10 presents average gross tonnage per ship from 2005 to 2013.

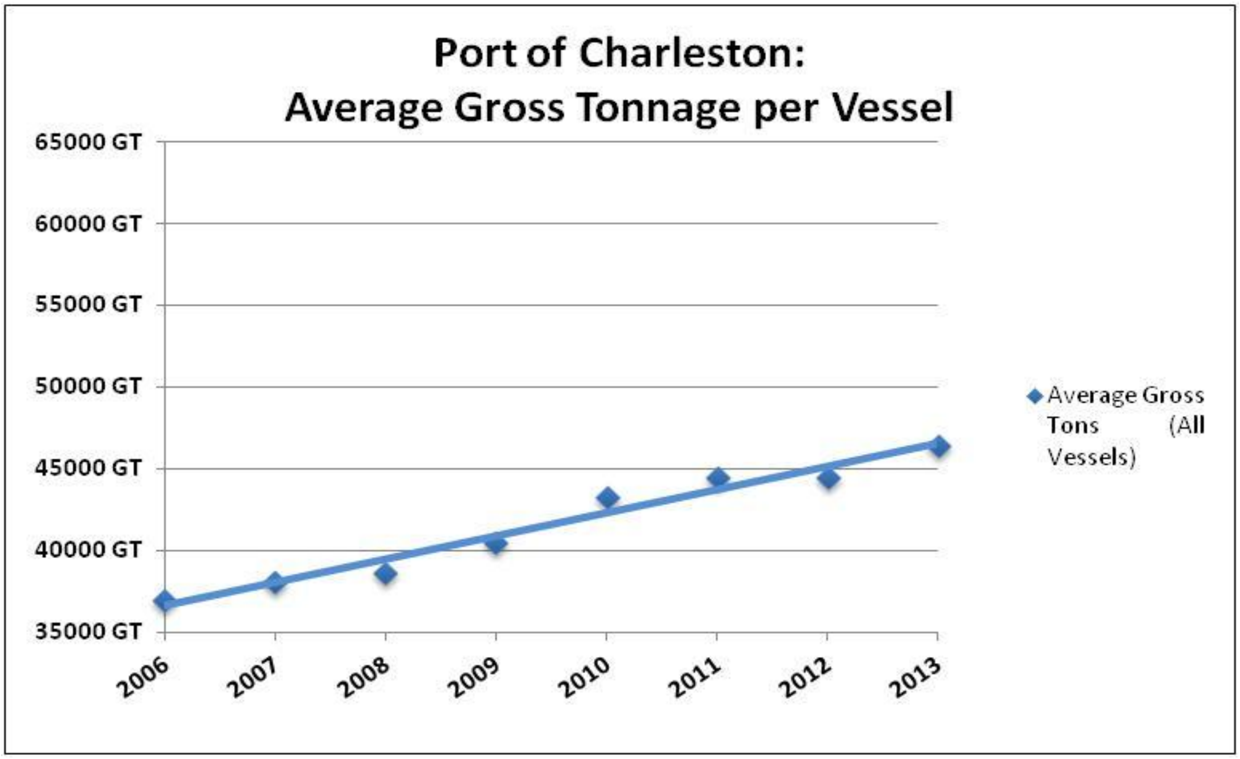


Figure 10: Average Gross Tonnage per Ship

While the average ship is not yet of the Post-Panamax class, Charleston is already handling a significant number of Post-Panamax ships. Through August 2011, Charleston had received 131 Post-Panamax containerships, or 15 percent of this trade. Of all containership calls in this same period, 264 inbound or outbound transits were deeper than current Panamax design draft vessel, which represents 21 percent of all containership transits for that year.

2.6 Shipping Operations

Most container vessels calling at Charleston Harbor are part of scheduled liner services that call at multiple East Coast ports in conjunction with Charleston Harbor. Consequently, shippers engage in the practice of "just in time" deliveries of cargo and avoid schedule disruptions whenever possible. Today, there are two container yards operational at the Harbor. Once reaching the outer most sea buoy, an inbound vessel transiting to the Wando Welch container yard will voyage approximately 1.5 hours to navigate to the terminal. A vessel transiting the North Charleston container yard will voyage around 2.5 hours. A third container yard is currently under construction. Vessels transiting to this terminal, former Navy Base, will take around 2 hours.

There are several channel segments that allow for two-way traffic in the harbor. There are channel bendings where two-way traffic is restricted depending on the size of the vessel. There are two bridges that intersect the Charleston Harbor. Vessels access the port's largest facility, the WWT, as well as the new terminal under construction at the former Navy Base and the NCT, by sailing underneath the Ravenel Bridge located at Hog Island Reach, which allows for 186 feet of vertical clearance at mean high water. Ships sailing to NCT must also transit underneath the Don Holt Bridge, located along the Filbin

Reach, which allows 155 feet of air draft. The harbor pilots have stated that approximately 2 feet of air draft clearance is required when transiting underneath these bridges.

2.6.1 Underkeel Clearance

The measure of underkeel clearance (UKC) for economic studies is applied according to planning guidance. According to this guidance, UKC is evaluated based on actual vessel operator and pilot practice within a harbor and subject to present conditions, with adjustment as appropriate or practical for with-project conditions. Generally, practices for UKC are determined through review of written pilotage rules and guidelines, interviews with pilots and vessel operators, and analysis of actual past and present practices based on relevant data for vessel movements. Typically, UKC is measured relative to immersed vessel draft in the static condition (i.e., motionless at dockside). When clearance is measured in the static condition, explicit allowances for squat, trim, and sinkage are unnecessary. Evaluation of when the vessel is moved or initiates transit relative to immersed draft, tide stage, and commensurate water depth allows reasonable evaluation of clearance throughout the time of vessel transit.

Evaluation of all movements renders a distribution of UKC requirements. Evaluation of minimal clearance (i.e., some level of clearance below which operators or pilots will not move a vessel due to concerns for insufficient safety) helps to quantify the period of time each day, within a tide cycle; a given vessel with a specified immersed draft can be moved relative to tide. Given the measurement of clearance in the described manner combined with input from pilots on their practices, UKC in Charleston is slightly more than many U.S. coastal ports.

Given general evaluation of practices for UKC at most coastal ports in the U.S., minimal clearances for all vessel types are often 2.0 to 3.0 feet measured in the static condition for many historical fleets having Panamax or lesser service. The average UKC for vessels of Handymax up through about Panamax is approximately 2.7 feet. Consider, however, that most coastal ports have comparatively limited distances between ocean approaches and dock facilities (i.e., less than 20 miles).

Regarding vessel size under with-project conditions, it is understood that most post-Panamax vessels need more clearance depending on blockage factors, currents, and relative confinement of the waterway. As such, most post-Panamax containerships need about 3.3 to 3.6 feet for vessels with breadths of 120 to nearly 150 feet, lengths overall (LOA) approaching 1,150 feet and summer loadline drafts of 46.0 to approximately 49.0 feet.

Table 9 provides the UKC requirements at Charleston for containerships. At Charleston, the required clearance for vessel sizes of Panamax and up through the first generation of post-Panamax hulls (approximately 123 feet in breadth and up to approximately 1,120 feet in length), based on pilot guidance and actual experience, is approximately 3.5 to 4.1 feet.

The largest Post-Panamax vessels (PPX II and PPX III) require more than four feet. It is assumed that any Panamax vessel with a reported sailing draft of 41.4 feet or greater and any of the largest Post-Panamax class vessels with a sailing draft of 40.9 feet or greater are effectively using tide to have sufficient water and clearance to sail at Charleston Harbor.

Table 9: Containerized Vessel Underkeel Clearance Requirements

Vessel Class	**Total Underkeel Clearance (feet)**
Sub-Panamax	3.5
Panamax	3.6
Post-Panamax Gen I	3.8
Post-Panamax Gen II	4.0
Post-Panamax Gen III	4.1

2.6.2 Tidal Range

The variability of sea level must be considered when determining the level of water needed for navigation (Figure 11). Charleston Harbor experiences a tide range of approximately 5.8 feet. According to the pilots' logs for 2011, over 32 percent of the Post-Panamax vessels currently calling at Charleston make use of the tide on the inbound transit. For outbound transits, the percentage increased to 40 percent. Currently, at a 45 ft channel depth, Charleston has 100 percent access for vessels drafting 41 feet and less. As larger vessels with potentially deeper sailing drafts call at Charleston in larger numbers, the percent of reliable access depth and the width of the tide window will become a constraint on vessel operations. The following graph shows channel reliability at alternative project depths. The current project depth of 45 feet is 96 percent reliable. That is, it provides at least 45 feet of water 96 percent of the time. A project depth of 48 feet would provide 48 feet of water with 96 percent reliability. A project depth of 50 feet would provide 50 feet of water with 96 percent reliability. A project depth of 52 feet would provide 52 feet of water with 96 percent reliability.

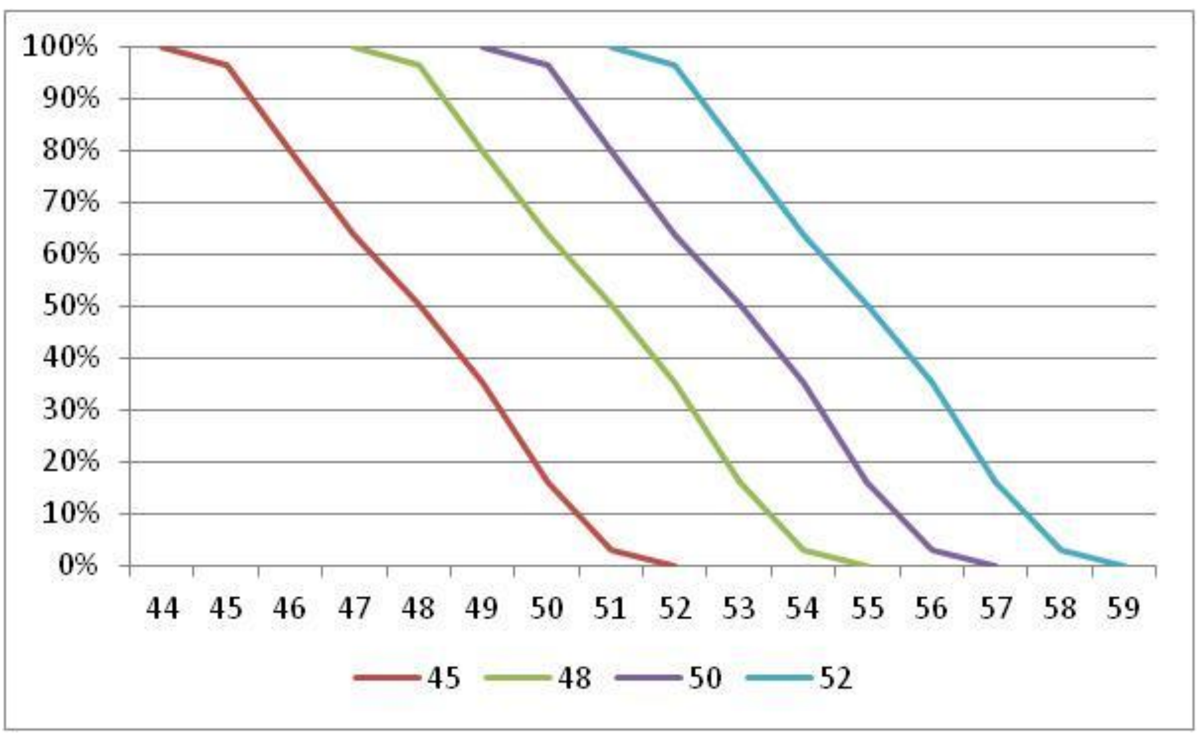
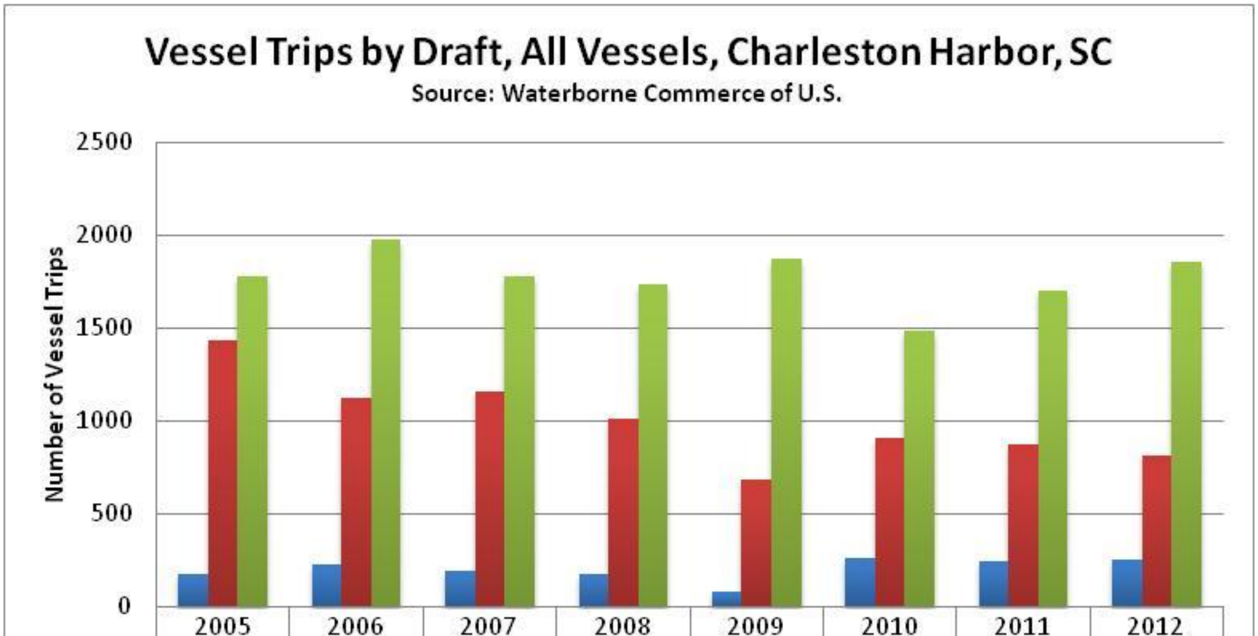


Figure 11: Channel Reliability by Project Depth

2.6.3 Sailing Practices

As shown in Figure 12, the vessel frequency and sailing drafts for all vessels grew between 2005 and 2006 for vessels with operating drafts of 30 to 35 feet. However, there was a slight decline between 2007 and 2008, and an increase in 2009, and a drastic decline in 2010, following the recession. The number of larger vessels, i.e., those with operating draft of 36 and above declined from 2005 to 2006 but increased slightly in 2007 and declined from 2007 to 2012.



	2005	2006	2007	2008	2009	2010	2011	2012
41+	178	227	189	171	82	264	244	250
36-40	1436	1126	1160	1013	680	911	876	808
30-35	1777	1981	1777	1737	1872	1487	1702	1855

Figure 12: Historical Vessel Sailing Draft – All Vessels

Figure 13 provides the arrival draft of containerized vessels from 2008 to 2013. As shown, the number of vessels arriving at Charleston sailing between 30 and 35 feet peaked in 2009. Vessels sailing between 36 and 40 feet dropped in 2009 but increased steadily through 2013. The number of containerized vessels arriving at a sailing draft of 41 feet or greater dropped in 2009 but then more than tripled in 2010. The percentage of containerships sailing at 41 feet or greater peaked in 2012 at 10 percent.

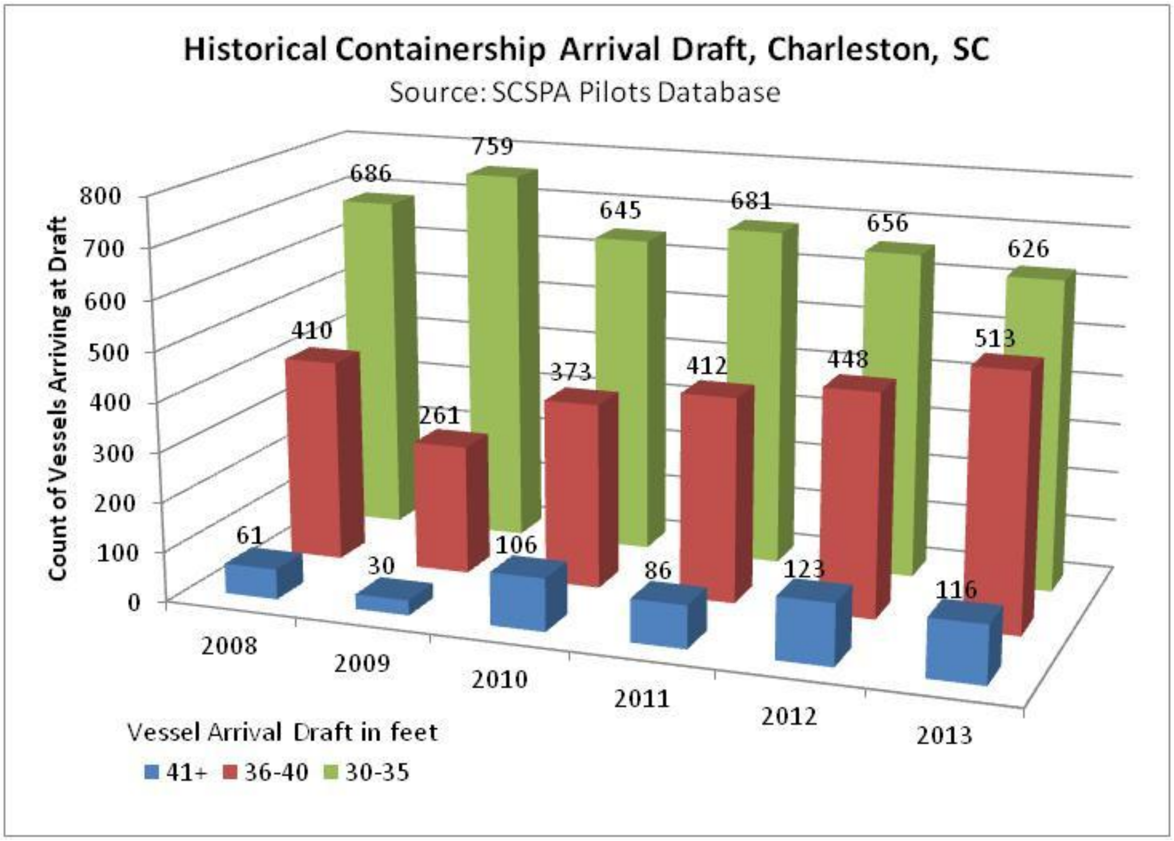


Figure 13: Historical Vessel Arrival Draft - Containerships

2.7 Design Vessel

The selection of vessel specifications for fleet service forecasts sometimes poses unique concerns given requirements to evaluate design and improvements for waterway systems over time. Generally, waterway improvements should be designed to be optimized across the entire forecasted fleet. In this case, it would include service by several forms or types of vessels (i.e., tankers and dry cargo carriers, etc.). Where vessel designs are relatively mature (tankers and dry bulk carriers), the task is straightforward. However, fully cellular containership designs are evolving. On a world fleet basis, containership designs continue to change with respect to size and cargo carrying capacity, and have not reached a limiting threshold.

Studies for Charleston harbor are primarily based on the anticipated service regime for future containerized movements with consideration of Sub-Panamax, Panamax, and Post-Panamax Generation I and II or new Panamax (PPX III) designs. With respect to current and projected fleet service for Charleston, post and new Panamax designs are divided into three general groupings, largely separated by capacity for nominal TEU intake and beam or breadth. Building trends for the first two groupings (Generation I and Generation II, with beams typically less than 150 to 152 feet) are reasonably well established with respect to physical dimensions and size relative to displacement. The Generation III class of containership (beams exceeding 150 feet through 168 feet) is less defined. This class has dimensions designed to consider the specifications of the new locks under construction for the Panama Canal expansion. The length and beam limitations of the new locks for the Panama Canal are known and these parameters are considered fixed. Conversely, while the specification for draft typically does have a limit, actual immersed draft can be adjusted or allowed to vary based on variability in cargo density, loading, and utilization of weight carrying capacity of the hull.

Studies for Charleston Harbor involve the assessment and projection of fleet service to multiple terminals located in separate reaches of the harbor. These include containerized cargo handling facilities located at the NCT and the proposed new Navy Base Terminal (NBT)[6] along the Cooper River and WWT, located on the Wando River, which currently handles most of the containerized cargo passing through Charleston Harbor. Two bridges, the Don Holt Bridge (en route to access of North Charleston Terminals) and the Ravenel Bridge (en route to the WWT and NBT) impose air draft limitations based on clearances of 156 and 186 respectively, relative to the applicable reference datum for waterway depth within protected reaches of the harbor.

An analysis of the projected needs for Charleston Harbor has determined that the WWT (Segment 1) and the new NBT terminal (Segment 2) will likely support the largest containerships that will serve the harbor via Atlantic crossing routes and the expanded Panama Canal. The NCT will primarily support post Panamax Generation I and II range vessels projected to serve the U.S. East Coast due to the air draft limitation of the Don Holt bridge. This is largely due to air draft limitations of the Don Holt Bridge, for which no options for replacement or modification are currently considered viable.

2.7.1 Segments 1 and 2

Figure 14 shows the three segments of the projects. For Segment 1 and 2 (blue and yellow sections), the economics team, in consultation with the Corps' IWR, recommended a containerized carrier vessel with the following specifications:

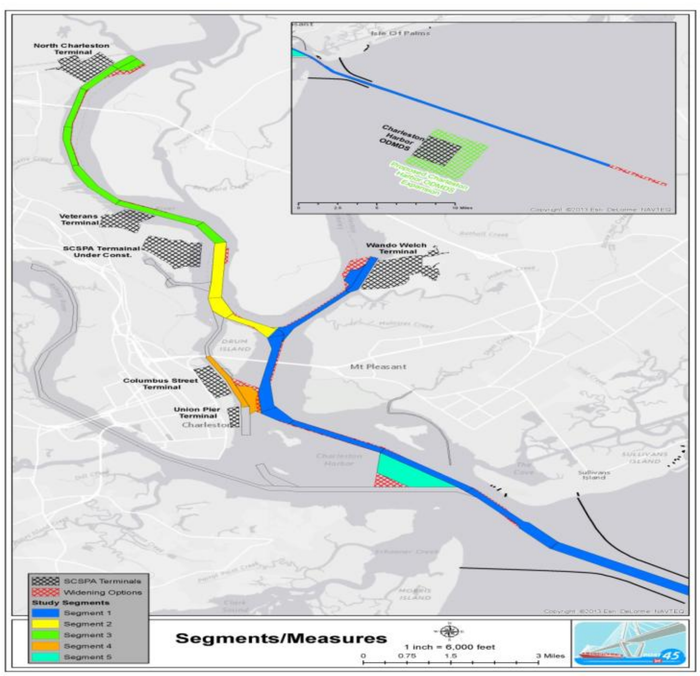


Figure 14: Project Segments

[6] Currently under construction – anticipated opening around 2018; see Section 3.1.2.

158.3 foot beam (extreme breadth (XB))

1,200 feet length over all (LOA)

50.0 foot maximum summer loadline draught (MXSLLD)

nominal TEU intake of 12,775 TEUs

deadweight rating of 138,000 metric tones

Economic analysis assumptions did not include Generation III Post-Panamax container ships transiting to the North Charleston Terminal under the Don Holt Bridge. The benefit analysis restricted container ships for segment 3 to only those smaller Post-Panamax ships loaded to a draft which allows for safe passage under the Don Holt Bridge vertical clearance of 155 feet. The following Figure 15, Ravenel Fixed Bridge Clearances, provides a diagram of Post-Panamax and New-Panamax design vessel air draft clearances for a light-loaded condition with an existing Federal channel project depth of 45 feet.

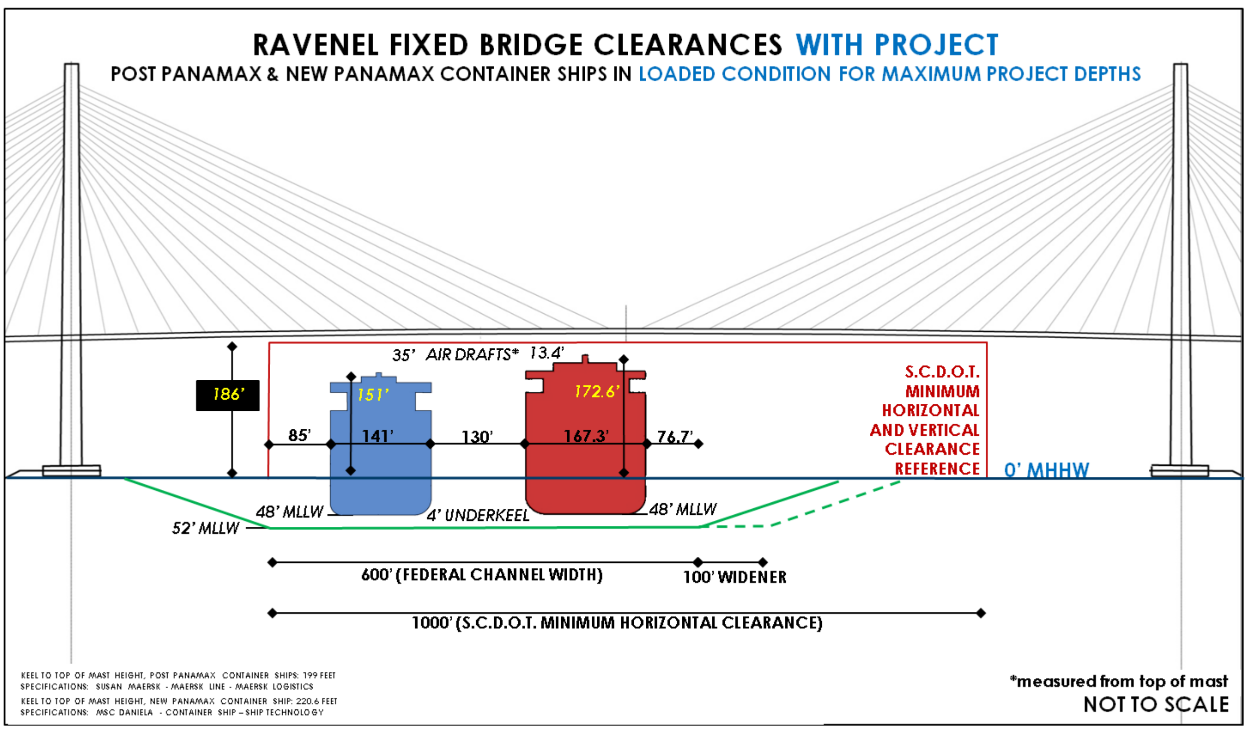


Figure 15: Post-Panamax and New-Panamax Design Vessel Air Draft

Review of the world fleet indicates that as of July 2012 there were about 200 Generation III ships (i.e., approximately 152 to nearly 168 feet in breadth) in service, under construction, or on order with TEU intake averaging nearly 12,400 nominal TEUs. Of that, about 68 percent were identified as the smaller sub-grouping (between 152 to nearly 160 feet in XB) of Generation III ships. There are about 140 in service, under construction, or on order to be delivered in five years or less with corresponding nominal

TEU intake capacities averaging nearly 11,800 TEUS. The upper 50 percent of this sub-group (as measured by TEU capacity) averaged about 13,060 nominal TEUs, 1,200 feet LOA, nearly 1,150 feet lower boundary point (LBP), 158 feet XB, and 51.1 feet in MXSLLD. For ships in the upper bound of the Generation III class range (with breadths of 160 to nearly 168 feet), review of statistics indicates the larger sub-group of Generation III averaged about 13,740 TEUs, 1,200 feet LOA, 1,047 feet LBP, 168 feet XB, and 51.3 feet in reported MXSLLD. The corresponding upper 50 percent of the sub-group averages approximately 14,000 nominal TEUs, 1,200 feet LOA, 168 feet in XB, and 51.7 feet in reported MXSLLD.

A review of new builds for containerized carriers as supported by the statistics reveal that for containerized carriers, the fixed dimensions of length, breadth, and draught largely converge toward the physical limits of the new locks presently under construction for expansion of the Panama Canal. Further, general evaluation indicates that more recent builds tend to have a greater proportion of nominal TEU capacity per rated deadweight tonne (DWT) with efforts to more fully utilize DWT capacity given typical cargo weights in containerized trade. The upper bound of 50 percent was assessed for sub-groupings as described and past experience has indicated physical dimensions and characteristics in the upper half of a sub-grouping for containerized carriers seem to provide a reasonable estimation for the general trends in characteristics for DWT and nominal TEU capacity for the foreseeable future. To develop parameters for specifications of the future fleet representative of interim to long-term building trends for studies related to Charleston Harbor, the upper 50 percent of fleet groupings or sub-groupings operating and on order as of mid-2012 was selected as the basis for compilation of aggregate statistics representative of the trend toward increased TEUs relative to DWT. Additionally, general review of information for pending or publicized designs indicates the approach as generally described is reasonable for fleet forecast of physical parameters for hull design.

One issue for review of statistics is the MXSLLD. The reported measures of length and breadth currently and historically available are often comparatively accurate across the reporting history of the world fleet database(s). However, the MXSLLD and requisite capacity based on related displacement is sometimes (initially) overstated because of confusion with initial reporting of draft for new builds of either MXSLLD or scantling draft without clarification as to which measure is actually reported or publicized followed by subsequent correction in the fleet characteristics database(s). The publicly stated capacity of the new locks under construction for expansion of the Panama Canal by physical dimension(s) is for a vessel not to exceed the following limits: 160 feet in XB, 50 feet in immersed draft (48.7 SLL immersion), 1,200 feet for LOA, and 190 feet for air draft above the immersed waterline. Research and review of MXSLLD indicates that with increasing breadths very few designs are being developed with MXSLLDs exceeding 50.0 to nearly 51.0 feet. While traditionally it was not uncommon to see Panamax ships with MXSLLDs exceeding canal draught allowances by a notable margin (i.e., typically a world fleet average of 42.0 to 43.0 feet), the threshold of 50.0 to nearly 51.0 feet appears to largely be driven by practical needs as a whole for port and berth depths as well as hydrologic considerations of the canal. With time, it is possible that the trend for increasing port depths will continue beyond limitations of the improved canal but will likely occur several years after canal improvements similar to the way Panamax carriers changed over time after the original locks were constructed and utilized. Accordingly, review of MXSLLD measurements for Generation II and lesser size carriers (which have been in existence and service comparatively longer than most Generation III hulls) indicate draft measurements are accurately or reasonably reported. However, some degree of adjustment may need to be applied to sub-groupings of Generation III carriers (i.e., hulls between approximately 150 and 158 feet in XB) with adjustment to 50.0 feet MXSLLD and relative capacity based on holding other dimensions and corresponding block coefficient(s) constant for estimation of change in associated displacement and DWT capacity.

Having reviewed vessel specifications and capacity, recommendations for Segments 1 and 2 for Charleston Harbor are for an aggregate design fully cellular containerized carrier approximately 158.3 feet in XP, 1,200 feet LOA, and 50.0 feet in MXSLLD (with nominal TEU intake of 12,775 TEUs) and DWT rating of 138,000.

2.7.2 Segment 3

For the NCT as shown in Figure 14 (red section), the recommendations are for an aggregate design vessel being a fully cellular containerized carrier (Generation II) of about 1,100 feet LOA, design draft of about 48 feet, and approximately 141 feet in XB. The Post-Panamax S-class containership was chosen as the design vessel for Segment 3 of the Charleston Harbor Post 45 study. This vessel is considered the best representation of the vessel of the future considering length, width, and draft.

3.0 Future Conditions

3.1 Terminal Expansions

The SCSPA maintains an up-to-date 10-year capital investment plan for its facilities and infrastructure. The 10-year container-related budget includes two expenditure-related components: existing facility expansions and new infrastructure.

3.1.1 Existing Container Terminal Facilities and Infrastructure

The SCSPA's current capital investment plan for WWT and NCT approximates $402 million in expenditures. The major components of this investment include rehabilitation and expansion of container berths; maintenance, repair and expansion of container yards; upgrade of container cranes and terminal handling equipment. The following outlines major equipment expenditures by berth:

- WWT
    - Expansion of empty container storage yard
    - Replacement of eight container gantry cranes
    - Annual throughput capacity approximately 2 million TEUs
- NCT
    - Replacement of four container gantry cranes
    - Container yard improvements
    - New interchange facility
    - Annual throughput capacity approximately 800,000 TEUs

3.1.2 New Container Terminal Facilities and Infrastructure

A new container terminal facility, the Navy Base Terminal (NBT), is currently under construction. The SCSPA has completed preliminary demolition, site preparation, and containment wall construction. The anticipated opening date of the terminal's 171-acre first phase is planned by FY 2019, or in alignment with market demands. The economic analysis assumes that the terminal will be operational by 2022, the base year of the period of analysis. At its completion, the NBT will be a state of the art, three-berth container facility. The terminal is located on the Cooper River at the south end of the former Charleston Navy Base, approximately 24 miles from the sea buoy. Key features of the project include:

- Minimum 45 feet berth depth, ultimate depth will align with the Post 45' project
- 1,070 lineal meters of container berth
- 12 super Post-Panamax container cranes with an outreach of 23 containers
- 286 gross terminal acres
- Direct access to I-26 via a new interchange
- Annual throughput capacity estimated to be approximately 1.4 million TEUs
- Access to rail through CSXT and NS

3.2 Operations

3.2.1 Container Terminal Use Plan

The SCSPA's future container terminal use plan will generally conform to its historical practices. Given their locations, physical attributes, air drafts, and capacities the WWT and new NBT will handle the largest carriers and the container vessels acquired by those carriers (including Post-Panamax Generation 3). These terminals are the closest terminals to the open ocean and have the most berthing areas, along with the largest capacities, capabilities, and the highest air drafts. Consequently, they will be the most efficient, productive terminals for SCSPA's' largest container vessels.

While SCSPA's competitive strategy is to have a Generation 3 vessel capability at NCT in order to maintain a competitive vessel capability comparable to New York and Norfolk, the Don Holt Bridge airdraft restriction precludes the SCSPA from practically achieving this capability at NCT. Consequently, NCT will continue to serve individual shipping lines and consortia whose vessels can transit beneath the Don Holt Bridge. Considering the existing world fleet, the air draft restricts vessels to those with a maximum design draft of 48 feet or less (post Harbor Deepening).

3.2.2 Panama Canal Expansion

In 2006, the Panama Canal Authority (ACP) announced plans for expansion of the Panama Canal. Their announcement came at the end of a multi-year comprehensive study and analysis by the ACP. Panama's president recommended Canal expansion to the National Assembly and it was passed during a national referendum before the Panamanian people at the end of 2006. Design plans include lock chambers of 1,400 feet long, 180 feet wide and 60 feet deep. Accordingly, the expansion will provide the capacity to accommodate vessels up to 1,200 feet long, 160 feet wide and 50 feet deep, or with a cargo volume up to 170,000 DWT and 12,000 TEU.

The original project schedule had construction being completed in 2014; however, contracting difficulties have extended the completion date. Construction of the Panama Canal expansion is underway. As of March, 2015, the project is reported as 85 percent complete, with the final estimated cost totaling over $7 billion, and a projected date of completion between December 2015 and the early months of 2016. The project will be funded through a variety of sources including existing ACP resources, toll increases, and external sources (e.g., bond, series of bonds, or credit). The Panama Canal's expansion will pave the way for larger containerships to be deployed to the U.S. East Coast. Presently, the Panama Canal has restricted container traffic shipments to vessels drafting less than 39.5 feet. This essentially prevented any Far East/East Coast U.S. shipments from taking advantage of the economies of scale of loading larger ships to deeper sailing drafts. In the evaluation of without project conditions for the Charleston Post 45 Deepening study, the Project Delivery Team (PDT) assumed that the expansion of the Panama Canal would be completed prior to the start year of the Post 45 deepening project and that carriers would begin making adjustments to their fleet soon after. This practice has been proven historically (i.e., maximizing vessel size through the canal) and was further supported by the carrier interviews. To back up this claim, the PDT examined new vessel orders and found them to be largely comprised of Post-Panamax vessels.

3.3 Commodity Forecast

3.3.1 Baseline

An essential step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port. Trends in cargo history can offer insights into a port's long-term trade forecasts and thus the estimated cargo volume upon which future vessel calls are based. Under future without and future with project conditions, the same volume of cargo is assumed to move through Charleston Harbor. However, a deepening project will allow shippers to load their vessels more efficiently or take advantage of larger vessels. This efficiency translates to savings and is the main driver of the NED.

To minimize the impact of potential anomalies in trade volumes on long-term forecast, four years of data were employed to establish the baseline for the commodity forecast. Empirical data from 2008 to 2011 were used to develop a baseline, allowing the forecast to capture both economic prosperity and downturn which occurred over that timeframe.

3.3.1.1 Containerized Imports

Table 10 illustrates historical containerized imports moved through the Port of Charleston from 2008 to 2011. As shown, containerized imports declined from 4.9 million tons in 2008 to 4.4 million tons in 2011. In 2009, the market experienced a drastic decrease but the import tonnage has rebounded since. Trade with Northern Europe (NEUR) dominated Charleston's market, followed by Indian subcontinent and Middle East (ISC/ME) and the Far East, East Coast U.S. deployment that calls Northern Europe before returning to Far East via a pendulum route (FE ECUS NEUR PEN). The top import commodities include furniture; auto parts; sheets, towels, blankets; fabrics including raw cotton; auto and truck tires and tubes; and general cargo. Average imports from all the world regions were estimated to total 4.4 million tons. This import trade volume represents the baseline from which forecasted commerce was conducted.

Table 10: Historical Containerized Imports (Metric Tons)

World Region Service	2008	2009	2010	2011	4-yr average
Africa	108,580	102,565	89,371	81,105	95,405
Caribbean CAM	109,330	12,442	0	0	30,443
ECSA	275,781	233,675	305,118	297,634	278,052
FE (Panama)	332,503	315,377	819,187	893,730	590,199
FE (Suez)	303,367	285,473	468,889	572,123	407,463
FE ECUS NEUR PEN	738,358	526,562	224,324	238,680	431,981
ISC ME	761,668	554,493	587,125	528,723	608,002
MED	272,430	122,822	84,014	74,042	138,327
NEUR	2,003,341	1,314,938	1,501,731	1,684,545	1,626,139
WCSA	115,550	108,595	192,518	167,077	145,935
Total	**4,907,367**	**3,470,357**	**4,081,768**	**4,372,591**	**4,351,946**

3.3.1.2 Containerized Exports

As shown in Table 11, containerized exports declined from 4.7 million tons in 2008 to 4.5 million tons in 2011. Since 2009, exports have exceeded imports in terms of tonnage. The top export cargo going through the port includes paper and paperboard, wood pulp, auto parts, logs and lumber, and fabrics and raw cotton. As with imports, containerized trade with NEUR dominated Charleston's market with 27 percent of trade volume, followed by ISC ME at 15 percent, and FE ECUS NEUR PEN at 12 percent. Average exports to all the world regions were estimated to total 4.7 million tons. This export trade volume represents the baseline from which forecasted commerce was conducted.

Table 11: Historical Containerized Exports (Metric Tons)

World Region Service	2008	2009	2010	2011	4 yr. average
Africa	277,257	183,558	248,259	261,564	242,659
Caribbean/CAM	160,115	20,602	0	0	45,179
ECSA	445,333	294,431	467,906	400,577	402,062
FE (Panama)	242,748	283,366	695,034	982,164	550,828
FE (Suez)	229,757	229,874	422,436	464,806	336,718
FE ECUS NEUR PEN	951,843	622,415	335,306	296,270	551,458
ISC ME	837,555	728,481	651,443	633,075	712,638
MED	391,642	233,938	162,506	133,846	230,483
NEUR	1,182,010	1,031,980	1,401,464	1,363,480	1,244,733
WCSA	368,006	284,900	421,401	389,288	365,899
Total	**4,720,266**	**3,630,653**	**4,386,364**	**4,537,792**	**4,682,658**

Table 12 summarizes the baseline for both imports and exports by world region and service route.

Table 12: Charleston Baseline Commodity Forecast (Metric Tons)

World Region Service	Imports	Exports	Total
Africa	95,405	242,659	338,065
Caribbean CAM	30,443	45,179	75,622
ECSA	278,052	402,062	680,113
FE (Panama)	590,199	550,828	1,141,028
FE (Suez)	407,463	336,718	744,181
FE ECUS NEUR PEN	431,981	551,458	983,439
ISC ME	608,002	712,638	1,320,640
MED	138,327	230,483	368,810
NEUR	1,626,139	1,244,733	2,870,872
WCSA	145,935	365,899	511,833
Total	**4,351,946**	**4,682,658**	**9,034,604**

3.3.2 Trade Forecast

3.3.2.1 Background

The preceding section described the methodology that was used to develop the import and export baseline. The following sections discuss the methodology employed to develop the import and export long-term trade forecasts.

The long-term trade forecast for the Charleston Post 45 combined data obtained from IHS Global Insight and empirical data obtained from the Port. Since 1959, IHS has been serving customers ranging from governments and multi-national companies to smaller businesses and technical professionals in more than 180 countries.

First, a baseline was established from historical trade information as discussed in Section 3.3.1. Next, a long-term trade forecast for the North Atlantic Region, South Atlantic Region, and Charleston Harbor was obtained from IHS Global Insight (GI). The GI forecast was obtained in 2011. The forecast was developed by applying the growth rates calculated from the GI commodity forecast for each world region to the baseline tonnage for each trade lane calling on the harbor. This methodology is consistent with the approach that has been used to perform a long-term commodity forecasts for other Corps deep draft analyses. In the following section, the methodology employed to develop a long-term containerized trade forecast for Charleston Harbor is discussed.

3.3.2.2 IHS Global Insight

In 2011, containerized trade forecasts were obtained from GI, which operates as a research firm to provide economic and financial coverage of countries, regions, and industries. It offers data collection of macro, regional and global economics; financial markets and securities; survey; U.S. economic; energy; industry; and international trade.

When making global trade forecasts, GI employs sophisticated macroeconomic models which contain all commodities that have physical volume. The commodities are then grouped into 88 categories derived from the International Standard Industrial Classification. GI tracks 66 major countries then groups the remaining world trade partners into 12 regions according to their geographic location. Accordingly, they forecast 88 commodities traded among 78 countries or regions and include 582,528 potential trade flows.

When performing the Charleston Harbor commodity forecast, GI considered four areas of concern that may threaten to slow the trajectory of global trade, among them the uncertainty over how the sovereign debt of the Eurozone will be resolved; concerns about China "hard-landing" and whether the government can prevent a recession; jitters about potential impact of sharply higher oil prices on the global economy; and political transitions in countries like Russia, China and Venezuela.

3.3.2.2.1 GI Trade Data Sources

GI obtains trade history data from several sources: Statistics Canada, Organization for Economic Co-operation and Development (OECD) International Trade by Commodity Statistics, U.S. Customs, and International Monetary Fund (IMF) Direction of Trade. The primary data source is the United Nations (UN), from which information is processed and published by Statistics Canada. Custom agencies in the UN member countries are the origin of these export and import trade statistics. U.S. Customs data and IMF Direction of Trade data are used to calibrate and supplement information obtained from Statistics Canada. Data are then recorded in different classification systems and units of measurement, converted into thousands of current U.S. dollars and converted into 1977 real commodity value.

GI world trade forecast models use its comprehensive macroeconomic history and forecast databases and in particular, data on population, GDP, GDP deflators, industrial output, foreign exchange rates, and export prices by country. The data are used as exogenous variables in the trade forecast models. Population growth, income levels, relative prices of traded goods for major trading partners - Far East, the Mediterranean, and Northern Europe - are key determinants of trade, exports and imports for the Port of Charleston. For international commodity prices, GI obtained data from the U.S. Bureau of Labor Statistics on international import and export prices. Other data such as foreign direct investment and import tariffs were also used as determinants of a country's export capacity and import costs.

