FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT / ENVIRONMENTAL IMPACT REPORT (EIS/EIR)

APPENDIX E: ECONOMICS

PORT OF LONG BEACH
DEEP DRAFT NAVIGATION STUDY
Los Angeles County, California

October 2021

US Army Corps of Engineers ®

Port of LONG BEACH
THE PORT OF CHOICE

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1 INTRODUCTION

This document presents the economic evaluations performed for the Port of Long Beach Deep Draft Navigation Feasibility Study. This study serves as an interim response to the Resolution of the House Committee on Public Works adopted 10 July 1968 and in response to the Port of Long Beach's (POLB) request to the U.S. Army Corps of Engineers Los Angeles District (USACE) seeking Federal assistance to address on-going operating constraints to the efficient movement of goods through the port. The study is part of a continued effort to identify projects to improve navigational efficiency and vessel safety throughout the POLB. The USACE Los Angeles District, together with the Deep Draft Navigation Planning Center of Expertise, performed the economic analyses contained within this document in support of the feasibility study.

1.1 Study Purpose and Scope

The purpose of the study is to identify and evaluate alternatives to increase transportation efficiencies, for container and liquid bulk vessels operating in the Port of Long Beach, for both the current and future fleet, and to improve conditions for vessel operations and safety in the event of vessel malfunction or weather-related events. The scope of this feasibility study involves analysis of existing conditions and requirements, identifying opportunities for improvement, preparing economic analyses of alternatives, identifying environmental impacts, and analyzing the National Economic Development (NED) plan.

Navigational challenges identified include existing channel depths that do not meet the draft requirements of the current and future fleet of larger container and liquid bulk vessels. Tide restrictions, light loading, lightering, and other operational inefficiencies result in economic inefficiencies that translate into increased costs for the national economy at one of the nation's busiest ports. Container movements along the secondary channels serving Pier J and Pier T/West Basin, and liquid bulk vessel movements along the main channel have been identified as constrained by current conditions.

The concerns of POLB were used to develop the problem statements, study goals, and objectives for this study. The primary problem is the existing channel depths and widths that create limitation of the harbor, resulting in inefficient operation of deep draft vessels in the main channel (Federal) and secondary channels within the Port complex, which increases the Nation's transportation costs. The planning objectives are to 1) increase transportation efficiencies, during the period of analysis, for container and liquid bulk vessels operating in the Port of Long Beach, for both the current and future fleet, and to 2) improve conditions, during the period of analysis, for vessel operation and safety, including reducing constraints of harbor pilot operating practices.

Potential navigation improvements include deepening and bend easing of navigation channels, construction of a new approach channel, turning basins, and a standby area.

1.2 Document Layout

Section 2 details the existing conditions at the POLB. Sections 3 examines the future without project and the future with project conditions and includes an evaluation and description of the trade forecast, port improvement projects, and the vessel fleet and operations at the harbor. Section 4 presents the transportation cost savings benefit analysis.

2 EXISTING CONDITIONS

The without project conditions, as well as benefits and costs for proposed alternatives, are evaluated over a 50-year period of analysis, beginning with a Base Year of 2027. The Base Year corresponds to the year in which it is reasonable to assume that construction of the chosen project alternative is complete, and it begins to accrue benefits. These projections reflect existing conditions at the completion of the Feasibility Study, as well as anticipated changes in conditions throughout the period of analysis. This section focuses on existing conditions prior to the Base Year, while the following section focuses on the projections of relevant changes under future without project conditions.

The existing POLB channels have depths from -50 to -53 feet MLLW, limiting containerships to 44-49 foot draft with tide riding. Vessels have an additional 2-3 foot draft of usable tide with tide riding; however, tidal delays are also incurred depending on the time of day and pilot practices. Bar pilot limitations have led to offshore-waiting periods for large liquid bulk vessels until the one-way traffic in the main channel is cleared. This limitation has had a historic impact on 5-10% of crude oil imports, and a current impact on approximately 15% of crude oil imports. Current transportation inefficiencies for container and liquid bulk vessels will further be exacerbated by future fleet changes.

The Port of Long Beach has undergone significant expansion in the past century and has become a major transportation and trade center, providing the shipping terminals for nearly one-third of the waterborne trade moving through the West Coast. Currently, trade valued at more than $194 billion is moving through the port, classifying the POLB as the second- busiest seaport in the United States. The port handles more than 7.5 million twenty-foot equivalent units (TEUs) and 82 million tons of cargo with top imports and exports, including crude oil, electronics, plastics, furniture, petroleum products, chemicals, and agriculture. The port has over 2,000 vessel calls annually and the port's facilities include 10 piers, 62 berths, and 68 Post-Panamax gantry cranes.

