U.S. Port and Inland Waterways Modernization:
Preparing for Post-Panamax Vessels

Institute for Water Resources

U.S. Army Corps of Engineers

US Army Corps of Engineers®

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IWR INSTITUTE FOR WATER RESOURCES

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FOREWORD

The United States is a maritime nation. From its origin as 13 former colonies to its place as the preeminent world power today, our Nation's success has been dependent on our coastal ports and inland waterways to conduct trade. Recognizing the importance of transportation to trade, the Nation had made a strong intergenerational commitment to develop its transportation networks. From the building of roads and canals in the early days of our Nation, to later construction of the transcontinental railroad and to the creation and development, just within my lifetime, of the Interstate Highway System, the Nation has committed the time and resources to enable and facilitate the large scale movement of raw materials and finished goods from their origin to manufacturer or market, both within our borders and internationally.

These networks of highways, railways and inland waterways connect the interior of our country to our ports, which connect us to the rest of the world. These transportation networks have contributed to our success by providing a cost-efficient and environmentally sustainable means to transport large quantities of cargo over long distances and across oceans, keeping this Nation competitive in world trade.

Population and income drive demand for trade, and trade drives the demand for transportation services. The U.S. population is expected to increase 32 percent, or almost 100 million people, in the next 30 years. The greatest population growth will occur in the South and West. Per capita income is expected to increase 170 percent in the same time period. These increases will drive increased trade, with imports expected to grow more than fourfold and exports expected to grow more than sevenfold over 30 years. The recent U.S. Navy Commercial (http://www.youtube.com/watch?v=EEtZ5r0ClYI), which states that 70% of the world is covered by water, 80% of all people live near water, 90% of all trade travels by water, highlights the importance of waterborne commerce to the Nation and the world.

Our interconnected transportation networks, built in the last century or earlier, resulted in a competitive trade position for this Nation. In order to pass on to future generations the benefits of our competitive trade position, the Nation needs to ensure effective, reliable, national transportation networks and interconnections for the 21st Century. However, as Admiral John C. Harvey, Jr., Commander of the U.S. Fleet Forces Command, put it, "…many of our citizens have taken our maritime services for granted – we are no longer a 'sea conscious' Nation – even though we live in a global economy where 90% of all commerce is still transported by ship…" Despite this, I believe we have an opportunity as a Nation to strategically position public and private investments to become again a world maritime leader.

The Nation is taking steps to seize that opportunity. The Conference Report for the Consolidated Appropriations Act of 2012 (Public Law 112- 74) requested a report from the Institute for Water Resources on how Congress should address the critical need for additional port and inland waterway modernization to accommodate *post-Panamax* vessels. *Post-Panamax* vessels are a reality today. They make up 16% of the world's container fleet, but account for 45% of the fleet's capacity. The efficiencies

of scale they provide drive the deployment of more and more of these vessels. By 2030, they are expected to make up 27% of the world's container fleet, accounting for 62% of its capacity. This report provides an analysis of the broad challenges and opportunities presented by the increasing deployment of *post-Panamax* vessels and outlines options on how the Congress could address the port and inland waterway infrastructure needs to accommodate those vessels.

This Nation must address the need and the challenges of a modern transportation system and evaluate potential investment opportunities. This report advances that objective. It contributes to an ongoing public discussion, which is already underway, and will help inform current and future decisions on the maintenance and future development of our ports and waterways and their related infrastructure.

Major General (MG) Michael J. Walsh
United States Army Corps of Engineers
Deputy Commanding General for Civil Works and Emergency Operations

Preface

The U.S. Army Engineer Institute for Water Resources (IWR) welcomed the opportunity provided by the Consolidated Appropriations Act of 2012 (P.L. 112-74) to prepare this report, *U.S. Port and Inland Waterways Modernization: Preparing for Post-Panamax Vessels*. We approached this assignment in a manner befitting the trust and confidence in IWR's work that is reflected in the Committee's designation for this important study.

The resulting document was developed as a true team effort, with the collaborative participation of not only IWR's own in-house specialists and visiting scholars, but also from experts in USACE's various navigation mission specialties from across the organization including the National Planning Centers of Expertise in Deep Draft Navigation and Inland Navigation, located at USACE Mobile and Huntington Districts, respectively, and cost specialists from Walla Walla District and USACE Headquarters. The Institute's efforts were also supported via contracts with the private sector and through a robust public outreach process administered by its Conflict Resolution and Public Participation Center. The Center helped to facilitate openness and transparency as the study progressed, providing public listening sessions and opportunities for input and comment from the navigation community and other interested parties.

Nevertheless, providing advice on "how the Congress should address the critical need for additional port and inland waterway modernization to accommodate *post-Panamax* vessels," as requested in P.L.112-74, implies that the Committee has substantial expectations regarding the certainty and utility of such advice. Let me clarify those expectations at the front and acknowledge that if the history of maritime transportation is any indication – despite what we think we know – uncertainty will persist in the years immediately after the opening of the expanded Panama Canal as to how the Canal's new capacity will specifically drive the future direction of intermodal freight logistics in the U.S., particularly with regard to the timing of the resulting infrastructure needs that will ultimately manifest.

As Christopher Koch, President and CEO of the World Shipping Council, testified earlier this year before the House Transportation and Infrastructure Committee's Water Resources and Environment Subcommittee, "There is neither a single issue nor solution to how to prepare for future maritime transportation infrastructure needs… There is a plethora of studies, opinions and prognostications about what the effects of the new [Panama Canal] locks will be on trade flows, ship sizes, volumes, transshipment port development, and which U.S. ports will benefit by the new locks…It will probably take some years before it is clear exactly what changes to cargo flow, and its supporting transportation network, will result from the new locks."

What we do know is that the world economy is changing, with the pace and scope of these changes accelerating and expanding in unpredictable ways. Shifts in global alliances and political structures, the critical role of emerging technologies, the waxing and waning of the wealth of nations, and even changes to the climate and the natural environment that are impacting agricultural production and the availability of water, are all manifesting right before our very eyes.

But that is the challenge – often we don't pick up the signals that announce many of these changes, nor truly appreciate the significance of the shifts while they are happening or understand the long-term implications associated with these permutations. It is only later, in retrospect, that we recognize some of these changes as transformative "game-changers" to the status quo we mistakenly assumed would continue into the future ad infinitum.

In fact, although many now trace the existence of today's modern containerships to the vision of American truck magnate Malcom McLean, who deployed the first container vessel in the U.S., the converted T2 tanker *Ideal X*, who among us realized that when the *Ideal X* carried 58 containers from Port Newark, NJ to Houston, TX on its maiden voyage on April 26, 1956 that we were witnessing the beginning of a revolution in modern shipping that represented a mega-shift in world trade? In his book "*The Box*," author Marc Levinson points out that "absolutely no one anticipated that containerization would open the way to vast changes in where and how goods are manufactured, that it would provide a major impetus to transport deregulation, or that it would help integrate East Asia into a world economy that previously had centered on North America."

By undertaking the current expansion, Panama will double the Canal's capacity. The resulting economy of scale advantage for larger ships will likely change the logistics chains for both U.S. imports and exports. Despite the uncertainties in timing and port-specific implications that still need to play out, the certain injection of successive new generations of *post-Panamax* vessels into the world fleet could be a "game-changer" for the U.S. over the long term, as it has the potential to not only provide a cost-effective complement to the intermodal transport of imports via the U.S. land bridge, while also re-shaping the service from Asia to the Mediterranean and on to the U.S. East Coast, but may also affect the highly competitive transport price structure along the Midwest to Columbia-Snake route for grain and other bulk exports bound for trans-Pacific shipping. Inland waterways play a key role in the cost efficient transport of grains, oilseeds, fertilizers, petroleum products and coal. Gulf ports play key roles in the transport of these commodities, such as New Orleans being the dominant port for the export of grains from the U.S. Therefore the expanded canal could provide a significant competitive opportunity for U.S. Gulf and South Atlantic ports and for U.S. inland waterways – if we are prepared.

Through effective planning and strategic investment the U.S. can be positioned to take advantage of this opportunity. The railroad industry has been investing $6-8 billion a year over the last decade to modernize railways and equipment, and U.S. ports plan public and private-sourced landside investments of the same magnitude over each of the next five years. Annual spending on waterside infrastructure has been averaging about $1.5 billion.

While the U.S. has ports on the West Coast (Los Angeles, Long Beach, Oakland and Seattle/Tacoma) and East Coast (New York, Baltimore and Hampton Roads) expected to be ready with *post-Panamax* channels in 2014, there is currently a lack of *post-Panamax* capacity at U.S. Gulf and South Atlantic ports – the very regions geographically positioned to potentially be most impacted by the expected changes in the world fleet. The Corps currently has 17 studies investigating the opportunity to economically invest in deep draft ports. At the Port of Savannah, USACE has identified an economically viable expansion to accommodate *post-Panamax* vessels. This project is estimated to cost $652 million dollars. It is possible

that several of the remaining studies will also show economic viability and, if so, the challenge will be to fund these investments. In addition, justified investments in inland waterway locks and dams will be needed to allow the waterway transport capability to take advantage of an expanded canal for U.S. exports. This emphasizes the strategic need to address the revenue challenge within the Inland Waterway Trust Fund.

Given this opportunity presented by the deployment of *post-Panamax* vessels, it is critical that the U.S. develop and move forward with a strategic vision for a globally competitive navigation system that sets the context for ensuring adequate investment in maintaining current waterside infrastructure and also facilitates the strategic targeting of investments to ensure the U.S. is ready for *post-Panamax* vessels and "cascade" fleet deployments consistent with the growth in global trade that is anticipated over the next twenty years.

Constrained Federal funding both for harbor channels and inland waterways can be expected due to overall economic and fiscal conditions and concerns about the deficit. This underscores the need to consider new and innovative public and private funding sources and financing methods with long-term reliability that can finance the navigation system maintenance and expansion that will be necessary to ensure a globally competitive U.S. navigation system. The Institute stands ready to support USACE, the Administration and Congress in realizing this 21st Century vision.

Robert. A. Pietrowsky
Director, Institute for Water Resources

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Executive Summary

"The potential economic gains from trade for America are far from exhausted. Roughly three quarters of world purchasing power and almost 95% of world consumers are outside America's borders... Trade remains an engine of growth for America."

Office of the United States Trade Representative
http://www.ustr.gov/trade-topics/economy-trade

The health of the U.S. economy depends, in part, upon the vitality and expansion of international trade. International trade depends upon the Nation's navigation infrastructure, which serves as a conduit for transportation, trade, and tourism and connects us to the global community. Marine transportation is one of the most efficient, effective, safe and environmentally sound ways to transport people and goods. It is a keystone of the U.S. economy. Ninety-five percent of our international trade moves through the Nation's ports.[1]

Cargo carriers, seeking to service this global trade more efficiently and lower costs, are commissioning the building of ever larger ships, known as *post-Panamax* vessels. These vessels are currently calling at U.S. ports and are expected to call in increasing number. The completion of the Panama Canal in 2014 will influence the timing of their arrival at certain ports. However, *post-Panamax* vessels will dominate world trade and call at U.S. ports regardless of the Panama Canal expansion as they are expected to represent 62 percent of total container ship capacity by 2030.

How the Nation invests in the maintenance and modernization of its navigation infrastructure presents financial challenges to be met and economic opportunities to be seized. Sustaining a competitive U.S. navigation system that can enhance economic opportunities for future generations without significant harm to the environment will require a coordinated effort between government, industry and other stakeholders.

Identifying Capacity Maintenance and Expansion Issues Associated with *post-Panamax* Vessels

Congress directed the USACE Institute for Water Resources to submit to the Senate and House committees on appropriations a "report on how the Congress should address the critical need for additional port and inland waterways modernization to accommodate *post-Panamax* vessels." This report fulfills that request. This report identifies capacity maintenance and expansion issues associated with the deployment of *post-Panamax* vessels to trade routes

[1] Complete Statement of the Honorable Jo-Ellen Darcy, Assistant Secretary of the Army (Civil Works) before the Committee on Transportation and Infrastructure, Subcommittee on Water Resources and Environment, United States House of Representatives, on the Economic Importance of Seaports: Is the United States Prepared for 21st Century Trade Realities – October 26, 2011

serving U.S. ports. This identification has been accomplished through an evaluation of the future demand for capacity in terms of freight forecasts and vessel size expectations and an evaluation of the current capacity of the Nation's inland waterways and coastal ports.

