FEASIBILITY REPORT
AND
ENVIRONMENTAL ASSESSMENT

WILMINGTON HARBOR NAVIGATION IMPROVEMENTS
Appendix A - Economics

June 2014

US Army Corps of Engineers

Wilmington District

Appendix A

Economics

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Introduction

The purpose of this economic analysis is to evaluate if the proposed widening of the Wilmington Harbor navigation channels is economically justified. This analysis is conducted from a National Economic Development (NED) perspective, where NED benefits are defined as the change in value of goods and services that accrue to the nation as a whole as a result of constructing the project and NED costs are defined as the total economic costs of constructing and maintaining the project. The average annual economic benefits of the project are compared to the average annual project costs to provide an estimated benefit-to-cost ratio. A project with a benefit-to-cost ratio greater than 1.0-to-1.0 is considered economically justified. Guidance is contained in U.S. Army Corps of Engineers Engineering Regulation (ER) 1105-2-100, as well as recent Economic Guidance Memoranda (EGM's) issued by Headquarters USACE (HQUSACE).

Project Description

The Wilmington Harbor project, located in Wilmington on the southeastern coast of North Carolina, requires improvements to address navigation inefficiencies and safety issues being faced by navigation vessels calling on the Port of Wilmington. The existing depth of the navigation channel ranges from 42 to 44 feet. The current alignment of the entrance channel near Bald Head Island has proven susceptible to rapid and persistent shoaling. The Battery Island navigation channel turn is problematic for some container vessels under certain conditions of wind and tide. Finally, the limited width of the existing anchorage basin causes delays for larger vessels currently utilizing the harbor. The economic use of the anchorage basin is to turn large deep draft vessels. Hence, in this report the anchorage basin is referred to as a turning basin.

Demographic Profiles

New Hanover and Brunswick Counties are located at the Southeastern portion of the state of North Carolina. The counties include 192 and 847 square miles respectively in land and water area. Table 1 provides population data for the United States, North Carolina, New Hanover and Brunswick Counties over the last 20 years for which data is available.

Table 1. New Hanover and Brunswick Counties Statistical Area - Total Population Data

Area	Percent Change '90-'12	2012	2000	1990
United States	25.76%	313,914,040	282,162,400	249,622,800
North Carolina	46.34%	9,752,073	8,081,600	6,664,000
New Hanover County	72.72%	209,234	160,842	121,140
Brunswick County	118.95%	112,257	73,756	51,271

*population estimates provided by U.S. Census

An estimated 321,000 residents lived in New Hanover and Brunswick Counties in 2012. This represents a population increase of 35 percent since 2000 and an increase of 86 percent since 1990.

The residents of New Hanover and Brunswick Counties contain a mix of races and ethnicities. Based on 2012 census figures, 15.0 percent of New Hanover County residents are black, and 5.3 percent are Hispanic, 1.2 percent Asian and 0.6 percent identified as Native American. The census of Brunswick County estimates that 11.6 percent of its residents are black, and 5.1 percent are Hispanic, 0.6 percent Asian and 0.8 percent identified as Native American.

In the state of North Carolina 22.0 percent of the population is black, 8.6 percent Hispanic, 2.3 percent are Asian, and 1.5 percent are Native American. Table 2 displays racial demographics for the Nation, State, New Hanover and Brunswick Counties.

Table 2. Population by Race

	New Hanover County	**Brunswick County**	**North Carolina**	**United States**
Population, 2012	206,189	112,257	9,752,073	313,914,040
White persons, percent	79.1%	85.4%	72.10%	78.1%
Black persons, percent	14.8%	11.6%	22.0%	13.1%
Hispanic	5.3%	5.1%	8.6%	16.7%
Asian persons, percent	1.2%	0.6%	2.3%	5.0%
Native(American Indian, Alaska Native, Hawaiian, etc)	0.6%	0.8%	1.5%	1.2%
Two or More Races	2.0%	1.5%	1.9%	2.3%

*population estimates provided by U.S. Census

Approximately 48 percent of the population for New Hanover County was sixteen years and over with 53.2 percent of the population in the labor force. The unemployment rate for the County is 10.4 percent. 37.2 percent of Brunswick County's population is sixteen or over, with 45.5 percent of the population in the labor force, and unemployment rate of 11.0 percent. The unemployment rates for North Carolina and the United states were 10.6 and 9.3 percents respectively.

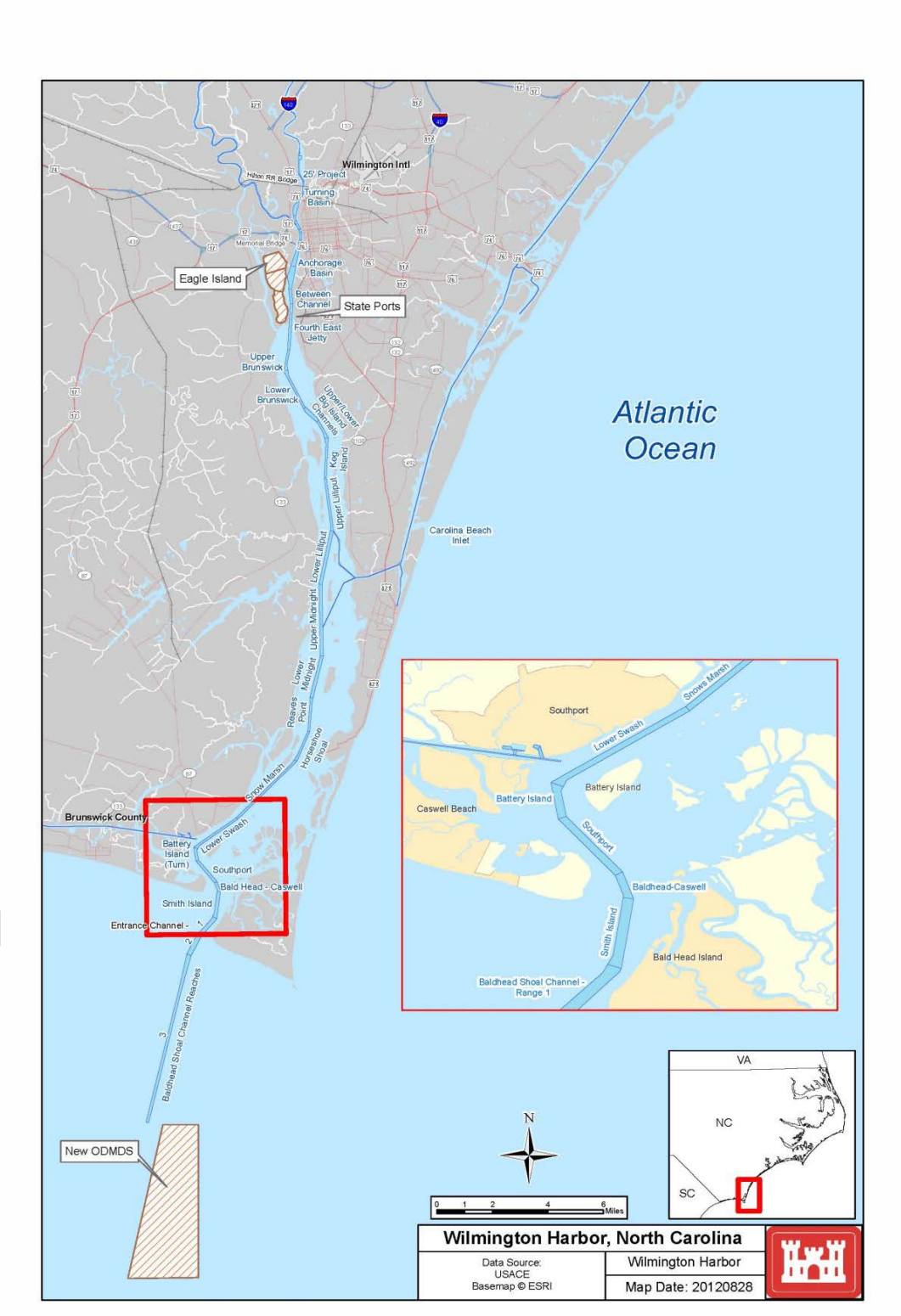

Figure 1: Wilmington Harbor – Vicinity Map

Table 3. Civilian Labor Force by Occupation

	New Hanover County	Brunswick County	North Carolina	United States
Civilian employed population 16 years and over	98,896	41,791	4,128,576	139,033,928
OCCUPATION				
Agriculture Forestry, Fishing, Hunting, Mining	0.18%	0.66%	1.37%	1.90%
Construction	6.89%	12.89%	6.85%	6.25%
Manufacturing	6.28%	6.94%	12.41%	10.39%
Wholesale Trade	3.10%	1.78%	3.03%	2.83%
Retail Trade	12.54%	16.60%	11.99%	11.65%
Transportation, Warehousing, Utilities	3.80%	5.02%	4.25%	4.92%
Information	3.15%	1.78%	1.69%	2.17%
Finance, Insurance, Real Estate, Rental, Leasing	5.43%	7.44%	6.35%	6.67%
Professional, Scientific, Management, Administrative, Waste Management Services	10.84%	9.03%	9.51%	10.58%
Educational Services, Healthcare, Social Assistance	25.15%	18.25%	23.41%	23.24%
Arts, Entertainment, Recreation, Accommodation, Food Services	13.54%	10.94%	9.25%	9.25%
Public Administration	3.28%	4.41%	4.86%	5.17%
Other Services, Except Public Administration	5.83%	4.26%	5.04%	4.97%

In 2010, the median household income of Brunswick County was $45,806, higher than the State's average of $43,326 but lower than the national average of $50,046. The mean household income was $57,088. The median household income of New Hanover County was $46,130 and the mean household income was $63,093 Table 4 shows the number of households in the New Hanover and Brunswick Counties, North Carolina, and the United States by the percentage of their respective incomes.

Table 4. Income

Total Households	New Hanover County	Brunswick County	North Carolina	United States
Less than $10,000	10.47%	7.64%	8.97%	7.64%
$10,000 to $14,999	9.98%	17.45%	13.01%	11.46%
$15,000 to $24,999	12.07%	10.86%	12.47%	11.17%
$25,000 to $34,999	10.85%	8.82%	11.59%	10.41%
$35,000 to $49,999	9.90%	11.76%	10.20%	9.27%
$50,000 to $74,999	17.91%	19.15%	18.39%	18.28%
$75,000 to $99,999	11.35%	11.36%	10.79%	11.81%
$100,000 to $149,999	11.15%	8.62%	9.05%	11.82%
$150,000 to $199,999	3.12%	2.04%	2.88%	4.20%
$200,000 or more	3.21%	2.30%	2.66%	3.94%

Source: http://www.usa.com/brunswick-county-nc.htm
http://www.usa.com/new-hanover-county-nc.htm

Existing Conditions

Wilmington Harbor is an active port located along the Cape Fear River in North Carolina, with access to the Atlantic Ocean. This Economic Appendix describes and analyzes the existing, future "without" and future "with" project conditions at the port. This section of the report portrays the existing conditions at the port using the latest data available, which is generally from 2009 and 2010, as available at the time of analysis. This section is divided into five sub-sections covering Port Facilities, Channel Features, Commodity Shipments, Fleet Characteristics and the HarborSym computer model. The Port Facilities sub-section provides information on the location and attributes of the port facilities at Wilmington Harbor. The Channel Features section provides information on the channel dimensions and characteristics. The Commodity Shipments sub-section covers existing and historic commodity shipments and distribution of commodities by type, as well as identifying recent trends at the harbor. The Fleet characteristics sub-section discusses the existing fleet that calls at Wilmington Harbor as well as trends in numbers of vessels and vessel sailing drafts. The HarborSym model section describes the HarborSym model, which is being used to conduct the economic evaluation, and provides specific information on the application of the model to existing conditions, which was used to calibrate the model.

Authorized channel depth along the Cape Fear River is -42 feet, while the depth of the ocean approach channel and inlet is authorized to -44 feet. In addition to depth limitations, the "S" curve shape of the Cape Fear River at the port entrance restricts the length of the ship entering the port to 965 feet. The Port of Wilmington also has an air draft restriction of 170.5 feet, which is the maximum vessel height permitted to clear electrical lines that cross the waterway, and a 1,200 foot wide turning basin in the Cape Fear River, which can accommodate vessels up to 965 feet long.

Hinterland

The Port of Wilmington's hinterland is primarily within the state of North Carolina. It includes Raleigh, Durham, Greensboro, Fayetteville and, of course, the Wilmington area. The port is connected to the Raleigh-Durham area by Interstate I-40 and to Greensboro by Interstate I-73. The primary Port facilities are approximately 75 miles from Interstate I-95 and 200 miles from Interstate I-85, which are the primary north / south transportation corridors through North Carolina. These highways connect the Port of Wilmington to Charlotte, Greensboro and Raleigh / Durham. Improvements to Interstate I-74 have added vehicle capacity between the port and I-85, which connects to Charlotte, North Carolina.

Landside transportation to and from the Port of Wilmington is primarily by truck. Trucks must pass through residential areas to reach the interstates. They must traverse Burnett Boulevard (two-lane road) to reach I-74, or Shipyard Boulevard and College Road (four lane bi-directional roads) with a series of stop lights to reach I-40. CSX provides daily rail service to the port through one line connecting to the main line at Hamlet. The rail route is through the City of Wilmington and crosses many of the city's major roads; most crossings within the city are "at-grade."

Port Facilities

Wilmington Harbor has a variety of marine facilities located on both the left and right banks of the Cape Fear River between river miles 26 and 31. The marine facilities are listed below beginning with the terminal located furthest upstream and include Kinder Morgan, Colonial Oil, Amerada Hess, Vopak, North Carolina State Port Authority berths one through nine, Apex Oil, the Invista Terminal, Carolina Marine Terminal, South Wilmington Terminal, National Gypsum Terminal, Sunny Point, also known as the Military Ocean Terminal and Archers Daniels Midland. The following paragraphs describe these terminals in greater detail.