3.3.2.2.2 GI Model Structure

The basic structure of the model for the trade flow of a commodity assumes that a country's imports from another country are driven by the importing country's demand forces, enabled by the exporting country's capacity of exporting (supplying) the commodity, and affected by the exporting country's export price and importing country's import cost for the commodity. A country will import more of a commodity if its demand for this commodity increases. At the same time, the country will import more of this commodity from a particular exporting country if that exporter's capacity to export this commodity is larger and its export price for this commodity is lower than in other exporting countries. Accordingly, importers will ultimately purchase based on the delivered cost, importing more when the import cost decreases. Distance between countries is an important factor when determining the scale of trade between countries; therefore the distance parameter is embedded in the GI models to help determine the scale of the base.

3.3.2.2.3 GI Trade Forecast – 2012.

The GI trade forecast for Charleston included 78 countries (e.g. Brazil) or regions (e.g. Other Southern Africa). First, the data by trade locations were grouped by the world region where they are geographically located. The world regions which trade with Charleston Harbor were used for this grouping: Africa, Caribbean and Central America (CAR CA), East Coast South America (ECSA), Northern Europe (NEUR), Far East (FE), Indian Subcontinent and Middle East (ISCME), Mediterranean (MED), and

West Coast South America (WCSA). Table 13 displays the world regions which trade with Charleston Harbor.

Table 13: Charleston Trade Partner and World Region Groupings

World Region	GI Trade Locations
Africa	South Africa; Kenya; Canada[7]; Other East Africa; Other Southern Africa; Western Africa
CAR CA	Caribbean Basin; Other Central America; Mexico
ECSA	Argentina; Brazil; Colombia; Venezuela; Other East Coast of S. America
NEUR	Italy; Slovenia; Spain; Turkey; Portugal; Bulgaria; Romania; Ukraine; Austria The Baltic; Belarus; Belgium; Czech Republic; Denmark; Finland; France Germany; Hungary; Ireland; Moldavia; Netherlands; Norway; United Kingdom; Poland; Russia; Slovakia; Sweden; Switzerland; Other Europe
FE	Australia; Hong Kong; Indonesia; Japan; Malaysia; New Zealand; Philippines South Korea; Taiwan; Thailand; Vietnam; Singapore; China; CIS Southeast
ISCME	India; Pakistan; Saudi Arabia; United Arab Emirates; Other Indian Continent; Other Persian Gulf
MED	Algeria; Croatia; Egypt; Greece; Israel; Libya; Morocco; Tunisia; Other Mediterranean
WCSA	Bolivia; Chile; Ecuador; Peru

3.3.2.2.3.1 GI's Containerized Imports

The GI database obtained for Charleston Post 45 contained over 4,310 rows of cargo-related data. Table 14 displays GI's imports forecast by world region for selected years occurring over the forecast period. The world region aggregate was developed by combining the tonnages from each country or region identified in Table 15. GI forecast indicates that FE Region[8], (NEUR) and the Indian Subcontinent – Middle East (ISCME) will dominate Charleston imports, growing to 5.2 million tons, 4.4 million tons, and 3.1 million tons, respectively, by 2037.

Table 14: GI's Charleston Harbor Containerized Trade Forecast – Imports

Charleston World Region	2015	2020	2025	2030	2035	2036	2037
AFRICA	116,083	133,669	156,266	178,575	202,693	208,555	213,754
CAR CA	106,490	122,297	141,732	161,220	184,195	189,346	194,732
ECSA	494,168	617,955	790,617	980,346	1,155,306	1,193,930	1,235,557
FE	1,990,131	2,616,143	3,486,518	4,349,174	5,017,398	5,144,618	5,288,493
ISC/ME	1,001,303	1,394,585	1,932,128	2,518,341	2,939,586	3,018,403	3,116,986
MED	38,646	46,022	55,484	65,372	76,961	79,643	82,372
NEUR	2,495,575	2,844,482	3,278,432	3,708,359	4,208,321	4,321,882	4,438,932
WSCA	126,368	137,474	151,070	165,615	182,247	185,911	189,638
Total Imports	**6,368,764**	**7,912,626**	**9,992,247**	**12,127,003**	**13,966,707**	**14,342,288**	**14,760,464**

Source: IHS Global Insight

[7] Canada was included in Africa world trade region because Charleston Harbor container services originating from Africa call to Canadian ports.
[8] The Far East Region is served by three service routes: FE (Panama), FE (Suez) & FE ECUS NEUR PEN.

The import forecast rate of change between each year is shown in Table 15. The rate of change was calculated from the annual commodity forecast developed by GI. The data illustrate that economic conditions are cyclical and that the fastest growth will take place in the FE, NEUR, and the ISCME.

Table 15: Charleston Harbor Import Forecast – Rate of Change

Charleston World Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AFRICA	3%	6%	4%	4%	3%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	3%	3%	3%	2%	3%
CAR CA	4%	7%	4%	4%	3%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	3%	3%	3%	2%	3%
ECSA	4%	8%	5%	5%	4%	6%	4%	4%	4%	5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	3%
FE	4%	9%	6%	6%	5%	7%	5%	5%	6%	7%	6%	6%	5%	6%	5%	5%	5%	5%	3%	3%
ISCME	8%	13%	9%	8%	7%	9%	6%	6%	6%	7%	7%	7%	7%	7%	7%	6%	6%	6%	2%	3%
MED	3%	6%	4%	4%	3%	5%	3%	3%	3%	4%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%
NEUR	5%	6%	3%	3%	2%	4%	2%	2%	2%	4%	3%	3%	3%	3%	3%	2%	3%	2%	2%	2%
WSCA	4%	4%	1%	1%	1%	3%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%

Source: IHS Global Insight

3.3.2.2.3.2 GI's Containerized Exports

The FE, NEUR and ISCME are forecast to receive 73 percent of exports shipped from Charleston (Table 16). Exports to NEUR are forecast to total 2.2 million tons in 2015 and growing to 4.6 million tons in 2037. Similarly exports to the FE are forecast to total 1.4 million tons in 2015 and growing to 4.7 million tons in 2037.

Table 16: GI's Charleston Harbor Containerized Trade Forecast – Exports

Charleston World Region	2015	2020	2025	2030	2035	2036	2037
AFRICA	312,837	389,637	471,498	553,197	643,229	664,252	682,397
CAR CA	193,952	245,755	296,945	350,240	412,509	426,296	440,880
ECSA	752,506	943,352	1,148,964	1,373,285	1,637,265	1,696,845	1,761,211
FE	1,410,624	2,018,677	2,881,146	3,915,564	4,489,984	4,607,573	4,737,197
ISCME	1,069,895	1,436,594	1,833,078	2,257,590	2,666,059	2,753,131	2,842,377
MED	143,683	182,023	222,333	264,847	313,072	323,869	335,083
NEUR	2,161,214	2,708,980	3,251,720	3,788,073	4,371,494	4,501,611	4,642,103
WCSA	279,924	347,914	410,823	471,334	541,146	557,090	573,854
Total Exports	**6,324,636**	**8,272,932**	**10,516,509**	**12,974,130**	**15,074,759**	**15,530,666**	**16,015,103**

Source: IHS Global Insight

The export forecast rate of change are shown in Table 17.

Table 17: Charleston Harbor Export Forecast – Rate of Change

Charleston World Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
AFRICA	9%	7%	6%	5%	4%	4%	5%	5%	5%	4%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%
CAR CA	5%	5%	5%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
ECSA	8%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	3%	4%
FE	9%	9%	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	2%	3%
ISCME	13%	12%	9%	8%	7%	6%	6%	6%	6%	5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	3%
MED	4%	5%	6%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	4%	4%	4%	4%	3%	3%
NEUR	3%	5%	5%	5%	5%	5%	5%	5%	4%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
WSCA	2%	4%	4%	4%	5%	4%	5%	4%	4%	4%	4%	3%	3%	3%	3%	3%	3%	3%	3%	3%

As illustrated the rate of change varies by trade region and year. The amount of uncertainty or risk of exports appears to be less pronounced than that of the forecasted imports. Also the rate of change in exports is slightly higher than that of imports.

3.3.3 Charleston Long Term Trade Forecast - Methodology

3.3.3.1 Container Services

Numerous container services call on Charleston Harbor which are operated by many carriers and have trade routes which originate in various parts of the world. Therefore services were grouped by the world region that they serve. For example, there are a number of services that call on various ports in the FE, transit the Panama Canal, proceed to ports along the east coast of the East Coast of the U.S. (ECUS), and then return to the FE. Services that represent trade within this world area were grouped and entitled "FE (Panama) ECUS". Other services generally involve trans-oceanic string of ports structured as a continuous loop. The FE ECUS NEUR PEN is a combined world region service and represents both the FE region and the NEUR services. Those services called on various ports in the FE, transit the Panama Canal, proceed to ports along the ECUS, proceed to NEUR, and then return to the FE. The "PEN" indicates a pendulum service.

The FE and NEUR services were initially analyzed separately but some parts or portions of these regions were later combined to create a pendulum because these services represent a fraction of the projected containerized movement for another service. Traffic for the FE Region was split as follows: FE (Panama) 37 percent, FE (Suez) 22 percent, and FE ECUS NEUR PEN 41 percent. Similarly containerized movement for the NEUR region was split into NEUR 68 percent and FE ECUS NEUR PEN by 32 percent. The FE ECUS NEUR PEN from FE region and FE ECUS NEUR PEN from the NEUR region were combined to create one pendulum. Services that represent trade within this world area were grouped and entitled FE ECUS NEUR PEN.

The FE (Panama) ECUS service calls on FE ports, crosses the Pacific Ocean, and transits the Panama Canal before calling on ECUS ports. After completing the vessel's ECUS rotation, the ship returns to the FE via the Panama Canal. Similarly, the FE (Suez) ECUS service calls on various ports in the FE and Africa before transiting the Suez Canal and stopping at the Mediterranean. After its Mediterranean port of call, the vessel crosses the Atlantic and calls on numerous ECUS ports before returning to the FE by calling on many of the same ports visited during the first leg of its voyage.

Table 18 presents the import and export growth rates that were developed by generating three additional service routes: FE (panama), FE (Suez), FE ECUS NEUR PEN from the FE and the NEUR region. In all, 10 service routes were employed to perform the commodity forecast for Charleston Harbor.

It should be noted that each trade route contains unique characteristics such as cargo volume, cargo weight, ports of call, vessel types, mix of vessels, etc. and, therefore, are evaluated separately before being combined as part of the NED analysis. Only six out of the ten service routes will benefit from channel modification at Charleston Harbor. However the non-benefiting routes were still carried forward in the evaluation as the number of future calls will contribute to harbor congestion and will influence other benefit categories outside the main transportation model (i.e., meeting area and tidal advantage analyses).

Table 18: Charleston Harbor Containerized Imports and Exports – Rate of Change (2011)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Rate of Change - Imports																										
AFRICA	3.3%	6.5%	3.8%	3.7%	2.6%	4.4%	2.4%	2.4%	2.5%	3.7%	3.0%	3.0%	3.0%	3.2%	3.1%	2.8%	2.7%	2.8%	2.2%	2.6%	2.6%	2.5%	2.6%	2.6%	2.9%	2.5%
CAR CA	3.9%	7.2%	4.1%	3.9%	2.6%	4.4%	2.3%	2.4%	2.4%	3.6%	2.9%	2.8%	2.7%	2.9%	2.8%	2.6%	2.6%	2.5%	2.5%	2.6%	2.6%	2.7%	2.8%	2.8%	2.8%	2.8%
ECSA	3.6%	7.7%	4.5%	4.9%	4.2%	6.0%	4.2%	4.2%	4.2%	5.5%	4.9%	4.9%	4.9%	5.1%	5.0%	4.7%	4.7%	4.7%	2.8%	3.4%	3.2%	3.4%	3.3%	3.4%	3.3%	3.5%
FE (Panama)	4.0%	8.5%	6.0%	6.2%	5.2%	7.0%	5.1%	5.3%	5.5%	6.8%	6.1%	5.7%	5.4%	5.6%	5.4%	5.0%	4.9%	4.8%	2.5%	2.9%	3.1%	2.7%	2.9%	2.9%	2.5%	2.8%
FE (Suez)	4.0%	8.5%	6.0%	6.2%	5.2%	7.0%	5.1%	5.3%	5.5%	6.8%	6.1%	5.7%	5.4%	5.6%	5.4%	5.0%	4.9%	4.8%	2.5%	2.9%	3.1%	2.7%	2.9%	2.9%	2.5%	2.8%
FE ECUS NEUR PEN	4.4%	7.1%	4.4%	4.7%	3.7%	5.6%	3.7%	3.8%	4.0%	5.3%	4.6%	4.3%	4.2%	4.4%	4.2%	3.9%	3.9%	3.8%	2.4%	2.7%	2.9%	2.6%	2.8%	2.8%	2.6%	2.8%
ISCME	8.0%	12.7%	8.7%	8.1%	7.0%	8.5%	6.2%	6.4%	6.1%	7.2%	6.7%	6.6%	6.6%	6.7%	6.5%	6.2%	6.1%	6.0%	2.4%	3.2%	3.3%	3.2%	2.8%	3.2%	2.7%	3.3%
MED	2.9%	6.4%	4.1%	4.3%	3.4%	5.1%	3.0%	3.1%	3.2%	4.4%	3.7%	3.7%	3.6%	3.8%	3.6%	3.3%	3.3%	3.3%	3.1%	3.3%	3.3%	3.3%	3.4%	3.4%	3.5%	3.4%
NEUR	4.7%	5.8%	2.9%	3.2%	2.3%	4.2%	2.2%	2.3%	2.3%	3.5%	2.8%	2.7%	2.6%	2.8%	2.7%	2.5%	2.5%	2.5%	2.3%	2.5%	2.5%	2.6%	2.6%	2.6%	2.7%	2.7%
WSCA	3.9%	3.8%	1.2%	1.0%	1.1%	3.2%	1.4%	1.5%	1.3%	2.4%	1.7%	1.7%	1.7%	2.0%	1.9%	1.9%	1.9%	1.8%	1.8%	1.9%	1.9%	1.9%	1.9%	2.0%	2.0%	2.0%
Rate of Change Exports																										
AFRICA	8.6%	6.8%	6.3%	4.7%	4.3%	4.4%	4.6%	4.7%	4.5%	4.1%	3.9%	4.0%	3.8%	3.6%	3.5%	3.3%	3.3%	3.3%	2.8%	3.0%	3.0%	3.1%	3.0%	3.1%	3.3%	2.7%
CAR CA	5.0%	5.1%	4.9%	4.8%	4.9%	5.0%	4.9%	4.8%	4.6%	4.1%	4.0%	3.9%	3.7%	3.5%	3.5%	3.4%	3.4%	3.4%	3.1%	3.3%	3.3%	3.4%	3.3%	3.4%	3.3%	3.4%
ECSA	8.1%	6.2%	5.3%	4.6%	4.6%	4.8%	4.7%	4.5%	4.5%	4.1%	4.2%	4.1%	3.9%	3.8%	3.7%	3.7%	3.7%	3.8%	3.3%	3.6%	3.5%	3.6%	3.6%	3.7%	3.6%	3.8%
FE (Panama)	8.6%	8.5%	8.2%	7.8%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	2.2%	2.7%	2.7%	2.9%	2.8%	2.8%	2.6%	2.8%
FE (Suez)	8.6%	8.5%	8.2%	7.8%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	2.2%	2.7%	2.7%	2.9%	2.8%	2.8%	2.6%	2.8%
FE ECUS NEUR PEN	5.3%	6.2%	6.6%	6.1%	5.9%	6.0%	6.0%	5.9%	5.8%	5.7%	5.6%	5.6%	5.5%	5.4%	5.5%	5.4%	5.5%	5.5%	2.4%	2.7%	2.8%	2.9%	2.8%	2.9%	2.8%	2.9%
ISCME	12.9%	11.7%	8.9%	7.9%	6.5%	6.2%	6.0%	5.9%	5.7%	5.2%	5.1%	5.0%	4.9%	4.8%	4.7%	4.5%	4.6%	4.6%	2.9%	3.3%	3.7%	3.1%	3.5%	3.3%	3.3%	3.2%
MED	4.1%	5.3%	5.6%	4.9%	4.9%	4.9%	4.9%	4.8%	4.6%	4.3%	4.2%	4.2%	4.0%	3.8%	3.8%	3.7%	3.6%	3.6%	3.1%	3.3%	3.4%	3.4%	3.5%	3.5%	3.4%	3.5%
NEUR	3.0%	4.6%	5.4%	4.8%	4.6%	4.8%	4.8%	4.6%	4.4%	4.0%	3.8%	3.8%	3.6%	3.4%	3.4%	3.2%	3.2%	3.1%	2.6%	2.8%	2.9%	2.9%	2.9%	3.1%	3.0%	3.1%
WCSA	2.2%	3.9%	3.5%	4.0%	4.6%	4.5%	4.6%	4.4%	4.1%	3.7%	3.5%	3.4%	3.2%	3.0%	3.0%	2.7%	2.8%	2.7%	2.7%	2.7%	2.8%	2.8%	2.8%	2.9%	2.9%	3.0%

3.3.3.2 Containerized Import Trade

The respective world region route import rates of change were applied to the 2011 baseline (Table 19) to estimate the Charleston Harbor long-term import forecast. Port capacity is forecast to be reached in 2037; therefore, the long-term forecast was constrained at that point. As shown in Table 19, it is forecasted that ISCME, NEUR and the FE trade will continue to dominate Charleston Harbor imports over the forecast period, growing from approximately 3.7 million tons in 2011 baseline to just 10.6 million tons in 2037. Imports from NEUR region service is expected to lead all Charleston Harbor services in total trade, closely followed by ISC/ME.

Table 19: Charleston Containerized Trade Forecast – Import Tons

Imports	2011 Baseline	2022	2027	2032	2037
Africa	95,405	138,969	161,125	182,961	208,030
CAR CA	30,443	44,907	51,491	58,428	67,038
ECSA	278,052	470,383	598,230	719,658	849,981
FE (Panama)	590,199	1,115,993	1,453,203	1,737,205	1,991,441
FE (Suez)	407,463	770,461	1,003,265	1,199,335	1,374,855
FE ECUS NEUR PEN	431,981	712,634	875,775	1,022,811	1,169,702
ISCME	608,002	1,385,121	1,897,996	2,330,735	2,707,374
MED	138,327	211,832	252,678	296,609	350,406
NEUR	1,626,139	2,319,978	2,642,871	2,984,639	3,401,183
WCSA	145,935	182,191	199,524	218,797	241,315
Total	**4,351,946**	**7,352,472**	**9,136,158**	**10,751,178**	**12,361,323**

3.3.3.3 Containerized Export Trade

The export tons forecast is shown in Table 20. As with imports, exports to ISCME, NEUR and the FE are forecast to dominate Charleston Harbor export trade over the period of the forecast, growing from 3.4 million tons in 2011 to 12.0 million tons in 2037. As with imports, the NEUR service route is expected to lead all Charleston Harbor services in total trade volume, closely followed by ISC/ME.

According to Global Insight, countries taking on an increasing share of exports over the forecast period include China, India, South Korea, South Africa, the Caribbean Basin, and Other Persian Gulf. These are developing countries whose economies are projected to grow at relatively higher rates, driven by higher domestic demand and an expansion of production capabilities for exportable products.

In contrast, relatively slower growth is anticipated in some developed countries, such as France, the United Kingdom, Italy, and Japan. Slower growth results in less demand for imported goods. Consequently, although exports to these countries will continue to grow over the forecast period, they will grow at a relatively slower rate, causing their relative importance as export destinations to drop.

Table 20: Charleston Containerized Trade Forecast – Export Tons

Exports	2011 Baseline	2022	2027	2032	2037
Africa	242,659	422,155	504,836	587,945	683,259
CAR CA	45,179	75,192	89,738	105,609	124,566
ECSA	402,062	691,363	834,855	994,715	1,190,048
FE (Panama)	550,828	1,249,974	1,783,317	2,217,322	2,543,131
FE (Suez)	336,718	764,102	1,090,132	1,355,436	1,554,602
FE ECUS NEUR PEN	551,458	1,038,408	1,356,054	1,631,356	1,879,789
ISCME	712,638	1,567,489	1,979,887	2,386,932	2,804,933
MED	230,483	385,196	466,153	551,062	652,923
NEUR	1,244,733	2,003,978	2,375,791	2,743,156	3,179,841
WCSA	365,899	558,178	649,789	743,531	857,564
Total	**4,682,658**	**8,756,034**	**11,130,552**	**13,317,063**	**15,470,654**

Using the containerized trade forecast for imports and exports and the average weight per loaded container, a loaded container forecast was developed. Table 21 provides the loaded import and export TEU forecast, along with the weight per loaded container for the trade regions.

Table 21: Loaded TEU Forecast - Import and Export

	Weight per Loaded Import TEU	2022	2027	2032	2037
		LOADED IMPORT TEUS			
Africa	8.46	16,427	19,046	21,627	24,590
CAR CA	6.17	7,278	8,345	9,470	10,865
ECSA	10.51	44,756	56,920	68,474	80,874
FE (Panama)	6.54	170,641	222,202	265,628	304,502
FE (Suez)	8.09	95,236	124,013	148,249	169,945
FE ECUS NEUR PEN	7.42	96,042	118,029	137,845	157,642
ISCME	7.63	181,536	248,754	305,470	354,833
MED	7.77	27,263	32,520	38,174	45,097
NEUR	8.09	286,771	326,684	368,929	420,418
WCSA	10.13	17,985	19,696	21,599	23,822
Total		**943,936**	**1,176,209**	**1,385,464**	**1,592,587**
	Weight per Loaded Export TEU	**2022**	**2027**	**2032**	**2037**
		LOADED EXPORT TEUS			
Africa	9.90	42,642	50,994	59,388	69,016
CAR CA	8.53	8,815	10,520	12,381	14,603
ECSA	9.31	74,260	89,673	106,844	127,825
FE (Panama)	10.12	123,515	176,217	219,103	251,298
FE (Suez)	9.57	79,843	113,911	141,634	162,445
FE ECUS NEUR PEN	8.78	118,270	154,448	185,804	214,099
ISCME	8.92	175,727	221,960	267,593	314,454
MED	9.61	40,083	48,507	57,343	67,942
NEUR	8.20	244,388	289,731	334,531	387,785
WCSA	10.02	55,706	64,849	74,205	85,585
Total		**963,250**	**1,220,811**	**1,458,825**	**1,695,053**

From the loaded TEU forecast, empty TEUs by trade region were developed. The percentage of empty TEUs to loaded TEUs for both import and export by trade region was derived from historical data. This percentage was then used to forecast empties to 2037 as shown in Table 22.

Table 22: Empty TEU Forecast - Import and Export

	% of Empty TEUs to Loaded TEUs, Imports	2022	2027	2032	2037
		EMPTY IMPORT TEUS			
Africa	108%	17,766	20,599	23,390	26,595
CAR CA	15%	1,110	1,273	1,444	1,657
ECSA	77%	34,569	43,965	52,889	62,467
FE (Panama)	3%	5,119	6,666	7,969	9,135
FE (Suez)	17%	16,403	21,359	25,533	29,270
FE ECUS NEUR PEN	7%	6,723	8,262	9,649	11,035
ISCME	7%	12,777	17,508	21,499	24,973
MED	34%	9,290	11,081	13,008	15,367
NEUR	8%	22,457	25,583	28,891	32,923
WCSA	128%	22,976	25,162	27,592	30,432
Total		149,190	181,457	211,865	243,855
	% Empty TEUs to Loaded TEUs, Exports	**2022**	**2027**	**2032**	**2037**
		EMPTY EXPORT TEUS			
Africa	4%	1,534	1,835	2,137	2,483
CAR CA	17%	1,472	1,756	2,067	2,438
ECSA	3%	2,361	2,851	3,397	4,064
FE (Panama)	75%	92,636	132,163	164,327	188,473
FE (Suez)	42%	33,426	47,688	59,294	68,006
FE ECUS NEUR PEN	23%	27,202	35,523	42,735	49,243
ISCME	22%	37,798	47,742	57,557	67,637
MED	9%	3,772	4,565	5,396	6,394
NEUR	17%	42,228	50,063	57,805	67,007
WCSA	20%	11,292	13,145	15,041	17,348
Total		**253,721**	**337,331**	**409,756**	**473,093**

The total number of TEUs, including loaded and empty containers, by import and export, and trade region are shown in Table 23. Import TEUs are forecasted to grow from 1.09 million in 2022 to 1.84 million in 2037, an increase of 68 percent. Export TEUs are forecasted to grow from 1.22 million in 2022 to 2.17 million TEUs in 2037, an increase of 78 percent. The compound average growth rate (CAGR) for each trade route represents the geometric average growth of imports and exports, which accounts for the effect of compounding growth over time. For NEUR, imports are projected to grow from 309,228 to 453,341 over the 15-year period at a CAGR of 2.6% per year.

Table 23: Total TEU Forecast[9] by Trade Route for Imports and Exports

TOTAL TEUS - IMPORTS					
	2022	**2027**	**2032**	**2037**	CAGR
Africa	34,193	39,644	45,017	51,185	2.7%
CAR CA	8,388	9,618	10,914	12,522	2.7%
ECSA	79,325	100,885	121,363	143,340	4.0%
FE (Panama)	175,760	228,868	273,597	313,637	3.9%
FE (Suez)	111,639	145,372	173,783	199,215	3.9%
FE ECUS NEUR PEN	102,765	126,291	147,494	168,677	3.4%
ISCME	194,313	266,262	326,969	379,806	4.6%
MED	36,553	43,601	51,182	60,465	3.4%
NEUR	309,228	352,267	397,821	453,341	2.6%
WCSA	40,961	44,858	49,191	54,253	1.9%
Total	**1,093,126**	**1,357,666**	**1,597,329**	**1,836,442**	3.5%
TOTAL TEUS - EXPORTS					
	2022	**2027**	**2032**	**2037**	
Africa	44,176	52,828	61,525	71,499	3.3%
CAR CA	10,287	12,277	14,448	17,041	3.4%
ECSA	76,621	92,524	110,240	131,888	3.7%
FE (Panama)	216,152	308,380	383,430	439,771	4.8%
FE (Suez)	113,269	161,599	200,928	230,452	4.8%
FE ECUS NEUR PEN	145,472	189,971	228,538	263,342	4.0%
ISCME	213,525	269,702	325,151	382,091	4.0%
MED	43,855	53,072	62,739	74,336	3.6%
NEUR	286,616	339,794	392,336	454,792	3.1%
WCSA	66,998	77,994	89,246	102,934	2.9%
Total	**1,216,971**	**1,558,142**	**1,868,581**	**2,168,146**	3.9%

3.4 Vessel Fleet

3.4.1 World Fleet

In addition to a commodity forecast, a forecast of the future fleet is required when evaluating navigation projects. To develop projections of the future fleet calling at Charleston, the study team obtained a World Fleet forecast of containerships developed by Maritime Strategies Inc., (MSI), a

[9] *The TEUs forecast was held constant at just over 4 million TEUs to ensure that sufficient capacity was available at the Port. Currently, Charleston has the capacity to handle 2.8 million TEUs which exceeds the projected volume up to 2026. Also, the former Navy Base terminal is anticipated to be completed between 2017 and 2019. Completion of the former Navy Base terminal is necessary for the port growth to continue in the future beyond 2.8 million TEUs.*

methodology to forecast total capacity calling at Charleston Harbor and a breakdown of that capacity calling into containership size and TEU classes.

Table 24: Fleet Subdivisions on Draft, Beam and LOA

			Feet	
			From	**To**
Sub Panamax		Beam	34.8	98.2
(TEU size brackets: 0.1-1.3, 1.3-2.9 k)		Draft	8.2	38.1
		LOA	221.7	813.3
			From	To
Panamax		Beam	98.4	106.3
(TEU size brackets: 1.3-2.9, 2.9-3.9, 3.9-5.2 k)		Draft	30.8	44.8
		LOA	572.0	967.5
Panamax Category 1 (to 899 ft LOA)		Beam	100.1	106.0
		Draft	30.8	38.9
		LOA	572.0	899.0
Panamax Category 2 (900-967.5 ft LOA)		Beam	98.4	106.1
		Draft	39.1	44.8
		LOA	899.3	967.5
			From	To
Post-Panamax Generation I		Beam	120.0	138.8
(TEU size brackets:		Draft	35.4	47.6
1.3-2.9, 2.9-3.9, 3.9-5.2, 5.2-7.6 k)		LOA	660.8	1,044.7
			From	To
Post-Panamax Generation II		Beam	138.8	143.9
(TEU size brackets: 5.2-7.6, 7.6-12 k)		Draft	39.4	49.2
		LOA	910.7	1,205.0
			From	To
New Panamax		Beam	144.0	168.0
(MSI size brackets: 5.2-7.6, 7.6-12, 12 k +)		Draft	42.7	49.5
		LOA	1,036.7	1,200.8
			From	To
New Post-Panamax		Beam	168	185.0
(TEU size brackets: 7.6-12, 12 k +)		Draft	50.9	52.6
		LOA	1,140.0	1,304.8

The methodology developed by MSI was then linked to the GI informed commodity forecast developed by the PDT. Table 24 shows the fleet subdivision using common vessel labeling terminology and vessels specifications for beam, LOA, and design drafts.

By combining information from the commodity forecast with MSI's forecasted fleet capacity and Charleston average share of cargo on a containerized vessel, the PDT was able to allocate a number of Post-Panamax, Panamax, and Sub- Panamax vessels calls to Charleston's fleet. The number of transits, particularly those made by larger vessels, is a key variable in calculating the transportation costs.

MSI's forecasting technique begins with performing a detailed review of the current world fleet and how it is deployed on the trade routes of the world. Forecasting of the world fleet was made possible through MSI's proprietary Container Shipping Planning Service (CSPS) model (Figure 16), which applies historical and forecasted time series data from 1980 to 2030 for:

- Macroeconomic and trade variables including:
  - Annual GDP growth rates by region
  - Industrial Production
  - Population Growth
  - Inflation and Interest Rates
  - Currency Exchange
- Global container trade and movements in TEU lifts by region including:
  - Primary Lifts
  - Transshipment Lifts
  - Loaded/Empty Lifts
- Sector-specific fleet dynamics including:
  - Fleet nominal capacity by vessel size and age
  - Contracting, order book, deliveries, cancellations, slippage and scrapping
  - Container fleet by size
- Sector-specific supply/demand balances
- Time charter rates and vessel operating costs
- Freight rates including:
  - Headhaul rates
  - Backhaul rates
- New building, second-hand (by age) and scrap prices for standard sizes

Data sources for the CSPS model include:

- Macroeconomics: Oxford Economics, leading investment banks;

- World Trade: UNCTAD, Drewry Shipping Consultants, Containerization International;
- Fleet Supply: LR-Fairplay, Worldyards, Howe Robinson; and
- Charter Rates, Freight Rates and Vessel Prices: Drewry Shipping Consultants, Howe Robinson, Clarksons and various contacts at shipping lines.

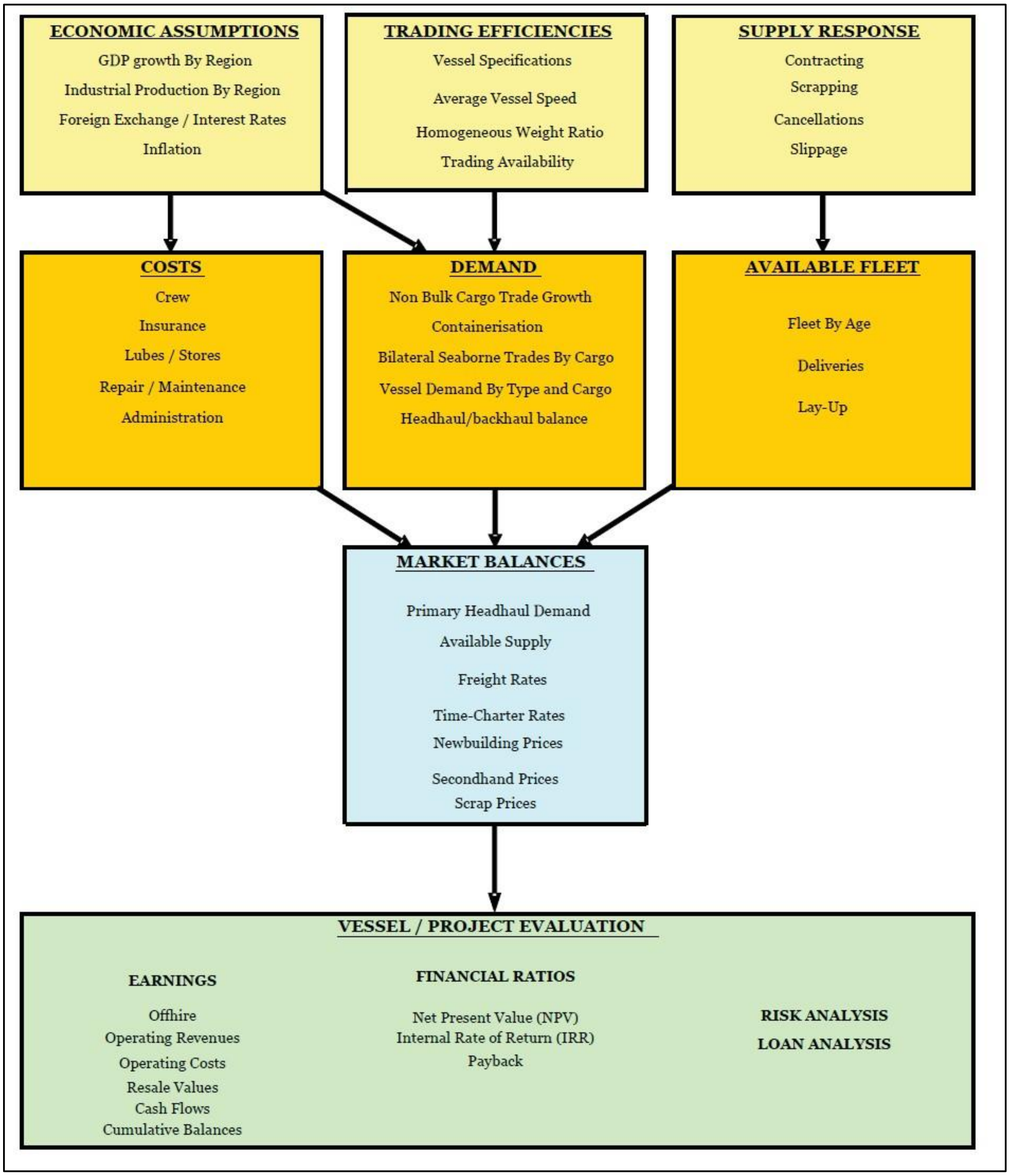


Figure 16: Schematic Overview of the CSPS Model

When evaluating data on vessel composition, vessel age, and container markets, MSI considered the "order book" to estimate new deliveries to the fleet into the future. Vessel scrapping is accounted for based on historical scrapping rates by vessel class and age. Containerships, particularly the largest ones, are relatively new, so widespread scrapping is not expected to take place until well in the future. Likewise, when economies are strong, vessel owners are more likely to hold onto their existing vessels (or build new ones) and less likely to scrap them. The forecasted world fleet provides a frame of reference to verify the validity of the Charleston fleet forecast and is provided as background information.

As new larger vessels become a greater percentage of the world fleet and are deployed to Charleston, they replace smaller vessels which are redeployed to shorter routes (e.g. intra-Caribbean), which may utilize the smaller vessels more efficiently.

There is a strong relationship between the economic condition of a port and its total nominal vessel capacity. As an economy grows, exports from the port often increase (from the increased output) or demand for imports increase (from increased consumer purchasing power). Vessels respond accordingly to satisfy this increased level of trade. In a previous East Coast U.S. port deepening study, MSI examined the empirical relationship between the nominal capacity of the fleet calling at the port and the historical tonnages moving through the port. MSI found the variables to be highly correlated, having an R-squared value of 0.967. This statistical relationship from that port's study was then applied to the forecasted tonnages in order to estimate future nominal TEU vessel capacity calling Charleston. As the tonnage in Charleston grows over time, the nominal TEU vessel capacity, i.e., the total number of available container slots, grows. Capacity is adjusted by operators to match demand. Once the forecasted nominal TEU vessel capacity at Charleston was determined, the future containers were allocated to various vessel classes (PPX, PX and SPX). The allocation to vessel classes was based on MSI's examination of historical utilization of Panamax vessels, current trends in vessel design and orders, and the worldwide redeployment of vessels affected by the expansion of the Panama Canal.

3.4.1.1 World Fleet End of Period 2011

A projection of the World Fleet provides the necessary background for evaluating the future fleet forecast for Charleston. The starting point for this projection was the world fleet by vessel class as extracted by MSI from the Lloyd's Register (LR)-Fairplay database for the year 2011[10]. The 2011 fleet is shown by TEU bands in Table 25.

Table 25: World Feet by TEU Band – 2011

TEU Band	Count
0.1 k to 1.3k TEU	1,635
1.3 k to 2.9 k TEU	1,440
2.9 k to 3.9 k TEU	343
3.9 k to 5.2 k TEU	721
5.2 k to 7.6 k TEU	483
7.6 k to 12 k TEU	309
12 k TEU +	78
Total	**4,864**

[10] LR Fairplay maintains the largest maritime databases covering ships, movements, owners and managers, maritime companies, ports and terminals.

3.4.1.2 The “Order Book”

The “order book” is short hand for the vessels that have been contracted to be built by ship builders around the world. Vessel deliveries are primarily a function of new building contracting. These contracts can take several forms. There are firm contracts for vessels that are under construction. There are also option contracts that secure the capacity of the shipyard but do not require the buyer to exercise the option to construct the vessel. Some contracts have financing that is committed, others do not. There are several other nuances and the challenge is to translate the number of vessels and types of contracts into future vessels coming on line at a specific time. This requires knowledge and expertise of this market and this process. Forecasts must be made for future contracts, vessel scrapping, and vessel deliveries[11]. Over the long term, new building investment tends to equate to the incremental demand for new tonnages to meet cargo growth or replacement of aged or obsolete ships.

A historical breakdown of contracting by TEU band was accomplished using a widely recognized fleet database provided by LR-Fairplay. The breakdown was expressed as a percentage of ships for each TEU band size band. These percentages were used as a baseline for forecasting future contracting. Figure 17 depicts historical contracting by TEU bands for fully cellular container (FCC) vessels[12].

[11] Factors such as economic conditions, price of steel, exchange rates, and a host of others can influence the forecasted world fleet.

[12] The term, “fully cellular” refers to vessels that are purpose built to carry ocean containers. The containers are generally stored in vertical slots on the ship.

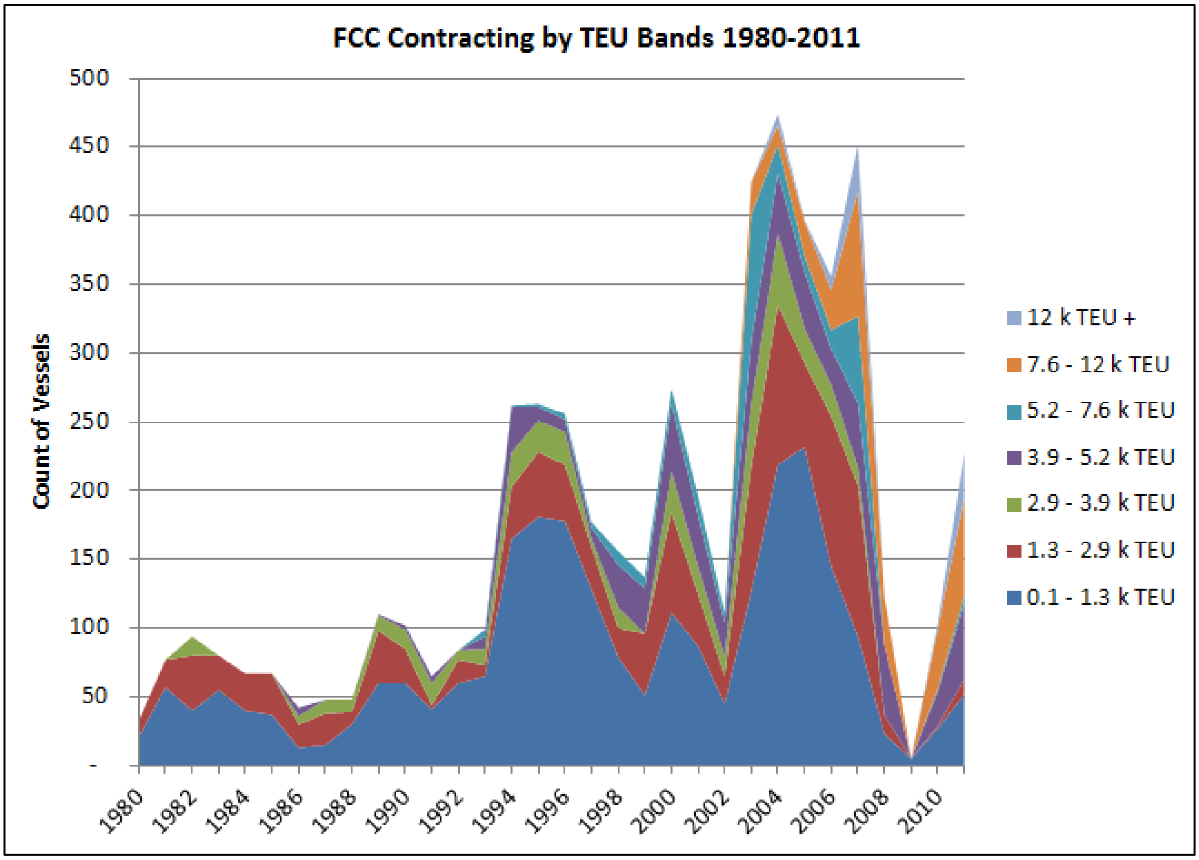


Figure 17: FCC Contracting 1980 to 2011

The steep economic contraction that occurred in 2009 led to an almost zero ordering that year. Cancellations and slippage produced a considerable change to the order book profile and the pace of deliveries to the fleet. Going forward, MSI perceives there to be an over-supply in containerships. This had material impacts on both expected deliveries and scrapping of vessels in the future.

3.4.1.3 Deliveries and Scrapping Assumptions

The perceived over-supply in containerships is expected to bear heavily on investors' sentiment, resulting in deliveries falling from historical expectations. Conversely, the retirements are expected to occur in excess of historical expectations. Long-term, container fleet growth expectations have been significantly reduced. However, it must be stressed that the ship classes that have suffered most from the fleet re-orientation were those with a capacity below 5.2 k TEU.

MSI modeled the relationship between annual contracting and annual deliveries by TEU band. The forecast of deliveries by TEU band are depicted in Figure 18. The number of new vessel deliveries is expected to increase each year until a 2020 peak, and then taper off to the end of the forecast period, with an upward bounce in 2027.