Despite the recent worldwide recession, the expected general trend for international trade is one of continued growth as the world's population and standard of living grow. As international trade expands, the number of *post-Panamax* vessels is expected to increase. The Nation's ability to attract these vessels and allow efficient use of their capacity is the key to realizing the transportation cost savings these vessels represent. For example, the Corps investigation of the Port of Savannah indicates a $652 million dollar investment where the benefits far exceed the cost.

Growth is expected in overall trade and deployment of *post-Panamax* vessels to U.S. ports is certain for multiple trade routes. The expansion of the Panama Canal, currently underway, will accelerate the timing of the deployment of these vessels to more U.S. ports. There is, however, uncertainty in the port specific details: at which ports they will call; when these vessels will arrive in large numbers; how deep these vessels will draft arriving and departing; and the supporting infrastructure needed (channel depth and width, number and sizes of cranes, size of available container storage area). Despite the lack of port specific certainty, the Nation can move forward identifying individual projects using established risk informed decision making methods.

The Panama Canal expansion is scheduled to be completed in 2014 and will double its existing capacity. The new locks will be able to pass vessels large enough to carry three times the volume of cargo carried by vessels today. The availability of larger, more efficient vessels passing though the new locks on the canal is expected to potentially have at least three major market effects. (1) Currently, there is significant freight shipped to the eastern half of the United States over the intermodal land bridge formed by the rail connections to West Coast ports. The potential for reduced cost of the water route through the canal may cause freight traffic to shift from West Coast to East Coast ports. (2) To take full advantage of the very largest vessels that will be able to fit through the expanded canal but may be too large to call at most U.S. ports, a transshipment service in the Caribbean or a large U.S. port may develop. The largest vessels would unload containers at the transshipment hub for reloading on smaller feeder vessels for delivery to ports with less channel capacity. (3) On the export side the ability to employ large bulk vessels is expected to significantly lower the delivery cost of U.S. agricultural exports to Asia and other foreign markets. This could have a significant impact on both the total quantity of U.S. agricultural exports and commodities moving down the Mississippi River for export at New Orleans.

There is uncertainty in the port specific details of when such vessels will arrive in large number, which ports they will call, how deep vessels calling will draft and, consequently, how deep navigation channels must be. Over time these uncertainties will reduce as experience replaces expectation. Even in the face of this uncertainty, individual ports are actively engaged in port expansions and studies to deepen and widen Federal access channels. We can predict that in the

absence of transshipment centers *post-Panamax* vessels will call in large numbers, they will call at most major ports and their sailing drafts will become known. Our challenge is to invest in capacity expansion in the right places at the right time consistent with industry needs.

Port capacity depends upon channel depths, channel widths, turning basin size, sufficient bridge heights, and port support structures such as dock and crane capacity to offload and onload goods. The deepest channel requirements are likely to be driven by "weight trade" services. Vessels can be filled to their weight capacity or their volume capacity. Vessels loaded to their weight capacity sail at their maximum design draft; they sit deeper in the water. For volume trade routes, channel width and turning basin size may be of greater importance than additional channel depth at some ports, as vessels loaded to their volume capacity often sail at significantly less than their design draft. The Asian export trade is considered a "cube trade" (i.e. volume trade). Careful consideration is needed when determining channel depth requirements at U.S. ports for this trade route.

> "I've talked a lot about the expansion of the Panama Canal in the last couple of years...but the one thing I've learned is that nobody really knows what's going to happen."
>
> –Ricky Kunz, Port of Houston Authority's vice president for origination, as quoted in the *New York Times*, February 18, 2012.

Post-Panamax Ready

For this report, a port is considered "*post-Panamax* ready" if it has a channel depth of about 50 feet with allowances for tide, as well as sufficient channel width, turning basin size, dock and crane capacity. U.S. West Coast ports at Seattle, Oakland, Los Angeles and Long Beach all have 50-foot channels. Northeastern U.S. ports at Baltimore and New York have or will soon have 50-foot channels. In the Southeast, Norfolk has 50-foot channels. South of Norfolk along the Southeast and Gulf Coasts there are no ports with 50-foot channel depths, although Charleston with a 45 foot channel depth and nearly 5 feet of tide can accommodate most *post-Panamax* vessels. This is also the region with the greatest forecast population and trade growth.

Cascade Effect

A system vision should extend beyond the major ports to include lower tier ports. New, large vessels are typically deployed on the longest and largest trade service – Asia to Northern Europe. The "smaller" vessels on that service re-deploy to the next most efficient service for that vessel size. Cascading typically increases average vessel size for each trade service. A navigation system vision should address this cascade effect and its impact on infrastructure for shallower ports. Analysis of individual ports will determine whether the port will need to accommodate *post-Panamax* vessels or the cascade effect.

Remaining Globally Competitive

To remain competitive in a changing global trade market, the U.S. would need to continue making the justified investments necessary to maintain and improve its navigation transportation infrastructure where it is appropriate and efficient to do so. Understanding the current funding challenges and making long-term plans for operations and maintenance (O&M) and justified investments are critical to developing an effective vision for a competitive navigation system.

USACE Civil Works appropriations to address waterside infrastructure have averaged about $1.5 to $2 billion per year for the last decade. These expenditures have been used to maintain, construct and improve the most highly justified inland and coastal navigation infrastructure projects, and reflect the nation's most efficient navigation investment strategy.

To accommodate expected increase in agricultural exports through the Gulf, the current inland waterways must be adequately maintained through maintenance dredging and justified major rehabilitation.

USACE currently has 17 active studies investigating possible port improvements, most associated with the desire to be *post-Panamax* ready. One such study at the Port of Savannah is nearing completion and indicates an economically justified project that will cost about $652 million. It is likely that other studies will also show economically justified projects, either to become "*post-Panamax* ready" or "cascade ready." The preliminary estimate to expand some ports along these two coasts was about $3-$5 billion. Specific investments in ports must be individually evaluated for their timing and economic and environmental merits.

Financing Options

Addressing "the critical need for additional port and inland waterway modernization to accommodate post-Panamax vessels" necessitates an examination of the current delivery mechanisms, the identification of issues and the offering of options for the future. Among the issues identified, securing funding sources to take advantage of modernization opportunities in a timely manner, given the constrained fiscal environment, was judged the most critical. A notional list of financing options is presented to initiate discussion of possible paths to meet this challenge—it is anticipated that a variety of options may be desirable, and in all cases individual project characteristics, including its economic merits, would need to be considered in selecting the optimal financing mechanisms. These options are illustrative only and do not necessarily represent any Administration, USACE or IWR position. Some options include:

- Coastal ports
    - Increase Federal appropriations in the USACE budget for harbor maintenance and improvements while maintaining current cost share responsibilities.

- Increase Harbor Maintenance Trust Fund (HMTF) user fees and allocate increased revenues to harbor improvements.
- Maintain or increase Federal appropriations and also increase local cost share requirements.
- Encourage individual port initiatives by phasing out the HMTF, expecting individual ports to collect their own fees and make their own investment and maintenance decisions.

- Inland waterways
  - To support waterway improvements, increase the fuel tax and provide increases in Federal appropriations to track with the increased revenues flowing into the IWTF; depending upon the revenues from the fuel tax, reduce the share of total costs that is paid from general appropriations.
  - Replace the fuel tax with a vessel user fee and/or combine the fuel tax with a vessel user fee and increase revenues and appropriations for improvements at least by the amount of the increased revenues[2].
  - Implement public-private partnerships with the responsibility for improving, operating and maintaining the inland waterway navigation infrastructure along specified segments of the system. Financing for these actions would be secured in private capital markets with revenues to repay the financed activities earned from a combination of vessel user fees (segment fees or lockage fees) and appropriations.

Regardless of the Federal government's role in funding future navigation improvements, maintenance and operations, USACE will continue to have an environmental regulatory oversight responsibility. Under most options USACE will continue its responsibility for performing environmental assessments and developing environmental protection and mitigation plans. However, if individual ports choose to proceed on their own with harbor deepening projects then USACE would need to provide permits for any proposed action.

Environmental Impacts

Since the 1970s, compliance with the National Environmental Policy Act (NEPA), Clean Water Act, Endangered Species Act (ESA) and other regulatory law has greatly reduced the adverse environmental impacts of many previous practices and positively transformed social attitudes toward the environment. Due to these changes in national commitments, future modernization actions that would have significant adverse impacts will be mitigated, often at great expense, and will play an important role in modernization decisions. In this section, the "environmental footprint" caused by the transportation system is first described to help identify the potential for future environmental impact and mitigation needs. Then indicators of potential impact

[2] The Administration transmitted a legislative proposal to the Congress to reform the laws governing the Inland Waterways Trust Fund as part of the Jobs Bill proposal in September 2011.

sources and vulnerabilities are compared to determine which regions may require the most impact mitigation as a consequence of modernization.[3]

The Environmental Footprint

The national footprint of adverse environmental impacts has accumulated over many decades and is not indicative of the present rate of adverse impact, which is much improved. Measured in geographical terms, the environmental footprint directly impacted by development of transportation system infrastructure is a small fraction of the conterminous United States. But the degree of adverse impact on natural systems and wild species of public interest has been particularly intense and the offsite impacts on air, water and habitat quality from systems operations have been far reaching. The sources of past environmental effects indicate the type of future modernization impacts that are likely to occur from expansion of harbor, port and intermodal infrastructure and from transportation systems operations. Modernization will need to be accompanied by justified mitigation to avoid further 1) degraded air and water quality that threatens human health and safety, especially of low income and minority groups; 2) loss of important natural and cultural heritage found in parks, refuges, wetlands and scarce species; or 3) loss of recreational, commercial and other economically important resources.

Potential infrastructural development along coasts and waterways is a concern because coastal ports and inland waterway infrastructure is closely associated with two of the scarcest types of ecosystems—free flowing rivers and estuarine wetlands. Lock and dam impoundments have contributed substantially to the imperilment of numerous freshwater species by reducing free-flowing river habitat. In general, dredging of nontoxic bottoms impacts coastal and riverine benthic organisms temporarily and bottoms typically recolonize quickly following disturbance. In the past, about 10 percent of bottom sediments were contaminated with toxic materials and resistant to colonization by some bottom species. Sediment toxicity directly affects bottom species and indirectly affects the fish and other species that feed on them and humans at the end of the food chain. Contaminated sediments are now disposed of in isolated containment areas. In 1992, USACE was authorized to beneficially use dredge material for environmental improvement. Today about 20 to 30 percent of port and waterway dredged material is used for habitat creation and other beneficial use. But dredging also has had some persistent effects, including some unavoidable take of imperiled species (e.g., sea turtle take is about 35 per year) and damage to shallow-water estuarine ecosystems. Deepening coastal navigation channels can also favor destructive saltwater intrusion into freshwater ecosystems and domestic water supplies.

With respect to operations, future emissions of potentially harmful materials into air and water, including green house gasses, also are a significant environmental concern. Because harbors concentrate transportation system operations in densely populated areas, they remain a significant source of air quality degradation and inequitable impact on low income and minority

[3] Please see the main report for *U.S. Port and Inland Waterways Modernization: Preparing for Post-Panamax Vessels,* Chapter 4: Environmental Impacts of Capacity Expansion, for references.

groups (which is inconsistent with Federal policies pertaining to environmental justice). Trucks contribute much more than any other mode to atmospheric emissions. In general, relying more on oceanic shipment by large vessel and inland shipment by train and waterway in place of truck transport is preferred because trucks are so much less fuel and emissions efficient. Ports have made improvements to reduce emissions and are planning more, consistent with social concerns. As freight transport operations increase, accidents may increase. Accidental collision of whales and other marine mammals with vessels approaching and leaving ports has been a significant mortality source, but may moderate with recent speed restrictions. Potential oil and other contaminants spills are associated with all modes.

Potential Regional Impact Differences

Past vulnerabilities and adverse impacts revealed in the transportation system footprint of ports and harbors informed selection of 11 indicators of potential impact, which was assessed regionally. These indicators reveal the potential for somewhat greater environmental impact in the Southeast Atlantic Region and, to less extent, in the Pacific Region. Freight transport is expected to grow most rapidly in those regions because of high regional population growth rate. In the Southeast, more harbor expansion is needed to accommodate the largest vessel sizes. In addition, in the Southeast Atlantic Region environmental impact mitigation may be more costly because of greater wetland and endangered species vulnerability. In the Pacific Region mitigation may be more costly due to greater vulnerability of economically important water resource use and low income and minority communities. The Northeast Atlantic Region was ranked lowest because it has the slowest population growth, the greatest amount of unused port capacity, and the least vulnerability to loss of wetlands, parks and other preserves, and threatened and endangered species. The Gulf Region was not ranked quite so low because of its high regional population growth rate, less unused port capacity and greater vulnerability to wetland and endangered species losses.

