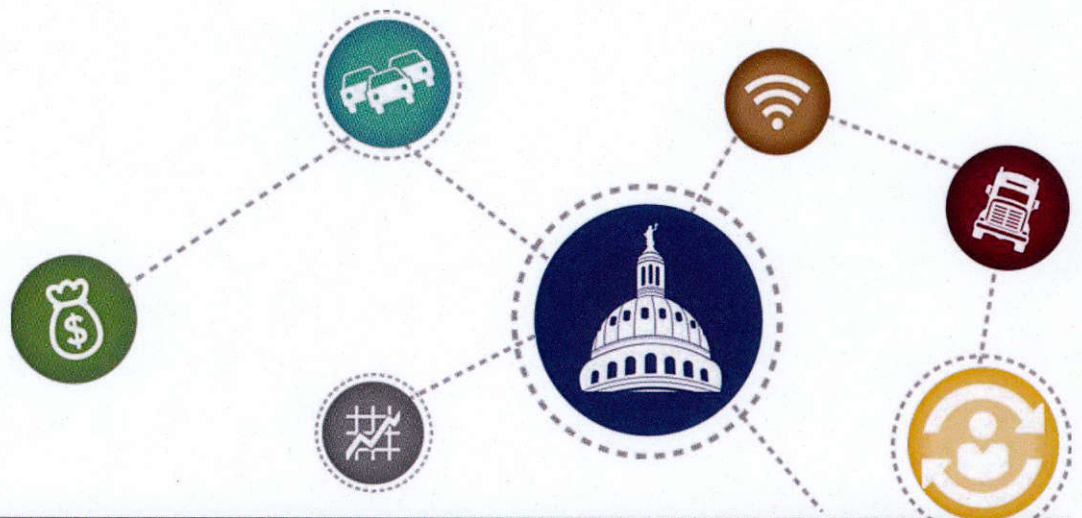
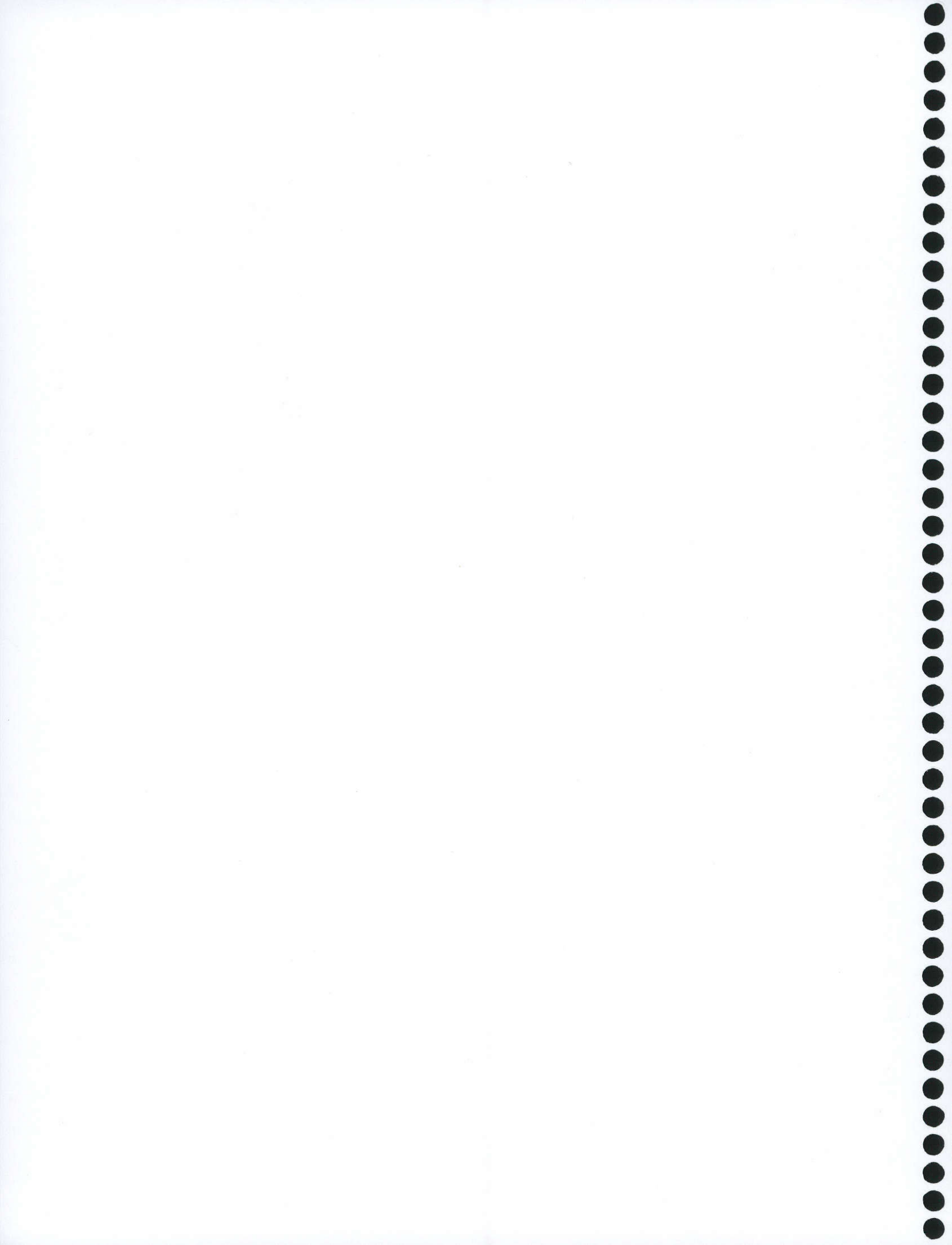


# The Potential Impacts of the Panama Canal Expansion on Texas Ports

*Final report*

PRC 17-78





# The Potential Impacts of the Panama Canal Expansion on Texas Ports

Texas A&M Transportation Institute

PRC 17-78

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## Potential Impacts of Panama Canal Expansion on Texas Ports

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The 2016 expansion of the Panama Canal allows significantly larger cargo ships traveling from East Asia to access the U.S. Gulf and East Coasts via an all-water route, which is typically the least costly way to transport goods. This study sought to examine the potential impacts specifically on Texas sea ports.

- The Port of Houston has predicted an increase in traffic in the long-term due to the Panama Canal expansion, expecting that the newly deepened Port will attract heavier or larger vessels to unload there. Other Gulf Coast ports also expect an increase. Expanded channels have been approved for the Ports of Brownsville, Corpus Christi, Freeport, and the Sabine-Neches Waterway, but no funding has been appropriated to these projects.
- To date, the greatest impact of the expansion appears to be associated with tankers, especially for liquefied petroleum gas (LPG) and liquefied natural gas (LNG). Some 86 percent of the world's LNG fleet can now pass through the Canal, compared to only 8 percent before the expansion.
- Prior to the expansion, about 40 ships passed through the Canal each day. The expansion increased the total capacity, but the maximum per-day capacity of the new locks is not yet known.
- Although the number of vessel transits through the expanded Panama Canal from 2015 to 2016 increased for tankers, the number of transits during the same period decreased for container ships and dry bulk vessels, defying some predictions.
- Canal officials predict a doubling of LNG vessel transits by 2020. Texas already has two Gulf Coast LNG terminals operating, and two more are expected to open in 2018.
- Seventy percent of Texas imports from East Asia arrive via an all-water route to Texas. For exports to East Asia, 21 percent by weight leave through California. High-value goods seem more likely to use the intermodal route through California than low-value goods.
- The faster travel time from north and central Asia to the U.S. via the Panama Canal will likely continue to give the Panama Canal the advantage between those two markets. However, imports from Southeast Asia will likely travel through the Suez Canal because of time savings on that already-established route.
- Despite the additional time needed to use other alternatives (i.e., going around South America, or using the Suez Canal) it is possible that shippers will choose longer routes to avoid Panama Canal tolls. Currently some shippers are avoiding the Panama and Suez Canals altogether because low fuel prices are making longer routes more affordable.

- Despite the potential afforded by its increased capacity, the expanded Panama Canal still faces a number of challenges, including: a decrease in global shipping, safety of the locks, difficulty in guiding bigger vessels through the locks, and an unreliable source for the greater amount of water needed to fill the locks.

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## Executive Summary

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### The Panama Canal Expansion

The Panama Canal is a set of locks that allows vessels to pass through the Isthmus of Panama. When the Panama Canal opened in 1914, it provided the first ever direct water passage between the Atlantic and Pacific Oceans. The new all-water global shipping route allowed for shorter maritime travel distances between several key markets and significantly cut costs for shippers (1). Since its opening, over 1 million ships have passed through the canal (2).

In 2016, the Panama Canal opened a second, larger set of locks to accommodate larger vessels. Larger vessels offer the potential for lower costs to shippers by lowering the per-TEU<sup>1</sup>, per-barrel, or per-ton costs.

Of interest to Texas, the expansion of the Panama Canal means that larger vessels traveling from East Asia can now access the U.S. Gulf and East Coast on an all-water route, which is often the cheapest way to transport goods. This report focuses largely on Asia- U.S. trade because

51 percent (in weight) of all traffic passing through the Panama Canal is goods traveling between the U.S. and Asia (3).

Prior to the expansion, any vessel too large to fit through the Panama Canal would have to use an alternative route between East Asia and the U.S. East and Gulf Coasts. Alternative routes include the U.S. intermodal route (vessels dock at West Coast ports, then ship goods over land via truck or rail), and the Suez Canal (traveling in the other direction around the world).

The canal itself has predicted a doubling in cargo capacity due to the expansion. At the other extreme, some reports predict that the canal expansion will have no effect on current shipping routes. For example, in a study released prior the opening of the new Panama Canal locks, it was predicted that the expansion would not impact routes from Asia to the East or West Coast because different commodity types have different shipping strategies, regardless of the size of the Panama Canal locks. High-value, time-sensitive goods tend to use West Coast ports to take advantage of time savings; low-value, low-cost goods tend to prefer East Coast ports because the all-water route is more cost effective (4).<sup>2</sup> To attract larger ships, some ports in the U.S. Gulf and East Coast have invested in infrastructure to accommodate Neopanamax vessels.

*“Panamax” vessels are the maximum size that can pass through the original locks.*

*“Neopanamax” vessels are the maximum size that can now pass through the new locks.*

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<sup>1</sup> “TEU” is the abbreviation for “twenty-foot equivalent unit.” It is the standard unit of measure for reporting containerized cargo activity. A container that is 20 ft long is one TEU; a container that is 40 ft long is two TEUs.

<sup>2</sup> This study did not isolate the Gulf Coast as a possible point of entry or exit for goods.

## **Port and Private Industry Interviews**

### *Port Interviews*

The research team interviewed six Gulf Coast ports about the potential effects of the Panama Canal expansion. The ports interviewed were:

- Port of Greater Baton Rouge, Louisiana.
- Port of Beaumont, Texas.
- Port of Corpus Christi, Texas.
- Port Houston, Texas.
- Port of Mobile, Alabama.
- Port Tampa Bay, Florida.

All Gulf Coast ports the research team interviewed said that the current impact of the Panama Canal expansion was non-existent or minimal. None of the ports interviewed have the depth of 50 ft that is needed to accommodate a fully loaded Neopanamax vessel.

Most of the ports interviewed stated that there is minimal impact predicted for the near future, and any impacts are conditional on infrastructure improvements, such as dredging of ports and surrounding waterways to deeper depths. Some ports stated that they deal mostly with trade routes that do not use the Panama Canal. Others stated that some commodities do not need the larger vessels that use the new locks.

Even if they did not expect to immediately receive many vessels that have passed through the new locks, some ports predicted other effects. For example, Port Houston (POH) expects a cascade effect. As Neopanamax vessels are deployed to service other ports, smaller ones will come to Port Houston. These smaller-than-Neopanamax vessels can handle 8,000–10,000 TEUs, and are larger than the current vessels in the gulf.

### *Private Industry Interviews*

The research team interviewed the following private industry stakeholders:

- Valero.
- Occidental Energy Marketing.
- Phillips 66.
- Greater Houston Port Bureau.

All private industry stakeholders interviewed by the research team said that the current impact of the Panama Canal expansion was non-existent or minimal. The reasons for this varied. One stakeholder stated that Asia already has crude oil suppliers in other locations, and does not need

new sources of crude from the Gulf Coast. Another stated that crude oil is often bought and sold in a very short time frame, and that the Panama Canal's strict reservation slots do not offer flexibility. Finally, one company stated that they use the Panama Canal only sporadically because their major trade routes do not need it.

Currently the canal processes about six Neopanamax vessels per day (total, counting both directions), but plans to increase the number to their maximum capacity of twelve, and increase the hours when LNG vessels can transit the locks (5).

## Panama Canal Data

To estimate potential effects of the Panama Canal expansion on transits and cargo weight, the study team compared Panama Canal traffic data from 2015 (prior to the new locks opening) to 2016 (the year when the new locks opened). Since the new locks were only open for 6 months in 2016, 2017 data will provide a more accurate picture once it is released because it will be the first full year that the new locks were in operation.

### *Vessel Transits and Tonnage*

The number of transits of some vessel types increased between fiscal years 2015 and 2016, while others decreased. Vessels that had increased transits in 2016 were chemical tankers, liquefied petroleum gas (LPG) tankers, and liquefied natural gas (LNG) tankers. Vessels that had decreased transits in 2016 were container ships and dry bulk vessels. The fact that container ship<sup>3</sup> transits decreased from 2015 to 2016 indicates that the new locks did not have the immediate effect of increasing transits of these vessels, which was often predicted.

Incorporating tonnage data provides more information on how heavily ships may have been loaded. The Panama Canal separates tonnage data into northbound and southbound through the canal. Figure 1 shows some of the major routes traveling northbound and southbound through the Panama Canal.

*Liquefied natural gas (LNG) is natural gas stored as a very cold liquid (between -120 and -170°C).*

*Liquefied petroleum gas (LPG) is a byproduct of natural gas processing and refining petroleum. It consists of a variety of elements, such as propane, butane, etc. and is stored in pressurized steel.*

*(Source: Alternative Fuel Systems, <http://www.afsglobal.com/faq/gas-comparisons.html>)*

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<sup>3</sup> Container ships in the Asian-North American trade routes tend to push the size limitations of the canal.



**Figure 1. Direction of Tonnage through Panama Canal.**

For container ships, transits and tonnage increased northbound, but decreased southbound. This suggests that there were increases on routes that use the Panama Canal traveling northbound, such as the Asia to U.S. East Coast route, and decreases on routes that travel south through the Panama Canal, such as the U.S. East Coast to Asia route.

Additionally, it appears that containerships and refrigerated vessels were either loaded heavier or larger in 2016 than 2015. For containerships, the ratio of tonnage to transit (i.e., how many tons were on each ship) increased in both the northbound and southbound direction. Refrigerated vessels had fewer transits in both the north and southbound directions, but they had higher tonnage in both directions during the same timeframe. This suggests that fewer refrigerated vessels carried more cargo.

Because the new locks were open for only 6 months of 2016, it may be too soon to see the full effects of the expansion.

*Trade Routes*

The Panama Canal collects tonnage data on different routes. Between 2015 and 2016, tonnage decreased on all routes that passed through the Panama Canal with origin or destination to the U.S. East Coast. Though the decrease in tonnage was minimal on many routes, including the Asia -U.S. East Coast route, there has been no immediate effect of increased traffic at East Coast U.S. ports. Table 1 shows the tonnage on key trade routes that utilize the Panama Canal (6).

**Table 1. Tonnage on Trade Routes Using the Panama Canal.**

Trade Route Between		PC/UMS Tons		Change
		2015	2016	
Asia	East Coast U.S.	104,903	104,791	Decrease
West Coast South America	East Coast U.S.	38,606	35,877	Decrease
Oceania	East Coast U.S.	5,698	5,617	Decrease
Pacific World	East Coast U.S.	3,587	1,846	Decrease
West Coast Canada	East Coast U.S.	618	585	Decrease
Europe	West Coast U.S.	10,190	12,318	Increase
East Coast South America	West Coast U.S.	2,512	6,169	Increase
East Coast Central America	West Coast U.S.	2,756	1,738	Decrease
West Indies	West Coast U.S.	1,038	1,171	Increase

## Conclusion

Gulf Coast Ports, including ports in Texas, have invested to accommodate larger vessels. However, it is unclear what the effect of the Panama Canal expansion on Texas will be in the medium and long term. Alternative trade routes between East Asia and Texas that avoid the Panama Canal are still heavily used. For example, most of what the Houston area currently imports from East Asia comes through West Coast ports, then travels to Texas via truck and rail, but it is possible that the reduced unit costs of using the Panama Canal could shift travel to Texas ports over time.

To date, it seems the largest impact of the Panama Canal expansion has been on tankers, especially for liquefied natural gas (LNG) and liquefied petroleum gas (LPG). Prior to the opening of the new locks, only about 8 percent of the world's LNG tankers could fit through the Panama Canal (7). Now, it is estimated that 86 percent of the LNG fleet can pass through the canal (8). Because of the Panama Canal expansion, LNG shipping costs could be reduced by 25 percent, and some research has argued that LNG exports could benefit more from the expansion than containers (7).

The study team analyzed data on larger than Panamax vessels that had transited the new locks on their way to, or coming from, Houston. Of the 14 vessels that passed through the expanded locks on their way to Houston, 8 were LPG vessels. Of the 156 vessels that left Port Houston and transited the new locks, 98 percent (153) were LPG carriers.

For LNG carriers, the Panama Canal has predicted a doubling of transits through the Panama Canal by 2020, and it plans to increase tolls to capitalize on high demand for transits (9, 10). Shipping of natural gas from the Gulf Coast to Northeast Asia could increase where there is high demand for affordable natural gas (8). For Texas exports, the new locks mean that larger shipments of natural gas can now use the Panama Canal. Two LNG terminals are expected to be operating at the Ports of Corpus Christi and Freeport in 2018, which would facilitate Texas

natural gas exports (11). There are already two LNG terminals operating on either side of Sabine Pass: The Golden Pass LNG Terminal in Texas, and the Cheniere LNG terminal in Louisiana (12, 13).

For Texas imports from East Asia traveling by water, 70 percent by value come directly to Texas (14). For Texas exports East Asia traveling by water, 55 percent by value leave the U.S. through Texas, and 43 percent by value leave through California (14). Commodity type may be one of the most important factors in considering route choice and potential effects of the canal expansion. For example, for electronic imports traveling by water from East Asia, half arrive in California first. Some factors that go into route choice, such as fuel cost, change constantly. And many options exist for shippers over long, complex routes. Predicting how and where a good will travel is challenging. In the short term, it appears that LNG and LPG will benefit the most from the expanded canal. However, given that the new locks at the Panama Canal opened in June 2016, it will likely take time to see the full impacts of the canal expansion.