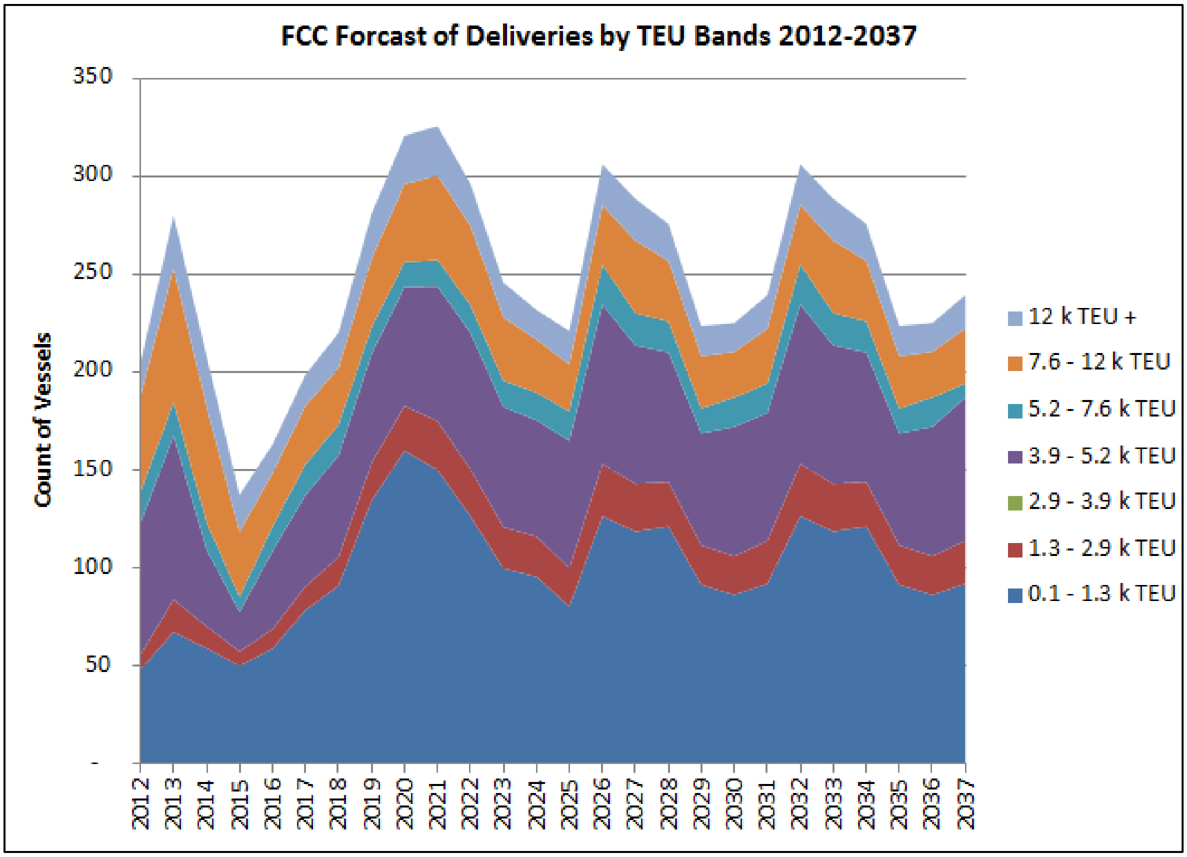


Figure 18: Forecast of Deliveries by TEU Band 2012 to 2037

An estimate of annual scrapping was accomplished by examining the LR-Fairplay database for the world fleet each year and noting which vessels drop out each year. This was done by TEU band and transformed into a scrapping profile for each band. Figure 19 shows the estimated scrapping by TEU band class. The surge in vessel scrapping in 2009 (210 vessels) was not expected to be repeated until 2022, when many vessels reach the end of their useful lives.

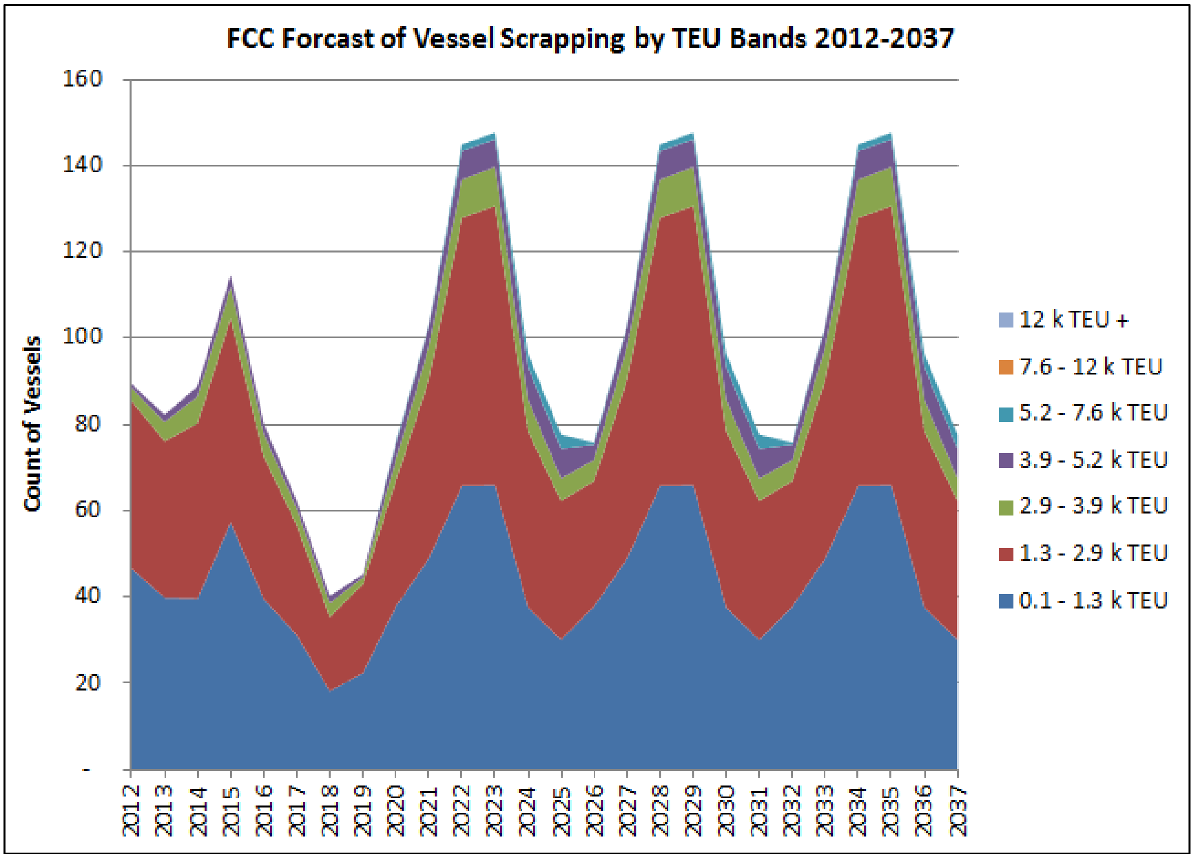


Figure 19: Forecast of Vessel Scrapping by TEU Bands 2012 to 2037

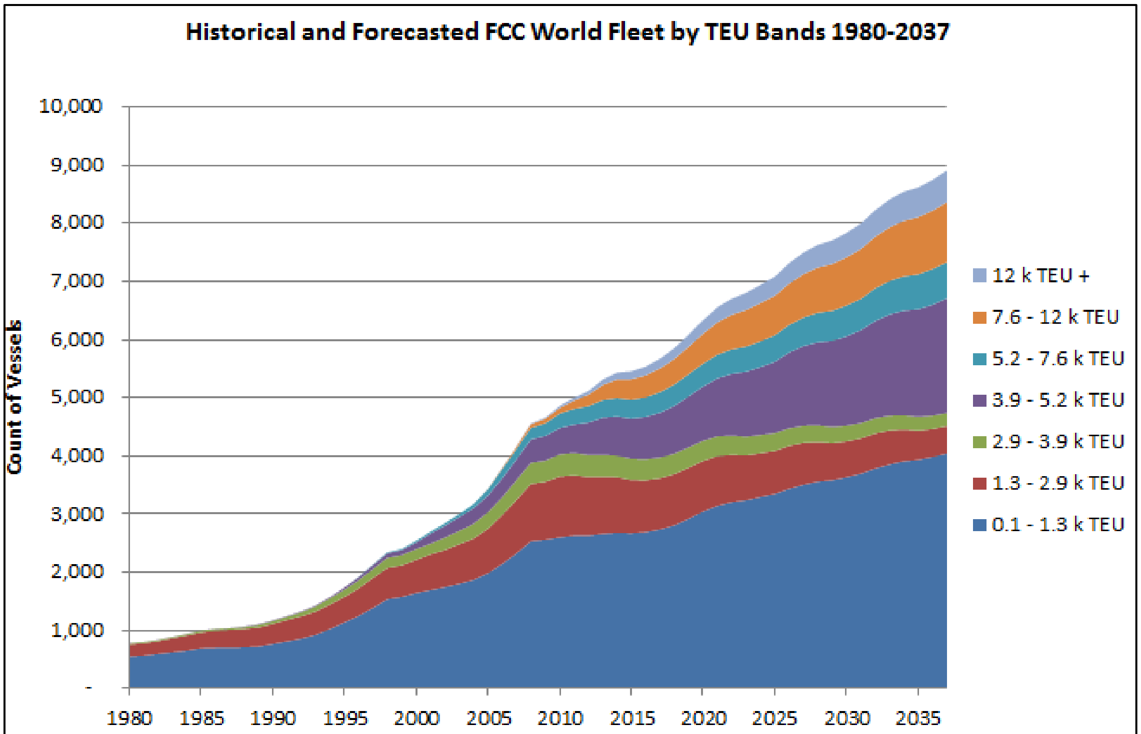
3.4.1.4 World Fleet Forecast

With data for deliveries, scrapping, and the 2011 fleet calculated, forecast of the fleet for the end of each forecast year was estimated using the following equation:

Equation 1: Fleet End of Period

Fleet EoP (Year) = Fleet EoP (Year-1) + Deliveries (Year) – Scrapping (Year) EoP = End of period

Figure 20 displays the world FCC forecast by TEU band through 2037.



TEU	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
0.1 - 1.3 k	548	689	763	1,133	1,641	1,982	2,598	2,668	3,041	3,344	3,632	3,933
1.3 - 2.9 k	208	274	344	441	568	764	1,045	919	872	741	616	502
2.9 - 3.9 k	21	30	53	127	189	284	385	366	347	309	271	235
3.9 - 5.2 k	3	4	10	36	114	288	451	687	932	1,225	1,538	1,850
5.2 - 7.6 k	0	0	0	0	29	108	248	325	395	455	529	602
7.6 - 12 k	0	0	0	0	0	3	97	352	513	680	829	982
12 k +	0	0	0	0	0	0	35	136	233	329	421	514

Figure 20: World Fleet Historical and Forecasted FCC by TEU Band 1980 to 2037

Figure 21 shows the growth in selected Post-Panamax TEU bands from the 2011 fleet. The figure shows the additional vessels added to the fleet. These types of vessels are a key factor in the evaluation of port deepening studies like Charleston Harbor.

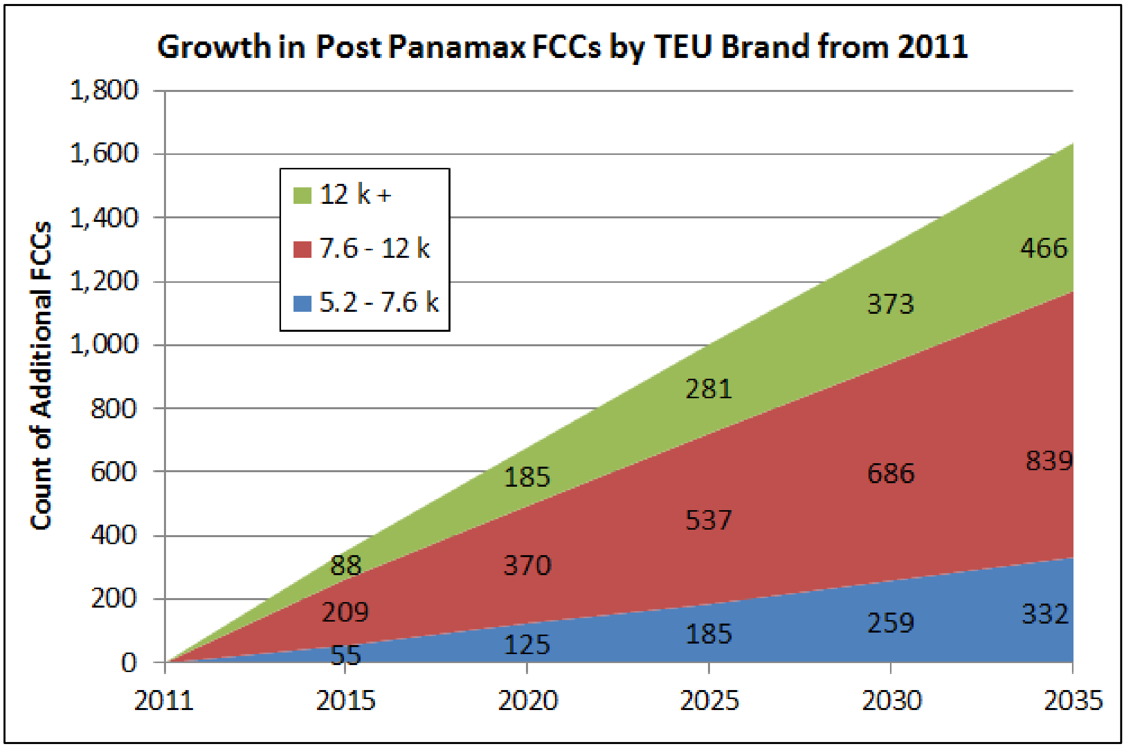


Figure 21: World Fleet Growth Forecast of Selected TEU Bands

3.4.2 Container Vessels Calling at Port of Charleston

3.4.2.1. Trade Through North America and Charleston Vessel Capacity

The Lloyd's Shipping Economist (LSE) is an annual publication that details the fleet deployment on most containership service routes. The report details the number of vessels deployed on each service by TEU-band. MSI had access to these publications since 2000, and used those as an indicator of deployment for the year prior to publication.

The TEU bands used by LSE do not specify vessel capacity. MSI used LR Fairplay data to calculate the average vessel size within the LSE size bands for each year. This capacity estimate was used to estimate the nominal capacity deployed on each route. For the purpose of this study all the services calling North American ports were aggregated.

The capacity deployed on each trade route was compared to the annual container volumes for the U.S. using a simple regression technique. The fit showed a very high R-squared of 94 against the observed data. This close relationship demonstrates how capacity is adjusted by operators to match demand. Figure 22 shows this relationship.

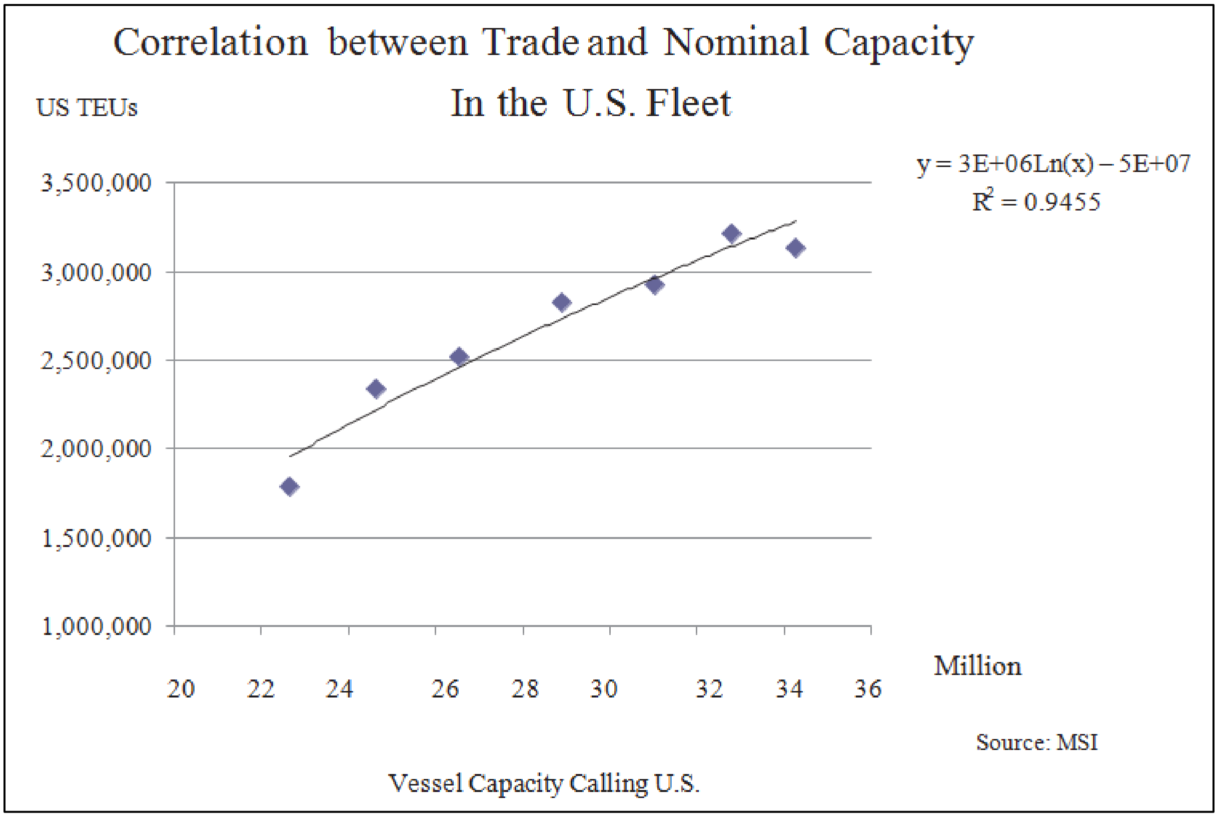


Figure 22: Correlation between Trade and Nominal Capacity in the U.S. Fleet

Similarly, MSI preformed an analysis of port throughput at an East Coast port with characteristic similar to that of Charleston's. TEU capacity of vessels calling at the port in each of the years between 2000 and 2010 was compared to TEUs. MSI noted a very high R-squared value of 0.967, confirming that forecasted trade volumes could be used to forecast capacity deployed on services calling at this port in the future. For the Charleston Post 45 study, this relationship was assumed between trade volumes and nominal capacities for the Port of Charleston. The correlation equation is as follows:

Equation 2: Nominal Capacity = 2.718(TEU) – 79967

Table 26 and Table 27 show the historical calls at Charleston by Size band and the percent share of the calls.

Table 26: Historical Vessel Calls at Charleston by Size Band 2000 to 2011

TEU	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0.1 - 1.3 k	319	288	217	195	220	271	316	310	258	111	75	79
1.3 - 2.9 k	782	788	670	709	767	728	685	590	499	488	491	495
2.9 - 3.9 k	404	405	489	487	473	510	555	559	572	525	495	525
3.9 - 5.2 k	0	0	0	8	4	2	104	128	141	107	173	150
5.2 - 7.6 k	0	0	0	0	0	1	0	0	0	0	41	57
7.6 - 12 k	0	0	0	0	0	0	0	0	0	0	0	5
12 k +	0	0	0	0	0	0	0	0	0	0	0	0

Table 27: Historical Share of Nominal Vessel Capacity Calling by TEU Band

TEU Bands	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0.1 - 1.3 k	2%	1%	1%	1%	1%	2%	1%	0%	0%	0%	0%	0%
1.3 - 2.9 k	33%	32%	24%	25%	27%	24%	21%	22%	16%	12%	9%	6%
2.9 - 3.9 k	27%	29%	32%	30%	33%	32%	25%	23%	21%	18%	14%	12%
3.9 - 5.2 k	38%	37%	43%	44%	39%	42%	42%	44%	56%	66%	58%	65%
5.2 - 7.6 k	0%	0%	0%	0%	0%	0%	11%	11%	8%	4%	14%	10%
7.6 - 12 k	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	8%
12 k +	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: MSI

3.4.2.2 Forecasted Vessel Capacity Calling Charleston

The Charleston TEU forecast was used to estimate total annual nominal capacity calling at Charleston for the years 2012 to 2037. The forecast was developed using the linear regression equation shown in Equation 2. Once the study team determined the total annual nominal capacity over the period of analysis, the estimated capacity was allocated into TEU bands since this demand is likely to be satisfied by a range of vessels. The allocation was based on TEU band shares developed by MSI.

3.4.2.3 Forecasted Post-Panamax Share of Vessel Capacity

The forecasted capacity calling at Charleston was allocated to Post-Panamax vessel classes according to MSI's forecast of capacity share, as shown in Table 28.

Table 28: Forecasted Share of Post-Panamax Vessel Capacity

Vessel Class	TEU Bands	2012	2015	2020	2025	2030	2035	2037
Gen I	5.2 - 7.6 k	21%	36%	45%	39%	31%	24%	22%
Gen II	7.6 - 12.0 k	11%	19%	26%	33%	40%	45%	47%
Gen III	12.0 k +	0%	0%	0%	10%	17%	23%	25%
TOTAL		**31%**	**55%**	**71%**	**83%**	**88%**	**92%**	**94%**

Source: MSI

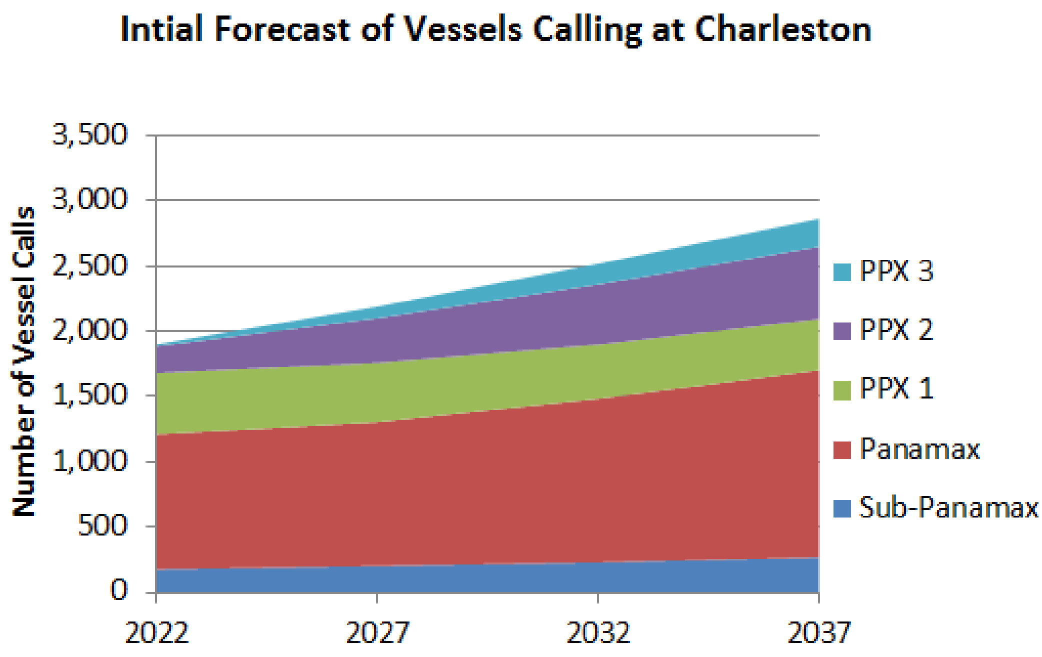
3.4.2.4 Initial Forecast of Post-Panamax Vessel Calls at Charleston

At this point, the PDT focused on developing an initial forecast of vessel calls on Charleston. This began with an assessment of the number of Sub-Panamax calls. As shown in Table 26 above, Sub-Panamax vessels up to 3.9k TEUs have steadily declined from 2000 to 2011. Based on the MSI forecast of the world fleet, these vessels are projected to decline during the period of analysis; however, they will continue to call on the harbor. Therefore, to account for this continued decline, the 2011 share of calling capacity for Sub-Panamax vessel was decreased by 50 percent from historical values on each trade lane.

Next, the PDT estimated the number of vessel calls for PPX 1, 2, and 3 vessels, since it is these vessels that will become more efficient with a deeper channel. The number of calls for each class was calculated using the composition of capacity calling provided in the MSI fleet forecast. In the forecast, the capacity of PPX 1 vessels anticipated to call in the future was forecasted by evaluating the calling capacity in the

5.2k to 7.6k TEU range. The PPX 2 vessels were included in the 7.6k to 12k TEU range and the PPX 3 vessels were included in the 12k TEU or higher range.

The initial forecast of containerized vessels through the year 2037 is depicted in Figure 23. These values were input into HarborSym's Container Loading Tool (CLT), which then estimated the number of vessel calls required to satisfy the commodity forecast, given the available fleet. The HarborSym model is discussed in Section 4.1.1. The CLT data and loading algorithm is discussed in Section 4.1.2.



Vessel Class	2022	2027	2032	2037
Sub-Panamax	176	202	229	269
Panamax	1,035	1,103	1,255	1,434
PPX 1	470	456	416	392
PPX 2	206	342	460	555
PPX 3	16	89	161	214
Total	**1,903**	**2,192**	**2,520**	**2,863**

Figure 23: Forecast of Vessel Calls at Charleston

3.5 Channel Widening

The following measures were identified for improved meeting areas in Charleston Harbor. These measures were modeled in HarborSym by changing the reach widths and removing the passing/meeting rules that these measures would alleviate, unless noted otherwise. Interviews with Pilots indicate that in the without project condition, Pilots have used areas in the lower harbor that are beyond but adjacent to the Federal channel where the natural depth is nearly equivalent to the existing project depth. Both of these areas are relatively short compared to the channel reaches they abut, but they have allowed pilots to create more room for two vessels to meet and pass each other with greater distance between them, and therefore a greater margin of safety. The areas are also used to gain a more favorable angle of attack on the next turn, especially in certain phases of tidal currents, again to increase the margin of safety in these maneuvers.

However, because these areas are outside the channel, they are not regularly surveyed, and the depths are not known with the same reliability as the channel. That results in these areas being restricted to ships of limited draft, more so than the federal channel, to maintain greater clearance between the bottom of the ship and the bottom of the harbor, to account for the relatively limited assurance of water depth. Though these areas will likely require very little dredging, it is critical to incorporate areas that naturally provide a strategic advantage to navigational safety into the Federal channel. As ships get larger and typical ship drafts get deeper, these natural attributes of the harbor will certainly add to the navigational safety of the port, but only if they are included within the federal channel boundaries so that they are included in funded survey programs that monitor and maintain federal channels.

The following sections discuss the proposed channel modifications and the changes to shipping operations with those changes in place. These modifications were modeled using the HarborSym Tool.

3.5.1 Segment 1

- Extend buoys in Mt. Pleasant Reach into existing deep water as a non-structural measure.
  - Widen the southern (outbound or green buoy) side of the reach about 200 feet in an area of existing deep water with depths ranging from about 65 to 69 feet deep.
  - Widen the northern (inbound or red buoy) side of the reach 100 feet in an area of existing deep water ranging from about 71 to 54 feet deep.
- Widen Bennis and Horse Reaches, to improve from one-way to future two-way traffic.
  - Widen Bennis Reach on the inbound (red buoy) side between buoys R28 and R34 and the outbound (green buoy) side from G27 to G35 and examine a maximum width of 100 feet.
  - Widen Horse Reach on the outbound (green buoy) side from Bennis Reach to G35 and examine a maximum width of 100 feet.
- Extend the west (outbound or green buoy) side of the Hog Island Reach, along the existing heading to intersect with Custom House Reach and evaluate a 275-foot widening measure parallel to the outbound side of Hog Island reach between green buoys 37 and 35 to accommodate two-way traffic passage as ships meet in the southern section of Hog Island Reach while preparing to navigate the turn.
- Widen Hog Island Reach, to accommodate two-way traffic along the entire length of the inbound or red buoy side of the reach and examine a maximum width of 100 feet.
- Widen Wando River Lower Reach[13], along the outbound or green buoy side of the reach to minimize the necessity of ships having to crab during specific weather conditions (even with tug assistance), effectively increasing beam width. Evaluate a maximum width of 100 feet.
- Expand existing Wando Welch Terminal turning basin, to accommodate new post panamax container ships by evaluating a maximum turning diameter of 1,800 feet.

3.5.2 Segment 2

- Widen Drum Island Reach and Myers Bend, to change the traffic pattern from one way to two-way. Evaluate a maximum width of 200 feet on the inbound side at the point of intersection of Drum Island Reach with Myers Bend near buoy R46 and a maximum width of 100 feet on the outbound side of the reach of Drum Island Reach near buoy G45.
- Expand Daniel Island Reach Turning Basin for new post panamax container vessels. Evaluate a maximum turning diameter 1,800 feet to accommodate the post panamax vessels. Need increase to operate but will not change transiting rules once constructed.

3.5.3 Segment 3

- Widen Clouter Creek Reach, 50 feet along the north inbound side of Clouter Creek Reach from about from buoy R50A to R52. Pilots indicate smaller ships may have room to pass with the proposed 50-foot widening measure in the Clouter Creek Range.
- Widen North Charleston and Filbin Reaches, by 50 feet on the inbound side of the channel for the entire length of each reach to reduce bank suction effects on docked ships at petroleum terminals in those reaches or shift the channel to avoid those impacts.
- Widen the intersection of the Filbin and Port Terminal Reaches on the east (inbound) side of the channel north of R58 for passing of a petroleum tanker at 801’ length x 140’ width and a 965’ length x 106’ width containership. Evaluate a maximum width of 100 feet.
- Expand turning basin at Ordnance Reach and evaluate a maximum turning diameter of 1,650 feet. This is to accommodate the Post-Panamax vessels (up to PPX II) anticipated to call on the terminal. The increase is needed to operate but does not change transiting rules once it has been constructed.

4.0 Transportation Cost Savings Benefit Analysis

The purpose of this analysis is to describe the benefits associated with the deepening and widening at the Port of Charleston channels. NED benefits were estimated by calculating the reduction in transportation cost for each project depth using the HarborSym Modeling Suite of Tools (HMST) developed by IWR. The HMST reflects USACE guidance on transportation cost savings analysis[14]. Separate models runs were completed for the origin-to-destination (OD) deepening benefits and the tidal advantage and meeting area benefits.

Within this section, the HMST is described in detail, including the widening and deepening aspects, and its application in the Post 45 study. The resulting benefits are described both separately and combined.

4.1 Methodology

Channel improvement modifications result in reduced transportation cost by allowing a more efficient future fleet mix and less congestion when traversing the port. The HMST was designed to allow users to

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[14] HarborSym, the Container Loading Tool (CLT), and the Bulk Loading Tool (BLT) are USACE certified planning models. See Attachment 1 for certification documentation.

model these benefits. With a deepened channel, carriers will be able to load Post-Panamax vessels more efficiently and thereby reduce transiting costs. In the future, these carriers are anticipated to replace smaller less efficient vessels with the larger more efficient vessels on East Coast service lanes that will call on Charleston Harbor. There are three primary effects from channel deepening that can induce changes in the future fleet at Charleston. The first is an increase in a vessel's maximum practicable loading capacity, if the vessel is depth constrained in the current channel. Channel restrictions can limit a vessels capacity by limiting its ability to load to its design draft. Deepening the channel can reduce this constraint and the vessel's maximum practicable capacity can increase towards its design capacity if commodities are available to transit, vessel loading practices allow, and the weight of all commodities on a vessel can "push" deeper into the water. This increase in vessel capacity utilization can result in fewer vessel trips being required to transport the forecasted cargo. The second effect of increased channel depth is the increased operational reliability of water depth, which encourages the deployment of larger vessels to high volume lanes. The third effect is a consequence of the second. The increase in Post-Panamax vessels displaces the less economically efficient Panamax class vessels.

While lesser in magnitude when compared to channel deepening, additional transportation cost saving benefits result from the channel modifications aimed at reducing congestion within the harbor. The creation of meeting areas reduces wait times within the harbor. HarborSym allows for detailed modeling of vessel movements and transit rules on the waterway.

To begin, HarborSym was setup with the basic required variables. To estimate OD cost saving benefits, the Container Loading Tool (CLT), a module within the HMST, was used to generate a vessel call list based on the commodity forecast at the Port of Charleston for a given year, Charleston's share of the world's vessel fleet, and available channel depth under the various alternatives. The resulting vessel traffic was simulated using HarborSym, producing average annual vessel OD transportation costs. The transportation costs saving benefits were then calculated from the existing 45-foot depth for each additional project depth. The Tentatively Selected Plan (TSP) was identified by considering the highest net benefit based on the OD transportation cost saving benefits. The same process was repeated for the Tidal Advantage and Meeting Area benefits, using the Bulk Loading Tool (BLT) to create traffic for non-containerized vessels and combining this traffic with the containerized vessel calls that was generated using the CLT for the OD transportation model.

4.1.1 HarborSym Model

IWR developed HarborSym as a planning level, general-purpose model to analyze the transportation costs of various waterway modifications within a harbor. HarborSym is a Monte Carlo simulation model of vessel movements at a port for use in economic analyses. While many harbor simulation models focus on landside operations, such as detailed terminal management, HarborSym instead concentrates on specific vessel movements and transit rules on the waterway, fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with the ocean voyage.

HarborSym represents a port as a tree-structured network of reaches, docks, anchorages, and turning areas. Vessel movements are simulated along the reaches, moving from the bar to one or more docks, and then exiting the port. Features of the model include intra-harbor vessel movements, tidal influence, the ability to model complex shipments, incorporation of turning areas and anchorages, and within-simulation visualization. The driving parameter for the HarborSym model is a vessel call at the port. A

HarborSym analysis revolves around the factors that characterize or affect a vessel movement within the harbor.

4.1.1.1 Model Behavior

HarborSym is an event driven model. Vessel calls are processed individually and the interactions with other vessels are taken into account. For each iteration, the vessel calls for an iteration that fall within the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all of the docks in the vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route. Potential conflicts with other vessels that have previously entered the system are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If a rule activation occurs, such as no passing allowed in a given reach, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. Vessels move from reach to reach, eventually arriving at the dock that is the terminus of the leg.

After the cargo exchange calculations are completed and the time the vessel spends at the dock has been determined, the vessel attempts to exit the dock, starting a new leg of the vessel call; rules for moving to the next destination (another dock or an exit of the harbor) are checked in a similar manner to the rule checking on arrival, before it is determined that the vessel can proceed on the next leg. As with the entry into the system, the vessel may need to delay departure and re-try at a later time to avoid rule violations and, similarly, the waiting time at the dock is recorded.

A vessel encountering rule conflicts that would prevent it from completely traversing a leg may be able to move partially along the leg, to an anchorage or mooring. If so, and if the vessel can use the anchorage (which may be impossible due to size constraints or the fact that the anchorage is filled by other vessels), then HarborSym will direct the vessel to proceed along the leg to the anchorage, where it will stay and attempt to depart periodically, until it can do so without causing rule conflicts in the remainder of the leg. The determination of the total time a vessel spends within the system is the summation of time waiting at entry, time transiting the reaches, time turning, time transferring cargo, and time waiting at docks or anchorages. HarborSym collects and reports statistics on individual vessel movements, including time in system, as well as overall summations for all movements in an iteration.

HarborSym was initially developed as a tool for analyzing channel widening projects, which were oriented toward determining time savings for vessels transiting within a harbor. It did not allow for assessing changes in vessel loading or in shipping patterns. The most recent release of HarborSym was designed to assist analysts in evaluating channel-deepening projects, in addition to the original model capabilities. The deepening features consider fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with ocean voyage.

Each vessel call has a known (calculated) associated cost, based on time spent in the harbor and ocean voyage and cost per hour. Also for each vessel call, the total quantity of commodity transferred to the port (both import and export) is known, in terms of commodity category, quantity, tonnage and value. The basic problem is to allocate the total cost of the call to the various commodity transfers that are made. Each vessel call may have multiple dock visits and multiple commodity transfers at each visit, but each commodity transfer record refers to a single commodity and specifies the import and export tonnage. Also, at the commodity level, the “tons per unit” for the commodity is known, so that each commodity transfer can be associated with an export and import tonnage. As noted above, the process is greatly simplified if all commodity transfers within a call are for categories that are measured in the same unit, but that need not be the case.

When a vessel leaves the system, the total tonnage, export tonnage, and import tonnage transferred by the call are available, as is the total cost of the call. The cost per ton can be calculated at the call level (divide total cost by respective total of tonnage). Once these values are available, it is possible to cycle through all of the commodity transfers for the vessel call. Each commodity transfer for a call is associated with a single vessel class and unit of measure. Multiplying the tons or value in the transfer by the appropriate per ton cost, the cost totals by class and unit for the iteration can be incremented. In this fashion, the total cost of each vessel call is allocated proportionately to the units of measure that are carried by the call, both on a tonnage and a value basis. Note that this approach does not require that each class or call carry only a commensurate unit of measure.

The model calculates import and export tons, import and export value, and import and export allocated cost. This information allows for the calculation of total tons and total cost, allowing for the derivation of the desired metrics at the class and total level. The model can thus deliver a high level of detail on individual vessel, class, and commodity level totals and costs.

Either all or a portion of the at-sea costs are associated with the subject port, depending on whether the vessel call is a partial or full load. The at-sea cost allocation procedure is implemented within the HarborSym Monte-Carlo processing kernel and utilizes the estimate total trip cargo (ETTC) field from the vessel call information along with import tonnage and export tonnage. In all cases the ETTC is the user’s best estimate of total trip cargo. Within the BLT and CLT, the ETTC field is estimated as cargo on board the vessel at arrival plus cargo on board the vessel at departure, in tons. ETTC can also be expressed as:

$$\text{ETTC} = 2^*\text{Cargo on Board at Arrival} - \text{Import tons} + \text{Export tons}$$

There is a basic algorithm implemented to determine the fraction of at-sea costs to be allocated to the subject port. First, if ETTC for a vessel call is equal to zero or null, then none of the at-sea costs are associated with the port. The algorithm then checks if import or export tons are zero for a vessel call. If either are zero, then the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\text{At-Sea Cost Allocation Fraction} = (\text{Import tons} + \text{Export tons})/\text{ETTC}$$

Finally, when both import and export tons are greater than zero, the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$\text{At-Sea Cost Allocation Fraction} = 0.5 * (\text{Import tons}/\text{Tonnage on board at arrival}) \\ + 0.5 * (\text{Export tons}/\text{Tonnage on board at departure})$$

Where:

Tonnage on board at arrival = (ETTC + Imports – Exports)/2

Tonnage on board at departure = Tonnage on board at arrival – Imports + Exports

4.1.1.2 Data Requirements

The data required to run HarborSym are separated into six categories, as described below. Key data for the Charleston Post 45 study are provided.

Simulation Parameters: Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay. These inputs were included in the model runs for the Charleston Post 45 General Reevaluation. The base year for the model was 2022. A model run was performed for the following years: 2027, 2032, and 2037. After 2037 the forecast number of TEUs was held constant until the end of the period of analysis. Each model run consisted of 10 iterations. The number of iterations was determined to be sufficient when comparing the average time of the fleet in the system. Figure 24 illustrates there is very little variation in vessel time in the system for the OD model runs. For the existing condition OD model run in 2022, the average total vessel time in the system after 10 iterations was 26,431 hours, with a standard deviation of 137 hours.

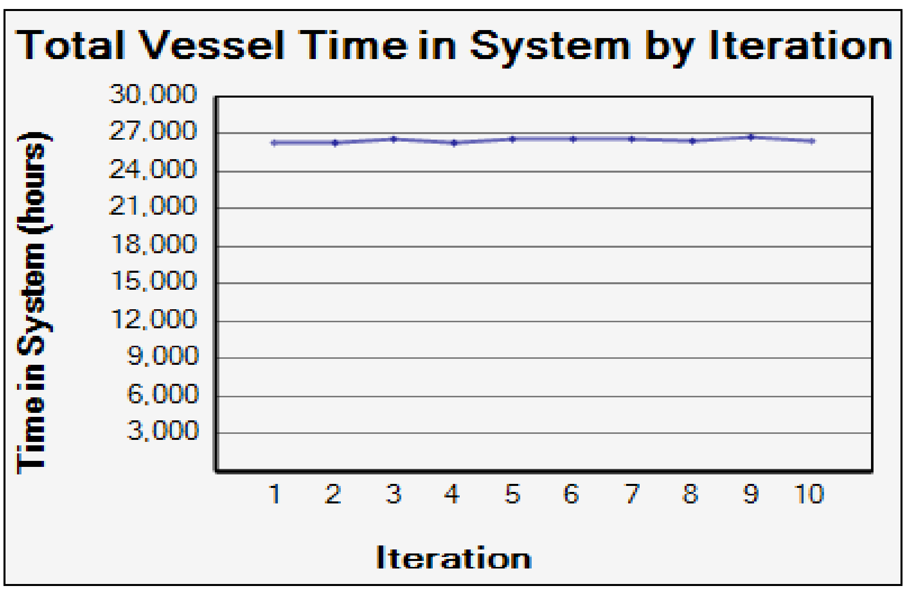

Figure 24: HarborSym Iterations – Hours

Physical and Descriptive Harbor Characteristics: These data inputs include the specific network of Charleston Harbor such as the node location and type, reach length, width, and depth, in addition to tide and current stations. This also includes information about the docks in the harbor such as length and the maximum number of vessels the dock can accommodate at any given time. Figure 25 displays the Node network used for Charleston Harbor.

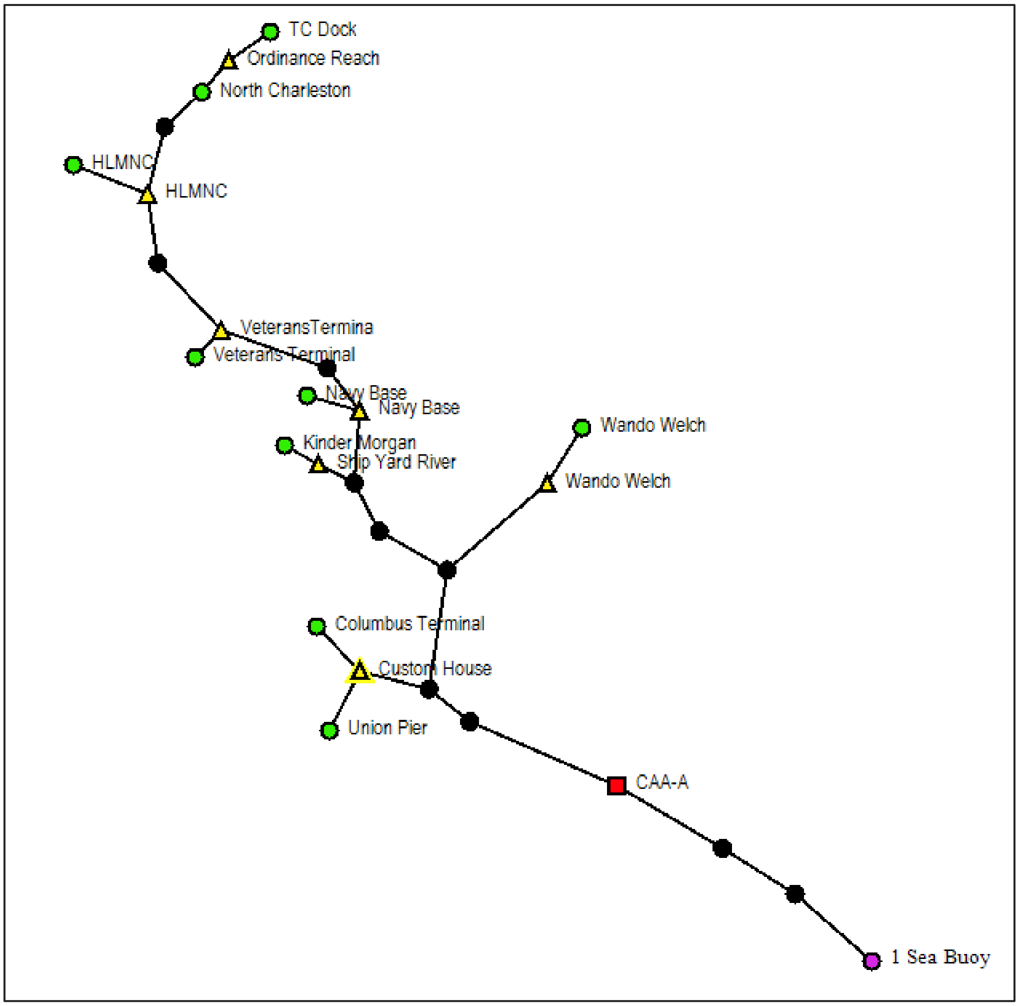

Figure 25: Charleston HarborSym Node Network

General Information. General information used as inputs to the model include: specific vessel and commodity classes, route groups (Table 29), commodity transfer rates at each dock (Table 30), specifications of turning area usage at each dock, and specifications of anchorage use within the harbor. Distances between the route groups were developed by evaluating the 24 trade routes calling on Charleston Harbor in 2011. Those routes were separated into 10 trade lanes based on their world region and itinerary. The route group distance included in the analysis for each trade lane is calculated from the average distance for each trade route that was identified for the specific trade lane.