> "Factoring in environmental and public health costs needs to be part of the decision making process at every step in order to ensure future sustainability of our ports, our coastline, and our population."
>
> –Environmental Defense Fund

The effects of Panama Canal expansion have the potential to redistribute some freight transport growth from Pacific Coast ports to Southeastern ports, raising their impact level as increased impact at Pacific ports fall somewhat. The canal expansion may also favor more transport of grains and soybeans on the Upper Mississippi and Illinois Rivers, increasing the need for lock maintenance. Adverse impacts from possible lock rehabilitation are expected to be minor except for the potential need to mitigate unavoidable loss of riparian wetlands. Some positive effects on air emissions are expected because of less time needed in lock transit.

Adaptive management is a wise strategy to use for future modernization, given the uncertainties held in future modernization actions and mitigation costs, which depend on specific locations, types of actions taken and other unknowns.

Non-Financial Considerations

There are many non-financial factors to be considered when modernizing the Nation's navigation infrastructure:

- A modernization strategy should be part of a national transportation strategy that considers multi-modal connectivity and capacity of the intermodal freight transportation corridors. This would necessitate consistency with other Federal programs such as DOT Tiger Grants.
- Navigation infrastructure modernization will have environmental impacts that will most likely require impact avoidance or replacement of lost environmental quality. Total avoidance of impact may be indicated where the effects are of such national significance that development of transportation infrastructure at the proposed site should not be supported at the Federal level.
- Opportunities to contribute to the Administration's initiative to increase exports, energy independence and enhance national security should be considered.
- Local sponsor commitment in terms of cost sharing and community support should be taken into consideration.
- Consideration should be given to ports that facilitate traffic to multiple regions of the country as opposed to serving only a local catchment area.
- When infrastructure projects are planned, designed and implemented, they should explicitly include the concept of adaptive management (i.e., the identification of sequential decisions and implementation based on new knowledge and thresholds) within a risk management framework.

Who Benefits?

Who benefits from deep water port and inland waterways maintenance and enhancement? The use of larger ships will provide economies of scale to the ocean carriers. These cost savings might be shared with the shippers, the producers and, ultimately, with consumers.

However, it should be noted that the portion of traffic transiting the Panama Canal will also benefit the Panama Canal Authority (ACP). In fact it may be possible for the ACP, through its toll structure, to extract a majority of the benefits on routes that use the canal, limiting the cost savings associated with the use of larger vessels through the canal that will be available to

carriers, shippers, producers or consumers. A careful understanding of this is required when choosing which ports to deepen and how to finance the project.

Ports could benefit from increased freight moving through them. As noted, reduced costs for an all-water route from Asia to the East Coast could cause a shift of some market share from the West Coast ports to the East Coast. However, given the expected overall increase in trade, it is not a zero sum game and it is possible that even if West Coast ports were to lose some market share, they will still see an increase in cargo moving through their ports. Moreover, West Coast ports and their rail partners are investing heavily to increase the capacity and efficiency of the intermodal land bridge to ensure it remains competitive and retains market share.

Transshipment might offer some cost savings to cargo headed for ports that are not *post-Panamax* ready. However, transshipment hubs add time and extra handling, costs that may exceed the benefits of using a larger vessel.

The opportunities for reduced costs available to U.S. agricultural exporters through the use of larger bulk carriers are also available to their competitors in international markets.

What seems certain is that some mix of these impacts will be realized gradually over time as market participants gain better certainty of the options they face.

Additional Thoughts

A modernization strategy should be part of an overall national intermodal freight transportation strategy. While the three dominant freight carrier modes – water, rail and truck – compete for market share, there is a growing recognition of the need for multi-modal linkages and for infrastructure investments to be coordinated across the modes to ensure that they complement each other and ensure the best overall use of the available funds for the Nation. This can be supported by prioritizing navigation investment according to their multi-modal connectivity. On March 1, 2012 USACE signed a Memorandum of Understanding with the Department of Transportation on collaboration with a purpose to identify and capitalize on opportunities to improve the Nation's transportation infrastructure investments where shared equities exist.[4]

A national intermodal freight transportation strategy could also consider local sponsor commitment in terms of cost sharing and community support. Opportunities to contribute to the Administration's initiative to increase exports, energy independence and enhance national security must be considered.

[4] See appendix C for a copy of this MOU.

Report Observations and Findings

The main observations and findings of the report are as follows:

- World trade and U.S. trade is expected to continue to grow.
- *Post-Panamax* size vessels currently call at U.S. ports and will dominate the world fleet in the future.
- These vessels will call in increasing numbers at U.S. ports that can accommodate them.
- Along the Southeast and Gulf coast there may be opportunities for economically justified port expansion projects to accommodate *post-Panamax* vessels.
    - This is indicated by an evaluation of population growth trends, trade forecasts and an examination of the current port capacities.
    - Investment opportunities at specific ports will need to be individually studied.
- The potential transportation cost saving of using *post-Panamax* size vessels to ship agricultural products to Asia, through the Panama Canal may lead to an increase in grain traffic on the Mississippi River for export at Gulf ports.
    - An analysis indicated the current Mississippi River capacity is adequate to meet potential demand if the waterways serving the agricultural export market are maintained.
    - A need for lock capacity expansion is not indicated.
- Despite the uncertainty in market responses to the deployment of *post-Panamax* vessels and the expansion of the Panama Canal, individual investment opportunities for port expansion can be identified using established decision making under uncertainty techniques. Adaptive management techniques can also be used to address uncertainty issues. Preliminary estimates indicate the total investment opportunities may be in the $3-$5 billion range.
- Environmental mitigation costs associated with port expansion can be significant and will play an important role in investment decisions.
- The primary challenge with the current process to deliver navigation improvements is to ensure adequate and timely funding to take advantage of potential opportunities.
    - A notional list of financing options is presented to initiate discussion of possible paths to meet this challenge—it is anticipated that a variety of options may be desirable, and in all cases individual project characteristics, including its economic merits, would need to be considered in selecting the optimal financing mechanisms.

Introduction

The United States, its navigation industry and the customers it serves face a potential opportunity. The continued expansion of international trade combined with the building of ever larger ships is reducing ocean transportation costs. However, the extent to where these larger vessels will call at U.S. ports will depend on many factors, including the strategic decisions made by the industry and the Nation, as well as decisions made by the Panama Canal Authority and other parties.

The Committees on Appropriations of the Congress have asked the U.S. Army Engineer Institute for Water Resources (IWR) to submit a report on "how the Congress should address the critical need for additional port and inland waterways modernization to accommodate *post-Panamax* vessels." This report identifies the needs and presents options for meeting the infrastructure needs for U.S. ports and inland waterways.

Post-Panamax vessels will call at U.S. ports in increasing number, either across the Atlantic or through the Panama Canal. How will this affect trade to the U.S., especially along the East and Gulf Coasts? To understand this, we first need to understand that some U.S. ports are already able to accommodate these vessels and others will soon be able to do so. We then need to consider the condition and capacity of some of our other major ports, in order to understand why they do not and will not soon be able to accommodate these vessels. Finally, we will need to consider the condition and capacity of the multi-modal infrastructure that supports cargo movements to and from all of these ports.

There is uncertainty concerning the way in which markets will respond to the deployment of *post-Panamax* vessels. However, with a general picture of the current condition and capacity of our major ports and the multi-modal infrastructure that serves them we can begin to understand the extent to which these vessels may provide an opportunity for further investment, so that options can be developed to move forward.

Given the time available to complete this report, IWR relied on currently available data and could not assess impacts through techniques such as the analysis of specific economic and environmental impacts or the economic modeling of alternative future scenarios.

Congressional Direction

Conference language from Public Law 112-74, the Consolidated Appropriations Act of 2012 (H.R. 2055): Within the funds provided, the Institute for Water Resources is directed to submit to the Senate and House Committees on Appropriations within 180 days of enactment of this Act, a report on how the Congress should address the critical need for additional port and inland waterway modernization to accommodate post-Panamax vessels. This study will not impede nor

delay port or inland waterway projects already authorized by Congress. Factors for consideration should include costs associated with deepening and widening deep-draft harbors; the ability of the waterways and ports to enhance the nation's export initiatives benefiting the agricultural and manufacturing sectors; the current and projected population trends that distinguish regional ports and ports that are immediately adjacent to population centers; the availability of inland intermodal access; and the environmental impacts resulting from the modernization of inland waterways and deep-draft ports.

About the Study Author

The U.S. Army Engineer Institute for Water Resources is a field operating activity under the staff supervision of the Deputy Commanding General for Civil and Emergency Operations and the Director of Civil Works, Headquarters, U.S. Army Corps of Engineers. The Institute is the USACE knowledge center for integrated water resources management (IWRM) and is specifically recognized as a national expertise center for planning methods, risk analysis, hydrologic engineering, conflict resolution and public participation, international water resources, global climate change science, and the collection, management and dissemination of Civil Works and navigation information, including the Nation's waterborne commerce data.

IWR was established by the USACE Chief of Engineers in 1969 with the approval of the House and Senate Appropriations Committees and the Subcommittees on Public Works in order "to enhance the capability of the Corps of Engineers to develop and manage the Nation's water resources, within the scope of the Corps' responsibilities, by developing essential improvements in planning to be responsive to the changing concerns of our society."

The Institute's mission is to facilitate the adaptation of the Civil Works program to future needs by providing USACE with the capability for developing forward-looking analysis and state-of-the-art methodologies. IWR fulfills this mission by supporting the Civil Works Directorate and USACE Major Subordinate Commands (MSCs) and District offices by providing: (a) analysis of emerging water resources trends and issues; (b) state-of-the-art planning, hydrologic engineering and risk assessment methods, models, training and custom applications; and (c) national data management of results-oriented program and project information across Civil Works business lines.

The Institute is a member of the Federal Laboratory Consortium for Technology Transfer (FLC), a nationwide network of over 250 Federal institutions chartered by the Federal Technology Transfer Act of 1986. IWR also has a cooperative relationship with the National Institutes for Water Resources (NIWR), which represents 54 state and U.S. territorial university-based water centers through the U.S. Department of the Interior and U.S. Geological Survey (USGS). The FLC and NIWR provide USACE with the framework for developing technology transfer strategies and opportunities by promoting and facilitating technical cooperation in cooperation with USACE Districts and expertise centers and among Federal laboratories, industry, academia, and state and local governments.

What Is Navigation Infrastructure?

For this report, the term navigation infrastructure refers to the basic facilities required for safe and efficient vessel movement and handling. This infrastructure includes:

For coastal ports

- channels (including harbor entrance channels, port channels, ocean-route canals and connecting channels)
- turning basins
- navigation jetties
- dredge material placement facilities
- berthing facilities (docks, dredged berths and anchorage areas)
- aids to navigation (channel buoys, global GPS, AIS and updated charts)

For inland waterways

- channels
- locks and dams
- channel training structures
- dredged material placement facilities
- tow marshalling areas
- berthing facilities (docks, dredged berths and anchorage areas)
- aids to navigation (channel buoys, global GPS, AIS and updated charts)

These lists are not exhaustive but are generally representative of the facilities included in navigation infrastructure. Other infrastructure, such as cranes, storage yard space and intermodal transfer connections are critical to the efficient movement of cargo, but are not considered navigation infrastructure.