## Panama Canal Expansion Literature Review

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### Overview

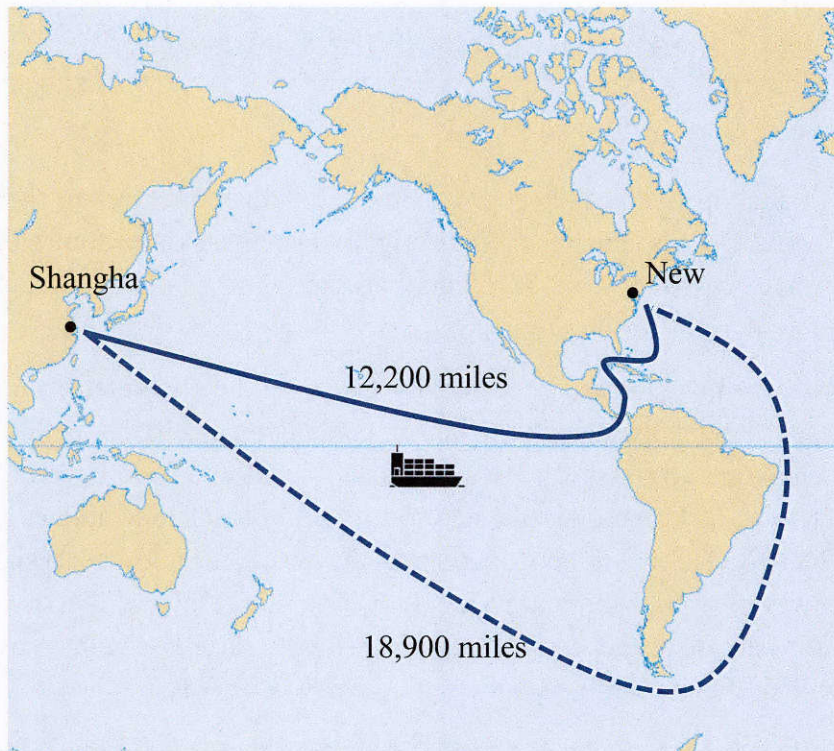
When the Panama Canal opened in 1914 it provided the first ever direct water passage between the Atlantic and Pacific Oceans. The new all-water global shipping route allowed for shorter maritime travel distances between several key markets and significantly cut costs for shippers (1). Since its opening, over 1 million ships have passed through the canal (2).

However, as the size of ships increased, the Panama Canal fell behind in terms of the maximum vessel size that could be accommodated. The largest container ships in the world and many tankers could no longer pass through the Panama Canal's locks and were forced to choose other routes. In 2016, the Panama Canal opened a new, larger set of locks to handle larger ships and increase global competitiveness. For container ships, the new locks allow for a significant increase in the number of twenty-foot equivalent unit containers (TEUs)<sup>4</sup> that the Panama Canal can process. About 5 percent of the world's total cargo passes through the Panama Canal, and the canal predicts it will double its cargo capacity with the new locks (8).

The location of the Panama Canal makes it possible to directly connect Asian ports and west coast South American ports with U.S. east coast ports by water. Without the canal, ships would have to travel around the tip of South America. The journey from Shanghai to New York, for example, without the Panama Canal would be about 18,900 miles around the southern tip of South America, as opposed to about 12,200 miles through the Panama Canal. Figure 2 shows these two routes from Shanghai to New York (15).

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<sup>4</sup> "TEU" is the abbreviation for "twenty-foot equivalent unit." It is the standard unit of measure for reporting containerized cargo activity. A container that is 20 ft long is one TEU; a container that is 40 ft long is two TEUs.



**Figure 2. Shanghai to New York via Water.**

### *Infrastructure*

The Panama Canal is almost 50 miles long and contains locks that allow ships to pass between the Pacific Ocean and the Caribbean Sea (2). In order to cross the Isthmus of Panama, it is necessary to raise the ships to the level of the man-made Lake Gatun; hence the need for locks at both ends of the canal. The old locks contain two parallel lock chambers for each set of locks, so two ships can pass through in opposite directions at the same time. There are three original sets of locks: Miraflores Locks, Pedro Miguel Locks, and Gatun Locks. The two new locks contain one lane each. Most of the channel through Panama, outside of the locks, can be shared by both Panamax and Neopanamax ships (16).<sup>5</sup>

It takes between 8 to 10 hours total to pass through the entire Panama Canal, with 2.5 to 3 hours needed to pass through the new lock structures specifically (2). Prior to the expansion, about 40 ships passed through the canal each day (17). The maximum capacity of vessels per day through the new locks is not yet clear. There are 12 reservation slots per day for the new locks; however, the actual capacity is likely much higher (18). Vessels can pay a premium to reserve a scheduled slot to pass through the canal, but may wait days if they show up without a reservation.

Figure 3 shows the location of the canal within Panama, as well as a close-up of the locks and channels within the canal.

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<sup>5</sup> Panamax ships are the largest vessels that can pass through the Panama Canal's original locks. Neopanamax ships (also known as Post Panamax or New Panamax), are the largest vessels that can pass through the Panama Canal's new locks.

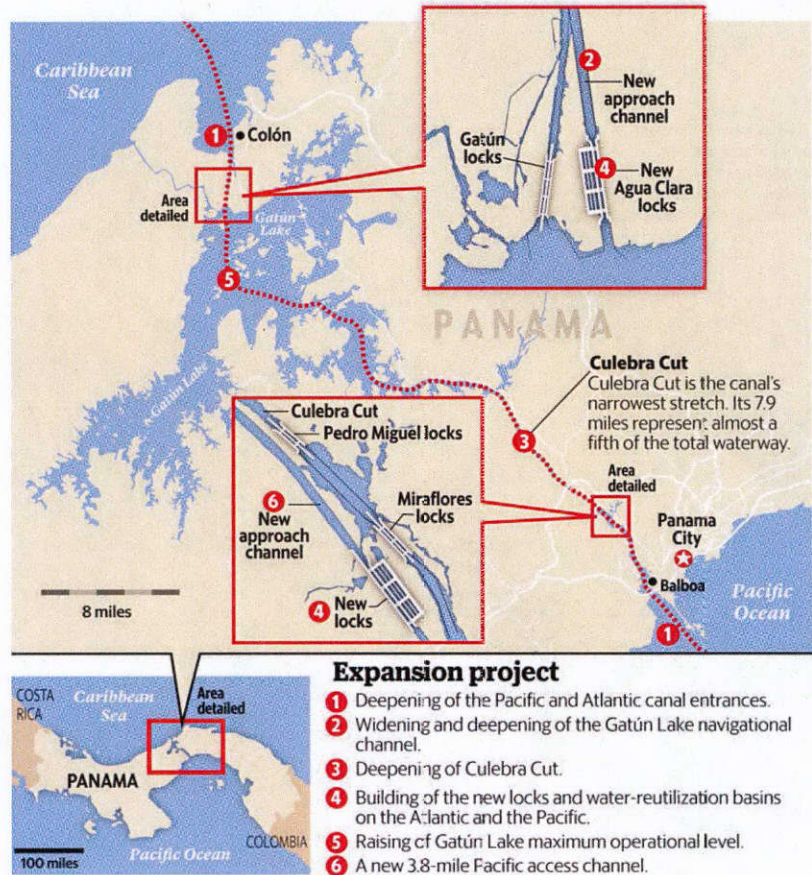


Figure 3. The Panama Canal Locks.

Source: Marco Ruiz, Miami Herald (19)

### Vessels

The Panama Canal is so important to maritime shipping that vessel sizes are named based on which set of locks they can pass through: Panamax ships are the maximum size that can pass through the original set of locks, and Neopanamax (also called Post Panamax or New Panamax) ships are the maximum size that can fit through the new set of locks.

Table 2 shows the maximum vessel specifications that can pass through either set of locks (20).

Table 2. Vessel Specifications for Old and New Locks.

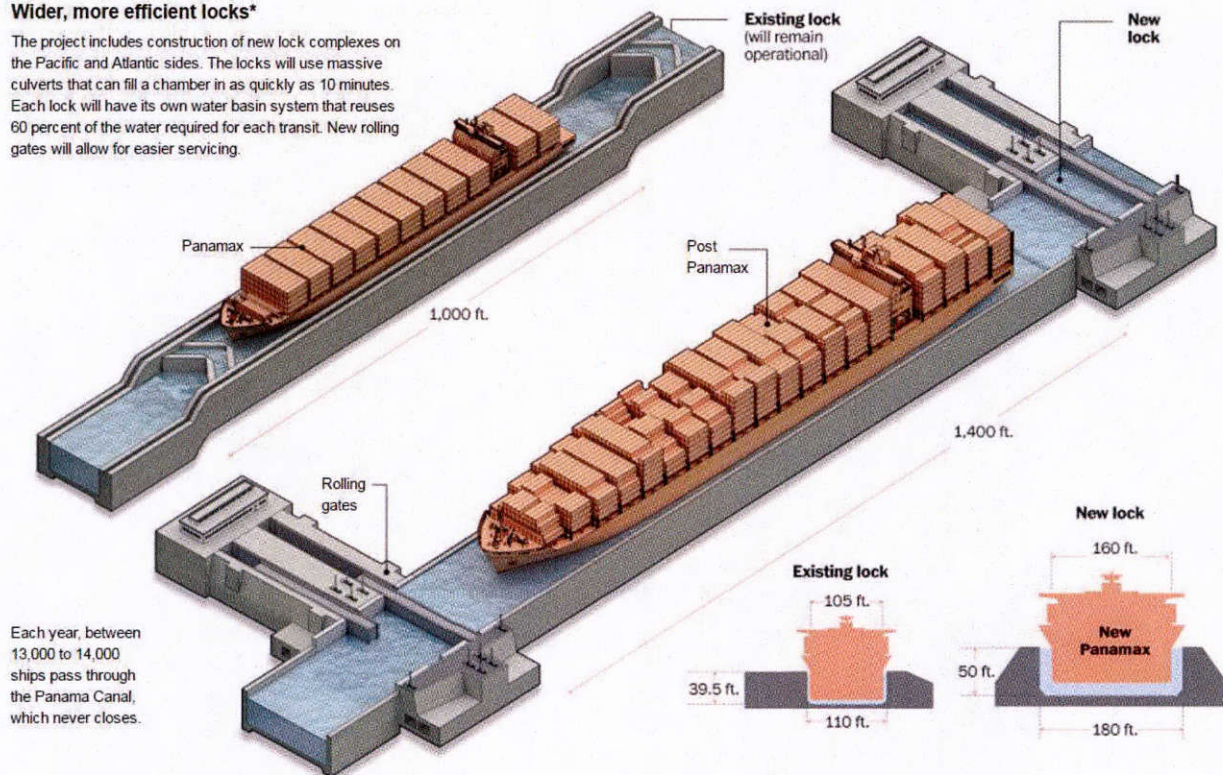
Locks	Maximum Length	Maximum Width	Maximum Draft	Maximum TEUs (21) <sup>6</sup>
Panamax (old locks)	294 m (965')	32.31 m (106')	12.04 m (39.5')	5,000
Neopanamax (new locks)	366 m (1,200')	49 m (160')	15.24 m (50')	13,000

<sup>6</sup> The maximum number of TEUs that these vessels can carry varies based on ship design. These are the generally accepted numbers. Source: Center for Ports and Waterways, Texas A&M Transportation Institute (TTI).

Figure 4 shows the vessel specifications that can pass through each set of locks, using container ships as an example (20).

**Wider, more efficient locks\***

The project includes construction of new lock complexes on the Pacific and Atlantic sides. The locks will use massive culverts that can fill a chamber in as quickly as 10 minutes. Each lock will have its own water basin system that reuses 60 percent of the water required for each transit. New rolling gates will allow for easier servicing.



**Figure 4. Maximum Vessel Size for Each Lock.**

Source: Washington Post (20)

Larger vessels offer the potential for lower per-TEU, per-barrel, or per-ton cost to shippers. This is because the fixed costs of the vessel are divided across a larger number of units. Loading a vessel as full as possible is cost effective for the same reason.

**Alternative Routes**

Shippers have many options when it comes to route choice, a decision that involves several factors. Some of the key factors are travel time, reliability, and cost. The focus of this section is on the Asia–U.S. East Coast trade route because it is the highest volume trade route to use the Panama Canal. There are a few alternative routes, however. These alternatives are discussed below.

***U.S. Intermodal Land Bridge***

A key alternative to the all-water Panama Canal route is the U.S. intermodal route: cargo travels by water from Asia to a West Coast Port, then by truck or rail inland. According to the United States Department of Agriculture, traveling from Asia to the U.S. West Coast takes 12.3 days by water (22). Traveling by truck or rail from the West Coast to the East Coast of the U.S. takes another 6 days. This means that the intermodal route from Asia to the U.S. East Coast takes a

total of 18.3 days (22). The same source states that using the Panama Canal to take an all-water route from the Asia to the U.S. East Coast takes approximately 20 days (22). This would mean that using the Panama Canal all-water route takes about 2 days longer than the intermodal route. Additional time may be needed to move the cargo from port to inland destination. Figure 5 shows these travel times.

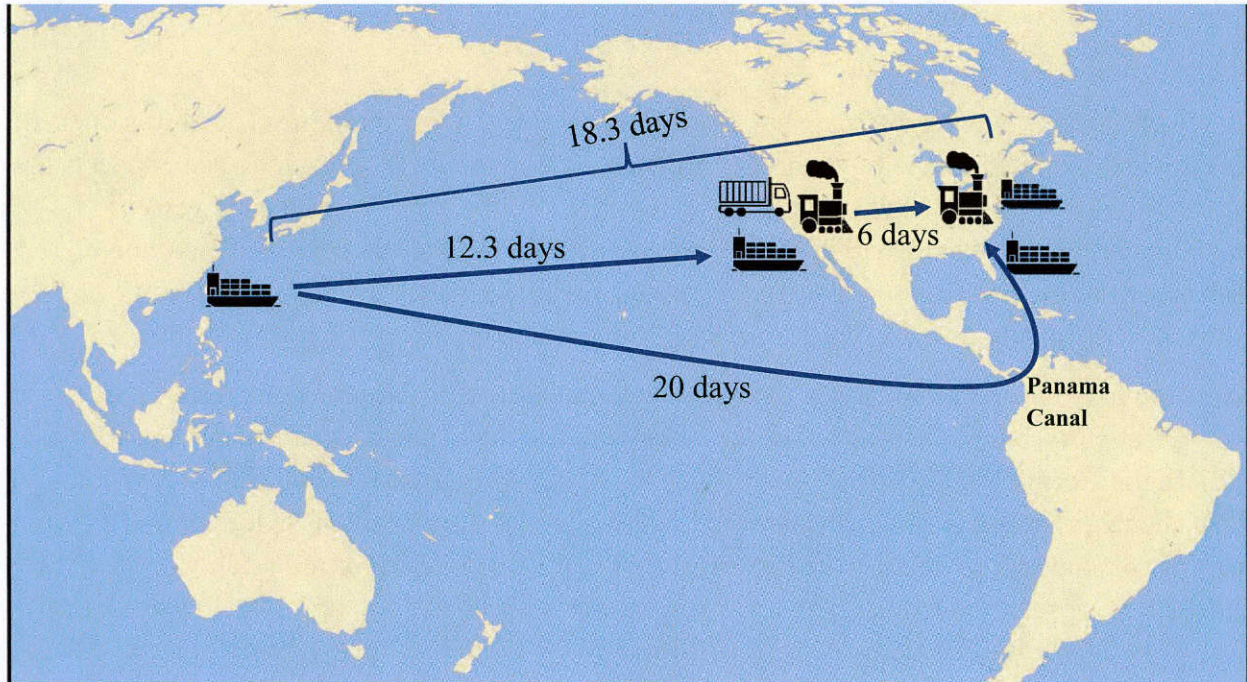


Figure 5. Travel Times from Asia to the U.S. East Coast.

A recent estimate by the Journal of Commerce, however, placed the time savings from using the intermodal route even higher, at almost 10 days, than the estimated time savings from the U.S. Department of Agriculture (23). Time savings associated with the intermodal route compared to the all-water route can vary widely because transit time is impacted by a number of factors, including weather, number of port stops, inspections, and bottlenecks at rail ramps. However, the intermodal route is more expensive than the all-water route—some estimates place the cost for using the intermodal route at about \$1,000 more per container than the all-water route (23).

#### *Possible Impact of Panama Canal Expansion on Container Traffic*

Water routes are generally less expensive per container than land routes, and shippers may decide that the lower cost is worth the additional travel time of using the Panama Canal, especially for goods that are not time-sensitive. For goods that are time-sensitive, shippers may prefer the speed of the intermodal route over the Panama Canal, despite the additional cost. Another incentive for using the intermodal route over the Panama Canal is that there is more flexibility on land than on water. For example, the final destination for a shipment arriving from China at the Port of Los Angeles can change from Memphis to Chicago once the shipment arrives in Los Angeles. The latter may result from the need for inventory in Chicago as opposed to Memphis since the shipment left China. Cargo moving by water cannot be re-routed until it

reaches a port, whereas cargo moving by surface transportation mode can easily be shifted from one destination to another.

Already there is evidence that traffic on the Asia–U.S. West Coast route grew more than traffic on the Asia–U.S. East Coast route from January–October 2016 (24, 25). Traffic to the U.S. Gulf Coast increased by 20 percent during the same time, but this still makes up a small portion of Asia–U.S. trade compared to the West Coast (24).

### *Suez Canal*

The Suez Canal is another alternative to the Panama Canal. The modern Suez Canal was opened in 1869 and is owned by the Egyptian Government. The canal is 118 miles long and connects the Mediterranean Sea to the Gulf of Suez on the Red Sea. Without the Suez Canal, a vessel traveling west from Shanghai to the U.S. East coast would have to travel around the Cape of Good Hope at the southern tip of Africa. The Suez Canal has no locks and can handle Neopanamax vessels. It has a transit time of 14 hours southbound and 10 hours northbound (22).

Some industry experts state that for U.S.-Asia trade, the key competition is not West Coast vs. East Coast ports, but rather whether or not a ship will use the Panama Canal vs. the Suez Canal (23). In the recent past, the Suez Canal increased in popularity because of an increased amount of goods being produced in South and Southeast Asia (24). However, there is evidence that a majority of shippers now prefer the Panama Canal to the Suez Canal for routes between the U.S. and Asia because of the reduced trip time, and the new expanded capacity of the Panama Canal (24). Figure 6 shows that Hong Kong is the cutoff point where the Panama Canal route and the Suez Canal route are the same distance to the U.S. East Coast (18).