Table 29: HarborSym Route Groups

Route Group Name	Description	Distance to Prior Port (nautical miles)	Distance to Next Port (nautical miles)	Additional Sea Distance (nautical miles)
Africa	African Continent	415	383	16,311
Carr CA	Caribbean - Central America	404	415	3,311
ECSA	East Coast South America	383	415	15,828
FE ECUS NEUR	Far East - East Coast U.S. - Northern Europe	72	618	30,313
FE ECUS Panama	Far East - East Coast U.S. - Panama	1,557	415	22,531
FE ECUS Suez	Far East - East Coast U.S. - Suez Canal	72	415	24,604
ISCME	Indian Sub-Continent - Middle East	415	72	18,353
MED	Mediterranean	72	3,987	10,420
NEUR	Northern Europe	3,887	423	11,511
WCSA	West Coast South America	525	404	12,514

Table 30: HarborSym Commodity Transfer Rates for Containers

Dock Name	Loading/Unloading Rate for Containerized Commodities (tonnes/hour)		
	Min	Most Likely	Max
Navy Base	950	1,000	1,200
North Charleston	950	1,000	1,200
Wando Welch	950	1,000	1,200

Vessel Speeds. The speed at which vessels operate in the harbor, by vessel class both loaded and light loaded, were determined for each channel segment by evaluating pilot logs and port records and verifying the data with the pilots. Vessel speed inputs are provided in Table 31 for each reach of the node network for containerized vessels.

Table 31: HarborSym Vessel Speed in Reach for Containerships (knots)

Reach	Sub-Panamax		Panamax		PPX1		PPX2		PPX3	
	Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded
Bennis	10	8	10	8	9	7	9	7	9	7
Clouter Creek	10	8	10	8	9	7	9	7	9	7
Custom House	10	8	10	8	9	7	9	7	9	7
Daniel Island	10	8	10	8	9	7	9	7	9	7
Daniel Island Bend	10	8	10	8	9	7	9	7	9	7
Drum Island	10	8	10	8	9	7	9	7	9	7
Filbin	10	8	10	8	9	7	9	7	9	7
Fort Sumter Range	16	14	16	14	15	13	15	13	14	12
HLMNC approach	8	8	8	8	7	7	7	7	7	7
Hog Island	10	8	10	8	9	7	9	7	9	7
Horse	10	8	10	8	9	7	9	7	9	7
Mt. Pleasant	16	14	16	14	15	13	15	13	14	12
Myers Bend	10	8	10	8	9	7	9	7	9	7
Navy Base approach	8	8	8	8	7	7	7	7	7	7
Navy Yard	10	8	10	8	9	7	9	7	9	7
North Charleston	10	8	10	8	9	7	9	7	9	7
Ordinance Lower	6	5	6	5	5	4	5	4	5	4
Ordinance Upper	6	5	6	5	5	4	5	4	5	4
Port Terminal	6	5	6	5	5	4	5	4	5	4
Rebellion	12	12	12	12	11	11	11	11	10	10
Ship Yard Lower	8	8	8	8	7	7	7	7	7	7
Ship Yard Upper	8	8	8	8	7	7	7	7	7	7
Tide Water	10	8	10	8	9	7	9	7	9	7
Town Creek Lower	10	8	10	8	9	7	9	7	9	7
VT approach	8	8	8	8	7	7	7	7	7	7
Wando River Lower	6	5	6	5	5	4	5	4	5	4
Wando River Upper	6	5	6	5	5	4	5	4	5	4

Vessel Operations. Hourly operating costs while in-port and at-sea were determined for both domestic and foreign flagged containerized vessels. Sailing speeds at-sea were also determined. These values are entered as a triangular distribution. The inputs are shown in Table 32.

Table 32: Containerized Vessel Operations

Description	Panamax	PPX 1	PPX 2	PPX 3	Sub Panamax
Foreign Hourly Operating Cost at Sea, Min	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foreign Hourly Operating Cost at Sea, Most Likely	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foreign Hourly Operating Cost at Sea, Max	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foreign Hourly Operating Cost in Port, Min	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foreign Hourly Operating Cost in Port, Most Likely	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Foreign Hourly Operating Cost in Port, Max	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Vessel Speed at Sea, Min (knots)	15.8	15.8	16.93	17.6	15.2
Vessel Speed at Sea, Most Likely (knots)	19.6	20.45	21.69	23	18.2
Vessel Speed at Sea, Max (knots)	23.1	24.6	25.99	27	21

Note: Vessel operating costs are not published because they were developed with information provided by various carriers with the acknowledgment from the Corps of Engineers that the data provided was proprietary in nature.

Reach Transit Rules. Vessel transit rules for each reach reflect restrictions on passing, overtaking, and meeting in particular segments of Charleston Harbor, and are used to simulate actual conditions in the reaches. For the Tidal Advantage and Meeting Area analysis, underkeel clearance requirements are also used along with tide to determine if a vessel can enter the system.

Under the without project condition, vessel movements are restricted for the Tidal Advantage and Meeting Area simulations as described. These rules are not activated in the Origin-Destination simulations to avoid double counting of benefits.

- Mt Pleasant Reach (entrance channel) – currently 2 way traffic is allowed in this reach
- Rebellion Reach – currently 2-way traffic allowed, inbound vessels decrease speed to at least 14 knots
- Bennis Reach – currently 1-way traffic for Post Panamax vessels, with project condition would allow for Post Panamax vessel to pass in this reach; tugs for vessels transiting to Columbus or Union Pier terminal meet vessels in this reach
- Hog Island Reach – currently, 2-way traffic is allowed; tugs for vessels transiting to the Wando Welch terminal meet in this reach around the intersection of the Ravenel Bridge
- Wando River/Lower Reach – 1-way traffic to the Wando Terminal. Widening of the channel is not anticipated to change the navigation restrictions
- Wando River Upper Reach - 1-way traffic, no change in transiting rules with the turning basin improvement
- Drum Island Reach/Myers Bend – currently a 1-way channel; widening to portions of both reaches is anticipated to change traffic to 2-way for Post Panamax vessels; tug assistance for vessel calling

on the new terminal (former Navy Base) are anticipated to meet with vessels in the Drum Island Reach

- Daniel Island Reach – currently 2-way traffic for smaller vessels, Panamax class or less
- Daniel Island Bend – there is no passing allowed in the reach
- Clouter Creek Reach/Navy Yard Reach – no passing allowed in these reaches
- North Charleston Reach – currently 1-way traffic is allowed. With a widening in place, smaller vessel may be allowed to pass (smaller than Panamax class)
- Fiblin Reach – currently 1-way traffic, tugs meet vessel calling on the North Charleston terminal around the Don Holt Bridge
- Port Terminal Reach/Ordinance Reach – 1-way traffic, no change in transiting rules with the turning basin improvement in Ordinance Reach.

Vessels Calls. The vessel call lists are made up of forecasted vessel calls for a given year as generated by the CLT (see Section 4.1.2) and BLT (see Section 4.1.3). Each vessel call list contains the following information: arrival date, arrival time, vessel name, entry point, exit point, arrival draft, import/export, dock name, dock order, commodity, units, origin/destination, vessel type, Lloyds Registry, net registered tons, gross registered tons, dead weight tons, capacity, length overall, beam, draft, flag, tons per inch immersion factor, ETTC, and the route group for which it belongs.

4.1.2 Containerized Vessel Call List

The forecasted commodities for Charleston Harbor were allocated to the future fleet using the CLT. The CLT module produces a containership-only future vessel call list based on user inputs describing commodity forecasts at docks and the available fleet. The module is designed to process in two unique steps to generate a shipment list for use in HarborSym. First, a synthetic fleet of vessels is generated that can service the port. This fleet includes the maximum possible vessel calls based on the user provided availability information. Second, the commodity forecast demand is allocated to individual vessels from the generated fleet, creating a vessel call and fulfilling an available call from the synthetic fleet.

In order to successfully utilize this tool on a planning study, users provide extensive data describing containership loading patterns and services frequenting the study port. The user provides a vessel fleet forecast by vessel class, season, and service, and a commodity forecast by dock, season, and region. The following sections discuss the CLT loading behavior algorithm and the CLT data inputs for the Charleston Post 45 study.

4.1.2.1 CLT Loading Algorithm

The CLT generates a vessel call list by first generating a synthetic vessel fleet based on user inputs. Each vessel in the fleet is randomly assigned physical characteristics based on parameters provided by the user.

To begin, tentative arrival draft is determined for each generated vessel based on user-provided cumulative distribution functions (CDFs). A random draw is made from that CDF and the arrival draft is initially set to that value. The maximum allowable arrival draft is then determined as the minimum of:

1. Prior port limiting depth,
2. Design draft, and
3. Limiting depth at the dock + underkeel clearance + sinkage adjustment + tidal availability + sea level change.

The tentative arrival draft is then compared to the maximum allowable arrival draft, and set to the lesser value, that is, either the statistically estimated value or the constrained value.

Next, the CLT conducts a Loading Factor Analysis (LFA) given the physical characteristics of each generated vessel. LFA explores the relationships between a ships physical attributes, considerations for operations and attributes of the trade route cargo to evaluate the operating efficiencies of vessel classes at alternative sailing drafts. Several intermediate calculations are required. The following variables are used by the LFA algorithm but are calculated from the inputs.

- Vessel operating cost per 1000 miles is calculated as 1000 miles divided by the applied speed times the hourly at sea cost
  = 1000 miles / (Applied Speed X Hourly Cost)

- The allocation of vessel space to vacant slots, empty and loaded containers is calculated by adding the cargo weight per box plus the box weight plus an allowance for the empty

- Total weight per loaded container =
  Average Lading Weight per Loaded TEU by Route (tonnes)
  + Average Container (Box only) Weight per TEU (tonnes)
  + (Average Container (Box only) Weight per TEU (tonnes)*(Percent Empty TEUs))

- Shares of vessel capacity are then calculated as:
  - Cargo Share = Average Lading Weight per Loaded TEU by Route (tonnes)
    Total weight per loaded container in tonnes
  - Laden Container Share = Average Container (Box only) Weight per TEU (tonnes)
    Total weight per loaded container in tonnes
  - Empty Container Share = ((Average Container (Box only) Weight per TEU (tonnes))*(Percent Empty TEUs))
    Total weight per loaded container in tonnes)

- Volume capacity limits are calculated as follows:
  - Number of vacant slots = Nominal TEU Rating * Percent vacant slots
  - Max Occupied Slots = Nominal TEU Rating - Number of vacant slots
  - Max Laden TEUs = Occupied Slots/(1+Percent Empties)
  - Max Empty TEUs = Occupied Slots - Laden TEUs

- Maximum Volume Restricted Tonnage is then calculated as:
  - Max weight for cargo (tonnes) = Max Laden TEUs * Average Lading Weight per Loaded TEU by Route (tonnes)

- Max weight for laden boxes (tonnes) = Max Laden TEUs * Average Container (Box only) Weight per TEU (tonnes)
- Max weight for empties(tonnes) = Max Empty TEUs * Average Container (Box only) Weight per TEU (tonnes)
- Total volume restricted tonnage (cubed out tonnage)(tonnes) = Max weight for cargo + Max weight for laden boxes + Max weight for empties

The LFA proceeds as follows:

- The initial draft is varied from the vessels maximum (loaded) to minimum (empty). At each sailing draft the total tonnage that can be carried is calculated using the Tons Per Inch Immersion (TPI) rating for the vessel.
  - DWT Available for Vessel Draft = DWT Rating (tonnes) – [(Aggregate Maximum Summer Load Line Draft – Sailing Draft)*12 inches*TPI]
- This capacity is then allocated, first to ballast and operations to yield capacity available for cargo.
  - Approximate Variable Ballast = DWT Available for Vessel Draft * Percent Assumption for Variable Ballast
  - Allowance for Operations in tonnes = DWT Rating (tonnes) * Percent Allowance for Operations
  - Available for Cargo = (DWT Available for Vessel Draft)
- (Approximate Variable Ballast) - (Allowance for Operations)
- The capacity available for cargo is restricted if the vessel has "cubed" or "volumed" out:
  - Available for Cargo adjusted for volume restriction if any (tonnes) = the lesser of Available for Cargo and Total volume restricted tonnage (cubed out tonnage)
- The tonnage available for cargo is then allocated to cargo, laden and empty containers based on the shares of vessel capacity:
  - Distribution of Space Available for Cargo (tonnes) = Available for Cargo adjusted for volume restriction if any in tonnes * Cargo Share in percent
  - Distribution of Space Available for Laden TEUs (tones) = Available for Cargo adjusted for volume restriction if any in tonnes * Laden Container Share in percent
  - Distribution of Space Available for Empty TEUs (tonnes) = Available for Cargo adjusted for volume restriction if any * Empty Container Share
- The number of TEUs is then estimated for each share use:
  - Number of Laden TEUs = Distribution of Space Available for Cargo/Average Lading Weight per Loaded TEU by Route (tonnes)
  - Number Empty TEUs = Distribution of Space Available for Empty TEUs /Average Container (Box only) Weight per TEU (tonnes)

- Occupied TEU Slots on Vessel = Number of Laden TEUs + Number Empty TEUs
- Vacant Slots = Nominal TEU Rating - Occupied TEU Slots

- The CLT then calculates the ETTC (estimate of total trip cargo) for each vessel call as the cargo on board the vessel at arrival plus the cargo on board the vessel at departure, in tons.

The CLT works to load each vessel available to carry the commodity on the given route until the forecast is satisfied or the available fleet is exhausted.

4.1.2.2 CLT Data Inputs for Charleston Harbor

There are a number of data required by the CLT. The commodity forecast can be found in Section 3.3 and the vessel fleet can be found in Section 3.4. Vessel sailing draft distributions are critical for determining the benefits of both the meeting area and tide delay analyses due to channel depth and underkeel requirements, as well as determining how much cargo a vessel can carry and thus how many trips are required to satisfy a commodity forecast. Figures 26- through Figure 30 below provide the arrival draft CDFs for containerized vessels by channel depth. The CDFs were developed by evaluating the arrival drafts of the container class vessels calling on the harbor from 2008 to 2011. Each call was separated into a container vessel class depending on the vessel characteristics of each call. A probability curve for the arrival draft of the vessels for the existing and future without project condition was developed using this information. The with-project arrival draft curves were developed with the assistance of the Institute for Water Resources (IWR). The assumption was made that for each additional foot of channel depth available to carriers the average Post-Panamax container vessel would use approximately 0.6 to 0.8 feet of that depth. Therefore, for the analysis, it was assumed that each Post-Panamax container vessel would sail with an additional 0.7 feet for each one foot increment of channel depth evaluated. The restriction placed on this assumption is that once a vessel class reaches its design draft on the curve the class no longer shifts regardless of the channel depth. This assumption explains figure 29 which is the Panamax arrival draft by channel depth. Regardless of channel depth, the Panamax class vessel arrival draft curve does not shift.

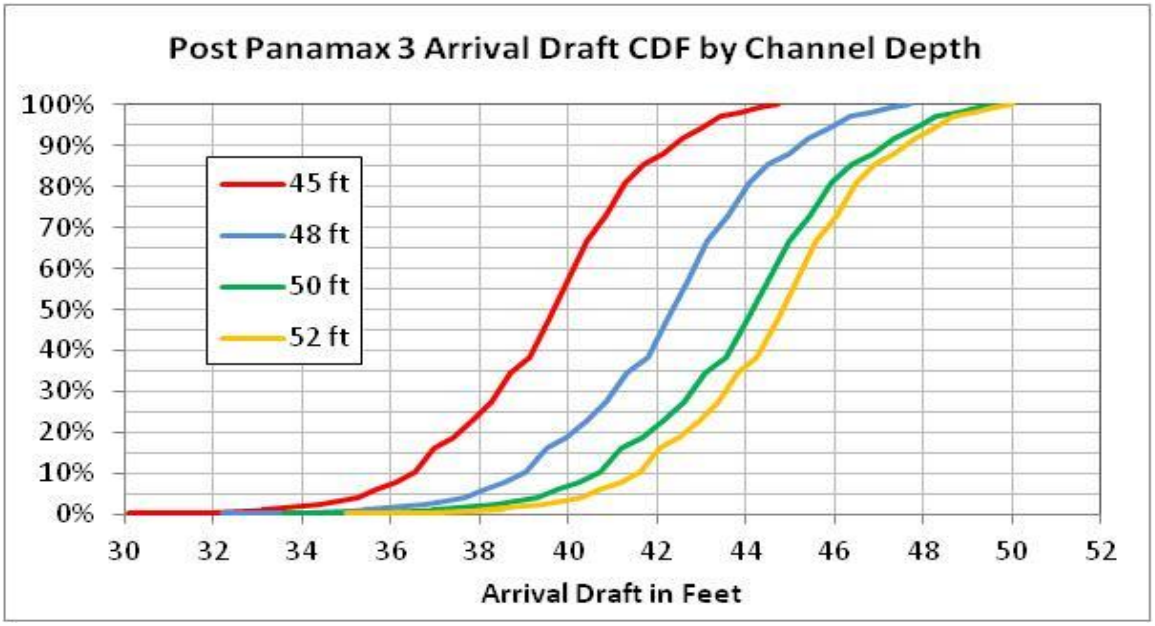

Figure 26: Post Panamax Gen III Arrival Draft by Channel Depth

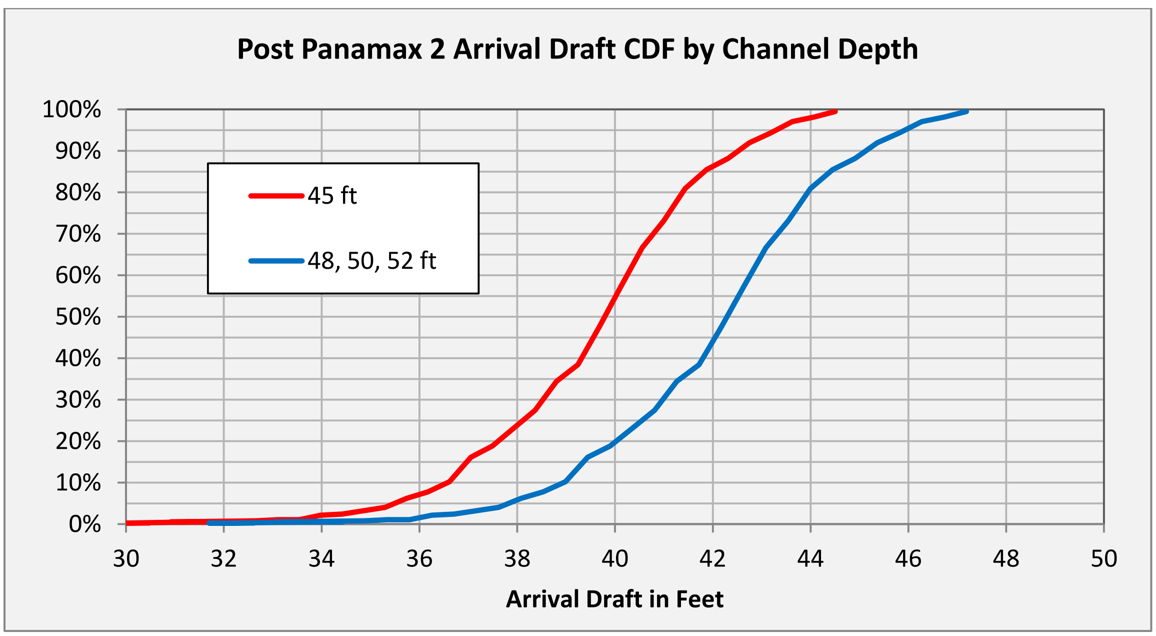

Figure 27: Post Panamax Gen II Arrival Draft by Channel Depth

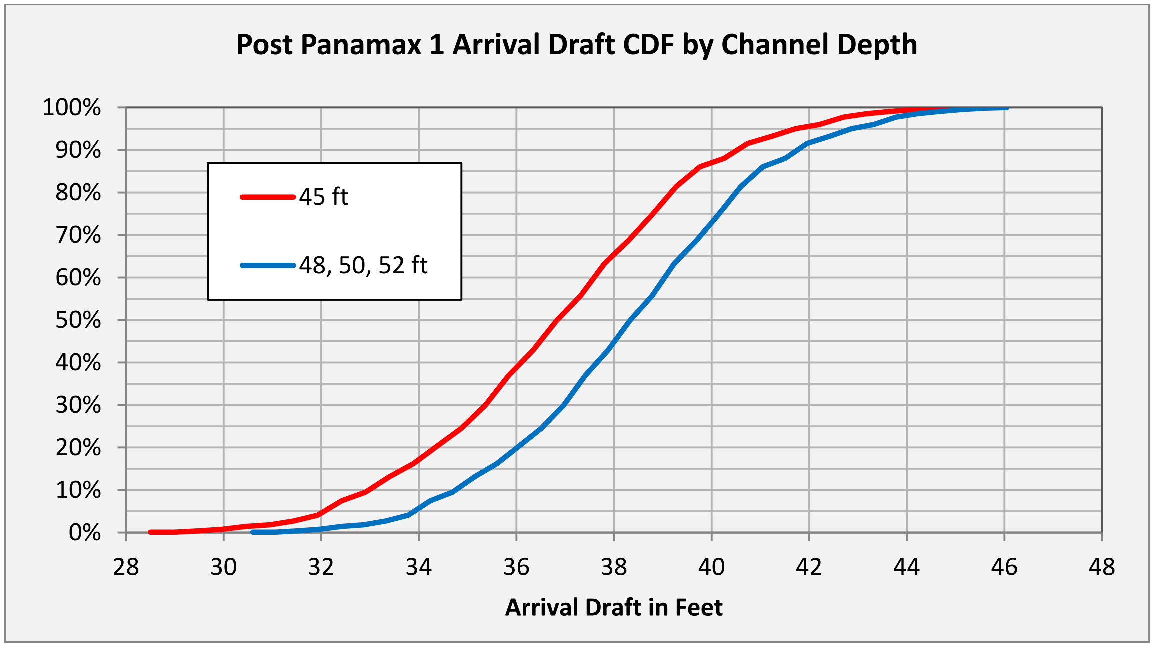

Figure 28: Post Panamax Gen I Arrival Draft by Channel Depth

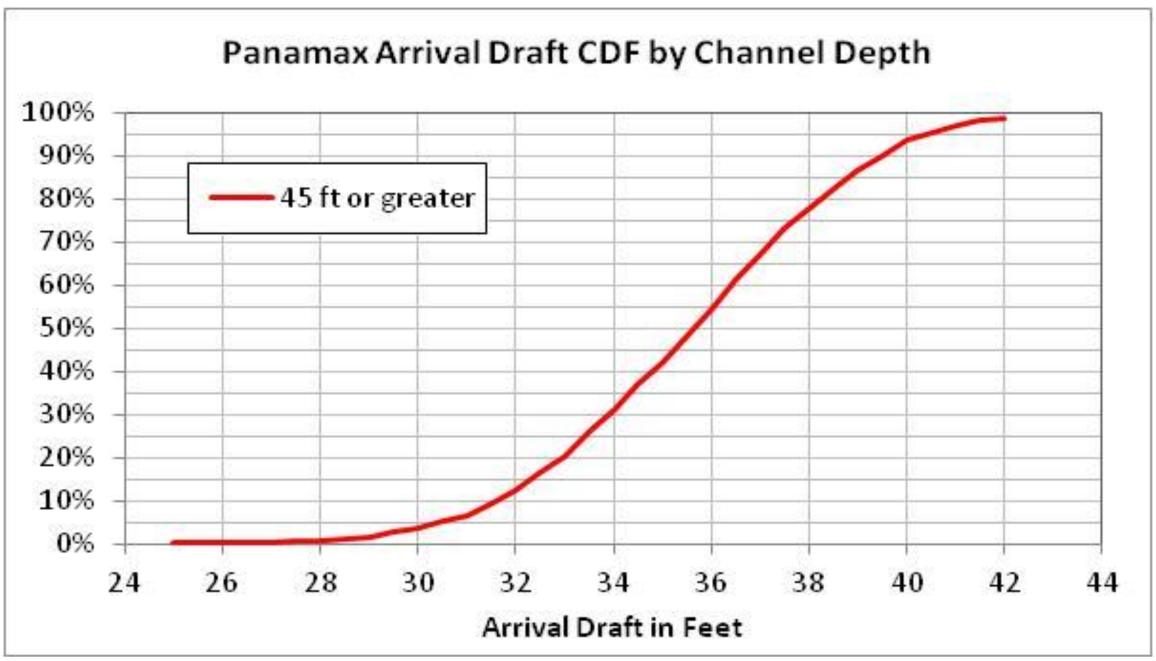

Figure 29: Panamax Arrival Draft by Channel Depth

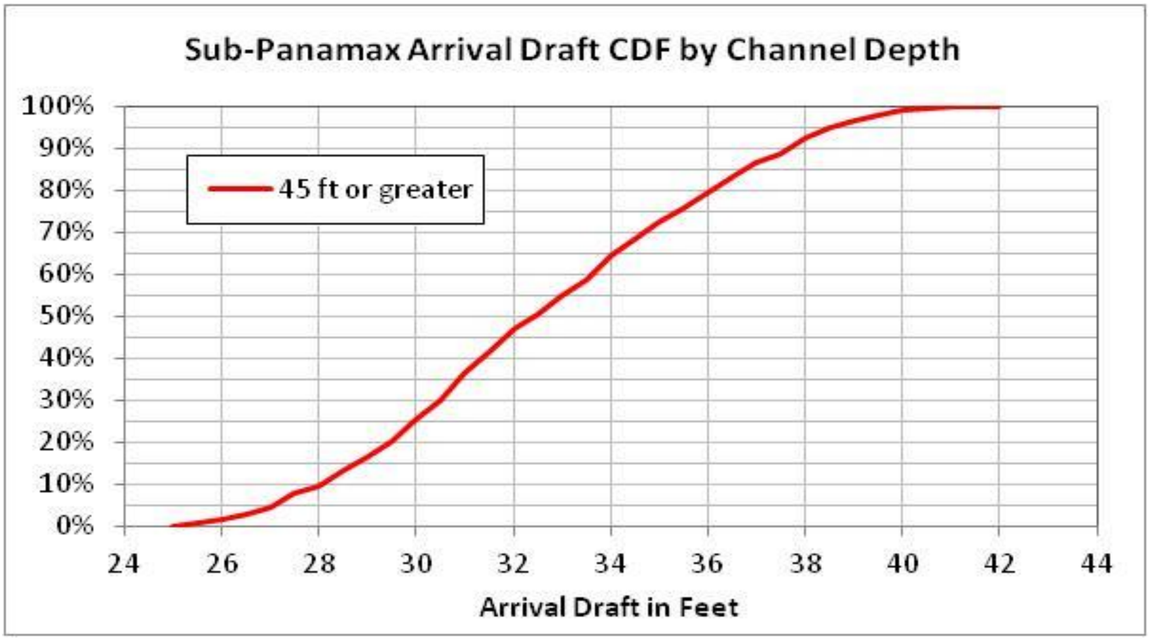

Figure 30: Sub-Panamax Arrival Draft by Channel Depth

Table 33 provides the vessel class assumptions used in the LFA, such as average lading weight per TEU (see Section 2.3.3), container weight, vacant slot allotment, variable ballast, import/export fraction (cargo share), etc. These inputs were developed using historical data provided by the Port and with the assistance of IWR (Lading Weight per Loaded TEU, Empty TEU and Vacant Slot allotment, Operations Allowance, and Variable Ballast by trade lane). The import/export fractions were calculated by evaluating the tonnage (both imports and exports) handled at the Port of Charleston for each individual call and the estimated total tonnage on each vessel, taking into account the vessel characteristics (LOA, beam, design draft, design hull, etc…) and each vessels sailing draft when calling on the harbor, by vessel class.

Table 33: Vessel Class Inputs

Service	Vessel Class	AVG Lading Weight Per Loaded TEU (tonnes)	AVG Container Weight Per TEU (tonnes)	Empty TEU Allotment	Vacant Slot Allotment	Operations Allowance (% of DWT)	Variable Ballast (% of DWT)	Import Fraction			Export Fraction		
								Min	Most Likely	Max	Min	Most Likely	Max
FE ECUS NEUR[1]	Panamax	8.2	2	11.4	7.6	7.1	14.9	0.02	0.08	0.09	0.02	0.10	0.11
FE ECUS NEUR	PPX 1	8.2	2	11.4	7.6	7.1	14.9	0.02	0.08	0.08	0.02	0.10	0.10
FE ECUS NEUR	PPX 2	8.2	2	11.4	7.6	7.1	14.9	0.02	0.08	0.08	0.02	0.10	0.10
FE ECUS NEUR	PPX 3	8.2	2	11.4	7.6	8.2	13.0	0.02	0.08	0.08	0.02	0.10	0.10
ISCME[2]	Sub-Panamax	8.6	2	2.5	4.7	8.5	14.9	0.15	0.16	0.19	0.20	0.22	0.27
ISCME	Panamax	8.6	2	2.5	4.7	7.1	14.9	0.15	0.16	0.26	0.18	0.22	0.24
ISCME	PPX 1	8.6	2	2.5	4.7	7.1	14.9	0.16	0.16	0.16	0.18	0.19	0.20
ISCME	PPX 2	8.6	2	2.5	4.7	7.1	14.9	0.16	0.16	0.16	0.18	0.19	0.20
ISCME	PPX 3	8.6	2	2.5	4.7	8.2	13.0	0.16	0.16	0.16	0.18	0.19	0.20
MED[3]	Sub-Panamax	8.9	2	2.5	4.7	8.5	14.9	0.02	0.03	0.03	0.05	0.05	0.05
MED	Panamax	8.9	2	2.5	4.7	7.1	14.9	0.03	0.06	0.07	0.10	0.12	0.15
MED	PPX 1	8.9	2	2.5	4.7	7.1	14.9	0.03	0.05	0.05	0.12	0.12	0.12
MED	PPX 2	8.9	2	2.5	4.7	7.1	14.9	0.05	0.05	0.08	0.12	0.12	0.12
MED	PPX 3	8.9	2	2.5	4.7	8.2	13.0	0.05	0.05	0.08	0.12	0.12	0.12
NEUR[4]	Sub-Panamax	8.2	2	2.0	4.7	8.5	14.9	0.07	0.08	0.10	0.06	0.09	0.09
NEUR	Panamax	8.2	2	2.0	4.7	7.1	14.9	0.07	0.13	0.15	0.13	0.14	0.17
NEUR	PPX 1	8.2	2	2.0	4.7	7.1	14.9	0.07	0.13	0.13	0.13	0.14	0.17
NEUR	PPX 2	8.2	2	2.0	4.7	7.1	14.9	0.07	0.13	0.13	0.13	0.14	0.17
NEUR	PPX 3	8.2	2	2.0	4.7	8.2	13.0	0.07	0.13	0.13	0.13	0.14	0.17
FE ECUS Panama[5]	Sub-Panamax	8.2	2	6.5	7.6	8.5	14.9	0.07	0.07	0.07	0.00	0.00	0.00
FE ECUS Panama	Panamax	8.2	2	6.5	7.6	7.1	14.9	0.13	0.15	0.20	0.14	0.20	0.22
FE ECUS Panama	PPX 1	8.2	2	6.5	7.6	7.1	14.9	0.14	0.14	0.14	0.14	0.14	0.14
FE ECUS Panama	PPX 2	8.2	2	6.5	7.6	7.1	14.9	0.14	0.14	0.14	0.14	0.14	0.14
FE ECUS Panama	PPX 3	8.2	2	6.5	7.6	8.2	13.0	0.14	0.14	0.14	0.14	0.14	0.14
FE ECUS Suez[6]	Panamax	8.7	2	8.7	4.7	7.1	14.9	0.07	0.14	0.22	0.09	0.14	0.20
FE ECUS Suez	PPX 1	8.7	2	8.7	4.7	7.1	14.9	0.17	0.18	0.18	0.12	0.12	0.12
FE ECUS Suez	PPX 2	8.7	2	8.7	4.7	7.1	14.9	0.20	0.20	0.20	0.14	0.15	0.15
FE ECUS Suez	PPX 3	8.7	2	8.7	4.7	8.2	13.0	0.18	0.20	0.22	0.15	0.15	0.15
Africa	Sub-Panamax	9.5	2	2.0	4.7	8.5	14.9	0.06	0.06	0.06	0.20	0.20	0.20
Africa	Panamax	9.5	2	2.0	4.7	7.1	14.9	0.04	0.04	0.04	0.12	0.13	0.13
ECSA[7]	Sub-Panamax	9.8	2	30.2	6.1	8.5	14.9	0.10	0.10	0.10	0.12	0.13	0.13
ECSA	Panamax	9.8	2	30.2	6.1	7.1	14.9	0.10	0.13	0.17	0.14	0.17	0.20
WCSA	Sub-Panamax	10	2	30.2	6.1	8.5	14.9	0.06	0.06	0.06	0.12	0.12	0.12
WCSA	Panamax	10	2	30.2	6.1	7.1	14.9	0.07	0.07	0.07	0.13	0.20	0.22
Carr CA[8]	Sub-Panamax	7.5	2	6.5	7.7	8.5	14.9	0.10	0.10	0.10	0.16	0.16	0.16

Table 34 provides details on the vessel subclasses, which is used by the CLT to create vessels to satisfy the commodity forecast. The user provides the linkage between the HarborSym vessel class and the IWR-defined vessel subclass. The percentage share of each subclass was defined by historical data provided by the Port.

Table 34: Vessel Subclass Inputs

Vessel Class	Vessel Subclass	LOA	LBP	Beam	Maximum SLLD	Capacity (DWT)	Applied Draft	TEU Rating	TPI Factor	Sinkage Adjustment	% of Class
Sub Panamax	SPM - Ag - CL 7	571	534	87	31	20,643	31.00 to 31.99	1,447	87	0.3	0.4
Sub Panamax	SPM - Ag - CL 8	576	540	84	32	22,184	32.00 to 32.99	1,529	87	0.3	11.2
Sub Panamax	SPM - Ag - CL 9	585	549	90	33	24,283	33.00 to 33.99	1,618	94	0.3	0.4
Sub Panamax	SPM - Ag - CL 10	596	559	92	35	24,812	34.00 to 34.99	1,778	96	0.3	6
Sub Panamax	SPM - Ag - CL 11	603	566	92	36	25,370	35.00 to 35.99	1,895	97	0.3	4.4
Sub Panamax	SPM - Ag - CL 12	657	621	98	36	31,139	36.00 to 36.99	2,268	114	0.3	22.4
Sub Panamax	SPM - Ag - CL 13	676	636	99	38	33,887	37.00 to 37.99	2,470	118	0.3	55.2
Panamax	PMX - Ag - CL 1	777	729	105	38	42,183	38.00 to 38.99	3,084	146	0.2	6.8
Panamax	PMX - Ag - CL 2	766	723	104	39	43,311	39.00 to 39.99	3,188	143	0.2	12.9
Panamax	PMX - Ag - CL 3	794	753	106	40	44,991	40.00 to 40.99	3,389	150	0.2	3
Panamax	PMX - Ag - CL 4	846	801	106	41	50,070	41.00 to 41.99	3,841	163	0.2	35.8
Panamax	PMX - Ag - CL 5	907	859	106	43	56,792	42.00 to 42.99	4,125	177	0.2	12.3
Panamax	PMX - Ag - CL 6	887	839	104	43	54,885	43.00 to 43.99	3,993	170	0.2	0.9
Panamax	PMX - Ag - CL 7	959	921	106	44	64,956	44.00 to 44.99	4,729	193	0.2	28.3
PPX 1	PPXGn I - CL 5.50	954	905	132	46	80,651	46.00 to 46.99	6,186	222	0.3	100
PPX 2	PPXGn II - CL 10.50	1106	1060	143	48	106,737	47.00 to 47.99	8,670	292	0.3	100
PPX 3	PPXGn III - CL 11.10	1200	1148	158	50	138,080	49.00 to 49.99	12,775	355	0.3	100

4.1.2.3 Containerized Vessel Calls

Vessel calls by vessel class are shown in Table 35. Vessel calls by route group are shown in Table 36. These are a result of the CLT loading algorithm, the containerized trade forecast for Charleston Harbor, the available vessel fleet by service, and the LFA data inputs.

Table 35: Vessel Calls by Vessel Class and Channel Depth

Vessel Class	45	48/47	50/47	52/47	48/48	50/48	52/48
2022							
Sub-Panamax	176	176	176	176	176	176	176
Panamax	1,035	954	950	948	924	921	918
PPX 1	470	470	470	470	470	470	470
PPX 2	206	206	206	206	206	206	206
PPX 3	16	16	16	16	16	16	16
Total	**1,903**	**1,822**	**1,818**	**1,816**	**1,792**	**1,789**	**1,786**
2027							
Sub-Panamax	202	202	202	202	202	202	202
Panamax	1,103	996	983	974	975	955	949
PPX 1	456	441	437	436	434	432	431
PPX 2	342	342	342	342	342	342	342
PPX 3	89	89	89	89	89	89	89
Total	**2,192**	**2,070**	**2,053**	**2,044**	**2,042**	**2,020**	**2,012**
2032							
Sub-Panamax	229	229	229	229	229	229	229
Panamax	1,255	1,115	1,090	1,074	1,082	1,055	1,050
PPX 1	416	395	389	387	389	383	380
PPX 2	459	460	459	460	459	460	459
PPX 3	161	161	161	161	161	161	161
Total	**2,520**	**2,359**	**2,328**	**2,310**	**2,320**	**2,287**	**2,279**
2037							
Sub-Panamax	269	269	269	268	269	269	269
Panamax	1,434	1,267	1,228	1,218	1,237	1,199	1,185
PPX 1	392	363	355	352	357	349	346
PPX 2	555	554	554	554	554	555	554
PPX 3	214	214	214	214	214	214	214
Total	**2,863**	**2,666**	**2,619**	**2,605**	**2,631**	**2,585**	**2,568**

Table 36: Vessel Calls by Route Group and Channel Depth

Route Group	45	48/47	50/47	52/47	48/48	50/48	52/48
2022							
Africa	110	109	109	109	109	109	109
Carr CA	22	22	22	22	22	22	22
ECSA	137	137	137	137	137	137	138
FE ECUS NEUR	370	355	352	352	348	347	346
FE ECUS Panama	203	193	193	192	189	189	189
FE ECUS Suez	142	132	132	131	129	129	129
ISCME	179	165	164	164	160	160	160
MED	113	107	108	108	107	106	106
NEUR	511	486	485	485	475	475	473
WCSA	116	116	116	116	115	115	114
Total	**1,903**	**1,822**	**1,818**	**1,816**	**1,792**	**1,789**	**1,786**
2027							
Africa	130	132	132	132	132	132	132
Carr CA	25	25	25	25	25	25	25
ECSA	167	167	167	167	167	167	167
FE ECUS NEUR	430	396	393	392	393	389	388
FE ECUS Panama	272	252	250	249	249	246	245
FE ECUS Suez	174	172	170	168	168	166	165
ISCME	220	196	192	191	189	187	186
MED	122	115	113	113	113	111	111
NEUR	518	481	475	472	472	464	460
WCSA	134	134	135	135	135	135	135
Total	**2,192**	**2,070**	**2,053**	**2,044**	**2,042**	**2,020**	**2,012**
2032							
Africa	171	172	172	172	172	172	172
Carr CA	29	29	29	29	29	29	29
ECSA	220	220	220	220	220	220	220
FE ECUS NEUR	399	380	376	374	375	370	371
FE ECUS Panama	311	288	283	280	283	277	276
FE ECUS Suez	196	192	188	186	188	183	182
ISCME	261	227	221	219	220	215	212
MED	140	132	130	130	131	129	129
NEUR	635	562	552	541	544	532	531
WCSA	159	159	159	159	159	159	159
Total	**2,520**	**2,359**	**2,328**	**2,310**	**2,320**	**2,287**	**2,279**

2037							
Africa	197	198	198	198	198	198	197
Carr CA	43	43	43	43	43	43	43
ECSA	268	266	265	264	265	264	264
FE ECUS NEUR	410	390	387	384	387	383	381
FE ECUS Panama	351	322	316	314	317	310	308
FE ECUS Suez	225	211	206	203	206	200	198
ISCME	291	253	245	242	247	239	236
MED	165	157	153	154	155	153	153
NEUR	730	644	626	622	632	613	607
WCSA	183	182	182	182	182	182	182
Total	**2,863**	**2,666**	**2,619**	**2,605**	**2,631**	**2,585**	**2,568**

4.1.2.4 Charleston Share of World Fleet

The previous tables provided the number of vessel calls by route group and vessel class for the Port of Charleston from 2022, 2027, 2032, and 2037. The estimated number of vessels required to transport the forecast cargo is shown in the following tables. The number of vessels is approximated and was derived by assuming an average string of vessels is made up of eight vessels calling weekly. The equivalent vessel numbers are a result of dividing the number of vessel calls in the previous tables by 52 weeks and multiplying by 8 vessels per service. While some services have fewer than eight vessels and some have more, depending on the frequency of service and the trade route distance, eight vessels is a general average. The percent of world fleet values is derived by simply dividing the equivalent number of vessels in a given year by the number of vessels in the respective classes by the historical and projected world fleet.

The purpose of this analysis and presentation is to serve as a cross check on the reasonableness of the projected number of vessel calls by comparing them to the historical and future world fleet. As shown in Table 37, the historical share of the world fleet calling in Charleston peaked for Panamax vessels in 2005. As PPX1 and PPX2 vessels began calling by 2010, the share of Panamax vessels declined. Table 38 presents the estimated future percent of the world fleet calling Charleston. As shown, it is estimated Charleston's share of Panamax vessels declines as the channel is deepened. This is because the Post-Panamax vessel classes are able to operate more efficiently with additional channel depth and therefore fewer Panamax vessels are required to satisfy the remaining commodity forecast. Charleston's share of the total world fleet remains consistent throughout the project alternatives.

The conclusion of the "backcheck" confirms that the projected vessel calls for the Port of Charleston do not result in an excessive amount of the total world fleet in the without or with project conditions, and supports the reasonableness of the results.

Table 37: Historical Percent of World Fleet Calling Once Per Week in Charleston

	2000		2005		2010	
45 foot Depth	**Vessels**	**% World Fleet**	**Vessels**	**% World Fleet**	**Vessels**	**% World Fleet**
SPX	55	3%	47	2%	13	0%
PX	205	31%	214	20%	171	12%
PPX1	0	0%	0	0%	30	7%
PPX2	0	0%	0	0%	7	3%
PPX3	0	0%	0	0%	0	0%
TOTAL	**260**	**11%**	**262**	**8%**	**221**	**5%**

Table 38: Estimated Future Percent of World Fleet Calling Once Per Week in Charleston

	2022		2027		2032		2037	
	Vessels	**% World Fleet**	**Vessels**	**% World Fleet**	**Vessels**	**% World Fleet**	**Vessels**	**% World Fleet**
45 foot depth								
SPX	30	1%	35	1%	40	1%	47	1%
PX	179	16%	191	19%	217	25%	248	36%
PPX1	81	8%	79	6%	72	4%	68	3%
PPX2	36	8%	59	12%	79	14%	96	16%
PPX3	3	0%	15	2%	28	3%	37	4%
TOTAL	**329**	**5%**	**379**	**5%**	**436**	**5%**	**496**	**6%**
48-48 foot depth								
SPX	30	1%	35	1%	40	1%	47	1%
PX	160	14%	169	17%	187	22%	214	31%
PPX1	81	8%	75	5%	67	4%	62	3%
PPX2	36	8%	59	12%	79	14%	96	16%
PPX3	3	0%	15	2%	28	3%	37	4%
TOTAL	**310**	**5%**	**353**	**5%**	**402**	**5%**	**455**	**5%**
50-48 foot depth								
SPX	30	1%	35	1%	40	1%	47	1%
PX	159	14%	165	16%	183	21%	208	30%
PPX1	81	8%	75	5%	66	4%	60	3%
PPX2	36	8%	59	12%	80	14%	96	16%
PPX3	3	0%	15	2%	28	3%	37	4%
TOTAL	**310**	**5%**	**350**	**5%**	**396**	**5%**	**448**	**5%**
52-48 foot depth								
SPX	30	1%	35	1%	40	1%	47	1%
PX	159		164	16%	182	21%	205	30%
PPX1	81		75	5%	66	4%	60	3%
PPX2	36		59	12%	79	14%	96	16%
PPX3	3		15	2%	28	3%	37	4%
TOTAL	**309**		**348**	**5%**	**394**	**5%**	**444**	**5%**

4.1.3 Non-Containerized Vessel Call List

The non-containerized vessel call list for future years was developed using the BLT, a tool within the HarborSym Modeling Suite of Tools. Users must provide data to specify the framework for generating the synthetic vessel call list. The BLT relies on much of the information and data from HarborSym, but has data additional specific requirements. Within the BLT, the input requirements include:

- Commodity forecasts (annual import/export) at each dock;
- Description of the available fleet by vessel class, including:
  - Statistical data describing the cumulative distribution function for deadweight tons of vessels within the class,
  - Regression information for deriving length overall (LOA), beam and design draft from capacity,
  - Regression information for calculating TPI based on beam, design draft, capacity and LOA;
  - The number of potential calls that can be made annually by each vessel class;
- Logical constraints describing:
  - Commodities that can be carried by each vessel class,
  - Vessel classes that can be serviced at each dock,
  - Parameters, defined at the vessel class/commodity level for determination of how individual calls and commodity transfers are generated, such as commodity loading factors, allocation priorities, and commodity flow direction (import or export calls).