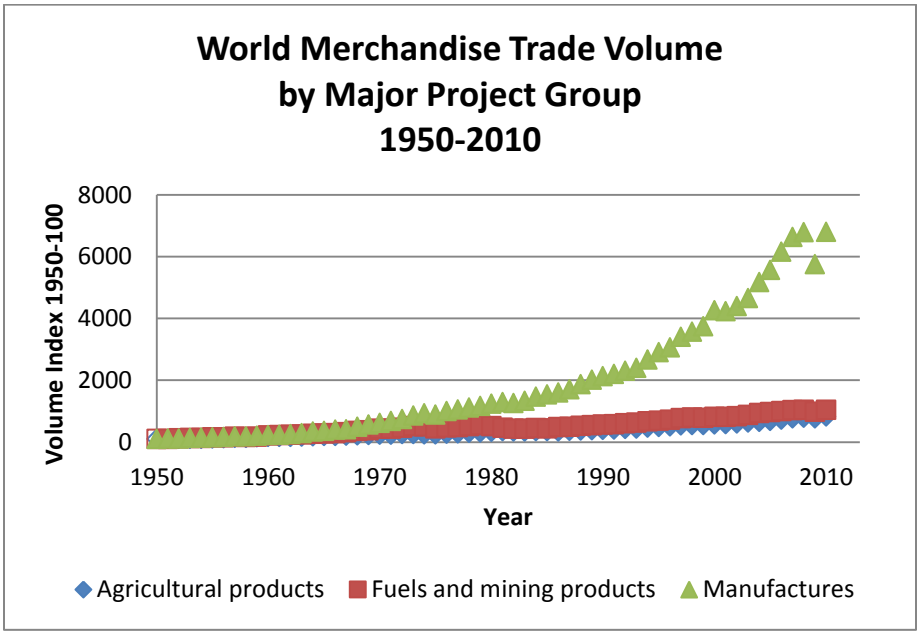
Acknowledgement

IWR thanks the U.S. Department of Transportation, Maritime Administration (MARAD) for their selfless cooperation and sharing of their work.

Chapter 1: Discussion of Demand for Future Capacity

The demand for future capacity within the U.S. freight transportation system is dependent on the volume of future trade. Transportation service is often referred to as a derived demand because it is the demand for goods and services that creates the demand for trade and, thus, for transportation services. For example, the level of world trade determines the demand for international transportation services.

The history of world trade has generally been one of expansion. The volume of world trade has increased about 100 fold (Figure 1) since 1950 according to the World Trade Organization.[5] Trade in agricultural products increased at an average annual rate of 3.6 percent between 1950 and 2011, fuels and mining products at 4.0 percent and manufactures at 7.3 percent. As populations and incomes increase globally, the opportunity and desire for trade expands. In this broad sense, the future is expected to look like the past.



Source: World Trade Organization; International Trade Statistics. 2011

Figure 1: World Merchandise Trade Volume

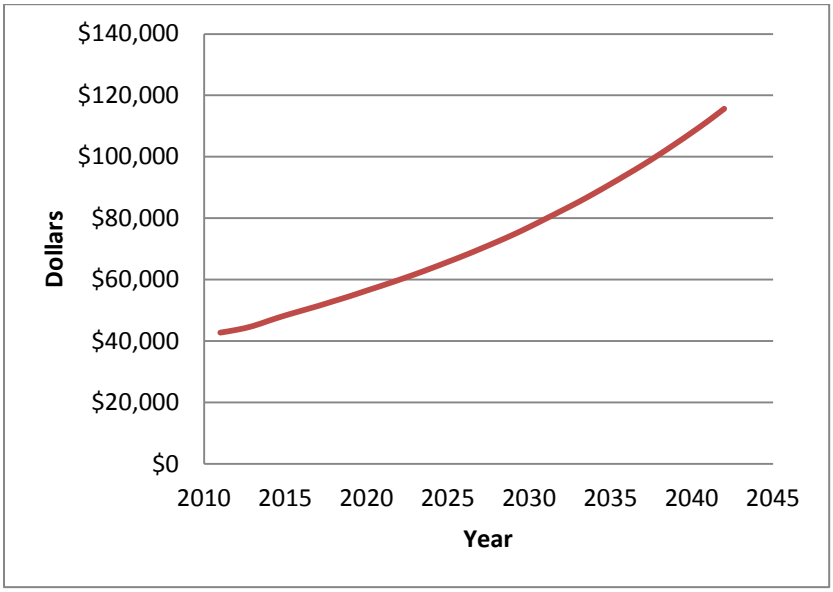
U.S. Population and Income

While global population and income expand world trade, population and income within the U.S. also influence trade volumes and patterns. The overall forecasts of U.S. income and population indicate support for increased demand for transportation services.

[5] World Trade Organization. 2011. International trade statistics.

Projections for Increases in U.S. Income Are Dramatic

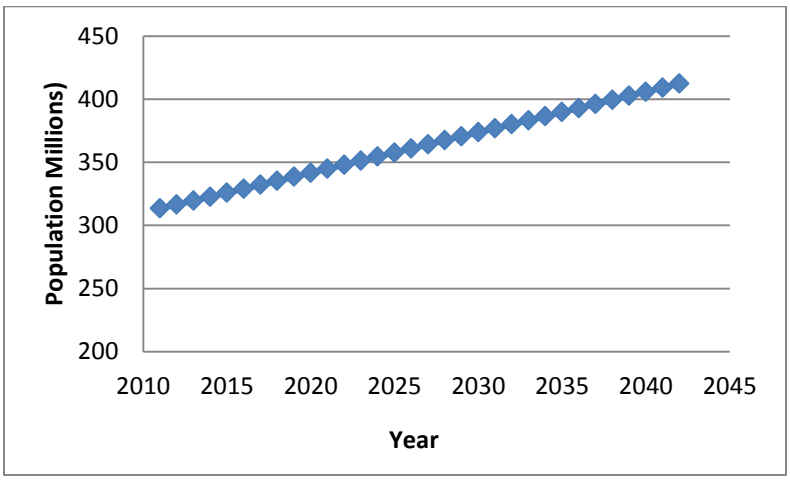
Figure 2 illustrates the expected growth in U.S. per capita income. From a base of $42,800 in 2011, per capita income is expected to increase 170 percent to $115,600 by 2042.



Source: Based on data from IHS Global Insight 2012

Figure 2: U.S. Per Capita Income Forecast 2011-2042

The U.S. population is expected to increase 32 percent from 313.4 million people in 2011 to 412.2 million in 2042, as shown in Figure 3.[6]

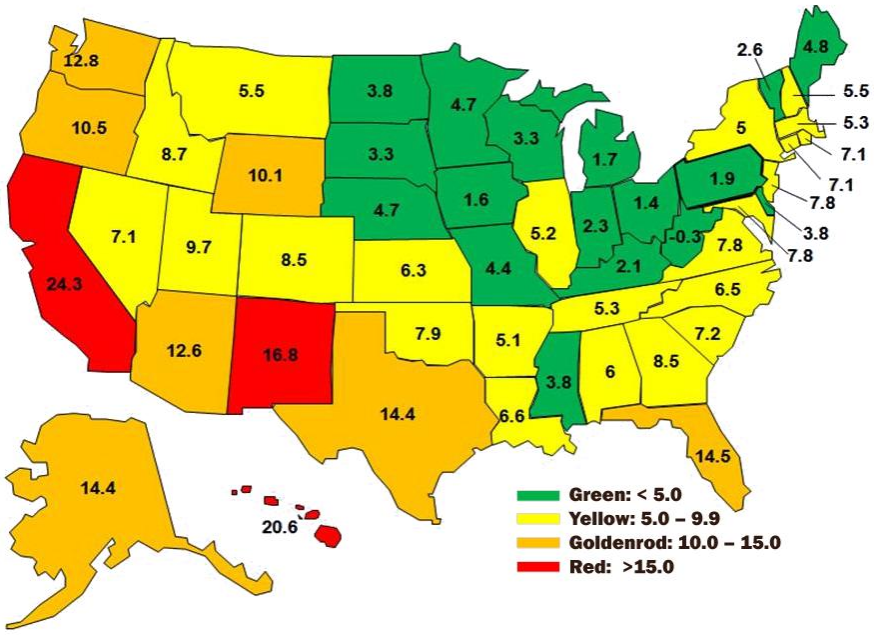


Source: Based on data from IHS Global Insight 2012

Figure 3: U.S. Population Forecast 2011-2042

[6] The U.S. Economy, The 30-Year Focus. 2012. IHS Global Insight, First Quarter 2012.

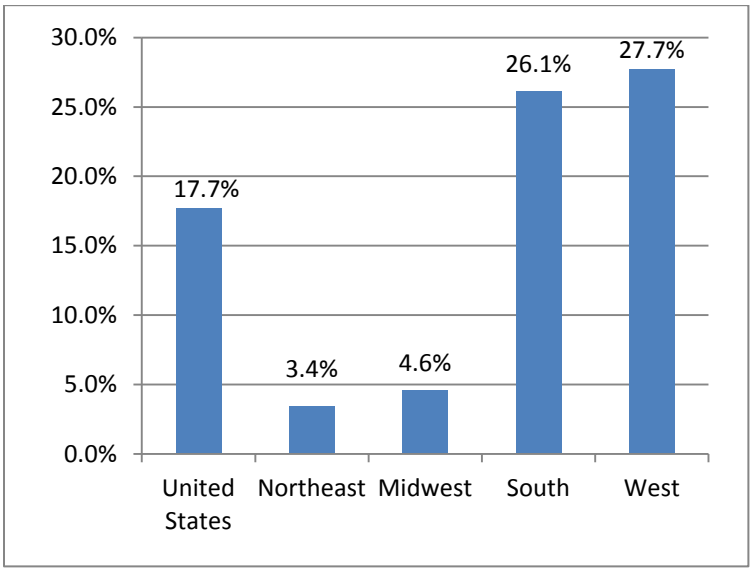
However, this growth in the U.S. is not expected to be evenly distributed geographically. It is predicted that the prevailing trend of population shifts to warmer, urban areas will continue over the next several decades. The growth in demand for transportation infrastructure and services will be greatest in those areas of the U.S. with the highest population growth.



Source: U.S. Census Bureau; Projections of the Total Population of States, 1995 to 2025

Figure 4: U.S. Population Growth by State 2015-2025

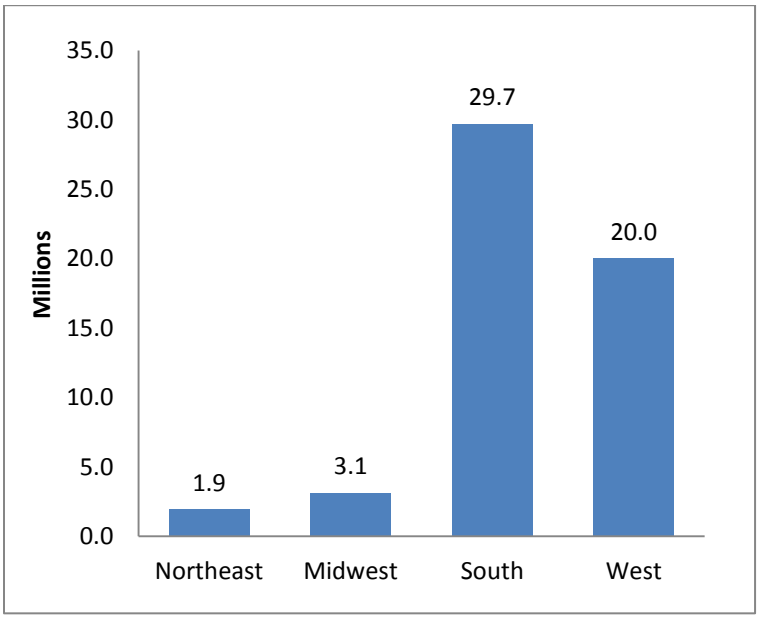
Figure 4 shows the percent population growth by state forecast by the U.S. Census Bureau between 2015 and 2025. Figure 5 shows percent growth projections by U.S. region and Figure 6 shows the forecast numerical change in population by region.



Source: U.S. Census Bureau, Population Division; 2005 Interim State Population Projections

Figure 5: Percent Change in Population by Region of U.S. 2010-2030

Each of these forecasts indicates greatest population growth in the West and South. Since change in demand for transportation services follows change in population, it follows that the largest growth in demand for future transportation services will be in the West and South.



