# APPENDIX B
# ECONOMICS

# DRAFT

## MOBILE HARBOR, MOBILE, ALABAMA

## Integrated General Reevaluation Report
## With Supplemental Environmental Impact Statement

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# 1 INTRODUCTION

## 1.1 Study Purpose

The role of the U.S Army Corps of Engineers (USACE) with respect to navigation is to reduce navigation hazards and enable reliable and efficient waterborne transportation systems for the movement of commerce, national security needs and recreation. The Planning Guidance Notebook (ER1105-2-100) was referenced in performing the economic analysis. National Economic Development (NED) benefits are contributions to National Economic Development that increase the value of the national output of goods and services. It is the primary basis for Federal investment in water resource projects and is measured in average annual equivalent (AAEQ) terms.

The purpose of this study is to evaluate Federal interest in alternative plans (including the No-Action Plan) for reducing transportation costs and addressing navigation safety issues for Mobile Harbor and assess the effects of the alternatives on the natural system and human environment, including economic development. The economic analysis focuses on the overall efficiency of the system and comparison of the cost of transportation.

The principal navigation problem is larger vessels are experiencing transportation delays due to insufficient channel depth and width. This problem is a result of increasing number and size of vessels entering and departing the port. The existing channel depths and widths limit vessel cargo capability and restrict many vessels to one-way traffic.

The period of analysis is 50 years, 2025 through 2074. The analysis uses the vessel operating cost from the Economic Guidance Memorandum (EGM), 17-04, Deep Draft Vessel Operating Costs FY 2016 Price Levels and the Federal discount rate from EGM, 18-01, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year (FY) 2018 of 2.75 percent. The benefits in the economic analysis are derived from transportation cost savings.

## 1.2 Study Area Delineation

Mobile Harbor is located in the southwestern part of Alabama at the confluence of the Mobile River and the head of Mobile Bay. The harbor is approximately 28 nautical miles north of the Bay entrance from the Gulf of Mexico and 170 nautical miles east of New Orleans, Louisiana. The Mobile Harbor Ship Channel provides access to numerous private and public docks and berthing areas. The current dimensions of the ship channel are 47 feet by 600 feet wide across the Mobile Bar and 45 feet deep by 400 feet wide in the bay and 45 feet deep by 400 feet wide in the Mobile River to a point about one mile below the Interstate 10 highway tunnels. The channel then becomes 40 feet deep and proceeds north over the Interstate 10 and U.S. 90 Highway tunnels to the Cochrane Bridge. In the southern region of Mobile Bay, access can be gained to the Gulf Intracoastal Waterway (GIWW) which stretches from St. Marks, Florida to Brownsville, Texas. The Theodore Industrial Canal provides for a 40 feet deep, 400 feet wide channel, branching from the main ship channel in Mobile Bay at a point about 2.8 miles north of Mobile Bay Light House and extending northwesterly about 5.3 miles to the shore of Mobile Bay. Figure 1 displays the project map.

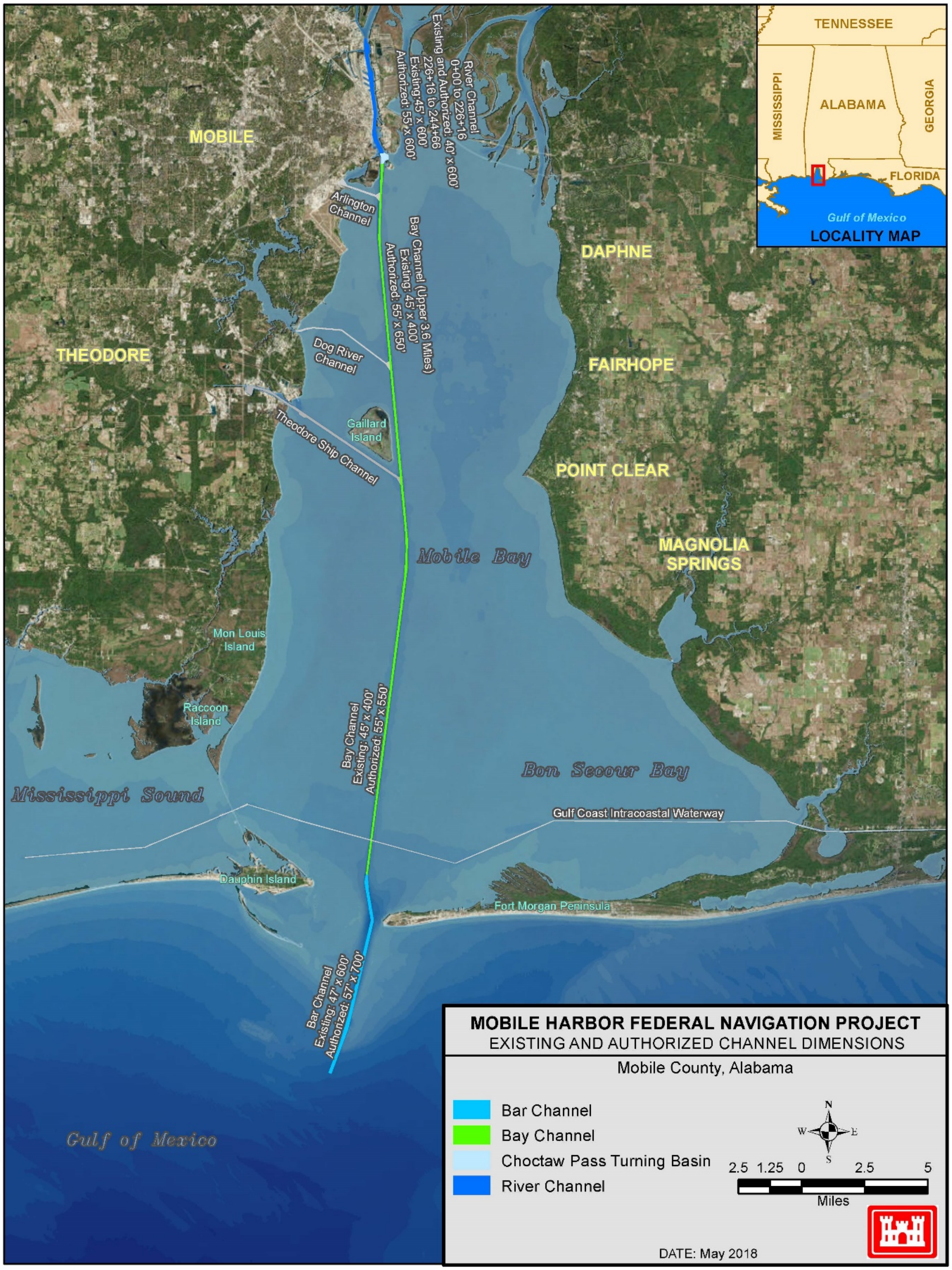



**FIGURE 1: MOBILE BAY SHIP CHANNEL**

# 2 EXISTING CONDITIONS

## 2.1 Economic Study Area

Mobile Harbor is comprised of both public and private port facilities located in Mobile, Alabama. Due to the nature of the cargo, vessel types, potential channel improvements and sailing drafts, the port facilities are segmented into three areas for ***economic analysis purposes***; the Lower Harbor, the Upper Harbor and Theodore Industrial Park[1]. The Lower Harbor has a 45-foot depth and serves the public terminals of Alabama State Port Authority (ASPA) Pinto Steel, ASPA McDuffie Coal, ASPA Intermodal Container Terminal and the Cruise Terminal. The Upper Harbor has a 40-foot draft and serves public and private terminals. Theodore Industrial Park serves publicly and privately-owned and operated facilities. Figure 2 shows a closer look at the segmented terminals in the harbor. North of the blue line are the Upper Harbor terminals that could benefit from channel widening improvements, channel dimensions are 40 feet deep by 400 feet wide. South of the blue line are the Lower Harbor terminals that could benefit from deepening and widening where channel dimensions are 45 feet deep by 400 feet wide.

[1] Economic analysis channel reaches differ from engineering reaches due to terminal segmentation for widening verses deepening and widening benefits.


**FIGURE 2: HARBOR TERMINALS**

Land side transportation to and from Mobile Harbor is by rail or truck. The transportation infrastructure connects to two interstates and four US highways. Mobile Harbor is very close to Interstate 10 which is a transcontinental highway stretching from the California Coast to the Florida Atlantic Coast. Just a few miles from Mobile Harbor is Interstate 65 whose southern limit is the intersection with Interstate 10 and the northern terminus in Indiana. Alabama State Port Authority has a variety of railways including five Class 1 and three short line railroads. Other transportation infrastructure includes rail ferry service, inland and intracoastal waterways and air cargo facilities (Brookley Complex) servicing the port.

### 2.1.1 Facilities and Infrastructure

**The Alabama State Port Authority (ASPA)** has a total of 41 berths. The facilities include the main complex, McDuffie Island, Choctaw Point and other sites. The main imports are heavy lift and oversized cargo, containers, coal, aluminum, iron, steel, copper, lumber, wood pulp, plywood, fence posts, veneers, toll and cut paper, cement and chemicals. Main exports are heavy lift and oversized cargo, containers, coal, lumber, plywood, wood pulp, laminate, flooring, roll and cut paper, iron, steel, frozen poultry, soybeans and chemicals.

#### 2.1.1.1 *Lower Harbor Terminals*

The Mobile Ship Channel terminals are located south of the Bankhead and Wallace vehicular tunnels. The facilities located on this segment of the river are the Alabama Cruise Terminal, McDuffie Coal Terminal, Pinto Island Terminal and APM Terminals Mobile.

The Alabama Cruise Terminal offers a two-story 66,000 square foot terminal that is located adjacent to I-10 and six miles from I-65, and offers a close proximity to numerous hotels, restaurants and attractions. Carnival Cruise Lines began passenger service at the Port of Mobile in 2004. Carnival launched its Fantasy Class service November 2009. In 2011, Carnival cancelled its Mobile service for commercial reasons, but resumed the Fantasy Class service in November of 2016.

APM Terminals Mobile (an independent division within the A.P. Moller-Maersk Group) is located at Choctaw Point near the mouth of the Mobile River and opened in 2008. Subsequent investment in the container terminal has extended annual throughput capacity to 750,000 Twenty Equivalent Units[2] (TEUs) when land and rail are considered. Ongoing expansion of the terminal and a dock extension will deliver an annual throughput capacity of 950,000 TEUs by year-end 2019, when land and rail are considered. The container intermodal investment at Choctaw Point has sufficient land available to support further expansion. At full build out, the marine and rail terminal could accommodate an estimated annual throughput capacity of two million TEUs. The inland trade region includes the southeast, in particular, Georgia, Birmingham, Alabama and Knoxville/Memphis Tennessee, but extends as far as Chicago, Illinois. The terminal improves capability in the U.S. Gulf for reaching Midwest markets as well as Alabama and neighboring states. The 115-acre terminal has a 45-foot channel and 2,000 feet of deep water berth to handle post panamax vessels. In 2016, the ASPA completed construction of a $32-million 80-acre rail terminal that permits direct and fluid transfer of containers between vessels and rail cars. APM Terminals also contributed an additional $50 million toward surface improvements, equipment and technology. The dock has a depth of 45 feet mean lower low water (MLLW) and equipped with two post

[2] A twenty-foot equivalent unit is a unit of cargo capacity often used to describe the capacity of containerships and container terminals.

panamax ship-to-shore (STS) cranes capable of a 19-row reach. In addition, two super post panamax cranes that span 22 rows of containers were delivered in June 2017.

The terminal has nine shipping lines that customers can utilize in Mobile. The regions served are Europe, Asia/Far East and Caribbean/Gulf of Mexico. Two additional services are expected by 2019. In 2018, a South America to Gulf service is expected and in 2019, a West Coast South America to Gulf of Mexico service is expected.

In 2016, it was announced that Walmart will construct an import distribution center (IDC) in Mobile County, Alabama. The IDC will be approximately 2,500,000 square feet on 400 acres of land in Irvington, Alabama. The IDC will be Walmart's sixth import facility in the Unites States. The purpose of the IDC is to receive containers from Asia to distribute the products to Walmart stores across the southeast. The containers will come through APM Terminals located approximately 15 miles from the IDC site. The Walmart distribution center will be a hub for the south east region of the U.S., serving around 800 stores and several regional distribution centers in Alabama, Mississippi and other areas to the north. Walmart opened the IDC in May 2018, and is the fourth in the state. The capacity of the IDC is around 160,000 TEUs.

McDuffie Coal Terminal is the third largest coal export terminal in the Nation serving primarily an export metallurgical coal market. McDuffie is capable of handling both import and export coal with a total annual throughput capacity of approximately 23 million tons. McDuffie services waterborne and rail coal shipments and is equipped with three ship berths capable of receiving vessels that draft 45 feet. The ship berths are equipped with three post-panamax unloaders and two loaders. Supporting equipment on the island includes stacker/reclaimers, barge loading/unloading stations, rail loading/unloading stations, conveyance systems and three loop tracks to support four storage yards.

Pinto Island Terminal**,** located near the mouth of the Mobile River, is capable of handling annually in excess of five million tons of semi-finished steel slabs. The 20-acre terminal provides 1,000 feet of deep-water dock dredged to 45 feet, as well as an automated barge loading system position between the ship berth and the shoreline. The terminal is equipped with three post panamax STS gantry cranes that are able to unload steel from ships to waiting barges or to the terminal storage yard possessing 150,000 metric tons of storage capacity.

#### 2.1.1.2 *Upper Harbor Terminals*

Alabama State Port Authority Main Docks Complex extends approximately 2.2 miles along the west bank of the Mobile River and is bordered by the Terminal Railway tracks to the west and Three Mile Creek to the north. The 570-acre terminal includes approximately 1.9 million square feet of warehouse space within the main port area and a 22-acre Bulk Handling Plant at the north end. The Terminal Railway, which is owned by ASPA, interchanges with five Class 1 Railroads and has immediate access to I-65 and I-10. The primary commodities handled within the main dock complex are forest products, iron and steel products, aluminum, and ro-ro cargoes. The facility is capable of handling 75,000 TEUs.

Blakeley Island Terminals are comprised of both public and private terminals located on the eastern shore of the Mobile River across from the northern end of the Alabama State Port Authority Docks. These terminals handle general cargo, equipment, crude oil, asphalt and fuel oil, dry bulk commodities and shipbuilding.

The Water Resources Reform and Development Act (WRRDA) of 2014 designated the Port of Mobile as an energy transfer port, which are ports of strategic significance to the national energy security interest of the U.S. There are six private petroleum/petroleum products terminals at various locations along the west and east banks of the Upper Harbor.

Vehicle Processing Roll On/Roll Off (ro-ro) Facility is a new facility that will allow vehicles to be driven on and off ships at Mobile. The ASPA is partnering with a joint venture out of South America to build and operate the facility. The new processing and logistics terminal will be built from a former bulk material handling facility expanding approximately 57 acres. The facility is expected to be in service by 2020.

#### 2.1.1.3 *Theodore Industrial Park*

The Theodore Industrial Canal is situated on 400 acres at the mouth of a deep water industrial canal. There are two docking facilities, one 1,700 feet and another 1,300 feet. The ports heavy lift capabilities allow essentially any cargo to off loaded and/or loaded. The Port services vessels any length and breadth through the Panamax class. There are on-berth and off-berth open and covered storage areas. Primary products handled at the Theodore Industrial Park are chemicals, cement, aggregates, fertilizers, over-dimensional cargo and some general cargo. It also supports offshore oil and gas production and installation projects, including subsea umbilicals, rigid spooled pipe and risers.

## 2.2 Historical Commerce

The Mobile Ship Channel serves the economy by moving millions of tons of cargo. Mobile Harbor handles both domestic and foreign cargo. The cargo is imported and exported in various types of ships including bulk carriers, containerships, general cargo, ro-ro and tankers. While domestic cargo is roughly half of the tonnage received or shipped through the Port, this analysis focuses on the movement of foreign tonnage through Mobile Harbor. Figure 3 shows the general trend of domestic verses foreign tonnage over the time period of 2007 through 2015. Although domestic and foreign tonnage have been fairly balanced, foreign tonnage has exceeded domestic tonnage for all years in this timeframe except 2009.

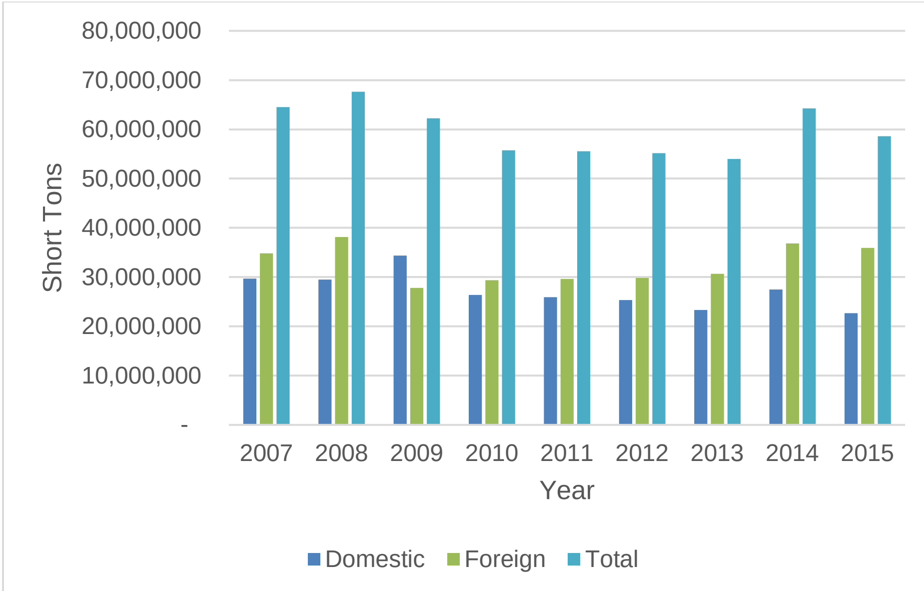



**FIGURE 3: FOREIGN AND DOMESTIC TONNAGE**

### 2.2.1 Foreign Commodity Shipments

Based on data for years 2010 to 2014, foreign shipments averaged 31.2 million short tons. Coal shipments have varied over the period, but remains the largest commodity with 47% of total foreign commerce. Primary manufactured goods came in second at 16% of the overall distribution and then crude materials, which averaged 13% of the total. Petroleum products accounted for 12% of total shipments and the remaining commodity categories accounted for 5% or less of total commerce. Figure 4 shows the commodity distribution from 2010 to 2014 for both imports and exports.

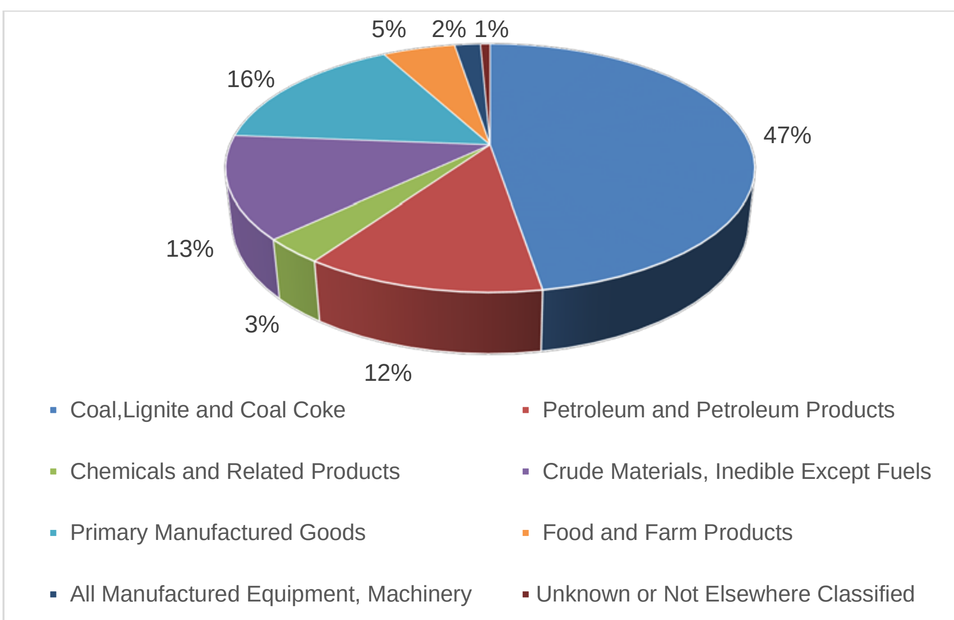



**FIGURE 4: MOBILE HARBOR COMMODITY DISTRIBUTION (2010-2014 AVERAGE)**

Within foreign commodity shipments, imports account for approximately 47% while exports account for 53% of the foreign trade at Mobile during the time period 2010 – 2014. Figure 5 shows total foreign commerce and imports and exports.

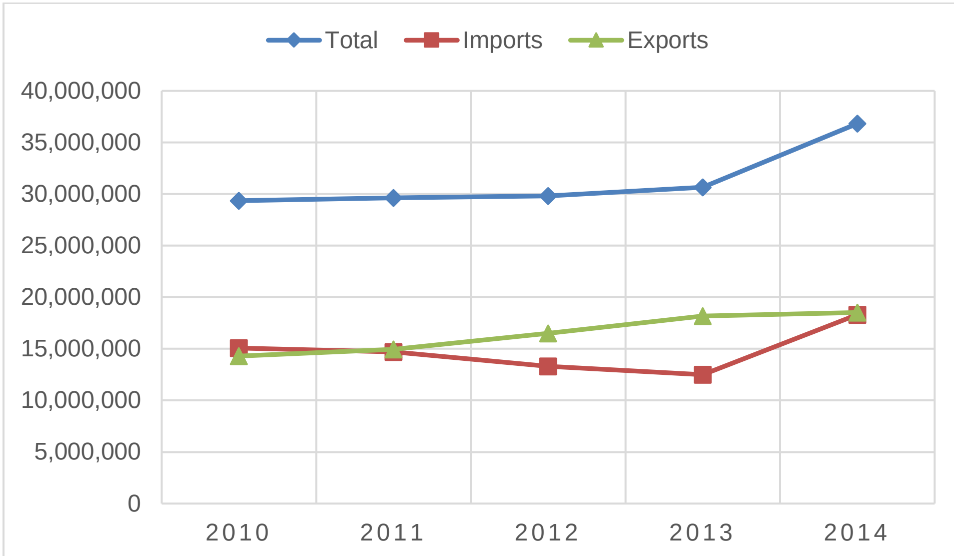



**FIGURE 5: FOREIGN COMMERCE 2010-2014**

Figure 6 shows foreign imports by commodity type from 2010 through 2014. As illustrated, the volume of coal has fluctuated, primary manufactured goods increased, and petroleum imports significantly increased from 2013 to 2014. The increase in petroleum products was due to the construction of a pipeline from a dock at Mobile Harbor to Pascagoula, Mississippi to transport crude oil. Other commodities did not experience significant changes.

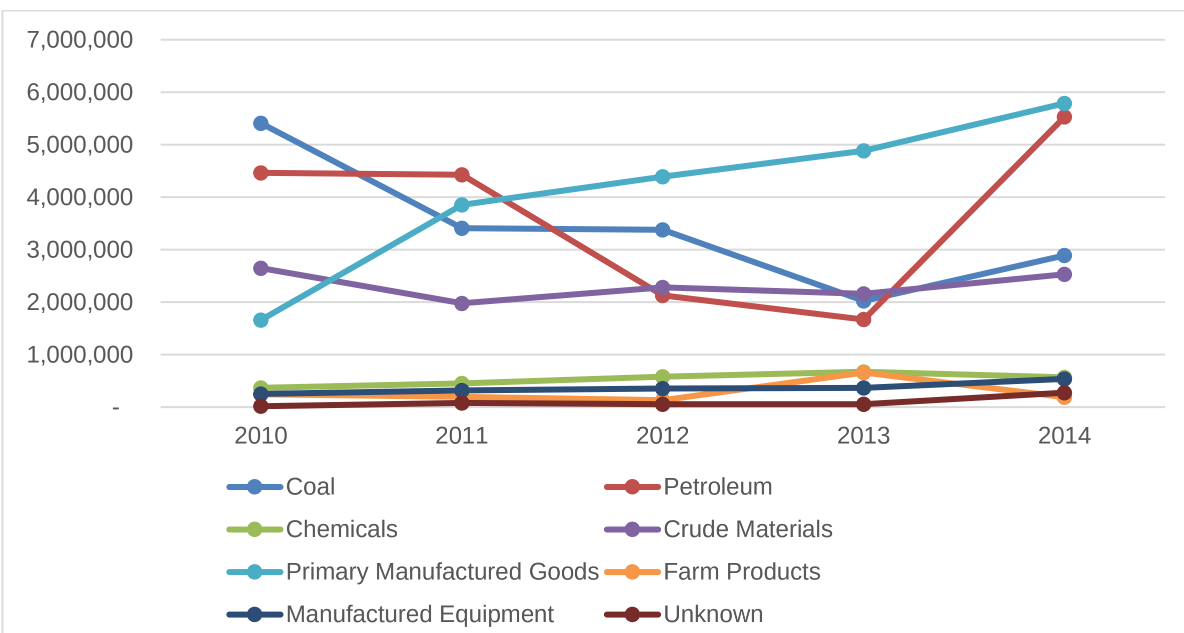



**Figure 6: Historical Imports by commodity type (short tons)**

Figure 7 shows foreign exports from 2010 through 2014 by commodity type. Coal has historically been the largest commodity exported.