**Figure 6. Hong Kong is the Cutoff for Using the Panama Canal vs. the Suez Canal to Reach the U.S. East Coast.**

As stated earlier, maritime travel times can vary based on speed of vessel, weather patterns, and other factors; however, using the Suez Canal to travel from Asia to the U.S. East Coast generally takes longer than using the Panama Canal. Bloomberg Markets recently estimated that the Asia–U.S. Gulf Coast all-water route using the Suez Canal takes 31 days (26). The same source estimated that avoiding the Suez Canal and going around the Cape of Good Hope in South Africa takes 34 days, and that using the Panama Canal to travel an all-water route from Asia to the U.S. East Coast takes 20 days, as shows in Figure 7 (26).

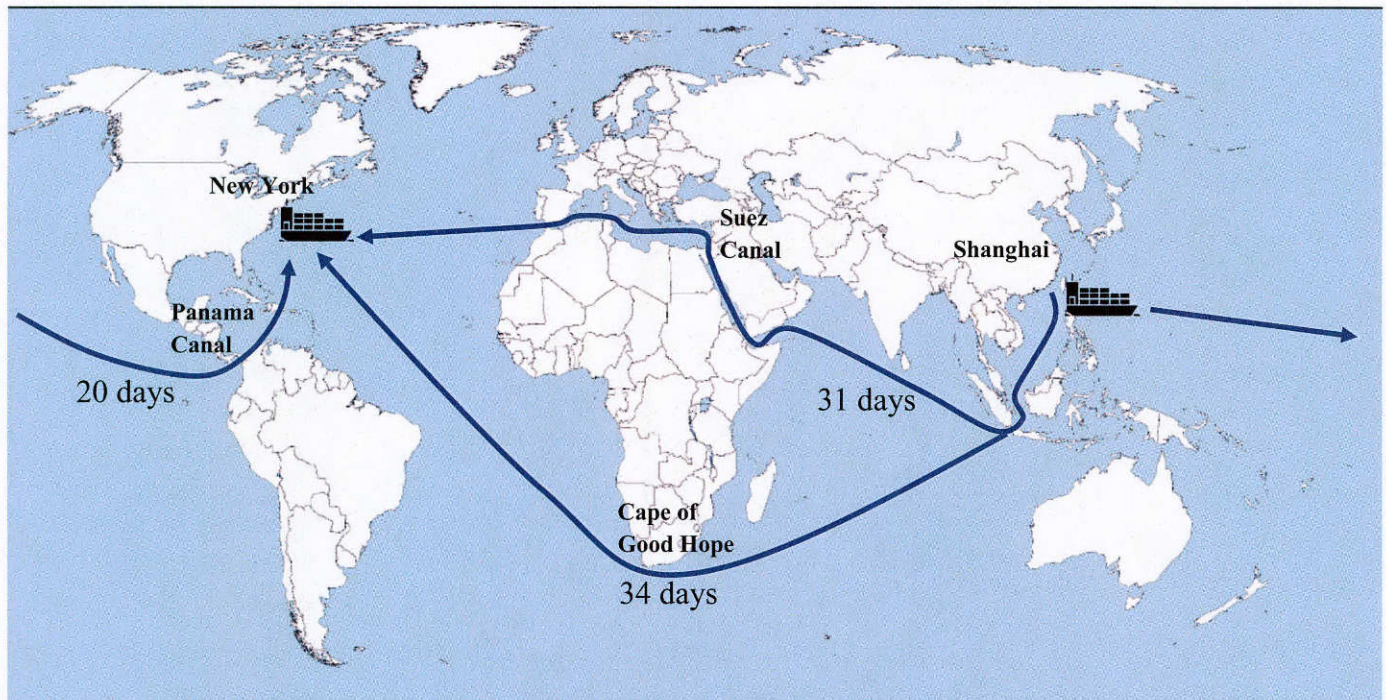


Figure 7. Suez Canal and Panama Canal All-Water Routes.

### *Possible Impact of Panama Canal Expansion*

According to the Bloomberg Markets estimate, traveling from north and central Asia to the U.S. East Coast via the Suez Canal takes 11 days longer than using the Panama Canal. However, Southeast Asia has begun to export more to the U.S., and the Suez Canal is the shorter route between these two markets (24,27). Twenty-five percent of U.S. imports from Southeast Asia travel through the Suez Canal, 65 percent travel through U.S. West Coast ports, and the final 10 percent travel through the Panama Canal.

The faster travel time from north and central Asia to the U.S. via the Panama Canal will likely continue to give the Panama Canal the advantage between those two markets. However, imports from Southeast Asia will likely travel through the Suez Canal because of time savings on that already-established route.

### **Additional Factors**

Aside from alternative route options, there are several additional factors that may influence shippers' decision to use the Panama Canal.

#### *Tolls*

The Panama Canal Authority (ACP) charges vessels a toll to pass through the canal. ACP changes tolls regularly; the current toll structure was implemented in 2016 (28). Tolls are calculated based on the type of vessel and whether the vessel is loaded ("laden") or empty ("in ballast").



Since 1994, tolls have been based on the Panama Canal Universal Measurement System (PC/UMS) net ton, which in turn is based on the international standard of vessel admeasurement (measurement of vessel capacity) established by the International Convention of Measurement of Ships of 1969. The system provides a mathematical formula for the measurement of total ship volume stated in net Panama Canal tons, a ton being equivalent to 100 cubic feet of volumetric capacity. The appropriate rate is applied depending on whether the ship is laden or in ballast (empty). The laden rate is applied to ships carrying cargo, containers, or passengers, and the ballast rate is applied to ships that are not carrying passengers, containers, or cargo.

In 2005, the Panama Canal Authority implemented a change in its admeasurement system for full container vessels and those vessels with container-carrying capacity on-deck.<sup>7</sup> The change was from PC/UMS Net Ton (the ACP's traditional measurement of full container vessels) to a twenty-foot equivalent unit (TEU). It also established the total TEU capacity, including on-deck, as the basis for the new charge.

The following sections explain the toll calculations for container ships, tankers, LNG carriers, and bulk cargo ships, the vessel types most likely to take advantage of the new lock dimensions. Other vessel types, although important to ACP's business, rarely require the use of locks larger than the pre-expansion locks.<sup>8</sup>

### *Container Ships*

Table 3 shows the current toll rate for containerships. To put this in perspective, the Journal of Commerce reported in its August 21, 2017, edition that the estimated ocean freight cost of moving one 40-ft container (FEU) from Shanghai to West Coast ports was \$1,661. This means the cost of moving a 20-ft container (TEU) was about half this amount, or \$830. The ocean freight cost of moving an FEU from Shanghai to East Coast ports was \$2,661, or about \$1,330 per TEU (29).<sup>9</sup> Using these estimates, the highest tariff possible per TEU (\$60) makes up 7 percent of the cost of shipping a TEU from Shanghai to U.S. West Coast ports, and 4.5 percent of the cost of shipping a TEU from Shanghai to East Coast ports.

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<sup>7</sup> "Full" in this case means that the vessel is designed to carry only containers. The vessel can be "full container" and be empty, which means it is designed to carry only containers, but is not currently carrying any.

<sup>8</sup> Different toll structures exist for dry bulk vessels, tanker vessels, chemical tanker vessels, liquefied petroleum gas carrier vessels, liquid natural gas carrier vessels, roll on/roll off (Ro-Ro) and vehicle carriers, passenger vessels, and refrigerate cargo, general cargo, and other segments. For more information, see:

<https://www.pancanal.com/eng/op/tolls.html>.

<sup>9</sup> These rates do not reflect volume incentives or other concessions made by carriers to preferred customers. Customers can receive discounts as part of a larger or longer-term contractual arrangement.

**Table 3. Panama Canal Toll Rate for Containerships.**

Locks	TEU Range	Tariff for Total TEU Allowance (TTA) Maximum Capacity	Tariff for Loaded Containers on Board (TEU)
<b>Panamax 1</b>	Less than 1,000	\$60	\$30
	1,000–1,999	\$60	\$30
	2,000–3,499	\$60	\$30
	3,500 or more	\$60	\$30
<b>Neopanamax 2</b>	Less than 6,000	\$60	\$40
	6,000–6,999	\$50	\$40
	7,000–7,999	\$50	\$40
	8,000–8,999	\$50	\$40
	9,000–9,999	\$50	\$35
	10,000–10,999	\$50	\$35
	11,000–11,999	\$50	\$35
	12,000 or more	\$50	\$35

The following examples illustrate the use of this table (30):

1. Laden vessel: capacity of 5,000 TEUs, with 3,000 loaded TEUs, using the Panamax locks:
  - 5,000 TEUs × \$60 = \$300,000 [TTA maximum capacity tariff].
  - 3,000 TEUs × \$30 = \$90,000 [TEU loaded tariff].
  - Total = \$390,000.
2. Laden vessel: capacity of 8,000 TEUs, with 4,800 loaded TEUs, using the Neopanamax locks:
  - 8,000 TEUs × \$50 = \$400,000 [TTA maximum capacity tariff].
  - 4,800 TEUs × \$40 = \$192,000 [TEU loaded tariff].
  - Total = \$592,000.

For customers who transport high volumes of containers through the canal each year, a loyalty program exists. Discounts in the capacity tariff are as follows:

- **\$1 per TEU discount on capacity tariff:** registered TEU capacity volume of 450,001–999,999.
- **\$2 per TEU discount on capacity tariff:** registered TEU capacity volume of 1,000,000–1,499,999.
- **\$3 per TEU discount on capacity tariff:** registered TEU capacity volume of 1,500,000 or more.

### *Tanker Vessels*

Tanker vessels carry oil and other liquid products, excluding LNG and chemicals. They move refined products from refineries to points near consumer markets. Table 4 shows the current toll rate for tankers posted on the Panama Canal Authority's website (proposed rates for 2016).

**Table 4. Panama Canal Toll Rate for Tankers.**

Panama Canal Universal Measurement System (PC/UMS) Bands (capacity)	Panamax Locks	Neopanamax locks		Ballast Tariff per PC/UMS	
	\$ per PC/UMS	Capacity tariff \$ per PC/UMS	Cargo Bands in metric tons (MT) 3		Cargo transported \$/MT (cargo)
First 10,000	\$5.00	\$5.17	First 20,000	\$0.30	\$4.14
Next 10,000	\$4.90	\$5.00	Next 20,000	\$0.20	\$3.99
Next 15,000	\$4.85	\$5.10	Next 20,000	\$0.35	\$3.80
Next 10,000	\$4.75	\$4.00	Next 20,000	\$0.18	\$3.60
Rest	\$4.55	\$3.25	Rest	\$0.10	\$3.45

The following examples illustrate the use of this table (31):

- Laden vessel: Capacity of 40,000 deadweight tonnage (DWT) or 18,490 PC/UMS using the Panamax locks:
  - Toll:  $(\$5.00 \times 10,000) + (\$4.90 \times 8,490) = \$91,601$ .
- Laden vessel: capacity of 100,000 DWT or 46,136 PC/UMS carrying 60,000 MT of cargo and using the Neopanamax locks:
  - Capacity tariff:  $(\$5.17 \times 10,000) + (\$5.00 \times 10,000) + (\$5.10 \times 15,000) + (\$4.00 \times 10,000) + (\$3.25 \times 1,136) = \$221,892$ .
  - Cargo tariff:  $(\$0.30 \times 20,000) + (\$0.20 \times 20,000) + (\$0.35 \times 20,000) = \$17,000$ .
  - Total = \$238,892.

### *Liquefied Natural Gas (LNG) Carriers*

Table 5 shows the current toll rate for LNG carriers posted on the Panama Canal Authority's website (proposed rates for 2016). LNG tolls are assessed on cubic meters of capacity rather than

Panama Canal Universal Measurement System (PC/UMS). The ballast rate applies when the vessel is transporting not more than 10 percent of its cargo carrying capacity. Laden vessels that make a return trip through the canal in ballast in less than 60 days are charged the ballast (roundtrip) rate.

**Table 5. Panama Canal Toll Rate for LNG Carriers.**

Bands in cubic meters	Laden	Ballast	Ballast (Roundtrip)
<b>First 60,000</b>	\$2.50	\$2.23	\$2.00
<b>Next 30,000</b>	\$2.15	\$1.88	\$1.75
<b>Next 30,000</b>	\$2.07	\$1.80	\$1.60
<b>Rest</b>	\$1.96	\$1.71	\$1.50

The following example illustrates the use of this table (32):

1. Laden vessel: capacity of 174,000 cubic meters:
  - $(\$2.50 \times 60,000) + (\$2.15 \times 30,000) + (\$2.07 \times 30,000) + (\$1.96 \times 54,000) = \$382,440$ .

### ***Bulk Carriers***

Rates for dry bulk vessels are differentiated according to the type of cargo. Table 6 shows the current toll rate for grain vessels posted on the Panama Canal Authority's website (proposed rates for 2016). Ballast (empty) grain vessels are charged the same rate for the Panamax and Neopanamax locks. The website has additional tables for coal, iron ore, and other dry bulk.

**Table 6. Panama Canal Toll Rate for Bulk Carriers-Grain.**

DWT Bands	Panamax Locks	Neopanamax locks		Both Locks
	\$ per DWT	Fixed Tariff (\$ per DWT)	Variable Tariff (\$ per Cargo MT)	Ballast Tariff (\$ per DWT)
<b>First 5,000</b>	\$4.09	\$5.74	\$0.35	\$2.75
<b>Next 5,000</b>	\$3.23	\$4.97	\$0.34	\$2.40
<b>Next 10,000</b>	\$2.57	\$4.21	\$0.33	\$2.00
<b>Next 20,000</b>	\$2.38	\$2.68	\$0.30	\$1.89
<b>Next 20,000</b>	\$2.09	\$1.91	\$0.25	\$1.75
<b>Next 25,000</b>	\$1.71	\$0.77	\$0.20	\$1.25
<b>Next 35,000</b>	\$1.28	\$0.38	\$0.15	\$0.45
<b>Rest</b>	\$0.86	\$0.38	\$0.10	\$0.25

The following examples illustrate the use of this table (33):

1. Laden vessel: capacity of 34,948 DWT, using the Panamax locks
  - $(\$4.09 \times 5,000) + (\$3.23 \times 5,000) + (\$2.57 \times 10,000) + (\$2.38 \times 14,948) = \$97,876.24$ .
2. Laden vessel: capacity of 82,000 DWT, with 75,000 tons of cargo, using the Neopanamax locks:<sup>10</sup>
  - Fixed Tariff:  $(\$5.74 \times 5,000) + (\$4.97 \times 5,000) + (\$4.21 \times 10,000) + (\$2.68 \times 20,000) + (\$1.91 \times 20,000) + (\$0.77 \times 22,000) = \$204,390$ .
  - Variable Tariff:  $(\$0.35 \times 5,000) + (\$0.34 \times 5,000) + (\$0.33 \times 10,000) + (\$0.30 \times 20,000) + (\$0.25 \times 20,000) + (\$0.20 \times 15,000) = \$20,750$ .
  - Total = \$225,140.

### ***Possible Impact of Panama Canal Expansion***

Despite the additional time needed to use the other alternatives (i.e., going around South America, or using the Suez Canal) it is possible that shippers will choose longer routes to avoid Panama Canal tolls. Currently some shippers are avoiding the Panama and Suez Canals altogether because low fuel prices are making longer routes more affordable (34). The Suez Canal, for its part, has recently offered toll discounts to shippers to compete with the Panama Canal and encourage shippers to use the Suez Canal instead of traveling around the Cape of Good Hope (35).

### ***Port Infrastructure***

The effect of the Panama Canal expansion on specific ports and regions will depend in part on the infrastructure at the port and in the surrounding region. To handle Neopanamax vessels, ports must have adequate infrastructure, such as special cranes and a channel depth that can accommodate the Neopanamax size.

Not all U.S. ports can accommodate the larger vessels that can now pass through the Panama Canal. However, ports that cannot accommodate Neopanamax vessels may still experience increased cargo volumes due to the canal expansion. This is because many vessels transload the containers they are carrying onto other vessels to get to their final destination. For example, a Neopanamax vessel may come fully loaded from Shanghai to a port in the Caribbean. It could then shift some of its cargo onto smaller vessels to spread out to other ports, much like a truck with a full container would shift its cargo onto smaller delivery trucks to reach individual homes or stores. There may also be a cascade effect; as larger ships replace the current fleet, the replaced ships will now be deployed to other ports, effectively increasing the average size of ships serving ports.

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<sup>10</sup> Example based on vessel with characteristics similar to *Trade Prosperity*, an existing grain carrier that is too large for the Panamax locks.

Figure 8 shows the U.S. Ports that have handled vessels larger than Panamax. These are vessels that have passed through the new locks, but are not necessarily the largest size vessel that can fit through the new locks.



**Figure 8. U.S. Container Ports that Have Handled Larger than Panamax Vessels.**

Table 7 shows some of the characteristics of the deepwater container ports that have handled larger than Panamax-sized vessels.

Table 7. Characteristics of U.S. Deepwater Container Ports.

	Port Name	Port Location	Maximum Channel Depth (36)	TEUs handled (2015) (37) <sup>11</sup>	Total Tonnage (Short Tons, 2015) (38)
<b>East Coast</b>	Massport	Boston, MA	45' (39)	191,198	16,843,278
	NY/NJ	New York, NY	50'	4,625,380	126,690,317
	South Jersey Port Corporation	Camden, NJ	40'	143,877	6,923,348
	Philadelphia	Philadelphia, PA	45'	315,130	19,966,352
	Wilmington	Wilmington, NC	42'	232,732	7,914,373
	Morehead City	Morehead City, NC	45'	-	2,896,233
	Baltimore	Baltimore, MD	50'	616,198	39,403,769
	Port of Virginia <sup>12</sup>	Norfolk, VA	50'	2,021,416	57,762,086
	Charleston	Charleston, SC	47' (40)	1,551,578	21,811,005
	Savannah	Savannah, GA	42'	2,824,529	35,204,956
	Jacksonville	Jacksonville, FL	40'	857,037	17,577,034
	Canaveral	Cape Canaveral, FL	46'	-	4,066,610
	Everglades	Fort Lauderdale, FL	43'	716,183	23,058,020
	Miami	Miami, FL	52' (41)	765,980	7,810,480
<b>Gulf Coast</b>	Tampa	Tampa, FL	43'	39,761	35,934,390
	Manatee	Palmetto, FL	40'	24,167	2,077,618
	Pascagoula	Pascagoula, MS	42'	-	26,589,863
	Mobile	Mobile, AL	45'	182,725	58,594,752
	Baton Rouge	Baton Rouge, LA	45'	-	68,781,974
	Plaquemines	Belle Chasse, LA	45'	-	53,506,448
	New Orleans	New Orleans, LA	45'	365,699	87,809,854
	South Louisiana	LaPlace, LA	45'	-	259,102,230
	Brownsville	Brownsville, TX	42'	-	7,779,109
	Beaumont	Beaumont, TX	40'	-	87,169,875
	Corpus Christi	Corpus Christi, TX	45'	-	85,674,966
	Freeport	Freeport, TX	45'	73,633	21,132,931

<sup>11</sup> Total of domestic and foreign containers, loaded and empty.