Procedures exist, using the Extreme Optimization package and some Access routines, to populate much of the required forecast information based on an examination of an existing vessel call list created from historical data. Statistical measures, commodity transfer amounts, and logical constraints can all be derived from an examination of a set of historical calls that have been stored in a HarborSym database. The system populator function facilitates data entry by providing a basis for the forecasts, which the user can edit as necessary.

4.1.3.1 BLT Loading Algorithm

With the user provided input requirements, the BLT creates and loads a synthetic fleet according to the following steps.

1. Generation of a fleet of specific vessels based upon a known number of vessel calls by class and a statistical description of the characteristics of the vessel class. This process begins by generating one specific vessel for each call in the class. The capacity of the vessel is set by a random draw from the cumulative density function that is stored for the class. Based on the regression coefficients that are stored for the class, each of which is of the form:
   - log (parameter) = a + b* log (Capacity)
   - LOA, Beam and Design Draft are determined for the vessel using a linear regression of the form:

TPI = a + b*Beam + c*Design Draft + d*Capacity + e*LOA

- The TPI is calculated based on the previously generated physical characteristics and coefficients stored, at the class level, for this regression model. This process is repeated until a unique vessel is created for each available call in the forecast. If no TPI is generated, the default TPI specified by the user for the vessel class is assigned.

2. Attempt to assign a portion of the commodity forecast at a dock to a vessel. Each commodity forecast at a dock is processed in turn. If a vessel is available that can serve the commodity at the dock, it is loaded for either export only, import only, or both export and import. Potential vessels that can carry the forecast are assigned in a user-specified (at the class level) allocation order, so that the most economical vessel classes will always be used first. Under the current assumptions, a vessel call handles a single commodity at a single dock, i.e., each call consists of a single dock visit and a single commodity transfer (which may contain both an export quantity and an import quantity). The specification of the actual call assignment and commodity loading is dependent upon the maximum that a vessel can draft and still reach and leave the dock.

   - The amount of the commodity forecast that is actually carried on the vessel is used to decrement the remaining quantity to be allocated for that particular commodity forecast. After a single vessel call is assigned to a particular forecast, the total number of remaining available vessels for the class is decremented and the next commodity forecast in turn is processed. That is, each forecast attempts to have a portion of its demand satisfied by a single vessel call and then the next forecast is processed. This is to prevent all of the most efficient vessels from being assigned to a single commodity forecast.
   - This process proceeds, in a loop, continually attempting to assign commodity to a vessel from the remaining available fleet. Whenever a successful assignment is made, this generates a vessel call, dock visit, and the associated commodity transfer. This effort continues until no more assignments to a vessel call can be made, either because all commodity forecasts have been satisfied or there is no available vessel that can service the remaining quantities (because there is no vessel of the required class that can handle the particular commodity/dock combination of the forecast or because no vessel can be loaded to satisfy the dock controlling depth constraint).

3. At the end of the process, when no more assignments are possible, arrival times are assigned for each vessel. The algorithm used to assign arrival times assumes a uniform inter-arrival time for all calls within a class. After the allocation process is complete, the number of calls made by each class of vessel is known. This is used to calculate the inter-arrival time of vessels for that class. The arrival of the first vessel in the class is set randomly at a time between the start of the year and the calculated inter-arrival time, but all subsequent vessel arrivals for the class will have the identical inter-arrival time.

4. The generated vessel calls are written to a HarborSym vessel call database and the user is presented with output information on which commodity forecasts were satisfied, any

remaining unsatisfied forecasts and detailed information on each vessel loading and the vessels that were used to satisfy each commodity forecast.

The intended approach is for the user to work iteratively within the BLT, making runs, examining the forecast satisfaction that is achieved and varying the fleet character and composition for subsequent runs, so that the final result is a balanced, reasonable projection of vessel calls to satisfy the input forecast demand. The BLT provides extensive output to assist the user in this regard.

Once a vessel is determined to be available for loading for a particular forecast, the BLT must determine the type of loading, the quantity loaded, and the arrival draft of the vessel. The user can control certain aspects of the process through data specification, in particular the type of call (import, export or both) and the percent of capacity that is loaded for import and export, as described below.

Any given vessel call can attempt to satisfy an import demand (arrive with cargo for the port, leave empty), an export demand (arrive empty, leave with cargo loaded at the port) or simultaneously an import and export demand (that is, arriving with cargo to unload at the port [import], and then departing with cargo bound for another port [export]), based on the user defined directional movement assigned to the vessel class. Four possibilities are defined for this behavior, with specification at the Vessel Class/Commodity Category level:

- Export Only
- Import Only
- Random
- Both Export and Import

Certain combinations of class and commodity categories might be exclusively import only or export only. A “Random” assignment designates that calls from the class/commodity combination can be either import or export at a dock, but not both simultaneously. If a “Random” type is assigned, then the ratio of calls that will be randomly generated as import is specified.

The quantity of a vessel’s capacity that is to be loaded for satisfaction of the import and export demands is described, again at the Vessel Class/Commodity Category level, by a triangular distribution that specifies a loading factor. A minimum, most likely, and maximum, in percent of total available capacity, is defined for both export and import.

When a vessel is available for satisfying a demand, first the type of satisfaction (import only, export only, random or both) is determined, as noted above. If “random” is associated with the current class/commodity, then a random draw is made from a uniform distribution and compared with the user-specified import ratio, to determine if the call is import only or export only. For example, if the user has entered a value of 70 percent for imports, indicating that 30 percent of the calls are exports, then a random draw is made from a uniform (0.1) distribution. If the random number is less than or equal to 0.7, then the call is assigned as an import, otherwise it is assigned as export.

Once the type of call is determined, the BLT must next ascertain how much capacity can be loaded on the vessel while satisfying the draft constraints. The process is similar for both export and import. First, a draw is made from the respective triangular distribution to get a percentage loading factor. This is then applied to the vessel DWT, adjusted to reduce the available tonnage based on allowance for operations, to get a tentative quantity to be loaded. The import/export capacity to be loaded is adjusted only if the available loading capacity is less than the initial calculation.

The tonnage associated with allowance for operations is based on IWR-developed data given fractional allowance for operations as a function of vessel tonnage (DWT), see Figure 31. The additional draft implied by the tentative quantity to be loaded is calculated based on the vessel TPI. A value of empty vessel draft for each vessel has previously been calculated, based on an assumption that the vessel DWT is associated with the vessel design draft. The empty vessel draft from which loading can start is then calculated as:

Empty Vessel Draft = Design Draft – (DWT/TPI)/12.0

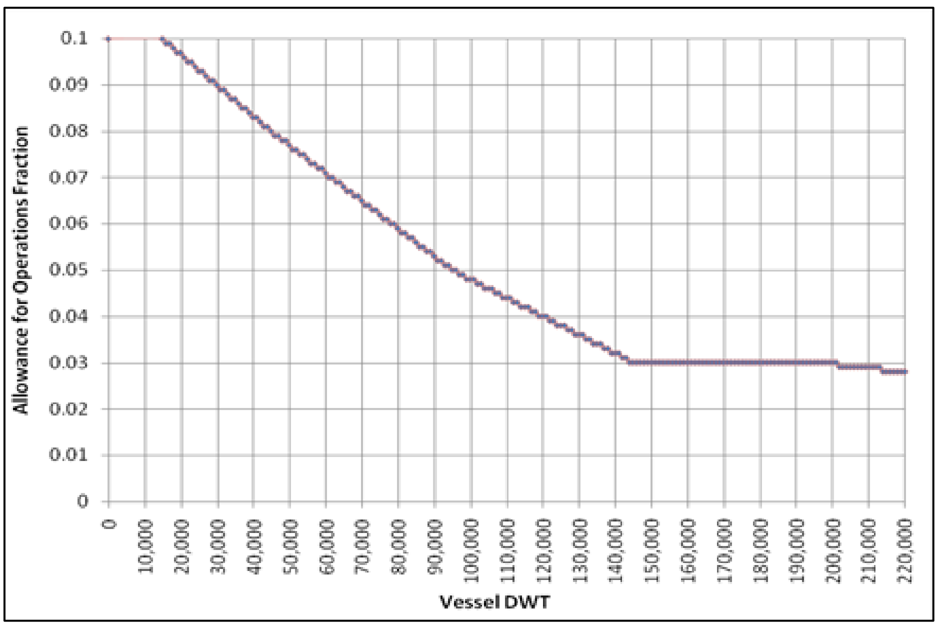

Figure 31: Allowance for Operations by Vessel DWT – Non-containerized Vessels

The total draft associated with the tentative loading is then calculated as the sum of four drafts:

Total Draft (tentative loading) = Empty Vessel Draft + Additional Draft Associated with Tentative Loading + Additional Draft associated with Allowance for Operations + Underkeel Clearance

In order to test the ability of the vessel to arrive at or leave the dock, to this total draft associated with tentative loading must be added the required underkeel clearance (a function of the vessel class). This gives the "test draft" that is checked against the limiting depth to the dock. Note that this is not the same as the eventually calculated arrival draft of the vessel at the bar, which is written to the vessel call data base. If this test draft is greater than the limiting depth to the dock (as defined by user input), the quantity loaded must be reduced, so that the calculated draft is less than the limiting depth to the dock. This calculation is executed to determine if the tentative loading can be reduced sufficiently to meet the dock limiting depth. If so, then the vessel is loaded with the amount of commodity to reach the target draft. If it is not possible to assign a commodity quantity that, when loaded on the vessel, does not exceed the dock limiting depth, then the vessel cannot service the allocation.

Once the commodity allocation has been completed, the vessel loading is known and the arrival draft (at the bar) must be determined. A class level "minimum sailing draft" has been specified by the user at the vessel class level. This minimum sailing draft, or empty vessel draft, reflects the ballasted draft at which a light vessel will sail. If a vessel is handling an export only, then it is assumed to arrive light, at the empty vessel sailing draft. If a vessel is handling an import to the port, then it arrives at the draft associated with the import loading (which may have been reduced to the limiting depth at the dock). It is important to note that underkeel clearance is not included in the arrival draft that is stored in the vessel call database because it does not factor into the actual sailing draft, but, as noted above it is used in checking the constraint associated with the limiting depth to the dock. In practice, underkeel clearance is used in the BLT to handle the depth constraint, but is not incorporated in the actual sailing draft. Underkeel clearance is then added back in as an additional constraint that is applied in HarborSym itself based on sailing rules. In this manner, the arrival draft is consistently calculated based on the sum of empty vessel draft, draft associated with loading, and draft associated with allowance for operations.

The BLT module writes all the needed fields to the vessel call database. Of note is how the ETTC field is handled. Within the BLT, ETTC is populated by simply adding together import tons and export tons, which assumes that all at-sea costs for a vessel call generated by the BLT are allocated to the subject port.

4.1.3.2 BLT Data Inputs

The bulk fleet was developed using historical calls from 2008 to 2011. The growth rate in the fleet was derived from that period and found to be 2.6 percent. This growth rate was assumed in bulk traffic until 2037 and then assumed constant from 2037 to 2071. Table 39 provides the resulting bulk vessel fleet.

Table 39: Non-Containerized Vessel Fleet Forecast

	2022	2027	2032	2037
General Cargo	145	165	187	213
Large Passenger	14	16	19	21
Large RoRo	241	274	312	354
Large Tanker	34	39	45	51
Larger Bulker	49	56	64	72
Medium Tanker	172	196	223	253
Small Bulker	23	25	29	33
Small Dry Cargo	7	9	9	10
Small Passenger	72	81	93	105
Small RoRo	68	78	88	101
Small Tanker	1	2	2	2
Total	826	941	1071	1215

4.2 Origin-Destination Transportation Cost Savings Benefits by Project Depth

Transportation cost benefits were estimated using the HarborSym Economic Reporter, a tool that summarizes and annualizes HarborSym results from multiple simulations. This tool collects the transportation costs from various model run output files and generates the transportation cost reduction for all project years, and then produces an Average Annual Equivalent (AAEQ). Results and calculations were verified using spreadsheet models used in previous deep draft navigation analyses as well.

Transportation costs were estimated for a 50-year period of analysis for the years 2022 through 2071. Transportation costs were estimated using HarborSym for the years 2022, 2027, 2032, and 2037. Since terminal capacity is expected to be reached in 2037, the transportation costs were held constant beyond 2037. The present value was estimated by interpolating between the modeled years and discounting at the current FY 2015 Federal Discount rate of 3.375 percent. Estimates were determined for each alternative project depth.

Table 40 provides the annual transportation costs in total and for the at-sea and in-port portions. For the Origin-Destination (OD) costs, at-sea costs comprise between 93 percent and 94 percent of the total costs and are associated with the Container Fleet. The bulk fleet was evaluated; however, the empirical data supported the conclusion that the benefits to the bulk fleet due to additional channel depth would be minimal. The transportation cost saving benefit is provided in Table 41. The AAEQ transportation costs and cost saving benefits are provided in Table 42. AAEQ cost statistics are provided in Table 43.

Table 40: Origin-Destination Annual Transportation Cost (in Million $)

Annual O-D At-Sea and In-Port Transportation Cost Allocated to Port (Million $)							
Year	**45**	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$780	$746	$745	$744	$735	$734	$733
2023	$819	$781	$778	$777	$770	$767	$766
2024	$858	$816	$812	$811	$805	$801	$799
2025	$897	$851	$846	$844	$840	$834	$832
2026	$935	$886	$879	$877	$874	$867	$864
2027	$974	$921	$913	$910	$909	$900	$897
2028	$1,011	$955	$946	$942	$943	$933	$929
2029	$1,049	$989	$979	$975	$976	$965	$961
2030	$1,086	$1,023	$1,011	$1,007	$1,010	$998	$993
2031	$1,123	$1,057	$1,044	$1,039	$1,044	$1,030	$1,025
2032	$1,160	$1,092	$1,077	$1,072	$1,077	$1,063	$1,057
2033	$1,194	$1,123	$1,107	$1,101	$1,108	$1,093	$1,087
2034	$1,228	$1,154	$1,137	$1,131	$1,139	$1,123	$1,116
2035	$1,262	$1,185	$1,167	$1,161	$1,170	$1,153	$1,145
2036	$1,297	$1,216	$1,197	$1,190	$1,201	$1,183	$1,175
2037-2071	$1,331	$1,247	$1,228	$1,220	$1,231	$1,213	$1,204
Annual OD In-Port Transportation Cost (Million $)							
Year	**45**	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$47	$46	$46	$46	$46	$46	$46
2023	$50	$49	$49	$49	$49	$49	$49
2024	$53	$52	$52	$52	$51	$51	$51
2025	$55	$54	$54	$54	$54	$54	$54
2026	$58	$57	$57	$57	$57	$57	$56
2027	$61	$60	$59	$59	$59	$59	$59
2028	$64	$62	$62	$62	$62	$62	$62
2029	$66	$65	$65	$65	$65	$64	$64
2030	$69	$68	$68	$67	$67	$67	$67
2031	$72	$70	$70	$70	$70	$70	$70
2032	$75	$73	$73	$73	$73	$73	$72
2033	$77	$76	$76	$75	$75	$75	$75
2034	$80	$78	$78	$78	$78	$78	$78
2035	$83	$81	$81	$81	$81	$80	$80
2036	$86	$84	$83	$83	$83	$83	$83
2037-2071	$88	$86	$86	$86	$86	$86	$85
Annual OD At-Sea Transportation Cost Allocated to Port (Million $)							
Year	**45**	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$733	$700	$698	$698	$689	$688	$687
2023	$769	$732	$729	$728	$721	$719	$717
2024	$805	$764	$761	$759	$753	$749	$748
2025	$841	$797	$792	$790	$786	$780	$778

2026	$877	$829	$823	$820	$818	$811	$808
2027	$914	$861	$854	$851	$850	$841	$838
2028	$948	$893	$884	$880	$881	$871	$868
2029	$982	$924	$914	$910	$912	$901	$897
2030	$1,017	$956	$944	$940	$943	$931	$926
2031	$1,051	$987	$974	$969	$974	$961	$955
2032	$1,085	$1,018	$1,004	$999	$1,005	$990	$985
2033	$1,117	$1,047	$1,032	$1,026	$1,033	$1,018	$1,012
2034	$1,148	$1,076	$1,059	$1,053	$1,061	$1,045	$1,038
2035	$1,180	$1,104	$1,087	$1,080	$1,089	$1,072	$1,065
2036	$1,211	$1,133	$1,114	$1,107	$1,117	$1,100	$1,092
2037-2071	$1,243	$1,161	$1,142	$1,134	$1,146	$1,127	$1,119

Notes: Bold values were obtained by model runs, non-bold values were interpolated. Values beyond 2037 were held constant.

Table 41: Origin-Destination Annual Transportation Cost Saving Benefits by Channel Depth (in Million $)

Annual OD At-Sea and In-Port Transportation Cost Saving Benefits (Million $)						
Year	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$33.5	$35.1	$35.6	$44.5	$45.8	$46.6
2023	$37.5	$40.3	$41.4	$48.7	$51.5	$52.7
2024	$41.5	$45.6	$47.1	$52.9	$57.1	$58.8
2025	$45.5	$50.8	$52.8	$57.0	$62.8	$65.0
2026	$49.5	$56.1	$58.5	$61.2	$68.4	$71.1
2027	$53.4	$61.4	$64.2	$65.4	$74.1	$77.2
2028	$56.4	$65.6	$69.0	$68.8	$78.7	$82.3
2029	$59.4	$69.9	$73.8	$72.3	$83.3	$87.4
2030	$62.4	$74.2	$78.6	$75.7	$87.9	$92.6
2031	$65.4	$78.5	$83.4	$79.1	$92.5	$97.7
2032	$68.4	$82.8	$88.2	$82.5	$97.0	$102.8
2033	$71.4	$86.9	$92.8	$85.9	$101.3	$107.5
2034	$74.4	$91.0	$97.3	$89.3	$105.5	$112.3
2035	$77.4	$95.1	$101.9	$92.6	$109.7	$117.0
2036	$80.4	$99.2	$106.4	$96.0	$114.0	$121.7
2037-2071	$83.4	$103.3	$111.0	$99.4	$118.2	$126.4
Annual OD In-Port Transportation Cost Saving Benefits (Million $)						
Year	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$0.8	$0.9	$0.9	$1.1	$1.2	$1.2
2023	$0.9	$1.0	$1.0	$1.2	$1.3	$1.4
2024	$1.0	$1.1	$1.1	$1.3	$1.4	$1.5
2025	$1.1	$1.2	$1.2	$1.4	$1.6	$1.7
2026	$1.2	$1.3	$1.4	$1.5	$1.7	$1.8
2027	$1.3	$1.4	$1.5	$1.6	$1.8	$1.9
2028	$1.4	$1.5	$1.6	$1.7	$1.9	$2.0

2029	$1.4	$1.6	$1.7	$1.8	$2.0	$2.1
2030	$1.5	$1.7	$1.8	$1.9	$2.1	$2.2
2031	$1.6	$1.8	$1.9	$2.0	$2.2	$2.3
2032	$1.7	$1.9	$2.1	$2.1	$2.3	$2.4
2033	$1.7	$1.9	$2.1	$2.1	$2.4	$2.5
2034	$1.8	$2.0	$2.2	$2.2	$2.4	$2.5
2035	$1.9	$2.1	$2.3	$2.3	$2.5	$2.6
2036	$1.9	$2.2	$2.4	$2.3	$2.6	$2.7
2037-2071	$2.0	$2.3	$2.4	$2.4	$2.7	$2.8
Annual OD At-Sea Transportation Cost Saving Benefits (Million $)						
Year	**48/47**	**50/47**	**52/47**	**48/48**	**50/48**	**52/48**
2022	$32.7	$34.2	$34.7	$43.4	$44.6	$45.3
2023	$36.6	$39.3	$40.3	$47.5	$50.2	$51.3
2024	$40.5	$44.5	$45.9	$51.5	$55.7	$57.3
2025	$44.4	$49.6	$51.6	$55.6	$61.2	$63.3
2026	$48.3	$54.8	$57.2	$59.7	$66.8	$69.3
2027	$52.2	$59.9	$62.8	$63.8	$72.3	$75.3
2028	$55.1	$64.1	$67.5	$67.1	$76.8	$80.3
2029	$58.0	$68.3	$72.1	$70.5	$81.3	$85.3
2030	$60.9	$72.5	$76.8	$73.8	$85.8	$90.4
2031	$63.8	$76.8	$81.5	$77.1	$90.3	$95.4
2032	$66.7	$81.0	$86.2	$80.5	$94.8	$100.4
2033	$69.6	$85.0	$90.6	$83.8	$98.9	$105.1
2034	$72.6	$89.0	$95.1	$87.1	$103.1	$109.7
2035	$75.5	$93.0	$99.6	$90.4	$107.2	$114.4
2036	$78.4	$97.0	$104.1	$93.7	$111.4	$119.0
2037-2071	$81.4	$101.0	$108.5	$97.0	$115.6	$123.7

Table 42: Origin-Destination AAEQ Transportation Cost and Cost Saving by Project Depth (Million $)

Project Depth	OD AAEQ Transportation Cost (Million $)	OD AAEQ Transportation Cost Savings (Million $)
45	$1,178.7	-
48/47	$1,108.6	$70.1
50/47	$1,093.8	$84.9
52/47	$1,088.1	$90.6
48/48	$1,094.2	$84.5
50/48	$1,079.8	$98.9
52/48	$1,073.7	$105.0

Table 43: Origin-Destination AAEQ Cost Statistics by Project Depth (Million $)

Statistic	45	48/47	50/47	52/47	48/48	50/48	52/48
Mean	$1,178.7	$1,108.6	$1,093.8	$1,088.1	$1,094.2	$1,079.8	$1,073.7
Standard Deviation	$5.4	$4.6	$4.4	$4.9	$5.0	$5.0	$4.8
Median	$1,179.2	$1,108.6	$1,094.8	$1,088.2	$1,094.5	$1,079.8	$1,073.7
Min	$1,165.9	$1,099.5	$1,084.7	$1,077.5	$1,083.5	$1,069.6	$1,062.9
Max	$1,186.5	$1,116.9	$1,100.2	$1,096.9	$1,101.7	$1,088.3	$1,081.3
Range	$20.5	$17.4	$15.6	$19.3	$18.2	$18.7	$18.4
Confidence for Mean +/-	$3.3	$2.9	$2.7	$3.0	$3.1	$3.1	$3.0

Note: Confidence calculation assumes a normal distribution and 95 percent confidence level

Table 44 provides the OD cost saving benefits for the benefiting trade routes for each alternative depth.

Table 44: Origin-Destination AAEQ Transportation Cost Saving Benefits by Route Group and Project Depth (Million $)

	48/47		50/47		52/47		48/48		50/48		52/48	
Route Group	**$**	**% TOT**	**$**	**% TOT**	**$**	**% TOT**	**$**	**% TOT**	**$**	**% TOT**	**$**	**% TOT**
FE ECUS NEUR	10.7	15%	12.7	15%	13.8	15%	12.8	15%	14.3	15%	15.7	15%
FE ECUS Panama	15.1	22%	18.7	22%	20.0	22%	18.5	22%	22.3	23%	23.8	23%
FE ECUS Suez	7.4	11%	9.7	12%	10.6	12%	9.2	11%	11.8	12%	12.4	12%
ISCME	16.7	24%	20.1	24%	21.4	24%	20.2	24%	23.3	24%	24.7	24%
MED	1.4	2%	1.7	2%	1.8	2%	1.8	2%	1.9	2%	2.0	2%
NEUR	17.9	26%	21.0	25%	22.1	25%	21.0	25%	24.3	25%	25.3	24%

Note: Results for benefiting routes only, totals affected by rounding.

4.3 Tidal Advantage and Meeting Area Benefits

The purpose of this analysis is to describe the Meeting Area and Tidal Advantage benefits achievable with the TSP. The 50/48 and 52/48 project depths were analyzed[15]. The Meeting Area and Tidal Advantage benefits are associated with the reduction in transit time required to navigate Charleston Harbor as a result of channel modifications which will reduce congestion within the harbor and lessen movement restrictions for all vessel classes. Transportation cost savings were estimated in terms of the reduction in harbor transit times and consequent vessel delays. Transit costs were estimate by analyzing the vessel calls most likely to occur with channel deepening against two scenarios: (1) including the inner harbor tidal advantage and meeting area improvements with tide rules enacted and (2) excluding the inner harbor tidal advantage and meeting area improvements with tide rules deactivated. The transit times/costs of these two sets of simulations for were compared to derive the benefits associated with the inner harbor tidal advantage and meeting area improvements. The transportation costs were derived using the HarborSym model as described in Section 4.1. Only in-port transportation costs were assumed, as the tidal advantage and meeting area improvements do not impact the at-sea portion of the vessels' voyage.

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[15] The tide and meeting area benefits for only these alternatives were calculated because these scenarios generate the highest origin to destination net benefits (see tables 41 and 42). Section 3.5.6 of the main report and Table 3-3 discuss this methodology in more detail.

Transportation costs were estimated for a 50-year period of analysis for the years 2022 through 2071. Transportation costs were estimated using HarborSym for the years 2022, 2027, 2032, and 2037. Since terminal capacity is expected to be reached in 2037, the transportation costs for both the container fleet and the non-container fleet were held constant beyond 2037 to simplify the assumptions in the analysis. The present value was estimated by interpolating between the modeled years and discounting at the current FY 2015 Federal Discount rate of 3.375 percent. Estimates were determined for the 50/48 and 52/48 alternative project depths.

Table 45 provides the inner harbor (in-port) Tidal Advantage and Meeting Area transportation costs. The annual transportation cost saving benefit is provided in Table 46. The AAEQ transportation costs and cost saving benefits are provided in Table 47.

Table 45: Tidal Advantage and Meeting Area Annual Transportation Cost (in Million $)

Annual Tidal Advantage/Meeting Area Transportation Cost (Million $)				
Year	50/48 Without	50/48 With	52/48 Without	52/48 With
2022	60.0	57.6	59.9	57.6
2023	62.9	60.4	62.7	60.4
2024	65.7	63.2	65.6	63.2
2025	68.6	65.9	68.5	65.9
2026	71.5	68.7	71.3	68.7
2027	74.4	71.5	74.2	71.4
2028	77.6	74.6	77.5	74.6
2029	80.9	77.7	80.8	77.7
2030	84.2	80.8	84.1	80.9
2031	87.5	84.0	87.4	84.0
2032	90.8	87.1	90.7	87.1
2033	93.8	90.0	93.7	90.1
2034	96.9	92.9	96.8	93.1
2035	100.0	95.9	99.9	96.1
2036	103.1	98.8	103.0	99.0
2037-2071	106.2	101.7	106.1	102.0

Notes: Bold values were obtained by model runs, non-bold values were interpolated. Values beyond 2037 were held constant.

Table 46: Tidal Advantage and Meeting Area Annual Transportation Cost Saving Benefits by Channel Depth (in Million $)

Year	50/48	Total Hours Delayed	52/48	Total Hours Delayed
2022	2.4	710	2.2	666
2023	2.5	741	2.3	701
2024	2.6	771	2.5	736
2025	2.7	802	2.6	770
2026	2.8	833	2.7	805
2027	2.9	818	2.8	795
2028	3.0	863	2.9	836
2029	3.2	909	3.1	876
2030	3.4	955	3.2	917
2031	3.5	1,001	3.4	958
2032	3.7	1,014	3.5	969
2033	3.8	1,059	3.6	1,001
2034	4.0	1,104	3.7	1,033
2035	4.2	1,148	3.9	1,065
2036	4.3	1,193	4.0	1,097
2037-2071	4.5	1,227	4.1	1,118

Notes: Bold values were obtained by model runs, non-bold values were interpolated. Values beyond 2037 were held constant. Total Hours Delayed was calculated by evaluating the total transit cost savings and the average hourly vessel operating costs for the future vessel fleet

Table 47: Tidal Advantage and Meeting Area AAEQ Transportation Cost and Cost Saving Benefits by Project Depth (Million $)

Project Depth	OD AAEQ Transportation Cost (Million $)	OD AAEQ Transportation Cost Savings (Million $)
50/48 Without	$92.5	-
50/48 With	$88.7	$3.8
52/48 Without	$92.4	-
52/48 With	$88.9	$3.5

4.4 Transportation Cost Saving Benefit Analysis

The benefit cost analysis presented in this section is for the project depths determined to be the most likely selected plans based on the OD benefits and the rough order cost analysis. The results of which are displayed in tables 41 and 42. Table 48 below provides the Origin-Destination benefit cost analysis for the 48/48, 50/48, and 52/48. The combined OD and Tidal Delay/Meeting Area benefit cost analysis by project depth are provided in Table 49. As shown, the 52/48 depth provides the greatest total net benefits in the OD analysis as well as the combined tidal advantage/meeting area benefit.

Table 48: Origin-Destination Benefit Cost Analysis (Million $)

Project Depth	Total AAEQ Costs	O-D AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
48/48	$20.90	$84.80	$63.90	-	4.06
50/48	$25.70	$99.20	$73.50	$9.60	3.86
52/48	$28.00	$105.30	$77.30	$3.80	3.76

Table 49: Origin-Destination and Tidal Advantage/Meeting Area Benefit Cost Analysis (Million $)

Project Depth	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
50/48	$25.70	$103.10	$77.4	-	4.01
52/48	$28.00	$108.90	$80.9	$3.50	3.89

Table 49 provides the final revised numbers of the Total AAEQ costs and the Total AAEQ Benefits derived from Table 3-7 of the Main Report. The AAEQ costs are based on the costs included in the Total Project Cost Summary, which includes Interest During Construction, increases in annual costs for O&M dredging and increased maintenance for aids to navigation. The $616,000 increase in costs for the aids to navigation was provided by the USCG, the agency responsible for maintaining navigation markers and aids. The Local Sponsor costs for terminal improvements & dredging of the berthing areas, LSF, ($26,966,000) were included in the total project cost as well. All costs are in 2015 price levels and were annualized using the FY15 (3.375%) discount rate.

4.5 Interest During Construction

Interest during construction (IDC) was calculated assuming that the schedule may vary depending on the time required to obtain congressional authorization and funding. Other areas of project uncertainties include the dredging industry execution of bid and contract requirements, availability of contractors' dredging equipment to comply with environmental windows for sea turtles and other endangered species, and delays due to unexpected weather conditions. Based on these uncertainties the construction duration for the project may vary from 40 to 76 months. For IDC estimating purposes the District used 30 months for PED and 76 month duration for construction, a total duration of 106 months. The IDC was computed with the 2015 fiscal year interest rate of 3.375 percent. Table 50 presents interest during construction for the LPP and the NED plan.

Table 50: Interest During Construction

	IDC for 50'/48' Alternative (Millions - 2015 Dollars)	IDC for 52'/48' Alternative (Millions - 2015 Dollars)
IDC (PED & Construction)	$54.7	$59.8

Notes: IDC for the 50'/48' and the 52'/48' Alternatives have PED duration of 30 months each and a Construction duration of 76 months and 76.23 months, respectively.

Interest During construction accounts for the opportunity cost of expended funds before the benefits of the project are available and is included among the economic costs that comprise the project costs. The amount of the pre-base year cost equivalent adjustments depends on the interest rate; the construction schedule, which determines the point in time at which costs occur; and the magnitude of the costs to be adjusted. The Preconstruction Engineering and Design (PED) durations are included in the IDC as well as the construction durations.

4.6 Incremental Analysis of Channel Widening

An incremental analysis was conducted to determine justification for the channel wideners for the National Economic Development Plan. HarborSym model runs were evaluated at the 50-48 foot channel depth with and without the wideners in place for each Segment separately. The benefits are generated by calculating the in harbor transiting costs for the existing channel width configuration to the in harbor transiting costs with the wideners for each segment in place. The incremental costs of constructing the wideners, along with the additional O&M and PED, were evaluated as well. Table 51 displays the incremental benefits and costs associated with each Segment.

Table 51: Incremental Analysis Channel Width – NED

	AAB	AAC	Net Benefits	BC Ratio
Segment 1	$2,941,000	$377,000	$2,564,000	7.8
Segment 2	$897,000	$531,000	$366,000	1.7
Segment 3	$359,000	$325,000	$34,000	1.1

5.0 Sensitivity Analysis

The Principle & Guidelines and subsequent ER1105-2-100 recognize the inherent variability to water resources planning. Navigation projects and container studies in particular are fraught with uncertainty about future conditions. Therefore a sensitivity analysis in which key quantitative assumptions and computations are changed is required to assess their effect on the final outcome. The sensitivity analysis for this study was a repeat of the primary analysis, substituting commodity and fleet forecasts with a range of values that were projected to be below and above the base scenario. The HarborSym model used in the basic evaluation included variations or ranges for many of the variables involved in the vessel costs, loading, distances, etc. However, it used only one basis commodity forecast, a key area of potential uncertainty. This sensitivity analysis presents the results of a large range of potentially different forecast of future commodity traffic at Charleston.

5.1 Data

Commodity forecast and fleet forecast for the low growth and high growth scenarios was obtained from IHS GI and MSI, respectively. The long-term trade commodity forecast combined data was obtained from GI and the empirical data were obtained from the Pilot's log. First, a baseline forecast was established from historical trade information, as discussed in Section 3.3.1. Next, a long-term trade forecast for the North Atlantic Region, South Atlantic Region, and Charleston Harbor was obtained from GI. The GI forecast was obtained in 2011 and the Corps decided that using the baseline established by empirical data and applying growth rates calculated from GI forecast would result in a forecast with less uncertainty than that which is typically present in long-term forecasts. The commodity forecast was used to develop growth rates, which were used to forecast import and export commodities for Charleston from 2012 to 2037 for the Low and High Growth scenarios.

Another scenario was developed using the baseline commodity forecast to evaluate a No Growth scenario from the base year 2022. HarborSym was run assuming that there was no change in export or import commodities for the years 2022 to 2037. For this scenario, the vessel fleet forecast is the same as the base scenario for 2022 and remains constant throughout the period of analysis. Table 52 presents the commodity forecast data for the No Growth scenario.

Table 52: No Growth (Tonnes) Commodity Forecast beyond Base Year

Service Route	Import	Export
AFRICA	138,969	422,155
CAR CA	44,907	75,192
ECSA	470,383	691,363
FE (Panama)	1,115,993	1,249,974
FE (Suez)	770,461	764,102
FE ECUS NEUR PEN	712,634	1,038,408
ISCME	1,385,121	1,567,489
MED	211,832	385,196
NEUR	2,319,978	2,003,978
WSCA	182,191	558,178
TOTAL	**7,352,472**	**8,756,034**

Table 53 provides projected tonnage volumes, assuming lower growth for imports and exports. NEUR, ISCME, and FE (Panama Canal) will dominate Charleston export and import from 2022 to 2037 for all service routes under the low growth scenario.

Table 53: Low Growth Commodity Forecast in Tonnes

Service Route	2022	2027	2032	2037
	Import Commodities			
AFRICA	130,068	146,063	160,326	175,832
CAR CA	42,031	46,677	51,199	56,662
ECSA	440,254	542,308	630,625	718,425
FE (Panama)	1,044,510	1,317,360	1,522,284	1,683,216
FE (Suez)	721,111	909,481	1,050,957	1,162,062
FE ECUS NEUR PEN	666,857	793,695	896,002	988,341
ISCME	1,296,400	1,720,574	2,042,385	2,288,341
MED	203,717	238,009	271,148	309,240
NEUR	2,170,315	2,394,063	2,613,163	2,872,141
WSCA	170,521	180,872	191,728	203,965
TOTAL IMPORTS	**6,885,784**	**8,289,102**	**9,429,817**	**10,458,225**
	Export Commodities			
AFRICA	396,751	460,166	518,688	582,111
CAR CA	70,667	81,798	93,169	106,125
ECSA	649,757	760,984	877,543	1,013,877
FE (Panama)	1,174,752	1,625,521	1,956,133	2,166,654
FE (Suez)	718,119	993,672	1,195,774	1,324,463
FE ECUS NEUR PEN	975,918	1,236,065	1,439,192	1,601,510
ISCME	1,473,159	1,804,697	2,105,764	2,389,699
MED	362,015	424,906	486,150	556,266
NEUR	1,883,381	2,165,571	2,420,027	2,709,107
WSCA	524,588	592,292	655,947	730,613
TOTAL EXPORTS	**8,229,107**	**10,145,672**	**11,748,387**	**13,180,425**

Table 54 provides the anticipated future vessel fleet assuming lower commodity growth than the base scenario. The percentage of calling capacity by vessel class is consistent with the base scenario assumption; however, with less forecasted tonnage transported through the Port, there are fewer vessels of each class.

Table 54: Low Growth Vessel Fleet Forecast

Vessel Calls	2022	2027	2032	2037
Sub Panamax	166	184	200	219
Panamax	835	807	859	930
PPX 1	441	392	351	320
PPX 2	193	306	394	463
PPX 3	16	81	138	179

Table 55 provides projected tonnage volumes, assuming higher growth for imports and exports. The NEUR, ISCME, and the FE (Panama Canal) will dominate Charleston export and import from 2022 to 2037 for all service routes under the high growth scenario.

Table 55: High Growth Commodity Forecast in Tonnes

Service Route	2022	2027	2032	2037
	Import Commodities			
AFRICA	147,773	176,021	205,347	239,873
CAR CA	47,752	56,251	65,576	77,299
ECSA	500,181	653,536	807,710	980,087
FE (Panama)	1,186,688	1,587,550	1,949,758	2,296,269
FE (Suez)	819,268	1,096,016	1,346,077	1,585,302
FE ECUS NEUR PEN	757,629	956,482	1,147,609	1,348,309
ISCME	1,472,865	2,073,463	2,615,908	3,121,789
MED	231,447	286,825	347,289	421,869
NEUR	2,465,736	2,885,085	3,346,967	3,918,219
WSCA	193,733	217,969	245,567	278,253
TOTAL IMPORTS	**7,823,072**	**9,989,198**	**12,077,808**	**14,267,269**
	Export Commodities			
AFRICA	447,301	549,051	656,496	783,376
CAR CA	79,670	97,598	117,922	142,818
ECSA	732,544	907,974	1,110,693	1,364,424
FE (Panama)	1,324,429	1,939,505	2,475,848	2,915,772
FE (Suez)	809,616	1,185,608	1,513,472	1,782,396
FE ECUS NEUR PEN	1,100,308	1,474,890	1,821,651	2,155,332
ISCME	1,660,857	2,153,291	2,665,234	3,215,936
MED	407,855	506,689	614,966	748,137
NEUR	2,123,425	2,583,930	3,063,042	3,645,830
WSCA	591,426	706,699	830,222	983,221
TOTAL EXPORTS	**9,277,431**	**12,105,235**	**14,869,546**	**17,737,242**

Table 56 provides the anticipated future vessel fleet assuming higher commodity growth than the base scenario. The percentage of calling capacity by vessel class is consistent with the base scenario assumption; however, with additional forecasted tonnage transported through the Port, there are more vessels of each class.

Table 56: High Growth Vessel Fleet Forecast

Vessel Calls	2022	2027	2032	2037
Sub Panamax	188	225	256	310
Panamax	972	973	1,086	1,378
PPX 1	497	481	448	415
PPX 2	216	366	501	582
PPX 3	18	96	174	225

Figure 32 and Figure 33 below show the import and export containerized commodity tonnage forecast scenarios, respectively.

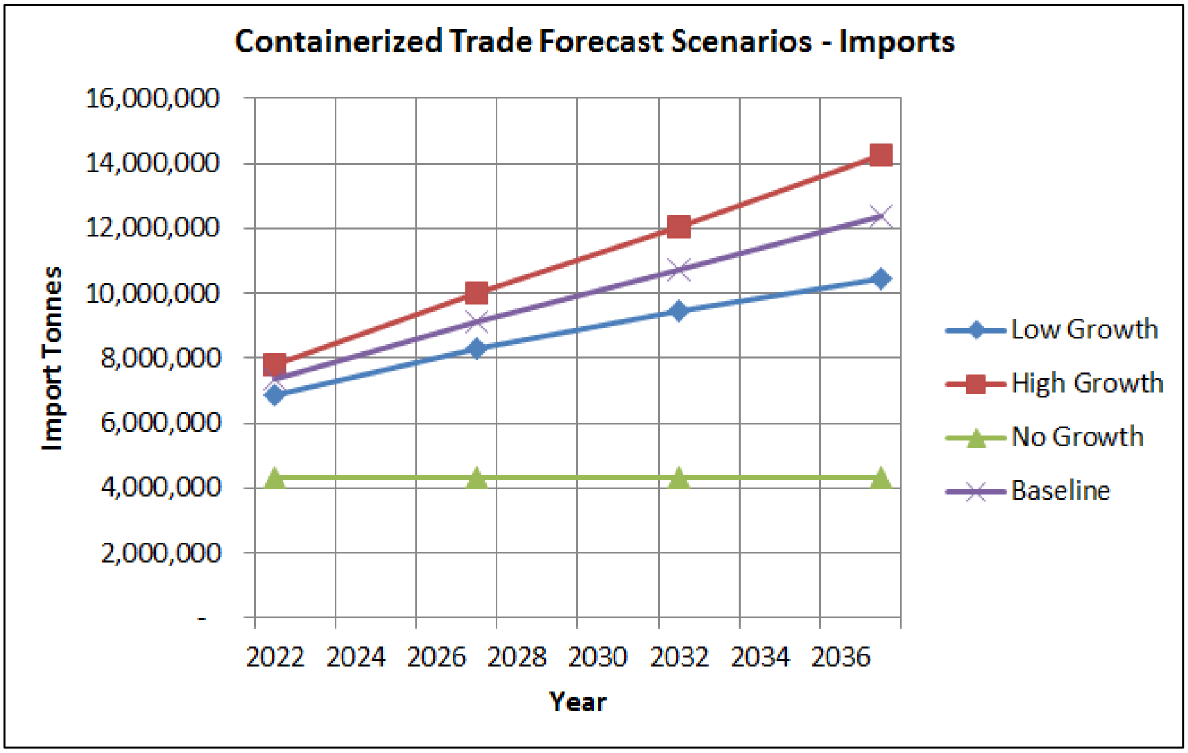

Figure 32: Containerized Trade Commodity Forecast Scenarios – Imports

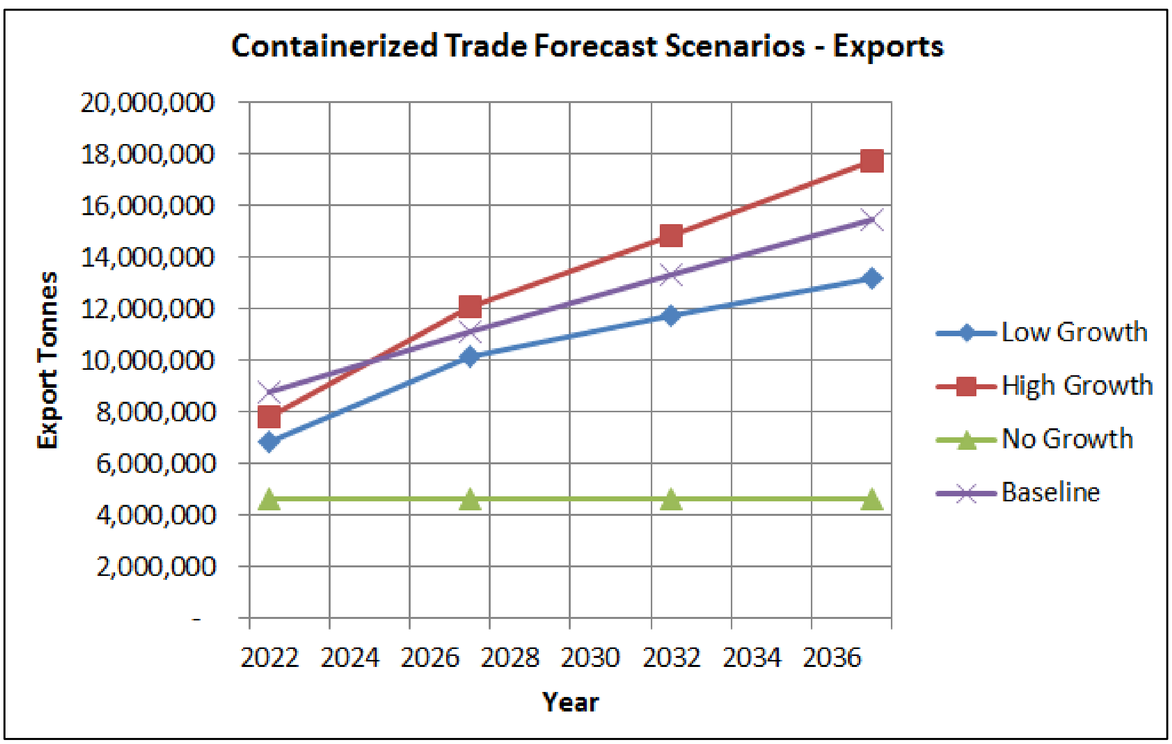

Figure 33: Containerized Trade Commodity Forecast Scenarios – Exports

5.2 Results

As an extreme-case sensitivity analysis, HarborSym was run with no change in commodities imported or exported over the base year tonnage. Table 57 provides results for the No Growth scenario. The Total AAEQ Benefits are lower than the Total AAEQ Costs for all three Alternatives: 48-foot, 50-foot, and 52-foot.