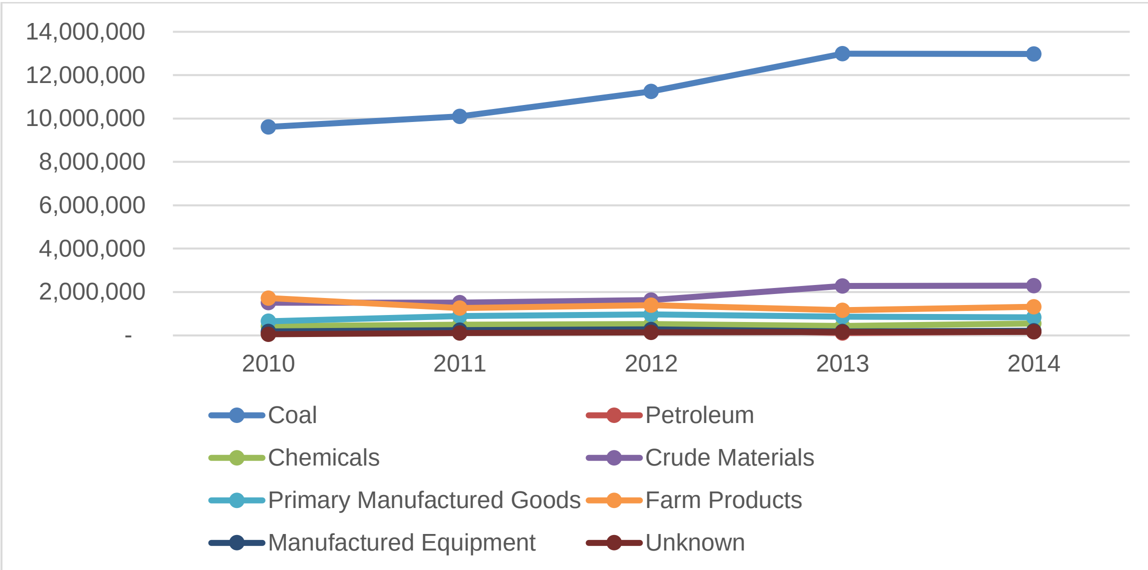


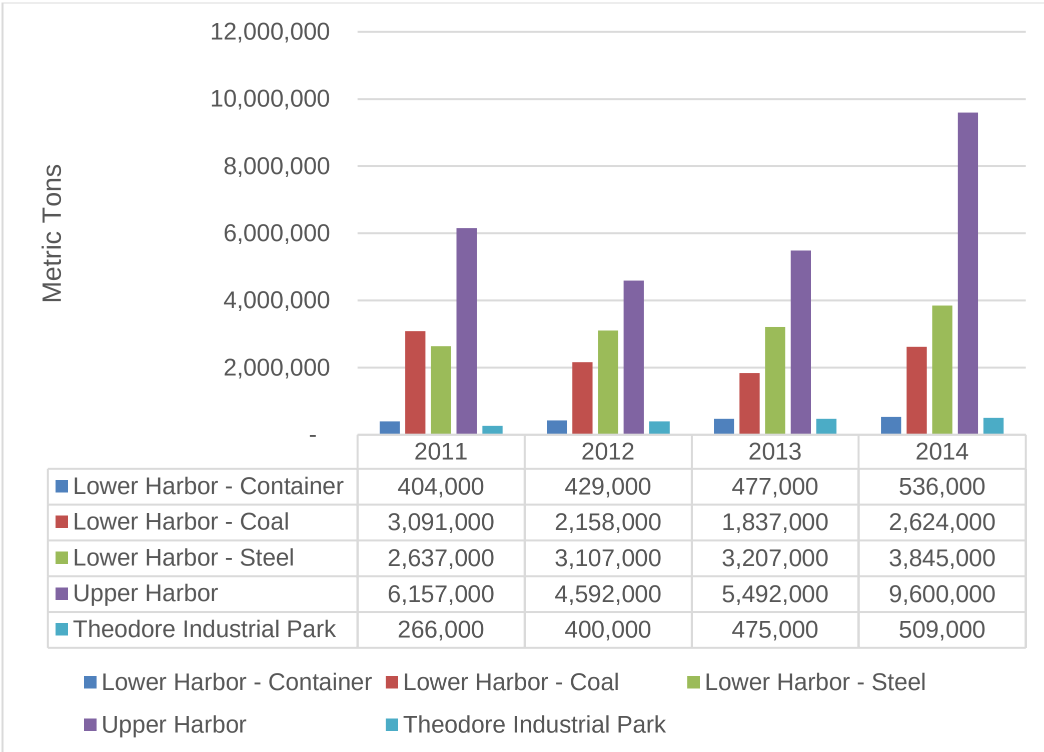

**FIGURE 7: HISTORICAL EXPORTS BY COMMODITY TYPE**

### 2.2.2 Cargo Imports

For detailed analysis, the data set is limited in years due to projections being based on latest years of data available at the time of analysis, 2010 to 2014. As discussed in Section 2.1, one criteria for the segmentation of the harbor for the economic analysis was the nature of the cargo. Since the carrying capacity of a vessel is in metric tons, the remainder of the analysis is presented in metric tons for commodity and fleet forecasting[3]. Figure 8 displays the historical imports by channel segment moving through Mobile Harbor from 2011 to 2014. As shown, containerized cargo and steel imports increase each year. Imported coal decreased from 2011 to 2013, then increased in 2014.

The Upper Harbor cargo volume varied by year and the overall Theodore Industrial Park tonnage continued to increase each year. The non-containerized import volumes include coal, steel, manufactured equipment machinery and products, food and farm products, fertilizers, crude materials and petroleum products.

[3] A short ton equals 2,000 pounds; a metric ton weighs 2,204.

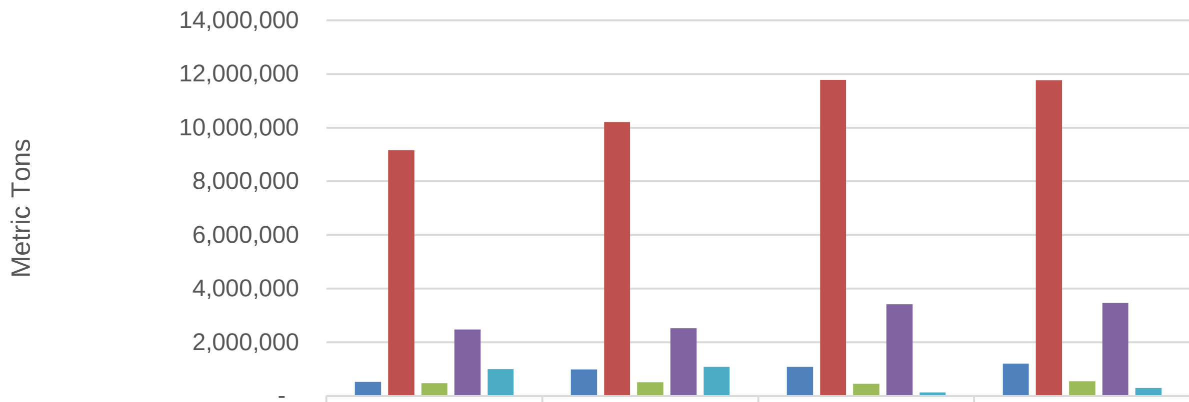



| | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Lower Harbor - Container | 404,000 | 429,000 | 477,000 | 536,000 |
| Lower Harbor - Coal | 3,091,000 | 2,158,000 | 1,837,000 | 2,624,000 |
| Lower Harbor - Steel | 2,637,000 | 3,107,000 | 3,207,000 | 3,845,000 |
| Upper Harbor | 6,157,000 | 4,592,000 | 5,492,000 | 9,600,000 |
| Theodore Industrial Park | 266,000 | 400,000 | 475,000 | 509,000 |

**FIGURE 8: CARGO HISTORICAL IMPORTS (METRIC TONS)**

### 2.2.3 Cargo Exports

For detailed analysis, the data set is limited in years due to projections being based on latest years of data available at the time of analysis, 2011 to 2014. Figure 9 shows historical exports moving through Mobile Harbor from 2011 to 2014. Containerized cargo and coal exports increase each year, and steel exports vary by year. The Upper Harbor cargo increases each year. Theodore Industrial Park tonnage to include iron ore, food, farm items and chemicals decline in 2013.




| | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| Lower Harbor - Container | 522,460 | 985,000 | 1,083,000 | 1,204,000 |
| Lower Harbor - Coal | 9,157,000 | 10,206,000 | 11,784,000 | 11,773,000 |
| Lower Harbor - Steel | 480,000 | 518,000 | 452,000 | 545,000 |
| Upper Harbor | 2,479,000 | 2,532,000 | 3,424,000 | 3,471,000 |
| Theodore Ship Channel | 998,000 | 1,090,000 | 135,000 | 296,000 |

**FIGURE 9: CARGO HISTORICAL EXPORTS (METRIC TONS)**

### 2.2.4 Containerized Cargo

As of 2016, nine shipping lines were calling APM Terminals in Mobile. Table 1 shows the operator, service, vessel TEU capacity and trade area. Routes include services to the Far East, Europe and transshipments in the Caribbean.

**TABLE 1: APM CONTAINER TERMINAL SERVICES**

| Operator | Service | Vessel TEUs | Routes | Trade Areas |
|---|---|---|---|---|
| Maersk & MSC | TA-3 | 6,000-7,000 | Europe/ Transatlantic | North Europe • Charleston • Freeport • Central America • New Orleans • Mobile |
| MSC | Lone Star Express | 4,000-5,000 | Far East | Asia • *Panama* Canal •Houston • Mobile • Miami • Freeport |
| CMA CGM & Evergreen | PEX3 | 5,000 | Far East | China • *Panama Canal* • Houston • Mobile • Miami • Jacksonville • South Africa • Singapore |
| Maersk | TP-18 | 4,000-5,000 | Far East | Houston • Mobile • Miami • *Panama Canal* • East Asia |
| COSCO/CS | GME | 4,250 | Far East | China • *Panama Canal* • Houston • Mobile |
| ZIM | CGX | 2,700-3,400 | Caribbean/Gulf | Caribbean • Mobile • New Orleans • Houston |

#### 2.2.4.1 *Container Facility and Capabilities*

In 2015, 186,619 loaded twenty equivalent units (TEUs) were handled through Mobile. Imports accounted for 82,379 TEUs, approximately 44% and exports account for 104,240 TEUs, 56%. Imports and exports varied, but exports were higher overall in terms of TEUs.  FIGURE 10 shows import and export loaded TEUs from 2008 to 2015.

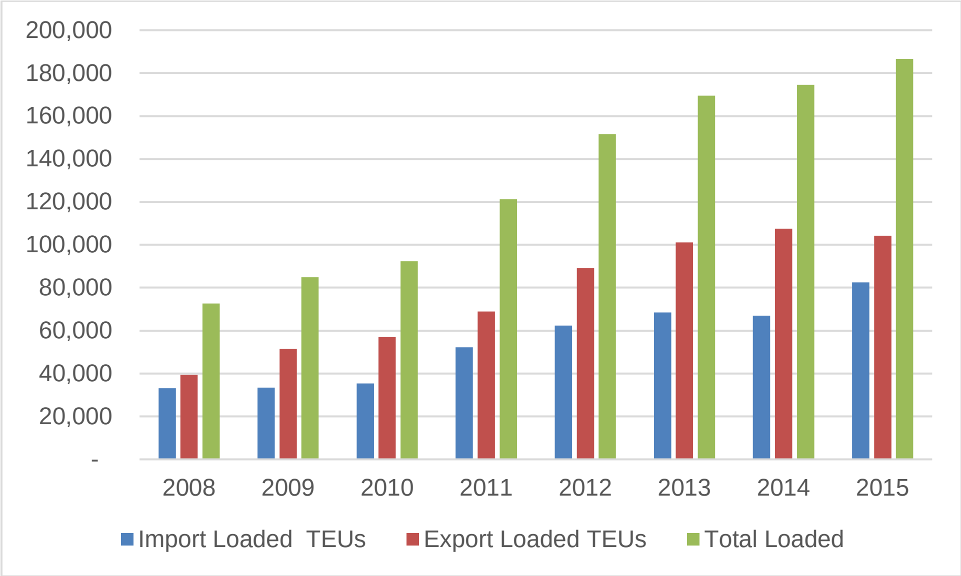



**FIGURE 10:  LOADED TEUs**

Figure 11 illustrates the volume of empty and loaded TEUs from 2008 to 2015.  Empty TEUs account for approximately 40% of inbound containers, while empty TEUs account for approximately 10% of outbound containers.

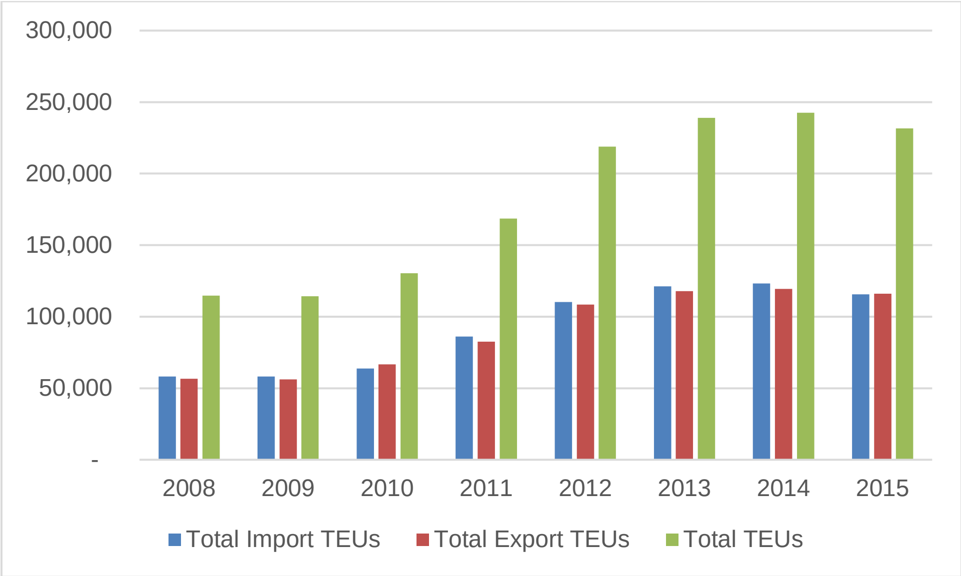
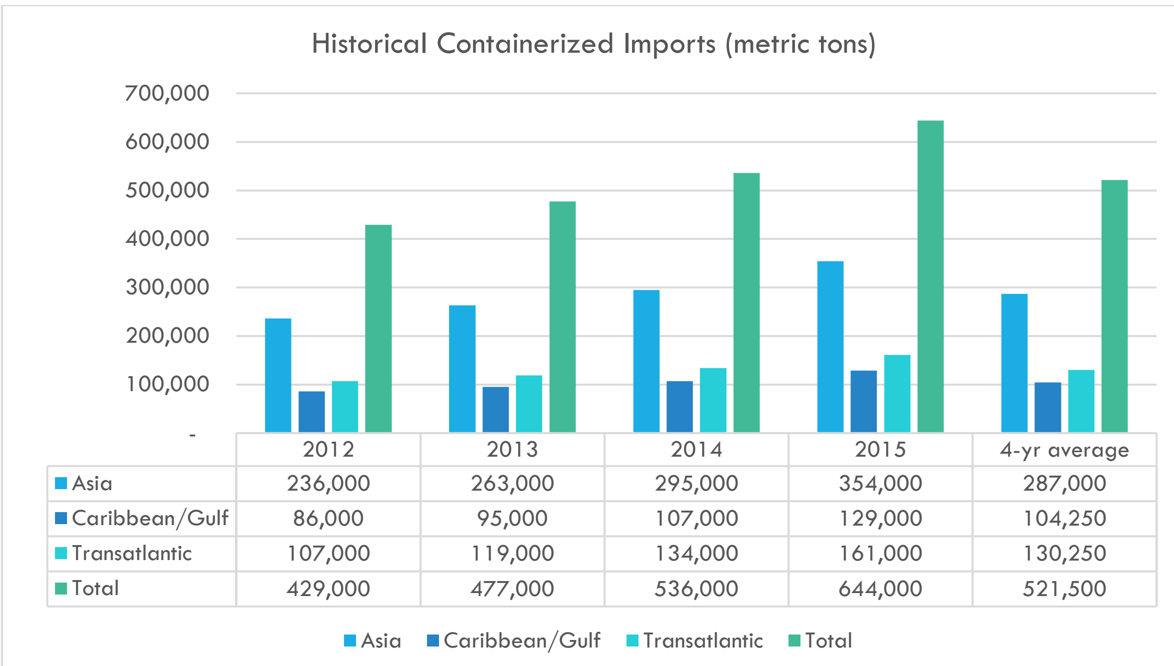



**FIGURE 11:  TOTAL LOADED AND EMPTY TEUS**

### 2.2.4.2 *Containerized Imports*

Figure 12 illustrates historical containerized imports that moved through Mobile Harbor by trade lane. As shown, in the time period 2012 to 2015 containerized imports continue to increase. Trade with Asia led containerized cargo for imports, followed by transatlantic trade and then Caribbean/Gulf trade. Top import commodities include auto parts, general consumer goods and hard woods. From Europe, tile floor, auto parts and general consumer goods are imported. The Caribbean was transshipment hub for Latin America, Mediterranean and West Africa. Imports from these regions include produce, textiles and raw materials. Average imports from all the world regions were estimated to total 522 thousand metric tons. The average trade volume from 2012 to 2015 represents the baseline from which commerce was forecasted.




| | 2012 | 2013 | 2014 | 2015 | 4-yr average |
|---|---|---|---|---|---|
| Asia | 236,000 | 263,000 | 295,000 | 354,000 | 287,000 |
| Caribbean/Gulf | 86,000 | 95,000 | 107,000 | 129,000 | 104,250 |
| Transatlantic | 107,000 | 119,000 | 134,000 | 161,000 | 130,250 |
| Total | 429,000 | 477,000 | 536,000 | 644,000 | 521,500 |

**FIGURE 12: HISTORICAL CONTAINERIZED IMPORTS BY TRADE LANE**

### 2.2.4.3 *Containerized Exports*

Figure 13 illustrates historical containerized exports that moved through Mobile Harbor by trade lane. As shown, in the time period 2012 to 2014 containerized exports continue to increase, then decline in 2015. Trade with Asia also leads containerized cargo for exports, followed by transatlantic trade and then Caribbean/Gulf trade. Top export commodities include forestry products, petrochemicals and frozen poultry. To Europe, forestry products, petrochemicals and peanuts are exported. The Caribbean is a transshipment hub for Latin America, Mediterranean and West Africa. To these regions are exported vehicles, frozen poultry, cotton and raw materials. Average exports from all the world regions were estimated to total 1.1 million metric tons. The average trade volume from 2012 to 2015 represents the baseline from which commerce was forecasted.

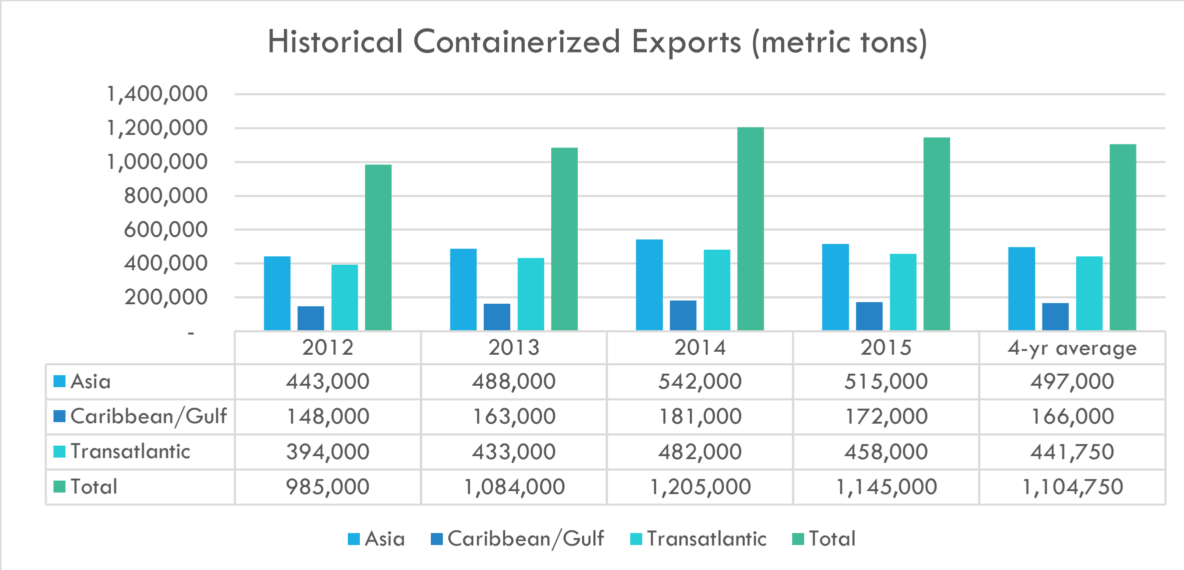



**FIGURE 13: HISTORICAL CONTAINERIZED EXPORTS BY TRADE LANE**

### 2.2.5 TEU Weight by Route Group

Data from 2012 to 2015 for inbound and outbound containership calls were analyzed in detail to determine the TEU weight by route group. The metric tons imported or exported were divided by the number of TEUs imported or exported to determine an average weight per TEU for import and export and by route group. Results are shown in Table 2. The assumed two-ton tare weight for all boxes was not included in this total.

**TABLE 2: TONS PER TEU BY ROUTE**

| Route Group Description | TEU Weight Import | TEU Weight Export |
|---|---|---|
| Far East | 8.2 | 11.5 |
| Caribbean/Gulf | 5.5 | 12.2 |
| Transatlantic | 12.4 | 12.3 |

### 2.2.6 Lower Harbor Dry Bulk

#### 2.2.6.1 *Coal*

Mobile serves Alabama and Illinois Basin coal production for their import and export operations. Imported thermal coal has declined due to companies using an alternate fuel source and to cost effectively reduce greenhouse gas emissions. However, in the near term, coal will still be used in the fuel mix at plants that utilize new clean coal technologies, and will continue to be imported through Mobile. Metallurgical grade coal is still being mined in Alabama for export. Figure 14 shows the coal hinterland.

Itinerary data from the Waterborne Commerce Statistics Center (WCSC) indicates bulk coal traffic is considered on a pendulum routes (back-and-forth to-and-from Mobile). These vessels primarily follow routes between Mobile and the following regions:

- Europe
- Africa
- Asia
- South America

The study assigned future vessel call route groups based on historical route groups by vessel class.