Kinder Morgan Terminal: The Kinder Morgan Energy Partners LP (KMI) dock is the only deep-draft terminal located upstream of the City of Wilmington. It is served by both barge and deep-draft vessels. It is located at approximately river mile 29.5 of the Cape Fear River. KMI purchased the petroleum and chemicals products terminal from ChemServe Inc. in 2008. The terminal stores and transfers a variety of products and has more than 40 tanks with 1.1 million-plus barrels of capacity. The terminal includes significant transportation infrastructure, liquid and heated storage, and custom tank blending capabilities for agricultural and chemical products. It offers a variety of both inbound and outbound services via rail, barge, ship, and truck, and has

direct access to two major highways. The facility handles caustic soda, urea-ammonium nitrate solutions, asphalt, methanol, and other liquid chemicals. KMI owns an interest in or operates more than 25,000 miles of pipelines and 165 terminals. Its pipelines transport natural gas, gasoline, crude oil, carbon dioxide, and other products, and its terminals store petroleum products and chemicals. The depth at this terminal is -32 feet mean low water (MLW).

Colonial Oil: Colonial Oil operates a berth located on the left bank of the Cape Fear River 0.5 miles below the Cape Fear Memorial Bridge at approximately river mile 26.5. This berth ships and receives petroleum products and chemicals. It has eight storage petroleum tanks with a total capacity of 406,000 barrels. The facility provides bunkering services. The dock is 720 feet long and depth alongside is -32 feet MLW. Colonial Terminals offers storage and distribution of petroleum and liquid chemicals as well as kaolin clays, fertilizer, and other dry bulk commodities by deep-draft vessels and barges.

Amerada Hess: Amerada Hess Corporation operates a wharf located on the left bank of the Cape Fear River 0.7 miles below the Cape Fear Memorial Bridge at river mile 26.3. The facility handles petroleum products such as gasoline, kerosene and jet fuel. This facility has 14 steel storage tanks with 580,000 barrels of storage capacity. The wharf is 550 linear feet long with a depth of -38 feet MLW.

Vopak: Vopak operates two terminals at Wilmington Harbor. The northern terminal is located on the left bank of the Cape Fear River at approximately river mile 25.8. The property is owned by the North Carolina State Port Authority and is leased by Vopak. This terminal is a private development that has one deep-draft berth and one barge berth. The terminal is served by ocean carriers, barge, rail and truck. Vopak handles bulk commodities from this facility, including petroleum products, chemicals, vegetable oils and bio-fuels. Vopak also operates the South Wilmington Terminal, which is discussed below. Both docks handle chemicals and related products. The north wharf has a total of 240 linear feet of berthing space and a -24 foot depth MLW. It has 7 steel tanks with 1.55 million gallons of storage capacity. The south wharf has a total of 1,010 linear feet of berthing space and a -42 foot depth alongside. This facility has 22 steel tanks with a total storage capacity of 34.1 million gallons.

North Carolina State Port Authority: The North Carolina State Port Authority (NCSPA) berths 1-9 are located on the left bank of the Cape Fear River at approximately river mile 28. This is the only public terminal suitable for deep-draft navigation on the Cape Fear River. Berths 1-6 handle a wide variety of commodities including shipments of forest products such as lumber, logs, woodchips, pulp and waste paper, as well as sulphur, clay, salt, and manufactured equipment and machinery. These docks handle roll-on/roll-off (Ro-Ro) and some limited containerized cargos. Berths 7, 8 and 9 handle containerized shipments primarily and the port has five modern container cranes, three of which are capable of servicing post-Panamax containerships. Berths 1 and 2 have a total of 1,213 linear feet of berthing area and a width of 300 feet. Berths 3, 4 and 5 have a total of 2,100 linear feet with berth 3 have a width of 60 feet, and berths 4 and 5 a width of 46 feet. Berths 6 and 7 have a total of 1,550 linear feet, with berth 6 being 110 feet wide and berth 7 being 120 feet wide and berths 8 and 9 have a total of 1,900

linear feet with berth 8 being 300 feet wide and berth 9 being 150 feet wide. The depth at all the NCSPA docks is -42 feet MLW. According to the Port of Wilmington, the port capacity for the container terminal is 500,000 TEUs.

Apex Oil: Apex Oil Company operates a wharf located on the left bank of the Cape Fear River at approximately river mile 27. The facility handles petroleum and petroleum products, including gasoline, jet fuel, kerosene, petroleum pitches, coke, asphalt, naptha, solvents and other chemicals. It has 17 steel storage tanks with a total capacity of 902,000 barrels. The wharf has a total of 800 linear feet of dock space and water depth is -42 feet MLW alongside.

Invista Terminal: Invista makes a wide variety of chemical products that are used in fabrics and fibers for apparel as well as commercial and residential uses, including automotive and industrial purposes. The Invista Terminal is located on the left bank of the Cape Fear River at approximately river mile 27. This terminal receives asphalt, petroleum products and chemicals. The terminal serves two facilities. The Koch Refining Co. which has five steel petroleum storage tanks with a total capacity of 256,000 barrels, ten chemical storage tanks with a total capacity of 21,300,000 gallons, and seven petroleum-products storage tanks with a total capacity of 363,000 barrels. The Citgo Asphalt Refining Company has five asphalt storage tanks with a total capacity of 273,000 barrels and two petroleum- products storage tanks with a total capacity of 74,000 barrels. The wharf has 700 linear feet of dock space and a depth of -38 feet MLW.

Carolina Marine Terminal: Carolina Marine Terminal (CMT) ships chromium, salt, and urea. They recently completed construction of a new bulk port. The facility has direct rail access and direct access to I-40 and I-95. The yard has storage capacity of 500,000 tons as well as 50,000 tons of dome storage capacity. The newly constructed concrete dock handles both ship and barge berthing, with 42 feet of available channel depth. Commodity transfer is via a 1,000 ton/hour capacity crane. CMT also maintains a dock at Eagle Island.

South Wilmington Terminal: The South Wilmington Terminal (SWT) is operated by Vopak. It has two berths to accommodate vessel and barge service. The facility handles bulk petroleum products, chemicals, and bio-fuels. The terminal occupies two docks located and is 1.2 miles below the Cape Fear Memorial Bridge. Both docks handle chemicals and related products. The north wharf has a total of 240 linear feet of berthing space and a -24 foot depth MLW. It has 7 steel tanks with 1.55 million gallons of storage capacity. The south wharf has a total of 1,010 linear feet of berthing space and a -38 foot depth alongside. This facility has 22 steel tanks with a total storage capacity of 34.1 million gallons.

National Gypsum: National Gypsum Corporation operates a wharf located on the left bank of the Cape Fear River at approximately river mile 26. In the past the facility received gypsum in self-unloading vessels. It is not currently in operation, but there is a possibility that it could resume operations in the future. It had a total storage capacity of approximately 100,000 tons of gypsum and a vessel unloading rate of 1,000 tons per hour. It also handled sand, gravel, stone,

rock, limestone, soil, and dredged material. The wharf has a total of 810 linear feet of dock space and water depth is -42 feet MLW.

Sunny Point (Military Ocean Terminal): The Military Ocean Terminal at Sunny Point is a large terminal located approximately between river miles 6 to 8. It has three large, widely separated docks which are each about 2,000 feet long. This terminal handles deep-draft shipments for the Department of Defense. The water depth is -42 feet MLW at the dock.

Archer Daniels Midland: The Archer Daniels Midland (ADM) plant located near Southport, North Carolina, at approximately river mile 5 of the Cape Fear River produces feed ingredients for livestock, equine, poultry, and aquaculture. The facility processes cereal grains and oilseeds into products used in food, beverage, industrial and animal feed markets worldwide. The terminal has a single dock which can handle vessels up to 1,000 feet long.

North Carolina International Terminal (NCIT): In 2006 the North Carolina State Ports Authority bought 600 acres near the entrance to the Cape Fear River at Southport, North Carolina to build the proposed $3 billion North Carolina International Terminal (NCIT) project. The reason for the NCIT was for Wilmington Harbor to capitalize on being a leading port in offering the deep draft conditions and a large container terminal to handle vessels that are expected to transit the new locks and channels that are under construction in the Panama Canal. The proposal has been controversial and the current study, being conducted by the state, is on hold. There is no Federal study regarding this proposed project at this time.

The Ports Authority purchased the undeveloped 600-acre site on the Cape Fear River for the potential NCIT in early 2006 for $30 million. The property is three miles from downtown Southport and 20 miles downriver from the Port of Wilmington. Development of the site would require extensive dredging, potentially up to minus 50 feet, and could potentially impact some natural areas along the river. Major highway and railway improvements would be necessary to access the site.

The project has attracted significant opposition. Opponents question the ability of the proposed new port to attract sufficient traffic to make it viable commercially. There is also concern regarding the proposed port's proximity to the Brunswick Nuclear Plant and potential emergency access to the facility. We currently have no indication that the State of North Carolina will continue to pursue development of the NCIT.

Remaining Facilities: The remaining facilities are not involved in commodity shipments. Atlantic Diving and Marine Contractors operate a lay berth located 0.2 miles below the Cape Fear Memorial Bridge on the right bank of the Cape Fear River. It has -32 feet MLW alongside and 800 linear feet of berthing space. Historically, it was used occasionally for mooring vessels, however deep-draft vessels now prefer to wait at anchor of the entrance to the Cape Fear River and this facility is not longer in use. It does not handle commodities.

The Cape Fear Towing Company operates a wharf located on the right bank of the Cape Fear River 0.3 miles below the Cape Fear Memorial Bridge. The facility is used to moor company owned tug boats. It has 450 linear feet of dock space and channel depth is -20 feet MLW.

The City of Wilmington's Market Street Wharf is located on the left bank of the Cape Fear River at river mile 30. It has 300 linear feet of dock space and a depth of -25 feet alongside. It is the home of the fireboat "Atlantic V."

The U.S. Coast Guard wharf is also located on the left bank of the Cape Fear River at river mile 30. Coast Guard vessels are moored at this dock. It has 747 linear feet of dock space and a water depth of -19 feet.

The City of Wilmington's London Wharf on the Riverwalk is located along the left bank of the Cape Fear River at river mile 30. Two excursion vessels are moored at this facility. The total length of the dock is 300 linear feet and the channel depth is -15 feet alongside.

The Wilmington Marine Center Boat Basin is located along the left bank of the Cape Fear River at river mile 26. It contains 74 berths. Total berthing space is 3,020 linear feet and the largest berth is 60 linear feet. Depth alongside the dock is -6 feet.

The Battleship U.S.S. North Carolina passenger landing is located on the right bank of the Cape Fear River at river mile 28. It is a landing for excursion vessels. It has 75 linear feet of dock space and a depth of -5 feet alongside. The U.S. Army Corps of Engineers Eagle Island Repair Yard is located on the right bank of the Cape Fear River at river mile 31. It has a total of 500 linear feet of dock space; the longest dock is 240 linear feet. Water depth alongside is -12 feet. McAllister towing is located on the right bank of the Cape Fear River at river mile 31. Company owned tugboats are moored at this facility. The total length of the wharf is 400 linear feet and the largest berth is 250 linear feet. The depth alongside the dock is -8 feet.

Channel Features

Over 40 topographical features were identified as part of the existing condition for the study. These relate to deep draft navigation in the Cape Fear River. They include a single entry/exit point, one turning basin[1], 14 docks and 16 channel reaches. The entry/exit point is located at the sea buoy; the turning basin is located just upstream of the North Carolina State Port Authority docks, on the south side of the channel, between the Vopak and Amerada Hess terminals. The 14 docks associated with deep draft commerce are, beginning with the most downstream, Archer Daniels Midland (ADM), Sunny Point (Military Ocean Terminal), South Wilmington Terminal (SWT), Carolina Marine Terminal (CMT), Invista, Apex Oil, North Carolina State Port Authority (NCSPA) docks 1-9, Vopak, Amerada Hess, Colonial Terminal, and the Kinder

[1] The turning basin is sometimes referred to as an anchorage; however it is only used to turn vessels and is not used as an anchorage.

Morgan International (KMI) Terminal. Complete dock information is provided in Table 5: Wilmington Harbor Docks.

Table 5: Wilmington Harbor Docks

ID	Dock	Commodities	Length (feet)	Vessel Capacity	Depth (feet)
1	Archer Daniels Midland	Chemicals	985	1	-42
2	Sunny Point (MOT)	Munitions, Military Cargo	6,000	6	-42
3	South Wilmington Terminal	Chemicals	815	1	-38
4	Carolina Marine Terminal	Bulk Commodities	700	1	-42
5	Invista	Chemicals, Petroleum	850	1	-38
6	Apex Oil	Chemicals, Petroleum	1,040	1	-42
7	NCSPA 7-8-9	Containers	2,645	3	-42
8	NCSPA 3-4-5-6	General Cargo	2,885	4	-42
9	NCSPA 1-2	General Cargo, Ro-Ro	1,212	2	-42
10	Vopak	Chemicals, Petroleum	1,012	1	-42
11	Amerada Hess	Chemicals, Petroleum	865	1	-38
12	Colonial Oil	Petroleum	600	1	-32
13	KMI	Chemicals/Petroleum	720	1	-32

A total of 25 channel reaches were identified. The length, width, and depth for each reach are provided in Table 6.