Table 57: No Growth Beyond Base Year Commodity Forecast-AAEQ Transportation Cost Savings (Million $)

Alternative	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
48/48	$20.90	$16.50	($4.40)	-	0.79
50/48	$25.70	$21.40	($4.30)	$0.10	0.83
52/48	$28.00	$22.70	($5.30)	($1.00)	0.81

Table 58 provides sensitivity analysis results for the Lower Growth scenario. Unlike the No Growth scenario, HarborSym was run with changes in commodities imported and exported from base year tonnage. Total import and export tonnages from 2022 to 2037 are 15,114,891 and 23,638,650 metric tons, respectively. The net benefits for the three alternatives are all positive, but the 52-foot Alternative produces the highest net benefit. This finding is consistent with the base scenario results in Section 4.2.

Table 58: Low Growth in Commodity Forecast-AAEQ Transportation Cost Savings (Millions $)

Alternative	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
48/48	$20.90	$52.80	$31.90	-	2.53
50/48	$25.70	$65.50	$39.80	$7.90	2.55
52/48	$28.00	$70.80	$42.80	$3.00	2.53

Table 59 provides sensitivity analysis results for the Higher Growth scenario. Unlike the No Growth scenario, HarborSym was run with changes in commodities imported and exported from base year tonnage. Total import and export tonnages from 2022 to 2037 are 17,100,503 and 32,004,511 metric tons, respectively. The net benefits for the three alternatives are all positive, but the 50-foot alternative produces the highest net benefit.

Table 59: High Growth in Commodity Forecast-AAEQ Transportation Cost Savings

Alternative	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
48/48	$20.90	$92.20	$71.30	-	4.41
50/48	$25.70	$108.70	$83.00	$11.70	4.23
52/48	$28.00	$111.10	$83.10	$0.10	3.97

Finally, an estimate of the benefits associated with no growth from the 2014 TEU throughput for the Port of Charleston was conducted for the Locally Preferred Plan. The analysis assumes a similar level of savings per TEU that was calculated for the no growth beyond the base year of the analysis scenario. The total TEUs handled by the Port during 2014 were just under 1.8 million TEUs therefore the total average annual equivalent benefits are approximately 17.77 million resulting in a Benefit Cost Ratio of about 0.63 to 1.

5.3 Discussion

As shown in Table 57, the No Growth commodity growth shows benefits below costs for all channel depths. The benefit- cost ratio for all Alternatives is less than 1. As shown in Table 58, the Lower Growth commodity growth shows all plans have benefits exceeding costs for all channel depths. Table 59 also shows that maximum net benefits are attained at 50-foot channel depth under higher growth.

6.0 Multiport Analysis

This multiport analysis presents the results of a systematic assessment of potential effects the deepening of the Charleston Harbor could have on other ports. The analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput and sea, port and land-based transportation options and costs. Since the purpose of a multiport analysis is to estimate potential changes in the with-project condition traffic forecasts, only the commodities affecting benefits and handled by alternative ports were analyzed. The detailed multiport analysis conducted for the Charleston Harbor Post 45 General Reevaluation is contained in Attachment 2 to this Economics Appendix.

Multiport analysis is performed as a series of steps to arrive at adjustments to NED benefits directly from the project. First, Charleston Harbor's economic study area was determined. For container traffic, principally imports, this study area was defined as a hinterland east of the Mississippi River consisting of the following major South and Midwest cities serving as a perimeter: Atlanta, Huntsville, Memphis, Chicago, and Cleveland. Twelve other cities were ultimately used to map the competitive hinterland for the least total delivered transportation cost analysis, including Huntsville, Jackson, Vance, Charlotte, Nashville, Knoxville, Louisville, Spartanburg, Greensboro, Columbus, Raleigh, and Greenville. A broad geographic hinterland was preferred to allow maximum latitude for possible with-project shifts of containers from other ports.

Next, the historical and projected volumes of container imports through Charleston Harbor and the alternative ports of Norfolk, Wilmington, Savannah, and Jacksonville were compiled. The historical volumes from 1990 through 2010 show that the South Atlantic ports experienced an average annual growth of 5.8 percent and the Port of Savannah experienced the greatest growth of 11.5 percent since 2000. Between 2011 and 2012 the Port of Charleston experienced growth of 9.7 percent compared to 0.7 percent for the Port of Savannah for the same time period. IHS-Global Insight forecast for containerized volumes for U.S. East Coast ports show that imports will increase from 7 million to 22 million for the period 2012 through 2037 and 0.6 million to 1.7 million for Port of Charleston.

Next, the current commodities and trading regions (partners) for each port was described.

The current cost of commodity (container) movements was compiled for Charleston Harbor, consisting of cargo-related port costs and hinterland transportation costs. Port cost, including vessel time in port, was compiled based on vessel and cargo services, including pilotage, tug assistance, dockage, wharfage, stevedoring, and container handling. Land transportation costs for truck movements between the ports and hinterland cities were also compiled. Rail movement was not calculated because the rail network does not provide enough direct routes from port directly to hinterland destinations. Voyage costs, origin to destination benefits, was assumed from HarborSym simulation.

The current total delivered transportation cost of container movements was determined for competing harbors - Norfolk, Wilmington, Savannah, and Jacksonville. The least total cost port was computed. Results show that Charleston has the least total delivered transportation cost for the major nodes Spartanburg, Greenville, Knoxville, Louisville, and Columbia. Similarly, Savannah, which competes primarily with the Port of Charleston, has the least total delivered transportation cost to six hinterland cities. Both Wilmington and Norfolk have the least total delivered transportation cost to three hinterland cities, respectively. A range of hinterlands based on incremental least total delivered transportation cost(s) of $50 per TEU was developed for sensitivity purposes for Charleston, Savannah, Jacksonville, Wilmington, and Norfolk.

The future cost of container movements under with-project conditions (45 to 52/48 feet) was determined for Charleston Harbor for benefiting services. The savings per TEU for ocean voyage costs range from about $32.97 to $60.50, depending on the trade route distance, percentage of Charleston cargo and other factors. The waterborne cost savings is approximately $42.50, which is the sum of the weighted cost savings per TEU for the benefiting routes. Compared to least cost, Nashville TN is the only hinterland city that may experience a shift of cargo from Savannah to Charleston as result of Charleston Harbor deepening and widening. Based on this exercise only, the waterborne cost savings will induce cargo from Savannah to Charleston. However, given that Savannah also has an authorized deepening project, we expect cost savings for Savannah deepening project to offset savings from Charleston deepening, resulting in no net change. In all, no shift in TEUs is expected between ports because, over time, most ports have deepened and deriving economies of scale from larger vessels calling. Thus the differences in cost between ports will be very negligible.

The Charleston Harbor multiport analysis confirms the conclusions in the SHEP analysis that port deepening alone will not cause traffic to be diverted from or to other ports. Other factors involved in port developments such as new container yard development, location of distribution centers, and landside transportation improvements appear to have a greater influence on cargo diversions.

7.0 Socioeconomic and Regional Analysis

The socioeconomics of the community area are summarized in this section. The parameters used to describe the demographic and socioeconomic environment include recent trends in population for thirteen counties that make up the immediate economic study area of the Port of Charleston, private sector employment, wage earnings by sectors for South Carolina and twelve sub-state geographic regions. Other social characteristics such as race composition, age distribution, poverty, and environmental justice (EJ) issues will be examined within the Tri-County region, whose communities may be directly impacted by the deepening and expansion of the Port.

7.1 Overview

7.1.1 Population

South Carolina is ranked as the 24th largest state in the Union in terms of resident population, as of April 1, 2010, with 4.6 million residents[16]. Between the years 1990 and 2010, South Carolina's population increased by 33 percent, from 3.5 million to 4.6 million persons[17], as shown below in Table 60, which is higher than the national growth over the same historical period. All counties within the immediate economic region of the Port of Charleston have seen a growth in population with the exception of Bamberg and Williamsburg counties.

Census data from 2010 show increases in population across the low country area. With a 42 percent growth rate, Dorchester County was the fastest growing county in the state between 2000 and 2010. Berkeley and Charleston Counties followed with 25 percent and 13 percent according to the census figures. Columbia remains the largest city in South Carolina, with a population of more than 120,000, and Charleston, North Charleston, and Mount Pleasant follow in population. The low-country continues to be a draw for people from other states. Census Bureau data show that a majority of residents of the Tri-County region were born in other states.

[16] 2010 United Sates Census.
[17] Ibid.

Table 60: South Carolina Population Trends 1990 to 2010

Geography	Population			Percentage Change		
	1990	2000	2010	1990 to '00	2000 to '10	1990 to '10
Bamberg County	16,902	16,658	15,987	-1%	-4%	-5%
Berkeley County	128,776	142,651	177,843	11%	25%	38%
Beaufort County	86,425	120,937	162,233	40%	34%	88%
Calhoun County	12,753	15,185	15,175	19%	0%	19%
Charleston County	295,039	309,969	350,209	5%	13%	19%
Clarendon County	28,450	32,502	34,971	14%	8%	23%
Colleton County	34,377	38,264	38,892	11%	2%	13%
Dorchester County	83,060	96,413	136,555	16%	42%	64%
Georgetown County	46,302	55,797	60,158	21%	8%	30%
Lexington County	167,611	216,014	262,391	29%	21%	57%
Orangeburg County	84,803	91,582	92,501	8%	1%	9%
Williamsburg County	36,815	37,217	34,423	1%	-8%	-6%
Richland County	285,720	320,677	384,504	12%	20%	35%
South Carolina	3,486,703	4,012,012	4,625,364	15%	15%	33%
United States	248,709,873	281,421,906.00	308,745,538	13%	10%	24%

Source: United States 2010 Census Data

7.1.2 Employment

South Carolina employment in 2010 totaled 1.7 million, with average annual wage of $37,566 as shown in Table 61 and 62, respectively. Of the major industry sectors within the State, the public administration sector employs the most persons, with 334,000 employees. Within the private sector, retail trade and total manufacturing constitute a significant percentage of total industry employment, following closely behind public administration in total employed persons, with 209,000 and 192,000, respectively. Combined service industries, i.e., NAICS industries 54 through 81, are also noteworthy sectors within the State, with the health care and social assistance services, and accommodation and food services industries employing the largest share of those aggregated sectors.

Sub-state region industry sectors yield employment distributions similar to the State total, with few exceptions. In the Trident region, retail trade, accommodation, and food services are more highly concentrated and manufacturing is predominant compared to other regions of the State. Health care and social services and manufacturing are relatively high as a percent of total industry employment, which may be attributable to the relatively higher population growth within the region.

Table 61: South Carolina Private Sector Employment – 2010

	NAICS Industry Sector	Low Country	Midlands	Trident	Waccamaw	Santee Lynches	Catawba	Lower Savannah	Pee Dee	Upper Savannah	Upstate	Greenville	Worklink	SC
11	Agriculture, Forestry, Fishing and Hunting	1,411	1,434	537	1,004	1,168	603	1,262	1,057	1,787	371	450	191	11,275
21	Mining		220	144	92	78	37	106	164	*	*	64	83	988
22	Utilities	472	3,747	1,028	490	145	*	5,249	855	256	357	250	2,168	15,017
23	Construction	4,506	11,967	12,718	6,684	3,027	3,329	16,255	3,053	2,551	5,332	8,982	4,625	83,029
31-33	Manufacturing	2,684	20,725	20,646	7,177	9,841	12,942	2,029	18,270	19,362	29,506	28,050	21,125	192,357
42	Wholesale Trade	1,126	11,417	7,073	2,524	1,062	4,158	14,218	4,110	1,543	6,476	10,749	2,652	67,108
44-45	Retail Trade	12,121	34,773	33,854	23,430	8,150	13,322	2,146	15,028	7,722	16,124	26,805	15,130	208,605
48-49	Transportation and Warehousing	1,052	5,467	9,327	1,606	1,574	2,018	867	3,918	1,739	5,005	7,832	1,020	41,425
51	Information	916	5,013	4,839	1,829	527	1,803	785	1,113	657	918	5,443	972	24,815
52	Finance and Insurance	1,904	20,274	6,927	3,634	1,358	6,483	2,963	4,317	1,291	4,179	7,865	2,384	63,579
53	Real Estate and Rental and Leasing	2,578	4,307	4,258	4,559	327	970	537	800	272	1,149	3,925	743	24,425
54	Professional and technical services	2,482	13,075	16,687	3,808	1,351	3,284	3,678	2,893	1,206	3,535	12,439	1,992	66,430
55	Management of companies and enterprises	442	3,569	1,278	689	314	260	104	987	284	1,507	4,007	305	13,746
56	Admin & Support & Waste Mgnt. & Remediation Serv.	4,723	18,560	19,322	7,326	2,547	5,982	12,209	3,163	3,317	6,830	27,007	4,608	115,594
61	Educational services	739	3,700	2,933	485	836	237	1,404	757	1,270	1,941	4,392	1,157	19,851
62	Health Care and Social Assistance	8,069	32,726	27,082	11,431	7,383	10,418	9,242	15,178	5,831	10,293	19,839	9,562	167,054
71	Arts, Entertainment, and Recreation	2,203	2,733	3,988	5,583	556	1,905	1,059	932	767	1,045	3,086	1,437	25,294
72	Accommodation and Food Services	12,278	26,721	31,202	30,290	4,692	8,471	8,446	9,328	4,831	12,230	19,296	12,757	180,542
81	Other Services (Except Public Administration)	4,026	9,254	7,981	3,459	1,813	2,148	2,085	2,863	1,623	3,006	6,237	2,702	47,197
92	Public Administration	15,105	72,277	56,760	21,087	14,032	16,887	19,659	23,954	18,607	23,042	28,293	24,499	334,202
	Total, Private and Government	78,846	301,959	268,584	137,185	60,780	96,648	104,304	112,741	74,954	133,037	225,012	110,112	1,704,162

Source: U. S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW), obtained from the South Carolina Commerce Workforce.

Table 62: South Carolina Average Annual Wage Earnings per Employee – 2010

	NAICS Industry	Low Country	Midlands	Trident	Waccamaw	Santee Lynches	Catawba	Lower Savannah	Pee Dee	Upper Savannah	Upstate	Greenville	Worklink	SC
11	**Agriculture, Forestry, Fishing and Hunting**	$31,352	$32,170	$26,622	$31,902	$29,512	$27,364	$28,790	$24,809	$28,916	$23,395	$17,682	$24,351	$28,764
21	**Mining**		48,186	45,965	45,568	72,846	38,568	51,784	34,171			51,614	39,507	46,847
22	**Utilities**	67,340	70,237	59,456	46,435	50,923		51,110	95,019	60,470	66,710	60,049	95,286	75,392
23	**Construction**	36,214	40,506	41,796	36,792	35,531	36,743	47,732	31,971	33,116	38,321	41,477	34,436	41,025
31-33	**Manufacturing**	37,045	50,641	61,719	43,963	41,353	50,167	43,729	48,741	39,822	51,990	52,917	44,819	49,563
42	**Wholesale Trade**	47,347	53,008	48,597	37,180	39,919	49,154	21,493	39,151	48,291	47,208	56,051	45,017	54,491
44-45	**Retail Trade**	23,199	25,102	26,007	22,362	22,370	26,075	36,315	21,805	21,511	22,824	27,285	23,324	24,456
48-49	**Transportation and Warehousing**	34,365	38,852	37,419	30,257	33,241	32,567	57,887	32,818	36,335	38,256	43,466	36,890	37,685
51	**Information**	49,936	56,565	46,575	41,874	55,289	52,309	35,892	40,264	46,522	43,844	55,058	45,942	50,666
52	**Finance and Insurance**	53,798	57,256	63,474	43,843	38,613	44,131	42,720	38,469	36,787	50,515	58,813	37,761	52,720
53	**Real Estate and Rental and Leasing**	34,119	39,576	37,981	25,363	24,802	41,380	27,434	27,467	21,128	36,294	31,684	26,439	33,388
54	**Professional and technical services**	57,737	57,820	61,655	40,092	40,390	55,580	73,588	46,401	34,748	51,476	63,272	38,557	58,547
55	**Management of companies and enterprises**	38,732	48,115	86,261	53,932	68,513	51,031	39,538	41,144	45,547	86,332	72,366	68,523	64,068
56	**Admin & Support & Waste Mgnt. & Remediation Serv.**	24,957	26,450	27,656	22,752	27,331	31,529	66,247	24,376	20,303	25,309	27,969	21,309	31,451
61	**Educational services**	27,318	31,817	37,363	24,725	28,339	18,035	29,431	21,301	29,592	33,335	33,246	28,935	31,845
62	**Health Care and Social Assistance**	36,890	41,460	42,918	41,649	33,082	39,534	31,446	36,172	34,899	38,725	47,690	37,290	40,284
71	**Arts, Entertainment, and Recreation**	23,642	15,884	18,651	18,076	16,270	13,641	17,987	14,792	13,761	18,037	16,338	14,113	17,532
72	**Accommodation and Food Services**	17,375	13,722	16,799	16,894	12,014	12,724	12,468	12,749	12,273	16,028	14,327	12,464	15,034
81	**Other Services (Except Public Administration)**	27,100	28,203	28,792	22,961	21,870	24,411	20,813	25,232	22,623	26,758	26,039	25,028	26,543
92	**Public Adminsitration**	40,787	45,915	50,843	44,561	37,524	38,689	47,783	40,602	39,557	42,012	45,739	44,318	45,904
	Total, Private and Government	$ 32,163	$ 39,062	$ 39,685	$ 29,556	$ 31,784	$ 36,650	$ 39,489	$ 33,922	$ 32,471	$ 38,583	$ 40,183	$ 34,700	$ 37,566

Source: U. S. Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW), obtained from the South Carolina Commerce Workforce.

7.1.3 Wage Earnings by Sector

Of the private sector industries, utilities sector employees are paid the highest in average annual earnings, slightly over $75,000 followed by employees within the wholesale trade. The average annual earnings of utilities sector employees double the average annual wage earnings across all industry sectors. Comparatively, the manufacturing sector, the major port user, generates average wages statewide of $49,600, with a low of $37,000 in the Low Country and a high of $61,700 in the Trident region. Unfortunately, the October 2011 unemployment rate for South Carolina was 10.5 percent, higher than all but four other states in the Union (e.g., Michigan, Mississippi, District of Columbia, California, and Nevada).

7.1.4 Median Household Income for Selected Counties

Median household incomes for selected counties in 2010 are shown in Table 63, with Beaufort County showing the highest median household income, followed by Lexington County, Dorchester County, Berkeley County, and Charleston County. Median household incomes for the Tri-County region (Berkeley, Dorchester, and Charleston Counties) are higher than the State average of $42,117.

Table 63: South Carolina Median Household Income for Selected Counties – 2010

Geography	Median Household Income	% of State Median Household Income
Bamberg County	$29,101	69.1%
Berkeley County	$49,284	117.0%
Beaufort County	$55,266	131.2%
Calhoun County	$37,507	89.1%
Charleston County	$46,187	109.7%
Clarendon County	$30,913	73.4%
Colleton County	$32,446	77.0%
Dorchester County	$51,132	121.4%
Georgetown County	$38,340	91.0%
Lexington County	$51,523	122.3%
Orangeburg County	$32,699	77.6%
Williamsburg County	$28,083	66.7%
Richland County	$45,994	109.2%
SC State	$42,117	100.0%

Source: Bureau of the Census, Small Area Income and Poverty Estimates Program

As shown in Table 64 below, the unemployment rate in the Tri-County region was lower than the State average, but remains higher than the national average.

Table 64: South Carolina State Unemployment for Selected Counties - 2010

Geography	Unemployment Rate
Bamberg County	15.6%
Berkeley County	10.0%
Beaufort County	8.8%
Calhoun County	11.8%
Charleston County	9.1%
Clarendon County	15.0%
Colleton County	13.2%
Dorchester County	9.3%
Georgetown County	12.3%
Lexington County	8.1%
Orangeburg County	15.3%
Williamsburg County	14.5%
Richland County	9.6%
SC State	11.2%

Source: Bureau of Labor Statistics, Local Area Unemployment Statistics (LAUS) Data 2010

7.1.5 Social Characteristics

This section describes social characteristics of the Tri-County region, each county within the region, and community study areas. The community study areas are illustrated in Figure 34 and are defined by a greater portion of the City of North Charleston, where most of the Port related infrastructures are located[18]. The social characteristics that are assessed in this section include population, race, age, education, income, poverty, and unemployment.

[18] With the exception of the Union Pier, Wando and the Columbus Street Terminals, most of the Port related infrastructures are in the City of North Charleston.

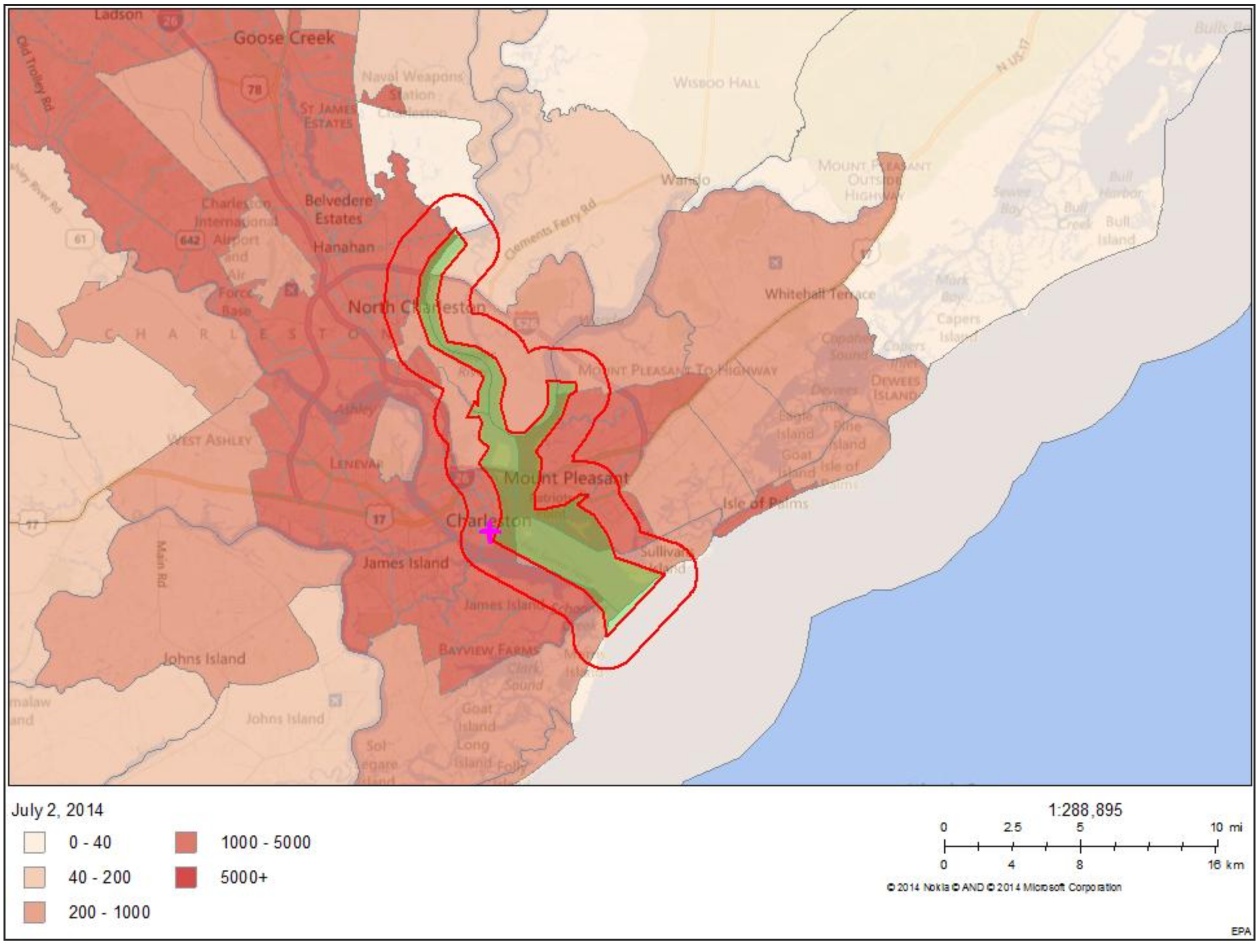

Figure 34: Community Study Area

7.1.5.1 Tri-County Region

Population Trends

The population growth trends from 1980 through 2010 for the Tri-County region are shown in Table 65. The Tri-County region as a whole has experienced a rapid rate of growth since 1980. According to 2010 U.S. Census, the Tri-County region has a 61.9 percent growth between 1980 and 2010, with a net population increase of 254,145 residents.

Table 65: Tri-County Region: Population Growth, 1980 to 2010

Place	1980	1990	2000	2010	Percent Increase 1980-2010
Berkeley County	74,727	128,776	142,651	177,843	138.0%
Charleston County	276,974	295,039	309,969	350,209	26.4%
Dorchester County	58,761	83,060	96,413	136,555	132.4%
Tri-County Region	410,462	506,875	549,033	664,607	61.9%
South Carolina	3,121,820	3,486,703	4,012,012	4,625,364	48.2%

Source: U.S. Census Bureau

The 2010 population density for the Tri-County region was estimated by the U.S. Census Bureau to be 257 persons per square mile. Population density varied extensively for the three counties from a low of 162 persons per square mile in Berkeley County, 238 persons per square mile in Dorchester County, and a high of 382 persons per square mile in Charleston.

Racial Composition

As shown in Table 66, all three counties, the Tri-County region, and the state of South Carolina have lower percentages of minority populations than the United States according to the 2010 U.S. Census. In the Tri-County region, Charleston County has a higher percentage of minority populations than Dorchester and Berkeley Counties. In 2010, the Tri-County region as a whole had a similar racial composition as the state of South Carolina, with approximately 65 percent white, 28 percent of the population black, and 7 percent of the population either American Indian, Asian, Hispanic, or other race.

Table 66: Tri-County Region: Racial Composition, 2010

Race	Berkeley County		Charleston County		Dorchester County		Tri-County Region		SC	U.S.
	No.	%	No.	%	No.	%	No.	%	(%)	(%)
White	118,265	66.50%	224,834	64.20%	92,584	67.80%	435,684	65.50%	66.20%	72.40%
Black	44,461	25.00%	104,362	29.80%	35,231	25.8	184,051	27.70%	27.90%	12.90%
American Indian	1,067	0.60%	1051	0.30%	956	0.70%	3,074	0.50%	0.40%	0.90%
Asian, Pacific	4,090	2.30%	4,553	1.30%	2,048	1.50%	10,691	1.60%	1.30%	4.80%
Hispanic (any race)	10,671	6.00%	18,911	5.40%	6,008	4.40%	35,590	5.40%	5.10%	16.30%
Other	178	0.10%	350	0.10%	137	0.10%	665	0.10%	1.80%	3.10%
Total Minority	60,467	0.34	129,227	0.37	44,380	0.33	234,074	35.20%	36.50%	38.0%

Source: U.S. Census Bureau, Census 2010

Age Distribution

The age characteristics of the Tri-County region are shown in Table 67. All three counties and the Tri-County region have lower median ages than the state of South Carolina and the nation according to the 2010 U.S. Census. In 2010, the median age was 34.5 for Berkeley County, 35.9 for Charleston County, 35.6 for Dorchester County, and 35.3 in the whole Tri-County region. The median ages for the State of South Carolina and the Nation were 37.5 and 37.2, respectively. The lower median age for the Tri-County region is partly because both Berkeley and Dorchester Counties have higher percentages of children under the age of 18 than the Tri-County region, the State of South Carolina, or the Nation.

Table 67: Tri-County Region Age Characteristics, 2010

Age Group	Berkeley County		Charleston County		Dorchester County		Tri-County Region		SC (%)	US (%)
	No.	%	No.	%	No.	%	No.	%	%	%
Under 18	22,439	24.4%	72,939	20.8%	37,396	27.2%	154,000	23.1%	23.3%	24.0%
18-64	59,739	65.5%	233,351	66.3%	85,848	62.4%	436,336	65.3%	63.0%	63.0%
65 or above	8,105	10.1%	45,192	12.9%	14,232	10.4%	74,405	11.6%	13.7%	13.0%
Median Age	34.5		35.9		35.6		35.3		37.5	37.2

Source: U.S. Census Bureau, Census 2010

Income and Poverty

The 2010 U.S. Census income and poverty data for the Tri-County region and the state of South Carolina are summarized in Table 68. All three counties in the region had median household incomes that were higher than that for the State.

Table 68: Regional Income and Poverty Data, 2010

	Berkeley	Charleston	Dorchester	South Carolina
Median Household Income	$49,427	$46,324	$50,908	$42,018
Per Capita Income	$22,270	$27,831	$23,010	$22,128
Total for whom poverty status is determined	173,743	340,249	135,737	4,493,865
Persons Below Poverty Level	26,399	64,143	14,852	815,755
Percent of Persons Below Poverty Level	15.20%	18.90%	10.90%	18.20%
Person Below 50% of Poverty Level	11,421	31,632	6,430	377,849
Percent of Persons Below 50% Poverty Level	6.6%	9.3%	4.7%	8.4%

Source: U.S. Census Bureau, Census 2010

Dorchester County had the highest median household income, while Charleston County had the lowest. However, in terms of per capita income, Charleston County had the highest income. In 2010, Charleston County had the highest percent of persons living below poverty level (18.9 percent) when compared to the other counties in the region and to the State of South Carolina. Berkeley and Dorchester Counties had 15.2 and 10.9 percent of their population living below the poverty level, respectively, and the State of South Carolina had 18.2 percent. Charleston County also had the highest percent of persons living below 50 percent of the poverty level.

7.1.5.2 North Charleston Community Study Area

Population Trends

An urbanized area surrounds the City of North Charleston, with a 2010 population density of approximately 1,361. Surrounding land uses include residential, office, institutional, and commercial uses. Based on the U.S. Census, the population in the North Charleston study area has increased from 79,641 residents in 2000 to 97,471 in 2010. This population increase of 22.4 percent is in lockstep with 26.4 and 61.9 percent population growths observed for Charleston County and Tri-County region, respectively.

Racial Composition

The racial composition of the North Charleston study area is 47.2 percent black and 37.9 percent white, which is in sharp contrast to the racial composition of Tri-County region (27.9 percent black and 65.5 percent white). In 2010, the total percent of minority residents living in North Charleston study area was nearly 62.1 percent.

Income Distribution

The income distribution for the North Charleston study area reveals a median household income of $37,049, which is much less than that for either Charleston County or the Tri-County region ($46,324 and $48,886, respectively). Also, the percent population in poverty for the North Charleston study area is 17.9 percent, which is much higher than 13.9 percent observed in Charleston County and 15.0 percent in the Tri-County region.

Educational Attainment

The educational attainment levels for the North Charleston study, Charleston County, and the Tri-County region are presented in the following text. In 2010, approximately 32.3 percent of the population 25 years and older had completed high school, compared to 23.2 percent for the Charleston County, and the 28.7 percent for the Tri-County region. Also, within this study area, 11.5 percent of the population age 25 and older earned a college degree. In Charleston County and the Tri-County region, 23.4 percent and 11.7 percent of the population age 25 years and older had college degrees, respectively.

7.1.6 Environmental Justice

An environmental justice analysis was conducted to assess whether the populations currently residing in the vicinity of the proposed Charleston Harbor Post 45 can be defined as minority and/or low-income populations. Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, provides that "*each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies and activities on minority populations and low-income populations*."

The proposed Charleston Harbor Post 45 project is located in Charleston and Berkeley Counties, South Carolina. According to the U. S. Bureau of Census 2010, Charleston and Berkeley Counties have an estimated population of 528,000. Minorities comprise approximately 35.9 percent of the population, most of whom are African Americans. With the exception of the Union Pier, Wando and the Columbus Street Terminals, most of the Port related infrastructures are in the City of North Charleston. According to the 2010 U.S. Census, the City of North Charleston – where extensive existing shipping facilities are expanding to meet demand – had a total population of 97,471, of which approximately 63.2 percent were minorities. Conversely, Mount Pleasant had a total population of 67,843, of which 10.7 percent were minorities. The median household income was $46,324 for Charleston County residents, $38,693 for North Charleston City residents, and $70,636 for the Town of Mount Pleasant residents.

Any individual with total income less than an amount deemed to be sufficient to purchase basic needs of food and shelter, clothing, and other essential goods and services is classified as poor. The amount of income necessary to purchase these basic needs is the poverty line or threshold and is set by the Office of Management and Budget (U. S. Census 2010). The 2010 poverty line for an individual under 65 years of age is $11,344. The poverty line for a three-person family with one child and two adults is $15,030. For a family with two adults and two children the poverty line is $22,491 (U. S. Census 2010).

Figure 35 below shows the communities of minority populations along the navigation channel where the majority of the construction would occur. These communities are disproportionately located near the North Charleston area. A few communities are located in Mount Pleasant, Clouter Creek, and Daniel Island. The proposed project includes dredging the 26.7 mile Federal Navigation Project to allow larger Post-Panamax ships to operate more efficiently. The harbor deepening alternatives consist of deepening the navigation channel from the ocean through the container terminals at Wando Welch and North Charleston. The existing activities, including deposition of dredged sediment, will not have significant impacts on any populations, including minority populations and low-income populations. The dredging activities would be focused in the Cooper River. Sediment deposition activities would be focused in the existing CDFs. No construction activities would occur on land at the Wando River, North Charleston Terminal, and Columbus River.

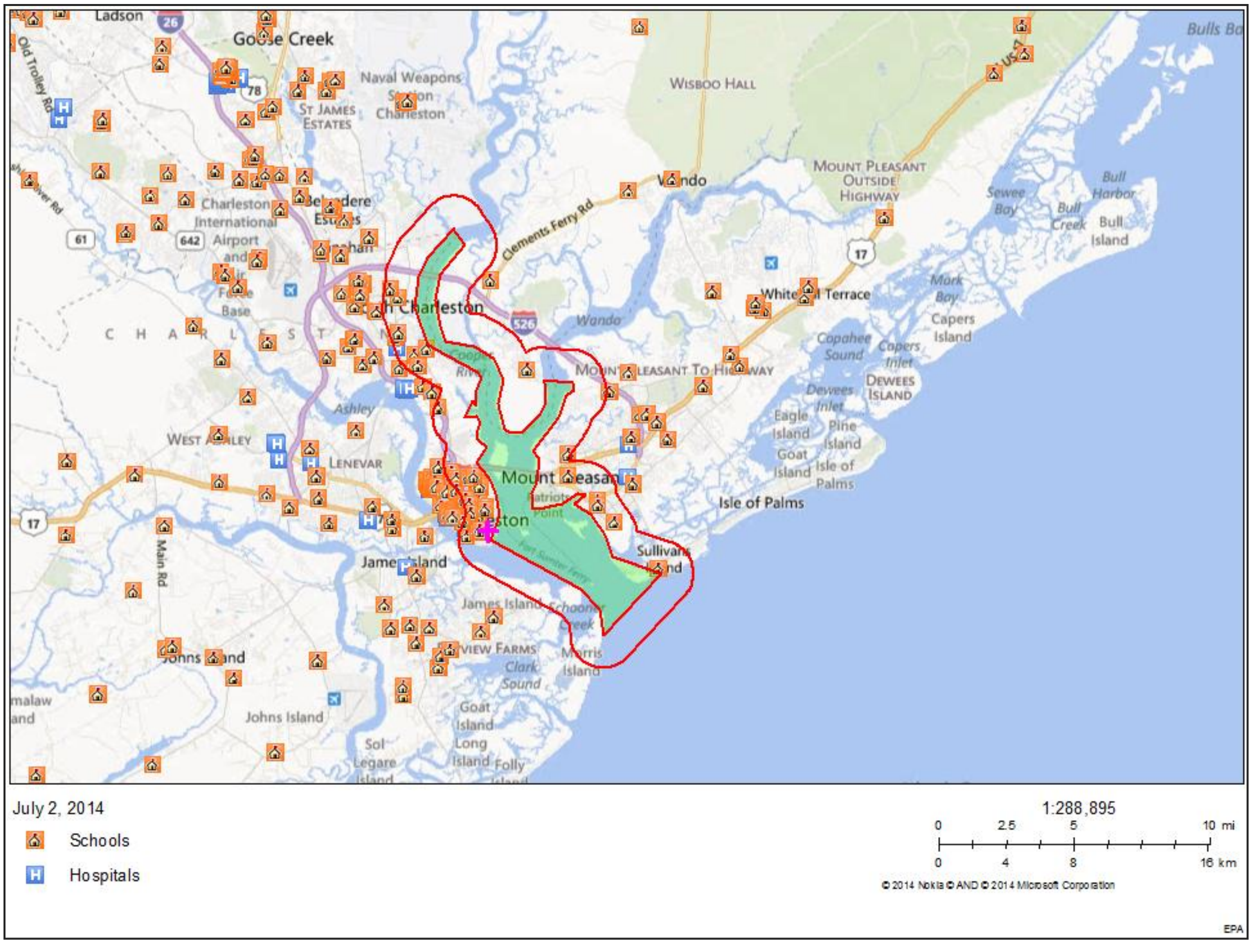

Figure 35: Minority Population Communities

The proposed harbor deepening would not increase the number of containers moving through the port on a given year. Although vessel fleet forecast predicts an increase in the number of containers moving through the port over time as a result of increasing demand, that increase is expected to occur in the Without Project Condition – independent of a harbor deepening project.

According to the SCSPA, the port will reach its landside cargo handling capacity near 2037 when the total number of TEU's reaches 4.2 million. It is anticipated that without deepening (i.e., the -45 foot depth) more vessels would be required to this cargo. With deepening of the harbor to a 52-foot depth, the total number of vessels would decrease (when compared to without project conditions) as vessels would be able to load more deeply under the improved conditions.

Since the number of containers per year is not predicted to increase as a result of the deepening, no landside changes in emissions would occur as a result of the deepening. The Corps predicts a reduction in the number of vessels used to transport the number of containers for each year (when compared to without project conditions) if the harbor is deepened. As a result, total emissions would decrease in a given year if the harbor is deepened (when compared to without project conditions). Since overall air emissions in the port would decrease slightly as a result of the project (when compared to without conditions), there is no technical need for the project to conduct a detailed analysis of the how those emissions disperse. Additionally, since there would be an overall decrease in emissions (including air toxins when compared to without project conditions), the Corps does not expect any National Ambient Air Quality Standards (NAAQS) violations as a result of harbor deepening. Therefore, a risk-based assessment of the health effects associated with the proposed action is not warranted. Any potential adverse effects of the presently permitted air emissions would be reduced if the harbor is deepened because of the reduction in vessels (when compared to without project conditions).

The Corps evaluated potential project impacts of the proposed harbor deepening and found that the information shows that the proposed action would not cause disproportionately high and adverse impacts to minority populations, low-income populations, or children.

7.2 Regional Economic Development Analysis

The regional economic development (RED) account measures changes in the distribution of regional economic activity that would result from each alternative plan. Evaluations of regional effects are measured using nationally consistent projection of income, employment, output and population.

7.2.1 Regional Analysis

The USACE Online Regional Economic System (RECONS) is a system designed to provide estimates of regional, state, and national contributions of federal spending associated with Civil Works and American Recovery and Reinvestment Act (ARRA) Projects. It also provides a means for estimating the forward linked benefits (stemming from effects) associated with non-federal expenditures sustained, enabled, or generated by USACE Recreation, Navigation, and Formally Utilized Sites Remedial Action Program (FUSRAP). Contributions are measured in terms of economic output, jobs, earnings, and/or value added. The system was used to perform the regional analysis for the Charleston Harbor Deepening and Widening Project.

This report provides estimates of the economic impacts of Civil Works Budget Analysis for New Analysis Project. The Corps' IWR, the Louis Berger Group, and Michigan State University developed RECONS to provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Work program spending, and stem-from effects for Ports, Inland Water Way, FUSRAP, and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE project locations. These multipliers were then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates.

Table 69 provides the project information while Table 70 provides the economic impact regions for the Charleston Post 45 analysis.

Table 69: Project Information

Project Name:	Charleston Harbor
Project ID:	
Division:	SAD
District:	Charleston District
Type of Analysis:	Civil Works Budget Analysis
Business Line:	Navigation
Work Activity:	CWB - Navigation Construction

Table 70: Economic Impact Regions

Regional Impact Area:	Micropolitan Area Generic Model
Regional Impact Area ID:	MICRO
Counties included	
State Impact Area:	South Carolina
National Impact:	Yes

7.2.2 Results of the Economic Impact Analysis

The RED impact analysis was evaluated at three geographical levels: Local, State, and National for the Locally Preferred Plan (52/48). The Local analysis represents the Charleston impact area which encompasses the area included in about a 50-mile radius around the project area. The State level analysis includes the State of South Carolina. The National level includes the 48 contiguous U.S.

Table 71 displays the overall spending profile that makes up the dispersion of the total project construction cost among the major industry sectors. The spending profile also identifies the geographical capture rate, also called Local Purchase Coefficient (LPC) in RECONS, of the cost components. The geographic capture rate is the portion of USACE spending on industries (sales) captured by industries located within the impact area. In many cases, IMPLAN's trade flows Regional Purchase Coefficients (RPCs) are utilized as a proxy to estimate where the money flows for each of the receiving industry sectors of the cost components within each of the impact areas.