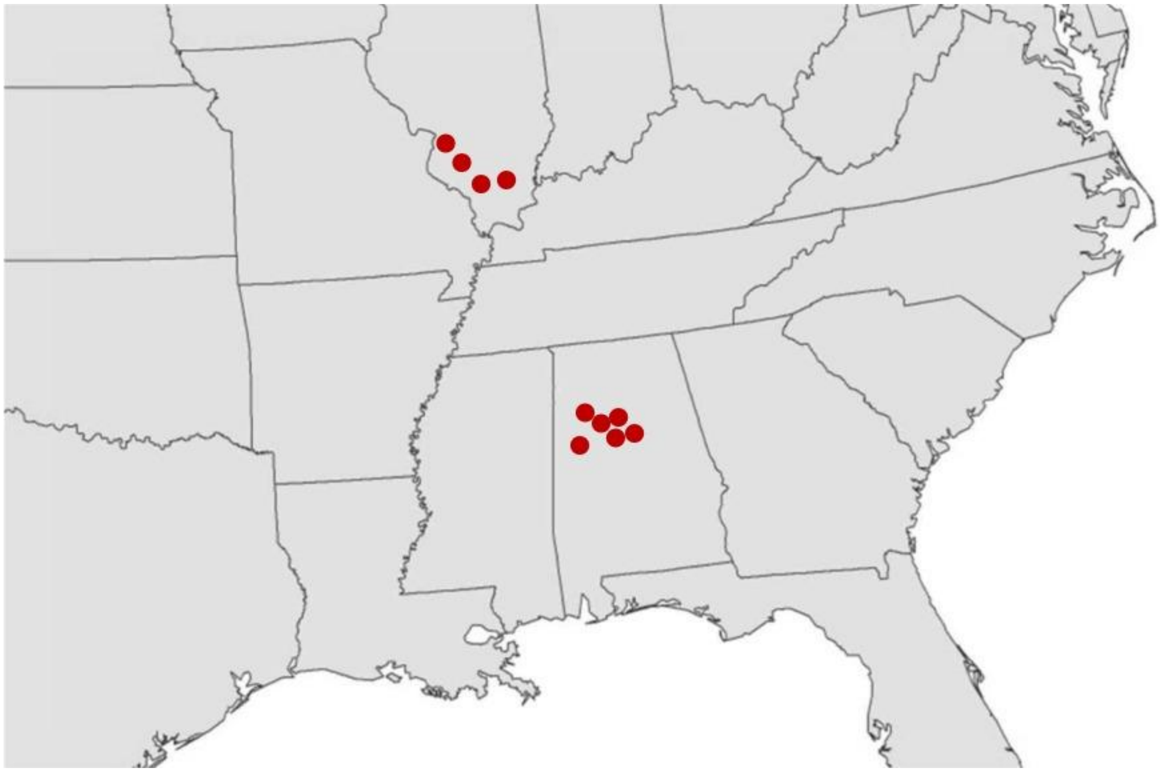


**FIGURE 14: COAL HINTERLAND**

#### 2.2.6.2 *Steel*

Mobile serves the Southeast U.S. iron, steel and non-ferrous metals market. Mobile has emerged as the second largest steel Port in the U.S.  Pinto Island Terminal primarily serves AM/NS, a steel processing plant located in Calvert, Alabama.  Although vessels that call this terminal draft 45 feet, personnel at AM/NS stated given the quantity and demand of steel shipped, no larger or deeper channel is needed.  Therefore, the quantity of tonnage and vessels utilizing the terminal are held constant.

### 2.3 Fleet Characteristics

Both long-term and short-term data was acquired from the WCSC and Mobile Harbor Pilots logs to determine vessel characteristics of the fleet calling the Port.

An analysis of the existing fleet data revealed six typical vessels calling Mobile Harbor in 2014 they are bulk carriers, containerships, general cargo, chemical tankers, oil tankers, and ro-ro cargo vessels.  For the most part, these vessels are representative of historical vessels calling on the Port.  Other vessel types that call the Port are research/survey and offshore supply vessels and vessels needing repair.  In 2016, the Carnival Cruise ship began year-round sailing from Mobile.  Figure 15 shows the distribution of the vessel types in 2014.  As shown, bulk carriers made up the largest vessel type calling with general cargo vessels and containerships vessels close behind.

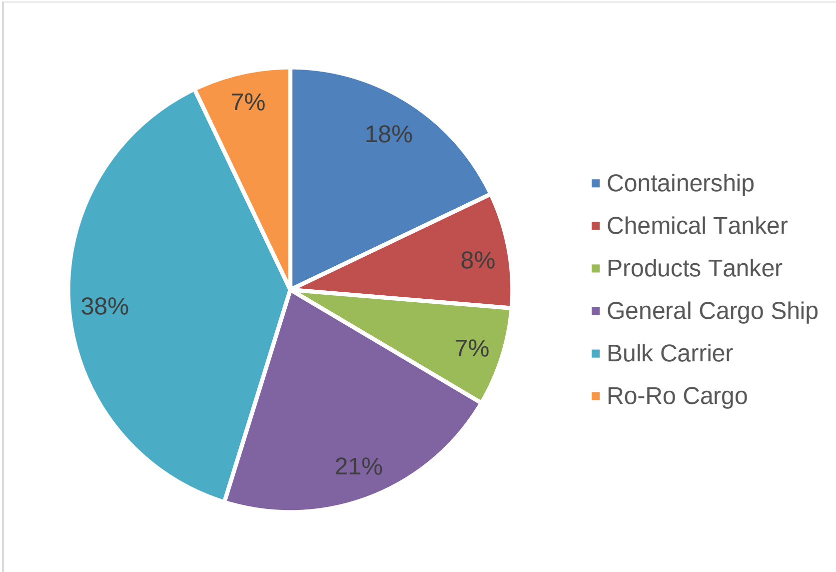
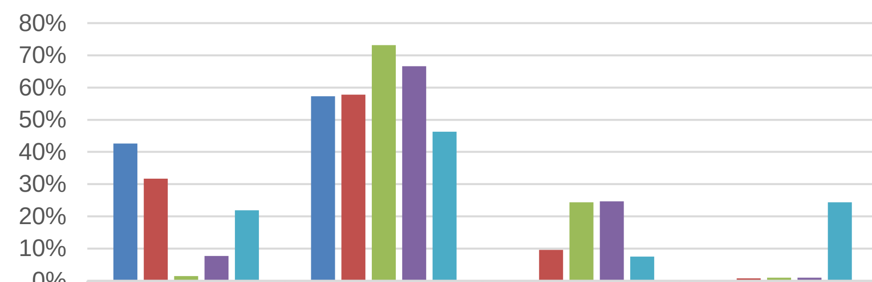



**FIGURE 15: VESSEL TYPE DISTRIBUTION**

### 2.3.1 Containership Fleet

From 2011 to 2015, the containership fleet calling Mobile Harbor consisted of sub-panamax (22%), panamax (61%) and post panamax (17%). Figure 16 provides an overview of containerships calls to APM Terminals.




| | Sub-Panamax | Panamax | Post Panamax Gen I | Post Panamax Gen II |
|---|---|---|---|---|
| 2011 | 43% | 57% | 0% | 0% |
| 2012 | 32% | 58% | 10% | 1% |
| 2013 | 1% | 73% | 24% | 1% |
| 2014 | 8% | 67% | 25% | 1% |
| 2015 | 22% | 46% | 8% | 24% |

2011 2012 2013 2014 2015

**FIGURE 16: CONTAINERSHIP CALLS**

The largest containership by deadweight tonnage to call Mobile Harbor was the MSC Judith in 2014. Table 3 shows characteristics of the largest containership vessels to call in this time frame.

**TABLE 3: LARGEST MOBILE HARBOR CONTAINERSHIP CHARACTERISTICS**

| Vessel Name | Beam | Draft | LOA | DWT | TEU Capacity |
|---|---|---|---|---|---|
| MSC JUDITH | 141.3 | 47.5 | 1,065 | 105,082 | 8,089 |
| MSC TEXAS | 141.3 | 47.5 | 1,096 | 101,898 | 8,238 |

### 2.3.2 Bulk Fleet

The bulk fleet includes bulk carriers, chemical tankers, general cargo vessels, ro-ro vessels and tankers. Figure 17 provides an overview of total foreign calls by vessel type. Bulk Carriers are the largest and most frequent type of bulk vessel. They carry steel and coal to the Lower Harbor and a variety of other commodities to the Upper Harbor. Tankers declined from 2011 to 2013, but rebounded in 2014 most likely based on the information in 2.2.1.

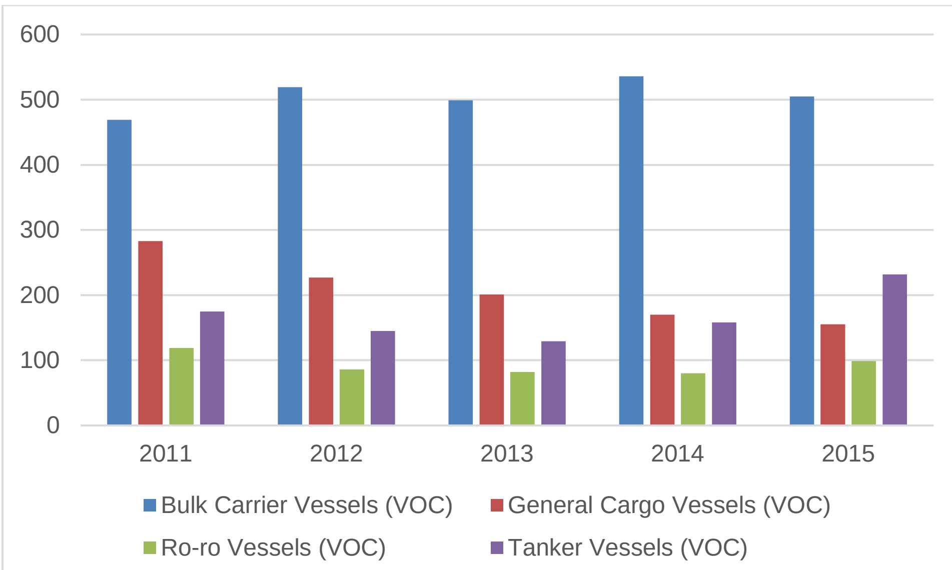



**FIGURE 17: BULK FLEET BY VESSEL TYPE**

## 2.4 Shipping Operations

The Mobile Harbor Bar Pilots have safety guidelines in which they follow for safe operation in the channel. The guidelines that are pertinent for this analysis are as follows: traffic is limited to one-way when a vessel whose beam exceeds 115 feet is transiting the channel, the maximum combined draft of two meeting vessels shall not exceed 85 feet, any two vessels with a combined length overall (LOA) of 1,650 feet or greater will not be allowed to meet in the channel if the combined draft is greater than 75 feet, and the maximum combined length of any two vessels that will be allowed to meet in the channel is 1,775 feet, regardless of draft.

### 2.4.1 Underkeel Clearance

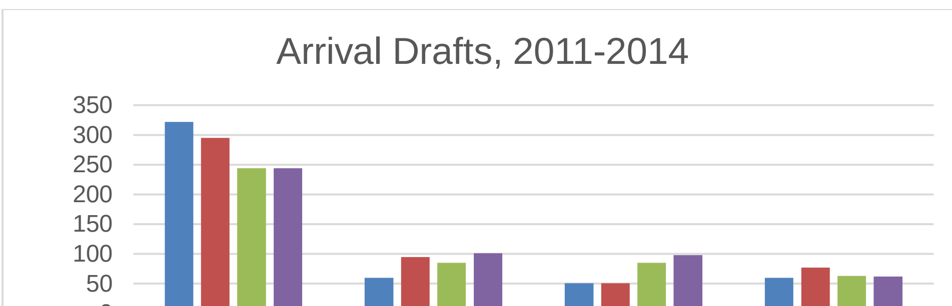
The measure of underkeel clearance (UKC) for economic studies is applied according to planning guidance. According to this guidance, UKC is evaluated based on actual vessel operator and pilot practices within a harbor and subject to present conditions, with adjustment as appropriate or practical for with-project conditions. The practices for UKC were determined through interviews with pilots and vessel operators and analysis of actual past and present practices. It is assumed that the UKC used in the existing condition will be in use with a deepened channel. For Mobile Harbor, clearance required varies by vessel type. The bulk carrier sailing drafts are frequently up to 45 feet. Containerships typically have sailing drafts of 41 feet, however, few have sailings drafts of 42 to 44 feet. Docks that tankers and general cargo vessels call are upriver where the channel converts to 40 feet. Sailing drafts for tankers and general cargo vessels are up to 40 feet.

### 2.4.2 Tidal Range

The tides in Mobile Bay are chiefly diurnal, occurring once daily. Under ordinary conditions, mean tidal range is 1.2 feet at the lower end and 1.5 feet at the upper end; extreme tidal range is 3.4 feet at the lower end and 3.6 feet at the upper end. Northern winds during the winter months may lower the water surface of the bay by as much as 1.5 feet below mean low water; hurricanes have been known to raise the level by as much as 11.5 feet. According to interviews with the harbor pilots and their ship logs, vessels currently calling Mobile Harbor do not depend on the tide to transit the channel.

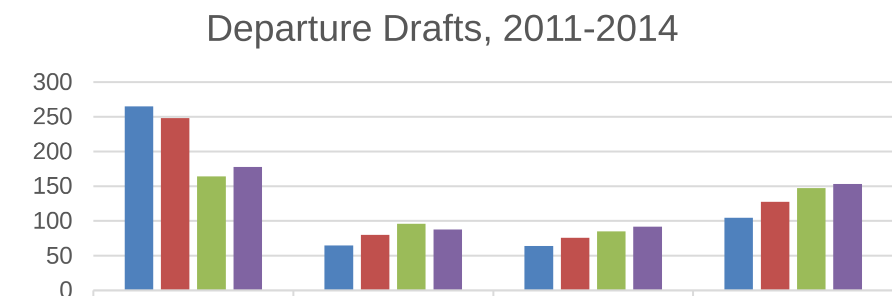
### 2.4.3 Sailing Practices

Figure 18 and Figure 19 show the vessel frequency and sailing drafts for bulk carriers and containerships between 2011 and 2014. The analysis was limited to these two vessels types since the other vessels types are carrying cargo upriver where the channel transitions to 40 feet, therefore, potential deepening of the channel will not provide a benefit to those commodities and resultant vessels.




| | <30 | 31-35 | 36-40 | 41-45 |
|---|---|---|---|---|
| 2011 | 322 | 60 | 51 | 60 |
| 2012 | 295 | 95 | 51 | 77 |
| 2013 | 244 | 85 | 85 | 63 |
| 2014 | 244 | 101 | 98 | 62 |

**FIGURE 18: ARRIVAL DRAFTS OF BULK CARRIERS AND CONTAINERSHIPS**




| | <30 | 31-35 | 36-40 | 41-45 |
|---|---|---|---|---|
| 2011 | 265 | 65 | 64 | 105 |
| 2012 | 248 | 80 | 76 | 128 |
| 2013 | 164 | 96 | 85 | 147 |
| 2014 | 178 | 88 | 92 | 153 |

**FIGURE 19: DEPARTURE DRAFTS OF BULK CARRIERS AND CONTAINERSHIPS**

## 2.5 Panama Canal Expansion

In June 2016, the Panama Canal Expansion was completed and opened a new set of locks with chambers of 1,400 feet long, 180 feet wide, and 60 feet deep, creating a third lane of traffic. The lock expansion provides the capacity to accommodate vessels up to 1,200 feet long, 161 feet wide and 50 feet deep. This amounts to containerships with cargo volumes up to 120,000 deadweight tonnage (DWT) and 13,000 TEU. The Panama Canal's Expansion paves the way for larger ships to be deployed to the U.S. Gulf Coast and East Coast from Asia, Oceana, and West Coast of South America. Previously, the Panama Canal was restricted to container traffic shipments to vessels drafting less than 39.5 feet. This essentially prevented any Asia/Gulf Coast/East Coast U.S. shipments from taking advantage of the economies of scale of loading larger ships to deeper sailing drafts.

In the first seven months of Fiscal Year (FY) 2017 (October 2017 – April 2017), over 1,000 vessels of the new Panamax dimensions transited the new locks. Tonnage through the Panama Canal increased by 22 percent in the first seven months of FY 2017 over FY 2016.

# 3 FUTURE CONDITIONS

## 3.1 Commodity Forecast

Estimates of Mobile Harbor's future commerce for the period of analysis are linked to the ports hinterland and the extent to which it shares commodity flows with other ports. An essential step when evaluating navigation improvements is to analyze the types and volumes of cargo moving through the port. Trends in cargo history can offer insights into a port's long-term trade forecasts and thus the estimated cargo volume upon which future vessel calls are based. Under future without and future with project conditions, the same volume of cargo is assumed to move through Mobile Harbor. However, a deepening project will allow shippers to load vessels more efficiently or take advantage of larger vessels. This efficiency translates to savings and is the main driver of NED. The ports share of the commodity projections remain the same as existing condition. Cargo projections ultimately drive vessel fleet projections in terms of the numbers and sizes of vessels for without- and with-project conditions.

The methodology to determine the forecast of import and export tonnage involved three steps. First, the baseline was established. The baseline is an average of historical data. Second, the rates of change for each commodity were established using sources such as U.S. Department of Energy, U. S. Department of Agriculture and an effort using IHS Global Insight (GI). Third, the rates of change were applied to the baseline to determine total import and export trade for Mobile Harbor.

It should also be noted that each trade route contains unique characteristics such as cargo volume, cargo weight, ports of call, vessel types, mix of vessels, etc. and therefore, are evaluated separately before being combined as part of the NED analysis. Two of the three trade routes will benefit from channel modification at Mobile Harbor. However, the non-benefitting routes were still carried forward in the evaluation as the number of future calls will contribute to harbor congestion and will influence other benefit categories.

### 3.1.1 Baseline

Empirical data and historical trends were established to serve as a baseline for the commodity forecast. To minimize the impact of potential variances in trade volumes on long-term forecast, four years of data were employed to establish the baseline for the commodity forecast. Empirical data from either 2011 to 2014 or 2012 to 2015 were used to develop a baseline, dependent on when the analysis was conducted and when data became available.

Using the data shown in Section 2.2.4, the averages of imports and exports were used to develop the baseline for the commodity forecast as shown in Table 4.

**TABLE 4: BASELINE TONNAGE (METRIC TONS)**

| Commodity | Baseline Period (years) | Import Baseline Tonnage | Export Baseline Tonnage |
|---|---|---|---|
| Containerized (total) | 2012-2015 | 522,000 | 1,104,800 |
| • Far East | 2012-2015 | 287,000 | 497,000 |
| • Caribbean/Gulf | 2012-2015 | 104,000 | 166,000 |
| • Transatlantic | 2012-2015 | 130,000 | 441,800 |
| Coal | 2011-2014 | 2,428,000 | 10,730,000 |
| Steel | 2011-2014 | 3,119,000 | 499,000 |
| Upper Harbor Terminals | 2011-2014 | 6,460,000 | 2,977,000 |
| Theodore Industrial Park | 2011-2014 | 413,000 | 630,000 |

### 3.1.2 Growth Rates

The long-term trade forecast for Mobile Harbor used forecast data from Department of Energy, Department of Agriculture, IHS Global Insight and regression. The forecast were developed by applying the rates of change from these sources for each commodity's baseline. This methodology is consistent with the approach used to perform long-term commodity forecast for other USACE deep-draft analyses.

In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. Data from 2006 to 2014 was used for regression analysis. The year and tonnage by import and export were used to determine rates of change. The source of cargo volumes is the WCSC.

#### 3.1.2.1.1 U.S. Department of Energy Forecast

Annual Energy Outlook (AEO) 2016 growth rates were used to forecast petroleum and petroleum products and coal at Mobile Harbor. The AEO uses the National Energy Modeling System, an integrated model that aims to capture various interaction of economic changes and energy supply, demand, and prices. The AEO provides multiple forecast cases based on different scenarios through 2050. This forecast used the "reference" case, which assumes trend improvement in known technologies, along with a view of economic and demographic trends reflecting the current central view of leading economic forecasters and demographers.

#### 3.1.2.1.2 U.S. Department of Agriculture Forecast

Growth rates from the USDA's Long-term Projections Report OCE-2016-1 were used to develop forecasts for food and farm products. The USDA uses specific assumptions about macroeconomic conditions, policy, weather, and international developments, with no domestic or external shocks to global agricultural markets to compile a forecast through 2025 by major commodity. The projections are one representative scenario for the agricultural sector for the next decade and reflect a composite of model results and judgment-based analyses. The reference case, used for this study, reflects relatively sluggish economic growth in developing countries, a strong dollar, and low oil prices in the near term, with stronger developing country growth, a somewhat weaker dollar, and rising oil prices in the long-term.[4] The USDA's Long-term Projections Report summarizes future food and farm trade as follows:

> *Steady world economic growth is projected over the next decade, despite a near-term slowdown in many developing countries. Projected global demand for agricultural products will rise, but at a slower rate than in the past decade. At the same time, world agricultural production is projected to increase more rapidly than world population, enabling a small increase in global per capita use of most agricultural products. Growth in world agricultural trade is projected to continue, albeit at a slower rate than in recent years. Together, these trends result in continued declines in the projected prices of agricultural commodities over the short term and the persistence of low prices throughout the projection period.*[5]

#### 3.1.2.1.3 IHS Global Insight Trade Forecast

Global Insight's trade forecast provided in 2016 informed the growth rates for containers. The model is based on the IHS World Trade Service (WTS) model. Conceptually, the WTS real value trade model uses a three-level process. Figure 20 provides a schematic of the WTS forecasting process. This multi-stage forecasting uses a combination of bottom-up and top-down approaches. Global Insight combines both approaches to increase forecast accuracy.

[4] https://www.ers.usda.gov/webdocs/publications/37809/56729_oce-2016-1.pdf?v=42508
[5] https://www.ers.usda.gov/webdocs/publications/37809/56729_oce-2016-1.pdf?v=42508

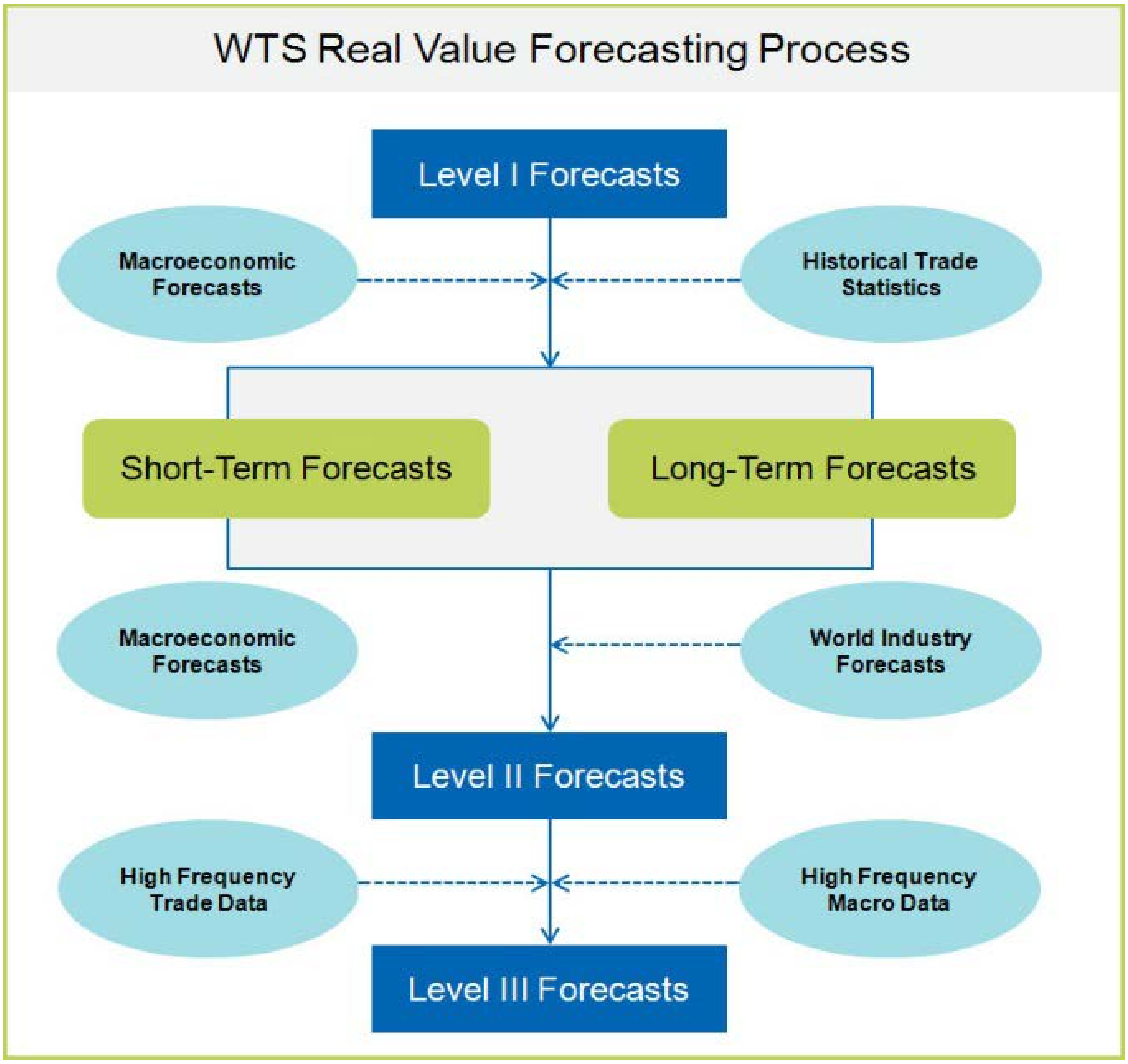



**FIGURE 20: WTS FORECASTING PROCESS**

Level I forecasts a country's imports of a commodity individually, without any exporter-level detail. The forecast at this stage is a bottom-up approach, which reflects heterogeneous behaviors of countries importing goods in each commodity group.