2.1 Economic Study Area (Hinterland) and Regional Distribution Centers

The POLB is on the coast of southern California in San Pedro Bay, approximately 20 miles south of downtown Los Angeles, California. To the west and northwest of San Pedro Bay are the cities of San Pedro and Wilmington, respectively, and to the east, the community of Seal Beach. The study area includes the waters in the immediate vicinity (and shoreward) of the breakwaters through the entire POLB, and the downstream reaches the Los Angeles River that have direct impact on the Bay, including Outer Harbor, Inner Harbor, Cerritos Channel, West Basin, and the Back Channel (**Figure 2-1)**.

POLB is served by more than 140 shipping lines with connections to 217 seaports worldwide. Once vessels reach POLB, nearly half of all the cargo is moved by rail to the rest of the country, much of it loaded right on dock.

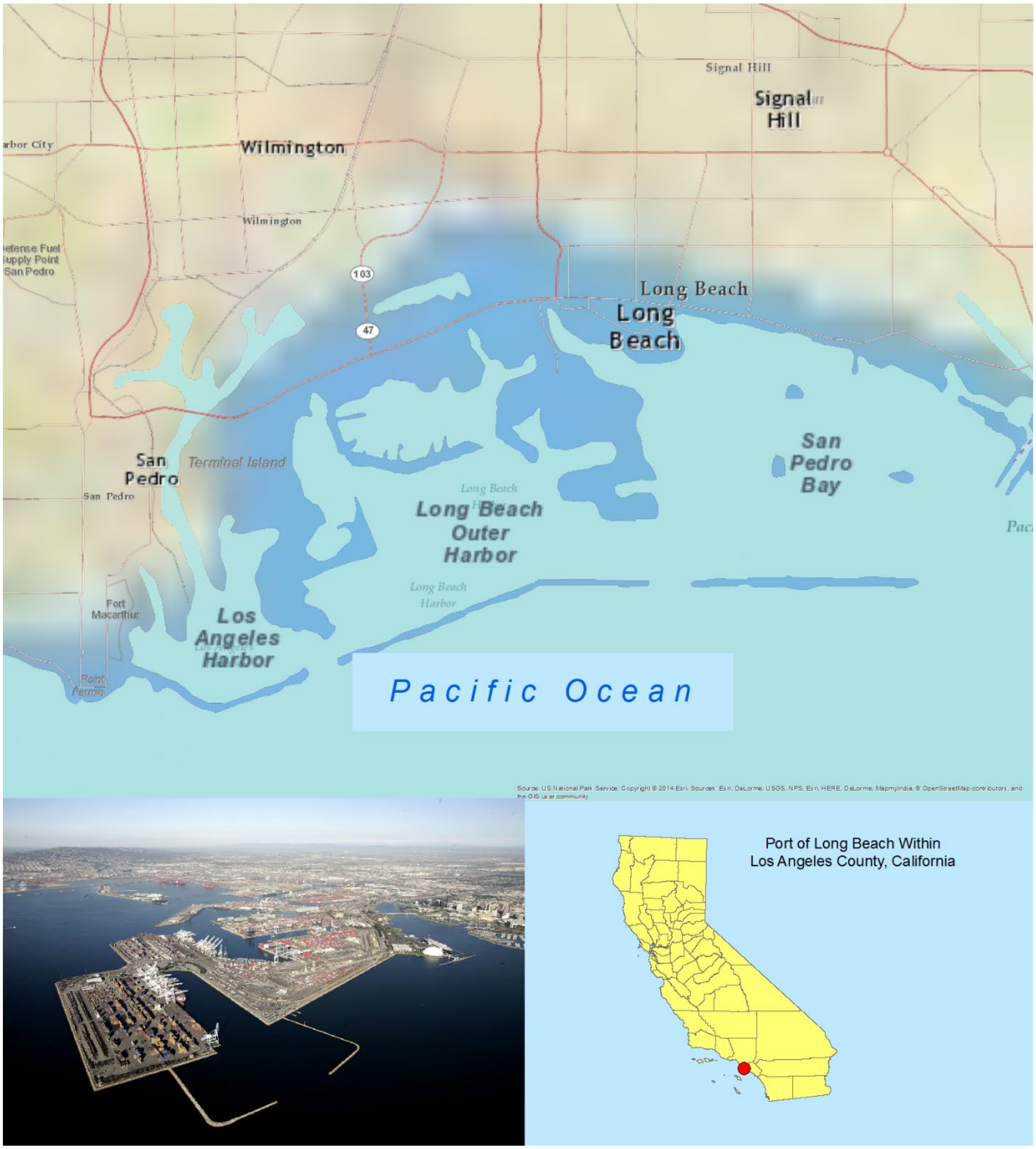


Figure 2-1: Study Area Location Map

The catchment area (geographic area from which the Port attracts a population that uses its services) for the San Pedro Bay Ports (Port of Long Beach and Port of Los Angeles) includes a local catchment area, comprising of area located within California, and an extended catchment area, including Colorado, New Mexico, Utah, Arizona, Nevada, and California (**Figure 2-2**Figure 2-2:).