Source: U.S. Census Bureau, Population Division; 2005 Interim State Population Projections

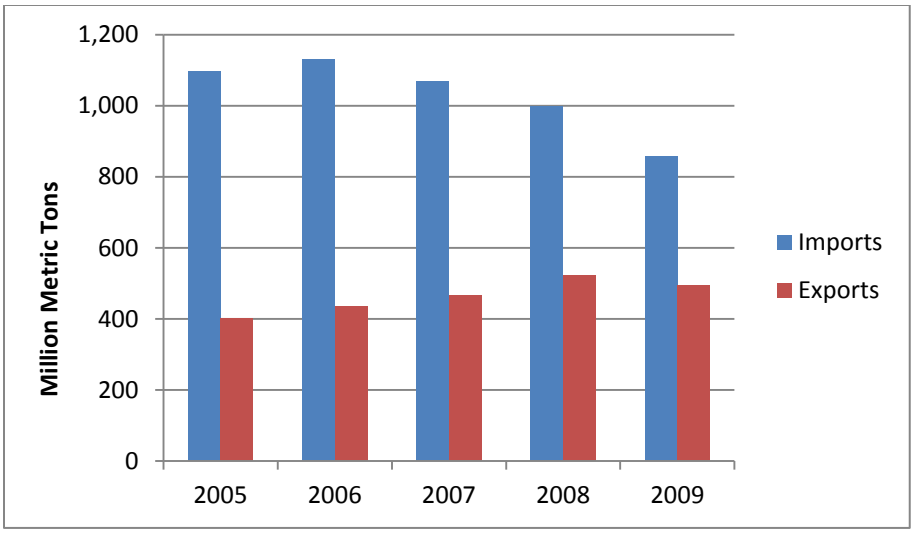
Figure 6: Change in Population by U.S. Region 2010-2030

U.S. Historical Commodities and Composition

U.S. Historical Trade

A look at historical U.S. trade adds perspective to the forecasts. In 2010 U.S. foreign water trade totaled 2.34 billion short tons[7]. Figure 7 shows the total U.S. imports and exports for a 5-year range. Petroleum products make up over half of all U.S. imports with respect to tonnage. Imports declined between 2006 and 2009 due to the U.S. economic recession. Exports increased between 2005 and 2008. Exports decreased slightly in 2009 reflecting the global economic downturn.

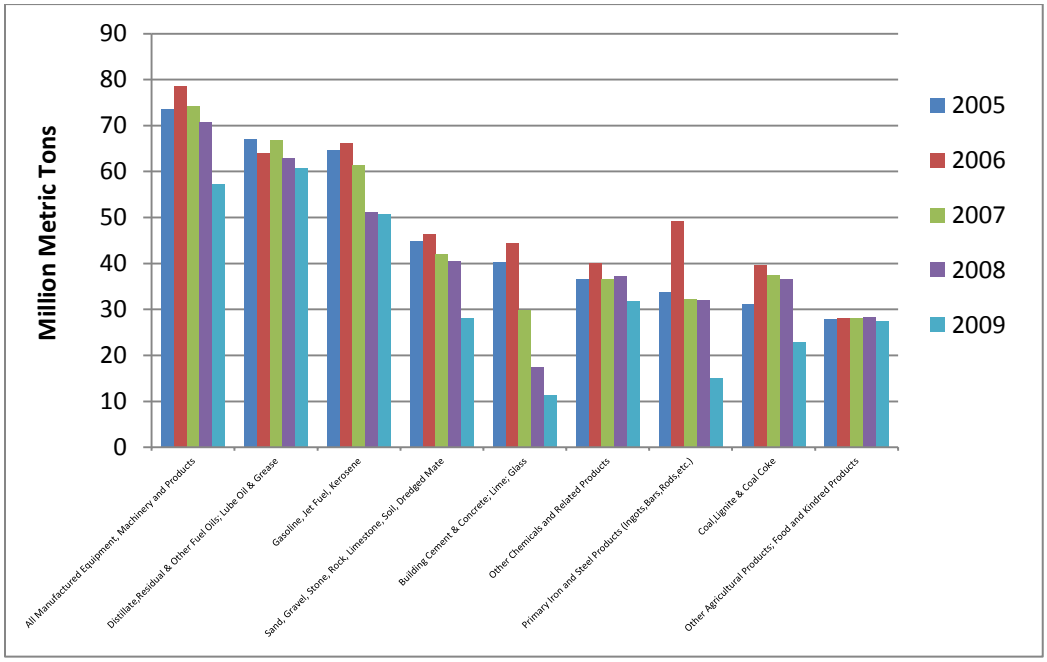
[77] Waterborne Commerce Statistics Center, Transportation Facts and Information, 2011.



Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center

Figure 7: Total U.S. Imports and Exports, Historical

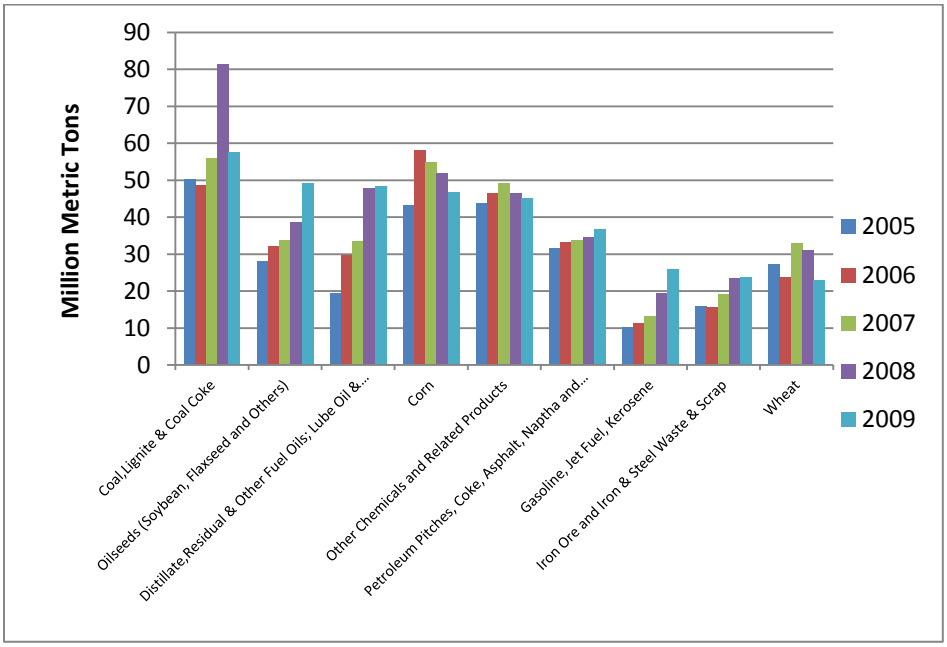
It is clear that while exports grew over the five-year period, imports appear to have been impacted by a series of events in the U.S. and abroad. Significantly impacted were commodities such as building cement, iron and steel, which have decreased more than 50 percent from their peak of the housing boom in 2006. Figure 8 shows U.S. imports by commodity type for the years 2005-2009.



Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center

Figure 8: U.S. Imports by Commodity Type 2005-2009

Figure 9 illustrates selected U.S. exports for the years 2005-2009 by commodity type. These exports represented the largest exports by volume based on 2009 tonnages. As shown, exports were dominated by coal products in 2009. While imports were clearly impacted by recessionary pressures, exports were affected less so. As a whole exports increased 23 percent from 2005 through 2009.

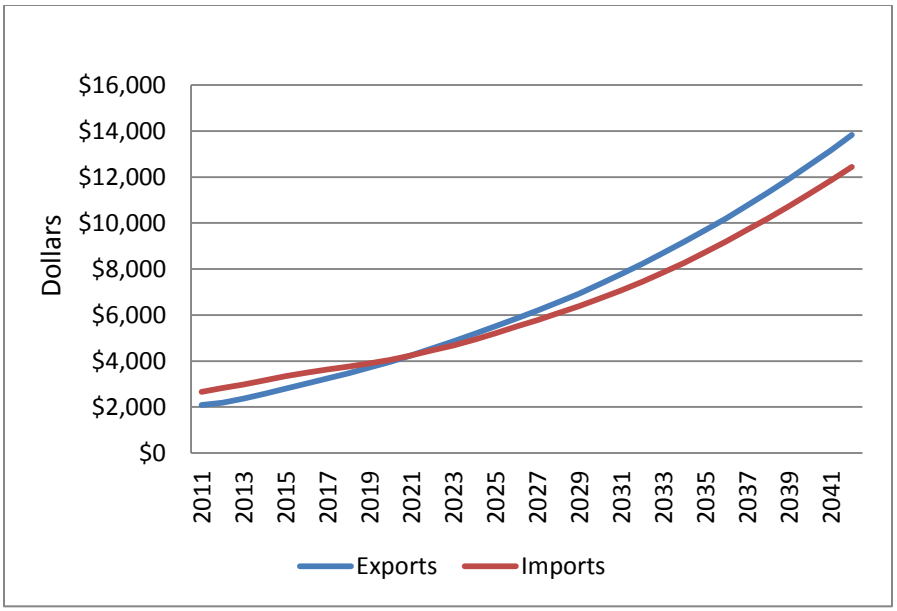


Source: USACE Institute for Water Resources, Waterborne Commerce Statistics Center

Figure 9: Selected U.S. Exports by Commodity Type 2005-2009

Trade Forecast

IHS Global Insight (IHS-GI) has forecast U.S. imports and exports through 2042. Imports are expected to grow from $2,666 billion in 2011 to $12,444 billion in 2042. Exports are projected to increase from $2,088 billion to $14,831 billion over the same time period. Exports are forecast to exceed imports beginning in 2022 (Figure 10).

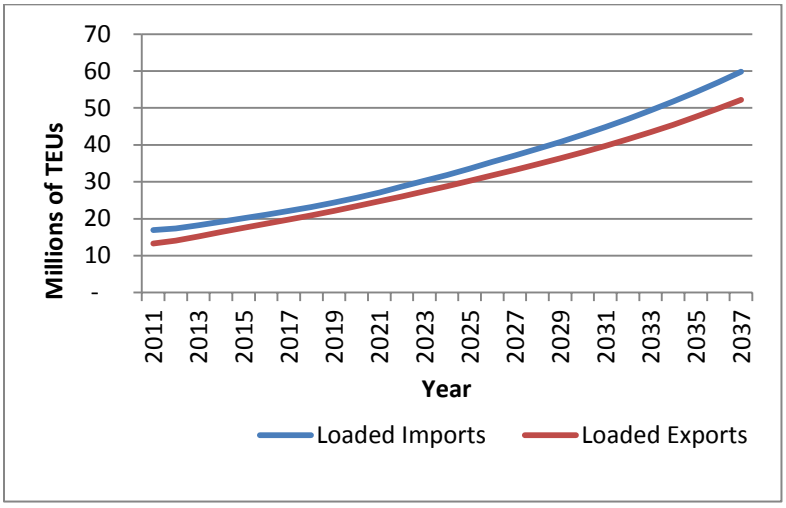


Source: IHS Global Insight, The U.S. Economy, The 30-Year Focus, First Quarter 2012

Figure 10: Forecast of U.S. Trade 2011-2042

Forecast and Containerized Cargo

IHS-GI forecasts for bulk and containerized trade is presented in Figure 11. Figure 12 indicates TEU imports increasing from about 17 million to 60 million from 2011 to 2037.[8] Exports are shown to increase from 13 million to 52 million containers over the same time period.



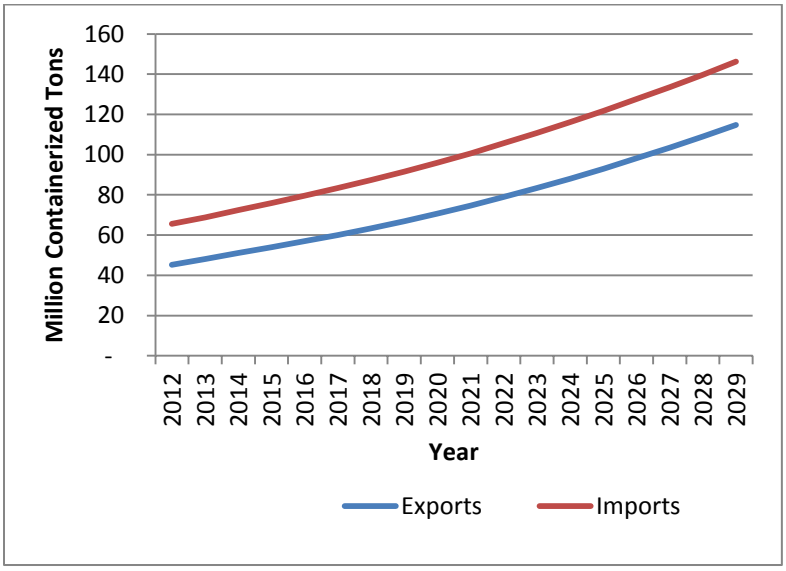
Source: IHS Global Insight

Figure 11: U.S. Forecast Import and Export TEUs 2011-2037

[8] TEU or **twenty-foot equivalent unit** is an inexact unit of cargo capacity often used to describe the capacity of container ships and container terminals. Actual containers vary in length from 20 to 53 feet.