Level II forecasts a country's imports of a commodity from an exporting country under the assumption that the country's aggregated imports of the commodity from all the exporting countries is controlled by this country's imports of the commodity forecasted at Level I. The second stage forecast can be described as a top-down controlled approach and conforms to the WTS demand-driven approach to trade. The IHS World Industry Service (WIS) and IHS other sectoral forecasts are utilized at this level to address the competitiveness and supply capacity of an exporting country. The WIS provides both historical and forecasted industry data by Standard Industrial Classification category across 78 countries.

Level III forecasts and makes adjustments to individual commodity flows between importing and exporting countries given the most updated monthly and quarterly trade statistics collected from a variety of national and international sources, including the U.S. Census Bureau and Eurostat, to capture the most recent trade developments during the current year. At this stage, Global Insight also takes into account the most up-to-date high-frequency macro data. After the adjustments, the forecasting procedures produce final globally consistent commodity-level trade forecasts between 106 countries/regions for 201 commodity categories.

### 3.1.3 Commodity Grouping for Growth Rates

The following section outlines the growth rates by commodity for Mobile Harbor. The forecast applies these growth rates to the baseline tonnage presented in Table 4 to develop a final forecast by commodity, organized by import and export. Table 5 lists the major commodities in the study area and the data source used to forecast.

**TABLE 5: FORECAST SOURCES**

| Commodity Name | Forecast Source |
|---|---|
| Containers | IHS Global Insight |
| Coal | AEO |
| Manufactured Equipment, Machinery and Products | Regression |
| Grain | USDA |
| Crude Petroleum | AEO |
| Petroleum Products | AEO |
| Iron Ore and Scrap | Regression |
| Other Agricultural Products | USDA |
| Other Chemicals and Related Products | Regression |
| Primary Iron and Steel | Regression |
| Metal Products | Regression |
| Primary Wood Products; Veneer; Plywood | Regression |
| Slag | Regression |
| Sulphur (Dry), Clay & Salt | Regression |
| Processed grain and animal feed | USDA |
| Building Cement & Concrete; Lime; Glass | Regression |
| Grain | USDA |
| Fertilizers | Regression |
| Fish | USDA |
| Forest Products Wood and Chips | Regression |
| Non-Ferrous Ores and Scrap | Regression |
| Oilseeds (Soybean, Flaxseed and Others) | USDA |
| Other Non-Metal Minerals | Regression |
| Paper & Allied Products | Regression |
| Pulp and Waste Paper | Regression |
| Soil Sand | Regression |
| Vegetable Products | USDA |

*AEO=Annual Energy Outlook; GI=Global Insight; USDA=US Dept. of Agriculture

#### 3.1.3.1 *Import Growth Rates*

Table 6 provides the import rate of change used for the commodity as calculated from the DOE's AEO, USDA's Long-Term Projections Report and Global Insight's WTS. A compound average growth rate (CAGR) was applied for the Upper Harbor commodities, as shown in the last column of Table 6. The forecasts were held constant after 2035 due to uncertainty and the additional change in cargo having little effect on benefits because of the discounting of future values to present value.

## TABLE 6: LOWER HARBOR - IMPORT RATE OF CHANGE

| Commodity | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | CAGR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Containers – Far East** | 6% | 6% | 6% | 7% | 7% | 7% | 7% | 6% | 6% | 6% | 6% | 5% | 5% | 5% | 5% | 4% | 4% | 4% | 3% | 4% | NA |
| **Containers - Caribbean** | 3% | 3% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 4% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 2% | 3% | NA |
| **Container - Transatlantic** | 3% | 3% | 3% | 3% | 3% | 4% | 3% | 3% | 4% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | NA |
| **Coal** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | NA |

## UPPER HARBOR IMPORT CAGR

| | CAGR 2016 - 2035 |
|---|---|
| Manufactured | 5% |
| Grain | 0% |
| Crude Petroleum | 0% |
| Petroleum Products | 3% |
| Iron Ore and Scrap | 5% |
| Other Agricultural Products | -7% |
| Other Chemicals | 2% |
| Primary Iron and Steel | 6% |
| Metal Products | 0% |
| Primary Wood Products | 0% |
| Slag | 8% |
| Sulphur Clay and Salt | 7% |
| Lime Cement and Glass | 0% |
| Fertilizer | 8% |
| Forest Products Wood and Chips | -19% |
| Non-Ferrous Ores and Scrap | 2% |
| Oilseeds | 1% |
| Other Non-Metal Minerals | -4% |
| Paper Products | 4% |
| Pulp and Waste Paper | -5% |
| Soil Sand | -7% |
| Unknown NEC | 0% |
| Vegetable Products | 0% |

#### 3.1.3.2 *Export Growth Rates*

Table 7 provides the export rate of change used for each commodity as calculated from the DOE's AEO, USDA's Long-Term Projections Report and Global Insight's WTS. The CAGR was applied to Upper Harbor export commodities as shown in the last column of Table 7. The forecasts were held constant after 2035.

### TABLE 7: LOWER HARBOR EXPORT RATES OF CHANGE

| Commodity | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | CAGR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Containers – Far East** | 6% | 6% | 6% | 6% | 7% | 7% | 7% | 7% | 7% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | 6% | NA |
| **Containers - Caribbean** | 5% | 5% | 5% | 5% | 4% | 4% | 4% | 4% | 4% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | NA |
| **Container - Transatlantic** | 3% | 3% | 3% | 3% | 3% | 3% | 4% | 3% | 3% | 4% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | 3% | NA |
| **Coal** | -11% | -5% | 4% | 4% | 4% | 4% | -1% | -4% | 0% | 0% | 1% | 1% | 1% | 1% | 2% | 3% | 3% | 6% | 3% | 1% | NA |

### UPPER HARBOR EXPORT CAGR

| | CAGR 2016 - 2035 |
|---|---|
| Manufactured | 5% |
| Grain | 3% |
| Petroleum Products | 2% |
| Iron Ore and Scrap | 7% |
| Other Chemicals | 4% |
| Primary Iron and Steel | 3% |
| Metal Products | 4% |
| Primary Wood Products | -5% |
| Sulphur Clay and Salt | -4% |
| Lime Cement and Glass | 8% |
| Fertilizer | 9% |
| Fish | 8% |
| Forest Products Wood and Chips | 1% |
| Non-Ferrous Ores and Scrap | 2% |
| Oilseeds | 1% |
| Other Non-Metal Minerals | 7% |
| Paper Products | 4% |
| Pulp and Waste Paper | 2% |
| Soil Sand | 0% |
| Unknown NEC | 0% |
| Vegetable Products | 6% |

### 3.1.4 Forecasts

Using the baseline estimated commerce volumes, the growth rates determined in the preceding section were applied to forecast total import and export tonnage for Mobile Harbor over the study period. The forecast applied these growth rates at a disaggregated level before summarizing commodity totals by commodity group. For purposes of the analysis, forecast are held constant after year 2035, however facility capacity is not expected to be reached by this time. The following sections summarize the forecast by import and export.

#### 3.1.4.1 *Containerized Import Trade*

The respective world region import rates of change were applied to the baseline to estimate the Mobile Harbor long-term import forecast.

**TABLE 8: CONTAINER IMPORT TRADE FORECAST**

| Container Imports Trade Forecast (metric tons) | | | |
|---|---|---|---|
| | 2025 | 2030 | 2035 |
| Far East | 1,500,000 | 1,645,000 | 1,781,000 |
| Caribbean/Gulf | 145,000 | 170,000 | 194,000 |
| Transatlantic/Europe | 176,000 | 206,000 | 235,000 |
| Total | 1,821,000 | 2,021,000 | 2,210,000 |

**TABLE 9: TEU IMPORTS**

| Region | 2025 | 2030 | 2035 |
|---|---|---|---|
| Far East | 183,700 | 201,500 | 218,000 |
| Caribbean/Gulf | 26,300 | 30,900 | 35,300 |
| Transatlantic/Europe | 14,900 | 17,400 | 19,900 |
| Total | 224,900 | 249,800 | 273,200 |

**TABLE 10: TOTAL IMPORT TEUS**

| | 2025 | 2030 | 2035 |
|---|---|---|---|
| Import Loaded TEU | 224,900 | 249,800 | 273,200 |
| Import Empty TEU | 91,900 | 104,100 | 117,400 |
| Total Import TEU | 316,800 | 353,900 | 390,600 |

#### 3.1.4.2 *Coal Imports*

Thermal coal is imported through Mobile Harbor. Although, imported coal has declined, it is expected that some will be needed to accommodate a couple of power plants in the southeast. Import coal volumes through the Port of Mobile originates from coal mines in Columbia. These mines produce a high BTU grade, low ash and low sulphar thermal coal desired by the U.S. power generation market. Although a shift from coal is occurring for environmental and cost-effective reasons, coal will still be utilized in its fuel mix at plants that utilize new clean coal technologies. Therefore, coal imports were held constant at 2,428,000 metric tons.

#### 3.1.4.3 *Upper harbor Imports*

The Upper Harbor terminals import a variety of commodities. As previously mentioned, dock tonnages were combined based on type of commodity and associated vessel type. Table 11 displays the Upper Harbor docks forecasted tonnage.

**TABLE 11: UPPER HARBOR FORECASTED IMPORT TONNAGE**

| Commodity | 2025 | 2030 | 2035 |
|---|---|---|---|
| General and Dry Bulk Cargo | 6,806,000 | 8,266,300 | 10,355,300 |
| Chemicals | 262,300 | 290,000 | 320,000 |
| Petroleum | 6,112,000 | 6,107,000 | 6,104,000 |

#### 3.1.4.4 *Theodore Industrial Park Imports*

The Theodore Industrial Park handles multiple commodities as well. For reporting purposes the commodities were aggregated into two categories; general and dry bulk cargo and chemicals based on vessel types. Table 12 shows the forecasted commodity tonnage.

**TABLE 12: THEODORE INDUSTRIAL PARK FORECASTED IMPORT TONNAGE**

| Commodity | 2025 | 2030 | 2035 |
|---|---|---|---|
| Chemicals | 503,000 | 707,000 | 1,005,000 |
| General and Dry Bulk Cargo | 281,000 | 338,000 | 430,000 |

#### 3.1.4.5 *Containerized Export Trade*

The respective world region route export rates of change were applied to the baseline to estimate the Mobile Harbor long-term export forecast. For purposes of this analysis, the forecast is held constant after year 2035.

**TABLE 13: CONTAINER EXPORT TONNAGE**

| Container Exports (metric tons) | | | |
|---|---|---|---|
| | **2025** | **2030** | **2035** |
| Far East | 1,924,000 | 2,206,000 | 2,568,000 |
| Caribbean/Gulf | 237,000 | 277,000 | 320,000 |
| Transatlantic/Europe | 593,000 | 697,000 | 799,000 |
| **Total** | 2,754,000 | 3,180,000 | 3,687,000 |

**TABLE 14: LADEN TEU EXPORTS**

| Laden TEU Exports | | | |
|---|---|---|---|
| | **2025** | **2030** | **2035** |
| Far East | 167,100 | 191,600 | 223,100 |
| Caribbean/Gulf | 19,400 | 22,700 | 26,200 |
| Transatlantic/Europe | 48,000 | 56,400 | 64,700 |
| **Total** | 234,500 | 270,800 | 314,000 |

**TABLE 15: TOTAL EXPORT TEUS**

| | 2025 | 2030 | 2035 |
|---|---|---|---|
| Export Loaded TEU | 234,500 | 270,800 | 314,000 |
| Export Empty TEU | 52,600 | 56,200 | 60,200 |
| Total Export TEU | 287,100 | 327,000 | 374,200 |

#### 3.1.4.6 *Lower River Coal Exports*

Mobile exports metallurgical coal for the steel markets. Table 16 shows the forecasted tonnage for exported coal.

**TABLE 16: COAL EXPORT FORECAST**

| Commodity | 2025 | 2030 | 2035 |
|---|---|---|---|
| Coal | 9,971,300 | 10,642,900 | 12,469,000 |

#### 3.1.4.7 *Upper Harbor Exports*

The Upper Harbor an assortment of commodities as well. Table 17 displays the combined Upper Harbor docks and their associated forecast tonnage.

**TABLE 17: UPPER HARBOR EXPORT TONNAGE**

| Commodity | 2025 Import | 2030 Import | 2035 Import |
|---|---|---|---|
| General and Dry Bulk Cargo | 5,836,000 | 6,689,000 | 7,813,000 |
| Chemicals | 30,000 | 36,000 | 43,000 |
| Petroleum | 266,000 | 295,000 | 328,000 |

#### 3.1.4.8 *Theodore Industrial Park Exports*

The Theodore Industrial Park commodity export aggregated totals are shown in Table 18.

**TABLE 18: THEODORE INDUSTRIAL PARK EXPORT TONNAGE**

| Commodity | 2025 | 2030 | 2035 |
|---|---|---|---|
| Chemicals | 225,000 | 267,000 | 317,000 |
| General and Dry Bulk Cargo | 507,000 | 674,000 | 906,000 |

## 3.2 Vessel Fleet Forecast

### 3.2.1 Design Vessel

Generally, waterway improvements should be designed for optimization across the entire forecasted fleet. In this case, it would include service by several forms or types of vessels. Where vessel designs are relatively mature (tankers and dry bulk carriers), the task is straightforward. However, fully cellular containership designs are evolving. On a world fleet basis, containership designs continue to change with respect to size and cargo carrying capacity and have not reached a limiting threshold.

The design vessels are defined per USACE guidance from EM 1110-2-1613 stating:

"…*the design ship or ships are selected on the basis of economic studies of the types and sizes of the ship fleet expected to use the proposed navigation channel over the project life*…" The design ship is defined by EM 1110-2-1613 as "…*the largest ship of the major commodity movers expected to use the project improvements on a frequent and continuing basis*…"

Two design vessels were used for this study, a containership and a bulk carrier. Attachment 1 and 2 of the economic appendix describe how the design vessels were selected.  Table 19 displays the design vessels characteristics.

**TABLE 19:  DESIGN VESSEL CHARACTERISTICS**

| Vessel Type | DWT | Beam | LOA | Design Draft | TEU |
|---|---|---|---|---|---|
| Containership | 119,000 | 158 | 1,100 | 50.8 | 10,100 |
| Bulk Carrier | 120,000 | 141.2 | 851.5 | 51.6 | NA |

### 3.2.2 World Fleet

In addition to a commodity forecast, a forecast of the future fleet is required to evaluate channel modifications.  To develop projections of the future fleet calling Mobile Harbor, the study made use of world fleet forecasts of containerships developed by Maritime Strategies Inc (MSI) and world fleet information for bulk carriers from Sea-web data. Figure 21 shows the bulk carrier world fleet data.

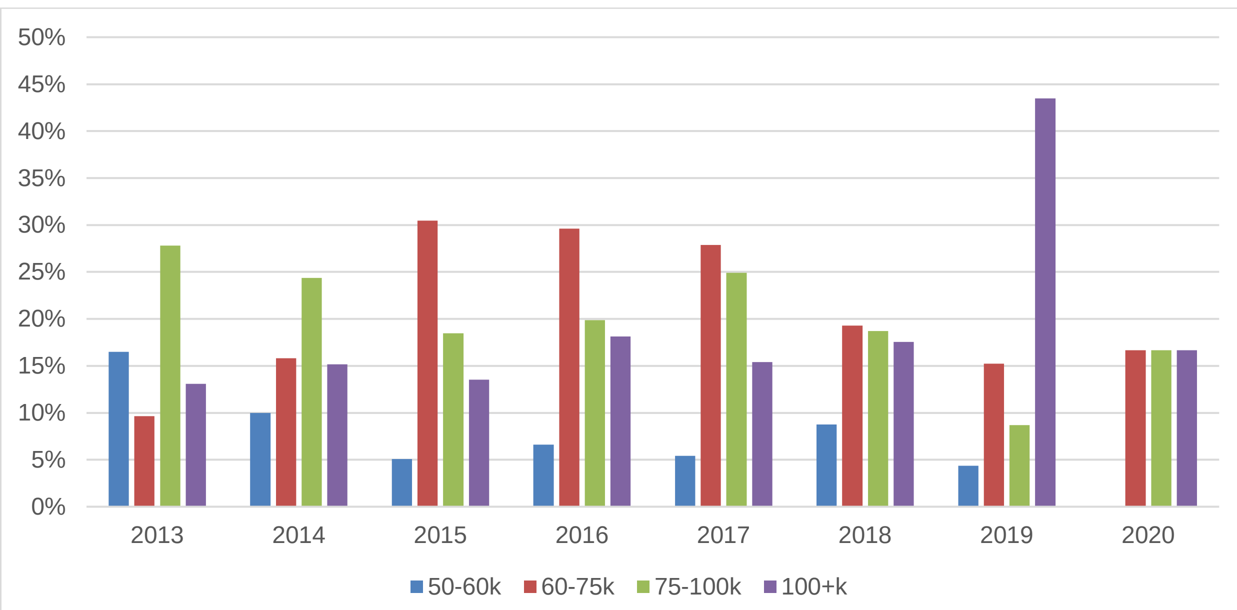



**FIGURE 21:  BULK CARRIER WORLD FLEET**

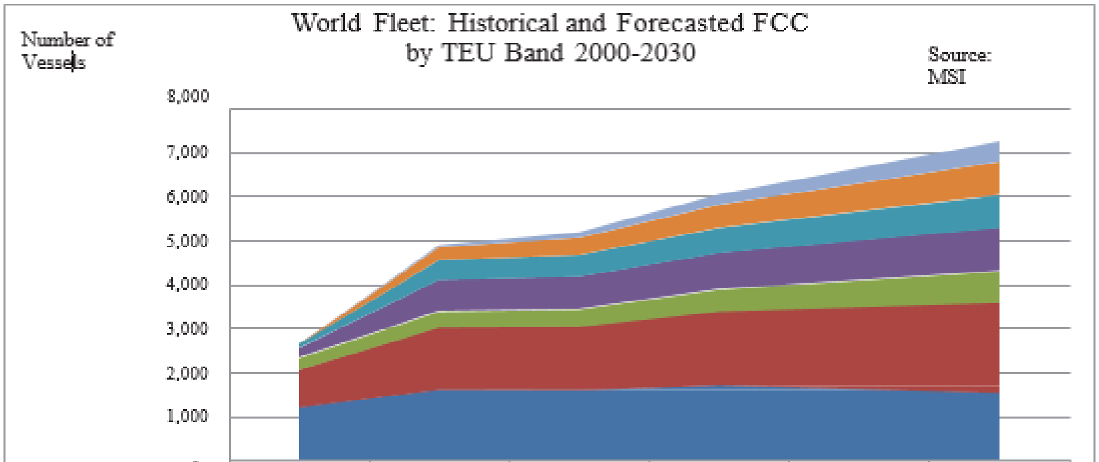
Maritime Strategies Inc forecasting technique begins with performing a detailed review of the current world fleet and how it is deployed on the trade routes of the world.  Forecasting of the world fleet was made possible through MSI's proprietary Container Shipping Planning Service (CSPS) model, which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

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

Data sources for the CSPS model include:

- Macroeconomics: Oxford Economics, leading investment banks
- World Trade: United Nations Conference of Trade and Development, Drewry Shipping Consultants, Containerization International
- Fleet Supply: LR-Fairplay, Worldyards, Howe Robinson
- Charter Rates, Freight Rates and Vessel Prices: Drewry Shipping Consultants, Howe Robinson, Clarksons, and various contacts at shipping lines

When evaluating data on vessel composition, vessel age, and container markets, MSI then considered the “order book” to estimate new deliveries to the fleet into the future. Vessel scrapping is accounted for based on historical scrapping rates by vessel class and age. Containerships, particularly the largest ones, are relatively new, so widespread scrapping is not expected to take place until well in the future. Likewise, when economies are strong, vessel owners are more likely to hold onto their existing vessels (or build new ones) and less likely to scrap them. Figure 22 provides an overview of the world containership fleet used in this study.




| | 2000 | 2011 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|
| 12 k TEU + | - | 47 | 124 | 232 | 348 | 458 |
| 7.6 k to 12 k TEU | - | 291 | 388 | 515 | 632 | 742 |
| 5.2 k to 7.6 k TEU | 104 | 456 | 498 | 577 | 654 | 747 |
| 3.9 k to 5.2 k TEU | 203 | 707 | 735 | 826 | 905 | 991 |
| 2.9 k to 3.9 k TEU | 272 | 364 | 393 | 497 | 600 | 708 |
| 1.3 k to 2.9 k TEU | 850 | 1,420 | 1,446 | 1,684 | 1,869 | 2,051 |
| 0.1 k to 1.3k TEU | 1,214 | 1,604 | 1,596 | 1,706 | 1,633 | 1,537 |

**FIGURE 22: WORLD FLEET 2000 - 2030**

### 3.2.3 Container Fleet Forecast for Mobile Harbor

The MSI forecast adapted for this study used the world fleet forecast to determine the expected fleet composition at Mobile Harbor over the study period. The forecast introduces a Post Panamax 3 (PPX3) containership vessel. Maritime Strategies Inc groups the Post Panamax Generation 2 (PPX2) and Post Panamax Generation 3 vessels into the same TEU band (7.6k to 12k). To determine the breakdown of this fleet, the study assumed a similar tonnage distribution across PPX2 and PPX3 anticipated for vessels that will call on other Gulf Coast ports as they are on the same services. The results of the fleet forecast are provided in Table 20.

**TABLE 20: FLEET FORECAST PERCENTAGES**

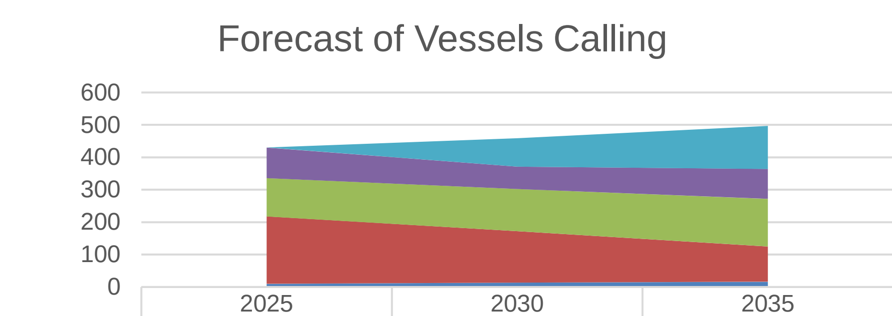
| Service and Vessel Class | % Tonnage on Service | | |
|---|---|---|---|
| | 2025 | 2030 | 2035 |
| Far East-North America-Panama Canal Sub-Panama (SPX) | 0% | 0% | 0% |
| Far East-North America-Panama Canal Panamax (PX) | 47% | 35% | 22% |
| Far East-North America-Panama Canal Post Panamax Generation 1 (PPX1) | 29% | 29% | 32% |
| Far East-North America-Panama Canal Post Panamax Generation 2 (PPX2) | 24% | 16% | 19% |
| Far East-North America-Panama Canal Post Panamax Generation 3 (PPX3) | 0% | 20% | 27% |
| Northern Europe-North America SPX | 1% | 1% | 1% |
| Northern Europe-North America PX | 57% | 36% | 27% |
| Northern Europe-North America PPX1 | 25% | 29% | 28% |

| | | | |
|---|---|---|---|
| Northern Europe-North America PPX2 | 18% | 15% | 18% |
| Northern Europe-North America PPX3 | 0% | 19% | 26% |
| Caribbean-Central America-North America SPX | 36% | 36% | 36% |
| Caribbean-Central America-North America PX | 64% | 64% | 64% |
| Caribbean-Central America-North America PPX1 | 0% | 0% | 0% |
| Caribbean-Central America-North America PPX2 | 0% | 0% | 0% |
| Caribbean-Central America-North America PPX3 | 0% | 0% | 0% |

For containerships, cargo is often loaded and unloaded simultaneously before calling at a string of other ports. As previously mentioned, the weight of cargo can vary greatly by trade route, whereas vessel operators can also carry large number of empty containers or sail with vacant slots.