<sup>12</sup> The Port of Virginia is also known as Hampton Roads.

	Galveston	Galveston, TX	45'	22,320	10,380,588
	Houston	Houston, TX	45'	1,753,106	240,933,410
	Port Arthur	Port Arthur, TX	40'	-	35,787,331
<b>West Coast</b>	Seattle	Seattle, WA	50'	1,236,563	22,606,608
	Tacoma	Tacoma, WA	51'	1,687,017	22,626,117
	Everett	Everett, WA	40'	30,451	1,599,169
	Kalama	Kalama, WA	43'	-	13,320,919
	Longview	Longview, WA	43'	-	11,061,788
	Vancouver	Vancouver, WA	43'	2,699	8,444,247
	Portland	Portland, OR	55'	16,612	18,624,568
	Coos Bay	Coos Bay, OR	47'	-	1,755,356
	Oakland	Oakland, CA	50'	1,724,556	17,565,619
	Los Angeles	Los Angeles, CA	53'	5,526,289	60,187,840
	Long Beach	Long Beach, CA	76'	5,236,011	78,164,597
	San Francisco	San Francisco, CA	55'	-	1,800,051
	San Diego	San Diego, CA	47'	60,167	1,454,921



### *Possible Impact of Panama Canal Expansion*

Port Houston is Texas's largest port and handles 95 percent of all waterborne container traffic in Texas. To prepare for the larger vessels using the Panama Canal, the port invested millions of dollars in larger cranes, longer docks, and dredging a deeper channel (42). Port Houston has predicted an increase in traffic in the long-term due to the Panama Canal expansion. They believe that the newly deepened Port will attract heavier or larger vessels to unload there (43). Other Gulf Coast ports, such as Mobile and New Orleans, also believe their traffic will increase (43). Port Freeport in Texas plans to dredge its channel with the hope of adding jobs (42). The federal government has approved expanded channels for the Port of Brownsville, Port of Corpus Christi, Port Freeport, and the Sabine-Neches Waterway, but no money has been appropriated to these projects.

Houston has the advantage of being one of the largest destinations for imports from Northeast Asia. Houston imports a large share of industrial products, such as chemicals and chemical products (8). However, 65 percent of goods destined for Houston from Northeast Asia by weight come through West Coast ports, not Port Houston (8). For high-value Northeast Asian goods destined for Houston, up to 90 percent enter through a West Coast port (8). This means that an increase of Asian imports to the Houston region may not necessarily lead to an increase in traffic at Port Houston.

*Sixty-five percent of goods destined for Houston from Northeast Asia by weight come through West Coast ports, not Port Houston.*

With regards to U.S.-Asia trade, Gulf Coast ports specialize in exporting agricultural commodities to Asia (8). Because the expanded Panama Canal allows for more cost-effective shipping by lowering per-unit costs, this may make Texas exports more competitive. Exports of cotton, a major Texas agricultural export, between the Gulf Coast and Asia are expected to increase as a result of the Panama Canal expansion (44). In terms of imports, the amount of international trade entering the Gulf Coast via the Panama Canal is relatively low but is growing (8, 24).

### *Challenges at the Canal*

Despite the potential benefits of the expanded Panama Canal, there are several issues that may hinder its use, at least in the short term.

1. The first is a **decrease in global shipping**, potentially due to a slowing Chinese economy (45). In October, there were reports that traffic at the new locks was far below capacity (18). The new locks have 12 transit slots available for reservations per day, and reports were that often less than a third were filled.
2. As recently as October, the International Transport Workers' Federation (ITF) raised concerns about the **safety of the locks**, specifically that the Panama Canal lacked

sufficient staff, tugs, training, and operational procedures to safely navigate vessels through the canal (46).

3. Another issue is the new tugboats being used to guide vessels through the new locks. Operators at the canal have complained that the tugs are difficult to maneuver and that there is **not enough room to guide new vessels through the locks** (47). A feasibility study done by the Panama Canal Authority in 2003 stated that the new locks would need to be 328 ft longer and 40 ft wider than they are in order for the tugboat system to operate safely and efficiently (48). Additionally, some vessels, such as oil tankers, need to be retrofitted with modifications so that they can be maneuvered by tugboats rather than the locomotives used to guide vessels through the old locks (49).
4. Finally, the Panama Canal requires a large amount of water to operate. Water to fill the locks comes from the man-made Gatún Lake in Panama. Recently, concerns have been raised that Gatún Lake and rainwater are **not reliable enough water sources to keep the locks functioning** properly. In February 2016, the Panama Canal Authority issued an advisory warning about the low level of Gatún Lake (50). One month later, shippers were asked to lighten their loads so as not to scrape the bottom of the channel (47).

## Panama Canal Data

### *Vessel Transits*

The new locks were opened in 2016. The study team compared Panama Canal traffic data from 2015 and 2016 to obtain initial insight into the potential effects of the Panama Canal expansion on transits and cargo weight. However, the new locks were only open for 6 months in 2016, so 2017 data will be a useful resource once it is released, because it will be the first full year that the new locks were in operation. The Panama Canal Authority does not release information on transits or tonnage separately for each set of locks. This means that transit and tonnage data represent what passed through both the old and new locks.

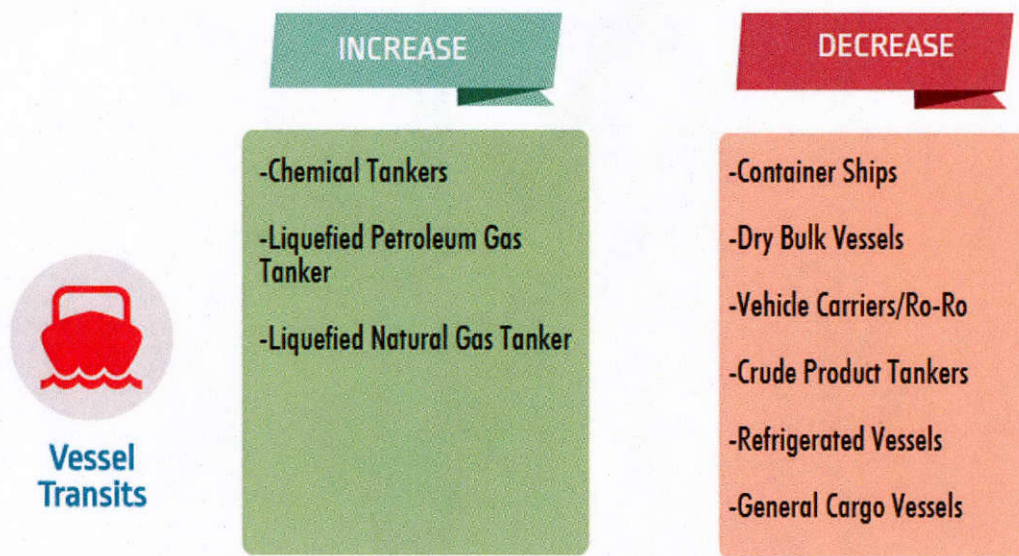
The number of transits by some vessel types increased between fiscal years 2015 and 2016, while others decreased. More chemical tankers, liquefied petroleum gas (LPG) tankers, and liquefied natural gas (LNG) tankers passed through the Panama Canal in fiscal year 2016 than in fiscal year 2015. Container ship and dry bulk vessel transits decreased during the same time. Figure 9 shows which types of vessels increased and decreased transiting through the canal from 2015 to 2016 (6).

*Liquefied natural gas (LNG) is natural gas stored as a very cold liquid (between  $-120$  and  $-170^{\circ}\text{C}$ ).*

*Liquefied petroleum gas (LPG) is a byproduct of natural gas processing and refining petroleum.*

*It consists of a variety of elements, such as propane, butane, etc. and is stored in pressurized steel.*

*(Source: Alternative Fuel Systems, <http://www.afsglobal.com/faq/gas-comparisons.html>)*



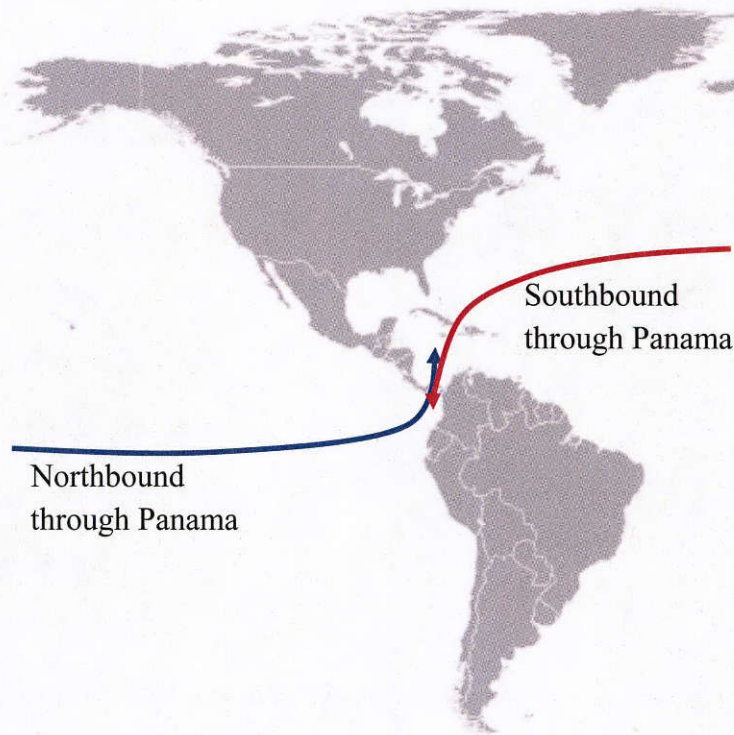
**Figure 9. Change in Number of Vessel Transits, 2015–2016.**

The new locks were built to accommodate larger ships. The fact that container ship<sup>13</sup> transits decreased from 2015 to 2016 indicates that the new locks did not have the immediate effect of increasing transits of these vessels. However, because the new locks were open for only 6 months of 2016, it may be too soon to see the effects of the expansion.

LNG tanker vessels are a market that could be greatly affected by the expansion of the Panama Canal. Prior to the opening of the new locks, only about 8 percent of the world’s LNG tankers could fit through the Panama Canal (7). Now, it is estimated that 86 percent of the LNG fleet can pass through the canal (8). Because of the Panama Canal expansion, LNG shipping costs could be reduced by 25 percent, and some research has argued that LNG exports could benefit more from the expansion than containers (7).

Separating north and southbound traffic through the Panama Canal provides more detailed information. Traffic that is traveling east to west passes through the canal in the southbound direction. Traffic traveling west to east passes through the canal in the northbound direction. Figure 10 shows some of the major routes traveling northbound and southbound through the Panama Canal.

<sup>13</sup> Container ships in the Asian-North American trade routes tend to push the size limitations of the canal.



**Figure 10. Direction of Travel through Panama Canal.**

For most vessel types, decreases or increases in transit or tonnage between 2015 and 2016 happened in both directions. For example, dry bulk decreased in transits and tonnage, both northbound and southbound. However, there were a few exceptions. For container ships, transits and tonnage increased northbound, but decreased southbound. This suggests that there were increases on routes that use the Panama Canal traveling northbound, such as the Asia to U.S. East Coast route, and decreases on routes that travel south through the Panama Canal, such as the U.S. East Coast to Asia route.

Additionally, it appears that containerships and refrigerated vessels were either loaded heavier or larger in 2016 than 2015. For containerships, the ratio of tonnage to transit (i.e. how many tons were on each ship) increased in both the northbound and southbound direction. Refrigerated vessels had fewer transits in both the north and southbound directions, but they had higher tonnage in both directions during the same timeframe. This suggests that fewer refrigerated vessels carried more cargo.

Table 8 shows the number of transits and tonnage by vessel type in 2015 and 2016, in both the northbound and southbound direction (6).

Table 8. Vessel Transits and Tonnage, 2015–2016.

Northbound						Southbound						
Number of Transits			Tonnage (Panama Canal/ UMS Net Tonnage, thousands) <sup>14</sup>			Market Segment	Number of Transits			Tonnage (Panama Canal/ UMS Net Tonnage, thousands)		
<b>1,549</b>	1,571	Increase	58,075	64,003	Increase	Container	1,520	1,406	Decrease	57,049	55,797	Decrease
<b>1,615</b>	1,358	Decrease	40,274	33,699	Decrease	Dry Bulk	1,649	1,276	Decrease	42,670	32,101	Decrease
<b>465</b>	446	Decrease	26,718	25,901	Decrease	Vehicle Carriers/Ro-Ro	379	363	Decrease	21,489	20,858	Decrease
<b>831</b>	918	Increase	17,255	19,281	Increase	Chemical Tankers	848	981	Increase	17,512	20,338	Increase
<b>324</b>	279	Decrease	9,097	7,447	Decrease	Crude Product Tankers	330	302	Decrease	9,186	8,128	Decrease
<b>221</b>	227	Increase	5,223	5,785	Increase	Liquefied Petroleum Gas (LPG)	199	222	Increase	4,943	5,757	Increase
<b>493</b>	481	Decrease	4,572	4,581	Increase	Refrigerated	470	467	Decrease	4,417	4,458	Increase
<b>446</b>	400	Decrease	4,683	4,782	Increase	General Cargo	358	310	Decrease	3,994	3,636	Decrease
<b>2</b>	10	Increase	38	826	Increase	Liquefied Natural Gas (LNG)	0	7	Increase	0	681	Increase

<sup>14</sup> The tonnage measurement system for Panama Canal tolls assessment, the Panama Canal Universal Measurement System (PC/UMS), as discussed earlier in this report.

## Tonnage

The Panama Canal collects tonnage data on different routes. Between 2015 and 2016, tonnage decreased on all routes that passed through the Panama Canal with origin or destination to the U.S. East Coast. This indicates that there has been no immediate effect of increased traffic at East Coast U.S. ports.

Almost all routes through the canal with origin or destination of the West Coast U.S., experienced increased tonnage in 2016. The exception was tonnage between East Coast Central America to West Coast U.S., which decreased. Table 9 shows the tonnage on key trade routes that utilize the Panama Canal (6).

**Table 9. Tonnage on Trade Routes Using the Panama Canal.**

Trade Route Between		PC/UMS Tons		Change
		2015	2016	
<b>Asia</b>	East Coast U.S.	104,903	104,791	Decrease
<b>West Coast South America</b>	East Coast U.S.	38,606	35,877	Decrease
<b>Oceania</b>	East Coast U.S.	5,698	5,617	Decrease
<b>Pacific World</b>	East Coast U.S.	3,587	1,846	Decrease
<b>West Coast Canada</b>	East Coast U.S.	618	585	Decrease
<b>Europe</b>	West Coast U.S.	10,190	12,318	Increase
<b>East Coast South America</b>	West Coast U.S.	2,512	6,169	Increase
<b>East Coast Central America</b>	West Coast U.S.	2,756	1,738	Decrease
<b>West Indies</b>	West Coast U.S.	1,038	1,171	Increase

## Top Users

Cargo originating or destined for the United States is the principal user of the Panama Canal, accounting for two-thirds of the cargo passing through the canal. This means that the U.S. was the origin or destination of more tonnage that passed through the canal than any other country. This is followed by China, Chile, Peru, and others. Table 10 shows the top countries using the Panama Canal by weight in long tons,<sup>15</sup> for fiscal year 2016 (6).

<sup>15</sup> A long ton is 2,240 lb.

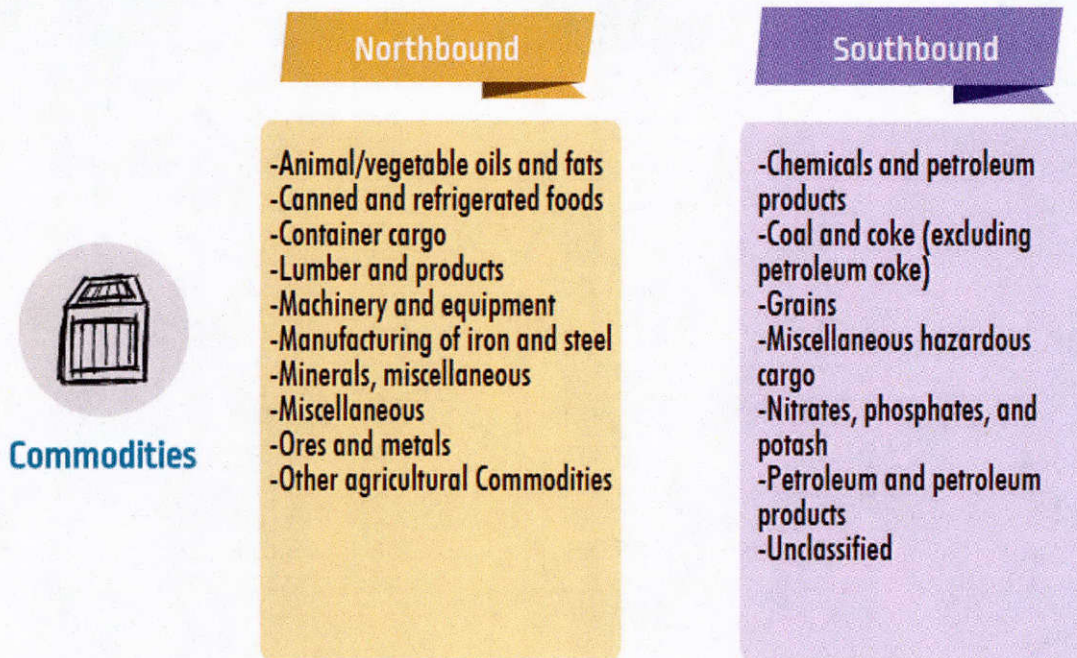
Table 10. Top Countries Using the Panama Canal by Cargo Weight (Fiscal Year 2016).