Table 71: Input Assumptions (Spending and LPCs)

Category	Spending (%)	Spending Amount	Local LPC (%)	State LPC (%)	National LPC (%)
Dredging Fuel	6%	$31,781,000	52%	52%	90%
Metals and Steel Materials	4%	$22,403,000	29%	29%	90%
Textiles, Lubricants, and Metal Valves and Parts (Dredging)	2%	$10,941,000	17%	18%	65%
Pipeline Dredge Equipment and Repairs	5%	$27,092,000	32%	40%	100%
Aggregate Materials	3%	$15,109,000	75%	75%	97%
Switchgear and Switchboard Apparatus Equipment	0%	$1,563,000	25%	25%	80%
Hopper Equipment and Repairs	2%	$9,899,000	3%	3%	97%
Construction of Other New Nonresidential Structures	14%	$70,856,000	84%	95%	100%
Industrial and Machinery Equipment Rental and Leasing	7%	$38,033,000	71%	72%	100%
Planning, Environmental, Engineering and Design Studies and Services	5%	$23,966,000	60%	60%	100%
USACE Overhead	7%	$34,386,000	85%	85%	100%
Repair and Maintenance Construction Activities	4%	$21,361,000	85%	94%	100%
Industrial Machinery and Equipment Repair and Maintenance	11%	$54,705,000	89%	91%	100%
USACE Wages and Benefits	13%	$69,293,000	75%	98%	100%
Private Sector Labor or Staff Augmentation	15%	$79,713,000	100%	100%	100%
All Other Food Manufacturing	2%	$9,899,000	28%	28%	90%
Total	**100%**	**$521,000,000**	**-**	**-**	**-**

The USACE is planning on expending $521,000,000 on the project. Of this total project expenditure $376,575,111 will be captured within the regional impact area. The rest will be leaked out to the state or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity in that can be measured in jobs, income, sales and gross regional product as summarized in the following table and includes impacts to the region, the State impact area, and the Nation. Table 72 is the overall economic impacts for this analysis.

The labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income. The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues The GRP, which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. An interesting note is that in the local geography, one job averages an annual wage of $51,975, the State equivalent is $51,783 and the National equivalent is $55,834 (labor income/job). The total impact, direct and secondary, yields a local average wage of $55,228, State average wage of $56,678, and $57,532 average wage at the national level.

Table 72: Overall Summary Economic Impacts

Impacts	Impact Areas	Regional	State	National
Total Spending		$521,000,000	$521,000,000	$521,000,000
Direct Impact				
	Output	$376,575,111	$406,198,903	$509,496,771
	Job	4,261.22	4,497.39	5,017.03
	Labor Income	$235,336,710	$254,903,327	$288,641,488
	GRP	$268,074,116	$290,513,535	$337,240,062
Total Impact				
	Output	$693,409,781	$747,332,764	$1,356,214,094
	Job	6,649.60	7,214.03	10,118.59
	Labor Income	$345,613,849	$373,567,450	$564,963,105
	GRP	$457,292,140	$494,295,371	$815,843,886

Tables 73, 74, and 75 present the economic impacts by industry sector both for each geographical region. Note that Labor -5001- is the largest impact area at the regional, state and national levels, implying that all the labor demand can be met at the regional level. Impacts at the National level show a tremendous expansion most certainly due to the many multiple turnover of money that ripples throughout the National economy.

Table 73: Economic Impact at Regional Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$12,604,613	1.48	$413,318	$1,936,685
171	Steel product manufacturing from purchased steel	$3,027,687	6.15	$516,172	$626,906
198	Valve and fittings other than plumbing manufacturing	$524,854	1.70	$126,164	$243,699
201	Fabricated pipe and pipe fitting manufacturing	$3,801,002	13.52	$894,755	$1,549,766
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$4,867,054	28.68	$2,269,087	$2,736,385
268	Switchgear and switchboard apparatus manufacturing	$162,058	0.43	$37,696	$78,036
290	Ship building and repairing	$215,417	0.88	$68,757	$83,023
319	Wholesale trade businesses	$10,077,401	57.29	$4,480,100	$7,871,148
322	Retail Stores - Electronics and appliances	$41,552	0.41	$18,087	$23,673
323	Retail Stores - Building material and garden supply	$2,726,828	32.75	$1,299,969	$1,870,198
324	Retail Stores - Food and beverage	$59,510	1.03	$30,632	$43,842
326	Retail Stores - Gasoline stations	$799,455	11.30	$329,215	$559,641
332	Transport by air	$14,221	0.05	$3,411	$6,213
333	Transport by rail	$460,154	1.30	$146,416	$247,841
334	Transport by water	$94,472	0.18	$20,038	$41,910
335	Transport by truck	$6,926,535	53.25	$3,133,761	$3,764,051
337	Transport by pipeline	$136,382	0.24	$45,440	$43,463
36	Construction of other new nonresidential structures	$59,175,009	413.72	$21,799,534	$26,041,908
365	Commercial and industrial machinery and equipment rental and leasing	$27,116,473	92.18	$7,131,670	$14,907,324
375	Environmental and other technical consulting services	$14,273,521	122.60	$9,946,571	$9,982,147
386	Business support services	$29,345,264	513.02	$18,128,156	$17,947,979
39	Maintenance and repair construction of nonresidential structures	$18,260,739	143.31	$7,606,797	$9,158,770
417	Commercial and industrial machinery and equipment repair and maintenance	$48,610,992	444.30	$29,742,133	$36,236,436
439	* Employment and payroll only (federal govt, non-military)	$51,969,750	441.03	$47,212,404	$51,969,750
5001	Labor	$79,713,000	1,876.12	$79,713,000	$79,713,000
69	All other food manufacturing	$1,571,168	4.31	$223,426	$390,322
	Total Direct Effects	$376,575,111	4,261.22	$235,336,710	$268,074,116
	Secondary Effects	$316,834,669	2,388.38	$110,277,139	$189,218,024
	Total Effects	**$693,409,781**	**6,649.60**	**$345,613,849**	**$457,292,140**

Table 74: Economic Impact at State Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$12,604,613	1.48	$413,318	$1,936,685
171	Steel product manufacturing from purchased steel	$3,027,687	6.15	$516,172	$626,906
198	Valve and fittings other than plumbing manufacturing	$681,143	2.24	$163,733	$316,267
201	Fabricated pipe and pipe fitting manufacturing	$6,117,838	21.76	$1,453,199	$2,522,181
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$4,867,054	28.68	$2,269,087	$2,736,385
268	Switchgear and switchboard apparatus manufacturing	$162,058	0.43	$37,696	$78,036
290	Ship building and repairing	$215,417	0.88	$68,757	$83,023
319	Wholesale trade businesses	$10,077,401	57.29	$4,480,100	$7,871,148
322	Retail Stores - Electronics and appliances	$46,176	0.46	$20,203	$26,441
323	Retail Stores - Building material and garden supply	$2,759,464	33.15	$1,315,528	$1,892,581
324	Retail Stores - Food and beverage	$68,985	1.19	$35,509	$50,822
326	Retail Stores - Gasoline stations	$855,193	12.09	$352,168	$598,659
332	Transport by air	$14,221	0.05	$3,411	$6,213
333	Transport by rail	$460,154	1.30	$146,416	$247,841
334	Transport by water	$94,472	0.18	$20,038	$41,910
335	Transport by truck	$6,926,535	53.25	$3,133,761	$3,764,051
337	Transport by pipeline	$136,382	0.24	$45,440	$43,463
36	Construction of other new nonresidential structures	$66,995,688	471.85	$24,680,600	$29,483,654
365	Commercial and industrial machinery and equipment rental and leasing	$27,352,769	93.07	$7,193,816	$15,037,228
375	Environmental and other technical consulting services	$14,273,521	122.60	$9,946,571	$9,982,147
386	Business support services	$29,345,264	513.02	$18,128,156	$17,947,979
39	Maintenance and repair construction of nonresidential structures	$20,067,218	158.60	$8,359,315	$10,064,819
417	Commercial and industrial machinery and equipment repair and maintenance	$49,943,290	458.88	$30,557,286	$37,229,580
439	* Employment and payroll only (federal govt, non-military)	$67,822,193	578.11	$61,626,621	$67,822,194
5001	Labor	$79,713,000	1,876.12	$79,713,000	$79,713,000
69	All other food manufacturing	$1,571,168	4.31	$223,426	$390,322
	Total Direct Effects	$406,198,903	4,497.39	$254,903,327	$290,513,535
	Secondary Effects	$341,133,861	2,716.64	$118,664,123	$203,781,836
	Total Effects	**$747,332,764**	**7,214.03**	**$373,567,450**	**$494,295,371**

Table 75: Economic Impact at National Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$23,795,925	2.99	$865,182	$3,985,318
171	Steel product manufacturing from purchased steel	$16,228,140	32.97	$3,013,417	$3,669,532
198	Valve and fittings other than plumbing manufacturing	$5,610,478	19.53	$1,389,386	$2,695,579
201	Fabricated pipe and pipe fitting manufacturing	$21,395,902	76.10	$5,139,723	$8,939,485
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$7,463,257	46.21	$3,479,473	$4,196,037
268	Switchgear and switchboard apparatus manufacturing	$977,248	2.65	$230,748	$476,129
290	Ship building and repairing	$9,470,026	39.65	$3,214,110	$3,860,024
319	Wholesale trade businesses	$12,111,426	69.81	$5,384,365	$9,459,863
322	Retail Stores - Electronics and appliances	$50,015	0.49	$21,986	$28,772
323	Retail Stores - Building material and garden supply	$2,797,154	33.62	$1,333,496	$1,918,514
324	Retail Stores - Food and beverage	$69,292	1.20	$35,667	$51,048
326	Retail Stores - Gasoline stations	$858,067	12.13	$353,379	$600,671
332	Transport by air	$30,284	0.12	$7,947	$14,146
333	Transport by rail	$617,962	1.77	$196,795	$333,099
334	Transport by water	$173,985	0.39	$36,903	$77,550
335	Transport by truck	$7,806,946	60.56	$3,532,084	$4,242,488
337	Transport by pipeline	$349,471	0.60	$139,499	$133,927
36	Construction of other new nonresidential structures	$70,856,000	500.54	$26,148,322	$31,378,969
365	Commercial and industrial machinery and equipment rental and leasing	$37,977,438	133.40	$9,988,118	$20,929,297
375	Environmental and other technical consulting services	$23,962,822	208.02	$16,698,606	$16,758,333
386	Business support services	$34,375,144	605.97	$21,315,655	$21,102,394
39	Maintenance and repair construction of nonresidential structures	$21,354,910	169.50	$8,901,821	$10,758,162
417	Commercial and industrial machinery and equipment repair and maintenance	$54,686,477	510.81	$33,473,131	$40,765,327
439	* Employment and payroll only (federal govt, non-military)	$69,292,993	590.83	$62,963,982	$69,292,994
5001	Labor	$79,713,000	1,876.12	$79,713,000	$79,713,000
69	All other food manufacturing	$7,472,409	21.05	$1,064,692	$1,859,404
	Total Direct Effects	$509,496,771	5,017.03	$288,641,488	$337,240,062
	Secondary Effects	$846,717,323	5,101.56	$276,321,617	$478,603,824
	Total Effects	**$1,356,214,094**	**10,118.59**	**$564,963,105**	**$815,843,886**

Total Charleston Harbor Post 45 Expansion Project economic impact for the State of South Carolina (Table 74) is composed of $747 million in sales, approximately 7,214 jobs, $374 million in labor income and a contribution of $494 million to GRP.

Table 76 presents the demographic data of the impact region. In 2008, the combined metropolitan impact area of Berkeley, Charleston, and Dorchester Counties had a population of 645,729 with an area of 2,791 square miles and a total personal income of $23.3 billion.

Table 76: Impact Region Definition (2008)

Regional Impact Area ID:	16
Regional Impact Area Name:	Charleston North Charleston Summerville SC MSA
Impact Area Type	Micropolitan Impact Area
State Impact Region::	South Carolina

County	FIPS	Area (sq. mi)	Population	Households	Total Personal Income (in millions)
Berkeley	45015	1,228	166,188	60,437	$5,304
Charleston	45019	987	348,957	144,593	$14,046
Dorchester	45035	576	130,584	47,968	$3,947
Total		**2,791**	**645,729**	**252,998**	**$23,297**

Table 77 shows the impact region profile for 19 selected sectors. It displays the geographical capture amounts for the Charleston - North Charleston - Summerville South Carolina MSA, which is that portion of USACE spending that is captured in the impact area. The labor income represents all forms of employment earnings (in IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income). The GRP is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. The total Charleston North Charleston Summerville MSA is composed of $49.55 billion in output (sales), 398,686 employment, $17.3 billion in labor income and a contribution of $26.25 billion to GRP. An interesting note is that in the MSA, one job averages an annual wage of $43,423 (labor income/employment).

Table 77: Impact Region Profile (2008)

Regional Impact Area ID:	16			
Regional Impact Area Name:	Charleston North Charleston Summerville SC MSA			
Impact Area Type	Metropolitan Impact Area			
State Impact Region::	South Carolina			
Section	**Output (millions)**	**Labor Income (millions)**	**GRP (millions)**	**Employment**
Accommodations and Food Service	$2,062	$690	$1,081	34,290
Administrative and Waste Management Services	$1,715	$872	$1,087	30,671
Agriculture, Forestry, Fishing and Hunting	$238	$47	$88	3,061
Arts, Entertainment, and Recreation	$647	$167	$256	8,954
Construction	$3,590	$1,215	$1,334	29,220
Education	$2,471	$2,074	$2,348	40,180
Finance, Insurance, Real Estate, Rental and Leasing	$4,603	$1,061	$3,041	35,352
Government	$3,956	$2,737	$3,543	34,812
Health Care and Social Assistance	$2,628	$1,409	$1,664	29,056
Imputed Rents	$3,481	$524	$2,223	23,021
Information	$1,862	$353	$697	6,257
Management of Companies and Enterprises	$214	$85	$114	1,236
Manufacturing	$12,176	$1,763	$2,620	22,661
Mining	$92	$10	$22	275
Professional, Scientific, and Technical Services	$3,618	$1,779	$2,051	30,626
Retail Trade	$2,889	$1,255	$1,968	45,066
Transportation and Warehousing	$1,354	$591	$819	13,927
Utilities	$353	$73	$260	827
Wholesale Trade	$1,603	$604	$1,038	9,192
Total	**$49,552**	**$17,312**	**$26,252**	**398,686**

Attachment 1: HarborSym Deepening and Associated Tools – Model Certification

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P 19 June 2012

MEMORANDUM FOR Director, National Deep Draft Navigation Planning Center of Expertise (DDN-PCX)

SUBJECT: HarborSym Deepening and Associated Tools - Model Certification

1. HarborSym Deepening is a planning-level model developed by the Corps of Engineers to assist in economic analysis of proposed deep draft channel improvements. This model is a complement to the HarborSym Widening, previously certified on 10 June 2011. HarborSym Deepening is a high quality, technically sound, and discrete event Monte Carlo simulation model. It measures the economic effects of modifications to deep draft harbors as overall reductions in transit times, associated changes in total vessel operating costs, and changes in vessel loading or shipping patterns. The model also incorporates calculations for both within harbor and ocean voyage costs through a route group concept. The associated tools are described as follows: (1) The Tide Tool provides information on astronomical tides at tidal stations around the world utilizing the tide prediction engine WTides; (2) The Data Analysis and Pre-Processor (W-DAPP) Tool extracts data collected by the Corps, processes that information, and exports it in the form of a port call list; and (3) The Automatic Identification System (AIS) Data Analysis and Pre-Processor (A-DAPP) Tool provides the capability to visualize, analyze, and synthesize historical AIS data for use in container port channel improvement studies and associated model simulations.

2. Adequate technical reviews have been accomplished and the model and associated tools meet the certification criteria contained in Engineer Circular (EC) 1105-2-412. This certification is based on the decision of the HQUSACE Model Certification Panel which considered the DDNPCX assessment of Version 1.4.8.0 and Kernal Version 1.0.25 of the model.

3. The DDNPCX must monitor future developments to keep the model current with the state of the art and coordinate significant modifications that could affect this certification with HQUSACE. The DDNPCX must ensure that the Economic Production Center and project delivery teams are utilizing the most recent version of the model. This Memorandum will be distributed to the Planning Community of Practice (CoP) and posted on the Planning CoP internet site. It must also be posted on the DDNPCX internet site and the internet site of the model proponent (IWR).

EXPIRES: 30 June 2019

THEODORE A. BROWN, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Attachment 2: Charleston Harbor Deepening and Widening Project – Multiport Analysis

CHARLESTON HARBOR DEEPENING & WIDENING PROJECT

Multiport Analysis

USACE Charleston District

October 2013

US ARMY CORPS OF ENGINEERS
BUILDING STRONG!

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I. EXECUTIVE SUMMARY

This multiport analysis presents the results of a systematic assessment of potential effects the deepening of the Charleston Harbor could have on other ports. The analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput, and sea, port and land-based transportation options and costs. Since the purpose of a multiport analysis is to forecast changes in traffic at the ports that would most likely be affected by proposed changes at the Port of Charleston, only the commodities affecting benefits and handled by alternative ports were analyzed.

Multiport analysis is performed as a series of steps to arrive at adjustments to NED benefits directly from the project. For Charleston Harbor, the multiport analysis determined the economic study area (Step 1 in Section IV) to be related to container traffic, principally imports, serving a hinterland east of the Mississippi River consisting of the following major South and Midwest cities serving as a perimeter: Atlanta, GA, Huntsville, AL, Memphis, TN, Chicago, IL, and Cleveland, OH. Twelve other cities were ultimately used to map the competitive hinterland for the least total delivered transportation cost analysis, including Jackson, MS; Vance, AL; Columbus, OH; Louisville, KY; Charlotte, Greensboro, and Raleigh, NC; Nashville, and Knoxville, TN; , Columbia, Spartanburg, and Greenville, SC. A broad geographic hinterland was preferred to allow maximum latitude for possible with-project shifts of containers from other ports.

The historical and projected volumes of container imports through Charleston Harbor and the alternative ports of Norfolk, Wilmington, Savannah, and Jacksonville were compiled (Step 2 in Section V). The historical volumes from 1990 through 2010 show that the South Atlantic ports experienced an average annual growth of 5.8% and the Port of Savannah experienced the greatest growth of 11.5% from 2000 to 2010. Between 2011and 2012 the Port of Charleston experienced growth of 9.7%. IHS-Global Insight forecast for containerized volumes for U.S. East Coast ports show that imports will increase from 7 million to 22 million for the period 2012 through 2037 and 0.6 million to 1.7 million for Port of Charleston.

The current commodities and trading regions (partners) for each port was described (Step 3 in Section VI).

The current cost of commodity (container) movements was compiled for Charleston Harbor (Step 4 in Section VII), consisting of cargo-related port costs and hinterland transportation costs. Port cost, including vessel time in port, was compiled based on vessel and cargo services, including pilotage, tug assistance, dockage, wharfage, stevedoring, and container handling. Land transportation costs for truck movements between the ports and hinterland cities were also compiled. Rail movement was not calculated because the rail network does not provide enough direct routes from port directly to hinterland destinations. Voyage costs, origin to destination benefits, was assumed from HarborSym simulation.

The current total delivered transportation cost of container movements was determined for competing harbors - Norfolk, Wilmington, Savannah, and Jacksonville (Step 5 in Section VIII). The least total cost port was computed. Results show that Charleston has the least total delivered transportation cost for the major nodes Spartanburg, Greenville, Knoxville, Louisville, and Columbia. Similarly, Savannah, which competes primarily with the Port of Charleston, has the least total delivered transportation cost to six hinterland cities. Both Wilmington and Norfolk have the least total delivered transportation cost to three hinterland cities, respectively. A range of hinterlands based on incremental least total delivered transportation cost(s) of $50 per TEU was developed for sensitivity purposes for Charleston, Savannah, Jacksonville, Wilmington, and Norfolk.

The future cost of container movements under with-project conditions (45 to 50/48 feet) was determined for Charleston Harbor for benefiting services (Step 6 in Section IX). The savings per TEU for ocean voyage costs range from about $32.97 to $60.50, depending on the trade route distance, percentage of Charleston cargo and other factors. The waterborne cost savings is approximately $42.50 per TEU, which is the sum of the weighted cost savings per TEU for the benefiting routes. Compared to least cost in Table 9 (page 24), Nashville TN is the only hinterland city that may experience a shift of cargo from Savannah to Charleston as result of Charleston Harbor deepening and widening. Based on this exercise only, the waterborne cost savings will induce cargo from Savannah to Charleston. However, given that Savannah also has an authorized deepening project, we expect cost savings for Savannah deepening project to offset savings from Charleston deepening, resulting in no net change. In all, no shift in TEUs is expected between ports because, over time, most ports have deepened and deriving economies of scale from larger vessels calling. Thus the differences in cost between ports will be very negligible.

The Charleston Harbor multiport analysis confirms the conclusions in the Savannah Harbor Expansion Project (SHEP) analysis that port deepening alone will not cause traffic to be diverted from or to other ports. Other factors involved in port developments such as new container yard development, location of distribution centers, and landside transportation improvements appear to have a greater influence on cargo diversions.

II. Introduction

This multiport analysis presents the results of a systematic assessment of potential effects the deepening of the Charleston Harbor could have on other ports. The analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput, and sea, port and land-based transportation options and costs. Since the purpose of multiport analysis is to estimate potential changes in the with-project condition traffic forecasts, only the commodities affecting benefits and handled by alternative ports were analyzed.

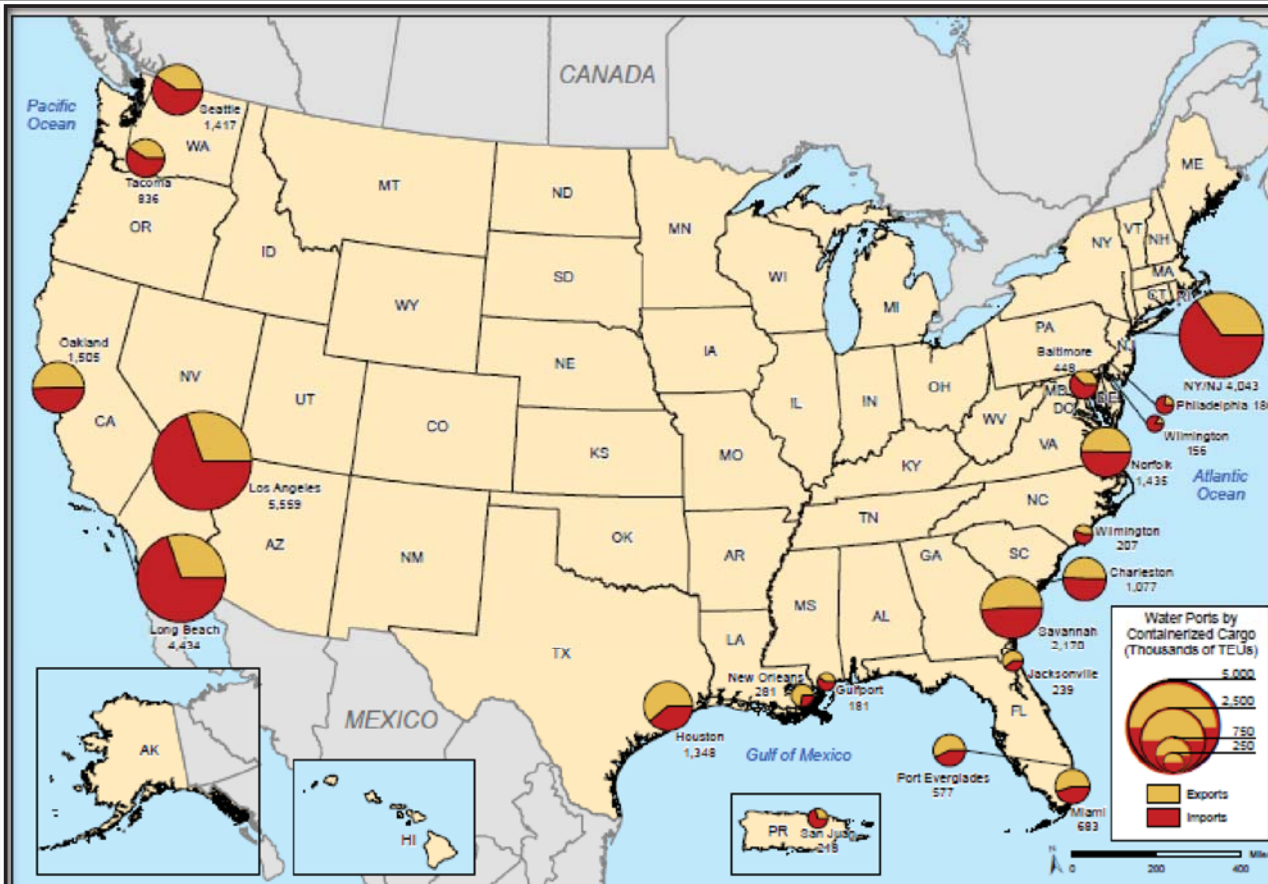
Shipping cargo from its origin to its final destination involves the utilization of a complex combination of the private and government owned and operated infrastructure and equipment. Governments own most of the major infrastructure components such as ports, harbors, inland waterways, airports and highways/roads. Private entities own most of the railroad infrastructure and operate most of the equipment that utilizes government owned infrastructure to transport cargo.

In recent years, the cargo transportation industry has rapidly adapted technological advances that have improved shipment planning and tracking capabilities to find faster and cheaper ways to transport cargoes around the globe using multiple transportation modes. Efficiencies and economic advantages have resulted in the development of a sophisticated intermodal freight transportation system that uses a combination of water, road and rail transportation modes to achieve the most timely, economic and environmentally-friendly delivery of commodities from their origins to their destinations. This system relies heavily on shipment of cargo in standardized containers that can be efficiently transferred between modes. The advantages and increasing use of standardized containers to transport cargo, worldwide, has brought about major changes in the way all modes of transportation are being used. For water-based transportation modes, the result is most clearly visible in the shift to much larger vessels. As commodity demand continues to grow, the on-going shift to larger vessels will continue to occur. The opportunity for these vessels to operate more efficiently in the future is driving the deepening of ports and related navigation facilities along the East Coast.

The expansion (widening and deepening) of the Panama Canal, scheduled for completion between December 2015 and early 2016, is a reaction to the shift to the larger vessel fleet. The expansion will result in larger cargo ships – post-Panamax – calling to U.S. ports. According to a recent U.S. Army Corps of Engineers Report (*U.S. Port and Inland Waterways Modernization: Preparing for post-Panamax Vessels*) post-Panamax vessels will account for 62% of the capacity of the world's container fleet by 2030 and these vessels will call in increasing numbers at U.S. ports that can accommodate them.

Around the country, ports are deepening their harbors and channels and improving their dockside/landside facilities to accommodate the changing fleet. A few ports are post-Panamax ready[1]: Seattle, Tacoma, Los Angeles, Long Beach, Norfolk, and Oakland. Four additional ports are projected to be post-Panamax ready by 2015: Baltimore, New York, Miami and Houston. Recently, post-Panamax vessels have been calling at Mobile, Port Everglades, Savannah, Jacksonville, Houston, and Charleston. Figure 1 shows the location of the Nation's top 20 maritime containerized port gateways for U.S. international containerized exports and imports in 2010.

[1] A port is considered post-Panamax ready when it has a channel depth of 50 feet with sufficient channel width and turning basin; has cranes capable of loading and unloading post-Panamax ships; and has docks engineered to handle the new bigger cranes. Norfolk and Baltimore are post-Panamax ready; New York will be post-Panamax ready by 2015, with funding approved to raise the Bayonne Bridge; and Miami will be post-Panamax ready by 2015, with dredging approved and super post-Panamax cranes ordered.



KEY: TEUs = twenty-foot equivalent units.

NOTE: The statistics include both government and non-government shipments by vessel into and out of U.S. foreign trade zones, the 50 states, District of Columbia, and Puerto Rico.

SOURCE: U.S. Department of Transportation, Maritime Administration, *U.S. Waterborne Container Trade by U.S. Custom Ports*, based on data provided by Port Import/Export Reporting Service, available at www.marad.dot.gov/library_landing_page/data_and_statistics/ Data_and_Statistics.htm as of August 2011.

Figure 1: Top 20 Water Ports by Containerized Cargo 2010

Seven East Coast ports, including Charleston, Jacksonville, Miami, New York/New Jersey, Port Everglades, Boston and Savannah Harbor are going through a federal approval process for deepening and expansion projects. According to a white paper prepared by Gulf Engineers & Consultants, the East Coast ports most envisioned to be affected by the Panama Canal expansion are those serving as interstate retail distribution centers for Asian imports such as Norfolk, Charleston, and Savannah. These ports serve overlapping US Midwest hinterlands. Port expansion may generate competition especially for those ports whose hinterlands overlap. Other impacts of the expansion are expected to include: changes to shipping routes, port development, and cargo distribution. The potential for reduced cost of water route transportation through the canal may cause freight traffic to shift from West Coast to East Coast ports. To understand the expected impacts on National Economic Development (NED) benefits of the with-project condition, a multiport analysis evaluates if port improvement at the Port of Charleston are likely to induce regional transfer of cargo among competing ports.

Purpose & Objective

The purpose of this multiport analysis is to forecast changes in traffic at the ports that would most likely be affected by proposed changes at the Port of Charleston. It estimates the nature and magnitude of the competition between ports and compares how this competition would be impacted by the with- and- without project conditions. The objective is to determine if meaningful changes in the competitive positions of other ports would be caused by proposed actions at Charleston Harbor.

Scope

This analysis considers factors related to port competition such as proximity, hinterland overlap, commodity throughput, and sea, port and land-based transportation options and costs. Since the purpose of multiport analysis is to estimate probability for potential changes in the with-project condition traffic forecasts, only the commodities affecting benefits and handled by alternative ports were analyzed. The analysis was defined to include major competing Mid-Atlantic and South Atlantic container ports of Norfolk, Wilmington, Savannah, and Jacksonville. The South Florida container ports of Miami and Port Everglades were excluded because they generally handle local cargo or transship between other world areas and the Caribbean and Latin American regions.

III. Methodology and Assumptions

Multiport analysis (MA) consists of a series of sequential steps. Conceptually, it extends the study scope to include a systematic assessment of effects of the with-project conditions on other ports.

The tasks to be performed for a multiport analysis are contained in the Water Resources Council adopted Principles and Guidelines (P&G). Guidance for implementation of P&G is prescribed for the Corps of Engineers in Engineering Regulation 1105-2-100 – Planning Guidance Notebook. These tasks, with some modifications[2], define the steps to be executed for the Charleston multiport analysis. The analysis consists of commodity flows in competitive (overlapping) port hinterlands and compares changes in total delivered transportation costs of container cargoes through Charleston Harbor to similar movements for other ports at Norfolk, Wilmington, Savannah, and Jacksonville. Only the trades that would benefit from deeper channels will be compared. The total cost components are compiled for that portion of the benefiting ocean voyage that precedes and follows Charleston Harbor as derived from the NED benefits methodology. The total delivered transportation costs framework embodied in the multiport analysis represents a compilation of different cost elements for sea[3], port, and land

[2] Some tasks will be combined and others will be discussed briefly. Vessel fleet composition has been sufficiently addressed in the Economics Appendix.

[3] Sea voyage costs (origin to destination benefits) will be assumed from HarborSym simulation. The computed sea costs savings will be put in perspective to total transportation cost.

transportation. Some of these cost elements contain parameter estimates to allow for the inclusion of a full data set of all related transportation cost components for the multiport analysis. Estimated values have been included in the total delivered cost analysis to serve as a proxy to reflect the inclusion of all nominal (estimated) transportation costs related to port and land cost elements that constitute the total transportation delivered cost framework of multiport analysis. The multiport analysis sorts the ports by "least total cost" for each trade and hinterland city for the transportation cost components (port and land) and the total costs and computes the incremental costs for each component to identify the least total cost port.

This analysis will test the hypotheses that:

1.) Authorized projects at competing ports will have no substantial effect on Charleston Harbor;
2.) The benefits of cargo substitutions from other ports are expected to be small.

This analysis assumes that:

- Unit costs for port and land elements will not change as a result of increased cargo carried under the with- project condition;
- The geographic footprint of a port's hinterland for both with- and without- project conditions is determined by the total delivered cost of commodities delivered within that footprint. Further, meaningful changes in hinterland footprints would not result without meaningful changes in total delivered costs for those commodities.

The following steps were employed to execute the multiport analysis:

First, the Charleston Harbor's economic study area was determined. For container traffic, principally imports, this study area was defined as a hinterland east of the Mississippi River. In all, seventeen cities were used to map the competitive hinterland for least cost total delivered transportation cost analysis. Second, the historic volumes flow of South Atlantic Ports from 1990 to 2012 is identified. The projected volume flow is calculated using Global Insight Commodity Forecast for US Atlantic Coast. Third, waterborne commerce at each port and the corresponding trade regions were identified. The current cost of commodity movements – Charleston Harbor without project conditions and the current cost of alternative movements was calculated in the fourth and fifth steps, respectively. Sixth, the future cost of commodity movement for Charleston Harbor with-project is discussed. And finally, a summary and conclusion of the findings will be presented.

IV. DETERMINE ECONOMIC STUDY AREA (1)

The economic study area for a multiport analysis of Charleston Harbor will reflect competing ports and the overlapping hinterlands and the primary hinterland for the Charleston Harbor and competing ports. Charleston shares a large common hinterland with container ports at Jacksonville, Savannah Harbor, Wilmington, and Norfolk. Combined, these seaports facilitate freight flow and international trade for both the long-established and populous Northeast and the growing areas along the Southeast Atlantic coast.

For a multiport analysis, the common port hinterlands are delineated by an analysis of competitive cargoes. It is envisioned that a multiport study for major container ports along the U.S. South Atlantic Coast would constitute the economic study area, including ports at Hampton Roads, Savannah, Wilmington, and Jacksonville and a domestic hinterland that extends from Huntsville upward along the Mississippi River that would include Memphis, Nashville, and Chicago and major urban areas east of these locations. According to Norbridge (NBI), the South Atlantic, Southeast, Gulf and Midwest region define the Port of Charleston's hinterland. The South Atlantic and Southeast accounted for an estimated 84 percent of the Port of Charleston loaded container traffic throughput during the period CY2008-CY2010. The remainder of the Port's loaded container traffic, on average, moved via the Midwest Region (8%), Gulf Region (4%), and All Other (4%).

The vessel fleet forecast indicates that containerships and containerized cargo comprise the bulk of vessels benefiting from a deepened Charleston Harbor. Six major types of services were identified as beneficiaries from a deeper Charleston Harbor: FE (Suez) ECUS, FE (Panama) ECUS, MED, FE ECUS NEUR PEN, ISC_MED, NEUR.

The FE (Suez) ECUS links the east coast of the U.S. (ECUS), including Charleston Harbor to the far-east services through the Suez. The FE (Panama) ECUS links the east coast of the U.S., including Charleston Harbor, with the transpacific portion of far-east Panama Canal services. The MED is the Asian ECUS Mediterranean service. The ISC_MED is the Indian subcontinent and Middle East service. The NEUR is the transatlantic northern Europe service. The FE ECUS NEUR PEN is the FE ECUS deployment that calls NEUR before returning to FE. The major container lines have generally adopted pendulum deployment services to compensate for Post-Panamax unable to transit the Panama Canal. Under a pendulum rotation, a string of vessels will call different port ranges in a back and forth type deployment. In some instances, the ports called will be the same in both directions; and in other instances different ports may be mixed or substituted in the forward and backward deployment.

The major world trade routes served by the benefiting services were determined to be the relevant overseas hinterlands for the purpose of imports and growth projections for containerized cargoes. These world areas include:

(1) North Europe;

(2) Northeast Asia;

(3) Indian subcontinent;

(4) West Coast South America;

(5) East Coast South America and

(5) All Others.

Charleston Harbor services calling these world regions for containerized imports are regarded as competing with the other major South Atlantic coast port(s) of Savannah, as well as Norfolk, Jacksonville, Wilmington for interior U.S. markets.

The South Atlantic ports of interest exclude the South Florida container ports of Miami and Port Everglades, because of the specificity of their hinterland relative to South Florida and associated transshipment services for the Caribbean and Latin America niche markets. Although normally regarded as a North Atlantic coast port, Norfolk is viewed as a competitor to Charleston for Midwest hinterland traffic by virtue of rail connections and emerging private sector marine terminal development by Maersk-Sealand. Figure 2 is the assumed domestic hinterland for Mid and South Atlantic Coast Ports. It depicts Charleston as the 4^{th} largest container port on the US East Coast: According to South Carolina Ports Authority (SCPA) 85 percent of its cargo measured in TEUs is moved by truck and 15 percent is moved by rail.

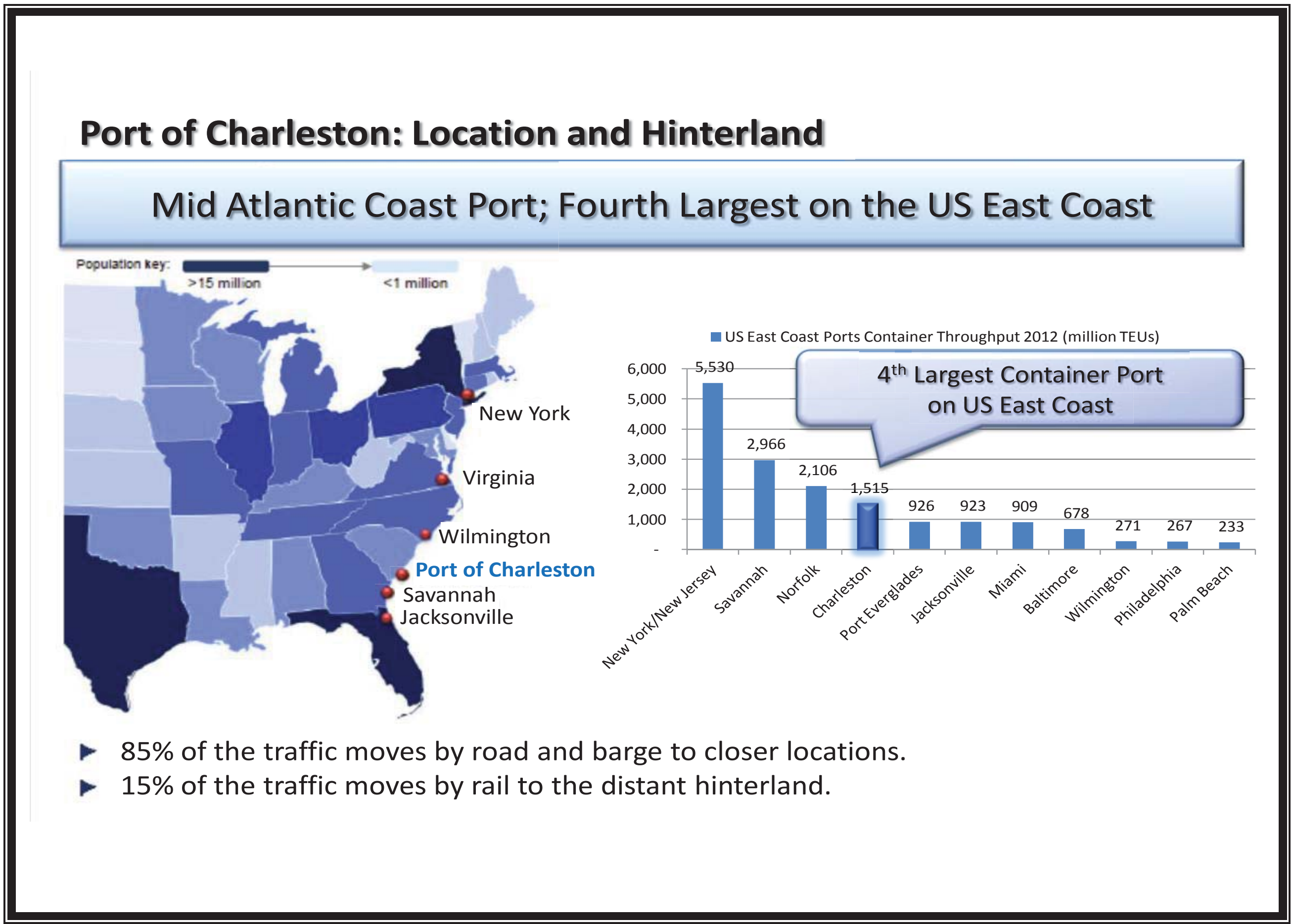


Figure 2: Assumed Domestic Hinterland for Mid and South Atlantic Coast Ports

According to Norbridge (NBI), the highway system supporting the Port of Charleston connects to a number of key metropolitan areas within 500 miles of the Port. The 500 mile distance is an important metric in evaluating a port's competitive hinterland since it approximates the maximum miles a truck operator can drive in a day given federal hours of service (HOS) regulation. The map below shows the markets within 500 miles of the Port which include Greenville, Spartanburg, Columbia, Charlotte, Raleigh, Greensboro, Knoxville, Atlanta, and other regional metropolitan centers. Overall, the Port is within one day's drive (500 miles) of 91 metropolitan areas and an estimated 60 million people. Figure 3 shows the geographic inland reach of Port of Charleston.

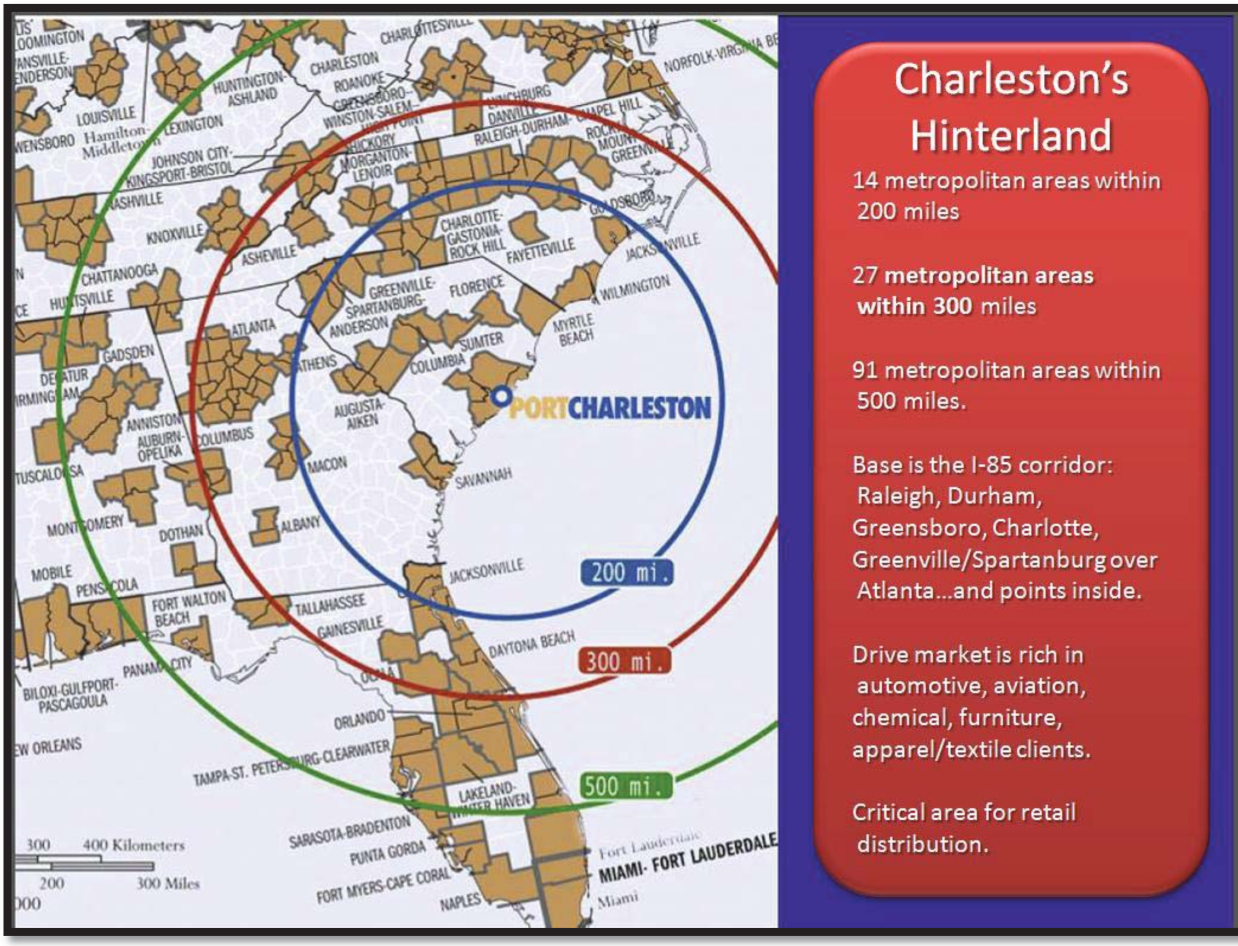


Figure 3: Geographic Inland Reach of Port of Charleston
Source: South Carolina Ports Authority

Determining a distinct domestic hinterland for containerized imports through the different South Atlantic ports is difficult because of the close proximity of several of the ports in relation to the geography of the South and Midwest. Although the hinterland of Wilmington overlaps with Charleston's, the commodities shared between the two ports are minimal and therefore the competition between the two is very limited. However, Wilmington will be a competitor to Charleston for the North Carolina cities of Raleigh and Charlotte.