A vessel loading analysis helps to capture valid relationships and parameters for estimating the disposition of cargo and non-cargo components of vessel loading which in turn helps to better estimate the amount of cargo on a ship at a given time. The basic methodology and logic of the load factor analysis (LFA) is based on long-established practices that have been historically applied to USACE economic evaluations of deep-draft waterway improvements. A better snapshot of the cargo aids in identifying requirements for vessel immersion and draft. Cargo components of an LFA include carried tonnages, containers that store the cargo and empty containers. Some of the non-cargo components that are considered in an LFA include allowances for ballast, bunkerage, vacant slots and any other load factor significant to reasonable estimate hull immersion and draft.

The number of calls for each class was calculated using the composition of capacity calling provided in Table 20. The initial forecast of containerized vessels through year 2035 is shown in Figure 23.




| | 2025 | 2030 | 2035 |
|---|---|---|---|
| PPXGn3 | | 88 | 133 |
| PPXGn2 | 94 | 69 | 92 |
| PPXGn1 | 118 | 130 | 147 |
| Panamax | 208 | 158 | 109 |
| SubPX | 10 | 14 | 16 |

**FIGURE 23: VESSEL FLEET FORECAST**

### 3.2.4 Bulk Fleet Forecast - Coal

In 2014, the largest vessel calling the Mobile Harbor coal terminal was the *New Delight* with a deadweight tonnage (DWT) of 181,279, 958 foot LOA, 148-foot beam and design draft of 60.3 feet. It was one of three vessels over 175,000 DWT that called that year. No vessel called between 120,000 and 175,000 DWT called that year and 15 vessels 100,000 to 120,000 DWT called.

Figure 24 shows the percent of vessel vessels that called from 2010 through 2015 by DWT range. The data shows an increasing trend in larger bulk carrier vessel sizes that call Mobile Harbor. The percentage of vessels used varied in the 60,000 to 80,000 DWT range and slightly increased over the time period in the 60,000 to 80,000 and 100,000 to 120,000 DWT range. The number of bulk carriers calling greater than 120,000 DWT size class distinctly decline.

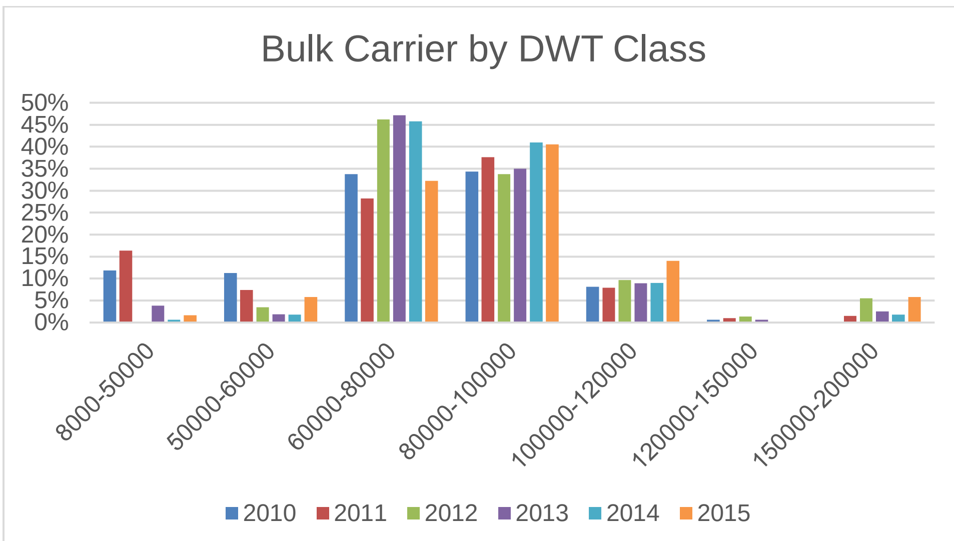
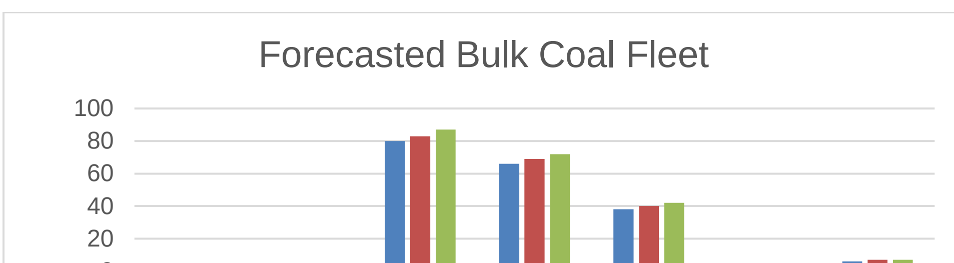



**FIGURE 24: MOBILE HARBOR BULK CARRIER BY DWT CLASS**

Figure 25 shows the bulk carrier forecasted fleet.

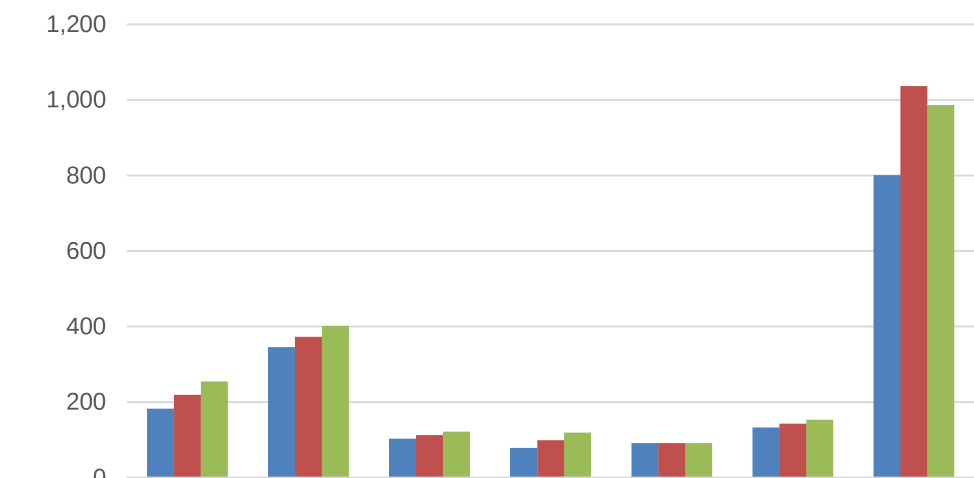



| | 8,000-50,000 | 50,000-60,000 | 60,000-80,000 | 80,000-100,000 | 100,000-120,000 | 120,000-150,000 | 150,000-200,000 |
|---|---|---|---|---|---|---|---|
| 2025 | 1 | 4 | 80 | 66 | 38 | 1 | 6 |
| 2030 | 0 | 3 | 83 | 69 | 40 | 1 | 7 |
| 2035 | 0 | 3 | 87 | 72 | 42 | 1 | 7 |

**FIGURE 25: MOBILE HARBOR FORECASTED BULK COAL FLEET**

The Upper Harbor and Theodore Industrial Park vessels fleet distributions remained relatively unchanged as existing condition. The vessel loading patterns were analyzed for each vessel type and class and the same parameters were applied to forecasted vessels.

Figure 26 shows the forecasted vessels for the Upper Harbor and Theodore Industrial Park terminals.




| | Bulk Carrier | General Cargo | Products Tanker | Chemical Tanker | Cruise | Ro-Ro | Total |
|---|---|---|---|---|---|---|---|
| 2025 | 183 | 345 | 103 | 78 | 91 | 133 | 801 |
| 2030 | 219 | 373 | 112 | 99 | 91 | 143 | 1,037 |
| 2035 | 255 | 401 | 122 | 119 | 91 | 153 | 987 |

2025 2030 2035

**FIGURE 26: MOBILE HARBOR FORECASTED VESSELS**

## 3.3 Alternatives for Economic Evaluation

Alternative plans were developed to address congestion, vessel delays and inefficient vessel loading issues throughout the channel. Alternatives are meant to be additive in that a combination of alternatives best meets the study's planning objectives; furthermore, a combination of plans further contributes to net economic development benefits. The following provides a summary of alternative plans evaluated by this study. The first set of alternatives were to address loading inefficiencies. Once deepening net benefits were determined, a widening component was added to address in harbor congestion.

Alternatives analyzed are channel depth from 47 feet to 55 feet and channel lengthening for two way vessel meetings for up to 15 miles in length. The deepening and widening alternatives were modeled in HarborSym by adding depth or changing the reach widths and modifying the passing/meeting rules that these measures could alleviate.

Analysis of existing conditions led to screening of alternatives that include the following:

- 53 feet and deeper was screened due to the design drafts and frequency of vessels that call Mobile Harbor
- 46 foot was eliminated due to a typical practice of minimum of two feet of deepening for a study
- The non-Federal sponsor (NFS) identified a constraint of deepening the channel greater than 50 feet; therefore, it is not required to analyze project plans greater than the plan desired by the NFS
- Channel widening lengths greater than three miles not economically feasible

An analysis of the remaining initial deepening and widening alternatives was conducted using rough order magnitude costs and benefits that the Project Delivery Team (PDT) considered an appropriate level of detail. As this analysis progressed, the results helped shape the focused array of alternatives that would utilize more refined cost and economic data. It was found that each of the deepening alternatives had positive net benefits. Once the depth was determined, a channel widening component was added to reduce in harbor delays. It was found that widening five miles of the channel with an additional width of 100 feet had negative net benefits. Based on this result widening lengths greater than five miles and widths greater than 100 feet would likely not be economically feasible for the depths being considered and therefore were dropped from consideration. Review of the 5-mile widening results and previously conducted ship simulation suggested that 100 feet of widening with a 3-mile length might be acceptable and economically feasible. With the above considerations, the focused array of alternatives considered is shown in Table 21.

**TABLE 21: FOCUSED ARRAY OF ALTERNATIVES**

| Measure | Alternatives | | | |
|---|---|---|---|---|
| Deepening | 47 | 48 | 49 | 50 |
| Widening | Additional 100 feet of width for 3 miles for each depth alternative | | | |
| | Additional 100 feet of width for 5 miles for each depth alternative | | | |

# 4 Transportation Cost Savings Benefits Analysis

The purpose of this analysis is to describe the benefits associated with the deepening and widening at Mobile Harbor. NED benefits were estimated by calculating the reduction in transportation cost for each project depth using the HarborSym Modeling Suite of Tools (HMST) developed by the Institute of Water Resources (IWR). The HMST reflects USACE guidance on transportation cost savings analysis. Separate models runs were completed for the origin-to-destination (OD) deepening benefits and the widening benefits.

Within this section, the HMST are described in detail, including the deepening and widening aspects and the application to Mobile Harbor. The resulting benefits are described both separately and combined.

## 4.1 Methodology

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

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

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

### 4.1.1 HarborSym Model Overview

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

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

### 4.1.2 Model Behavior

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

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

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

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

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

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

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

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

ETTC = 2*Cargo on Board at Arrival – Import tons + Export tons

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

At-Sea Cost Allocation Fraction = (Import tons + Export tons)/ETTC

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

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

Where:

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

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

### 4.1.3 HarborSym Data Inputs

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

**Simulation Parameters**. Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay.  The base year for the model was 2025.  A model run was performed for the following years for deepening: 2025, 2030 and 2035.  And model runs were completed for 2025 and 2035 for widening.

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

**General Information**.  General information used as inputs to the model include: specific vessel and commodity classes, route groups, specifications of turning area usage at each dock, and specifications of anchorage use within the harbor Route groups were developed by evaluating the trade routes calling on Mobile Harbor.  Those route distances were separated into trade lanes based on their world region and itinerary. The route group distance included in the analysis for each trade lane is calculated from the average distance for each trade route that was identified for the specific trade lane, as shown in Table 22.  This data was taken from container services calling Mobile Harbor as of 2016.  Distances were calculated using Sea-distances.com and values are in nautical miles.

**TABLE 22: ROUTE GROUP DISTANCES**

| Route Type | Region | Total Sea Distance | | |
|---|---|---|---|---|
| | | Total Distance Min | Total Distance Most Likely | Total Distance Max |
| Bulk Cargo | Europe-Bulk | 8,780 | 10,260 | 14,850 |
| | Africa | 15,200 | 16,000 | 16,800 |
| | Far East | 17,790 | 19,900 | 19,900 |
| | South America-Coal Exports | 6,610 | 9,700 | 12,600 |
| | South America- Coal Imports | 2,600 | 3,000 | 3,930 |
| | Mediterranean | 11,460 | 12,630 | 13,400 |
| Containerized Cargo | Far East-USGC | 22,690 | 23,990 | 24,590 |
| | Container CGX/ZIM | 4,250 | 4,650 | 5,050 |
| | Europe-USGC | 11,400 | 12,550 | 13,700 |

Bulk commodities other than coal that benefit from widening were assigned a default route group since no origin to destination benefit was calculated.  The default route group can be assigned when benefits are attributed to in harbor modifications.

**Vessel Operations**.  Hourly operating costs while in-port and at-sea were determined for all vessels.  The data also includes inputs for at-sea speed by vessel class.  The values are entered as a triangular distribution in HarborSym, but are displayed below as the average most likely speed at sea.  The minimum and maximum vessel operating cost used is 10 percent minus or plus the most likely.  The minimum and maximum for speed is a five percent variation around the most likely. Only the containership and bulk carriers that transport coal are shown in the table as they are the OD benefitting vessels.

**TABLE 23: SPEEDS AT SEA**

| Vessel Type | Average Most Likely Speed at Sea |
|---|---|
| Containership | 20.38 |
| Bulk Carrier | 12.6 |

**Reach Transit Rules**. Vessel transit rules reflect restrictions on meeting, daylight restrictions, vessel size limitations, UKC requirements and other pilot guidelines are used to simulate actual conditions in the channel. Alleviating pilot guidelines associated with meeting restriction and daylight transit rules was evaluated by this study. Table 24 summarizes the current guidelines in the Bay Channel. The Harbor Pilots follow additional guidelines, but they are not expected to change with any channel modification.

**TABLE 24: HARBOR PILOTS GUIDELINES**

| 2018 Guidelines and Practices |
|---|
| The channel shall be limited to one-way traffic when a vessel whose beam exceeds 115' is transiting the ship channel |
| Maximum combined draft of two meeting vessels shall not exceed 85 feet |
| Any two vessels with a combined LOA of 1,650' or greater will not be allowed to meet in the channel if the combined draft is greater than 75' |
| The maximum combined length of any two vessels that will be allowed to meet in the channel is 1,775 regardless of draft |

In 2017, Ship Simulation for a channel 500 feet wide was conducted at ERDC. Based on the simulation, the following changes can be made for the guidelines for a 500-foot width channel. For purposes of modeling in HarborSym, some guidelines are expressed as a percentage. Table 25 displays the current guidelines and the anticipated changes allowed with a wider channel.

**TABLE 25: HARBOR PILOT PROPOSED GUIDELINE CHANGES**

| Existing 400' Width Guidelines | Estimated 500' Width Guidelines |
|---|---|
| Combined beam width cannot exceed 56.5% of the channel | Combined beam width cannot exceed 51.2% of the channel. |
| Combined LOA cannot exceed 1,775' | Combined beam width cannot exceed 2,165' |
| Combined draft cannot exceed 85' | Combined draft cannot exceed 94' |
| Two vessels with combined LOA of 1,650' if combined draft is 75' | Two vessels with combined LOA of 2,063 if combined draft is 83 |

**Vessels Calls**. The vessel call lists are made up of forecasted vessel calls for a given year as generated by the CLT (see Section 4.1.4) and BLT (see Section 4.1.5). Each vessel call list contains the following information: arrival date, arrival time, vessel name, entry point, exit point, arrival draft, import/export, dock name, dock order, commodity, units, origin/destination, vessel type, Lloyds Registry, net registered tons, gross registered tons, dead weight tons, capacity, length overall, beam, draft, flag, tons per inch immersion factor, ETTC, and the route group for which it belongs.

### 4.1.4 Containerized Vessel Call List

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

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

#### 4.1.4.1 *CLT Loading Algorithm*

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

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

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

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

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

- Vessel operating cost per 1000 miles is calculated as 1000 miles divided by the applied speed times the hourly at sea cost = 1000 miles / (Applied Speed X Hourly Cost)
- The allocation of vessel space to vacant slots, empty and loaded containers is calculated by adding the cargo weight per box plus the box weight plus an allowance for the empty
- Total weight per loaded container = Average Lading Weight per Loaded TEU by Route (tonnes) + Average Container (Box only) Weight per TEU (tonnes) + (Average Container (Box only) Weight per TEU (tonnes)*(Percent Empty TEUs))
- Shares of vessel capacity are then calculated as:
- Cargo Share = Average Lading Weight per Loaded TEU by Route (tonnes)
- Total weight per loaded container in tonnes
- Laden Container Share = Average Container (Box only) Weight per TEU (tonnes)
- Total weight per loaded container in tonnes
- Empty Container Share = ((Average Container (Box only) Weight per TEU (tonnes))*(Percent Empty TEUs)) Total weight per loaded container in tonnes
- Volume capacity limits are calculated as follows:
- Number of vacant slots = Nominal TEU Rating * Percent vacant slots
- Max Occupied Slots = Nominal TEU Rating - Number of vacant slots
- Max Laden TEUs = Occupied Slots/(1+Percent Empties)
- Max Empty TEUs = Occupied Slots - Laden TEUs
- Maximum Volume Restricted Tonnage is then calculated as:
- Max weight for cargo (tonnes) = Max Laden TEUs * Average Lading Weight per Loaded TEU by Route (tonnes)
- Max weight for laden boxes (tonnes) = Max Laden TEUs * Average Container (Box only) Weight per TEU (tonnes)
- Max weight for empties(tonnes) = Max Empty TEUs * Average Container (Box only) Weight per TEU (tonnes)
- Total volume restricted tonnage (cubed out tonnage)(tonnes) = Max weight for cargo + Max weight for laden boxes + Max weight for empties

The LFA proceeds as follows:

- The initial draft is varied from the vessels maximum (loaded) to minimum (empty).

- At each sailing draft the total tonnage that can be carried is calculated using the Tons Per Inch Immersion (TPI) rating for the vessel.
- DWT Available for Vessel Draft = DWT Rating (tonnes) – [(Aggregate Maximum Summer Load Line Draft – Sailing Draft)*12 inches*TPI]
- This capacity is then allocated, first to ballast and operations to yield capacity available for cargo.
- Approximate Variable Ballast = DWT Available for Vessel Draft * Percent Assumption for Variable Ballast
- Allowance for Operations in tonnes = DWT Rating (tonnes) * Percent Allowance for Operations
- Available for Cargo = (DWT Available for Vessel Draft) - (Approximate Variable Ballast) - (Allowance for Operations)
- The capacity available for cargo is restricted if the vessel has “cubed” or “volumed” out:
- Available for Cargo adjusted for volume restriction if any (tonnes) = the lesser of Available for Cargo and Total volume restricted tonnage (cubed out tonnage)
- The tonnage available for cargo is then allocated to cargo, laden and empty containers based on the shares of vessel capacity:
- Distribution of Space Available for Cargo (tonnes) = Available for Cargo adjusted for volume restriction if any in tonnes * Cargo Share in percent
- Distribution of Space Available for Laden TEUs (tones) = Available for Cargo adjusted for volume restriction if any in tonnes * Laden Container Share in percent
- Distribution of Space Available for Empty TEUs (tonnes) = Available for Cargo adjusted for volume restriction if any * Empty Container Share
- The number of TEUs is then estimated for each share use:
- Number of Laden TEUs = Distribution of Space Available for Cargo/Average Lading Weight per Loaded TEU by Route (tonnes)
- Number Empty TEUs = Distribution of Space Available for Empty TEUs /Average Container (Box only) Weight per TEU (tonnes)
- Occupied TEU Slots on Vessel = Number of Laden TEUs + Number Empty TEUs
- Vacant Slots = Nominal TEU Rating − Occupied TEU Slots
- The CLT then calculates the ETTC (estimate of total trip cargo) for each vessel call as the cargo on board the vessel at arrival plus the cargo on board the vessel at departure, in tons.

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

#### 4.1.4.2 *CLT Data for Mobile Harbor*

There are a number of data required by the CLT. The commodity forecast can be found in Section 3.1 and the vessel fleet can be found in Section 3.2. Vessel sailing draft distributions are critical for determining the benefits due to channel depth and underkeel requirements, as well as determining how much cargo a vessel can carry and thus how many trips are required to satisfy a commodity forecast.

Figure 27 through Figure 31 provide the arrival draft cumulative distribution functions (CDF) for containerized vessels by channel depth. The CDFs were developed by evaluating the arrival drafts of the vessels by container class calling on the harbor from 2011 to 2015 using arrival draft data. Each call was separated into a container vessel class depending on the vessel characteristics of each call. A probability curve for the arrival draft of the vessels for future project conditions was developed using this information. The arrival draft curves were developed with the assistance of the IWR. The assumption was made that for each additional foot of channel depth available to carriers the average Post-Panamax container vessel would use approximately 0.6 to 0.8 feet of that depth. Therefore, for the analysis, it was assumed that each Post-Panamax container vessel would sail with an additional 0.7 feet for each one-foot increment of channel depth evaluated. The restriction placed on this assumption is that once a vessel class reaches its design draft on the curve the class no longer shifts regardless of the channel depth.