Rank	Country	Origin (Long Tons)	Destination (Long Tons)	Intercoastal (Long Tons)	Total (Long Tons)	Percent of Total
1	United States	90,601,908	48,425,590	1,872,249	139,027,498	67.0%
2	China	14,309,907	24,346,444	-	38,656,351	18.9%
3	Chile	11,690,237	13,625,533	-	25,315,770	12.4%
4	Peru	7,083,524	12,363,533	-	19,447,057	9.5%
5	Japan	5,672,413	13,361,308	-	19,033,721	9.3%
6	Korea	9,365,172	6,864,052	-	16,229,224	7.9%
7	Mexico	6,601,069	9,457,746	651,353	16,058,815	7.5%
8	Colombia	8,639,924	7,260,834	402,702	15,900,758	7.6%
9	Ecuador	5,054,404	7,315,911	-	12,370,315	6.0%
10	Canada	8,453,316	2,678,470	-	11,131,786	5.4%
11	Guatemala	2,021,304	5,669,781	24,699	7,691,085	3.7%
12	Panama	851,136	4,835,022	78,266	5,686,158	2.7%
13	Trinidad and Tobago	3,521,850	270,024	-	3,791,874	1.9%
14	Spain	1,231,179	2,396,811	-	3,627,990	1.8%
15	Belgium	1,448,507	2,091,516	-	3,540,023	1.7%

### Commodities

Data are also available on what commodities travel through the canal, and in which direction. Separating commodities by north and southbound travel can help provide insight into what goods might be traveling on what routes. For example, more animal/vegetable oils and fats travel northbound than southbound, which means that they are more prevalent on routes that travel north through the Panama Canal, such as Asia to the U.S. East Coast. Additionally, a much higher amount of grain travels southbound than northbound, suggesting that grains may be traveling from the U.S. Gulf Coast Ports to Asia, but not likely from Asia to the U.S. Gulf Coast. Figure 11 shows the dominant direction for each commodity (6).<sup>16</sup>

<sup>16</sup> The category “miscellaneous” includes clay, paper products, slag (waste from metal refinement), and other products. For more information, see: <https://www.panacanal.com/eng/op/transit-stats/2016/Table07.pdf>.



**Figure 11. Commodities Transiting the Panama Canal by Direction, 2016.**

Overall, there was a decrease in total commodities crossing through the Panama Canal from 2015 to 2016. However, certain commodities increased in volume. Some commodities increased in one direction, and decreased in the opposite direction. An example of this is chemicals and petroleum chemicals, which increased southbound through the canal, but decreased northbound. This potentially indicates that the production of chemicals and petroleum products in North America was increasing, resulting in more exports and a reduced need for imports. Table 11 shows commodity weight by direction from 2014 to 2016 (6).



Table 11. Commodities at the Panama Canal by Direction, 2014–2016, Thousands of Long Tons.

Northbound				Southbound				
2014	2015	2016	Change 2015–2016	Commodity	2014	2015	2016	Change 2015–2016
2,414	2,216	2,230	Increase	Animal/Vegetable Oils and Fats	459	418	340	Decrease
2,488	2,332	2,478	Increase	Canned and Refrigerated Foods	58	145	91	Decrease
4,101	5,117	3,940	Decrease	Chemicals and Petroleum Chemicals	8,393	8,608	12,466	Increase
2,618	2,584	2,451	Decrease	Coal and Coke (excluding petroleum coke)	11,671	7,601	6,671	Decrease
24,952	21,592	22,601	Increase	Container cargo	21,884	18,417	18,099	Decrease
3,943	2,979	5,018	Increase	Grains	44,679	49,345	35,794	Decrease
1,634	1,584	1,889	Increase	Lumber and Products	1,380	935	571	Decrease
2,984	3,383	3,521	Increase	Machinery and Equipment	1,898	1,800	1,693	Decrease
5,045	6,431	4,603	Decrease	Manufacturing of Iron and Steel	1,685	539	620	Increase
9,199	11,388	6,912	Decrease	Minerals, Miscellaneous	202	172	127	Decrease
4,439	3,913	3,374	Decrease	Miscellaneous <sup>17</sup>	3,036	2,736	2,568	Decrease
257	132	264	Increase	Miscellaneous Hazardous Cargo	765	1,035	951	Decrease
3,602	3,631	3,295	Decrease	Nitrates, Phosphates, and Potash	4,116	4,086	4,007	Decrease
11,353	12,341	9,192	Decrease	Ores and Metals	3,702	2,001	1,842	Decrease
2,063	2,102	1,746	Decrease	Other Agricultural Commodities	513	992	1,119	Increase
8,452	9,713	6,904	Decrease	Petroleum and Petroleum Products	32,230	36,821	34,174	Decrease
91	449	674	Increase	Unclassified	1,210	1,610	3,477	Increase
89,635	91,887	80,094	Decrease	Total	137,882	137,259	124,611	Decrease

<sup>17</sup> Miscellaneous includes bricks, cement, flour, glass, paper, rubber, seeds, and textiles, among other products. For more information, see: <https://www.pancanal.com/eng/op/transit-stats/2016/Table07.pdf>

## Texas – East Asia Trade

Not all Texas exports destined for East Asia leave directly from Texas. Some commodities are first shipped to another state before they leave the country. Texas exports to East Asia that leave through other states almost exclusively leave through California. Because this report is focused on marine transportation, this section focuses on exports and imports from East Asia by water. Goods shipped by plane between East Asia and the U.S. are excluded.

In 2015, 77 percent of Texas exports to East Asia (by weight) left directly from Texas.<sup>18</sup> Twenty-one percent of Texas exports to East Asia by weight left the U.S. through California (14).

For Texas imports from East Asia, 78 percent (by weight) traveled directly by water to Texas in 2015. Twelve percent of imports from East Asia to Texas entered the U.S. through California (14). Figure 12 shows where Texas **exports** leave the U.S. for East Asia by weight (14). Figure 13 shows where **imports** from East Asia to Texas entered the U.S. by weight (14).

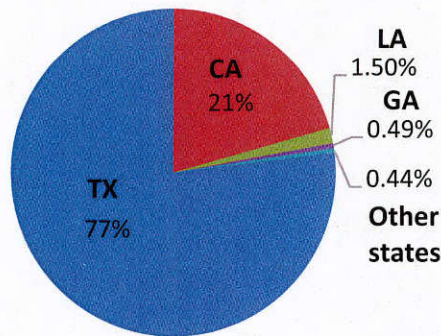


Figure 12. Where Texas Exports to East Asia Exit the U.S. (Weight, 2015).

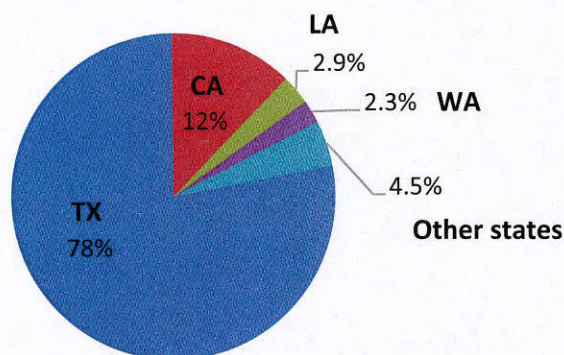
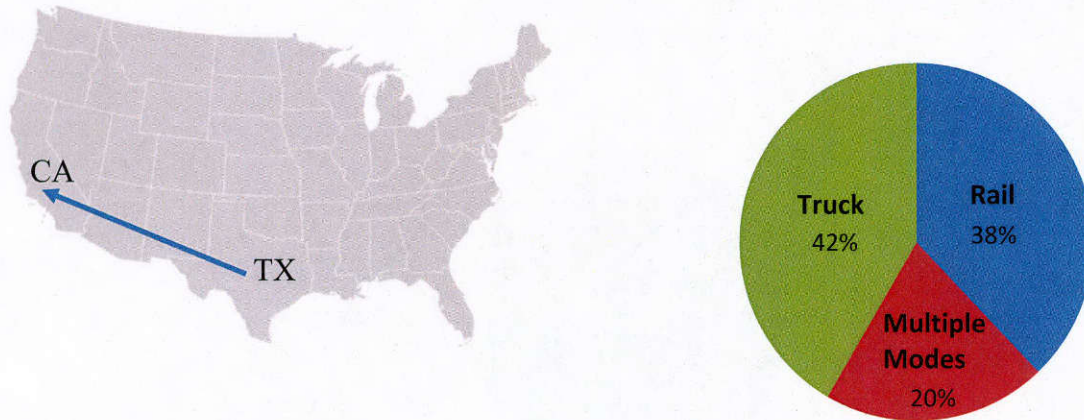


Figure 13. Where Texas Imports from East Asia Enter the U.S. (Weight, 2015).

<sup>18</sup> East Asia includes China (including Hong Kong and Macao), Japan, Mongolia, and North and South Korea. The international FAF regions are based on the United Nations Geographic Regions. For more information, see: <https://unstats.un.org/unsd/methodology/m49/>.

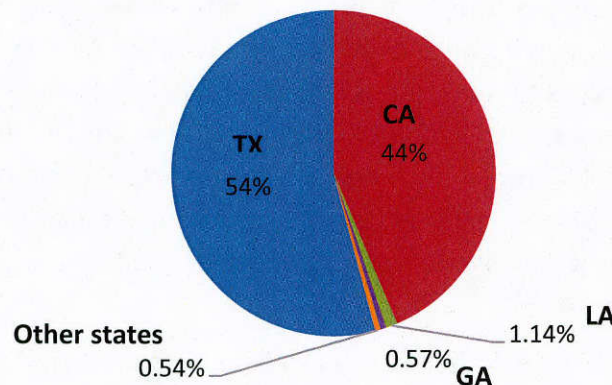
California is an important exit point for Texas exports to East Asia. Figure 14 shows the transportation modes used to move Texas exports to California. Truck and rail transport similar weights of Texas – East Asia exports to California. Trucks transport 42 percent of goods, and rail exports 38 percent of goods. This is followed by multiple modes with 20 percent (14).



**Figure 14. How Texas Exports to East Asia Reach California (by Weight, 2015).**

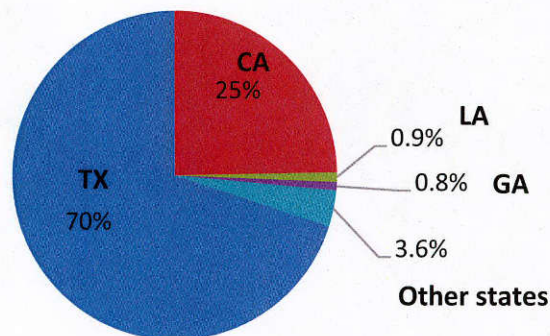
Comparing goods by weight to goods by value provides more information on how more expensive commodities are traveling. In the case of Texas trade with East Asia, a higher percentage of more expensive goods (higher value) leave or enter from another state, especially California. The intermodal route between East Asia, California, and Texas is faster than the all water route to Texas, and there is evidence that shippers prefer more expensive, time-sensitive goods to use West Coast ports because of the time savings (4).

Almost half of the value of Texas **exports** leave the U.S. for East Asia through California - forty four percent of Texas exports to East Asia by value left the U.S. though California (14). The other half leave through Texas (14). Figure 15 shows where Texas exports leave the U.S. for East Asia by value.



**Figure 15. Where Texas Exports to East Asia Leave the U.S. by Water (Value, 2015).**

More **imports** travel directly between East Asia and Texas than exports. However, the percentage of Texas imports by value entering through other states is still higher than the percentage by weight. This suggests that higher value imported goods are more likely to come through other states, but it is not as pronounced as in the case of exports. Figure 16 shows where Texas imports from East Asia enter the U.S. (14).



**Figure 16. Where Texas Imports from East Asia Enter the U.S. by Water (Value, 2015).**

### *Texas Commodities*

The same commodity traded between Texas and East Asia may have different points of exit and entry. For example, 91 percent of alcoholic beverages exported from Texas to East Asia (by weight) leave through California. And 92 percent of alcoholic beverages imported from East Asia enter directly in Texas (14).

This suggests that the logistics chain for Texas exports of alcoholic beverages to East Asia is different than for Texas imports of alcoholic beverages from East Asia. There are many different factors that can influence this: different commodities within this sector (i.e., beer vs. vodka), capacity differences, costs, etc.

For other commodities, the point of exit for exports and point of entry for imports is the same. In the case of fuel oils, 99 percent of Texas fuel oils exported to East Asia (by weight) leaves through Texas. And 86 percent of fuel oils imported from East Asia enters directly in Texas (14). This suggests that Texas has a specialization in handling this commodity, or that shipping it over land to or from California is less economical than entering or exiting through a Texas port. The mode of transportation may also be an important factor. Overland routes use mostly containers. But fuel oils are mostly moved in tankers, making intermodal transfers difficult and not cost-effective.

For some commodities, there is no dominant supply chain between East Asia and Texas in either direction. Plastics and rubbers are an example of this. For Texas exports of plastics and rubbers to East Asia, 39 percent by weight leave through Texas and 59 percent leave through California.

For Texas imports of plastics and rubbers from East Asia, 36 percent by weight enter in Texas, and 29 percent enter through California (14).

Table 12 shows selected commodities Texas trades with East Asia and their state of entry or exit. States with at least 5 percent of the volume are listed under “other states.” Percentages have been rounded to the nearest whole number, and states that have less than 5 percent of the volume are not included in the table. This explains why rows may not add up to 100 percent.

For example, the first line of Table 12 can be interpreted in the following way:

“For basic chemicals exported from Texas to East Asia, 96 percent, by weight, left the U.S. directly from Texas. One percent left the U.S. via California. For basic chemicals imported from East Asia to Texas, 86 percent, by weight, entered the U.S. in Texas. Four percent had California as the point of entry to the U.S., and seven percent had Oregon as the point of entry.”

A complete list can be found in Appendix A: Texas-East Asia Traded Commodities.

Table 12. Point of Exit for Texas Export Commodities to East Asia (by Weight, 2015)/Point of Entry for Texas Import Commodities from East Asia (by Weight, 2015).

Commodity	Exit State (exports)			Entry State (imports)		
	Texas	California	Other states <sup>19</sup>	Texas	California	Other states <sup>19</sup>
Basic chemicals	96%	1%		86%	4%	Oregon: 7%
Cereal grains	97%	2%		35%	3%	Virginia: 34% Georgia: 28%
Chemical products	33%	56%	Louisiana: 9%	55%	11%	Louisiana: 24% Georgia: 6%
Crude petroleum	100%	-		-	-	
Electronics	17%	83%		53%	43%	
Fuel Oils	99%	-		86%	14%	
Live Animals/Fish	100%	-		-	-	Virginia: 75% Georgia: 25%
Logs	57%	43%		-	100%	
Machinery	33%	66%		68%	22%	
Meat/seafood	42%	56%		87%	11%	
Milled grain products	97%	1%		92%	4%	
Other agricultural products <sup>20</sup>	41%	58%		17%	77%	Maryland: 6%
Pharmaceuticals	15%	34%	Georgia: 36% Louisiana: 8%	35%	36%	Georgia: 21% South Carolina: 5%
Plastics/rubber	39%	59%		63%	29%	New Jersey: 9%
Precision instruments	27%	73%		73%	23%	

<sup>19</sup> Other states are listed if they have 5 percent or higher.

<sup>20</sup> This includes agricultural products other than animal feed and grains, such as tomatoes, bananas, apples and raw cotton. For more information, see: <https://www.census.gov/svsd/www/cfsdat/cfs071200.pdf>.

## Port Interviews

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### Issues Included

This section of the report includes information gathered from port interviews about the potential effects of the Panama Canal expansion. Ports were asked about the following subjects:

- Current infrastructure and capacity at the port.
- Current impacts of the Panama Canal expansion.
- Expected future effects of Panama Canal expansion.
- Challenges facing ports.
- Help the port needs to succeed.

Appendix B: Port Interview Questions includes a copy of the questions that were asked of the port representatives.

### Participants

Several port executives were interviewed regarding the effects of the Panama Canal expansion on their port community. To be certain that all relevant factors and effects were considered, ports along the entire Gulf Coast were contacted. A secondary objective was to see how Texas ports were faring in comparison to other Gulf ports, since the Gulf of Mexico is considered a homogeneous region for Panama Canal traffic analyses. The ports that provided interviews to the research team were:

- The Port of Greater Baton Rouge, Louisiana.
- The Port of Beaumont, Texas.
- Port of Corpus Christi, Texas.
- Port Houston, Texas.
- The Port of Mobile, Alabama.
- Port Tampa Bay, Florida.

### Methodology

Port surveys were conducted through in-person and phone interviews. Some respondents provided written responses.

## Interview Results

### *Port Infrastructure and Capacity*

Estimating the maximum vessel size a port can accommodate is not always straightforward. Maximum vessel size is sometimes measured in terms of volume (i.e., number of TEUs per vessel). However, physical dimensions are a more accurate descriptor, as vessels of the same dimensions can have different carrying capacities based on vessel design.

Maximum depth is included here because it is one of the crucial factors deciding whether a ship will use a port. The maximum draft the new locks at the Panama Canal can accommodate is 50 ft. Some of the characteristics of the ports that were interviewed are included in Table 13.



**Table 13. Characteristics of Ports Interviewed.**

Port Name	Maximum Vessel Draft (ft)	Maximum Vessel Size	Maximum Cargo Capacity
<b>Baton Rouge</b>	45	Aframax Vessel (medium-sized crude tanker) - 816' length overall (LOA), up to 144' beam (width of the vessel).	80,000–120,000 tons
<b>Beaumont</b>	40	Can handle Aframax tankers, but those vessels are not loaded to capacity.	The maximum load handled to date is 60,000 tons (which happens fairly frequently).
<b>Corpus Christi (POCC)</b>	45	Can handle a Very Large Crude Carrier (VLCC), with dimension of 1,200' long, 220' wide, and an air draft of no greater than 138'. This represents the extreme limits and only a few docks can accommodate a ship of that size.	The cargo capacity of a VLCC would be 2 million barrels, but due to draft restrictions of 45', the vessel cannot be loaded to maximum capacity. POCC recently had a vessel with 900,000 barrels (the largest load to date).
<b>Houston</b>	45	Port Houston (POH) terminals have the following LOA/Beam/Draft limitations: Bayport: 1096'×143'×40' Bayport (once Flare Bend Easing project is complete): 1160'×150'×45' Barbours Cut (Berths 2-6): 1000'×138'×45' Barbours Cut (Berth C1): 1158'×141'×45'  POH has “22 wide” cranes, which means that the crane can reach across 22 rows of containers.	Currently, the largest ships POH handles regularly are in the 6,600-6,800 TEU range. A typical ship size right now is 4,500 TEUs. POH feels that the land side of their operations is ready to handle the larger vessels. When the Bayport Flare Bend Easing is complete, port should be able to handle vessels up to 10,000 TEU. <sup>21</sup> They expect a Maersk Class A vessel, which is rated at 9,200 TEU, Barbours Cut is ready for these large vessels.
<b>Mobile</b>	45		Can handle container vessel with capacity of about 8,700 TEU. Most ships currently handled range between 4,000 and 6,000 TEU. The larger ships to date have been mostly part of the European services.
<b>Tampa Bay</b>	43	Draft of 43'.	Container vessels up to 9,000 TEU and bulk vessels up to 80,000 tons.