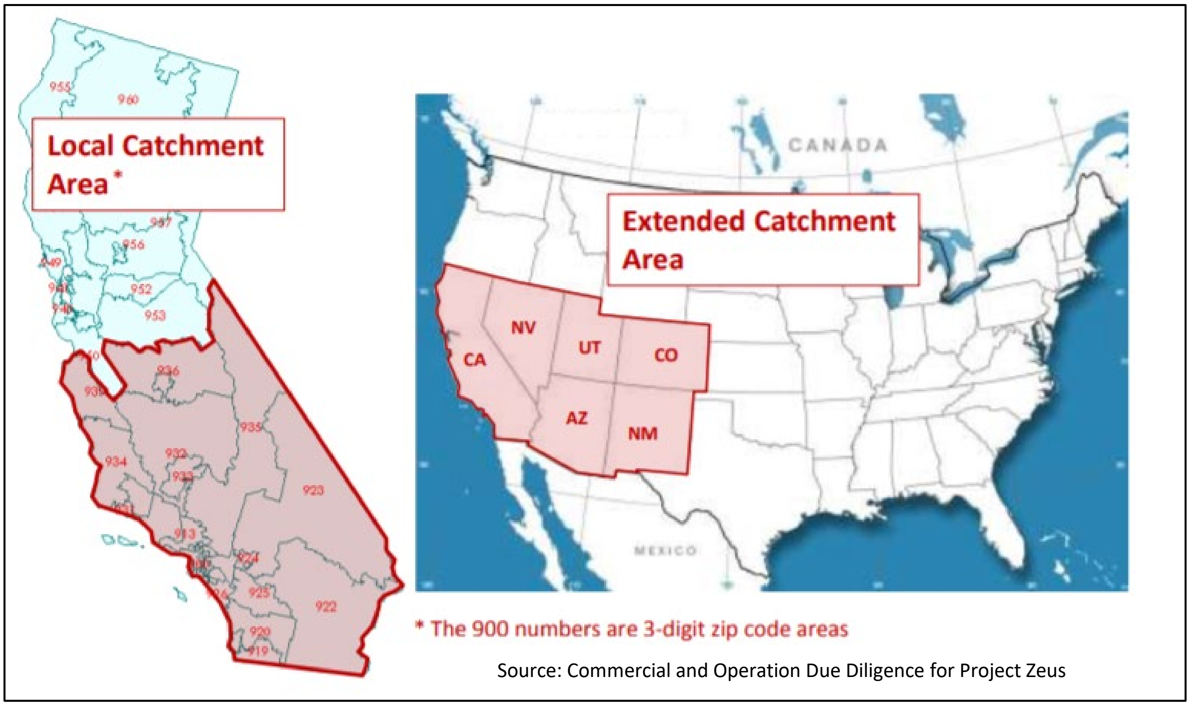


Figure 2-2: Local and Extended Catchment Areas for San Pedro Bay Ports

Because a majority of the services that call the POLB also call at the Port of Oakland, the local catchment encompasses only the areas in California that are closer in over-the-road mileage to the POLB. Areas that extend beyond this are included in the extended catchment area. Northern California is included in the extended catchment area due to importers stopping at the POLB to discharge containers with goods for consumption across California, emphasizing those that are trans-loaded because most of the population of California is located in Southern California. The other five states included in the extended catchment area are land-locked, with a majority of goods that are trans-loaded being handled through the POLB or the Port of Los Angeles.

Non-crude oil is the only high-volume commodity associated with liquid bulk exports. This encompasses refined products that are exported from local refineries in Southern California. The two high-volume commodities being shipped through the POLB are gypsum and salt. Gypsum accounts for the largest portion of dry bulk imports and is a major input to the construction industry. High commodity dry bulk exports include petroleum coke, coal, and metal scraps.