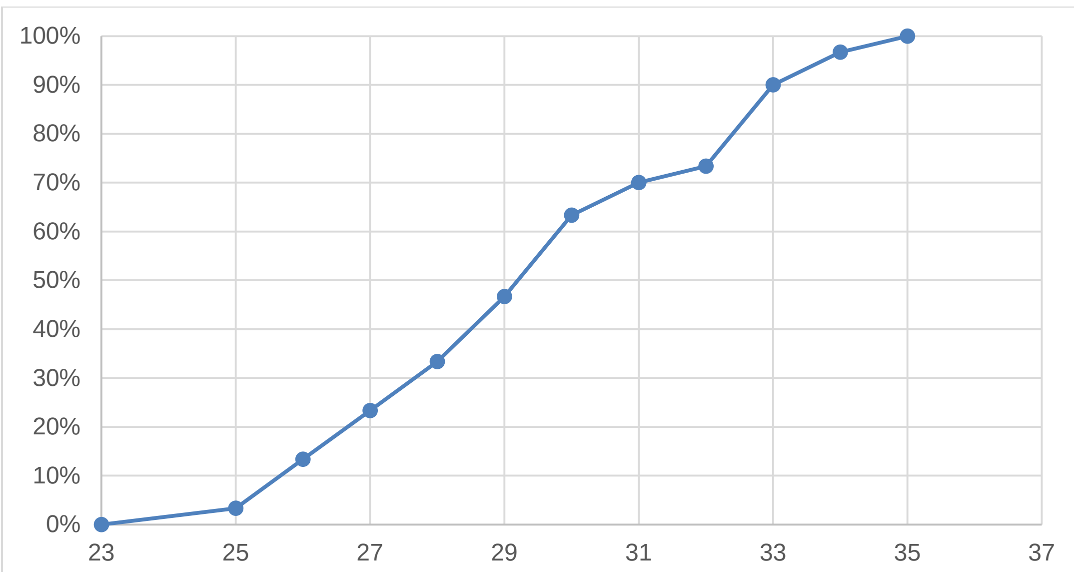



**FIGURE 27: SUBPANAMAX ARRIVAL DRAFT BY CHANNEL DEPTH**

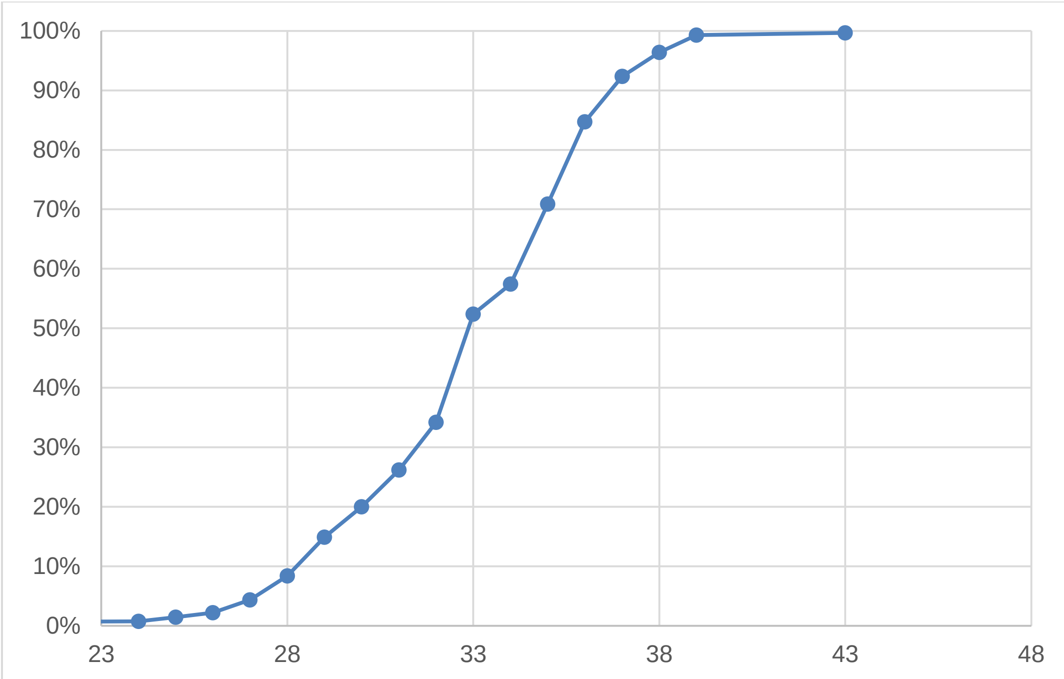



**FIGURE 28: PANAMAX ARRIVAL DRAFT BY CHANNEL DEPTH**

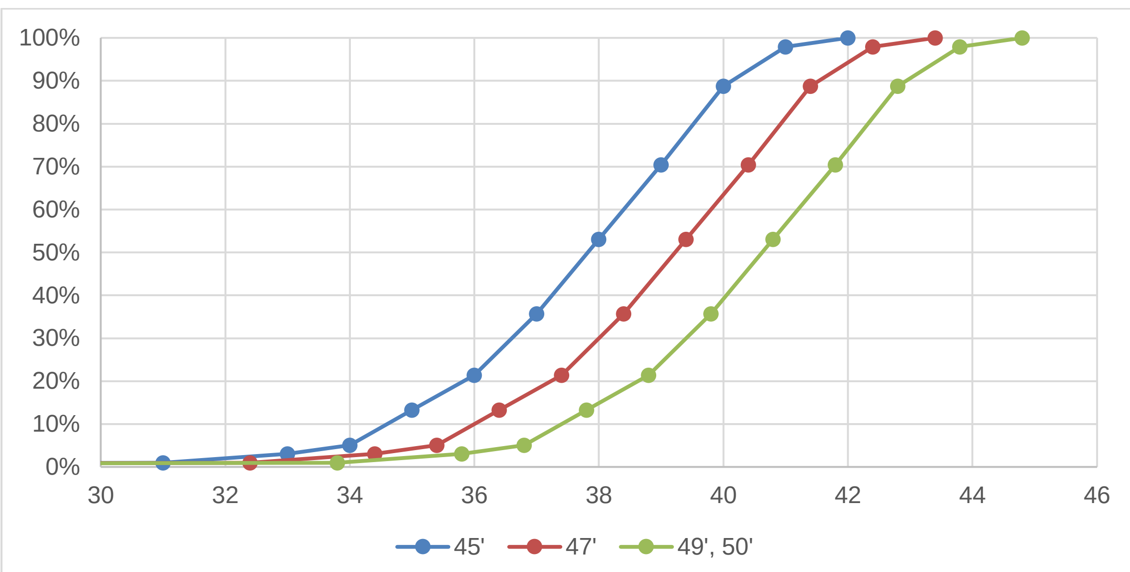



**FIGURE 29: POST PANAMAX GENERATION 1 ARRIVAL DRAFT BY CHANNEL DEPTH**

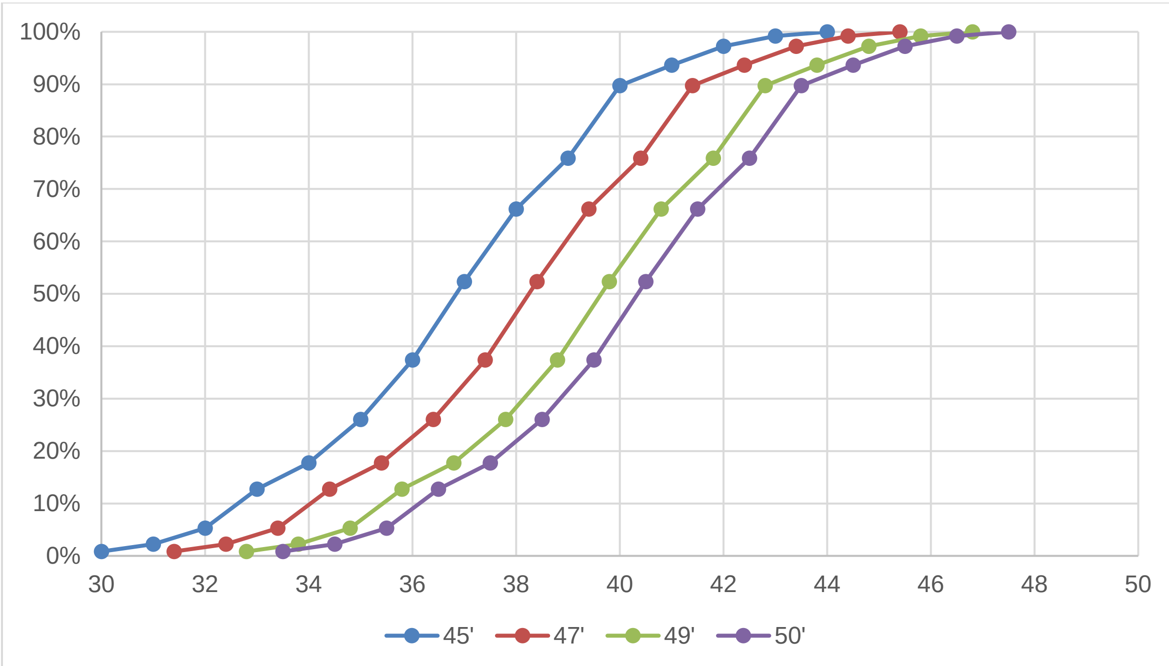



**FIGURE 30: POST PANAMAX GENERATION 2 ARRIVAL DRAFT BY CHANNEL DEPTH**

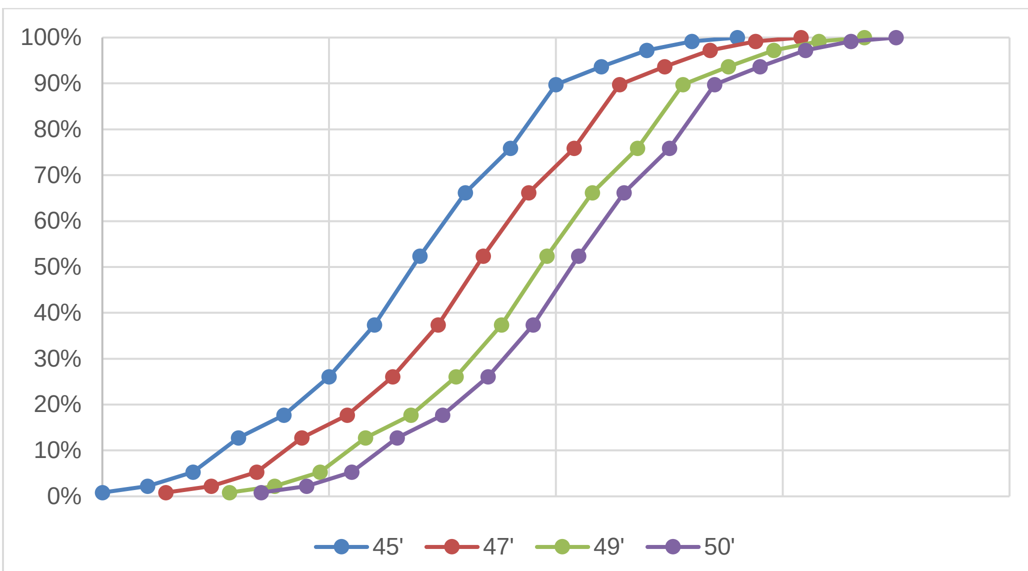



**FIGURE 31: POST PANAMAX SAILING DRAFT GENERATION 3**

Table 26 provides the vessel class assumptions used in the LFA, such as average lading weight per TEU, container weight, vacant slot allotment, variable ballast, import/export fraction (cargo share), etc. These inputs were developed using historical data provided by the Port and with the assistance of IWR (Lading Weight per Loaded TEU, Empty TEU and Vacant Slot allotment, Operations Allowance, and Variable Ballast by trade lane). The operations allowance represents tonnage used for bunkerage (fuel) and ships stores. The import/export fractions, which is the fraction of imported/exported tons to ship capacity, were calculated by evaluating the tonnage (both imports and exports) handled at Mobile Harbor for each individual call and the estimated total tonnage on each vessel, taking into account the vessel characteristics (LOA, beam, design draft, design hull, etc.) and sailing draft when calling on the harbor, by vessel class.

**TABLE 26: CLT INPUTS AND ASSUMPTIONS**

| Service | Vessel Class | Avg. lading weight per TEU | Avg. Tare Weight per TEU | Empty TEU allotment | Vacant Slot Allotment | Operations Allowance (% DWT) | Variable Ballast | Import Fraction | Export Fraction |
|---|---|---|---|---|---|---|---|---|---|
| Caribbean/Gulf | SubPX | 8.75 | 2.2 | 48 | 7.65 | 6.7 | 11 | 0.18 | 0.28 |
| Caribbean/Gulf | Panamax | 8.75 | 2.2 | 48 | 7.65 | 6.7 | 11 | 0.18 | 0.44 |
| Far East | Panamax | 9.9 | 2.2 | 27 | 7.65 | 6.7 | 11 | 0.13 | 0.21 |
| Far East | PPXGn1 | 9.9 | 2.2 | 27 | 7.65 | 6.7 | 11 | 0.13 | 0.21 |
| Far East | PPX2 | 9.9 | 2.2 | 27 | 7.65 | 6.7 | 11 | 0.13 | 0.21 |
| Far East | PPX3 | 9.9 | 2.2 | 27 | 7.65 | 6.7 | 11 | 0.13 | 0.21 |
| Transatlantic | Panamax | 12.4 | 2.2 | 15 | 7.65 | 6.7 | 11 | 0.13 | 0.15 |
| Transatlantic | PPX1 | 12.4 | 2.2 | 15 | 7.65 | 6.7 | 11 | 0.09 | 0.17 |
| Transatlantic | PPX2 | 12.4 | 2.2 | 15 | 7.65 | 6.7 | 11 | 0.05 | 0.15 |
| Transatlantic | PPX3 | 12.4 | 2.2 | 15 | 7.65 | 6.7 | 11 | 0.05 | 0.15 |

Table 27 provides details on the vessel subclasses that is used by the CLT to create vessels to satisfy the commodity forecast. The user provides the linkage between the HarborSym vessel class and the IWR-defined vessel subclass.

**TABLE 27: VESSEL SUBCLASS DETAILS**

| Vessel Class ID | LOA | LBP | Beam | Max SLLD | Capacity | TEU Rating | TPI Factor | Baseline Underkeel Clearance | Sinkage Adjustmen t | % of Class |
|---|---|---|---|---|---|---|---|---|---|---|
| SubPX | 676 | 636 | 99 | 37.6 | 33,887 | 2,470 | 117.7 | 2.7 | 1 | 100% |
| Panamax | 907 | 859 | 106 | 42.5 | 56,792 | 4,125 | 176.7 | 2.8 | 1.1 | 50% |
| Panamax | 959 | 921 | 106 | 44.4 | 64,956 | 4,729 | 192.7 | 2.8 | 1.2 | 50% |
| PPX1 | 989 | 942 | 132 | 46.2 | 86,060 | 6,549 | 233.1 | 2.0 | 1.2 | 50% |
| PPX1 | 992 | 944 | 132 | 46.2 | 102,179 | 6,600 | 233.7 | 2.0 | 1.2 | 50% |
| PPX2 | 1,099 | 1,053 | 143 | 47.6 | 105,458 | 8,528 | 289.2 | 2.0 | 1.3 | 100% |
| PPX3 | 1,100 | 1,050 | 158 | 50.8 | 117,000 | 10,500 | 315 | 2.0 | 1.3 | 100% |

#### 4.1.4.3 *Containerized Vessel Calls*

Vessel calls by vessel class are shown in Table 28. These are a result of the CLT loading algorithm, the containerized trade forecast for Mobile Harbor, the available vessel fleet by service and the LFA data inputs.

**TABLE 28: CONTAINERSHIP CALLS BY VESSEL CLASS**

| Year | Vessel Class | FWOP | 47 | 49 | 50 |
|---|---|---|---|---|---|
| 2025 | SPX | 10 | 10 | 10 | 9 |
| | PX | 230 | 217 | 208 | 194 |
| | PPX1 | 118 | 118 | 118 | 118 |
| | PPX2 | 94 | 94 | 94 | 94 |
| | PPX3 | 0 | 0 | 0 | 0 |
| | | | | | |
| 2030 | SPX | 14 | 14 | 14 | 12 |
| | PX | 185 | 167 | 143 | 128 |
| | PPX1 | 131 | 131 | 131 | 131 |
| | PPX2 | 69 | 69 | 69 | 69 |
| | PPX3 | 88 | 88 | 88 | 88 |
| | | | | | |
| 2035 | SPX | 16 | 16 | 16 | 14 |
| | PX | 133 | 104 | 91 | 58 |
| | PPX1 | 147 | 146 | 144 | 144 |
| | PPX2 | 92 | 92 | 92 | 92 |
| | PPX3 | 132 | 132 | 132 | 132 |

### 4.1.5 Non-containerized Vessel Call List

The future fleet of non-containerized vessels was determined by how much more cargo a vessel can accommodate for each additional foot of deepening. This was completed by determining the immersion factor by vessel class and using the equation below to calculate the additional tonnage a vessel could load per foot.

(Immersion Factor) x (# of Inches of Cargo Space)

Table 29 shows the vessel class and associated immersion rate used. However, the first three vessel classes did not change loading patterns as the design drafts are typically at existing channel depth.

**TABLE 29: IMMERSION RATES BY VESSEL CLASS**

| Vessel Class by DWT | Immersion Rate |
|---|---|
| Bulk Carrier 1 12,500 to 50,000 | 116 |
| Bulk Carrier 2 50,001 to 60,000 | 145 |
| Bulk Carrier 3 60,001 to 80,000 | 165 |
| Bulk Carrier 4 80,001 to 100,000 | 201 |
| Bulk Carrier 5 100,001 to 120,000 | 238 |
| Bulk Carrier 6 120,001 to 150,000 | 262 |
| Bulk Carrier 7 150,001 to 200,000 | 289 |

The non-containerized vessel call list for future years was developed using the BLT, a tool within the HMST. Users must provide data to specify the framework for generating the synthetic vessel call list. The BLT relies on much of the information and data from

HarborSym, but has data additional specific requirements. Within the BLT, the input requirements include:

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

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

#### 4.1.5.1 *BLT Loading Algorithm*

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

1. Generation of a fleet of specific vessels based upon a known number of vessel calls by class and a statistical description of the characteristics of the vessel class. This process begins by generating one specific vessel for each call in the class. The capacity of the vessel is set by a random draw from the cumulative density function that is stored for the class. Based on the regression coefficients that are stored for the class, each of which is of the form:

    • Log (parameter) = a + b*log (Capacity)

    • LOA, Beam and Design Draft are determined for the vessel using a linear regression of the form: o TPI = a + b*Beam + c*Design Draft + d*Capacity + e*LOA

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

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

The amount of the commodity forecast that is actually carried on the vessel is used to decrement the remaining quantity to be allocated for that particular commodity forecast. After a single vessel call is assigned to a particular forecast, the total number of remaining available vessels for the class is decremented and the next commodity forecast in turn is processed. That is, each forecast attempts to have a portion of its demand satisfied by a single vessel call and then the next forecast is processed. This is to prevent all of the most efficient vessels from being assigned to a single commodity forecast.

This process proceeds, in a loop, continually attempting to assign commodity to a vessel from the remaining available fleet. Whenever a successful assignment is made, this generates a vessel call, dock visit, and the associated commodity transfer. This effort continues until no more assignments to a vessel call can be made, either because all commodity forecasts have been satisfied or there is no available vessel that can service the remaining quantities (because there is no vessel of the required class that can handle the particular commodity/dock combination of the forecast or because no vessel can be loaded to satisfy the dock controlling depth constraint).

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

4. The generated vessel calls are written to a HarborSym vessel call database and the user is presented with output information on which commodity forecasts were satisfied, any remaining unsatisfied forecasts and detailed information on each vessel loading and the vessels that were used to satisfy each commodity forecast.

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

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

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

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

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

The quantity of a vessel's capacity that is to be loaded for satisfaction of the import and export demands is described, again at the Vessel Class/Commodity Category level, by a triangular distribution that specifies a loading factor. A minimum, most likely, and maximum, in percent of total available capacity, is defined for both export and import. When a vessel is available for satisfying a demand, first the type of satisfaction (import only, export only, random or both) is determined, as noted above. If "random" is associated with the current class/commodity, then a random draw is made from a uniform distribution and compared with the user-specified import ratio, to determine if the call is import only or export only. For example, if the user has entered a value of 70 percent for imports, indicating that 30 percent of the calls are exports, then a random draw is made from a uniform (0.1) distribution. If the random number is less than or equal to 0.7, then the call is assigned as an import, otherwise it is assigned as export.

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

The tonnage associated with allowance for operations is based on IWR-developed data given fractional allowance for operations as a function of vessel tonnage. The additional draft implied by the tentative quantity to be loaded is calculated based on the vessel TPI. A value of empty vessel draft for each vessel has previously been calculated, based on an assumption that the vessel DWT is associated with the vessel design draft. The empty vessel draft from which loading can start is then calculated as: Empty Vessel Draft = Design Draft – (DWT/TPI)/12.0.

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

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

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

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

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

#### 4.1.5.2 *BLT Data Inputs*

Using the immersion rate by vessel class and alternative channel depths, the amount of cargo a vessel can load was determined. The bulk fleet loading changes used historical call information from 2011 to 2014 such as the minimum, most likely (ML) and maximum loading by vessel class to determine loading changes. Table 30 shows the percent loading by alternative used in the BLT.

**TABLE 30: LOADING PERCENTAGE BY VESSEL CLASS AND ALTERNATIVE**

| | Without Project | | | 47' Channel Depth | | | 49' Channel Depth | | | 50' Channel Depth | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIN | ML | MAX | MIN | ML | MAX | MIN | ML | MAX | MIN | ML | MAX |
| BC1 | 85% | 90% | 100% | 85% | 90% | 100% | 85% | 90% | 100% | 85% | 90% | 100% |
| BC2 | 67% | 91% | 100% | 67% | 91% | 100% | 67% | 91% | 100% | 67% | 91% | 100% |
| BC3 | 33% | 88% | 100% | 33% | 88% | 100% | 33% | 88% | 100% | 33% | 88% | 100% |
| BC4 | 28% | 86% | 99% | 28% | 92% | 100% | 28% | 94% | 100% | 28% | 94% | 100% |
| BC5 | 54% | 81% | 98% | 54% | 85% | 98% | 54% | 89% | 99% | 54% | 92% | 99% |
| BC6 | 48% | 48% | 48% | 48% | 51% | 53% | 48% | 53% | 58% | 48% | 56% | 65% |
| BC7 | 55% | 61% | 69% | 55% | 64% | 73% | 55% | 66% | 77% | 55% | 67% | 79% |

The minimum value of loading did not change because it was assumed vessels could always load to that minimum value since doing so currently. Table 31 summarizes bulk carrier calls (coal only) for FWOP and the deepening alternatives. The study uses the total reductions in the vessel calls to calculate benefits to measure that increase loading efficiency. The vessel classes in Table 31 were developed based on vessel operating cost tables and classified by deadweight ton capacity.

**TABLE 31: BULK CARRIER CALLS**

| Year | Vessel Class | FWOP | 47 | 49 | 50 |
|---|---|---|---|---|---|
| 2025 | Bulk Carrier1 | 0 | 0 | 0 | 0 |
| | Bulk Carrier2 | 0 | 0 | 0 | 0 |
| | Bulk Carrier3 | 40 | 34 | 32 | 30 |
| | Bulk Carrier4 | 60 | 60 | 60 | 60 |
| | Bulk Carrier5 | 40 | 40 | 40 | 40 |
| | Bulk Carrier6 | 1 | 1 | 1 | 1 |
| | Bulk Carrier7 | 6 | 6 | 6 | 6 |

| Year | Vessel Class | FWOP | 47 | 49 | 50 |
|---|---|---|---|---|---|
| 2030 | Bulk Carrier1 | 0 | 0 | 0 | 0 |
| | Bulk Carrier2 | 0 | 0 | 0 | 0 |
| | Bulk Carrier3 | 45 | 39 | 35 | 34 |
| | Bulk Carrier4 | 64 | 64 | 64 | 64 |
| | Bulk Carrier5 | 42 | 42 | 42 | 42 |
| | Bulk Carrier6 | 1 | 1 | 1 | 1 |
| | Bulk Carrier7 | 7 | 7 | 7 | 7 |
| | | | | | |
| 2035 | Bulk Carrier1 | 0 | 0 | 0 | 0 |
| | Bulk Carrier2 | 0 | 0 | 0 | 0 |
| | Bulk Carrier3 | 64 | 57 | 54 | 53 |
| | Bulk Carrier4 | 71 | 71 | 71 | 71 |
| | Bulk Carrier5 | 46 | 46 | 46 | 46 |
| | Bulk Carrier6 | 1 | 1 | 1 | 1 |
| | Bulk Carrier7 | 7 | 7 | 7 | 7 |

## 4.2 Transportation Cost Savings

Since the objective of USACE deep draft navigation projects is to lower transportation costs, this is usually done through better utilization of present vessels, or by use of larger, more efficient vessels. Future cost of commodity movements, given the projected vessel fleet composition for each commodity and the vessel operating costs, are estimated using price levels at a common point in time. The efficiencies will improve because vessels can carry more goods.

Transportation cost benefits were estimated using the HarborSym Economic Reporter, a tool that summarizes and annualizes HarborSym results from multiple simulations. This tool collects the transportation costs from various model run output files and generates the transportation cost reduction for all project years, and then produces an Average Annual Equivalent (AAEQ).

Transportation costs were estimated using HarborSym for the years 2025, 2030 and 2035. The transportation costs were held constant beyond 2035. The present value was estimated by interpolating between the modeled years and discounting at the FY 2018 Federal Discount rate of 2.75 percent for the 50-year period of analysis, 2025 through 2074. Estimates were determined for each alternative project depth.

### 4.2.1 Origin Destination Transportation Cost Savings

The analysis includes summaries of total transportation costs, transportation cost savings, and AAEQ transportation cost and cost savings. The overall reduction in total number of container calls and bulk vessel calls is the driving force behind origin-destination benefits.

Table 32 provides the annual transportation costs in total and for the at-sea and in-port portions. For the OD costs, at-sea costs comprise 96 percent of the total costs. The deepening alternatives modeled in HarborSym were without-project condition, 47 feet, 49 feet and 50 feet, the values for 48 feet were interpolated. The transportation cost reduction and AAEQ cost savings benefits are provided in Table 33 and Table 34.

Benefits for containerships range from 72 percent to 77 percent of total benefits by alternative, with bulk carriers collecting 23 percent to 28 percent of overall benefits. The Panamax vessel type had the greatest benefits, with 60 percent of the overall benefits. Within the containerships vessel type, the Far East route had the highest benefits of approximately 65 percent of total containership benefits, with Europe making up the other 35 percent. For the bulk carrier vessel type, the Europe route had the majority of the benefits making up approximately 94 percent of bulk benefits. Table 35 shows the AAEQ transportation cost statistics for channel deepening. The 48 foot information is not included since that alternative was not modeled.