<sup>21</sup> The Bayport Flare-Bend Easing of the Bayport Ship Channel is a widening and deepening project located at the intersection of the Houston Ship Channel and the entrance to the Bayport Terminal and its facilities. The project will broaden a turn that will allow larger ships to safely navigate the channel. For more information, see: [http://www.swg.usace.army.mil/Portals/26/docs/Planning/Review%20Plans/HSCPDR/Review%20Plan%20\(Bayport%20Flare%20to%20HSCPDR\)%20Oct%202015\(%20IEPR%20EXCL\).pdf](http://www.swg.usace.army.mil/Portals/26/docs/Planning/Review%20Plans/HSCPDR/Review%20Plan%20(Bayport%20Flare%20to%20HSCPDR)%20Oct%202015(%20IEPR%20EXCL).pdf).

### *Current Effects of Expanded Panama Canal*

The study team asked the port representatives the following questions about the impacts that the expanded Panama Canal already had on the ports to date:

1. How many vessels has the port received that used the expanded Panama Canal?
2. What specific vessel type (tankers, container ships) went through the expanded Panama Canal?
3. Do you have a count of such vessels by type?
4. Since June of last year, has the port seen an increase in the volume of trade that used the Panama Canal (both old and new locks)?
5. Imports? Exports? What types of commodities?

Most port representatives reported that the ports have not yet received any vessels that have gone through the expanded Panama Canal. Detailed information for each port follows.

#### *Port of Greater Baton Rouge*

Current impact of Panama Canal expansion: Unknown.

The port does not keep statistics on whether vessels used the expanded Panama Canal on its route to Baton Rouge; therefore, they do not know if they have received any vessels that used the new Panama locks.

#### *Port of Beaumont*

Current impact of Panama Canal expansion: None.

The port has a controlling draft of 40 ft. Vessels that use the new Panama Canal locks have drafts deeper than 40 ft; therefore, the port does not expect the canal expansion to have any impact on them until the channel is deepened.

#### *Port of Corpus Christi (POCC)*

Current impact of Panama Canal expansion: None.

The port has not handled any vessels that have come through the new Panama Canal locks yet. The large tankers that would use the new locks cannot be accommodated at POCC, so the Panama Canal expansion will not immediately affect the port.

#### *Port Houston*

Current impact of Panama Canal expansion: Minimal.

So far, Port Houston staff, which only tracks container vessels, reports receiving two container vessels that have used the expanded Panama Canal.

The port receives three container services per week. One of these container services started in May 2016 (2M Alliance). The port feels that this new container service may be due to the Panama Canal expansion. Overall, the number of containers Port Houston receives that went

through the Panama Canal (old and new locks) has increased since the early 2000s. In 2002, none of the containers received or shipped at POH came through the Panama Canal. Currently, about 37 percent of loaded import containers come through the Panama Canal from Asia.

### *Port of Mobile*

Current impact of Panama Canal expansion: Unknown.

One of the container services at the Port of Mobile is using a Neopanamax vessel in their string, so the port may receive ships that use the new locks. However, they cannot currently report how many vessels they have received that used the new locks.

Two new Asian services were initiated at Mobile in June 2017. They now have three regular container services. The port feels that this is in part due to the canal project, but not entirely.

### *Port Tampa Bay*

Current impact of Panama Canal expansion: None.

Port Tampa Bay reported that the Panama Canal expansion has not yet affected the port.

### *Future Effects of Expanded Panama Canal*

The study team asked port representatives the following questions related to what they expect for the future:

1. Do you expect to see a change in volume due to the Panama Canal expansion in the medium to long term?
  - a. If yes, what commodities?
  - b. How much of a difference in tonnage and vessel calls do you predict?
  - c. If yes, what specifically have you done to prepare for an increase in volume?

### *Port of Greater Baton Rouge*

The port does not expect any new opportunities for their users from the expanded canal. The Port of Baton Rouge does almost no business with Asia. Almost all their trade is east and south.

Baton Rouge is located on the Mississippi River, which is the key route for exports from the grain producing region of the U.S. The port does not believe their agricultural shipments will be influenced by the expanded Panama Canal. This is because the operator of their grain elevator operator already has facilities on the West Coast. The grain trade in Baton Rouge is typically a north-south business.

### *Port of Beaumont*

The Port of Beaumont believes they will benefit from the expanded canal once the Sabine-Neches Waterway (SNWW) is deepened. The deepening of the SNWW to 48 ft is approved, but not yet funded by Congress. Once the channel deepening project is completed the Port of Beaumont expects an immediate effect on bulk shipments, both dry and liquid. The port expects

dramatic gains in economies of scale, with more cargo per vessel resulting in lower cost per ton. The deeper channel will make trade with Asia much more competitive.

In the meantime, the port is building all new docks to handle 50-ft drafts. When existing docks are refurbished, they are being deepened to 50 ft. When the channel is deepened, they expect the port to rebuild some of their docks. They expect private industries that have facilities on the SNWW to rebuild some of their docks as well.

### ***Port of Corpus Christi***

The Port of Corpus Christi thinks that future impacts from the expanded Panama Canal will be minimal, as most of their trade is south or east, not with Asia. The biggest opportunities for using the new locks are in LNG and crude oil exports.

The Harbor Bridge replacement will raise the vertical clearance from 138 ft to 205 ft to accommodate larger ships. The new bridge should be complete in three years, and is funded by Nueces and San Patricio Counties, POCC and state and federal sources (51). The Port of Corpus Christi also plans to start dredging to 52 ft in a few years, once the bridge is complete. The port has their financial match for dredging the channel; they are waiting on the federal money.<sup>22</sup> The Port of Corpus Christi signed an agreement with the U.S. Army Corps of Engineers in September 2017 allowing construction to begin with port money, prior to federal appropriations (52). On the land side, the port finished expanding their rail facilities two months ago. The storage yard now has eight tracks.

### ***Port Houston***

Port Houston expects larger vessels once certain infrastructure improvements are completed at the port. When the Bayport Flare-Bend Easing is completed, they expect to handle vessels with up to 10,000 TEUs. They expect a Maersk Class A vessel, which is rated at 9,200 TEU. Barbours Cut can already service these large vessels.

To prepare for larger vessels, Port Houston recently widened the Bayport Channel, but pilots must be comfortable maneuvering within the space to use it. If pilots are uncomfortable, vessels will not come to POH. In 2017, Port Houston purchased three Super Post Panamax cranes as part of a \$700 million modernization program for Barbours Cut. Four others were delivered to Barbours Cut in 2015 (53). It is expected that Port Houston will increase terminal capacity from 1.2 to 2 million TEUs (54). Port Houston is also extending its gate hours and expanding the number of truck lanes (55).

Consumer goods are the major import commodity at Port Houston (i.e., anything you buy at Walmart, Home Depot, furniture). Major exports are resins—resins alone are about 35 percent of

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<sup>22</sup> Traditionally for a depth up to 45 ft the Army Corps of Engineers paid 100 percent of maintenance dredging cost after the channel was improved. Starting in 2014, the Army Corps of Engineers now pays 100 percent of maintenance dredging costs up to 50 ft. Beyond 50 ft, the local sponsor is responsible for 50 percent of the maintenance dredging cost.

all POH exports, and chemicals make up 15 percent of all exports. POH expects to see resin exports increase as new facilities come on line in 2017 and 2018. Both resins and chemicals are transported in containers.

### *Port of Mobile*

The Port of Mobile believes that only a few Gulf ports, such as Mobile and Houston, will benefit from the expanded canal. The expanded canal will have the most effect on Asian trade; therefore, ports with high volumes and strong Asian trade will benefit the most. In the Gulf, that means Mobile and Houston.

To prepare for the expanded Panama Canal, Port of Mobile already purchased Super Post Panamax cranes in June 2017. The port already has Neopanamax cranes with a reach of 19 rows.

In terms of commodities, a Walmart distribution center will soon be in Mobile. Mobile already has a healthy trade in automobile manufacturing components.

Aside from containers at the Port of Mobile, the port reported that LNG out of Texas will benefit from the expanded canal. Grain may also benefit somewhat at other ports. At the Port of Mobile, lumber and forest products and steel both use vessels with 40 ft drafts or less, so these commodities will not be affected by the canal expansion. The Port of Mobile's coal trade is heavily concentrated on the East Coast of South America, Europe, and the Mediterranean; none of which use the Panama Canal.

### *Port Tampa Bay*

Port Tampa Bay thinks that the canal expansion may result in a weekly container service at the port, which could amount to 50,000 TEU annually. These would be Asian direct services. Port Tampa Bay does not currently have a weekly container service. With vessels now willing to come into the Gulf on a regular basis to Houston and Mobile, it would be a minor adjustment for them to call at Tampa as well.

Last year Port Tampa Bay acquired Neopanamax cranes that reach across 21 rows of containers, in anticipation of container traffic into Tampa. Container service is the one area the port expects the canal expansion to have a direct influence on their opportunities.

### *Challenges at Ports*

The study team asked the following question to port representatives about the challenges they are facing:

1. What challenges does the port face in benefiting from the expanded Panama Canal? (i.e., competitors, landside access to port, funding)

### *Port of Greater Baton Rouge*

A major challenge at the port is the dredging costs of keeping the Mississippi River accessible year-round.

### ***Port of Beaumont***

The major challenge at the Port of Beaumont is getting the channel deepened, which is currently at 40 ft. Once the channel is deepened, the port feels that other things will fall into place.

### ***Port of Corpus Christi***

One of the challenges is the lack of local demand for goods, because Corpus Christi is a small town and the port is not a container port. For example, a high percentage of the containers handled at Port Houston stay in Houston, and 80 percent of the containers go no further than Dallas. This is not the case in Corpus Christi. Another challenge is the need for the new bridge construction to be completed. Currently, the new bridge is being built, which will provide a higher clearance for vessels.

Another challenge is that a high volume of oil is coming to the area via pipeline, because of a boom in Texas oil exports, and the Texas coast is running out of storage for oil.

### ***Port Houston***

A major challenge at Port Houston is dredging. The justification for dredging in the past focused primarily on tankers, but now container ships are playing an increasingly important role.

Another challenge is roads and bridges. Port Houston needs a good road system to move cargo out. The recently passed SB 1524 (heavy haul legislation) was helpful. The bill allows a 93,000-lb weight limit for trucks with 6 axles within 30 miles of the dock, and 100,000 lb for trucks with seven axles. The new weight limits will take effect January 1, 2018 (56). The current weight limit is 80,000 pounds or 84,000 with a permit (56).

Rail connectivity is also a challenge. Only one intermodal train leaves the port per week. POH has on-dock rail, and a train (“Texas Shuttle”) leaves POH to Dallas. However, POH needs help with rail connectivity, and Texas in general needs to figure out how to move more cargo by rail. Some companies are moving their polyethylene resin products in hopper cars to packaging facilities, for example in Dallas/Fort Worth and Charleston, South Carolina, which then load containers and ship them to the East or West Coast, as opposed to using POH. Companies have given POH feedback that the problem with using POH is not the port, but the connectivity. Increasing rail capacity to Port Houston would help keep business in Texas.

POH says they need more transit and storage yard capacity. The Houston area needs more local rail capacity, storage, and yards. This issue was raised in a previous effort conducted by the Texas A&M Transportation Institute (TTI) Policy Research Center, and the railroads responded. Union Pacific stated that the company maintains extra capacity to accommodate excess demand, and in the past UP has contracted with third party for extra rail yard capacity. Union Pacific has invested in capacity to accommodate increased resin shipments, and plans to continue to invest in response to demand (57).

### ***Port of Mobile***

The only potential obstacle they see to benefitting from the expanded canal is the possibility of trade wars due to limitations on free trade. Most of the competitive pressure they face is in the European market.

### ***Port Tampa Bay***

One of the biggest challenges they face is publicizing the amount of opportunity located in the I-4 corridor between Tampa and Orlando. There is a lot of warehousing and distribution activity in Central Florida, but most freight moves by truck, rail, or through East Coast Florida ports. Port Tampa Bay is located on the West Coast of Florida.

As far as potential cargo expansion, on the import side the primary potential is in containers. On the export side, there may be potential to expand non-fertilizer agricultural shipments.

### ***Help Needed to Increase Competitiveness***

The study team asked port representatives:

1. What would be the greatest help (e.g., needed investments) in increasing the port's competitiveness (and therefore volume) to attract more vessels that traverse the expanded Panama Canal?

### ***Port of Greater Baton Rouge***

Additional dredging funding.

### ***Port of Beaumont***

Deepening the channel.

### ***Port of Corpus Christi (POCC)***

Dredging is their top priority. POCC wants to get to 52 ft, and they are authorized to this depth. They need the Harbor Bridge construction to be completed quickly.

### ***Port Houston***

Houston has a lot favoring it. For example, Houston has a large market for goods. The port also has the land-side infrastructure it needs to accommodate larger vessels.

Depth and width: POH has a 45-ft operating depth and they need help with dredging.<sup>23</sup> The justification for dredging in the past focused primarily on tankers, but now container ships are playing an increasingly important role and should also be a focus.

POH needs help with freight mobility, especially rail connectivity to main markets. POH would like more cooperation from the railroads. The trend they see currently is rail using West Coast

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<sup>23</sup> Operating depth is the maximum draft a vessel can have and maintain sufficient clearance under the vessel.

ports for Texas goods. Texas ports are limited by the number of Class 1 railroad connections. They also need a good road and bridge system to move cargo out.

### ***Port of Mobile***

Port of Mobile needs to expand the length of their container docks to take full advantage of the expanded canal. Right now, they have two 1,000-ft berths, which is not enough to dock two vessels at the same time. They would need to add another 400 ft to accommodate two vessels at once. They hope to start construction on dock lengthening next year.

### ***Port Tampa Bay***

Their biggest challenge is spreading the word that they can offer competitive services.

### ***Potential Impact of Panama Canal Expansion***

A few port representatives provided information in response to the following question:

1. Do you have anything else to add on the potential impact of the Panama Canal that you could share with us?

### ***Port of Corpus Christi***

The biggest opportunities for using the new locks are in LNG and crude oil exports.

### ***Port Houston***

Port Houston expects a cascade effect of receiving 8,000–10,000 TEU vessels coming to the Gulf due to the Panama Canal expansion. This means that as the new, largest container vessels go to other ports, smaller ones (but larger than the current vessels in the gulf) will come to Port Houston.

### ***Additional Information***

The Port of Freeport and the Port of Brownsville have invested to facilitate larger vessels. The study team did not interview these ports, but Port Freeport recently completed Velasco Terminal Berth 7, which has two cranes to handle Neopanamax vessels. They also plan to add two more berths at the same terminal, and will eventually widen their main channel from 400 to 600 ft (11). The Port of Brownsville currently has \$43 billion in projects, and has authorization from Congress to deepen from 42 to 52 ft (58). Some see Brownsville and other ports as alternatives to Port Houston because of the congestion in the Houston Ship Channel.



## Industry Interviews

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This section of the report includes information gathered from interviews with industry stakeholders about the potential effects of the Panama Canal expansion. Stakeholders were asked about the following:

- Industry trends.
- Industry special needs.
- Current impacts of the Panama Canal expansion.
- Expected future effects of Panama Canal expansion.

## Participants

The study team reached out to several companies, but only a few agreed to be interviewed. The companies that were interviewed were:

- Valero.
- Occidental Energy Marketing.
- Phillips 66.
- Greater Houston Port Bureau.

## Valero

### *Industry Trends*

In 2016, a 40-year ban on exporting crude oil to countries other than Canada was lifted. Prior to this, the U.S. typically exported about 200,000 to 300,000 barrels per day to the only country it could export to, Canada. The most recent data, from May 2017, shows the U.S. exported about 1.2 million barrels per day to foreign markets (59). The large increase in crude exports is partly because the U.S. can now export to other foreign countries, and partly due to the significant increase in production from fracking.

Valero uses all Texas ports, as they have refineries all over Texas. They also use the Port of New Orleans, and have multiple facilities on the Mississippi. They use Florida ports as well. They do not export through West Coast ports, as it makes more sense to use the port closest to their facilities. They do ship their products to the West Coast, especially ethanol by rail, as a final market destination.

### *Industry Special Needs*

Port capacity is an important issue. Infrastructure improvements at ports are needed to support current exports and facilitate growing crude oil, LNG, and petrochemical exports. This is especially true in Texas because many pipelines lead to Texas ports. There is a growing market

for crude, now that the U.S. can export to other countries, but the U.S. must compete with other countries' oil.

Most industry analysts predict that crude oil production will increase in the future, and Valero sees significant investment in crude oil logistic assets (pipelines and terminals) to support the expected growth. Capacity is not only an issue at ports, but also for pipelines. For example, there is a need for more pipeline infrastructure out of the Permian Basin.

### *Current Impact of the Panama Canal Expansion*

Current impact of the Panama Canal expansion: None.

Despite the Panama Canal Expansion, there has not been a significant increase in crude exports to Asia. This is because Asia has other suppliers and does not need U.S. crude. Asia gets a large portion of their crude from the Middle East. The U.S. expects crude exports to Asia to grow in the future, and the expanded Panama Canal will facilitate this trade relationship.

Valero is a refiner who does not participate in the exploration or production of oil. Valero refines a mix of domestic and imported foreign raw materials. Valero has not seen an impact on raw material supplies due to the expanded canal. Valero regularly ships clean products (i.e., gasoline, diesel, and jet fuel) through the canal serving customers on the Pacific side of Central and South America in vessel sizes that do not need to use the expanded locks. It is possible that as U.S. crude oil production grows, a steady movement of U.S. crude to Asia could occur and utilize the expanded canal. Shipments to date have tended to be test cargos for Asian refiners to validate the quality and processing impacts in their facilities.

### *Expected Future Effects of Panama Canal Expansion*

Use of fracking technology has led to growth in the production of natural gas in the U.S. as various facilities come into operation. Valero is monitoring port congestion due to the incremental growth in LNG shipments, which thus far has not been problematic to their marine traffic. The expanded canal provides an efficient route to Asian markets for LNG producers, and traffic is increasing to these markets.

## **Occidental Energy Marketing**

### *Industry Special Needs*

Crude oil tries to take advantage of arbitrage opportunities—the simultaneous purchase and sale of crude to take advantage of the difference in cost and the price they can sell for. Arbitrage opportunities are fleeting and short-term in nature, and there is no way to predict when they will need to make a shipment through Panama.