Regional Breakdowns

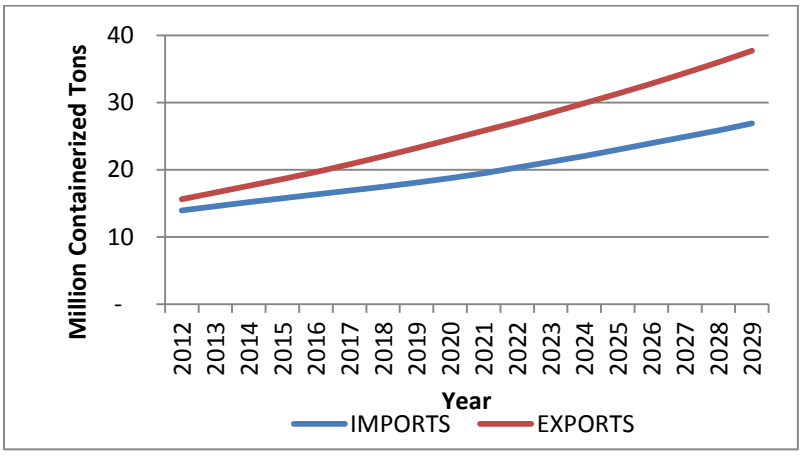
Several regional forecasts were available to this study. Two from IHS-GI represented the East and Gulf Coast forecast of containerized tons. One from the Tioga Group focused on San Pedro Bay. One from MSI forecast total East Coast TEU traffic. Figure 12 shows containerized tons on the East and Gulf Coasts through 2029. On the East Coast, import and export tonnage is expected to grow from 65.66 million tons to 146.3 million tons, an increase of 123 percent by 2029.



Source: IHS Global Insight

Figure 12: East Coast Containerized Imports and Exports 2012-2029

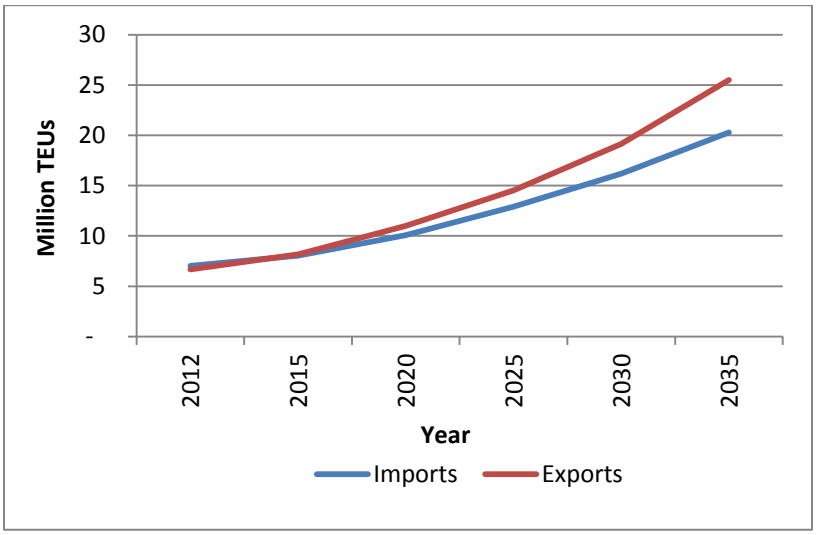
Figure 13 illustrates that Gulf Coast containerized tonnage is expected to grow from 29.6 million tons to 64.6 million tons, an increase of 118 percent by 2029.



Source: IHS Global Insight

Figure 13: Gulf Coast Containerized Imports and Exports 2012-2029

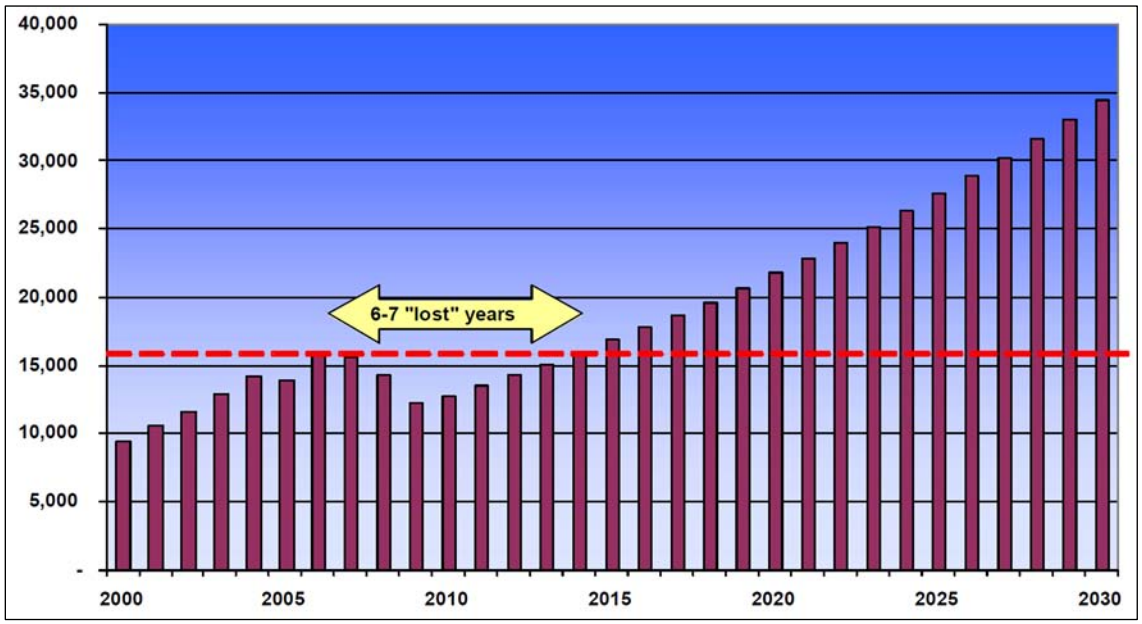
The MSI TEU forecast from 2010 to 2035 is shown in Figure 14. Movements of TEUs through East Coast ports are expected to triple from the current 15 million TEUs to about 45 million TEUs in 2035.



Source: MSI

Figure 14: East Coast Forecast TEUs 2012-2035

A forecast for San Pedro Bay TEU traffic, which is representative of West Coast trends, was obtained from the Tioga Group (Figure 15). This forecast was completed prior to the economic downturn of 2008 and then subsequently updated. The adjusted forecast shows traffic rebounding to historical levels by 2013 and projects growth to 36.7 million TEUs by 2030.



Source: Tioga Group; San Pedro Bay Container Forecast Update

Figure 15: San Pedro Bay TEU Forecast 2010-2030

Maritime Transportation Technology

Transportation Infrastructure and Global Trade

Global trade is encouraged by trade policies that act to remove barriers and protections for domestic producers. Seaborne trade linking continental land masses (e.g., Asia and North America) benefits from continuing advances in oceangoing vessel efficiencies and supporting infrastructure.

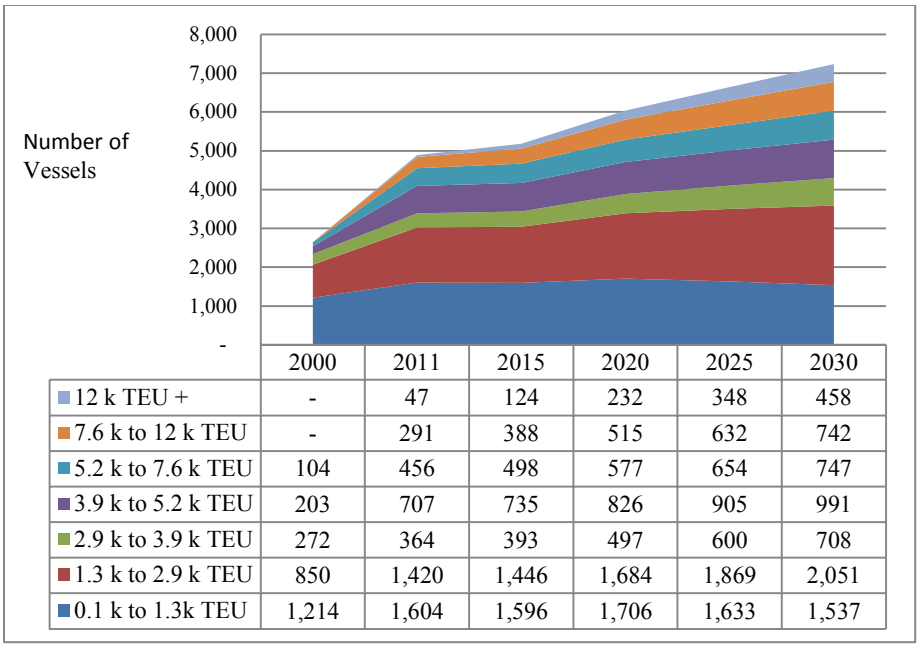
In the U.S., this infrastructure includes port facilities, port channels, ocean-route canals and connecting channels, highway and rail connections to ports, and overland and waterway feeder systems and line routes. Any inefficiencies in this transportation system act as a damper on U.S. exporters' abilities to realize the full potential of the export market and the vessels engaged in that trade.

World Vessel Fleet

The composition of today's world vessel fleet and what portion of that fleet calls at U.S. East, West and Gulf Coast ports is a basis for understanding how the fleet is changing and the ramifications that changes in fleet composition could have on U.S. ports. Vessels can be characterized by type and size. Shippers and carriers are using larger ships in global trade to gain transportation efficiencies and cost savings, which have enormous importance in this very competitive market. The larger containerships, tankers and bulk commodity vessels are currently in excess of 1,000 feet long, more than 125 feet wide and can draw in excess of 50 feet of water. The world vessel fleet is not static. Every year new ships are built and added to the fleet.

Containerships

Containerships are cargo ships that carry their load in containers measured in Twenty-Foot Equivalent Unit (TEU) "boxes." Since the inception of containerized cargo in the 1950s, the container shipping industry has continued to evolve toward greater efficiency. Greater efficiency means moving more loaded boxes per voyage, which in turn creates incentives to build even larger vessels. However, there are constraints to increased vessel sizes. Perhaps the most obvious constraint is the size of the Panama Canal, which is currently undergoing an expansion. *Post-Panamax* vessels exceed 5,200 TEU.



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

Source: MSI

Figure 16: Historical and Forecast Fully Cellular Container by TEU Band 2000-2030

According to the *Journal of Commerce*, half of containerships on order exceed 10,000 TEU capacities. Vessels of 10,000 TEUs and over accounted for 48 percent of the order book as of October 2011. It is evident that large ships are displacing smaller ships in all trade routes due to cost efficiencies of larger ships, which leads to a growth in average container vessel size over time. In 2000, the average container vessel size was 2,900 TEUs. In 2012, the average vessel size has grown to 6,100 TEUs. Figure 16 depicts this increase in size and number of larger vessels that make up the world fleet.

While the number of *post-Panamax* vessels projected for 2030 is only 30 percent of total vessels, Table 1 demonstrates they will represent 62 percent of the total TEU capacity of the container vessel fleet at that time.

Table 1: Unconstrained Forecast of TEU Capacity as a Percent of Total by TEU Band 2012-2030

Vessel Size	2012	2015	2020	2025	2030
0.1 k TEU to 1.3k TEU	8%	6%	6%	5%	4%
1.3 k to 2.9 k TEU	18%	15%	14%	13%	12%
c 2.9 k to 3.9 k TEU	7%	6%	6%	7%	7%
d 3.9 k to 5.2 k TEU	21%	19%	17%	15%	14%
e 5.2 k to 7.6 k TEU	19%	18%	17%	16%	15%
f 7.6 k to 12 k TEU	17%	20%	20%	21%	21%
g 12 k TEU +	9%	15%	20%	24%	26%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Note: post-Panamax vessel bands shaded in gray
Source: MSI

Bulk Carriers

A bulk carrier is specially designed to transport unpackaged bulk cargo such as grains, coal, ore and cement. The current trend is to "light load" bulk vessels at New Orleans for vessels that serve export markets via the Panama Canal. These vessels do not currently fill to their full capacity due to draft restrictions at the Panama Canal. For vessels with a 45 foot design draft, which currently light load to 39.5 feet, transportation cost savings have been estimated to be $0.04 per bushel of grain for foreign flag vessels.[9] It is expected that these vessels would be able to fully load after the Panama Canal expansion. "Small" *Capesize* vessels (80,000+ Dead Weight Tons (DWT)) will be able to fit through the expanded canal. They will be capable of redeployment to serve the U.S. export market.