**TABLE 32: TOTAL ANNUAL AT SEA AND IN-PORT TRANSPORTATION COST ALLOCATED TO PORT**

| Year | Without Project | 47FT Deepening | 48FT Deepening | 49FT Deepening | 50FT Deepening |
|---|---|---|---|---|---|
| 2025 | $436,105,000 | $419,649,000 | $415,217,000 | $410,785,000 | $405,856,000 |
| 2026 | $446,925,000 | $430,051,000 | $424,734,000 | $419,417,000 | $413,686,000 |
| 2027 | $457,744,000 | $440,452,000 | $434,250,500 | $428,049,000 | $421,515,000 |
| 2028 | $468,564,000 | $450,854,000 | $443,767,000 | $436,680,000 | $429,344,000 |
| 2029 | $479,383,000 | $461,255,000 | $453,283,500 | $445,312,000 | $437,174,000 |
| 2030 | $490,203,000 | $471,657,000 | $462,800,500 | $453,944,000 | $445,003,000 |
| 2031 | $505,524,000 | $485,909,000 | $477,210,500 | $468,512,000 | $458,261,000 |
| 2032 | $520,846,000 | $500,160,000 | $491,620,500 | $483,081,000 | $471,520,000 |
| 2033 | $536,168,000 | $514,412,000 | $506,030,500 | $497,649,000 | $484,778,000 |
| 2034 | $551,489,000 | $528,664,000 | $520,441,000 | $512,218,000 | $498,036,000 |
| 2035 | $566,811,000 | $542,915,000 | $534,850,500 | $526,786,000 | $511,295,000 |

**TABLE 33: ANNUAL TRANSPORTATION COST REDUCTION BENEFIT BY ALTERNATIVE**

| Year | 47FT Deepening | 48FT Deepening | 49FT Deepening | 50FT Deepening |
|---|---|---|---|---|
| 2025 | $16,456,000 | $20,888,000 | $25,320,000 | $30,249,000 |
| 2026 | $16,874,000 | $22,191,000 | $27,508,000 | $33,239,000 |
| 2027 | $17,292,000 | $23,494,000 | $29,696,000 | $36,229,000 |
| 2028 | $17,710,000 | $24,796,500 | $31,883,000 | $39,219,000 |
| 2029 | $18,128,000 | $26,099,500 | $34,071,000 | $42,210,000 |
| 2030 | $18,546,000 | $27,402,500 | $36,259,000 | $45,200,000 |
| 2031 | $19,615,000 | $28,313,500 | $37,012,000 | $47,263,000 |
| 2032 | $20,685,000 | $29,225,000 | $37,765,000 | $49,326,000 |
| 2033 | $21,755,000 | $30,136,500 | $38,518,000 | $51,389,000 |
| 2034 | $22,825,000 | $31,048,000 | $39,271,000 | $53,453,000 |
| 2035 | $23,895,000 | $31,959,500 | $40,024,000 | $55,516,000 |

**TABLE 34: ORIGIN-DESTINATION AAEQ BENEFITS BY PROJECT DEPTH**

| Alternative | AAEQ Transportation Cost Reduction Benefit |
|---|---|
| 47 Foot Deepening | $22,276,000 |
| 48 Foot Deepening | $30,086,000 |
| 49 Foot Deepening | $37,896,000 |
| 50 Foot Deepening | $51,253,000 |

**TABLE 35: AAEQ TRANSPORTATION COST STATISTICS**

| Statistic | WOP | 47FT | 49FT | 50FT |
|---|---|---|---|---|
| Mean | $541,094,903 | $518,819,207 | $503,198,608 | $489,841,941 |
| SD | $16,070,348 | $19,239,114 | $13,193,417 | $1,077,765 |
| Median | $534,950,872 | $509,013,983 | $501,528,636 | $489,691,379 |
| Min | $523,771,659 | $500,341,334 | $487,426,433 | $487,749,174 |
| Max | $563,866,203 | $546,116,218 | $522,028,056 | $491,483,522 |
| Range | $40,094,544 | $45,774,884 | $34,601,622 | $3,734,347 |
| Confidence of Mean +/- | $7,043,140 | $8,431,913 | $5,782,270 | $472,352 |

### 4.2.2 In Harbor Transportation Cost Savings

The purpose of this analysis is to describe the widener benefits achievable with the optimized depth of 50 feet. The widener benefits are associated with the reduction in transit time required to navigate the Mobile Harbor Channel. Transportation cost savings were estimated in terms of reduction in harbor waiting times. In-harbor costs were estimated by analyzing the vessel calls most likely to occur with channel deepening against two scenarios: (1) include the in-harbor passing lane improvements and (2) exclude the in-harbor passing area improvements. The transit time and costs of these two sets of simulations were compared to derive the benefits associated with the in-harbor meeting area improvements. The transportation cost were derived using the

HarborSym model as described in Section 4.1. Only in-harbor transportation costs were assumed as the widener does not impact the at-sea portion of the vessel's voyage.

Transportation costs were estimated for a 50-year period of analysis of 2025 through 2074. Transportation costs were estimated using HarborSym for the years 2025 and 2035. The present value was estimated by interpolating between the modeled years and discounting at the FY18 Federal discount rate of 2.75 percent. Table 36 provides the in-port transportation costs. The transportation cost are greater in 2025 because there is a greater number of priority Panamax containerships than 2035. Table 37 show the transportation cost reduction. The AAEQ transportation costs savings benefits are provided in Table 38.

**TABLE 36: IN-PORT TRANSPORTATION COST**

| In-Port Annual Transportation Cost | | |
|---|---|---|
| **Year** | **without channel widening** | **with channel widening** |
| 2025 | $1,411,472,800 | $1,410,582,800 |
| 2026 | $1,348,691,300 | $1,347,817,800 |
| 2027 | $1,285,909,900 | $1,285,052,900 |
| 2028 | $1,223,128,500 | $1,222,287,900 |
| 2029 | $1,160,347,000 | $1,159,523,000 |
| 2030 | $1,097,565,600 | $1,096,758,100 |
| 2031 | $1,034,784,200 | $1,033,993,100 |
| 2032 | $972,002,700 | $971,228,200 |
| 2033 | $909,221,300 | $908,463,200 |
| 2034 | $846,439,900 | $845,698,300 |
| 2035-2074 | $783,658,400 | $782,933,300 |

**TABLE 37: TRANSPORTATION COST REDUCTION, 2025 TO 2035**

| Year | 50FT Widening |
|---|---|
| **2025** | **$890,000** |
| 2026 | $873,500 |
| 2027 | $857,000 |
| 2028 | $840,500 |
| 2029 | $824,000 |
| 2030 | $807,500 |
| 2031 | $791,100 |
| 2032 | $774,600 |
| 2033 | $758,100 |
| 2034 | $741,600 |
| **2035** | **$725,100** |

**TABLE 38: AAEQ WIDENING COST SAVINGS**

| | |
|---|---|
| AAEQ Channel Widening Cost Savings | $755,000 |

### 4.3 Initial Project Costs of Deepening

In the evaluation and comparison of project depth alternatives, which is necessary to arrive at the selected plan, NED costs play a critical role. NED costs include both the financial and economic costs associated with a project throughout its lifecycle. Each of these types of costs and their sources are discussed in this section of the report. Additionally, the NED costs for the depth and width alternatives being considered in this analysis will be identified.

#### 4.3.1 NED Cost – Financial

Financial costs of the proposed project consist of the construction and mitigation costs accrued during construction of the project and over its lifecycle. More specifically these costs include:

- Land Construction Costs
- Dredging Costs
- Planning, Engineering, and Design Costs (PE&D)
- Supervision and Administration Costs (S&A)
- Contingency Costs
- Supervision, Inspection, and Overhead Costs (SIOH)
- Mitigation Costs

Mobile District Cost Engineering prepared the cost estimate for the proposed deepening and widening alternatives for use in the economic analysis. The sum of these costs is used to determine Interest During Construction (IDC), which represents the economic cost of building a project. The next section defines IDC and provides an explanation as to how it is calculated and included in the analysis. Together, these costs represent the estimated first cost of construction.

Another financial cost not included above is the annual cost accrued over the life of a project due to Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) activities that represent an increase over the current OMRR&R costs to maintain the channel. OMRR&R was excluded from the list of financial costs above because it is not included in the calculation of IDC. IDC takes into account only those costs incurred during construction.

#### 4.3.2 NED Cost – Economic

Interest During Construction represents an economic cost of building a project that is considered in the selection of the recommended plan, but does not factor in as a paid cost. Interest During Construction is the cost of the foregone opportunity to invest the money required to construct a project for another use. The hypothetical return on another investment, measured as IDC, is counted as an NED cost. As an economic, rather than a financial cost, IDC is not considered in the determination of cost-sharing responsibilities.

Interest During Construction reflects that project construction costs are not incurred in one lump sum, but as a flow over the construction period. This analysis assumes that construction expenditures are incurred at a constant rate over the period of construction, an assumption which is supported by the *NED Manual for Deep Draft Navigation*.

### 4.3.3 NED Channel Deepening Cost

Table 39 contains the project costs associated with each project depth evaluated in this analysis. The cost were annualized at the FY18 discount rate of 2.75 percent over 50 years.

Costs analyses for USACE deep draft projects include associated costs which are components of the direct construction costs of the recommended Federal project, but are a necessary non-Federal responsibility or U.S. Coast Guard (USCG) responsibility due to the channel modifications. These costs are not typically cost-shared. Associated costs include items like Aids to Navigation (ATONs), required improvements to docking or berthing areas, and sometimes mitigation efforts. No mitigation efforts are currently included in the associated costs for this study, but they are included in the risk-based contingency for construction elements.

**TABLE 39: PROJECT COST FOR DEEPENING (MILLIONS)**

| Project Depth | Project Cost | Associated Cost | Total Investment Cost | Months used for IDC | IDC | AAEQ Project Cost | Annual O&M | Total AAEQ Cost |
|---|---|---|---|---|---|---|---|---|
| 47' | $164.7 | $4.7 | $ 169.4 | 27 | $7.1 | $6.5 | $0.9 | $7.4 |
| 48' | $231.2 | $7.2 | $ 238.4 | 34 | $9.98 | $9.2 | $1.3 | $10.5 |
| 49' | $293.0 | $9.6 | $ 302.5 | 41 | $17.0 | $11.8 | $1.8 | $13.6 |
| 50' | $361.6 | $11.9 | $ 373.5 | 49 | $21.0 | $14.6 | $2.2 | $16.8 |

In addition to the deepening cost, channel widening cost were also determined. The PDT had screened the widening distance, depth and width and therefore, only needed cost for three miles of widening at 47 through 50 feet at a width of 500 feet. The cost for the widening measure are shown in Table 40.

**TABLE 40: PROJECT COST FOR WIDENING**

| Widening Depth | Project Cost (includes associated Cost) | Associated Cost | Total Investment Cost | PED & Construction Duration (months) | IDC | O&M Cost | Total AAEQ Cost |
|---|---|---|---|---|---|---|---|
| 50’ | $14,200,000 | $143,400 | $14,343,000 | 12 | $211,000 | $161,400 | $701,000 |

## 4.4 Benefit Cost Analysis

Net NED benefits are NED benefits reduced by NED costs. NED costs are essentially the costs to the Nation for a specific project implementation. The comparison of NED benefits and costs is generally expressed as a ratio of benefits to costs. Economic justification requires that benefits exceed costs and therefore the benefit/cost ratio must exceed 1.0. The most efficient use of resources is when benefits exceed costs by the maximum amount. Therefore, maximum net NED benefits are uses as the primary determinant of the most efficient plan. However, for this study, there was a constraint in which channel depth would not exceed 50 feet.

The benefit cost analysis presented in this section is for the project depths 47 feet to 50 feet. Table 41 displays the origin to destination benefit and cost analysis.

**TABLE 41: CHANNEL DEEPENING BENEFITS AND COSTS**

| | Project Depth | | | |
|---|---|---|---|---|
| | **47** | **48** | **49** | **50** |
| Total AAEQ Benefits | $22,276,000 | $30,086,000 | $37,896,000 | $51,253,000 |
| Total AAEQ Costs | $7,440,000 | $10,531,000 | $13,605,300 | $16,810,000 |
| Net Benefits | $14,836,000 | $19,555,000 | $24,290,700 | $34,443,000 |

Table 42 shows the widening benefit cost analysis at the 50-foot depth. This feature includes widening the channel an additional 100 feet for three miles at 50 feet deep.

**TABLE 42: WIDENING BENEFIT COST ANALYSIS**

| Benefit and Cost Information | |
|---|---|
| Total AAEQ Benefits | $755,000 |
| Total AAEQ Costs | $701,000 |
| Net Benefits | $54,000 |

The 50-foot deepening alternative has the highest net benefits and an economically justified widening area. Therefore the Tentatively Selected Plan (TSP) includes channel deepening to 50 feet with a three mile widener at 100 feet wide. Table 43 displays the TSP benefits, costs, net benefits and benefit-to-cost ratio (BCR).

**TABLE 43: TSP BENEFIT COST ANALYSIS**

| TSP Benefit Cost Analysis | |
|---|---|
| AAEQ Deepening Benefits | $51,253,000 |
| AAEQ Widening Benefits | $755,000 |
| **Total Benefits** | **$52,008,000** |
| Total First Cost (incl. assoc. cost) – Deepening | $373,463,000 |
| Total First Cost (incl. assoc. cost) – Widening | $14,343,000 |
| Interest During Construction – Deepening | $21,041,000 |
| Interest During Construction - Widening | $197,000 |
| **Total Project First Cost** | **$409,044,000** |
| **Average Annual Cost** | **$15,151,000** |
| Annual O&M - Deepening | $2,197,000 |
| Annual O&M - Widening | $161,000 |
| **Total Average Annual Cost** | **$17,510,000** |
| Net Benefits | $34,500,000 |
| **Benefit-to-Cost Ratio** | 3.0 |

# 5 Attachment 1: Bulk Carrier Design Vessel Selection

## Mobile Harbor Bulk Design Vessel

In 2014, the largest vessel calling the Mobile Harbor coal terminal was the *New Delight* with a DWT of 181,279, 958 LOA, 148-foot beam and design draft of 60.3 feet. It was one of three vessels over 175,000 DWT that called that year. No vessel called between 120,000 and 175,000 DWT called that year and 15 vessels 100,000 to 120,000 DWT called.

Figure 32 shows the percent of vessel vessels that called from 2010 through 2015 by DWT range. The data shows an increasing trend in larger bulk carrier vessel sizes that call Mobile Harbor. The percentage of vessels used varied in the 60,000 to 80,000 DWT range and slightly increased over the time period in the 60,000 to 80,000 and 100,000 to 120,000 DWT range. The number of bulk carriers calling greater than 120,000 DWT size class severely decline.

In selecting the design vessel, the 100,000 to 120,000 DWT vessel class is the largest to have recurrent calls. Within this class range, the typical vessel dimensions are as follows: 851.5-foot LOA, 141.2-foot beam and design draft 51.6 feet.

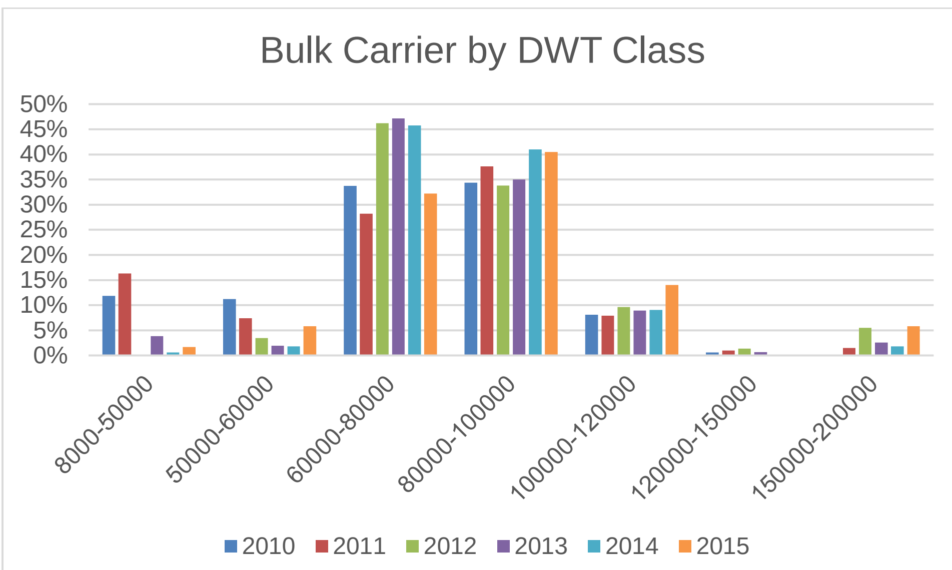



**FIGURE 32: BULK CARRIER BY DWT CLASS**

# 6 Attachment 2: Gulf Coast – Mobile Harbor Design Vessel Selection

## Existing Condition - Gulf Coast

Gulf Coast Container Services are centered on trade at Houston Ship Channel, New Orleans, and Mobile Harbor. Houston handles roughly 65 percent of all Gulf Coast containers. Together, Houston, New Orleans, and Mobile handle over 85 percent of all Gulf Coast containers. Houston, New Orleans, Mobile, and Freeport are the only Gulf Coast ports reasonably able to handle Post-Panamax containerships. Table 44 gives the dimensions of the largest calling vessel at each Gulf Coast port.

**TABLE 44: CONTAINER TRADE BY GULF COAST PORT**

| Port | 2014 TEUs | Max Vessel Capacity | | | |
|---|---|---|---|---|---|
| | | Beam | LOA | Transit Draft | TEU |
| Houston | 1,664,448 | 140 | 1,000 | 45 | 8,000 |
| New Orleans | 329,768 | 141 | 1,089 | 45 | 8,000 |
| Mobile | 174,731 | 141 | 1,065 | 45 | 8,000 |
| Gulfport | 149,269 | 106 | 800 | 36 | 3,000 |
| Freeport | 62,060 | 132 | 960 | 32 | 5,500 |
| Tampa | 38,049 | 107 | 925 | 45 | 4500 |
| Panama City | 27,400 | 95 | 800 | 40 | 900 |
| Galveston | 19,625 | 95 | 800 | 40 | 900 |
| Cedar Bayou | 12,157 | 95 | 800 | 40 | 900 |
| Port Manatee | 12,013 | 95 | 800 | 40 | 900 |

When determining a Gulf Coast Design Vessel for containerships, USACE will primarily look to future services at Houston, New Orleans, and Mobile. Table 45 provides the services with the largest vessels currently calling at these three ports. Several of these services call at two or more of these ports.

**TABLE 45: CURRENT GULF COAST CONTAINER SERVICES**

| Operator | Service | Houston | NOLA | Mobile | Vessel TEU | Trade Area | Panama Canal? |
|---|---|---|---|---|---|---|---|
| 2M | TA3 | | x | x | 7,169 | GC-East Coast-Europe | |
| Maersk | TA-6 | x | | | 6,600 | GC-Europe | |
| Hamburg Sud | UCLA 1 | x | | | 6,500 | GC-East Coast South America | |
| Maersk | MECL 1 | x | | | 6,400 | GC-Suez-Middle East-East Asia | |

| Operator | Service | Houston | NOLA | Mobile | Vessel TEU | Trade Area | Panama Canal? |
|---|---|---|---|---|---|---|---|
| Hapag-Lloyd | GS1 | x | x | | 6,000 | GC-Caribbean-East Coast South America | |
| CMA CGM | PEX3 | x | | x | 5,000 | GC-South Africa-East Asia | yes |
| Maersk | TP-18 | x | | x | 5,000 | GC-East Asia | yes |
| Hapag-Lloyd | AX2 | x | x | | 5,000 | GC-East Coast-Europe | |
| Maersk | TA-1 | x | | | 4,800 | GC-Europe | |
| Hapag-Lloyd | MGX | x | x | | 4,400 | GC-East Coast-Europe | |
| COSCO/CS | GME | x | | x | 4,250 | GC-East Asia | yes |
| CMA CGM | Victory | x | x | | 4,200 | GC-East Coast-Europe | |
| Zim | CGX | x | x | x | 3,400 | GC-Caribbean | |

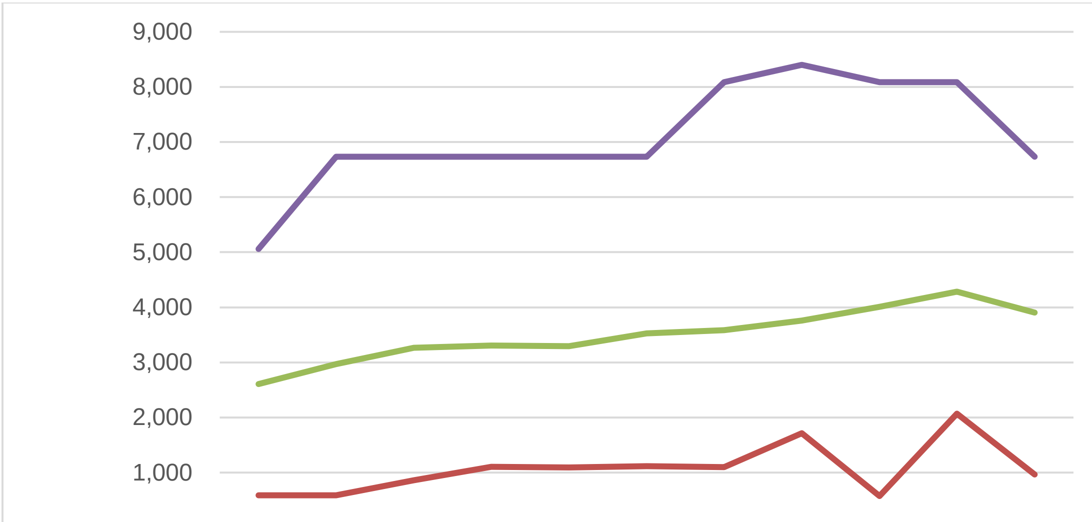
Currently, TA3 (operated by 2M) is the largest Gulf Coast container service. It calls at New Orleans and Mobile before servicing the U.S. East Coast and Mediterranean. The typical vessel size on this service has a nominal capacity of 7,169 TEUs.

Table 46 provides the minimum, average, and maximum TEU capacity vessels calling Houston, New Orleans, and Mobile in 2015[6]. Figure 33, Figure 34, and Figure 35 provide the historical trend for each port from 2005-2015. For the most part, average vessel TEU capacity has been growing along the Gulf Coast[7].