Table 6: Wilmington Harbor Channel Reaches

ID	Reach	Length (feet)	Width (feet)	Depth (feet)
1	Baldhead Shoal Reach 3	26,658	500	44
2	Baldhead Shoal Reach 2	4,342	900	44
3	Baldhead Shoal Reach 1	4,500	700	44
4	Smith Island	5,100	650	44
5	Baldhead-Caswell	1,912	500	44
6	Southport	5,363	500	44
7	Battery Island	2,589	500	44
8	Lower Swash	9,789	400	42
9	Snows Marsh	15,775	400	42
10	Horseshoe Shoal	6,102	400	42
11	Reaves Point	6,531	400	42
12	Lower Midnight	8,241	600	42
13	Upper Midnight	13,736	600	42
14	Lower Lilliput	10,825	600	42
15	Upper Lilliput	10,217	400	42

ID	Reach	Length (feet)	Width (feet)	Depth (feet)
16	Keg Island	7,726	400	42
17	Lower Big Island	3,616	400	42
18	Upper Big Island	3,533	510	42
19	Lower Brunswick	8,161	400	42
20	Upper Brunswick	4,079	400	42
21	Fourth East Jetty	4,652	500	42
22	Between Channel	2,827	400	42
23	Memorial Bridge	8,481	450/1,200	42/38
24	CSX RR Bridge	9,573	400	32
25	End of Project	9,277	200/300	32/25

Commodity Shipments

Based on Waterborne Commerce of the United States, Wilmington Harbor handled a total of 6.7 million tons[2] of commerce in 2009, including 4.9 million tons of foreign commerce and 1.8 million tons of domestic commerce, making it the 42nd largest port in the United States in terms of total tonnage[3]. Foreign imports made up 3.5 million tons while foreign exports accounted for 1.3 million tons. Much of the foreign commerce moving through the port is containerized. In 2010 the port handled 199 thousand twenty-foot equivalent units (TEU's)[4] of containers, making it the 17th largest U.S. container port for foreign commerce.[5] Commodity shipments have been highly variable in recent years; total shipments reached a high of nearly 9.5 million tons in 2004, but have declined steadily since that time. The overall decline in shipments appears to be related primarily to barge movements. Figure 2 displays the historic trend in total commerce at Wilmington Harbor between 1996 and 2010. Total commerce includes all foreign and domestic shipments.

[2] All references to commodity shipments in "tons" refer to "short tons" of 2,000 pounds.
[3] Source: http://www.ndc.iwr.usace.army.mil/wcsc/portton09.htm
[4] The TEU, or Twenty-foot Equivalent Unit, is a standard unit of measure in the industry that provides comparability for different sizes of containers.
[5] Source: http://www.ndc.iwr.usace.army.mil/wcsc/by_porttons10.html

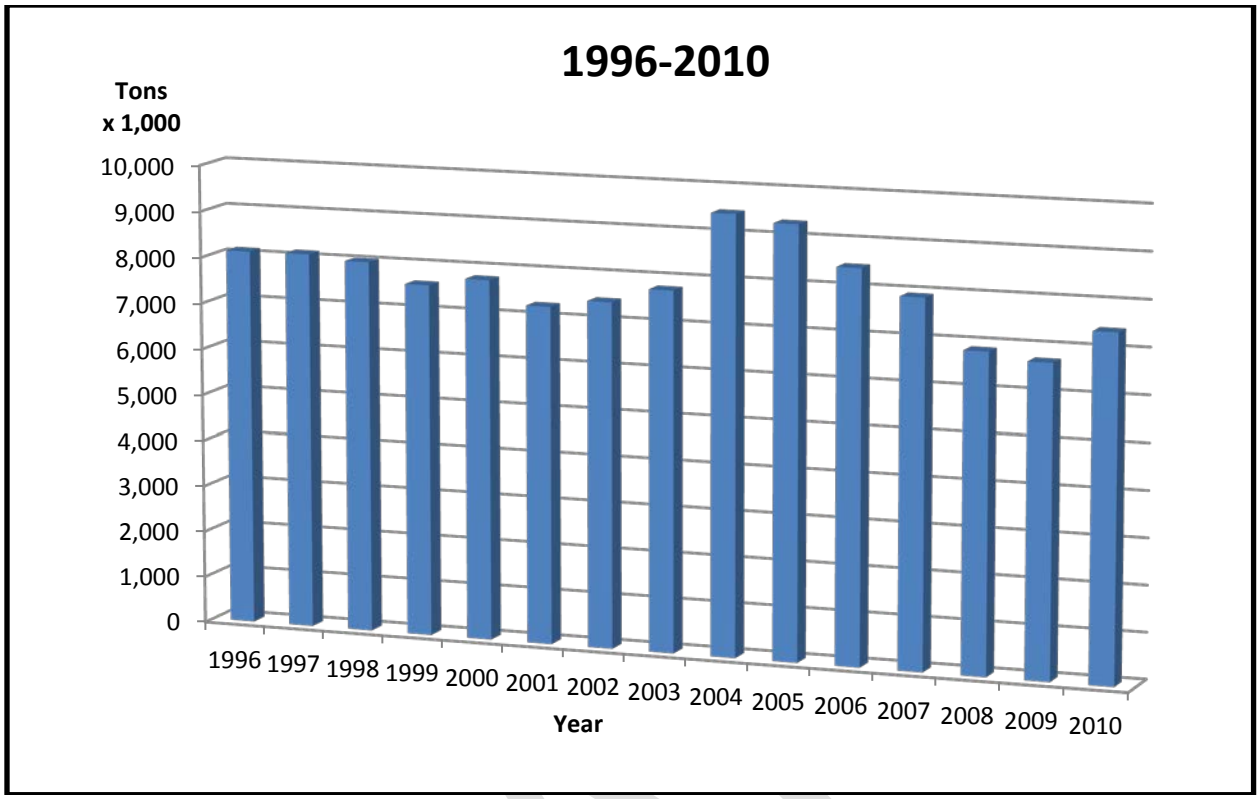

Figure 2. Trends in Total Commerce, 1996-2010

Source: Waterborne Commerce of the United States 1996-2010

Based on the most recent six years for which data is available (2005 through 2010[6]), total shipments averaged 7.9 million tons per year, varying from a high of almost 8.5 million tons in 2006 to a low of 6.7 million tons in 2009. Coal shipments, which moved by barge, exceeded 1.0 million tons in 2006, but no longer move on the waterway due to the closing of an electric generating facility upstream of the City of Wilmington. Petroleum products averaged about 31.6% of total shipments, or 2.4 million tons. The most significant products in this category were gasoline (14.0%), residual fuel oil (8.1%), distillate fuel oil (5.2%), asphalt, tar and pitch (2.1%) and petroleum coke (1.9%). The port does not handle crude petroleum. Chemicals averaged 24.3% of total shipments or 1.85 million tons. The most significant commodities in this category were hydrocarbons (8.7%), alcohols (8.0%), nitrogenous fertilizers (2.6%) and sodium hydroxide (1.6%). Crude materials averaged 17.6% of total shipments or 1.34 million tons. These include pulp and waste paper (6.0%), lumber (5.0%), gypsum (3%), non-ferrous ores not elsewhere classified (NEC) (1.4%) and non-metallic minerals NEC (1.4%).

Primary manufactured goods accounted for an average of 8.8% of total shipments or 669,000 tons over the five year period. The most significant commodities in this category were cement and concrete (3.6%), fabricated metal products (1.2%) and smelted metal products (1.1%). Coal and lignite accounted for an average of 7.8% of total shipments, or 593,000 tons, but declined to

[6] The study generally employs 2009 data, as this was the most recent year for which a complete data set was available; however some 2010 data has been obtained and is included in the report.

less than 100 tons in 2009. Manufactured equipment and machinery averaged 6.0% of the total or 455,000 tons. Manufactured products NEC was the most significant commodity in this category (2.0%) followed by textile products (2.0%). Food and farm products averaged 3.4% of the total or 261,000 tons, with wheat, and fresh and frozen meat being the most significant commodities (1.0% each). Figure 3 displays the distribution of commodities at Wilmington Harbor.

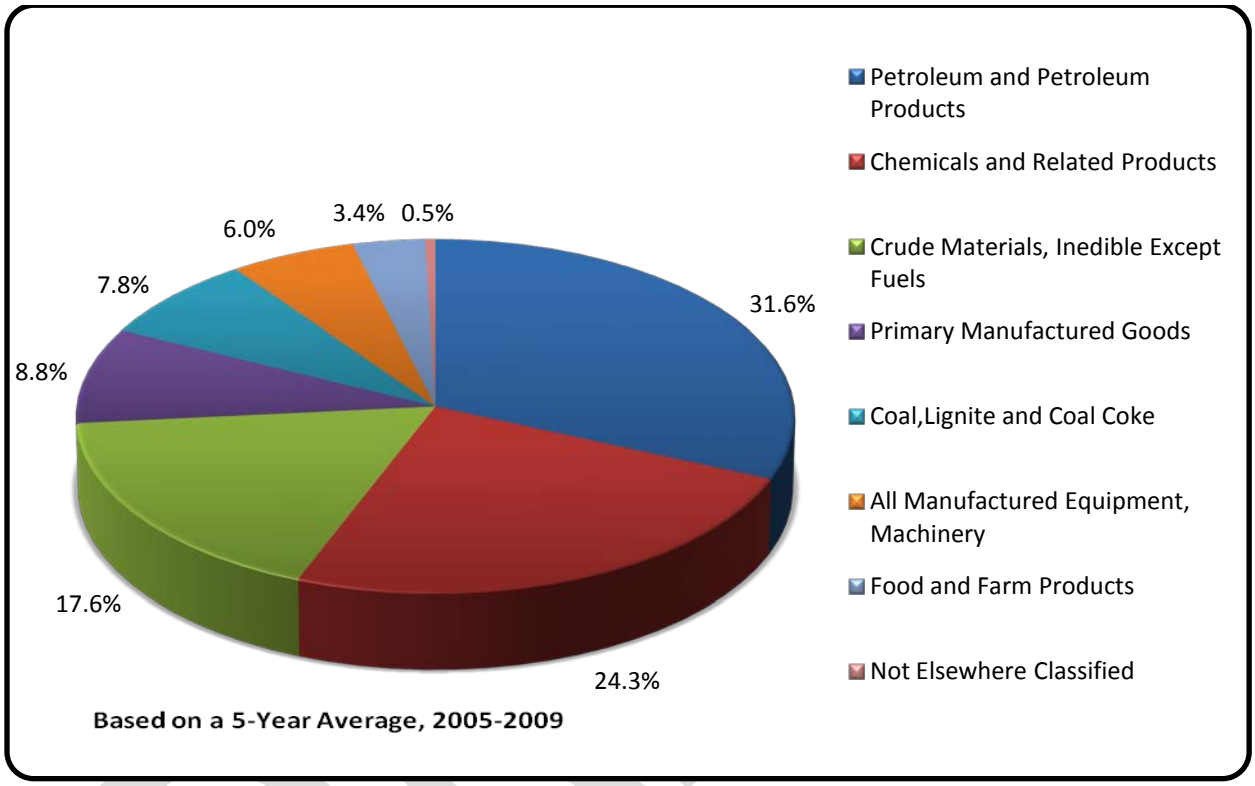

Figure 3. Wilmington Harbor, Distribution of Commodities

Source: Waterborne Commerce of the United States 2005-2009

Foreign shipments and receipts made up about 85.7% of all shipments in 2005, and 98.6%-99.9% of all commodity shipments during the period 2006-2009. Domestic shipments and receipts made up a mere 14.3% of total shipments in 2005 and ranged from 1.4% to 0.1% for the remainder of the five year period. Imports account for approximately 75% of the foreign trade at Wilmington Harbor during the period 2005 to 2009, while exports amount to about 25%. Graph displays the trend in foreign trade between 2005 and 2010, including imports, exports and total foreign trade, which has remained relatively flat overall in recent years.

When measured by volume, containerized cargo represents more than half of the foreign commerce moved through the Port of Wilmington. Grains and various wood products represent 79% of non-containerized tonnage handled in 2010. Volumes of grain and breakbulk lumber products are limited by currently available storage capacity at the terminal. The recent global economic crisis and U.S. housing crisis negatively affected the volumes of construction-related

commodities, including breakbulk exports and imports, handled by the Port of Wilmington during this time period.

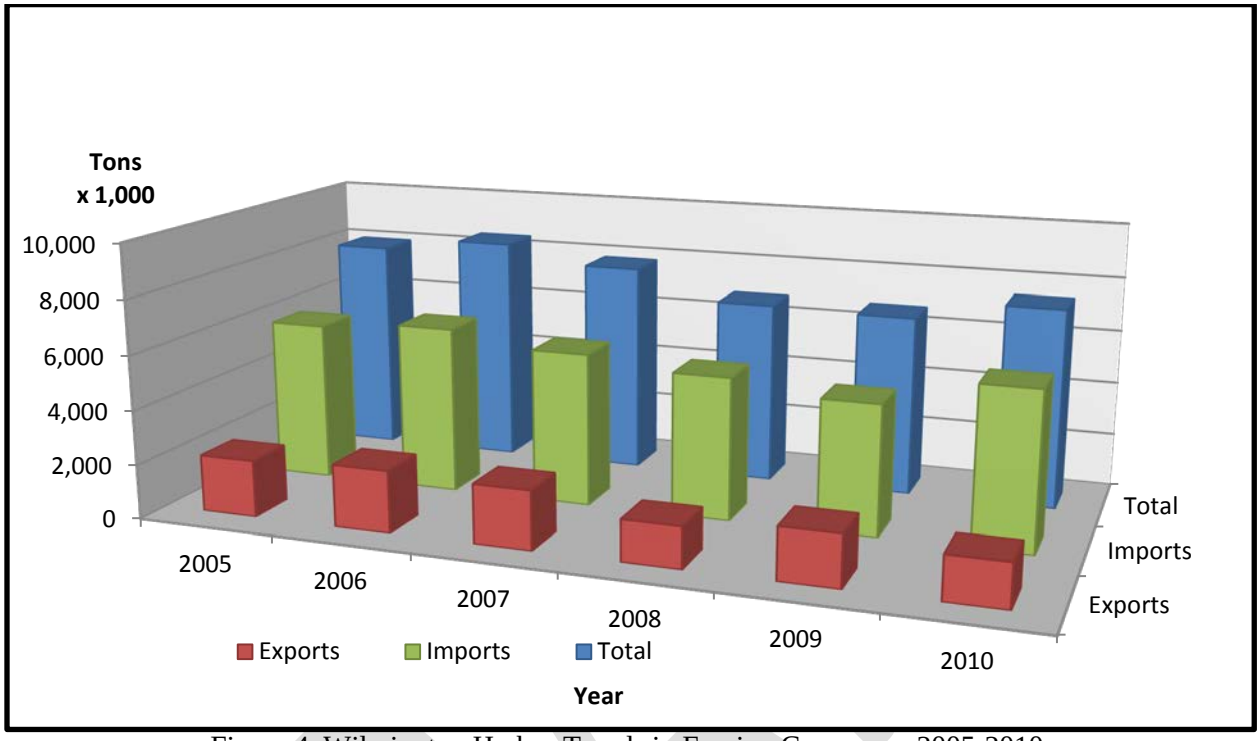

Figure 4. Wilmington Harbor Trends in Foreign Commerce 2005-2010

Source: Waterborne Commerce of the United States 2005-2010

Wilmington Harbor is considered to be a South Atlantic port. Other substantial South Atlantic ports in order from north to south are Charleston Harbor, Savannah Harbor, Jacksonville Harbor, Port Everglades and Port of Miami. Table 7 lists these ports and their associated tonnage.