Like containerships, bulk carriers on order are also trending to larger sizes. Ship designers are working on new *Panamax* vessel designs to maximize the capacity and efficiency of the expanded canal. Table 2 shows the world bulk vessel fleet and the order book in 2010. Capacity growth is greatest in the *post-Panamax*, *Capesize* and *Very Large Ore Carryer* (VLOC) vessel classes. The *post-Panamax* fleet is expected to increase by 153 percent, the *Capesize* vessel class by 83 percent and the VLOC by 109.8 percent.

[9] USACE Institute for Water Resources

Table 2: Bulk Vessel Fleet and Order Book – 2010

Type of Vessel	Size (dwt)	Current Fleet		On Order		% Change of Fleet Capacity
		No. of Vessels	Capacity (mdwt)	No. of Vessels	Capacity (mdwt)	
Handysize	10,000-40,000	2,636	72.0	793	25.9	35.4%
Handymax	40,000-60,000	1,801	89.2	884	50.4	55.9%
Panamax	60,000-80,000	1,408	101.1	273	20.3	20.2%
Post-Panamax	80,000-110,000	311	27.7	461	40.5	153.0%
Capesize	110,000-200,000	793	131.0	625	107.0	83.0%
VLOC	200,000+	172	41.4	151	43.8	109.8%
Total		7,121	462.4	3,187.0	287.9	62.7%

Note: million deadweight tons (mdwt)

Source: U.S. Department of Agriculture and U.S. Department of Transportation; Study of Rural Transportation Issues. April 2010

The Panama Canal expansion offers an example of the effect that larger vessels and lower ocean rates can have on shipper opportunities. Informa Economics, Inc. estimates that the larger, more efficient *Cape* class ships reduce the cost of the movement of grains to northeast Asia by an all-water Panama Canal route by $0.31 to $0.35 per bushel of grain.[10] Delay times through the Canal will also be reduced – an additional benefit for bulk commodities that could not justify paying fees for reserving slots in the current canal. In fact, any infrastructure improvement that allows ports to take advantage of the larger global fleet enhances the competitive position of that port relative to other ports, and vessel efficiencies can be expected to have the same impact on other dry bulk commodity rates. This is significant to coal producers, the other dry bulk commodity exported in volume by the U.S.

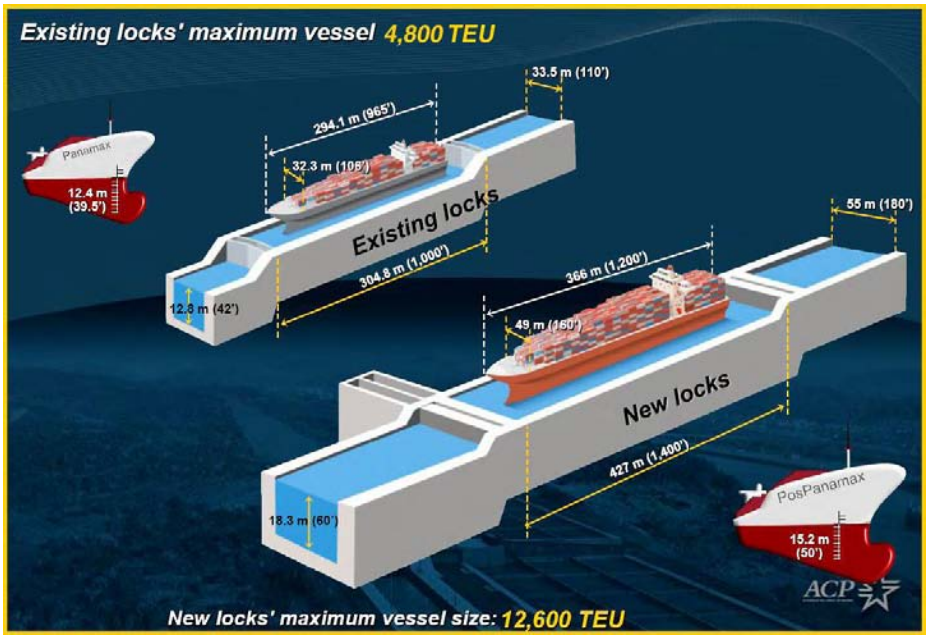
Panama Canal Expansion

The Panama Canal is set to double its cargo throughput capacity when it completes expansion plans in 2014. The new locks will move vessels large enough to carry three times the volume of what can move through the canal today, although the existing locks will remain *Panamax* limited. More efficient and larger vessels passing though the canal are expected to impact markets, although these impacts will depend on the structure and level of the Panama Canal fees and a variety of other factors. If there is a significant reduction in the cost of the water route as a result of going through the canal, some freight traffic may shift from calling at West Coast ports to calling at East Coast ports. Figure 17 shows the change in lock size of the Panama Canal expansion. Figure 18 shows a selected Asia to U.S. East Coast service route.

If ships transiting the Panama Canal are too large to call at East Coast or Gulf Coast ports, a transshipment service in the Caribbean or at a large East or Gulf Coast port may develop. A transshipment service allows the largest vessels to unload containers at the transshipment hub for reloading on smaller feeder vessels for delivery to ports with less channel capacity. These ideas are more fully explored in chapter 3.

[10] Panama Canal Expansion: Impact on U.S. Agriculture, Informa Economics, September 2011.
Note: This estimate of transportation cost savings assumes a Cape class vessel.

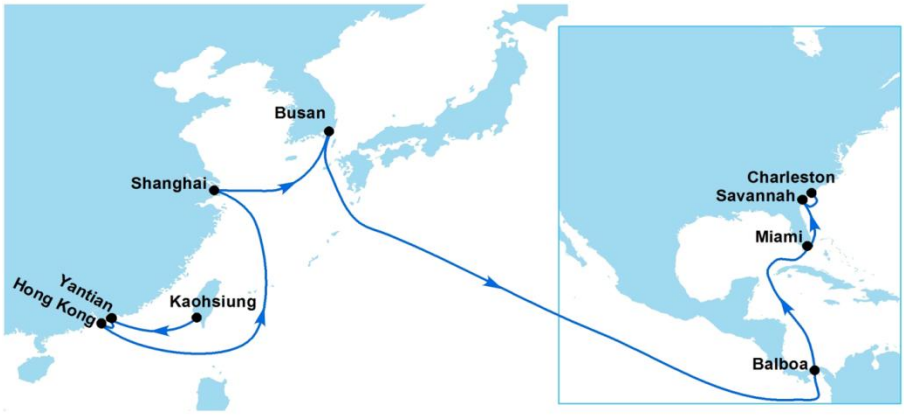
Vessels Transiting the Panama Canal 40% Longer, 64% Wider and 50 Ft Draft



Source: Panama Canal Authority, February 2011

Figure 17: Panama Canal Dimensions

Larger Vessels from the Pacific Rim Can Travel Directly to the Atlantic Coast



Source: A.P Moeller Maersk Group, 2011 Service Schedule

Figure 18: Routes from Pacific Rim to Atlantic Coast

The ability to employ larger bulk vessels could potentially lower the delivery cost of U.S. agricultural exports to Asia. This is not likely to have a significant impact on the mix or quantity of total U.S. agricultural or other commodities exported, but could have a significant impact on the mix or quantity of U.S. agricultural or other commodities moving down the Mississippi River for export at New Orleans.

However, there is uncertainty concerning the extent to which the Panama Canal expansion and the growth in average vessel size will impact trade and trade routes, but the industry is preparing for expected changes. West Coast ports and their rail partners are investing heavily now to increase the capacity and efficiency of the intermodal land bridge to ensure it remains competitive and keeps market share. While the possibility of building transshipment hubs at some ports is being explored, their use may add time and cost that may exceed the benefits of using larger vessels. The Panama Canal Authority may set its fee structure to capture the majority of transportation cost savings, which would limit the cost savings experienced by the shipper or carrier, the producer or the consumer. What seems certain is that some mix of these impacts will be realized gradually over time as market participants gain better certainty of the options they face.

Panama Canal Expansion Impacts on Vessel Fleets

There are mixed opinions regarding what kind of changes the Panama Canal expansion will bring to the fleet mix calling at U.S. ports and the routes that they follow. Shipper responses to change are affected by delivery time, reliability, capacity limits on alternative routes and volume. These variables can be linked to port facilities. Port facilities differ regionally regarding channel depths, crane capabilities and landside intermodal operations. Gulf and East Coast ports mainly distribute containers by truck, whereas West Coast distribution occurs mainly by rail. Many of the West Coast ports already provide adequate water depths to accommodate large vessels.

Experts in the shipping industry expect that once the Panama Canal expansion is complete in 2014, deployment from Asia to the East Coast will begin to closely resemble the fleet mix calling at the West Coast. IHS-GI has forecast the container fleet expected to call at East Coast ports. Table 3 shows the number of ships expected to be deployed on East Coast services through 2035. According to the forecast, in 2012, *post-Panamax* vessels are limited to trans-Atlantic trade. In 2015, with the expansion of the Panama Canal, the transition to *post-Panamax* vessels will include Asian origins. *Post-Panamax* vessels will dominate the East Coast fleet by 2020. This forecast assumes the East Coast ports have the capacity to accommodate the *post-Panamax* fleet. The actual number of vessels deployed to the East Coast and how efficiently these vessels are utilized will depend on the ports' future capacities, including channel depth and width, turning basin size, dock length and crane size.

Table 3: Forecast East Coast Container Fleet 2012-2035

	2012	2015	2020	2025	2030	2035
0.1 - 1.3 k TEU	24	11				
1.3 - 2.9 k TEU	34	12	6	4	3	3
2.9 - 3.9 k TEU	28	12	10	4	4	2
3.9 - 5.2 k TEU	140	95	78	58	42	29
5.2 - 7.6 k TEU	86	114	153	156	159	168
7.6 - 12.0 k TEU	26	61	96	155	227	322
12.0 k TEU +		3	13	42	82	136

Note: *post-Panamax* vessel bands shaded in gray
Source: MSI

Summary

Despite the recent worldwide recession, world trade is expected to increase along with population and income growth, as it has for the last 100-years. The world vessel fleet is projected to increase both in number and vessel size. The larger vessels have already begun to call at U.S. ports and will increase in number and size over time. This trend will be accentuated by the expansion of the Panama Canal.

Chapter 2: Current Capacity

Multi-Modal Transportation System

The U.S. multi-modal freight transportation system is comprised of deep-water ports, inland waterways, railways and highways. They all play a role in the movement of goods domestically and internationally.

Inland waterways, such as the Mississippi, Columbia-Snake and Ohio River systems, have the highest impact on grains, oilseeds and coal exports. Alternatively, northeast Asia is the largest export trading partner for West Coast ports.

Ocean transportation overland rail rates determine the geographic break point between making the haul by rail from the Midwest to the West Coast versus a barge haul to New Orleans along the Mississippi River System to make the lengthy ocean voyage to Northeast Asia. Oceangoing containership rates are generally stable due to negotiated rates. Bulk carrier rates are more susceptible to swings in demand, like the sudden rise caused by the growing Chinese demand for ores, coal and grain.

In recent years, *post-Panamax* vessels have started to call at U.S. ports. It is believed that the Panama Canal expansion will increase the opportunities for trade as it will enable carriers to deploy larger, *post-Panamax* vessels to its Asia-East Coast and Asia-Gulf services ports. Previously large vessel class trade with Asian markets occurred mainly at West Coast ports.

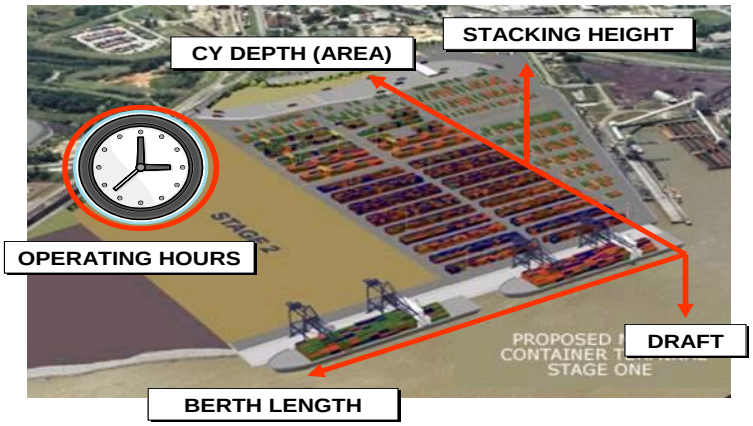
"Multi-modal" vs. "Intermodal"

Multi-modal refers to a multi-faceted transportation system, such as the one in the U.S. that encompasses deep-water ports, inland waterways, railways and highways in which freight carriers typically ship using at least two different methods of transportation but are financially liable for the cargo from start to finish.