2.1.1 Cargo Profile

In Calendar Year (CY) 2019, the POLB served just under 2,700 large self-propelled vessels, including approximately over 7.6 million TEU's. The port's break bulk cargo totaled approximately 1.5 million tons in 2019. Top commodities include consumer goods, construction materials, machinery, chemicals, plastics, and woods. The POLB was the state's busiest seaport, moving more than 200 million barrels of petroleum liquid bulk in 2018. **Table 2-1** gives an overview of the commodities for the Port of Long Beach from 2013 through 2019. Petroleum and petroleum products accounts for close to 50% of the total tonnage in 2019.

Table 2-1: Commodity Report for Port of Long Beach

Commodity	CY 2019	CY2018	CY 2017	CY 2016	CY 2015	CY 2014	CY 2013
Coal, Lignite, & Coal Coke	1,473,813	1,292,556	1,241,887	310,439	628,263	1,662,778	1,610,989
Petroleum and Petroleum Products	35,896,310	38,033,907	39,942,990	34,549,242	33,667,183	36,508,670	36,525,023
Chemicals and Related Products	3,566,857	3,940,013	3,905,301	4,150,415	3,985,862	4,560,923	4,865,026
Crude Materials	5,351,823	5,442,023	5,565,988	5,403,920	5,615,393	6,397,247	7,452,433
Primary Manufactured Goods	5,983,504	7,019,591	5,826,873	5,592,172	5,698,318	6,334,496	6,203,893
Food and Farm Products	8,675,166	8,503,167	8,207,360	8,413,161	8,423,959	8,275,904	8,337,633
Manufactured Equipment	18,473,470	20,504,352	19,538,746	17,711,594	18,557,878	19,643,239	18,545,534
Waste Material	661	207	112	105	142	85	62
Miscellaneous	1,271,802	1,800,338	1,767,835	1,682,185	1,587,599	1,642,722	952,146
Total	80,693,406	86,536,154	85,997,092	77,813,233	78,164,597	85,026,064	84,492,739

2.1.2 Cargo Value

Table 2-2 presents the top ten U.S seaport districts in dollar value of goods handled in the Calendar Year (CY) 2019. As shown in the table below, the Los Angeles/Long Beach district ranks number one in dollar value of shipments, with cargo valued at about $380 billion in CY 2019. Imports totaled more than $300 billion and exports totaled more than $60 billion for CY 2019.

Table 2-2: Top Ten U.S Seaport Districts in Dollar Value (Millions) of All goods Handled CY 2019

Port District	**Imports**	**Exports**	**TOTAL**
Los Angeles/Long Beach, CA	$ 319,307.72	$ 64,580.56	$ 383,888.28
Houston-Galveston, TX	$ 78,772.87	$ 142,498.31	$ 221,271.18
New York City, NY	$ 163,182.64	$ 42,610.81	$ 205,793.45
Savannah, GA	$ 91,431.45	$ 34,242.69	$ 125,674.14
New Orleans, LA	$ 30,553.52	$ 61,218.51	$ 91,772.03
Seattle, WA	$ 62,938.59	$ 20,030.32	$ 82,968.91
San Francisco, CA	$ 51,224.44	$ 29,814.22	$ 81,038.67
Charleston, SC	$ 47,692.39	$ 27,324.86	$ 75,017.25
Norfolk, VA	$ 50,063.09	$ 24,871.75	$ 74,934.85
Baltimore, MD	$ 43,440.98	$ 14,967.28	$ 58,408.25

*"Exports" are FAS value of U.S. exports of domestic
**Source: U.S Census Bureau Merchandise Trade Report FT920 December 2019

2.2 Facilities and Infrastructure

The Port of Long Beach has undergone significant expansion in the past century and has become a major transportation and trade center, providing the shipping terminals for nearly one-third of the waterborne trade moving through the West Coast. There are 22 shipping terminals to process break bulk (lumber, steel), bulk (salt, cement, and gypsum), containers, and liquid bulk (petroleum). The surrounding area includes 1.7 billion square feet of warehouse and distribution facilities. See **Figure 2-3** for an overview of the POLB facilities.

The following sections focus on terminals, vessel fleets and characteristics, trade, shipping operations, and design vessels for container and liquid bulk vessels, which are the vessel types that are the focus of this Feasibility Study.