Table 7. South Atlantic Ports – 2011 Short Tons

Port Name	Total	Domestic	Foreign	Imports	Exports
Port of Wilmington	6,972,535	1,788,182	5,184,353	3,766,990	1,417,363
Charleston Harbor	17,916,618	2,422,591	15,494,027	9,477,707	6,016,320
Savannah Harbor	35,459,297	2,351,500	33,107,797	16,720,274	16,387,523
Jacksonville Harbor	16,827,591	6,824,886	10,002,705	7,513,504	2,489,201
Port Everglades	20,955,921	10,580,678	10,375,243	6,891,615	3,483,628
Port of Miami	7,177,761	170,542	7,007,219	3,397,377	3,609,842

Containerization

Many waterborne commodities move in containers, which are standardized metal boxes that are typically shipped in specialized vessels called containerships. In 2010, the latest year for which data are available, U.S. ports handled a total of about 27,582,000 loaded TEU's, of which

16,448,000 (59.6%) were imports and 11,134,000 (40.4%) were exports. TEU is an acronym for twenty-foot equivalent unit, which is a standardized way of measuring containers of different sizes; thus a 40-foot container is 2 TEU's and a 45-foot container is 2.25 TEU's. Containerships also move empty containers, which are not included in the U.S. totals. Approximately 98.6 % of all loaded U.S. container imports and exports are handled by the 25 largest U.S. ports. Nearly 200,000 loaded TEU's were handled at Wilmington Harbor in 2010, making it the 17th largest container port in the United States and the 8th largest container port on the U.S. Atlantic coast. Table 8 is a list of the 25 largest container ports in the United States in terms of foreign commerce.

Imports at Wilmington accounted for almost 114,000 loaded TEU's (57%) and exports accounted for about 86,000 loaded TEU's (43%). Empty containers account for an additional 13% of import containers and 25% of export containers at Wilmington. Historically, exports have increased at a faster pace than imports. In 2005 exports made up only about 33% of total shipments. Despite the fact that commodity shipments have been relatively flat at Wilmington Harbor, both import and export container shipments have displayed significant growth since 2005. As indicated by Figure 4, if current trends continue, total container shipments would exceed 300,000 TEU's by 2015.

Table 8. Twenty-five Largest U.S. Container Ports in 2010 (loaded TEU's in foreign trade)

#	Port	State(s)	Inbound Loaded TEU's	Outbound Loaded TEU's	Total Loaded TEU's
1	Los Angeles	CA	3,817,193	1,662,158	5,479,351
2	Long Beach	CA	3,036,147	1,374,011	4,410,158
3	New York	NY/NJ	2,605,673	1,400,050	4,005,723
4	Savannah	GA	1,042,082	1,105,710	2,147,792
5	Oakland	CA	733,891	760,350	1,494,241
6	Norfolk Harbor	VA	710,232	708,801	1,419,032
7	Seattle	WA	865,346	547,474	1,412,820
8	Houston	TX	510,568	818,274	1,328,842
9	Charleston	SC	543,282	518,044	1,061,326
10	Tacoma	WA	493,489	316,768	810,257
11	Miami	FL	305,369	373,547	678,916
12	Port Everglades	FL	244,209	328,241	572,450
13	Baltimore	MD	277,709	166,302	444,011
14	New Orleans	LA	76,817	197,874	274,692
15	Jacksonville	FL	91,548	144,499	236,047
16	San Juan	PR	151,188	64,629	215,817
17	Wilmington	NC	113,829	85,899	199,727
18	Gulfport	MS	101,147	76,025	177,172
19	Philadelphia	PA	119,934	43,729	163,663
20	Wilmington	DE	131,967	22,730	154,698
21	Portland	OR	67,289	61,707	128,996
22	Boston	MA	79,557	43,753	123,310
23	Palm Beach	FL	24,765	84,222	108,987
24	Mobile	AL	34,308	46,645	80,953
25	Chester	PA	46,830	33,723	80,553

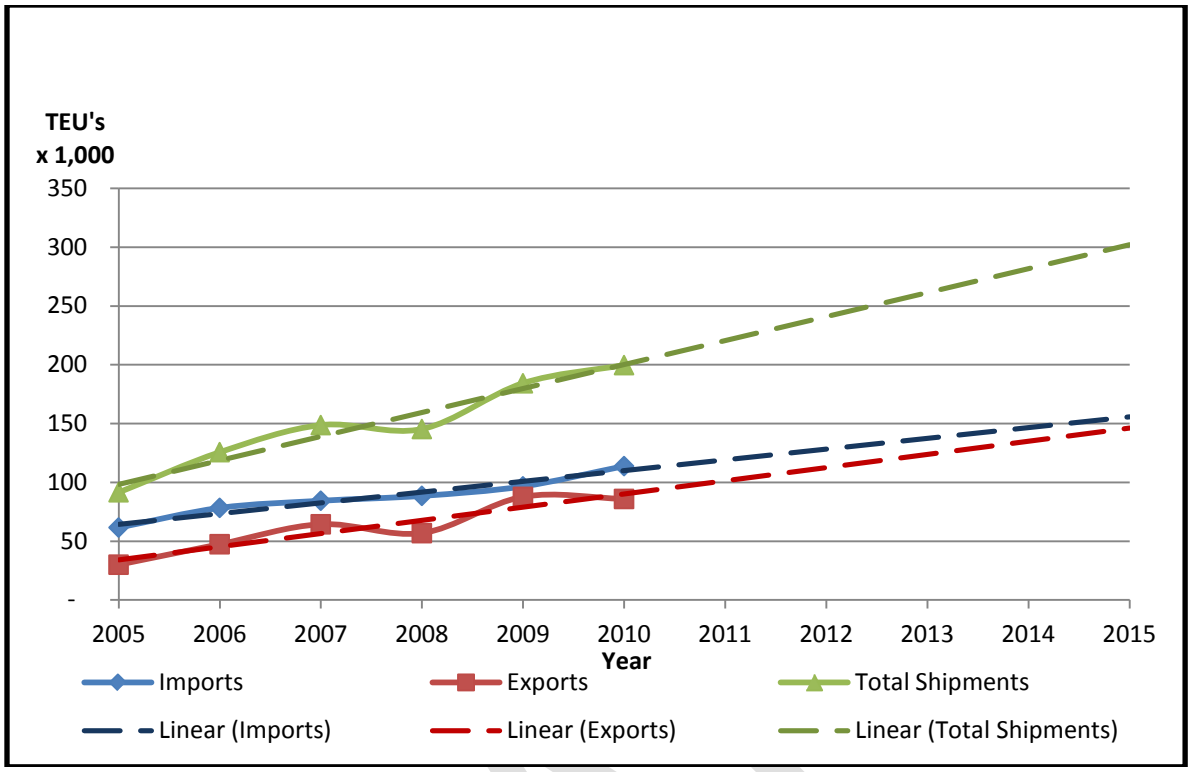

Figure 5. Shipments of Loaded Containers, 2005-2010, Extrapolated to 2015

Source: Waterborne Commerce of the United States 2005-2010

Fleet Characteristics

Based upon data contained in Waterborne Commerce of the United States, there were a total of 31,200 commercial vessel transits7 of Wilmington Harbor in 2009. This is a sharp decline from the 80,374 commercial vessel transits that occurred in 2005. The vast majority of the vessel transits were tugs and barges with drafts of less than 10 feet. Of the 2009 total, 29,694 transits (95%) were vessels with drafts of less than 10 feet, while the 2005 there were 78,826 vessel transits (98%) with drafts of less than 10 feet. The decline in vessel transits between 2005 and 2009 is primarily related to vessels drafting less than 10 feet, which are presumably tugs and barges which are not constrained by the channel. Figure 6 shows the distribution of vessel types calling Wilmington Harbor. The distribution of vessel transits by sailing draft for the period 2005 to 2009 is presented in 5. There were a total of 1,506 vessel transits with drafts at 10 feet or greater in 2009; of these approximately 1,250 transits were in vessels drafting greater than 14 feet. The total number of transits for vessels drafting greater than 10 feet has varied over the period 2005 to 2009 from a high of 1,754 transits in 2006 to a low of 1,149 transits in 2008. In 2009, there were a total 190 vessel transits in the 36-foot to 38-foot sailing draft range. This number varied from a low of 102 vessel transits in 2005 to a high of 204 vessel transits in 2008. The data suggests that there is an increasing trend to fully utilize the existing channel depth at Wilmington Harbor. However, no sailing drafts greater than 38 feet were reported in 2009; although the harbor pilots have reported that in recent years, vessels have occasionally transited

[7] A "transit" is a single vessel movement in or out of a channel. A "call" includes both the inbound and outbound vessel movements, as well as any shifting from dock to dock.

the channel with drafts of up to 40 feet. Vessels that transit the channel at drafts greater than 38 feet use tide and are typically containerships. The tidal range is four feet and occurs twice a day.

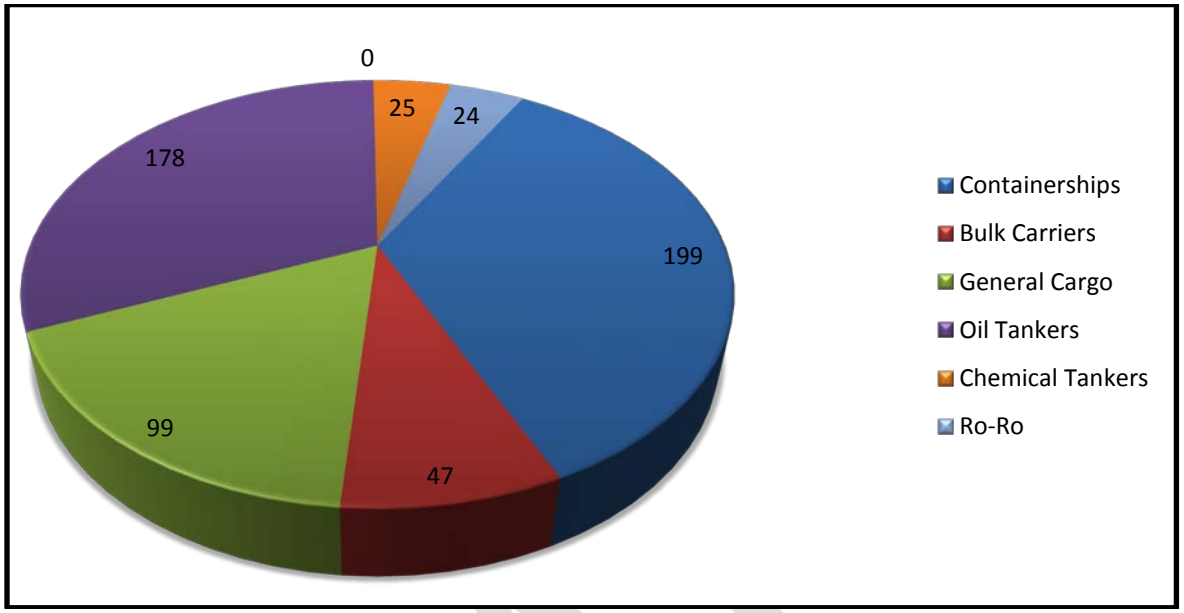

Figure 6. Distribution of Vessel Types at Wilmington Harbor in 2009

Source: 2009 Harbor Pilot Logs and Waterborne Commerce of the United

A thorough analysis the existing fleet data for vessels calling at Wilmington Harbor in 2009 revealed six typical vessel types: (1) Containerships, (2) Bulk Carriers, (3) General Cargo Vessels, (4) Petroleum Tankers (5) Chemical Tankers, and (6) Ro-Ro Vessels (includes Vehicle Carriers). It was further determined that each vessel class could be furthered categorized into representative sub-classes based on vessel size as measured by deadweight tonnage (DWT). The vast majority of Containerships fit into three sub-classes of 65,000 DWT, 50,000 DWT and 21,000 DWT. Similarly Bulk Carriers could be divided into two sub-classes of 50,000 DWT and 25,000 DWT. General Cargo Vessels were divided into three sub-classes of 40,000 DWT, 15,000 DWT and 7,500 DWT. Petroleum Tankers were divided into seven sub-classes of 73,000 DWT, 65,000 DWT, 47,500 DWT, 37,500 DWT, 31,000 DWT, 22,200 DWT and 12,000 DWT. Chemical Tankers were divided into three sub-classes of 32,000 DWT, 19,500 DWT and 16,500 DWT. Finally, Ro-Ro Vessels were sub-divided into three classes of 42,600 DWT, 21,200 DWT and 10,400 DWT. A few refinements were made to these vessel types and sub-classes for the HarborSym model runs. These refinements are explained in the HarborSym section of this appendix.

Containerships made up nearly 35% of the deep-draft vessels calls at Wilmington Harbor in 2009. The largest vessels that call at Wilmington Harbor at the present time are Hanjin and Yang Ming Panamax sized containerships of 62,000 to 65,000 deadweight tons (DWT). These vessels travel between Far East ports such as Hong Kong and Singapore, and the East Coast of the United States, calling at the North Carolina State Port Authority docks 7, 8 and 9. They are between 950 and 965 feet long, 106 feet in beam and have design drafts of between 42 and 44

feet. Their actual sailing drafts were 38 feet or less when calling at Wilmington Harbor in 2009. Containerships maintain an underkeel clearance of at least 10 percent of sailing draft in the channel at all times. There were 63 calls at the port for this sub-class of vessel in 2009. They can carry up 4,400 to 4,800 TEUs, however they generally transfer less than 1,500 TEUs at the port, which are split between imports and exports.