**TABLE 46: TEU VESSEL CAPACITY BY PORT (2015)**

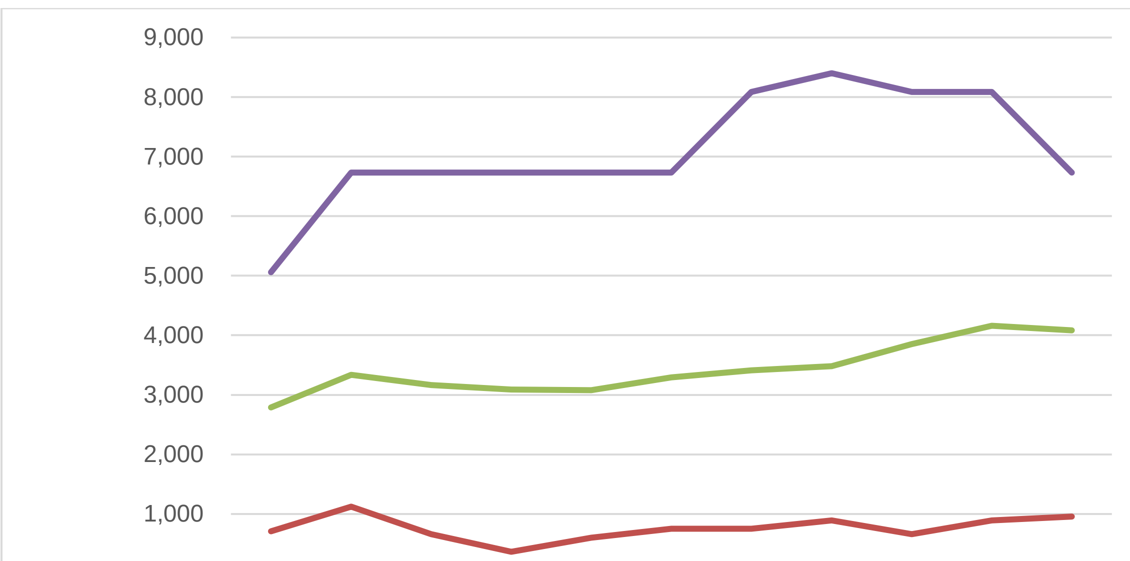
| Port | Min TEU | Avg TEU | Max TEU |
|---|---|---|---|
| Houston Ship Channel | 966 | 3,902 | 6,732 |
| New Orleans | 974 | 4,082 | 6,732 |
| Mobile | 974 | 4,775 | 6,732 |

[6] http://www.marad.dot.gov/wp-content/uploads/pdf/DS_ContainershipSizes2015_Final.pdf
[7] 2015 data taken from Marad. All other taken from NNOMPEAS



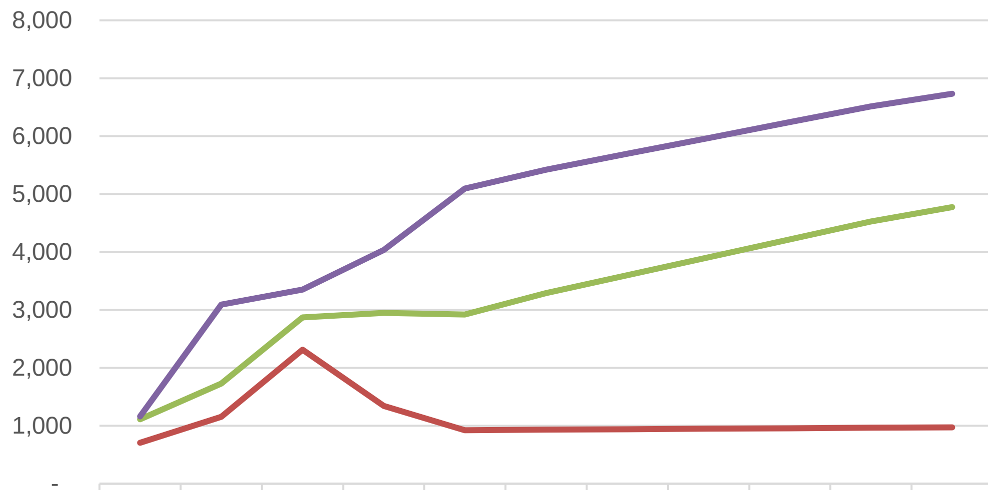

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Min TEU | 591 | 591 | 862 | 1,104 | 1,092 | 1,118 | 1,102 | 1,713 | 575 | 2,070 | 966 |
| Avg TEU | 2,608 | 2,969 | 3,267 | 3,309 | 3,297 | 3,526 | 3,586 | 3,759 | 4,008 | 4,284 | 3,902 |
| Max TEU | 5,059 | 6,732 | 6,732 | 6,732 | 6,732 | 6,732 | 8,089 | 8,401 | 8,089 | 8,089 | 6,732 |

**FIGURE 33: HOUSTON SHIP CHANNEL MINIMUM, AVERAGE, AND MAXIMUM VESSEL CAPACITY**




| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Min TEUs | 707 | 1,122 | 660 | 364 | 600 | 751 | 751 | 889 | 660 | 889 | 957 |
| Avg TEUs | 2,788 | 3,335 | 3,162 | 3,091 | 3,078 | 3,296 | 3,413 | 3,479 | 3,853 | 4,160 | 4,082 |
| Max TEUs | 5,059 | 6,732 | 6,732 | 6,732 | 6,732 | 6,732 | 8,089 | 8,401 | 8,089 | 8,089 | 6,732 |

**FIGURE 34: PORT OF NEW ORLEANS MINIMUM, AVERAGE, AND MAXIMUM VESSEL CAPACITY**




| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010* | 2011* | 2012* | 2013* | 2014* | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Min TEUs | 707 | 1,156 | 2,314 | 1,341 | 923 | 933 | 942 | 950 | 959 | 967 | 974 |
| Avg TEUs | 1,113 | 1,731 | 2,871 | 2,950 | 2,922 | 3,293 | 3,602 | 3,910 | 4,219 | 4,528 | 4,775 |
| Max TEUs | 1,162 | 3,091 | 3,352 | 4,038 | 5,095 | 5,422 | 5,695 | 5,968 | 6,241 | 6,514 | 6,732 |

[8]

**FIGURE 35: MOBILE HARBOR MINIMUM, AVERAGE, AND MAXIMUM VESSEL CAPACITY**

**Future Fleet**

USACE does not have access to vessels on order for Gulf Coast services alone. Assumptions must be made using the world order book. Figure 36 gives vessels in-service and on-order from 1996-2020 by TEU. The average new build is now significantly larger than vessels currently calling the Gulf Coast; however, by tracking vessels by TEU band currently in-service, it is apparent that the largest vessels are not likely to call the Gulf Coast in the near future. Table 47 gives calls by draft class and service. Importantly, no vessels with a design draft beyond 50 feet currently call the Gulf Coast. Order books to 2020 indicate a shift to larger nominal TEU capacity vessels. This should lead to growth in nominal TEU capacity for vessels calling at Mobile Harbor as operators transition larger vessels to Gulf Coast services. Figure 36 provides the sum of vessels in-service and on-order by nominal TEU class.

[8] *Interpolated

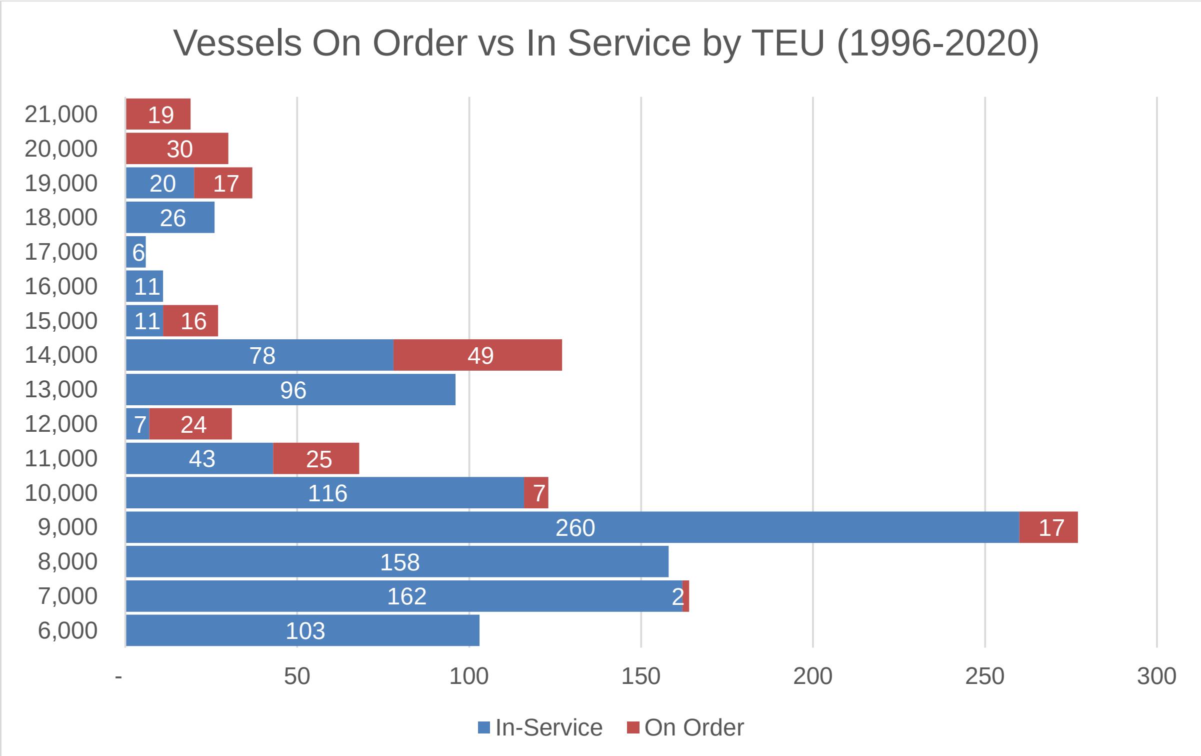



**FIGURE 36: VESSELS ON-ORDER AND IN-SERVICE BY TEU (1996-2020)**

**TABLE 47: TRADE AREA BY DRAFT CLASS FOR VESSELS IN-SERVICE**

| Draft Class | n/a | Central America - Far East | Europe-Far East | Far East | Africa-Europe-Far East | West Coast US - Far East - Europe | Total |
|---|---|---|---|---|---|---|---|
| **<50** | 784 | | | | | | 784 |
| **50.9** | 170 | | 13 | | | | 183 |
| **51.2** | 1 | | 5 | | | 2 | 8 |
| **51.8** | | | 14 | | | | 14 |
| **52.5** | 4 | 1 | 88 | 2 | 1 | 5 | 102 |
| **54.1** | | | 4 | | | 3 | 7 |
| **Total** | **959** | **1** | **124** | **2** | **1** | **10** | **1097** |

This observations narrows limits future Gulf Coast calls to sub 14,000 TEU vessels. Fourteen vessels currently in-service and on-order have a capacity of 14,000 TEUs. This represents the top 1.5 percent of all vessels with drafts at 50 feet and below. Breadths of these vessels are all 167 feet. Of these 14 vessels, five are currently in service. All five currently operating trade on a Europe to Asia route. This likely limits any near-term Gulf Coast calls to an 11,500 TEU or smaller vessel (there are no vessels currently on-order between 11,500 TEUs and 14,000 TEUs and all vessels in this range currently in-service trade exclusively in East Asia, Europe, or the U.S. West Coast).

**Recommendation**

Given current data, design vessels on the Gulf Coast should be no larger than 11,500 TEUs. The maximum dimensions of such a vessel are provided in Table 48 along with maximum dimensions for smaller TEU size Vessels.

Average TEU vessel size for the Gulf Coast has grown around four percent compound annual growth since 2005. This trend should continue given the Panama Canal Expansion. Consequently, the design vessel should at least equal the current largest ship frequently calling. This would place the lower bound at around an 8,500 TEU vessel for Houston and around a 7,000 TEU vessel for Mobile and New Orleans.

**TABLE 48: MAX DIMENSIONS BY TEU CLASS**

| TEU Capacity | Average Beam | Average Draft | Average LOA |
|---|---|---|---|
| 6,000 | 131.8 | 46.0 | 945 |
| 6,500 | 132.8 | 46.5 | 985 |
| **7,000** | **136.6** | **46.6** | **969** |
| 7,500 | 140.4 | 47.6 | 1,014 |
| 8,000 | 142.4 | 47.3 | 1,067 |
| 8,500 | 145.2 | 47.3 | 1,080 |
| 9,000 | 152.2 | 47.3 | 1,041 |
| 9,500 | 150.9 | 48.2 | 1,063 |
| 10,000 | 155.7 | 48.9 | 1,092 |
| 10,500 | 155.0 | 35.4 | 1,083 |
| 11,000 | 137.1 | 44.9 | 998 |
| **11,500** | **151.9** | **50.5** | **1,141** |
| 12,000 | 118.6 | 39.4 | 812 |
| 12,500 | 158.5 | 50.9 | 1,201 |
| 13,000 | 158.2 | 51.4 | 1,202 |
| 13,500 | 161.3 | 34.6 | 1,201 |
| 14,000 | 167.2 | 51.1 | 1,202 |
| 14,500 | 167.7 | 51.1 | 1,205 |

## Mobile Harbor Design Vessel Selection

### Existing Condition

From 2011 to 2014, the containership fleet calling Mobile Harbor consisted of Sub-panamax (21%), Panamax (64%), Post Panamax Generation 1 (15%) and Post Panamax Generation 2 (1%). Figure 37 provides an overview of vessel calls at Mobile Ship Channel.

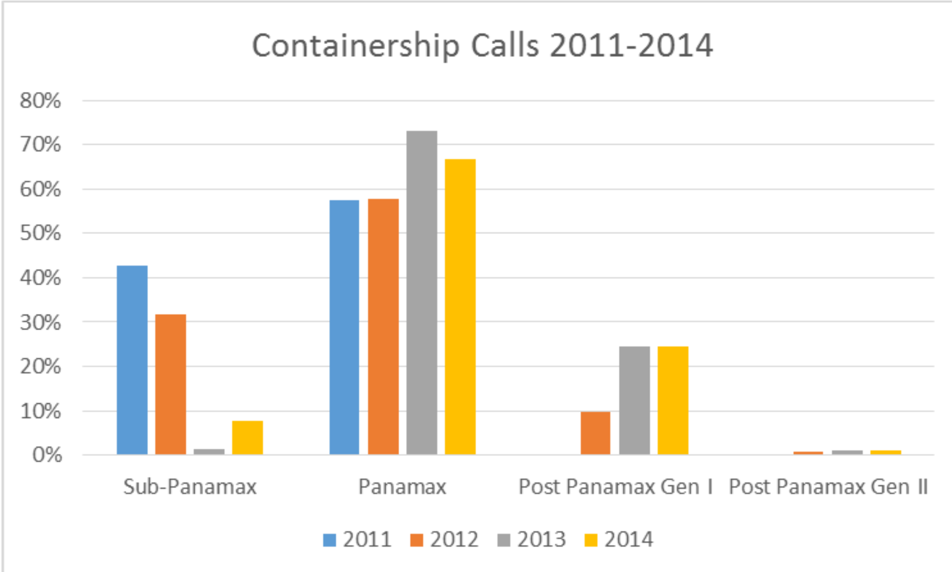



**FIGURE 37: CONTAINERSHIP FLEET DISTRIBUTION AT MOBILE SHIP CHANNEL**

The largest containership that called Mobile by deadweight tonnage was the MSC Judith in 2014. The dimensions are given in Table 49.

**TABLE 49: LARGEST VESSEL CALL 2014**

| Vessel Name | Beam | Draft | LOA | DWT | TEU Capacity |
|---|---|---|---|---|---|
| MSC JUDITH | 141.3 | 47.6 | 1,065 | 105,000 | 8,089 |

The following services call Mobile Container Terminal. Table 50 provides the operator, service, vessel TEUs and trade area for all services ordered largest to smallest by vessel TEU capacity.

**TABLE 50: MOBILE CONTAINER TERMINAL SERVICES**

| Operator | Service | Vessel TEUs | Trade Areas |
|---|---|---|---|
| Maersk & MSC | TA-3 | 6,000-7,000 | North Europe • Charleston • Freeport • Central America • New Orleans • Mobile |
| MSC | Lone Star Express | 4,000-5,000 | Asia • *Panama Canal* •Houston • Mobile • Miami • Freeport |
| CMA CGM | PEX3 | 5,000 | China • *Panama Canal* • Houston • Mobile • Miami • Jacksonville • South Africa • Singapore |
| Maersk | TP-18 | 4,000-5,000 | Houston • Mobile • Miami • *Panama Canal* • East Asia |
| COSCO/CS | GME | 4,250 | China • *Panama Canal* • Houston • Mobile |
| ZIM | CGX | 2,700-3,400 | Caribbean • Mobile • New Orleans • Houston |

Table 51 provides the deadweight tonnage percentile of the largest vessels calling the Mobile Container Terminal and deadweight tonnage percentile of similar vessels in-service and on-order for each operator's vessel fleet.

**TABLE 51: LARGEST VESSEL BY OPERATOR AND REPRESENTATIVE VESSELS**

| Operator | Vessel Name | Current DWT %ile | Possible Largest Future Vessel by Operator* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Vessel Dimensions | | | | | | In-Service | | On-Order | |
| | | | Represen-tative Vessel | DWT | TEU | Beam | LOA | Draft | Count | %ile | Count | %ile |
| MSC | **MSC Judith** | 72% | MSC Margrit | 140,000 | 13,102 | 158 | 1,202 | 50.9 | 14 | 86% | 29 | 72 |
| | **MSC Ilona** | 67% | MSC Joanna | 117,333 | 9,178 | 150 | 1,100 | 50.8 | 8 | 83% | 24 | 62** |
| Maersk | **Maersk Kawasaki** | 69% | Maersk Guayaquil | 119,000 | 10,100 | 158 | 1,100 | 50.8 | 2 | 90% | 7 | 69 |

The vessels listed above should be considered representative for their class. It is assumed that vessels similar to these will call Mobile Harbor in the future. The following vessel dimensions should be considered for channel design requirements.

**TABLE 52: DESIGN VESSEL DIMENSIONS**

| DWT | Nominal TEUs | Beam | LOA | Draft |
|---|---|---|---|---|
| 115k-125k | 10k-11k | 158 | 1,100 | 50.8 |

FIGURE 38 shows the vessels in service and on order by draft class. Table 53 shows the average vessel dimensions by draft class.

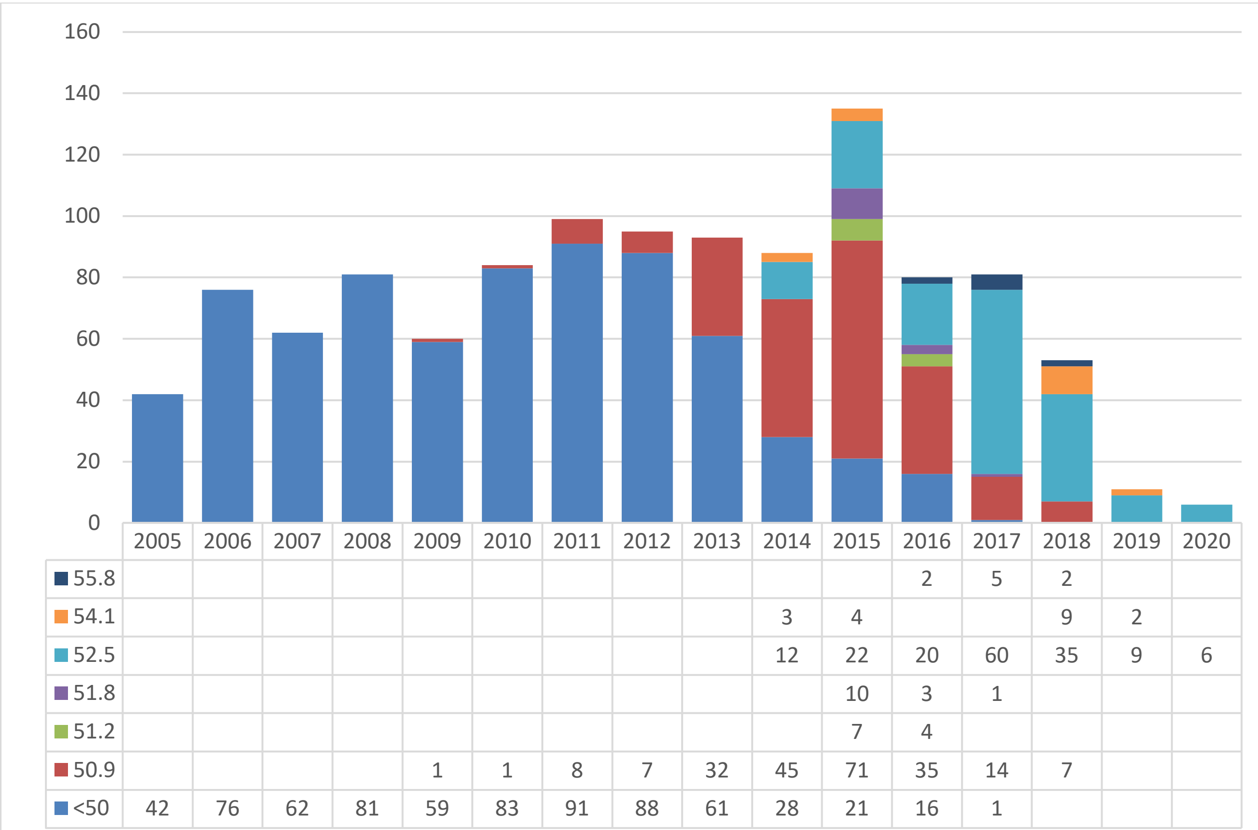
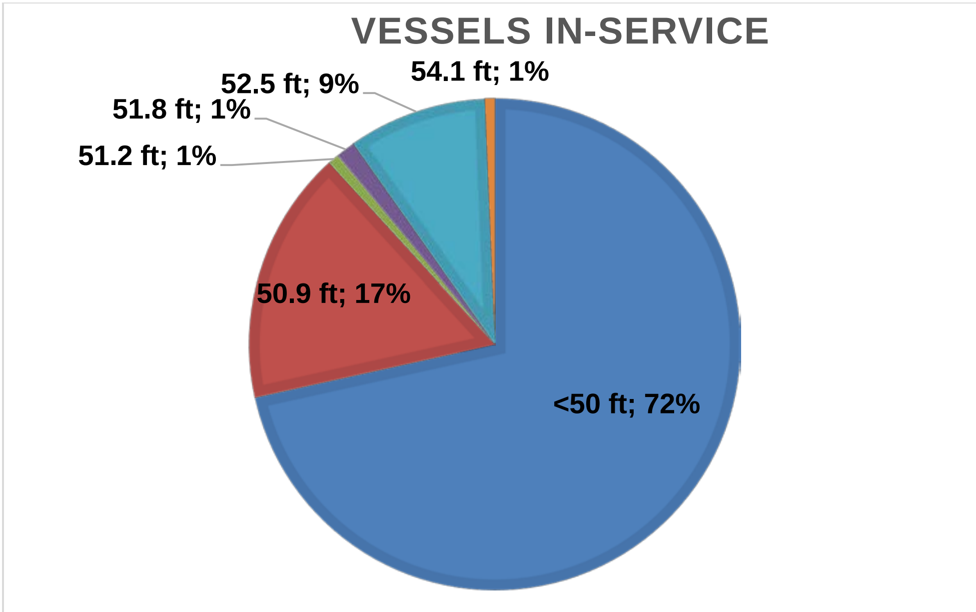
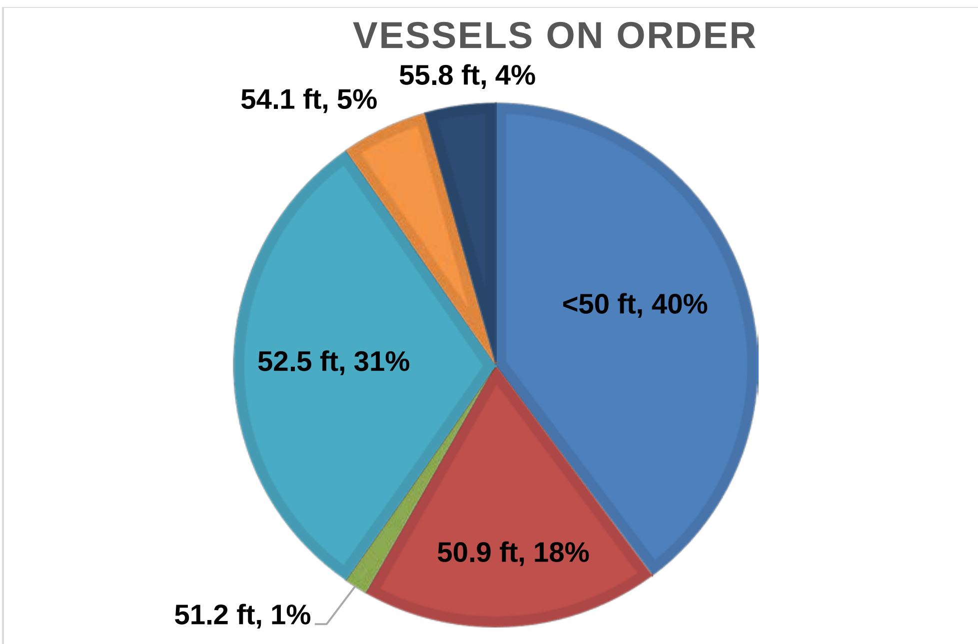



**FIGURE 38: VESSELS IN-SERVICE AND ON-ORDER BY DRAFT CLASS (2005-2020)**

**TABLE 53: AVERAGE VESSEL DIMENSIONS BY DRAFT CLASS**

| Draft Class | Avg. TEU | Avg. DWT | Avg. Beam | Min Draft | Max Draft |
|---|---|---|---|---|---|
| 55.8 | 15,300 | 145,935 | 176 | 55.77 | 55.77 |
| 54.1 | 17,091 | 180,020 | 179 | 54.13 | 54.13 |
| 52.5 | 16,858 | 179,459 | 181 | 52.49 | 52.58 |
| 51.8 | 13,916 | 149,193 | 167 | 51.79 | 51.84 |
| 51.2 | 13,950 | 160,721 | 168 | 51.18 | 51.18 |
| 50.9 | 12,574 | 139,296 | 159 | 50.85 | 50.94 |
| <50 | 8,336 | 100,070 | 144 | 39.37 | 49.94 |


VESSELS IN-SERVICE
52.5 ft; 9%
54.1 ft; 1%
51.8 ft; 1%
51.2 ft; 1%
50.9 ft; 17%
<50 ft; 72%


VESSELS ON ORDER
55.8 ft, 4%
54.1 ft, 5%
<50 ft, 40%
52.5 ft, 31%
50.9 ft, 18%
51.2 ft, 1%