### *Current Impact of the Panama Canal Expansion*

Current impact of the Panama Canal expansion: None.

Occidental Energy Marketing, Inc. (OEMI) executives visited Panama in spring 2017 and were disappointed by what the new canal could offer them in terms of crude oil shipments.

The problem, they felt, was in the reservation system. For container lines that have a fairly fixed schedule, reservations seem effective. However, crude oil tries to take advantage of arbitrage opportunities. As explained above, there is no way to predict when they will need to make a shipment through Panama.

It is OEMI's understanding that right now Panama is only allowing 3 transits per day each way through the new locks (6 total). The authority plans to go to 10 or 12 total eventually, but this is still a limited number of transits daily. If shippers make a reservation and miss it, they must wait for an unreserved opening, which can be a few days, and in turn could wipe out an arbitrage opportunity. Crude oil marketers need more flexibility than what a reservation system allows.

It is also OEMI's understanding that when an LNG ship goes through, the other two sets of locks at that end of the canal must be vacant.

Given this background, an improved ship channel will not help OEMI take advantage of the Panama Canal. OEMI's terminal is in Corpus Christi, which has a depth of 45 ft. For the very large vessels OEMI wants to handle, it would still be impossible to fully load the vessel even at the 50-ft depth the port authority is seeking to achieve (which is also the limitation of the new locks). A 50-ft depth at POCC would help marginally in shipping to other markets. They could load a Suezmax vessel to the full one million barrels instead of their current limitation of 900,000 barrels imposed by the current 45-ft water depth at POCC. Being able to load vessels fuller would save 20 to 25 cents per barrel on shipping cost, depending on the final market destination. However, a very large crude carrier (VLCC) needs a 66-ft draft when fully loaded (60). Therefore, whether they have 45 or 52 ft, they would still have to partially load the VLCC at their terminal and then top it off with a lightering run out in the gulf.

## **Phillips 66**

### *Industry Trends*

As a refiner, Phillips 66 imports crude oil from various regions and produces refined products such as diesel, gasoline, jet fuel and kerosene. The ships they employ to transport their various liquid hydrocarbons transit the Panama Canal only sporadically. While a typical crude import would be a fully loaded Suezmax tanker from West Africa, this movement would not require a canal transit. Despite the recent expansion of the canal system in June 2016, a fully laden Suezmax would still be too deep to pass through the increased lock dimensions – though one loaded to only 80 percent of capacity would normally fit through.

Phillips 66 processes both domestic and imported crude at their three refineries on the Gulf Coast. These refineries then export refined products through their marine terminals at Belle Chasse, LA; Lake Charles, LA; and Freeport, TX. Once the crude oil is refined, Phillips 66 exports refined products to many places. A regular outlet for diesel produced in these refineries would be Europe, where diesel is usually preferred to gasoline. Latin America and West Africa have also been recurring destinations for their exported fuels.

Phillips 66 has limited exports to Asia, as this region can usually meet its need for refined products from shorter haul sources. Further, refineries in Asia, the Middle East, and India continue to grow in number and size, making regional sourcing an obvious choice.

### *Industry Special Needs*

While port infrastructure can usually be built or improved with capital expenditures, one port related item that needs continual attention is water levels within the ports. Over time, silt and sediment can build in a ship channel, as well as individual terminals, thereby limiting the draft of the vessel that can call the port. As the depth within a channel decreases, vessels are forced to load less cargo, which increases costs by reducing the gains from economies of scale. The solution to the silting issue is to have a specialized vessel known as a “dredge” effectively dig out the newly formed channel bottom and return the waterway to its original depth. This is effective, but time consuming, and tends to be temporary as silting is a perpetual process.

### *Current Impact of the Panama Canal Expansion*

Current impact of the Panama Canal Expansion: None.

The expanded Panama Canal system has led to increased volumes transiting between the Pacific and Atlantic oceans. This increase is from a combination of additional lanes being added, which allow for a higher number of ships, but also because the new locks can accommodate even larger ships. With the old locks having a width of 32.2 meters, the limiting factor for a ship transiting the canal was its beam. In terms of oil tankers, the largest size ship that could transit the old locks with this restriction could carry about 55,000 tons of cargo. The new, wider locks allow for a 49 m beam. Within the tanker world, this means that not only can an Aframax vessel (approximately 75,000-ton cargo capacity) transit the canal, but a partially laden Suezmax vessel can transit. While a fully laden Suezmax can lift roughly 135,000 tons, a vessel using the canal would light load to only about 80 percent of capacity, or about 110,000 tons.

Within the LPG trade, the largest ship size is called a Very Large Gas Carrier (VLGC), which carries roughly 44,000 metric tons of liquefied petroleum gas. Only a handful of VLGCs can pass through the old Panama Canal locks, so most of these ships can only use the new locks.

All told, Phillips 66 uses the Panama Canal only sporadically because their major trade routes do not need it.

The expanded locks are more likely to impact the liquefied natural gas (LNG) and containership sectors than tankers and dry bulk. Sourcing patterns and trade routes for these ship classes benefit more from the expanded lock dimensions than other shipping markets.

### *Expected Future Effects of Panama Canal Expansion*

Currently, Phillips relies on the Panama Canal for some of its crude, refined product and liquefied petroleum gas (LPG) shipping needs, but these volumes are small relative to their global shipping footprint. However, there are many companies that are heavy Panama Canal

users. Any issue at the canal or geopolitical shock could drastically change trade patterns overnight, and shippers would have to adjust and change quickly to meet demand.

## **Greater Houston Port Bureau**

The Greater Houston Port Bureau is the industry association for users of the Houston Ship Channel (61).

### *Industry Trends*

Maintenance dredging is a big issue. Texas ports need deeper and wider channels.

The biggest issue limiting use of the canal is the port's channel depth, but width is also an issue. Many of the larger vessels are getting wider rather than longer, and that may cause the pilots to impose one-way or daylight restrictions on traffic. Having a wider channel would make it possible to increase the traffic without diminishing safety.

### *Current Impact of the Panama Canal Expansion*

Current impact of Panama Canal expansion: Minimal.

The Greater Houston Port Bureau feels that the effects of the expanded Panama Canal have been minimal to date.

### *Expected Future Effects of Panama Canal Expansion*

The Greater Houston Port Bureau believes that only two types of ships will use the larger locks consistently—container ships and gas carriers (LPG and LNG).

Increased resin production in conjunction with the expanded canal may create an interesting scenario. Currently, when containers come into Dallas from Los Angeles or Long Beach, the opportunities for backhaul are minimal; therefore, revenue from backhauls is minimal. Railroads do not want to move containers for minimal revenue, which is what happens when they return with empty containers.

However, resin exporters will pay a much higher rate for exports. Carriers, such as Maersk, might even be motivated to lower the water rate on imports to Houston, to capitalize on backhaul resins, because carriers make more money when they have a backhaul rather than returning empty. POH provides an alternative to trains from the west coast that might leave Dallas empty.<sup>24</sup> This could force the railroads to lower rates, leading to a very competitive transportation system. Railroads might even improve north-south lines in response. The Greater Houston Port Bureau expects growth to track population growth and gross domestic product (GDP), rather than infrastructure differences.

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<sup>24</sup> Rail carriers are also trying to improve container movement out of Dallas, because there are instances where there is a lack of fast intermodal service from Houston to the East and West Coast. The "Dallas to Dock" service (a partnership of Union Pacific and Katoen Natie, a global logistics services supplier) ships plastic pellets from the Gulf Coast to Dallas, where they are packaged and sent to other ports. (Source: Petrochemical Supply Chain & Export Logistics)

The Greater Houston Port Bureau stated that a limit to throughput capacity at the new locks is not the size of the locks, but the amount of water they use. There is a limited amount of water available for the locks.

Only large ports will have the financial resources and staff to build and operate terminals for these larger ships. Mobile and New Orleans will not likely be viable alternatives for current large ships. The canal is an important traffic artery for the Gulf. If it gets interrupted, it will have major economic repercussions.

## Panama Canal Data Update

The research team combined data from the Panama Canal Authority and Port Houston (POH) to determine the number of vessels that had used the expanded Panama Canal locks to or from Houston. The research team used a list of vessels that had passed through the new locks and matched them with vessel movement data in IHS Maritime’s Sea-Web online database to see which ones called at Houston. This resulted in a list of larger than Panamax vessels processed by POH from June 2016 to June 2017.

Table 14 shows the vessels that used the expanded locks to reach Port Houston from June 2016 to June 2017.

**Table 14. Larger than Panamax Vessels to Houston.**

Vessel Type	Number
Full Containership	6
LPG Carrier	8
<b>Total</b>	<b>14</b>

Table 15 shows the vessels that departed Port Houston and used the expanded locks to reach their final destination, from June 2016 to June 2017.

**Table 15. Larger than Panamax Vessels from Houston.**

Vessel Type	Number
Full Containership	1
Chemical Tanker	2
LPG Carrier	153
<b>Total</b>	<b>156</b>

The tables show a large number of larger than Panamax LPG carriers that have used the expanded locks, especially leaving from Houston.

## Conclusion

The Panama Canal plays an important role in U.S.-Asia trade. Of all traffic passing through the Panama Canal, 51 percent (in weight) is goods traveling between the U.S. and Asia (3). With the

new locks, shippers now have the option of using the Panama Canal for Neopanamax vessels. The canal itself has predicted a doubling in cargo capacity. However, the total number of transits and total amount of cargo that crossed through the canal decreased between 2015 and 2016 (62).

Predictions have varied about the impact of the Panama Canal on shipping routes and ports. Some predict that the expansion of the Panama Canal will have no effect on current shipping routes. For example, in a study released prior the opening of the new Panama Canal locks, it was predicted that the expansion would not impact routes from Asia to the East or West Coast because different commodity types have different shipping strategies, regardless of the size of the Panama Canal. High-value, time-sensitive goods tend to use West Coast Ports to take advantage of time savings, and low-value, low-cost goods tend to prefer East Coast ports because the all-water route is more cost effective (4).<sup>25</sup> However, since the opening of the locks, southern ports, such as Savannah, Charleston, and Norfolk have increased their import share from Asia (63). The Gulf Coast has a smaller market share of Asian imports, but has also seen increases (63). The U.S. Department of Transportation stated in 2013 that the greatest impact of the Panama Canal expansion on the Gulf Coast may be the cost savings on bulk cargo exports (8).

All Gulf Coast ports the research team interviewed said that the current impact of the Panama Canal expansion was non-existent or minimal. Most stated that there is minimal impact predicted for the future, and any impacts are conditional on infrastructure improvements. None of the ports interviewed have the depth of 50 ft that is needed to accommodate a fully-loaded Neopanamax vessel. Most of the ports interviewed stated that there is minimal impact predicted for the future, and any impacts are conditional on infrastructure improvements, such as dredging of ports and surrounding waterways to deeper depths. Some ports stated that they deal mostly with trade routes that do not need the Panama Canal. Others stated that some commodities do not need the larger vessels that use the new locks.

Gulf Coast Ports, including ports in Texas, have invested to accommodate larger vessels. However, it is unclear what the effect of the Panama Canal expansion on Texas will be in the medium and long term. For example, most of what the Houston area currently imports from Northeast Asia comes through West Coast ports, but it is possible that the reduced unit costs of using the Panama Canal could shift travel to Texas ports over time. However, the cost savings from shifting goods from West Coast ports to Gulf Coast ports via the Panama Canal would be minimal, and may not outweigh the additional travel time (8).

To date, it seems the largest impact of the Panama Canal expansion has been on tankers, especially for liquefied natural gas (LNG) and liquefied petroleum gas (LPG). Almost all the world's LNG tankers can now pass through the Panama Canal, as opposed to the fewer than 10 percent that could use the old locks. The current research showed that of the 14 Neopanamax

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<sup>25</sup> This study did not isolate the Gulf Coast as a possible point of entry or exit for goods.

vessels that passed through the expanded locks on their way to Houston, 8 were LPG vessels. Of the 156 vessels that left Port Houston and transited the new locks, 98 percent were LPG carriers.

For LNG carriers, the Panama Canal has predicted a doubling of transits through the Panama Canal by 2020, and it plans to increase tolls to capitalize on high demand for transits (9, 10). Shipping of natural gas from the Gulf Coast to Northeast Asia could increase, where there is high demand for affordable natural gas (8). For Texas exports, the new locks mean that larger shipments of natural gas can now use the Panama Canal. Two LNG terminals are expected to be operating at the Ports of Corpus Christi and Freeport in 2018, which would facilitate Texas natural gas exports (11). An additional nine LNG Export Terminals are currently proposed in the Gulf Coast, including five in Texas (64).

Interviews with crude oil industry stakeholders reflected the sentiment that the Panama Canal expansion would not immediately impact the crude industry. This was because the Asian market already has crude suppliers, and does not need U.S. oil, and because of the limited slots per day for tankers in the expanded canal. Currently the canal processes about six Neopanamax vessels per day, but plans to increase the number to their maximum capacity of twelve, and increase the hours when LNG vessels can transit the locks (5). They are currently processing fewer than the maximum capacity as personnel become familiar with navigating the new locks, and some companies are complaining that it is too difficult to book a slot for LNG transits (5, 10, 65).

For Texas imports from East Asia, almost all (93 percent by weight) come on an all-water route directly to Texas (14). For Texas exports to East Asia, 21 percent by weight leave the U.S. through California (14). Commodity type may be one of the most important factors in considering route choice and potential effects of the canal expansion. High value goods are more likely to use the intermodal route through California than low value goods. And shippers appear to have strong route preferences for certain commodities, which may have to do with existing infrastructure or relationships. For example, 100 percent of building stone exported from Texas to East Asia leaves through California, whereas 97 percent of cereal grains to East Asia leave directly from Texas (14).

Some factors that go into route choice, such as fuel cost, change constantly. And many options exist for shippers over long, complex routes. Predicting how and where a good will travel is challenging. In the short term, it appears that LNG and LPG will benefit the most from the expanded canal. However, given that the new locks at the Panama Canal opened in June 2016, it will likely take time to see the full impacts of the canal expansion.



## Appendix A: Texas-East Asia Traded Commodities

Table 16 shows the commodities Texas trades with East Asia and their state of entry or exit.

Table 16. Point of Exit for Texas Export Commodities to East Asia (by Weight, 2015)/Point of Entry for Texas Import Commodities from East Asia (by Weight, 2015).

Commodity	Exit State (exports)			Entry State (imports)		
	Texas	California	Other states <sup>26</sup>	Texas	California	Other states
<b>Alcoholic Beverages</b>	9%	91%		92%	8%	
<b>Animal Feed</b>	12%	87%		18%	81%	
<b>Articles-base metal</b>	27%	71%		91%	4%	
<b>Base metals</b>	24%	76%		89%	2%	Louisiana: 7%
<b>Basic chemicals</b>	96%	1%		85%	4%	Oregon: 7%
<b>Building stone</b>	0%	100%		58%	42%	
<b>Cereal grains</b>	97%	2%		35%	3%	Virginia: 34% Georgia: 28%
<b>Chemical products</b>	33%	56%	Louisiana: 9%	55%	11%	Louisiana: 24% Georgia: 6%
<b>Coal</b>	-	11%	Maryland: 89%	-	100%	
<b>Crude petroleum</b>	100%	-		-	-	
<b>Electronics</b>	17%	83%		53%	43%	
<b>Fertilizers</b>	92%	7%		15%	-	Louisiana: 85%
<b>Fuel Oils</b>	99%	-		86%	-	Georgia: 14%
<b>Furniture</b>	14%	85%		74%	23%	
<b>Gasoline</b>	No data	No data	No data	-	100%	

<sup>26</sup> Other states are listed if they have 5 percent or higher.

<b>Gravel</b>	No data	No data	No data	1%	99%	
<b>Live Animals/Fish</b>	100%	-		-	-	Virginia: 75% Georgia: 25%
<b>Logs</b>	57%	43%		-	100%	
<b>Machinery</b>	33%	66%		68%	22%	
<b>Meat/seafood</b>	42%	56%		87%	11%	
<b>Metallic Ores</b>	3%	89%	New York: 7%	54%	4%	Louisiana: 42%
<b>Milled grain products</b>	97%	1%		91%	4%	
<b>Miscellaneous manufactured products<sup>27</sup></b>	35%	65%		84%	13%	
<b>Mixed freight<sup>28</sup></b>	31%	11%	Georgia: 58%	40%	20%	Georgia: 37%
<b>Motorized vehicles</b>	10%	89%		77%	20%	
<b>Natural sands</b>	-	100%		28%	-	Florida: 72%
<b>Newsprint/paper</b>	67%	33%		42%	51%	
<b>Nonmetal mineral products</b>	3%	95%		80%	6%	Washington: 14%
<b>Nonmetallic minerals</b>	4%	39%	Washington: 57%	65%	32%	
<b>Other agricultural products<sup>29</sup></b>	41%	58%		17%	77%	Maryland: 6%
<b>Other foodstuffs<sup>30</sup></b>	18%	59%	Georgia: 22%	72%	19%	Illinois: 5%
<b>Paper articles</b>	51%	23%	Georgia: 21% Alabama: 5%	83%	15%	
<b>Pharmaceuticals</b>	15%	34%	Georgia: 36%	35%	36%	Georgia: 21%

<sup>27</sup> This includes goods such as arms, toys and games, sporting equipment, and works of art. For more information, see: <https://www.census.gov/svsd/www/cfsdat/cfs071200.pdf>

<sup>28</sup> This includes goods such as restaurant supplies, hardware supplies, and office supplies. For more information, see: <https://www.census.gov/svsd/www/cfsdat/cfs071200.pdf>

<sup>29</sup> This includes agricultural products other than animal feed and grains, such as tomatoes, bananas, apples and raw cotton. For more information, see: <https://www.census.gov/svsd/www/cfsdat/cfs071200.pdf>

<sup>30</sup> This includes goods such as milk, cheese, and butter. For more information, see: <https://www.census.gov/svsd/www/cfsdat/cfs071200.pdf>

			Louisiana: 8%			South Carolina: 5%
<b>Plastics/rubber</b>	39%	59%		63%	29%	
<b>Precision instruments</b>	27%	73%		73%	23%	
<b>Printed products</b>	1%	89%	Georgia: 9%	89%	10%	
<b>Textiles/leather</b>	-	95%		73%	23%	
<b>Tobacco products</b>	-		Georgia: 96%	71%	1%	Georgia: 28%
<b>Transportation equipment</b>	-	100%		55%	22%	Washington: 16%
<b>Waste/scrap</b>	31%	67%		1%	1%	Pennsylvania: 97%
<b>Wood products</b>	47%	42%		67%	25%	

## Appendix B: Port Interview Questions

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1. What is the maximum vessel size that the port can handle when the channel is maintained to authorized dimensions? What is the cargo carrying capacity of a vessel of that size?
2. What is the maximum vessel draft allowed in your channel at this time?
3. Since the expanded Panama Canal has opened:
  - a. How many vessels has the port received that used the expanded Panama Canal?
  - b. What specific vessel type (tankers, container ships) went through the expanded Panama Canal?
  - c. Do you have a count of such vessels by type?
  - d. Since June of last year, has the port seen an increase in the volume of trade that used the Panama Canal (both old and new locks)?
    - i. Imports? Exports? What types of commodities?
4. Do you expect to see a change in volume due to the Panama Canal expansion in the medium to long term?
  - a. If yes, what commodities?
  - b. How much of a difference in tonnage and vessel calls do you predict?
  - c. If yes, what specifically have you done to prepare for an increase in volume?
5. What challenges does the port face in benefiting from the expanded Panama Canal? (i.e., competitors, landside access to port, funding)
6. What would be the greatest help (e.g., needed investments) in increasing the port's competitiveness (and therefore volume) to attract more vessels that traverse the expanded Panama Canal?
7. Can you provide us with the contact information for exporters and importers that we can interview to better understand the potential cost savings for Texas commodities that are benefitting or are expected to benefit from the expanded canal?
8. Do you have any analyses of the potential impact of the Panama Canal that you could share with us?