Hanjin and Yang Ming also employ somewhat smaller containerships in the 50,000 DWT class on the Far East route. These are generally about 850 feet long and have the Panamax beam of 106 feet. They have design drafts of about 41-42 feet. They can carry up to about 4,000 TEU's. There were 49 vessel calls for this sub-class in 2009.

The third containership sub-class is employed in the European (ICA) and Central/South American trades (Maersk). These vessels are generally between 20,000 DWT and 22,000 DWT. They are typically 525 to 550 feet in length, with beams ranging from 82 to 93 feet and design drafts between 32 and 35 feet. They can carry up to approximately 1,300 TEUs. There were 87 vessel calls to Wilmington Harbor by this sub-class in 2009. There were about a dozen miscellaneous containership calls that did not fit neatly into any of these categories. These were typically single voyages not associated with a service. It is noted that over all, about 13 percent of the import containers are empties, while about 32 percent of the export containers are empties.

The largest non-container vessels that call at the port are Oil Tankers, which call primarily at the Amerada-Hess terminal. These vessels are range in size from 70,000 DWT to 76,000 DWT with a length of 700 to 750 feet, with beams of 106 to 131 feet and design drafts ranging from 40 to 46 feet. The actual sailing drafts of these vessels in Wilmington Harbor were 38 feet or less in 2009. There were 17 vessel calls by this sub-class in 2009.

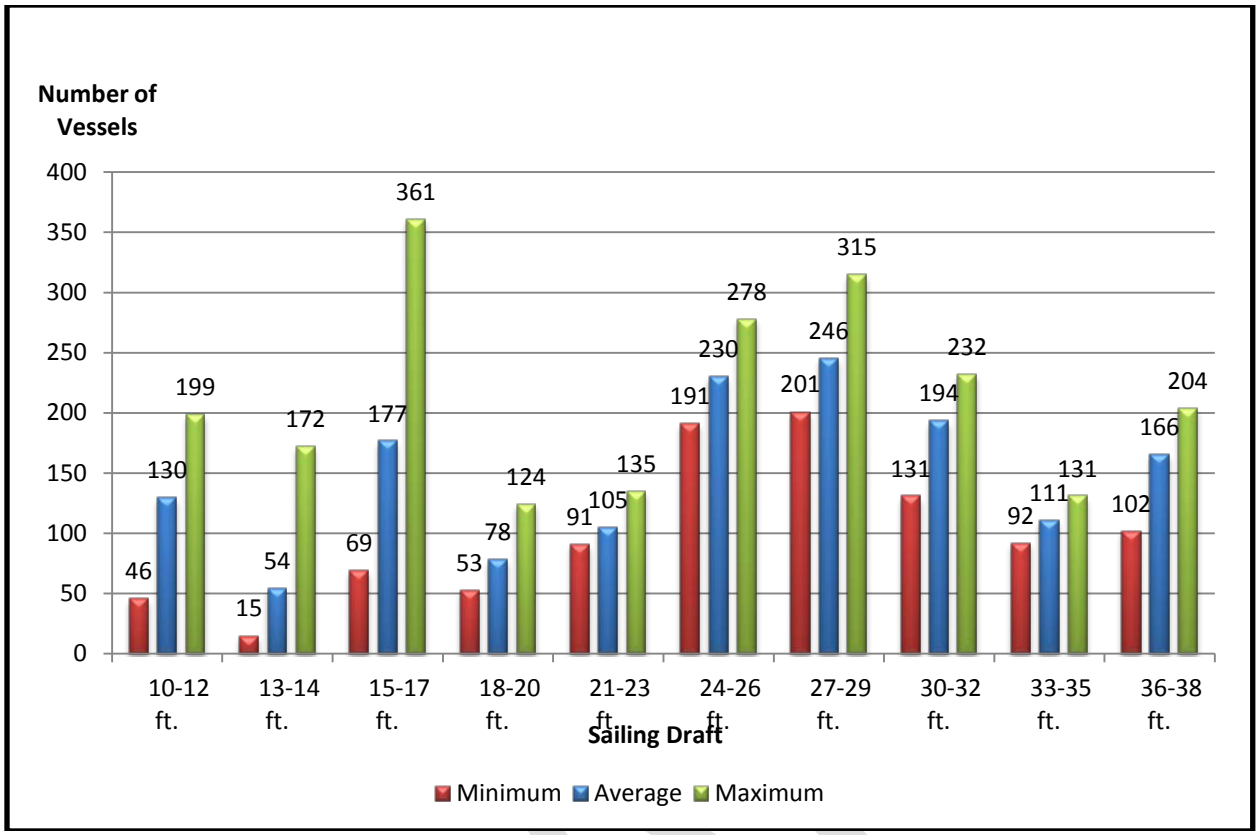

Figure 7. Distribution of Vessel Transits by Sailing Draft, 2005-2009

Source: Waterborne Commerce of the United States 2005-2009

The largest Bulk Carriers were rated at about 55,000 DWT with a length of 656 feet, a beam of 106 feet and a design draft of 38 feet. The largest General Cargo vessels were rated at about 47,000 DWT with a length of 656, a beam of 102 feet and a design draft of 40.4 feet. Some examples of typical vessels that called at the Wilmington Harbor channel in 2009 are identified in Table 9.

Containership Operations

Hanjin and Yang Ming operate the vast majority of large Panamax and medium sized containerships at Wilmington Harbor. The large Panamax containerships are rated at about 4,000 to 4,800 TEUs and are between 62,500 and 65,200 DWT. They are typically 950 feet to 965 feet long with beams of approximately 106 feet. They have design drafts of 42.7 feet to 44.4 feet and typically sail at 32 feet to 37 feet. In 2009, Hanjin operated 10 vessels in this size range and they made 47 calls at Wilmington Harbor. They docked at the North Carolina State Ports Authority Docks 7, 8, & 9. These vessels were deployed in the Far East-East Coast United States trade and their previous port was usually New York, NY or Newark, NJ (90% of the time). Their next port of call was Savannah, GA (94% of the time). In that same year Yang Ming employed 3 vessels in this size range and they represented 13 calls. They were also deployed in the Far East-East Coast US trade and their previous port was Savannah, GA (4 calls Jan-Apr) and Charleston, SC (9 calls, May-Dec 2009). Their next port of call was New York (7 calls) and Taiwan (6 calls).

Hanjin and Yang Ming also operate most of the vessels in the 50,000 DWT size range. These vessels are typically 44,000 to 53,600 DWT and are rated at 3,000 to 3,500 TEU. They are 797 feet to 879 feet long and have the Panamax beam of about 106 feet. In 2009, Hanjin had 3 vessels in this size range and they represented 3 calls. They were deployed in the Far East-East Coast US trade and came from Newark, NJ (2 calls) and Norfolk, VA (1) call. Their next port of call was Savannah, GA. In 2009, Yang Ming had 6 vessels in this size range and they represented 38 calls. They also were deployed in the Far East-East Coast US trade. Their previous ports of call were primarily Charleston (24 calls) and Savannah (10 calls). Their next ports of call were primarily Taiwan (25 calls) and New York (11 calls).

Table 9: Typical Vessels Calling at Wilmington Harbor in 2009

Vessel Name	Vessel Type	DWT	Length (feet)	Beam (feet)	Design Draft (feet)
YM Los Angeles	Containership	65,123	964.7	105.6	44.4
Hanjin San Francisco	Containership	62,799	949.9	105.6	42.7
YM Hamburg	Containership	49,238	849.7	105.6	39.3
Maersk Tangier	Containership	21,238	528.3	92.5	32.8
Imperial Fortune	Bulk Carrier	53,505	623.2	106.0	40.4
Atlantic Fortune	Bulk Carrier	27,776	554.6	88.6	31.7
Star Fuji	General Cargo	40,850	614.2	96.7	38.8
Magdalena Green	General Cargo	17,520	465.9	70.5	31.8
Smolyan	General Cargo	8,647	405.5	68.9	26.3
Angistri	Oil Tanker	76,002	699.7	121.7	46.0
Stena Performance	Oil Tanker	65,065	600.1	131.3	42.7
Colin Jacob	Oil Tanker	74,950	748.0	106.8	47.0
Isola Celeste	Oil Tanker	50,553	600.4	106.0	42.7
Nord Observer	Oil Tanker	47,406	598.8	105.6	42.7
Jo Sypress	Oil Tanker	36,752	598.1	105.2	35.2
Stolt Helluland	Oil Tanker	31,454	573.2	96.8	33.3
Stolt Spray	Oil Tanker	22,201	533.5	77.8	33.1
Turchese	Oil Tanker	12,000	446.4	67.0	26.4
Stolt Integrity	Chemical Tanker	32,035	579.7	88.7	33.9
Valerie	Chemical Tanker	19,819	539.2	75.5	31.2
Ojars Vacietis	Chemical Tanker	16,341	497.0	73.6	28.0
Saudi Diriyah	Ro-Ro	42,600	816.2	106.0	36.5
Virginian	Ro-Ro	21,541	511.8	105.0	29.5
Dobrudja	Ro-Ro	10,429	417.0	68.9	29.5

Far East-East Coast U.S. Containership Routes

The Hanjin route typically includes calls at Shanghai, China and Busan, South Korea in the Far East. It transits the Panama Canal to the East Coast US ports of New York, NY, Wilmington,

NC and Savannah, GA. The total distance of this route is 21,532 nautical miles. The Yang Ming route includes Kaohsiung, Taiwan, Hong Kong, China, Qingdao, China, and Busan, South Korea. It also goes through the Panama Canal and calls at Savannah, GA or Charleston, SC, as well as Wilmington, NC. This service generally returns to Taiwan after calling at Wilmington, but also calls at New York, NY about 30% of the time. The total distance of this route varies from 22,440 to 23,362 nautical miles. This information was used to develop a Far East-Panama-East Coast US route group (FE-PAN-ECUS) for the HarborSym computer model.

A total of 87,901 TEUs were exported to the Far East through Wilmington Harbor in 2009. Of these, 65,612 TEUs were loaded, with a total cargo weight of 833,168 tons or 12.7 tons of cargo per loaded export TEU. The remaining 22,289 TEUs, or 25.4% of the total export TEUs, were empty. Imports amounted to a total of 88,687 TEUs were imported from the Far East through Wilmington Harbor in 2009. Of these, 81,268 were loaded, with a total cargo weight of 558,023 tons, or 6.9 tons per loaded import TEU. Tare or empty container weights vary significantly depending on whether the containers are 20-foot, 40-foot, or some other length. An estimate of 2 tons per TEU was used in this report. Table 10 displays the number of calls by vessel type for each shipping company and service/route. There were a total of 198 containership calls in 2009 including 101 calls from the Far East services, 42 calls from the Central American service, 40 calls from the European service and 15 other miscellaneous calls. Sixty-one of those calls were large Panamax containerships in the 62,000 to 65,000 DWT class.

Table 10: Wilmington Harbor Containership Routes and Calls - 2009

Shipping Company	Vessel Type	Calls	Service / Route
Hanjin	Large Panamax Containership	47	Far East
	Medium Containership	3	Far East
Yang Ming	Large Panamax Containership	13	Far East
	Medium Containership	38	Far East
Maersk	Small Containership	42	Central America
ICL	Small Containership	40	Europe
All Other	Large Panamax Containership	1	Miscellaneous
	Medium Containership	10	Miscellaneous
	Small Containership	4	Miscellaneous

Other Containership Routes

Maersk and ICL operate small 1,300 TEU containerships in the 20,000 to 22,000 DWT size range. Maersk serves Honduras and Guatemala in Central America and ICL serves Belgium and the United Kingdom in Europe. Maersk operated two such vessels in 2009 and they made 42 calls at Wilmington. They are 21,200 and 21,300 DWT. They are 528 feet in length, 92.5 feet in beam and have design drafts of 32.8 feet. Their sailing drafts are typically 17 to 31 feet, with 23 feet being an average. Their previous port was Savannah, GA and their next port was generally Norfolk, VA (41 of 42 calls). This service called at Puerto Cortes, Honduras and Santo Tomas

de Castilla, Guatemala. The total round trip distance was 3,406 nautical miles. This information was used to develop a Central America-East Coast US route group (CA-ECUS) for the HarborSym model.

ICL operated four small 1,300 TEU containerships in the 20,000 to 22,000 DWT size range. They made a total of 41 calls at Wilmington, NC in 2009. These vessels were 550 feet long, had beams of 83 to 91 feet and had design drafts of 32.3 to 33.5 feet. They typically sailed at 26 to 30 feet. Their previous port of call was Chester, PA (40 of 41 calls) and their next port was Antwerp, Belgium. They also called at Liverpool, United Kingdom to complete a circuit. The total distance of this service was 8,215 nautical miles. This information was used to develop a Europe-East Coast US route group (FE-ECUS) in the HarborSym model.

A few of the containerships that made calls at Wilmington, NC in 2009 were not associated with any regular services. There were 15 of these miscellaneous vessel calls and they represented all size ranges from 65,000 to 5,000 DWT. Their routes included Europe, the mid-East and other parts of the world. These were mostly single voyage calls; however a few of these vessels called at Wilmington multiple times. Table 6 provides information on the average number of loaded and empty TEU's per vessel call for each of the Far East - East Coast U.S. services. It also provides the average total weight per call in tons, which includes the tare weight of the loaded and empty containers. On the average, each containership in the Far East – East Coast U.S. trade imports a little more than 800 loaded TEU's and just under 75 empty TEU's per call, while exporting a little less than 650 loaded TEU's and 220 empty TEU's per call. The total weight of the containers and the goods they carry averages 7,277 total import tons per call and 9,989 total export tons per call.