Intermodal, on the other hand, refers to the ability to move containerized cargoes relatively seamlessly using a multi-modal transportation system; for example, moving goods in the same container from a ship to a truck or rail car.

U.S. Port Capacities

The capacity of a port broadly describes a port's ability to accommodate large volumes of cargo as well a wide variety of vessel sizes. A port's ability to handle influxes of cargo that accompany "just in time" delivery practices is critical. If, for example, a port were to approach its capacities and be unable to accommodate additional vessels or cargo, shippers may choose a different service route for their cargo.



Source: Tioga Group

Figure 19: Elements of Port Capacity

> "Just in time" delivery practices are planned to reduce the amount of time a ship is idle, thereby reducing transportation costs.

Many factors contribute to a port's ultimate capacity. Channel depth is important as it can indicate the maximum allowable sailing draft for a particular vessel (or the maximum vessel size) that could call at the port. Intermodal access, terminal space, stacking height rules, operating hours and productivity all play critical roles in moving cargo effectively and efficiently. There is little benefit to providing deeper channels if terminals do not have capacity to accommodate larger vessels. Likewise, if channels become a bottleneck, there is little benefit to expanding terminals unless channels will be improved. Therefore, a comprehensive look at both landside and waterside capacity is required.

Port Utilization

Since the advent of containerized cargo in 1956, U.S. ports have been seeking ways to accommodate larger vessels as well as provide space for an anticipated increase in containers. Physical limitations such as channel depth, storage yard space, berthing facilities, and landside productivity (i.e., container turnover rates) determine how much throughput a port can potentially handle in a given year. IWR is studying the near-term throughput capacities for a number of marine container terminals located in the U.S., several Canadian ports, a Mexican port and a potential "transshipment" port.[11]

That study will address the following questions:

- What are the near-term and long-term capacities of the major container ports in the U.S.?
- What factors constrain the capacities of these ports?
- How well is capacity currently utilized?
- How well are the major ports prepared to handle larger vessels?
- How do the smaller container ports or terminals fit into the picture?

[11] U.S. Army Corps of Engineers, Institute for Water Resources. *IWR Container Ports Capacity Report 2012 (draft).*

The preliminary conclusions of that draft study are that ports on the East and Gulf Coasts have sufficient used and unused physical capacity in the near term, particularly in the South Atlantic. The West Coast ports are closer to capacity than the East and Gulf Coast ports. Many industry observers interpreted the 2004 peak season congestion as a sign that the ports of Los Angeles and Long Beach were reaching capacity. However, that 2004 peak season congestion was followed by little or no congestion in subsequent years, in spite of increased cargo volumes; container yard capacity appears to be the most constrained.

Table 4 describes capacity metrics for major U.S. ports.[12] Values close to 100 percent would indicate a port is operating at or near capacity; low percentages often indicate capacity for growth.

- ***Container Yard/Gross Ratio*** reflects the proportion of the entire terminal that is dedicated to containers. Many U.S. ports have relatively low densities when compared with Asian and European counterparts. Asian and European terminals, however, typically devote almost all their terminal space to container yard (CY) functions and rarely have on-dock rail, chassis storage, warehousing, or other functions in the terminal acreage. As a result, Asian and European ports show much higher throughput per acre than in the U.S.

- ***Container Yard Utilization*** measures the productivity of the space dedicated to containers. It is often a function of the operating hours, crane speed and density of cargo. The figures range from a low of 14 percent in Mobile to 83 percent in the Port of Virginia.

- ***Crane Utilization*** in terms of annual TEU is relatively low, averaging 34 percent for the U.S. as a whole. This relatively low utilization might imply an excess of crane capacity. The primary purpose of crane capacity is to turn vessels quickly. Whether there is one vessel per week or five, each vessel will need two or more cranes. The terminals surveyed averaged two cranes per berth. Crane utilization is co-determined with berth and vessel utilization. A vessel is far more costly to own and operate than the cranes that serve it, so crane utilization is effectively sacrificed to vessel utilization.

- ***Berth Utilization*** is based on the number and lengths of berths as well as vessel calls. As most container vessels in service are less than 1,000 feet long and 1,000-foot berths are common, berth length *per se* has seldom been a limiting factor. That will eventually change as *post-Panamax* and *Super-post-Panamax* vessels become more common on the East and Gulf Coasts. As of 2010, the figures show significant potential for increased utilization. In practical terms, berths that are handling two vessels per week could probably handle four. This conclusion, however, depends on vessel size and the total cargo discharged and loaded. The average vessel capacities are low compared to the maximum vessel sizes that ports say that they can accommodate with the available

[12] IBID

draft. Ports typically receive few if any calls from the maximum size vessels, so most calls are made by a mix of smaller container ships.

- **Throughput** could be increased by using larger vessels for the same number of calls, making more calls with the same vessels, discharging and loading more of the vessel capacity at each call, or any combination of these changes. In each case, more container cranes and/or crane time would be required to handle the increased cargo while keeping the vessel on schedule. The crane capacity estimates are based on availability for two shifts per day, 250 days per year (4,000 annual hours). The cranes are, in fact, generally available 24 hours per day if the terminal operator needs the additional shifts to turn the vessel on schedule and is willing to pay for overtime.

The capacity and utilization measures presented in table 4 provide insights into the performance of U.S. container ports and the challenges they face in accommodating the nation's growing trade.

The container yard (CY) is the operating heart of the marine container terminal, the area where containers are held, sorted, and transferred between vessel arrivals and departures. On average, about 50 percent of the gross terminal space at U.S. terminals is devoted to CY operations. The average is lower at ports with extensive on-dock rail terminals, consolidation facilities, and other operations within the terminal boundaries.

Container yard utilization reflects the ability of the terminal to accommodate growth with existing handling methods. Industry rules of thumb suggest that about 80 percent utilization is a practical upper limit beyond which periodic congestion becomes likely. Ports and terminals approaching this limit, such as NYNJ at 75 percent, New Orleans at 82 percent, or LALB at 75 percent, can accommodate growth by expanding or shifting to more land-intensive operating systems.

Utilization of shore side container cranes is typically low, averaging 34 percent across U.S. ports. Cranes are usually used for one daily shift, with additional shifts used to accommodate tight vessel schedules. Crane utilization is secondary to the utilization and rescheduling of the far more costly container ships, so ports and terminals will usually have enough cranes to handle peak demand. Crane utilization may be particularly low at ports such as Mobiles and Virginia which have recently added new terminals and cranes to accommodate future growth.

The average size of vessels actually calling at the ports is usually much smaller than the maximum that could be accommodated. The ratio is highest for ports such as Philadelphia (Delaware River), Savannah, Jacksonville, Houston, and Portland with shallow drafts. The table likewise shows that a vessel does not typically discharge and load its full capacity at each port. The highest average is at LA/LB, where an average vessel discharges and loads 56% of its capacity (equivalent to discharging 28% and loading 28%). Most ports share vessel calls with multiple U.S. and foreign ports, with the average discharge/load ratio correspondingly lower.

Table 4 provides three measures of berth utilization. The first focuses on the number of vessel calls. On average, U.S. ports receive about 29 percent of the maximum number of vessel calls that could be accommodated. The average is higher at smaller ports, and at ports handling multiple trade routes and steamship lines. Where the average approaches 80 percent, such as at Savannah or New Orleans, there may be a need to extend berths. Berth utilization with average vessels measures the extent to which port volume can grow using the current vessel mix and discharge/load ratio. In several cases U.S. ports are approaching this limit, and will need to start handling larger vessels to accommodate increased traffic. Berth utilization with the maximum vessel sizes is generally much lower, except at Savannah where the shallow draft has constrained the use of larger vessels.

The table provides the same measures for the two Canadian port complexes in British Columbia. These ports have substantial reserve capacity and the ability to handle very large vessels in competition with U.S. ports.

Table 4: 2010 Capacity & Utilization Measures

Container Yard	CY/Gross Ratio	CY Utilization	Crane Utilization	Berth Utilization - Vessel Call Basis	Avg. vs. Max. Vessel Capacity	Avg. Vessel Utl Discharge/Load	Berth Utilization - Avg. Vessel Basis	Berth Utilization - Max. Vessel Basis	Nominal Maximum Channel/Berth Draft (Feet)	Estimated Maximum Vessel TEU
North Atlantic Ports										
Boston	49%	31%	21%	35%	73%	38%	35%	25%	45'	5,183
NY/NJ	59%	75%	36%	43%	53%	55%	43%	23%	50'	7,470
Delaware River	29%	68%	29%	30%	65%	52%	40%	26%	40'	3,420
Baltimore	50%	23%	18%	18%	44%	71%	14%	6%	50'	7,470
VPA	42%	83%	30%	60%	54%	32%	77%	41%	49'	6,967
S. Atlantic Ports										
Charleston	43%	25%	35%	79%	61%	30%	89%	55%	47'	6,031
Savannah	41%	36%	45%	71%	101%	39%	89%	89%	42'	4,067
Jacksonville	33%	24%	17%	13%	69%	104%	13%	9%	37'	3,420
Port Everglades	85%	42%	49%	43%	56%	60%	57%	32%	39'	4,067
Miami	72%	53%	31%	40%	77%	66%	27%	20%	42'	4,067
Gulf Ports										
Mobile	58%	14%	12%	9%	114%	55%	9%	10%	42'	3,420
New Orleans	62%	45%	31%	57%	65%	31%	57%	31%	45'	5,183
Houston	63%	57%	37%	51%	92%	67%	46%	42%	40'	3,420
West Coast Ports										
LA/LB	55%	75%	43%	25%	37%	112%	25%	18%	50'	13,000
Oakland	57%	53%	29%	40%	65%	28%	40%	26%	50'	7,470
Portland	59%	26%	8%	15%	97%	47%	15%	14%	43'	4,419
Seattle	49%	64%	21%	40%	68%	36%	40%	27%	50'	7,470
Tacoma	56%	37%	15%	23%	53%	52%	23%	12%	51'	7,997
U.S. Mainland Ports	51%	51%	34%	39%	n/a	61%	30%	n/a	n/a	n/a
Canadian W. Coast Ports										
Prince Rupert	46%	76%	40%	50%	43%	36%	61%	26%	61'	15,048
Vancouver	56%	63%	52%	40%	40%	64%	46%	19%	51'	13,000

Source: USACE Institute for Water Resources

While some ports on the U.S. West Coast (LA/LB in particular) are closer to their capacity in percentage terms, the system as a whole could handle roughly double 2008 volumes before hitting CY or berth capacity constraints. However, that result would only be attained if the increased trade were distributed according to the available capacity – an unlikely outcome. A far more likely outcome is that some ports and terminals would see a disproportionate share of the cargo growth and hit capacity constraints in the long term while other ports and terminals remained underutilized.

Table 5 displays the reserve container capacity by region, which is a key indicator of the ability to handle increased traffic and cargo.

Table 5: Reserve Container Port Capacity by Coast

Metric	N. Atlantic Ports	S. Atlantic Ports	Gulf Ports	West Coast Ports
2010 TEU	8,239,000	6,687,000	2,409,000	18,960,000
Reserve CY Capacity-TEU	10,612,402	13,869,035	2,669,003	10,484,996
Reserve Crane Capacity – TEU	20,895,164	12,501,742	4,423,466	37,237,002
Reserve Berth Capacity – Vessel Calls	9,964	4,013	1,105	13,923
Reserve Berth Capacity – Avg. Vessel Basis	11,832,298	1,922,907	2,799,609	53,031,819

Source: USACE Institute for Water Resources

Secondary Ports

The map below (Figure 20) shows primary and secondary ports in the U.S. Primary ports often feature more dedicated container or bulk terminals. Secondary ports supplement the capacity of the major ports and handle trades and cargoes that do not fit in well with the large, dedicated container terminals. Secondary ports handle a mix of containerized, bulk and break-bulk shipments, so their container capacities are difficult to determine with precision. This mix of capabilities does, however, provide flexibility, particularly for project cargoes and other limited-duration needs. While these ports handle relatively small volumes of containers, several have specific importance to the imported fruit trade (e.g., bananas) and other niche markets. Some are part of larger complexes that include major military shipping points.