## References

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1. Noel Maurer and Carlos Yu, "What Roosevelt Took: The Economic Impact of the Panama Canal, 1903-37." Harvard Business School Working Paper No. 06-041, July 5, 2006. Available at: <http://hbswk.hbs.edu/item/what-roosevelt-took-the-economic-impact-of-the-panama-canal-1903-29>, accessed February 2017.
2. The Panama Canal Authority, Frequently Asked Questions. Available at: <http://www.pancanal.com/eng/general/canal-faqs/tolls.html>, accessed February 2017.
3. Jorge Quijano, Live Webinar, Lamar University, February 24, 2017.
4. "Transportation Cost Equivalence Line: East Coast vs. West Coast Ports," Global Research and Consulting, July 2014. Available at: [http://ftlcollect.com/fr2/614/58107/Transportation-Cost-Equivalence-Line-July-2014\\_\(2\).pdf](http://ftlcollect.com/fr2/614/58107/Transportation-Cost-Equivalence-Line-July-2014_(2).pdf), accessed February 2017.
5. "LNG Reservations Becoming Difficult for Panama Canal," Icis.com, August 3, 2017. Available at: <https://www.icis.com/resources/news/2017/08/03/10130641/lng-reservations-becoming-difficult-for-panama-canal/>, accessed August 2017.
6. The Panama Canal Authority, Transit Statistics. Available at: <https://www.pancanal.com/eng/op/transit-stats/>, accessed March 2017.
7. Jolanda Prozzi and Megan Kenney, "Moving Texas Exports: Examining the Role of Transportation in the Liquefied Natural Gas Export Supply Chain," The Texas A&M Transportation Institute, March 2016. Available at: <https://tti.tamu.edu/policy/freight/moving-texas-exports/the-liquefied-natural-gas-export-supply-chain/>, accessed April 2017.
8. U.S. Department of Transportation Maritime Administration, "Panama Canal Expansion Study Phase I Report," November 2013. Available at: [https://www.marad.dot.gov/wp-content/uploads/pdf/Panama\\_Canal\\_Phase\\_I\\_Report\\_-\\_20Nov2013.pdf](https://www.marad.dot.gov/wp-content/uploads/pdf/Panama_Canal_Phase_I_Report_-_20Nov2013.pdf), accessed February 2017.
9. "Panama Canal's LNGC Transits to Nearly Double by 2020," World Maritime News, April 26, 2017. Available at: <http://worldmaritimeneews.com/archives/218666/panama-canals-lngc-transits-to-nearly-double-by-2020/>, accessed August 2017.
10. "Panama Canal Eyes More Transit Slots as Demand Escalates." Available at: <https://fairplay.ihs.com/commerce/article/4287441/panama-canal-eyes-more-transit-slots-as-demand-escalates>, accessed August 2017.
11. TJ Costello and Bruce Wright, "Will and Expanded Panama Canal Increase Texas Trade?" *Fiscal Notes*, Office of the Texas Comptroller of Public Accounts, April 2017. Available at: <http://comptroller.texas.gov/economy/fiscal-notes/2017/april/panama-canal.php#article>, accessed April 2017.
12. Golden Pass LNG Terminal. Available at: <http://goldenpassterminal.com/>, accessed November 2017.
13. Cheniere, Sabine Pass LNG Terminal. Available at: <http://www.cheniere.com/terminals/sabine-pass/>, accessed November 2017.
14. Federal Highway Administration, Freight Analysis Framework Data Tabulation Tool (FAF4). Available at: <http://faf.ornl.gov/fafweb/Extraction4.aspx>, accessed March 2017.

15. American Journal of Transportation, "Panama Canal Inauguration: A Strategic Route for World Trade and CMA CGM Group's Vessels," June 24, 2016. Available at: <https://www.ajot.com/news/panama-canal-inauguration-a-strategic-route-for-world-trade-and-cma-cgm-gro>, accessed February 2017.
16. Mimi Whitefield, "Panama Canal Ushers in New Era of International Trade and Megaships," The Miami Herald, June 17, 2016. Available at: <http://www.miamiherald.com/news/nation-world/world/americas/article84389637.html>, accessed February 2017.
17. Sophie Hughs, "The Panama Canal in Numbers," The Telegraph, June 6, 2016. Available at: <http://www.telegraph.co.uk/travel/destinations/central-america/panama/articles/Panama-Canal-in-numbers/>, accessed February 2017.
18. Bruce Barnard, "Panama Canal Struggles to Boost Container Ship Transits," The Journal of Commerce, October 13, 2016. Available at: [http://www.joc.com/port-news/panama-canal-news/panama-canal-struggles-boost-container-ship-transits\\_20161013.html](http://www.joc.com/port-news/panama-canal-news/panama-canal-struggles-boost-container-ship-transits_20161013.html), accessed February 2017.
19. Ruiz, Marcos, "Panama Canal Expansion to Bring Benefits to PortMiami – Slowly", The Miami Herald, July 16, 2016. Available at: <http://www.miamiherald.com/news/business/international-business/article90018882.html>, accessed November 2017.
20. "Modernization of the Panama Canal," The Washington Post, January 13, 2013. Available at: <http://www.washingtonpost.com/wp-srv/special/world/modernization-of-panama-canal/>, accessed April 2017.
21. Maritime Connector, "Panamax and New Panamax." Available at: <http://maritime-connector.com/wiki/panamax/>, accessed February 2017.
22. Impact of the Panama Canal Expansion on the U.S. Intermodal System, The United States Department of Agriculture, January 2010. Available at: <https://www.ams.usda.gov/sites/default/files/media/Impact%20of%20Panama%20Canal%20Expansion%20on%20the%20U.S.%20Intermodal%20System.pdf>, accessed January 2017.
23. Bill Mongelluzzo, "Larger Panama Canal No Guarantee of More Asian Cargo for Eastern U.S. Ports," The Journal of Commerce, September 16, 2016. Available at: [http://www.joc.com/port-news/us-ports/larger-panama-canal-no-guarantee-more-asian-cargo-eastern-ports\\_20160916.html](http://www.joc.com/port-news/us-ports/larger-panama-canal-no-guarantee-more-asian-cargo-eastern-ports_20160916.html), accessed February 2017.
24. Bruce Barnard, "Panama Canal Overtakes Suez on Asia-U.S. East Coast Route," The Journal of Commerce, November 22, 2016. Available at: [http://www.joc.com/maritime-news/trade-lanes/panama-canal-overtakes-suez-asia-us-east-coast-route\\_20161122.html](http://www.joc.com/maritime-news/trade-lanes/panama-canal-overtakes-suez-asia-us-east-coast-route_20161122.html), accessed February 2017.
25. "Port of Oakland: So Far, Wider Panama Canal Not a Factor," The Port of Oakland Press Release, September 27, 2016. Available at: <http://www.portofoakland.com/press-releases/port-oakland-far-wider-panama-canal-not-factor/>, accessed February 2017.
26. Alex Nussbaum & Naureen Malik, "A New Trade Route for Natural Gas Opens in Panama," August 9, 2016, Bloomberg Markets. Available at: <https://www.bloomberg.com/news/articles/2016-08-09/a-new-trade-route-for-natural-gas-opens-in-panama>, accessed February 2017.

27. David Roman, "U.S. Is Rare Bright Spot in Southeast Asia as China Exports Drop," Bloomberg Markets, October 5, 2016. Available at: <https://www.bloomberg.com/news/articles/2016-10-05/u-s-is-rare-bright-spot-in-southeast-asia-as-china-exports-drop>, accessed March 2017.
28. The Panama Canal Authority, Tolls Assessment, May 11, 2015. Available at: <https://www.pancanal.com/eng/op/tolls.html>, accessed March 2017.
29. "JoC By the Numbers," The Journal of Commerce, August 21, 2017.
30. The Panama Canal Authority, Tolls Calculation Guide for a Container Vessel. Available at: <http://www.pancanal.com/peajes/pdf/TollsCalculationGuideContainership.pdf>, accessed February 2017.
31. The Panama Canal Authority, Tolls Calculation Guide for Tankers. Available at: <http://www.pancanal.com/peajes/pdf/examples/Tanker-n-Chemical.pdf>, accessed March 2017.
32. The Panama Canal Authority, Tolls Calculation Guide for LNG Carriers. Available at: <http://www.pancanal.com/peajes/pdf/examples/LNG-n-LPG.pdf>, accessed March 2017.
33. The Panama Canal Authority, Tolls Calculation Guide for Bulkers. Available at: <http://www.pancanal.com/peajes/pdf/examples/DryBulkVessels-Rev20160530.pdf>, accessed March 2017.
34. Michael Casey, "Ships are Bypassing the Suez and Panama Canals Because Oil Is So Cheap," Vice News, March 22, 2016. Available at: <https://news.vice.com/article/ships-are-bypassing-the-suez-and-panama-canals-because-oil-is-so-cheap>, accessed February 2017.
35. Dustin Braden, "Suez Canal Beefs Up Transit Discounts to Head Off Panama Pressure," The Journal of Commerce, June 6, 2016. Available at: [http://www.joc.com/maritime-news/container-lines/suez-canal-deepens-extends-container-transit-discounts-head-panama-pressure\\_20160606.html](http://www.joc.com/maritime-news/container-lines/suez-canal-deepens-extends-container-transit-discounts-head-panama-pressure_20160606.html), accessed February 2017.
36. American Association of Port Authorities (AAPA), AAPA Seaports of the Americas, 2017 Membership Directory. Available at: <http://www.nxtbook.com/naylor/AAPD/AAPD0017/index.php#/1>, accessed March 2017.
37. U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, U.S. Waterborne Container Traffic by Port/Waterway in 2015. Available at: [http://www.navigationdatacenter.us/wcsc/by\\_porttons15.html](http://www.navigationdatacenter.us/wcsc/by_porttons15.html), accessed March 2017.
38. U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, Tonnage for Selected U.S. Ports in 2015. Available at: <http://www.navigationdatacenter.us/wcsc/porttons15.html>, accessed March 2017.
39. "Pick Your Port 2016," Global Trade, April 5, 2016. Available at: <http://www.globaltrademag.com/list/pick-your-port-2016>, accessed March 2017.
40. Grace Wang and Anthony Pagano, "Select U.S. Ports Prepare for Panama Canal Expansion," NAIPO Research Foundation, 2015. Available at: <http://www.naiop.org/en/Research/Our-Research/Reports/Select-US-Ports-Prepare-For-Panama-Canal-Expansion.aspx>, accessed March 2017.
41. Miami Harbor Deepening, U.S. Army Corps of Engineers. Available at: <http://www.saj.usace.army.mil/Missions/Civil-Works/Navigation/Navigation-Projects/Miami-Harbor-Deepening/>, accessed March 2017.

42. Chris Tomlinson, "Panama Canal Project Overpromised and Underdelivered," The Houston Chronicle, August 12, 2016. Available at: <http://www.houstonchronicle.com/business/columnists/tomlinson/article/Panama-project-over-promised-and-under-delivered-9139361.php>, accessed February 2017.
43. Peter T. Leach, "U.S. Gulf Ports Investing for Growth from the New Panama Canal Locks," The Journal of Commerce, February 15, 2016. Available at: [http://www.joc.com/port-news/us-ports/port-houston/us-gulf-ports-investing-growth-new-panama-locks\\_20160215.html](http://www.joc.com/port-news/us-ports/port-houston/us-gulf-ports-investing-growth-new-panama-locks_20160215.html), accessed February 2017.
44. Jolanda Prozzi and Megan Kenney, "Moving Texas Exports: Examining the Role of Transportation in the Cotton Supply Chain," The Texas A&M Transportation Institute, March 2016. Available at: <https://tti.tamu.edu/policy/freight/moving-texas-exports/the-cotton-supply-chain/>, accessed August 2017.
45. Carrie Kahn, "The \$5 Billion Panama Canal Expansion Opens Sunday, Amidst Shipping Concerns," NPR, June 25, 2016. Available at: <http://www.npr.org/2016/06/25/483523910/the-5-billion-panama-canal-expansion-opens-sunday-amidst-shipping-concerns>, accessed February 2017.
46. "ITF Raises New Safety Concerns about Panama Canal's Locks," World Maritime News. Available at: <http://worldmaritimeneeds.com/archives/204747/itf-raises-new-safety-concerns-about-panama-canals-locks/>, accessed February 2017.
47. Walt Bogdanich, Jacqueline Williams, and Ana Graciela Méndez, "The New Panama Canal: A Risky Bet," The New York Times, June 22, 2016. Available at: [https://www.nytimes.com/interactive/2016/06/22/world/americas/panama-canal.html?\\_r=0](https://www.nytimes.com/interactive/2016/06/22/world/americas/panama-canal.html?_r=0), accessed February 2017.
48. The Panama Canal Authority, "Feasibility Evaluation of a Tug Assisted Locks Vessel Positioning System," April 4, 2003. Available at: <http://www.pancanal.com/esp/plan/estudios/0202-exec.pdf>, accessed February 2017.
49. Liz Hampton, "Big Oil Tankers' Need for Retrofit Delays Use of New Panama Canal," Reuters, August 23, 2016. Available at: <http://www.reuters.com/article/us-panama-canal-tanker-idUSKCN10Y29K>, accessed February 2017.
50. The Panama Canal Authority, "Advisory to Shipping No. A-05-2016," February 17, 2016. Available at: <http://www.pancanal.com/common/maritime/advisories/2016/a-05-2016.pdf>, accessed February 2017.
51. Port of Corpus Christi, "World Class Harbor Bridge Construction Project Ready to Go," August 9, 2016. Available at: <http://portofcc.com/world-class-harbor-bridge-construction-project-ready-to-go/>, accessed August 2017.
52. Port Corpus Christi, Press Release: Port of Corpus Christi and U.S. Army Corps of Engineers Sign Project Partnership Agreement for Deepening & Widening of the Corpus Christi Ship Channel, September 11, 2017. Available at: <http://portofcc.com/press-release-port-of-corpus-christi-and-u-s-army-corps-of-engineers-sign-project-partnership-agreement-for-deepening-widening-of-the-corpus-christi-ship-channel/>, accessed November 2017.
53. "More Super Post-Panamax Cranes for Port Houston," Business Wire, October 23, 2017. Available at: <http://www.businesswire.com/news/home/20171023006441/en/Super-Post-Panamax-Cranes-Port-Houston>, accessed November 2017.
54. Port Houston, "New Cranes 'En Route' to Barbours Cut Container Terminal," August 1, 2017. Available at: <http://porthouston.com/portweb/new-cranes-en-route-to-barbours-cut-container-terminal/>, accessed August 2017.



55. Joseph Bonney, "Houston and Other U.S. Gulf Ports Are Expanding to Handle Increased Container Volumes," *The Journal of Commerce*, May 15, 2017.
56. Joseph Bonney, "Texas Set to Raise Truck Weight Limits at Ports," *The Journal of Commerce*, May 18, 2017. Available at: [https://www.joc.com/port-news/us-ports/port-houston/texas-set-raise-truck-weight-limits-ports\\_20170518.html](https://www.joc.com/port-news/us-ports/port-houston/texas-set-raise-truck-weight-limits-ports_20170518.html)
57. Jolanda Prozzi and Megan Kenney, "Moving Texas Exports: Examining the Role of Transportation in the Plastic Resin Export Supply Chain," *The Texas A&M Transportation Institute*, March 2016. Available at: <https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2016-5.pdf>, accessed August 2017.
58. David Hunn, "Companies Skip Busy Ship Channel for Less Crowded, Lower-Cost Ports," *The Houston Chronicle*, June 2, 2017. Available at: <http://www.houstonchronicle.com/business/article/Success-hurts-Companies-leave-busy-Ship-Channel-11192573.php?cmpid=btfpm>, accessed August 2017.
59. U.S. Energy Information Administration, U.S. Exports of Crude Oil. Available at: <https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCREXUS2&f=M>, accessed August 2017.
60. "Supertankers Tested at Port Corpus Christi," *San Antonio Business Journal*, May 26, 2017. Available at: <https://www.bizjournals.com/sanantonio/madness/supertankers-tested-at-port-corpus-christi.html>, accessed August 2017.
61. The Greater Houston Port Bureau, available at: <https://txgulf.org/>, accessed August 2017.
62. The Panama Canal Authority, Transit Statistics, "Panama Canal Traffic by Fiscal Years." Available at: <https://www.pancanal.com/eng/op/transit-stats/index.html>, accessed March 2017.
63. Bill Mongelluzzo, "Asian Imports Drift to U.S. East, Gulf Coasts," *The Journal of Commerce*, May 17, 2017. Available at: [https://www.joc.com/port-news/us-ports/asian-imports-drift-us-east-gulf-coasts\\_20170517.html](https://www.joc.com/port-news/us-ports/asian-imports-drift-us-east-gulf-coasts_20170517.html), accessed August 2017.
64. Federal Energy Regulatory Commission, "Proposed North American LNG Export Terminals," August 28, 2017. Available at <https://www.ferc.gov/industries/gas/industryact/lng/lng-proposed-export.pdf>, accessed November 2017.
65. Autoridad del Canal de Panamá, Monthly Canal Operations Summary – July 2017. Available at: <https://www.pancanal.com/common/maritime/advisories/2017/a-25-2017-Rev.pdfm>, accessed August 2017.