Table 11: Far East Service, Loaded and Empty TEUs and Weights per Call

Shipping Company	**Average Loaded TEU's Per Call**	**Average Empty TEU's Per Call**	**Average Total Weight Per Call[8]**
	(TEU's)	***(TEU's)***	***(Tons)***
Hanjin – Imports	705.0	136.7	7,048
Hanjin – Exports	651.1	87.5	9,910
Yang Ming – Imports	902.3	11.4	7,506
Yang Ming – Exports	648.2	351.3	10,068
Total Imports	803.6	74.5	7,277
Total Exports	649.6	219.4	9,989

[8] Includes the tare (empty) weight of the containers.

Table 12: Far East Container Services - 2009 Detail

Service/Region	Commodity Weight	Total Weight	Tare Weight	Loaded TEUs	Empty TEU's	Tons/ TEU	Percent Empty
Hanjin Imports	268,410	352,398	83,988	35,250	6,836	7.6	16.2%
Hanjin Exports	421,632	495,488	73,856	32,553	4,375	13.0	11.8%
Total Hanjin Commerce	690,042	847,886	157,844	67,803	11,211	10.2	14.2%
Yang Ming Imports	289,613	382,815	93,202	46,018	583	6.3	1.2%
Yang Ming Exports	411,536	513,482	101,946	33,059	17,914	12.4	35.1%
Total Yang Ming Commerce	701,149	896,297	195,148	79,077	18,497	8.9	19.0%
Far East Imports	558,023	735,213	177,190	81,268	7,419	6.9	8.4%
Far East Exports	833,168	1,008,970	175,802	65,612	22,289	12.7	25.4%
Total Far East Commerce	1,391,191	1,744,183	352,992	146,880	29,708	9.5	16.8%

Source: Waterborne Commerce of the United States – 2009 and North Carolina State Port Authorities data for 2009.

Table 12 provides additional details for the Far East – East Coast U.S. container services including the total weight of the commodities moved in containers by those services in 2009 as well as the tare weight and total weight of the containers. It also provides the total number of loaded and empty TEU's, the average tons per TEU and the percentage of empty containers for imports, exports and total commerce by Far East service and the region as a whole. In that year, commodity imports from the Far East totaled 558,023 tons, while commodity exports totaled 833,168 tons for a total of 1,391,191 tons, or 1,744,183 tons when the tare weight of the containers in included. A total of 81,268 loaded TEU's were imported and 65,612 loaded TEU's were exported in the Far East trade. Import commerce (excluding tare weight) averaged 6.9 tons per TEU and export commerce averaged 12.7 tons per TEU, for an overall port average of 9.5 tons per TEU. On the average, empty containers made up 8.4% of import TEUs and 25.4% of export TEUs.

Other Terminals

In 2009, Apex Oil and Amerada Hess traded primarily with Canada and the Netherlands. Carolina Marine terminal traded primarily with Venezuela and the Netherlands. Colonial Oil traded with extensively with South Africa and to a lesser extent with Trinidad and Colombia. Invista Terminal traded infrequently with Portugal and Brazil. Kinder Morgan International traded mostly with Russia and other Eastern European nations. South Wilmington Terminal traded mostly with Brazil, Finland and the Netherlands. The Vopak terminal traded with a wide variety of countries but the majority of its commerce was with Saudi Arabia, Bahrain, Trinidad and the Netherlands. Archer Daniels Midland traded occasionally with Canada, the Ukraine and

Finland being the primary partners. Sunny Point also traded occasionally, with Poland and Sweden being the primary partners.
Because of the wide variation in trading partners and the fact that the proposed channel improvements at Wilmington Harbor are not expected to impact these vessels outside the confines of the Cape Fear River area, the remaining vessels were assigned to a default route group in the HarborSym model.

Existing Condition HarborSym Model

Introduction

The HarborSym computer model, version 1.5.5.0 was used for the Wilmington Harbor Channel Improvement Study. The HarborSym model was developed by the U.S. Army Corps of Engineers Institute for Water Resources, located in Ft. Belvoir, Virginia, in cooperation with the Corps National Deep Draft Navigation Planning Center of Expertise, located in the Corps South Atlantic Division office in Atlanta, Georgia.

HarborSym is a computer simulation model that attempts to replicate vessel operations within the channel under various scenarios, including existing and future ”without” project conditions as well as “with” project alternatives. Model inputs include information on port structures, such as channel segments, docks, turning basins and anchorages, commodity information, vessel / fleet information, including estimates of vessel operating costs, tides, port traffic and a set of transit rules.

The HarborSym computer model was set up to run the existing conditions at Wilmington Harbor based on 2009 data. It is noted that the economic analysis will be based on a comparison of the future “without” and “with” project conditions and that these will be developed based on the 2009 data, plus any changes in commodity shipments and the fleet specifications which have occurred or are expected to occur in the future. Development of the existing condition model required development of the following: (1) a link/node network to represent the Cape Fear River and Wilmington Harbor, (2) time and speed assumptions (3) vessel types, (4) route groups, (5) commodity information, (6) port structures, (7) port traffic, (8) tides and currents, and (9) port transit rules. Each of these elements will be discussed in greater detail.

Link/Node Network and Port Structures – The link/node network included 17 nodes. One node represented the channel entrance/exit. Eight nodes represented docks including (1) Archer Daniels Midland, (2) Sunny Point (Military Ocean Terminal), (3) a node which represented South Wilmington Terminal, Carolina Marine Terminal, Invista Terminal, and Apex Oil, (4) North Carolina State Port Authorities Docks 7-9, (5) North Carolina State Port Authorities Docks 1-6, (6) Vopak, (7) Amerada Hess and Colonial Oil, and (8) Kinder Morgan International. One node represented the turning basin. The remaining seven nodes were topological and were selected to represent significant changes in the channel features, such as width, depth and/or bearing.

Time and Speed Assumptions

The Wilmington Harbor Pilots Association provided vessel speeds for each vessel type in each reach of the harbor. The fastest vessels were the containerships which average 14 knots when light and 12 knots when loaded in unrestricted reaches of the channel. Bulk Carriers, Oil and Chemical Tankers were the slowest, averaging 11 knots light and 9 knots loaded. These speeds were reduced by 3 to 4 knots in restricted portions of the channel, such as the Battery Island Turn. In addition, vessels are restricted to 5 knots in the Wilmington Harbor area, beginning at, and upstream of South Wilmington Terminal. The Pilots also provided docking, undocking and turning times for each vessel type. Docking times ranged from 30 minutes to one hour, while undocking times ranged from 8 to 30 minutes. It was noted that smaller vessels turn at the dock while larger vessels use the turning basin. The pilots indicated that typical vessel turning times at the turning basin averaged about 10 minutes, with a minimum of 8 minutes and a maximum of 15 minutes. Larger Panamax vessels require two extra minutes per turn due to the constricted boundaries of the turning basin. Vessel loading and unloading rates were estimated for each dock and were based primarily on North Carolina State Port Authority data; specific data for the private docks was not available. Gross commodity transfer rates were used; these relate the amount of commodity moved to the amount of time spent at the dock for all purposes.

Reaches

The 17 nodes in the Wilmington Harbor link/node network were connected by 16 reaches. These were (1) Baldhead Shoal, (2) Smith Island-Southport, (3) Battery Island Turn, (4) Swash-Reeves Point, (5) Sunny Point, (6) Midnight-Lower Lilliput, (7) Upper Lilliput-4th East Jetty, (8) SWT-CMT-Invista-Apex, (9) NCSPA 7-9, (10) NCSPA 1-6, (11) Vopak, (12) Turning Basin, (13) Hess-Colonial, (14) Memorial Bridge, (15) KMI, and (16) as short reach to Archer Daniels. The length, width and depth of each channel segment are defined in the model. The reach width is 400 feet and the channel depth is -42 feet, for most of the channel below the Memorial Bridge, with the exception of the entrance channel segments which vary from 500 feet to 900 feet in width and are -44 feet in depth, and the Midnight-Lower Lilliput segment, which is 600 feet in width to accommodate passing and overtaking for large vessels.

Vessel Types

Eight basic vessel types were put into the existing condition model. These included (1) Panamax Containership, (2) Containership, (3) General Cargo, (4) Bulk Carrier, (5) Chemical Tanker, (6) Oil Tanker and (7) Vehicle Carrier or Roll on – Roll off (Ro-Ro) vessel. The eight vessel type was the Post-Panamax Containership, which was not used in the existing condition model because no vessels of this type had called in 2009. The Panamax Containership type was represented by two sub-classes, the 65,000 DWT vessel and the 50,000 DWT vessel. The Containership type included one sub-class, the 21,000 DWT vessel. The General Cargo type was represented by two sub-classes of 25,000 DWT and 50,000 DWT. The Bulk Carrier type include three sub-classes of 7,500 DWT, 15,000 DWT and 40,000 DWT. The Chemical Carrier was represented by three sub-classes of 16,500 DWT, 19,500 DWT and 32,000 DWT. The Oil Tanker type included seven sub-classes of 12,000 DWT, 22,200 DWT, 31,000 DWT 37,500 DWT, 47,500 DWT, 65,000 DWT and 73,000 DWT.

Vessel attributes were defined for each vessel sub-class, including dimensions, speed, and operating costs at sea and in port.9 Underkeel clearance requirements, vessel immersion factors (stated in tons per inch (TPI), and vessel operating costs are provided for each vessel sub-class. Underkeel clearance requirements are based on input provided by the pilots and amount to ten percent of the maximum sailing draft for each vessel sub-class. The vessel operating costs and immersion factors are based on data acquired by the U.S. Army Corps of Engineers Institute for Water Resources. For some inputs, the HarborSym model requires a range of data, including for example, minimum, most likely and maximum vessel operating costs at sea and in port. The vessel operating cost data are considered proprietary and cannot be disclosed.

Route Groups

Each vessel type was associated with a specific route group. The Panamax and Post Panamax Containerships were associated with the Far East-East Coast U.S. route through the Panama Canal (FE-PAN-ECUS). The remaining containerships were associated evenly between the European route (EU-ECUS) and the Central American route (CM-ECUS). All other vessels were assigned to a default route group since no changes in these vessels was expected between the future "without" and future "with" project conditions.

Commodities

Commodity information for the existing condition model was obtained primarily from two sources. The North Carolina State Port Authority provided detailed information for the public terminal, including detailed information regarding container shipments. The U.S. Army Corps of Engineers Waterborne Commerce of the United States data provide by the Navigation Data Center was used for the private terminals. The model contains specific commodity assignments for each vessel call. The commodity assignments are based on data provided from Waterborne Commerce of the United States and the North Carolina State Port Authority. An estimate of two tons per TEU was included for container shipments to account for the tare (empty) weight of the containers. This amounted to about 450,000 tons. In addition, it is noted that there was a significant amount of missing or unreported commodity data, primarily for the private terminals. Where commodity data was missing, an estimate was made of type and amount of commodity transferred. These estimates were based on the size and type of vessel, the terminal at which the vessel was calling, the arrival and departure drafts, and the vessel's immersion factor. The missing data amounted to about 550,000 tons.

Port Traffic

Vessel names, as well as arrival and departure times and drafts were obtained from the Wilmington Harbor Pilots Logs, as well as Waterborne Commerce of the United States and the North Carolina State Port Authority. Vessel dimensions were obtained from online services such as MarineTraffic.com, imonumber.com (an IMO number database), and VesselFinder.com.

[9] Vessel operating costs employed in the model were based on Deep-Draft Vessel Operating Costs obtained from the U.S. Army Corps of Engineers Institute for Water Resources.

Route sailing distances were determined using the online services Sea-Distances.com and Sea-Rates.com.

Tides and Currents

Tidal information was obtained from the NOAA tide stations located along the Cape Fear River. Six tide stations were used in the model. These included Bald Head, South Port, Fort Caswell, Reeves Point, Orton Point and Wilmington. Wilmington District Engineering determined the proper association between the tide stations and the reaches employed in the HarborSym model. It is noted that no NOAA current stations are available to the model for this area. NOAA reports that typical currents average 2.2 knots (flood) to 2.9 knots (ebb) at the Cape Fear River entrance, but generally average two knots or less in the upper channel above Southport.

Port Transit Rules

Port transit rules were based on input from the Harbor Pilots, who indicated that they attempt to pass large vessels primarily in the portion of the channel that is 600' wide. Meetings where at least one post Panamax vessel is involved and the other is approximately 550' thru Panamax are restricted to the passing lane reaches which are lower Midnight, Upper Midnight and Lower Lilliput. Additionally, the Bar Reach (2) and the inshore 1.5 mile of Reach 3, Southport Reach and the 4th East Jetty reach. Tug assist is always available and often required in this reach, however, since these conditions will be the same in the with and without project conditions, tug assist was not accounted for. It is noted that, while this rule accurately portrays the way the Pilots attempt to operate in the channel, they do not have a written rule that defines this practice.

Existing Condition Model Results

The HarborSym model described above was run for a duration of 8,784 hours, or slightly more than one year (2009). There were 625 vessels in the call list. The model was run for 50 iterations.

An average of 5,989,047 tons was moved, with a standard deviation of 12,122 tons. Total overall vessel cost was $12 million, with a standard deviation of $190,000. The average time in the system was 21.10 hours. The average gross loading / unloading time was 13.58 hours. Average vessel waiting time was 7.2 minutes with a maximum of 12.5 hours and a minimum of zero.

An average of 2.49 deleted vessels were noted (the model occasionally deletes a vessel when it get stuck in the simulation). The maximum number of deleted vessels was six and the minimum number was zero.

The existing condition was used to calibrate the model and will form the basis for the future "without" and "with" project condition models; however these will also reflect changes in

commodity shipments and fleet characteristics which have occurred and are anticipated to occur since 2009.

Future Condition – Without and With Project

Commodity Forecast

An important step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port. Cargo history can offer key insight into a port's long term trade forecast which is the estimated cargo volume upon which future vessel calls are based. In the without and in the future with project conditions, the same volume of cargo is assumed to move through Wilmington Harbor; however, channel modifications will allow for more efficient vessel use.