According to port officials, about 90% of the Port of Jacksonville's current container traffic is on the north/south trade lanes. In terms of total import and export tonnage, the port's major trading partners are the Caribbean (41%), followed by South America (36%), North America (9%), Europe (8%), Asia (3%) and Africa (1%). Over a dozen ocean carriers call to the port including Maersk, MSC and Crowley. Most of the container traffic through Jacksonville is with Puerto Rico and a few Caribbean countries in shallow draft vessels.

V. HISTORIC AND PROJECTED VOLUMES OF SOUTH ATLANTIC PORTS (2)

Figure 4 illustrates the historic container volumes through South Atlantic ports. The South Atlantic ports have experienced an average annual growth of 5.8% over the last 20 years (3.3% since 2000). The Port of Savannah has experienced the greatest growth in the South Atlantic since 2000 with an average annual growth of 11.5%. The Port of Norfolk has experienced an average annual growth of 3.5% between 2000 and 2010. Jacksonville experienced a 1.9% average annual growth during this period and Port Everglades saw an average annual growth of 1.6%. The ports of Charleston and Miami experienced average annual declines of 1.8% and 0.2% respectively.

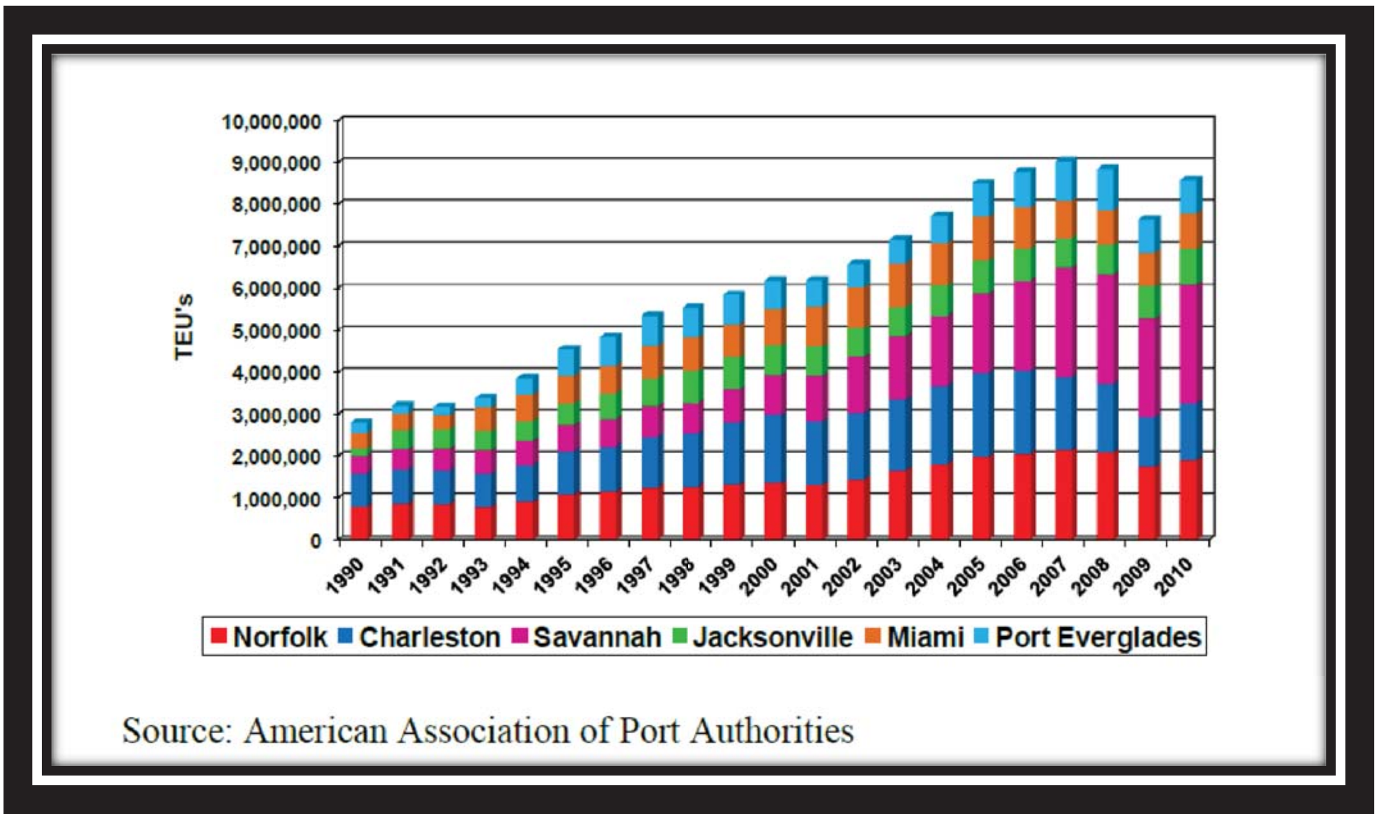


Figure 4: Historical Container Volumes (Loaded TEUs) at South Atlantic Ports

Between 2011 and 2012 the Department of Commerce reports that the cumulative traffic for key container ports along the East Coast of North America increased by 10.9%. Across ten major US ports, only two, Wilmington and Philadelphia recorded yearly declines in 2012. Table 1 shows the major East Coast container ports loaded TEU volumes between 2011 and 2012.

Table 1: Major East Coast Container Ports TEU Volumes 2011-2012 (Thousands of TEUs)

Rank	Port	TEUs 2011	TEUs 2012	Growth Rate	US East Coast Market Share
1	New York/New Jersey	5,503	5,530	0.5%	34%
2	Savannah	2,945	2,966	0.7%	18%
3	Norfolk	1,918	2,106	9.8%	13%
4	Charleston	1,381	1,515	9.7%	9%
5	Port Everglades	912	926	1.5%	6%
6	Jacksonville	900	923	2.6%	6%
7	Miami	907	909	0.2%	6%
8	Baltimore	632	678	7.3%	4%
9	Wilmington	287	271	-5.6%	2%
10	Philadelphia	291	267	-8.2%	2%
11	Palm Beach	210	233	11.0%	1%

Charleston posted a 9.7% growth rate, but its closest rival, Savannah, recorded a 0.7% growth rate. Charleston still ranks 4th among the ports in East Coast of the U.S, showing a container throughput totaling 1,514,590 TEUs, which comprises 9% of the US East Coast market share. New York/New Jersey, Savannah, and Norfolk together make up 65% of the market share.

Projected Volumes and Commodity Flows of South Atlantic Ports and the Port of Charleston

IHS-Global Insight forecasts for containerized trade at US East Coast port and the Port of Charleston containerized are presented in Figures 5 and 6, respectively. Figure 5 illustrates TEU imports (loaded) for the U.S. East Coast increasing from about 7 million to 22 million from 2012 to 2037. Exports are projected to increase from 6.6 million to 28.6 million containers over the same time period.

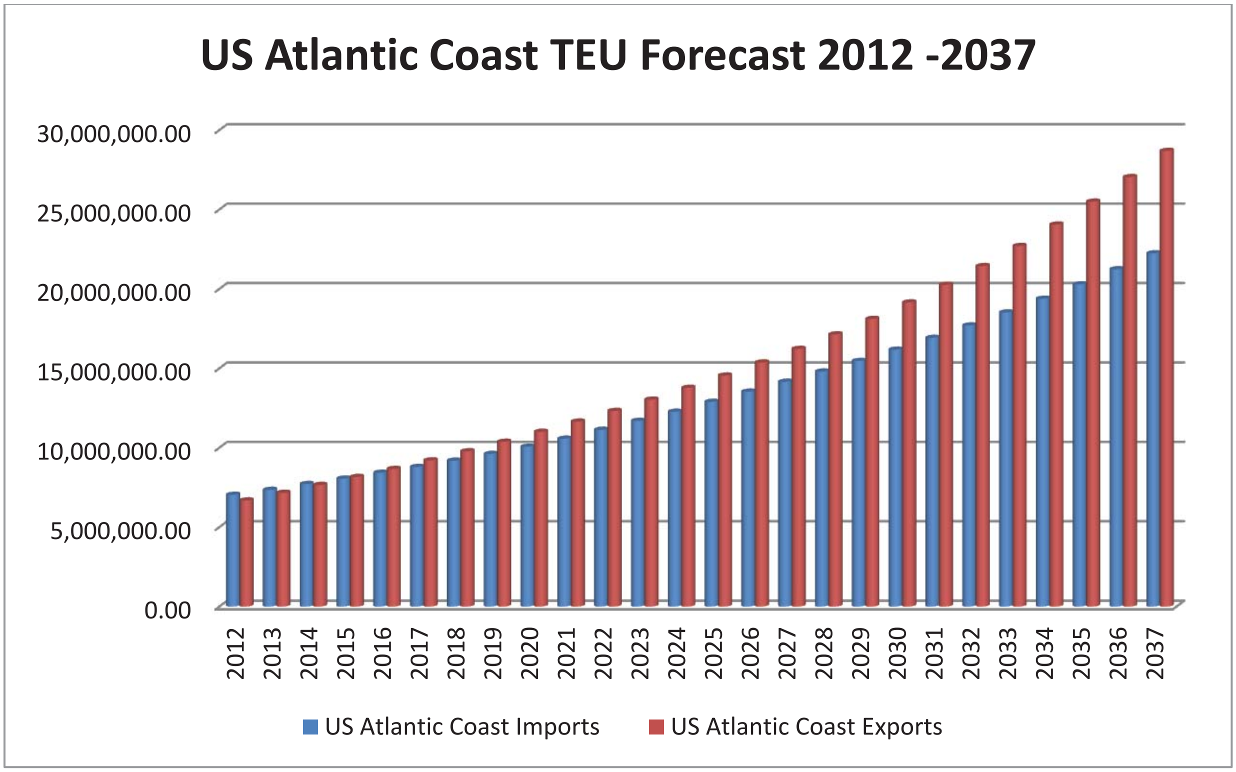


Figure 5: US East Coast Projected Volumes 2012-2037
Source: IHS Global Insight

Figure 6 indicates TEU imports for the Port of Charleston increasing from about 0.6 million to 1.7 million from 2012 to 2037. Exports are projected to increase from 0.6 million to 2.6 million containers over the same time period. Exports are forecast to exceed imports beginning in the year 2015 for most Ports in the US Atlantic Coast and 2014 for the Port of Charleston.

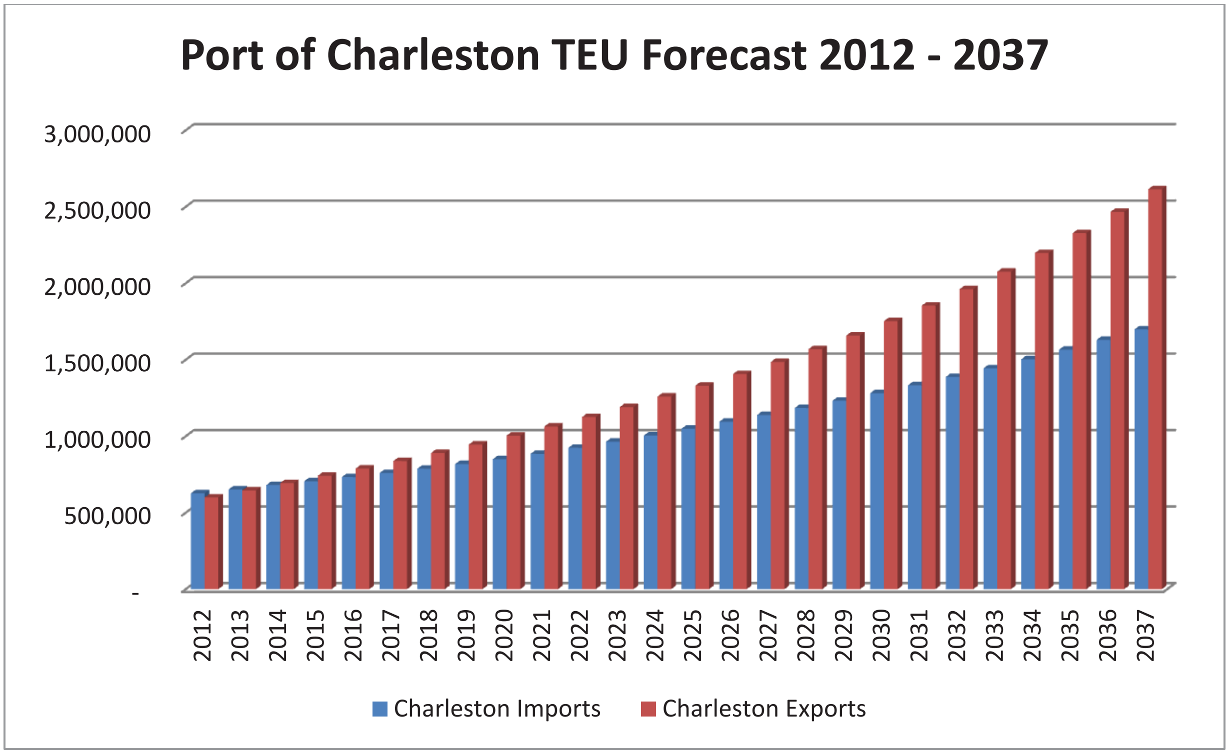


Figure 6: Port of Charleston Projected Volumes 2012-2037
Source: IHS Global Insight

VI. DETERMINE CURRENT COMMODITIES AND TRADING REGIONS (PARTNERS) FOR EACH PORT (3)

The Port of Savannah

Until 2011, the Port of Savannah grew faster than most ports in the Atlantic region. The Port's success has been attributed to the development of a network of distribution centers (DC) in its vicinity. Much like Charleston, the port is gearing itself for Asian trade, especially the anticipated development in Suez-routed services. The trade lanes served by Savannah are similar to those served by Charleston, except that Savannah has captured a much larger share of Asian cargo, accounting for about 60% of its overall trade. The port is served by many lines, the largest of which are Hapag-Lloyd, followed by Maersk Line and Zim, providing 40 separate shipping services.

The Port of Savannah is the biggest portal for imports from China in the U.S. Mid and South Atlantic (Norfolk to Miami). In FY11, it handled 48%, or 552,674 TEUs, of the total Mid and South Atlantic trade with China (1,156,833 TEUs). During FY11, the top import from China to Savannah was furniture, which was one of the fastest growing commodities during this time period. Other fast growing import commodities over the same period were machinery/Appliances/Electronics (+19%, +10,371 TEUs) and Hardware & Houseware (+10%, +6,761 TEUs). The top import commodities entering Mid and South Atlantic ports from China in FY11 were Furniture (229,833 TEUs), Retail Goods (175,595 TEUs), and Hardware (143,184 TEUs). Savannah was the number one destination.

The Port of Savannah is the biggest portal for exports to China from the U.S. Mid and South Atlantic (Norfolk to Miami). In FY11, it handled 44%, or 193,274 TEUs, of the total Mid and South Atlantic trade with China (442,426 TEUs). During FY11, the fastest growing export to China from Savannah was cotton, which was up 56% (+4,988 TEUs) from 8,936 TEUs in FY10 to 13,924 TEUs in FY11. Other fast growing export commodities over the same period were Logs/Lumber (+35%, +3,878 TEUs), Textiles (+21%, +1,461 TEUs) and Wood Products (+139%, +1,028 TEUs). The top export commodities from Mid and South Atlantic ports to China in FY11 were Paper Waste (95,834 TEUs), Wood Pulp (58,817 TEUs), and Logs and Lumber (46,374 TEUs). Savannah was the number one exporting port for wood pulp.

The Port of Charleston

The Port of Charleston has three container terminals (Wando, North Charleston and Columbus Street) and is the fourth largest container port on the US East Coast (USEC), after New York, Savannah and Norfolk. Wando Welch is the most frequently called terminal, with most of its calls coming from Europe. Overall, the port has an excellent combination of deep water access[4] for post-Panamax containerships, high capacity, and highly efficient port operations. It has an integrated rail[5] and highway system with access to 60 million people within 500-mile radius. CSX and Norfolk Southern operate dockside rail service at Columbus Street, Union Pier, and North Charleston Terminals. The Wando Welch Terminal is connected by intermodal service via direct dray to the railhead.

The Port of Charleston provides highly efficient access to the global marketplace and it directly serves more than 150 countries, with strong growth in India and other Asian markets. The Port's main trade is with Northern Europe (36%); Northern Asia (22%); India and other Asia (12%); South America East Coast (6%) & South America West Coast (5%). The port is served by many lines, the largest of which is Maersk, followed by MSC, Evergreen and others, providing a total of total of about 40 separate shipping line services. As indicated in Figure 6, above, TEU imports for the Port of Charleston are projected to increase from about 0.6 million to 1.7 million containers from 2012 to 2037. Exports are projected to increase from 0.6 million to 2.6 million containers over the same time period (IHS Global Insight). Exports are forecast to exceed imports beginning 2015 for most Ports in the US Atlantic Coast and 2014 for the Port of Charleston. The top export cargo going through the port includes paper & paperboard, wood pulp, auto parts, logs & lumber and fabrics & raw cotton. The top import commodities include furniture; auto parts; sheets, towels, blankets; fabrics including raw cotton; auto and truck tires and tubes; and general cargo.

[4] *The Port of Charleston is one of the few ports in South Atlantic Coast which can accommodate post-Panamax ships at high tide.*

[5] *Class I rail operators include CSX and Norfolk Southern*

The Port of Virginia

The Port of Virginia has five primary terminals – Norfolk International, Portsmouth Marine, Newport News, Virginia Inland and the APM terminal. The first three terminals (Hampton Roads) are responsible for a large percentage of the trade volume of South Atlantic Ports. Hampton Roads is centrally located for commercial traffic to numerous metropolitan regions of the United States. As the largest intermodal facility on the U.S. East Coast, the Port of Virgina offers six direct-service trains to 28 major cities every day. A modern network of interstate and local highways permits fast, direct and motor-freight transportation to any point in the United States.

The top trading partners with Port of Norfolk include Italy, Netherlands, United kingdom, France, & Germany (Northern Europe); China & South Korea (Asia Northeast); Brazil (South America); India (India & Others); Turkey (Mediterranean). When measured in TEUs, the top countries sending goods to Port of Norfolk were China, Brazil, Germany, India, Italy and the Netherlands; and the top countries receiving goods from Port of Norfolk were China, Belgium, Germany, United Kingdom, Netherlands, Japan, and Italy. Top export commodities include Mineral fuel, Oil Etc, Misc, Grain, seed, Fruit; Wood pulp; Food Waste, Animal Feed; & Wood. Top import commodities are Machinery; Furniture & Bedding; Salt, Sulfur, Earth & Stone, Beverages; Vehicles; & Fertilizers.

The Port of Jacksonville (JAXPORT)

The Port of Jacksonville (JAXPORT) owns and manages three cargo terminals in Jacksonville, Florida, including the Blount Island Marine Terminal, the Dames Point Marine Terminal and Talleyrand marine Terminal. The port and its maritime partners handle containerized cargo, automobiles, recreational boats and construction equipment (Ro/Ro), dry and liquid bulks, breakbulk commodities, and oversized and specialty cargoes. In 2012, JAXPORT's three cargo terminals handled a total of 8.2 million tons of cargo, including more than 923,000 TEUs and more than 608,000 vehicles. JAXPORT now ranks as the No. 1 vehicle export port in the United States, and Jacksonville is the top container port in the State of Florida. According to Trade Development & Global Marketing, in CY 2011 the top export commodities of the Port of Jacksonville were automobiles (26%), general cargo (5%), grocery product misc. (5%), paper and paperboard (5%), Poultry, fresh and frozen (5%). The top export lanes were Puerto Rico (53%), Israel (8%), Brazil (4%), China (3%), and Saudi Arabia (3%). For the same year imported commodities include coal & coke (24%), gasoline & aviation (17%), petroleum/crude & fuel oil (13%), limestone chips (9%), paper & paperboard inc. waste (9%). The major import trade lanes include Colombia (24%), Virgin Islands (15%), Canada (8%), Bahamas (7%), Puerto Rico & Mexico (5%).

The Port of Wilmington

The Port of Wilmington is the smallest of all the ports in this analysis. Although large international shipping lines call on this port, each line has only one service on a weekly, monthly, or bi-monthly schedule. It is ranked 18^{th} on the list of U.S. Port rankings for volume for the first quarter of 2012. As reported in Port of Wilmington statistics, the port realized 290,666 TEUs in 2011, the highest since 2005.

In 2012, the top 5 import commodities were chemicals, grain, urea, ore, mica, schist, and machinery/pts. The top export commodities were forest products, woodpulp, woodchips, general merchandize/miscellaneous, and food products. The top import trading partners include China (21%), Great Britain (20%), Trinidad & Tobago (12%), Canada (10%), and Belgium (9%). The top export trading partners are (China (34%), Turkey (18%), South Korea (11%), Belgium (11%), and Great Britain (6%).

VII. DETERMINE CURRENT COST OF COMMODITY MOVEMENTS – CHARLESTON HARBOR-WITHOUT PROJECT CONDITION (4)

This section of the analysis will discuss the three cost components of Multiport Analysis of sea (vessel), port, and land. However, sea cost will not be calculated but would be referenced as part of the overall transportation cost of moving cargo from point of origin to destination. For the multiport analysis, inland transportation costs and port and cargo costs need to be calculated for vessels and cargos at each competing port. These costs will serve as the baseline for later projections and least cost analysis.

Port Cost

Table 2 shows the Port costs which include wharfage, dockage, pilotage, tug assistance, and container loading and unloading and handling. Cost inputs were obtained through a desktop review of each port's terminal tariff and through communications with individual associations. Where updated information was not available, the data used for the 2012 Savannah study multiport analysis was used.

Table 2: Port Costs for Five South Atlantic Ports

Port	Wharfage $/ton	Dockage $/foot	Container Charges $/TEU*	Pilotage $/TEU*	Tug Services $/TEU*
Norfolk	$4.66	$9.77	$150.00	$2.44	$1.33
Wilmington	$2.58	$2.84	$150.00	$2.33	$1.33
Charleston	$4.50	$9.60	$150.00	$2.33	$1.33
Savannah	$4.40	$9.65	$150.00	$2.30	$1.33
Jacksonville	$4.36	$9.96	$150.00	$2.19	$1.33

*Source: Port tariffs from Charleston, Norfolk, Wilmington, Savannah, and Jacksonville websites and communications with individual associates. *Container, Pilotage, & Tug assistance charges were assumed from SHEP Multiport Analysis.*

Table 3 modifies Table 2 above so all cost inputs are expressed in the same unit of measurement (TEUs). Total port costs consist of wharfage, dockage, tug assistance, pilotage, and container charges. Table 3 shows that Norfolk has the highest estimated port cost per TEU ($211.33) and Wilmington has the lowest port costs per TEU ($183.89). Charleston, Savannah and Jacksonville fall in between.

Table 3: Post Costs for Five South Atlantic Ports Expressed in TEUs

Port	Wharfage $/TEU	Dockage $/TEU	Container Charges $/TEU	Pilotage $/TEU	Tug Services $/TEU	Total Port Costs $/TEU
Norfolk	$51.36	$6.19	$150	$2.44	$1.33	$211.33
Wilmington	$28.44	$1.80	$150	$2.33	$1.33	$183.89
Charleston	$49.60	$6.08	$150	$2.33	$1.33	$209.34
Savannah	$48.50	$6.12	$150	$2.30	$1.33	$208.25
Jacksonville	$48.06	$6.32	$150	$2.19	$1.33	$207.90

Note: Some cost input have been estimated. Wharfage per ton and Dockage per foot were converted to TEUs to match other cost inputs by using the formula employed by G.E.C., Inc: 1 ton equals 11.022 TEU and 1 foot equals 0.634 TEU.

Land Transportation Cost

There are two sets of land transportation costs for truck and rail intermodal services. The total land transportation cost is determined by calculating the truck cost or rail cost, assuming that specific ports have direct rail service to one of the 17 hinterland cities. Table 4 contains the highway mileages for major southeast U.S. ports and hinterland.

The major competitive cargoes for overlapping hinterlands related to the total delivered cost basis would customarily exclude import and exports in close proximity to the port and most likely focus on containerized imports that move by rail or truck to interior hinterland destinations greater than or equal to 250 miles from Charleston.

Table 4: Highway Distances in Miles from Port Cities to Hinterland Cities

	Mid-Atlantic and South Atlantic Ports				
	Highway Distances in Miles from Port Cities to Hinterland				
	Savannah	Charleston	Norfolk	Jacksonville	Wilmington
Atlanta, GA	249	315	566	345	405
Charlotte, NC	252	200	327	384	196
Chicago, IL	953	901	885	1100	987
Cleveland, OH	764	713	558	897	700
Columbia, SC	159	115	386	290	215
Columbus, OH	725	673	594	857	658
Greensboro, NC	317	273	236	448	209
Greenville, SC	231	192	384	349	275
Huntsville, AL	430	504	742	492	602
Jackson, MS	629	695	947	727	785
Knoxville, TN	415	364	519	548	491
Louisville, KY	659	607	654	768	693
Memphis, TN	637	778	916	733	843
Nashville, TN	497	541	705	594	668
Raleigh, NC	323	280	184	455	133
Spartanburg, SC	241	185	356	342	250
Vance, AL	430	510	800	505	602

Source: MapQuest & Rand McNally Tripmaker

This assumption is based on containerized import cargoes that dominate the shared hinterlands of these ports, compared to containerized export cargoes, which tend to be less substantial in volume and /or value and more localized in nature. Table 4 indicates that the shortest truck distance (115 miles) is from Charleston, SC to Columbia, SC. The greatest distance (1,100 miles) is from Jacksonville to Chicago.

Calculating Truck Cost

For purposes of this analysis, truck cost will dominate the calculation of land cost unless otherwise stated. Among other reasons, this is because trucks characteristically handle most of the East Coast port containers moving less than 500 miles and at other distances, trucks are usually used for a portion of the distance. Table 5 shows the average distances in miles that a particular truck would travel from each of the five southeastern U.S. ports. Based on these distances, Charleston appears to be more centrally located with an average distance to major hinterland cities of 461; that is followed closely by Savannah (465), Wilmington (521), Norfolk (566), and Jacksonville (578).

Table 5: Average Distance in Miles Traveled from each Southeastern Port

Port	Mean	Standard Deviation
Savannah	465	227
Charleston	461	240
Norfolk	566	234
Jacksonville	578	232
Wilmington	521	267

Truck costs per TEU are based on driving time and fuel surcharge costs. Driving time is based on the highway distances between ports and hinterland cities shown in Table 4, which are divided by an average underway speed of 55 miles per hour. The total truck driving hours (distance in miles divided by 55 miles per hour) were multiplied by $68.21 (average carrier cost per hour) plus an additional fuel surcharge (32% fuel surcharge applied to trucking cost). Fuel surcharge is obtained by multiplying fuel and oil cost ($23.58) by the surcharge rate 32%, which is then multiplied by driving time. Table 6 shows the truck cost for Charleston harbor associated with 17 hinterland cities. The hinterland city with the most expensive truck land cost per TEU from Charleston was Chicago ($620.50). The hinterland cost with the least expensive truck land cost per TEU from Charleston was Columbia, SC ($79.20).

Table 6: Truck Costs for Port of Charleston Associated with Hinterland Cities

	Truck Cost for Port of Charleston				
	Driving Time in Hours	Fuel Surcharge ($)	Driving Cost ($)	Total Truck Land Cost ($)	Truck Land Cost/TEU ($)
Atlanta, GA	5.7	43.2	390.7	433.9	216.9
Charlotte, NC	3.6	27.4	248	275.5	137.7
Chicago, IL	16.4	123.6	1117.4	1241	620.5
Cleveland, OH	13	97.8	884.2	982.1	491
Columbia, SC	2.1	15.8	142.6	158.4	79.2
Columbus, OH	12.2	92.3	834.6	927	463.5
Greensboro, NC	5	37.5	338.6	376	188
Greenville, SC	3.5	26.3	237.7	264	132
Huntsville, AL	9.2	69.1	625.1	694.2	347.1
Jackson, MS	12.6	95.3	861.9	957.3	478.6
Knoxville, TN	6.6	49.9	451.4	501.4	250.7
Louisville, KY	11	83.3	752.8	836.1	418
Memphis, TN	14.1	106.7	964.9	1071.6	535.8
Nashville, TN	9.8	74.2	670.9	745.2	372.6
Raleigh, NC	5.1	38.4	347.3	385.7	192.8
Spartanburg, SC	3.4	25.3	228.8	254.1	127.1
Vance, AL	9.3	70	632.5	702.5	351.2

Source: American Transportation Research Institute 2011 Average Carrier Cost per hour ($68.21) pg. 11. Fuel & Oil cost amount to $23.58 per hour; a 32% fuel surcharge is applied to fuel cost for each hour. H&J Trucking, Inc. provided surcharge rates.

Calculating Rail Cost

Rail intermodal (trailer and container on flatcar) services compete with trucks on a cost and service basis. Rail service is commonly regarded as less expensive, but often less reliable and slower. Trucks characteristically handle most of the East Coast port containers moving less than 500 miles. Calculating rail intermodal cost is fraught with difficulties because rail intermodal does not serve all the hinterland cities directly with all competing ports, which complicates computation of moving cargo from port of origin to destination compared to truck transportation[6]. Thus rail cost was not considered in land transportation cost calculations. The SHEP MP analysis assumed truck cost for land transportation.

[6] For the Port of Charleston, the rail share of transportation is 15% compared to the 85% for truck; for Norfolk 32% rail compared to 65% truck

VIII. DETERMINE CURRENT COST OF ALTERNATIVE MOVEMENTS (5)

Table 7 compares the land transportation costs (truck) per TEU for the five Mid-Atlantic and South Atlantic ports based on truck cost. The basic cost framework developed for Port of Charleston was applied to the other ports. For all ports, Chicago is the most expensive land destination city for Charleston ($620.50), Savannah ($656.32), Jacksonville ($757.56), Norfolk ($609.49), and Wilmington ($679.73). Norfolk's most expensive land destination city is Jackson, MS ($652.19).

Table 7: Land Cost per TEU Based on Truck for Five Mid-Atlantic and South Atlantic Ports

	Mid-Atlantic and South Atlantic Ports				
	Land Cost per TEU Based on Truck Cost				
Hinterland					
	Charleston	**Savannah**	**Norfolk**	**Jacksonville**	**Wilmington**
Atlanta, GA	$216.94	$171.48	$389.80	$237.60	$278.92
Charlotte, NC	$137.74	$173.55	$225.20	$264.46	$134.98
Chicago, IL	$620.51	$656.32	$609.49	$757.56	$679.73
Cleveland, OH	$491.03	$526.16	$384.29	$617.75	$482.08
Columbia, SC	$79.20	$109.50	$265.83	$199.72	$148.07
Columbus, OH	$463.49	$499.30	$409.08	$590.20	$453.16
Greensboro, NC	$188.01	$218.31	$162.53	$308.53	$143.94
Greenville, SC	$132.02	$159.29	$264.66	$240.49	$189.04
Huntsville, AL	$347.10	$296.14	$414.59	$338.83	$511.01
Jackson, MS	$478.64	$433.18	$652.19	$500.68	$540.62
Knoxville, TN	$250.68	$285.81	$357.43	$377.40	$338.15
Louisville, KY	$418.03	$453.84	$450.40	$528.91	$477.26
Memphis, TN	$535.80	$438.69	$630.84	$504.81	$580.56
Nashville, TN	$372.58	$342.28	$485.52	$409.08	$460.04
Raleigh, NC	$192.83	$222.45	$126.72	$313.35	$91.60
Spartanburg, SC	$127.06	$166.11	$245.45	$235.53	$172.31
Vance, AL	$351.23	$296.14	$550.95	$347.79	$414.59

Notes: Some cost inputs have been estimated

Source: USACE Charleston

Mid-Atlantic and South Atlantic Ports Comparison for Total Landside Cost

The total delivered transportation cost is calculated by adding the port costs and land costs components. Total land transportation cost is calculated by the truck cost or rail cost, assuming that specific ports have direct rail service to one of the 17 hinterland cities. However, for this report, total land cost will be assumed on a truck cost basis only. As earlier mentioned, the rail network does not provide enough direct routes from port directly to hinterland destinations. Table 8 presents total cost summary for the five Mid-Atlantic and South Atlantic ports. Total cost combination of truck and port components indicate that it cost more to move goods to Chicago compared to other cities in the hinterland.

Table 8: Total Cost Comparisons for Five Mid-Atlantic & South Atlantic Ports

	Mid-Atlantic and South Atlantic Port				
	Total Cost Comparisons				
Hinterland					
	Charleston	Savannah	Norfolk	Jacksonville	Wilmington
Spartanburg, SC	$336.40	$374.36	$456.77	$443.43	$356.20
Greensboro, NC	$397.35	$426.56	$373.86	$516.43	$327.83
Memphis, TN	$745.14	$646.94	$842.16	$712.71	$764.46
Greenville, SC	$341.36	$367.54	$475.99	$448.39	$372.94
Jackson, MS	$687.98	$641.43	$863.51	$708.57	$724.51
Huntsville, AL	$556.44	$504.39	$625.92	$546.73	$694.90
Atlanta, GA	$426.28	$379.73	$601.12	$445.49	$462.81
Charlotte, NC	$347.08	$381.80	$436.53	$472.35	$318.88
Nashville, TN	$581.92	$550.53	$696.85	$616.98	$643.94
Knoxville, TN	$460.02	$494.06	$568.75	$585.30	$522.04
Louisville, KY	$627.37	$662.09	$661.73	$736.81	$661.15
Vance, AL	$560.57	$504.39	$762.28	$555.68	$598.48
Columbus, OH	$672.83	$707.55	$620.41	$798.10	$637.05
Chicago, IL	$829.85	$864.57	$820.81	$965.45	$863.63
Raleigh, NC	$402.17	$430.70	$338.04	$521.25	$275.49
Columbia, SC	$288.54	$317.75	$477.16	$407.62	$331.96
Cleveland, OH	$700.37	$734.41	$595.61	$825.65	$665.98

Least Total Landside Transportation Cost

The total port and land transportation cost was calculated for the five Mid-Atlantic and South Atlantic ports with destinations for cargo to 17 hinterland cities. Table 9 provides a summary of the incremental landside costs of each port over the least cost of shipping to various locations in the hinterland. The results in Table 9 are incremental differences in total landside transportation costs on a TEU basis. Charleston is the least total land cost port to Spartanburg, compared to Norfolk which is $120.37 more expensive to transport cargo to the same hinterland city.

Table 9: Incremental Difference in Least Cost for Competing Ports

	Mid-Atlantic and South Atlantic Ports				
	Difference in Total Cost				
	Charleston	Savannah	Norfolk	Jacksonville	Wilmington
Hinterland	$	$	$	$	$
Spartanburg, SC	0.00	37.96	120.37	107.03	19.80
Greensboro, NC	69.52	98.73	46.03	188.60	0.00
Memphis, TN	98.20	0.00	195.22	65.76	117.51
Greenville, SC	0.00	26.18	134.63	107.03	31.58
Jackson, MS	46.54	0.00	222.08	67.14	83.08
Huntsville, AL	52.05	0.00	121.53	42.35	190.52
Atlanta, GA	46.54	0.00	221.39	65.76	83.08
Charlotte, NC	28.20	62.92	117.65	153.48	0.00
Nashville, TN	31.39	0.00	146.32	66.45	93.41
Knoxville, TN	0.00	34.03	108.73	125.28	62.02
Louisville, KY	0.00	34.72	34.35	109.44	33.78
Vance, AL	56.19	0.00	257.89	51.30	94.10
Columbus, OH	52.42	87.14	0.00	177.70	16.64
Chicago, IL	9.03	43.75	0.00	144.64	42.81
Raleigh, NC	126.68	155.21	62.55	245.76	0.00
Columbia, SC	0.00	29.21	188.62	119.08	43.42
Cleveland, OH	104.76	138.79	0.00	230.04	70.36

Notes: Highlighted cells denote least total transportation delivered costs for particular cities and ports.

As shown in Table 5 above, the average highway distance between Charleston and hinterland cities (461) and Savannah and hinterland cities (465) are almost identical. Table 9 shows that Savannah is the least total cost port to six hinterland cities consisting of Memphis, Jackson, Huntsville, Atlanta, Nashville, and Vance. The analysis also shows that Charleston is the least total cost port to five hinterland cities, among them Spartanburg, Greenville, Knoxville, Louisville, and Columbia.

Hinterland Cities Less than $50/TEU Difference in Total Landside Cost (Without Project)

Hinterland cities with less than $50 difference in total landside cost that overlap each other are: Jackson, Atlanta, Charlotte, Nashville, Columbus, Columbia, Louisville, Knoxville, Huntsville, Greenville, Greensboro, Spartanburg, and Chicago. The hinterland cities of Spartanburg, Columbia, Greenville, Louisville, and Chicago are overlapped by the port cities of Savannah and Wilmington. The hinterland city of Chicago is overlapped by the port cities of Charleston, Wilmington, and Savannah. Seven hinterland cities – Charlotte, Knoxville, Columbus, Atlanta, Jackson, Nashville, and Greensboro are all within $50 difference in total landside cost but do not overlap with other Mid-Atlantic and South Atlantic ports.

IX. DETERMINE FUTURE COST OF COMMODITY MOVEMENTS CHARLESTON HARBOR WITH-PROJECT CONDITIONS (6)

The without-project conditions analysis identified the sea, port and land transportation costs. The only unit cost change under the with-project conditions is the average total sea costs per unit of carried (total TEUs). Cargo handling costs (port cost) and land transportation costs (truck cost) per TEU will not change. As a result, total cost expressed per TEU under the with-project conditions will decrease but not in proportion to the change in voyage cargoes from deeper sailing drafts.

Table 10 presents cost savings per TEU by route for existing condition and for future with project condition for Charleston Harbor. The transportation costs are calculated for each vessel class by each service route for the existing (45-foot) and future with project (50/48-foot). Table 10 shows that the largest cost saving per TEU for imports will come from the FE ECUS NEUR service route.

Table 10: Average Voyage Cost Savings per Service Route

Route	Cost Savings per TEU	**Weighted Cost Savings per TEU[7]**
FE ECUS NEUR	$60.50	$8.13
FE ECUS Panama	$48.16	$7.77
FE ECUS Suez	$54.27	$5.14
ISC/ME	$40.32	$6.93
MED	$35.19	$1.63
NEUR	$32.97	12.90

The average voyage cost savings[8] per service route range from about $32.97 to $60.50, depending on the trade route distance, percentage of Charleston cargo and other factors. The waterborne cost savings is approximately $42.5, which is the sum of the weighted cost savings per TEU for the benefiting routes. Compared to least cost in Table 9, Nashville TN is the only hinterland city that may experience a shift of cargo from Savannah to Charleston as result of Charleston Harbor deepening and widening. Based on this analysis only, the waterborne cost savings will induce cargo from Savannah to Charleston. However, given that Savannah also has an authorized deepening project, we expect cost savings for Savannah deepening project to offset savings from Charleston deepening, resulting in no net change. In all, no shift in TEUs is expected between ports because, over time, most ports have deepened and deriving economies of scale from larger vessels calling. Thus the differences in cost between ports will be very negligible.

Cost savings are lost by relatively small increases in land based distances. According to SCPA, based on estimated marketing and sales knowledge not hard data, the estimated share of Charleston container volume delivered within 50-mile radius for local consumption or use in production is 5%. The estimated share of container volume delivered for warehousing, inland distribution, rail transport within a 50-mile radius of the Port is 30%. Approximately 35% of cargo is delivered between 50 – 250-mile radius and 30%

[7] Weighted cost savings per TEU is derived by multiplying the percentage of TEU per service route by the cost savings per TEU. The waterborne cost savings, $42.5, is the sum of the weighted cost savings.

[8] Average voyage costs savings for other port cities are ignored because the differences in voyage costs between ports are much less significant than the differences in landside transportation costs. Assuming the ports are at same depth, the differences in total transportation costs will be due to landside transportation costs.

beyond 250 miles. In all, about 70% of all container cargo is delivered within 250-mile radius of the Port of Charleston.

X. SUMMARY AND CONCLUSION (7)

In summary, the future cost of container movements under with-project conditions was determined for Charleston Harbor for six benefiting services. The analysis determined that the cost savings associated with the with-project conditions would be too small to result in a diversion of containers from other ports on the basis of least total transportation cost (voyage, port and hinterland).

The use of Charleston Harbor under without and with-project conditions with respect to imported containers was determined. An analysis of transportation costs from port cities to 17 hinterland cities showed that Charleston has the least total delivered transportation cost under the without-project conditions for major nodes of Spartanburg, Greenville, Knoxville, Louisville, and Columbia. Alternatively, Savannah has the total delivered transportation cost for the major nodes Memphis, Jackson, Huntsville, Atlanta, Nashville, and Vance. Norfolk has the least total delivered transportation cost for the major nodes of Columbus, Chicago, and Cleveland.

The Charleston Harbor multiport analysis confirms the conclusions in the SHEP analysis that port deepening alone will not cause traffic to be diverted from or to other ports. Other factors involved in port developments such as new container yard development, location of distribution centers, and landside transportation improvements appear to have a greater influence on cargo diversions.

This conclusion is supported by the fact that there has been no discernible cargo diversion from other ports as a result of deepening the Port of Norfolk from 45 feet to 50 feet in 1988. To the contrary, between 1998 and 2008, the Port of Savannah led all U.S. ports in TEU growth (258.1%), not because of its depth (43-foot), compared to Norfolk’s 50 feet, but because of its regional distribution centers, good rail connections, and the ability of the port to mix and match different types of cargo efficiently.

The results of this analysis highlight that the high cost of land-based transportation, relative to water-based transportation and the presence of land-based transportation and other infrastructure, such as factories and distribution centers that utilize the cargo have the predominant influence on the delineation of port hinterland boundaries. This should not be interpreted to mean that the economic benefits associated with water-based transportation improvements are small. Instead, it indicates that the per unit cost savings from improvements can be negated by relatively small increases in transportation distances via much more costly and less efficient land-based transportation modes. In addition to the economic advantages, it is worth noting that water-based transportation of cargo has also been proven to be safer (fewer accidents and injuries/TEU-mile), have much lower levels of fuel consumption and air contaminant emissions, lower congestion related impacts and cause less damage to infrastructure investments.

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