It is imperative to understand how the goods are moving to project commodity forecasts as to not double count tonnage in the commodity forecast. For example, if commodities are moving in containers, the tonnage should not also be accounted for in a separate forecast. Based on 2009 and 2010 data, approximately 34% of foreign commodities are moving in containers. Over the past 10 years, tonnage has primarily remained flat or declining except for containers. Therefore, the commodities not moving in containers, other than Petroleum or chemicals, the tonnage will remain constant.

For forecasting containers, the category of manufactured equipment, machinery and products, half of the crude materials, about one third of food and farm products, half of Primary Manufactured goods and NEC will be included in the container forecast. The other commodity categories and the remaining percentage of the categories mentioned above will be forecasted separately, or remain constant.

In 2006, the Panama Canal Authority (ACP) announced plans for expansion of the Panama Canal. 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 13,000 TEU. The schedule had construction being completed in 2014, however, construction is behind and not expected to be complete until mid-year 2015. Since the base year for Wilmington Harbor is 2018, the delay is unlikely to affect the economic analysis significantly. The project is estimated to cost $5.25 billion and 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 US shipments from taking advantage of the economies of scale of loading larger ships to deeper sailing drafts.

Container Forecast

Considering containership deployment history to North America East Coast, reasonable assumptions about future deployment can be determined. The total tonnage moving in containers in 2009 was approximately 1,687,500 short tons and in 2010 was 1,863,432 short tons. The tonnage moving in containers was calculated by summing the tons from each commodity category and then summing the total commodity tons moving in containers. Table 13 shows the average of commodity percentages of how they are moving on vessels for 2009 and 2010.

Table 13: Commodity Category Percent Breakout

	Containers	**Tankers**	**General Cargo**	**Bulk**	**Ro-Ro**
Manuf. Equip, Mach & Products	94%	0%	4%	0%	1%
Chemicals & Related Products	11%	75%	2%	13%	0%
Crude Materials	52%	0%	18%	30%	0%
Food & Farm	37%	1%	6%	56%	0%
Petroleum and Petroleum Products	0%	100%	0%	0%	0%
Primary Manufactured Goods	54%	0%	7%	39%	0%
NEC	63%	30%	4%	0%	1%
Total	**34%**	**40%**	**6%**	**19%**	**0%**

Given the tonnage for 2009 and 2010, the next step was to determine the trade routes in which the goods are moving. The port provided container vessel information for FY2009 and FY2010. The port data included the vessel name, the status of the container, whether it was empty or loaded and whether it was an import or export, the total number of TEUs and the total number of FEUs for a call. The FEUs were converted to TEUs to sum the total TEUs for a call. Using the Waterborne Statistics import and export data, the foreign port of the calling vessel was determined to understand the trade routes of the vessels calling Wilmington Harbor. There were four main regions of the world for which vessels call Wilmington Harbor: Europe, Central America, Far East and primarily the Middle East. Once the trade routes were determined, the commodity tonnage and TEUs were allocated on the appropriate trade route. This was done by taking the vessels on the trade route and grouping the vessels to determine the total tonnage and TEUs. The baseline was established by taking the average of 2009 and 2010 tonnage by world region and import or export and calculating the percent of tonnage based on the South Atlantic total tonnage forecast expected for the region. Containerized trade forecasts were obtained from Global Insight for the South Atlantic Region. The short tons for the South Atlantic trade for 2009, 2010, and 2011are from the Global Insight forecast. An average of two years was used in an effort to reduce the impact that a single year or potential anomaly in trade volume may have on long term forecast. Table 14 displays the world regions with the South Atlantic trade volumes for 2009 and 2010 and Wilmington Harbors percent share of that volume. The average volume for 2009 and 2010 were used to calculate the share for 2011. The 2011 percent share is

held constant for the remainder of the forecast, meaning that the percent of the South Atlantic total is held constant.

Table 14: Container Tonnage Baseline

World Region		2009 (short tons)	2010 (short tons)	2011 (short tons)
Far East	South Atlantic Import	7,163,118	8,647,707	9,038,998
	Wilmington Imports	552,753	561,669	557,211
	% Share	7.7%	6.5%	6.2%
	South Atlantic Export	7,133,790	8,630,537	9,309,853
	Wilmington Exports	833,261	708,693	770,977
	% Share	11.7%	8.2%	8.3%
Europe	South Atlantic Import	1,277,712	1,584,153	1,487,962
	Wilmington Imports	86,175	134,227	110,201
	% Share	6.7%	8.5%	7.4%
	South Atlantic Export	1,647,562	2,022,960	2,223,891
	Wilmington Exports	134,227	270,275	202,251
	% Share	8.1%	13.4%	9.1%
Central America	South Atlantic Import	1,707,615	1,878,438	1,939,223
	Wilmington Imports	27,897	32,663	30,280
	% Share	1.6%	1.7%	1.6%
	South Atlantic Export	1,185,678	1,386,144	1,531,870
	Wilmington Exports	46,646	78,921	62,784
	% Share	3.9%	5.7%	4.1%
Middle East/Other	South Atlantic Import	591,820	766,090	875,890
	Wilmington Imports	1,099	-	550
	% Share	0.2%	0.0%	0.1%
	South Atlantic Export	1,100,100	1,317,736	1,489,700
	Wilmington Exports	5,533	2,031	3,782
	% Share	0.5%	0.2%	0.3%

Once the baseline for tonnage was established, Wilmington Harbor's percent share was held constant and applied to the Global Insight's South Atlantic forecast through 2022; the change by year determined the growth rates for each trade region. Table 15 shows the average growth rate by trade region. Table 16 shows the forecasted tonnage by trade route.

Table 15: Wilmington Harbor Growth Rates by World Region

World Region	Average Annual Growth Rates (2012-2022)

World Region	Average Annual Growth Rates (2012-2022)	
Far East	Wilmington Imports	6.0%
	Wilmington Exports	7.5%
Europe	Wilmington Imports	3.1%
	Wilmington Exports	4.1%
Central America	Wilmington Imports	2.4%
	Wilmington Exports	5.4%
Middle East/Other	Wilmington Imports	8.6%
	Wilmington Exports	7.9%

Table 16: Forecasted Container Tonnage (short tons)

	Far East		**European**		**Central America**		**Other**		**Total**
Year	Import	Export	Import	Export	Import	Export	Import	Export	
2009	552,753	833,261	86,175	134,227	27,897	46,646	1,099	5,553	1,687,611
2010	561,669	708,693	134,227	270,275	32,663	78,921	-	2,031	1,931,972
2011	557,211	770,977	110,201	202,251	30,280	62,784	550	3,782	1,809,783
2015	696,405	1,064,789	124,558	237,385	33,461	77,517	812	5,802	2,321,823
2020	933,255	1,497,524	143,765	292,512	37,306	101,817	1,180	7,863	3,108,821
2022	1,062,250	1,715,965	153,450	313,788	39,182	111,507	1,362	8,726	3,406,230

Based on the commodity tonnage forecast, the number of TEUs by trade region can be forecasted to determine the fleet forecast. Detailed historical TEU data such as number of loaded imports, exports and empty containers from fiscal year 2009 and 2010 and calendar year 2011 were analyzed to determine a baseline in which to forecast future years. However, since not all the import and export data for every trade route was available, the TEU forecast is a total of imports and exports, except for the Far East trade region. The Port provided data on the containership calls by year and their associated TEUs and Forty Foot Equivalent (FEU). The baseline was established by averaging the TEUs and then calculating the percent of the Wilmington Harbor share based on the South Atlantic region by trade region. Table 17 shows the average growth rate by trade region for 2012-2022. Because of the container terminal capacity is 500,000 TEUs, the tonnage or TEU forecast does not extend beyond when the container terminal reaches capacity. This forecast includes import, export and empty containers. Table 18 shows the TEU forecast through 2022.

Table 17: TEU Growth Rates by World Region

World Region	Average Annual Growth Rates (2012-2022)

Far East	Wilmington	7%
Europe	Wilmington	4%
Central America	Wilmington	4%
Middle East/Other	Wilmington	6%

Table 18: TEU Forecast by Trade Region

Year	Total	Far East	European	Central America	Middle East	Empty
2010	235,678	160,543	27,492	10,187	1,505	35,951
2011	286,467	189,890	32,518	12,049	1,780	50,230
2012	257,219	175,216	30,005	11,118	1,643	39,237
2018	395,319	278,906	38,822	14,735	2,553	60,303
2020	447,977	319,166	41,693	15,918	2,864	68,335
2022	509,700	366,925	44,708	17,119	3,197	77,751

More data was available for the Far East trade region and it is the most significant tonnage and TEUs moving through Wilmington Harbor. The baseline was established for 2011 by averaging the 2009 and 2010 import and export data. The 2011 percent share of TEU volume for the Far East was calculated and that constant percent applied to the remainder of the forecasted years. Table 19 shows the Far East TEU data. Empty containers averaged about 20 percent of total TEUs. Table 20 shows the total TEUs for the Far East trade region.

Table 19: Far East TEU Trade Forecast

Loaded Imports	**2011**	**2012**	**2015**	**2020**	**2022**
China	2,023,163	2,112,949	2,574,234	3,584,786	**4,146,710**
Southeast Asia	493,399	497,042	547,830	653,874	**709,276**
Northern Far East	345,194	362,954	420,834	480,625	**506,238**
Total	2,861,756	2,972,945	3,542,898	4,719,286	**5,362,224**
Wilmington TEU Share	**80,995**	**84,142**	**100,273**	**133,568**	**151,765**
Loaded Exports					

Northern Far East	671,651	725,273	866,768	1,106,086	**1,207,234**
Southeast Asia	417,901	430,999	501,279	682,696	**766,624**
China	1,193,091	1,329,765	1,811,137	2,862,744	**3,436,945**
Total	2,282,643	2,486,038	3,179,184	4,651,527	**5,410,804**
Wilmington TEU Share	**62,470**	**68,036**	**87,006**	**127,300**	**148,080**

Table 20: Far East Trade Region TEU Forecast

	Import	**Export**	**Empty**	**Total**
2011	80,995	62,470	29,939	173,404
2012	84,142	68,036	30,436	182,614
2015	100,273	87,006	37,456	224,735
2020	133,568	127,300	52,174	313,042
2022	151,765	148,080	59,969	359,814

Petroleum and Petroleum Products

Historically, petroleum tonnage has been approximately 30% of the total average between the 2000-2010 time period. The quantity of total foreign petroleum has varied from year to year, but increased for the most part. In terms of foreign tonnage, petroleum and petroleum products is approximately 16% of total foreign cargo on average from 2005-2009. A linear regression using data from 2000-2011 shows an average growth rate of approximately 2% per year. It should be noted that growth rate projections will never be absolutely correct because the highs and lows of the business cycle cannot be accurately forecasted through a linear or exponential growth rate

Based on historical information from Waterborne Commerce, regression values were determined then applied to the remaining years in the forecast. Table 21 shows the number of short tons in selected years. The tonnage is held constant after year 2030.

Table 21: Petroleum Forecast

	Inbound	**Outbound**	**Total**
2011	777,188	3,243	780,431
2012	806,211	3,499	809,710
2015	893,280	4,266	897,546
2020	1,038,396	5,543	1,043,939
2025	1,183,512	6,821	1,190,333

	Inbound	Outbound	Total
2030	1,328,628	8,099	1,336,726

According to the U.S. Energy Information Administration (EIA), the growth rate for the South Atlantic region is about 1% for the main petroleum and petroleum product commodities imported through Wilmington Harbor. Using this forecast for the region, the forecast of short tons for Petroleum at Wilmington Harbor is shown in Table 22.

Table 22: US EIA Petroleum Forecast

	Total Foreign
2011	492,162
2012	497,084
2015	502,054
2020	507,075
2025	512,146
2030	517,267

Chemicals and related products

Historically, chemical tonnage has been approximately 31% of the total average of the 2000-2010 time period. The quantity of total foreign chemicals has varied from year to year, but increased for the most part. In terms of foreign tonnage, chemicals and related products is approximately 24% of total foreign cargo on average from 2005-2009.

Based on historical information from Waterborne Commerce, regression values were determined then applied to the remaining years in the forecast. A linear regression from 2000-2011 shows an average growth rate of approximately 4%. Table 23 shows the number of short tons in selected years, 2011-2030 and held constant after 2030.

Table 23: Chemical and Related Products Forecast

	Inbound	Outbound	Total
2011	1,523,227	201,532	1,724,759
2012	1,639,349	196,744	1,836,093
2015	1,935,040	245,886	2,180,926
2020	2,427,858	327,790	2,755,648
2025	2,920,676	409,693	3,330,370
2030	3,413,494	491,597	3,905,091

Fleet Forecast

In addition to a commodity forecast, an accurate forecast of the future fleet is required when evaluating navigation projects. As an economy grows, exports from the port often increase

(from the increased output) or demand for imports increase (increased consumer purchasing power). Vessels respond accordingly to satisfy this increased level of trade. To develop projections of the future fleet calling Wilmington Harbor, information from the historical vessels and general methodology to forecast total capacity calling Wilmington Harbor and a breakdown of the capacity calling into containership size and TEU classes was determined. By combining information from the commodity forecast with the forecasted fleet capacity, a number of Post Panamax, Panamax and Sub-Panamax vessel calls for Wilmington Harbor's fleet can be estimated. The number of transits, particularly those made by larger vessels is a key variable in calculating the transportation costs.

According to representatives of the port, carriers will deploy Post Panamax vessels ranging from 5,500 to 13,000 TEUs to the East Coast subsequent the Panama Canal expansion. Wilmington Harbor expects an approximate 6,100 - 6,500 TEU post Panamax vessel to call in the future with Panamax vessels continuing to service the port as well, either from the existing trade lanes/services or transshipments from other Atlantic Ocean ports.

The Wilmington Harbor vessel call list from 2009 and available information for 2010 and 2011 was used to determine the tons per vessel call and the average sailing draft of each vessel call. Information from the IWR Load Factor Analysis tables (LFT) from a regional service that had similar tons per TEU was used to determine the maximum practical capacity of the calling vessel and the Nominal TEU rating. The Nominal TEU rating was the basis for the classification of each vessel pulled from the LFT. The maximum practicable capacity was determined based on sailing draft and the maximum TEU capacity. The Wilmington Harbor tonnage and TEUs were then determined as a percentage of the total capacity of the vessel for imports and exports.

The Container Loading Tool (CLT) was used to produce a containership forecasted vessel call list for the three trade regions calling Wilmington Harbor; Far East service, European service and a Central American service. Historical loading patterns and services frequently calling Wilmington Harbor was used in the CLT. Four classes of containerships were identified in visiting the North Carolina State Port Authority berths 7, 8 and 9, which is identified as Dock 3 in the CLT. These berths primarily handle containerized shipments and have five modern container cranes, three of which are capable of servicing post Panamax containerships. The vessel classes identified in the CLT are broken out by classes of small sub-Panamax containerships (21,000 DWT), medium Panamax containerships (50,000 DWT), large Panamax (65,000 DWT) and post Panamax vessels. The tidal availability used in the CLT is four feet because the limiting depth at the berth is -42 feet. No duration is associated with tide availability at the dock; therefore, it is assumed -42 feet is always available.

Due to the Panama Canal lock expansions, the analysis assumes that a portion of the Far East service will transition to a Post Panamax Generation 1 (PPX1) vessel subsequent to the new locks opening. The representative PPX1 vessel used in other East Coast, US deep draft navigation studies is the vessel proposed to visit Wilmington in transitioning to a larger vessel on the Far East trade route. The vessels design characteristics are 953.76 LOA, 131.75 beam and 46.05 design draft.

Wilmington Harbor did not have fluctuations in commodities based on seasons. The quantity of commodities remained fairly consistent across all months of the year. The season description in the CLT was 'all' meaning that the shipping season was considered the entire year.

In the CLT, three services including the Far East, Europe and Central America were identified as the descriptions for the world regions calling on Wilmington Harbor. The Europe service includes the miscellaneous cargo and calls from the Middle East and other regions using the Atlantic Ocean. Arrival draft functions were specified by the cumulative distribution function. Sailing drafts from 2009, 2010 and 2011 were used to determine the arrival draft function for the sub-Panamax, Panamax and post Panamax vessel classes. The same arrival draft function curve was used for the Post Panamax vessel calls as the panamax vessels since there is no record of Post Panamax calling Wilmington Harbor.

The vessel classes used for the Far East service had an average lading weight of 9.5 tons per loaded TEU based on empirical data, assumed 6.46% of the TEUs were empty and 7.65% of the slots were vacant. This information was taken from the load factor tables for the Far East service route. The vessel classes used for the Europe service had an average lading weight of 7.9 tons per loaded TEU based on empirical data, assumed 2% empty and 4.6% were vacant slots, this information was taken from the load factor table for the Europe route. The Central American route had an average lading weight of 7.5 tons per loaded TEU based on empirical data, assumed 6.46% empty and 7.65% vacant slots based on the load factor tables from Central America. An average of 2 tons was used for the container weight per TEU.

For the Far East trade route in 2018, it is reasonable to assume a PPX1 vessel will be calling weekly to Wilmington Harbor. According to the LFT, the PPX1 vessel maximum practicable capacity (MPC) is 29,824 metric tons. The MPC for the PPX1 vessel is the average of the sailing draft of 34 to 38 feet. This distribution was chosen because over 50 percent of the Panamax vessels on the Far East route were calling between these sailing drafts. The remaining cargo will continue to be transported on the Panamax and sub-Panamax size vessels. It is assumed by year 2022, the year capacity is reached for containers, that post Panamax vessels will continue to call weekly. The 2022 forecasted tonnage for the Far East is allocated first to the Post Panamax vessels calling weekly and the remainder is allocated to the Panamax class.

To determine the number of vessels needed, the empirical relationship between the nominal TEU capacity of the calling fleet from the LFT and the historical tonnages moving through Wilmington were observed. The percentage of Wilmington Harbor TEUs was divided by the Nominal TEUS to get the percentage of capacity Wilmington Harbor TEUs were using per trade route.

Without and With Project Condition

The without project condition consist of those future conditions most likely to prevail in the absence of the proposed project. The base year for this project is 2018 when the proposed alternatives will be fully functional and start generating benefits and continues to year 2068.

It is assumed that the commodity flows and the fleet composition is the same in the without project and the with project condition.

Measure TB1 – Widen Existing Turning Basin to 1,450'

The TB1 measure would widen the existing anchorage/turning basin to 1,450 feet. This length is recommended because it is the minimum turning basin design width for the longest vessel currently calling on the port, which is the 965' LOA Panamax size vessel. Vessels typically use the turning basin after discharging and before sailing out of the harbor. Depending on the size of the vessel, turning time once in the turning basin varies from 10 minutes to 20 minutes. Vessels measuring 625 feet or less may turn at the dock or another location. The vessel call list determined the vessels that do not have to use the turning basin based on LOA. For modeling purposes, the vessels that use the Sunny Point, SWT-CMT Invista, KMI and Archer Daniels docks do not use the anchorage/turning basin in the analysis. The assumption is the vessels that use these docks will turn at the dock. NCSPA 1-9, Vopak and Hess-Colonial typically have vessels that will need to use the turning basin. Out of the vessels that use the turning basin, Panamax and post Panamax vessels will benefit from the increased turning basin size. The Cape Fear River pilots said that in the without project condition, Panamax size vessels turn on average about 12 minutes. It is assumed that vessels of Panamax and post Panamax size will continue to take about 12 minutes to turn. To capture the uncertainty and based on information from the pilots, a minimum turning time of 10 minutes and a maximum turning time of 17 minutes were used in HarborSym.

In the Future With Project condition, the turning basin will be expanded to 1,450 and the pilots indicated that turning times will be reduced on average of about 5 minutes for the Panamax and since the Post Panamax vessels are expected to turn like the Panamax vessels, it can be expected a times savings of around 5 minutes for those vessels as well.

The Operations and Maintenance of the turning basin would require removal of 200,000 cubic yards of material at $10 per cubic yard annually. The total O&M cost would result in $2,000,000 per year.

Interest During Construction (IDC) is added to the project First Cost. Interest During construction is computed from the start of PED through the construction period. IDC for the Turning Basin is estimated to be $273,000, the average annual IDC is $11,639.

As mentioned, the main vessel types that experience the cost savings are Panamax and Post-Panamax. When taking the difference in transportation cost in the future without project and future with project, and multiplying that difference by the number of vessels in that vessel class results in the net present value of transportation cost savings for a 50 year period of analysis is $4,570,100. Using the FY14 discount rate of 3.5% the average annual benefits are $195,000. The cost of expanding the turning basin is $37,901,000 with operations and maintenance of $2,000,000 and interest during construction (IDC) of $273,000. Table 26 displays the cost, benefits and BCR for the turning basin. As shown in Table 24, the benefits do not outweigh the cost and the component of the project is not justified.

Table 24. Turning Basin Cost and Benefits @ 3.5%

Total Benefits	$4,570,100
Average Annual Benefits	$195,000
Project Cost	$37,901,000
IDC	$273,000
Total Investment Cost	$ 38,174,000
Average Annual Project Cost	$ 1,627,000
Annual O&M	$2,000,000
Average Annual Cost	$ 3,627,000
BCR	0.05

Measure BI1 – Widen Existing Battery Island Turn

The pilots indicated that vessels drafting over 36 feet must wait for tide to navigate around Battery Island. It is expected this practice will continue and with the introduction of post Panamax vessels in the fleet mix, and it is expected a tug will be required for the post Panamax vessels. It has been confirmed in the Engineering Appendix there is a deficiency in the channel width for the larger vessels. Therefore, in the without project condition it was modeled that vessels drafting greater than -36 feet would wait for tide to navigate Battery Island turn and post Panamax vessels would require a tug to assist in the turn. Tidal availability is approximately four feet twice a day. For modeling purposes, there needed to be an input to make the vessel wait for tide. Seven feet of underkeel clearance was used instead of the 10% of vessel draft. The seven feet is the -36 feet of channel depth plus underkeel clearance plus four feet to make the vessel wait for tide.

In the with project condition, it is assumed vessels drafting greater than -36 feet do not have to wait for tide and post Panamax vessels do not need tug assist around the bend because the bend will be widened to 750 feet. In the model, the 10% of vessel draft was used for this condition to simulate vessels not having to wait for tide to navigate Batter Island turn. When taking the cost savings and multiplying by the vessel type, the transportation cost savings for the year are

calculated. Using the FY14 discount rate of 3.5% over a 50 period of analysis the average annual transportation cost saving benefits are $1,106,000.

The existing average shoaling rate for the Battery Island segment of the channel is 6,000 cubic yards per year and a dredge cycle of every two years. The two years after the widening, an additional 6,000 cubic yards is anticipated. The additional 3,000 cubic yards in year 1 and year 2, totaling 6,000 cubic yards is attributed to the widening. The 6,000 cubic yards at $7.50 per cubic yard totals $45,000, when PED is included the cost is $49,500. The average annual equivalent rounded is approximately $2,000.

Interest During Construction (IDC) is added to the project First Cost. Interest During construction is computed from the start of PED through the construction period, approximately 13 months. IDC for Battery Island is estimated to be $255,000. The project First Cost plus IDC represents the total investment cost required to place the project in operation. Total Investment Cost for Battery Island is estimated to be $14,907,000.

Tug Assist Benefits

The Battery Island bend easing has another benefit component. It is assumed in the Future without project condition, post Panamax vessels will need tug assistance navigating around Battery Island in addition to the tide. By widening the bend to 750 feet, tug assistance will no longer be needed for the post Panamax vessels. It is not assumed the tug will be removed from the harbor for not being needed in the with project condition, therefore, only variable operating cost of the tug will be used for benefit. The variable cost were calculated using the crew cost of one captain and two crew members, the number of crew members was provided by the tug company as well as the gallons of fuel needed per hour. An average fuel cost was calculated by using diesel fuel prices for the past five years. The tug company provided that six hours of time would be needed for a tug to help post Panamax vessels around the Battery Island Bend, and uses 100 gallons of fuel per hour. Based on the vessel call lists, the maximum number of post Panamax vessel transits is 63. The benefits by year were calculated by taking the crew cost for six hours ($375) plus the fuel cost for six hours ($1,932) times the number of transits of post Panamax vessels (63). The average annual benefits for reduction in tug assistance is $145,000.

Table 25 shows the costs and benefits for the Battery Island bend easing.

Table 25. Battery Island Costs and Benefits @ 3.5%

Costs and Benefits	
Total Benefits	$29,341,000
Average Annual Transportation Cost Savings Benefits	$1,106,000
Average Annual Reduction in Tug Assist Benefits	$145,000
Total Average Annual Benefits	$1,251,000

Costs and Benefits	
Project First Cost	$14,652,000
Interest During Construction	$255,000
Total Investment Cost	$14,907,000
Average Annual Project Cost	$636,000
Average Annual O&M	$2,000
Average Annual Cost	$638,000
Net Benefits	$613,000
BCR	2.0

Sensitivity Analysis

The Principles & 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. A sensitivity analysis is a useful technique that addresses uncertainty by systematically adjusting parameters in a model to determine the effects of such changes.

Sensitivity 1: Half Commodity Growth for the Far East

The commodity growth forecast prepared by Global Insight has been used for other East Coast navigation projects and is substantiated. However, it is recognized that the commodity growth rates are subject to variability and are influenced by many hard to predict factors like interest rates, national conflict or meteorological events. For this reason, an adjustment was made to the Far East trade route that assumed half of the growth than the original economic analysis beginning with the baseline year of 2012 and for the remainder of the analysis until throughput capacity is reached. The change was made for the Far East trade route only because the majority of the trade and benefits were derived from this region. The other trade regions, Europe and Central America, account for a much smaller percentage of the trade and change in the commodity forecast for these regions would not likely change the outcome. The channel remains at 42 feet and generally requiring 10% of underkeel clearance. The assumption for the fleet remained that by 2018 one of the Far East services would transition to a Post Panamax vessel. The remained of the tonnage/TEUs would be carried on a panamax containership.

Table 26 shows the commodity growth by trade region for tonnage.

Table 26. Commodity Half Growth for Far East

World Region	Percent Growth
Central America	5%
Far East	4%
Europe/Other	5%
Total Tonnage	4%

Once the commodity tonnage and TEUs were determined, the container loading tool was used to load the vessels by import and export tonnage for years 2018, 2024 and 2031. The same assumptions for the Future Without Project and Future With Project were assumed and the economic analysis results are below.

Table 27: Half Growth Far East Benefits and Costs @ 3.5%

Half Growth Far East Benefits and Costs	
Total Benefits	$18,546,300
Average Annual Transportation Cost Savings Benefits	$620,000
Average Annual Reduction in Tug Assist Benefits	$171,000
Total Average Annual Benefits	$791,000
Project First Cost	$14,652,000
Interest During Construction	$255,000
Total Investment Cost	$14,907,000
Average Annual Project Cost	$636,000
Average Annual O&M	$2,000
Average Annual Cost	$638,000
Net Benefits	$153,000
BCR	1.24

Sensitivity 2: No Growth Scenario

Another sensitivity analysis performed assumed no growth in the commodity forecast past 2018. It was assumed that growth for all trade regions occurred until the base year of 2018 and held constant afterwards. Hence, the number of calls per vessel type remained constant through the period of analysis, 2018 through 2067.

Table 28: No Growth Benefits and Costs @ 3.5%

Far East No Growth Benefits and Costs	
Total Benefits	$21,191,727
Average Annual Transportation Cost Savings Benefits	$767,000
Average Annual Reduction in Tug Assist Benefits	$136,000
Total Average Annual Benefits	$903,000
Project Cost	$14,800,000
Interest During Construction	$255,000
Total Investment Cost	$15,055,000

Far East No Growth Benefits and Costs	
Average Annual Project Cost	$642,000
Average Annual O&M	$2,000
Average Annual Cost	$644,000
Net Benefits	$259,000
BCR	1.40