2.3 Container Services

According to the Waterborne Commerce Statistics Center, in 2019, the POLB was the third largest U.S container port in terms of TEU throughput. The container terminals are located at Piers A, C, E, G, J, and T. These terminals handle various kinds of cargo moving within the standard shipping containers -- primarily finished goods like clothes, toys, and furniture. East Asia accounts for approximately 90% of container shipments. **Figure 2-3** depicts the container terminals and their design depths.

POLB Container Terminals					
Pier	**Operator**	**Size (Acres)**	**Cargoes**	**On Dock Rail**	**Design Depth**
A	SSA Terminals	159.3	General	Yes	50'
C	SSA Terminals	70	General & Autos	No	42'
E	Long Beach Container Terminal, Inc.	170	General	Yes	55'
G	International Transportation Service	246	General	Yes	42'-52'
J	Pacific Container Terminal	256	General	Yes	50'
T	Total Terminals, International	385	General	Yes	55'

Figure 2-3: POLB Container Terminals

2.3.1 Existing Container Terminals and Capabilities

As discussed, the POLB container terminals include Pier A, Pier C, Pier E, Pier G, Pier J, and Pier T. The terminals had a record throughput of 8 million TEUs in CY 2018, with a 10.7% increase from the previous year. **Figure 2-3** outlines the container terminals infrastructure.

2.3.2 Carriers and Trade Lanes

According to the data gathered from the Port, the POLB has had, on average, about 17 weekly container calls from 2010-2019. **Table 2-3** provides a snapshot of the weekly ocean carrier services for the POLB. Some of the major lines include Maersk, MSC, CMA CGM, OOCL, and Evergreen.

Table 2-3: Port of Long Beach Weekly Ocean Carrier Services

TERMINAL	ALLIANCE	CARRIER	SERVICE CODE	ROTATION
SSA Pier A	Oceana Vessel Sharing Agreement	Hamburg Sud Hapag-Lloyd ANL MSC PIL	PANZ - WSN - PCX - Oceana Loop 1 - AOS	Oakland - Seattle - Vancouver - LONG BEACH - Auckland - Sydney - Melbourne - Adelaide - Sydney - Tauranga - Papeete - Oakland
SSA Pier A	Independent	Hamburg Sud Polynesia Line	SSEA	Papeete - Apia - Pago Pago - LONG BEACH - Oakland - Papeete
SSA Pier A	Independent	Swire	WCNA - West Coast North America	Brisbane - Port Kembla - Melbourne - Tauranga - Vancouver BC - Everett - LONG BEACH - Suva - Brisbane
SSA Pier A	Independent	SM Lines	CPX China Pacific Express	Ningbo - Shanghai - Kwangyang - Busan - LONG BEACH - Busan - Kwangyang - Ningbo
SSA Pier A	Independent	Hamburg Sud Hapag-Lloyd	MPS MedPac Service	Cagliari - Livorno - Genoa - Marseilles-Fos - Barcelona - Valencia - Cartagena - Puerto Quetzal - Manzanillo (Mexico) - LONG BEACH - Oakland - Seattle - Vancouver - Oakland - LONG BEACH - Manzanillo (Mexico) - Cartagena - Caucedo - Tangier - Valencia - Cagliari
SSA Pier C	Independent	Matson	CLX1 - China Long Beach Express	Naha - Ningbo - Shanghai - LONG BEACH - Honolulu - Guam - Naha
SSA Pier C	Independent	Matson	Hawaii Service Loop 2	Honolulu - LONG BEACH - Honolulu
Long Beach Container Terminal (LBCT) Pier E	OCEAN Alliance	OCEAN Alliance COSCO OOCL CMA CGM Evergreen APL	AAS - PVCS - SCS South China Sea - SC6 South China Loop 6	Cai Mep - Hong Kong - Yantian/Shenzhen - Kaohsiung - LONG BEACH - Kaohsiung - Cai Mep

TERMINAL	ALLIANCE	CARRIER	SERVICE CODE	ROTATION
Long Beach Container Terminal (LBCT) Pier E	OCEAN Alliance	OCEAN Alliance COSCO OOCL CMA CGM Evergreen APL PIL	AAC4 - PCC1 - HIX Hibiscus Express - PCC1 - CC9 Central China Loop 9 - AC7	Ningbo - Shanghai - Busan - LONG BEACH - Busan - Ningbo
International Transportation Services (ITS) Pier G	THE Alliance	THE Alliance ONE Hapag-Lloyd Yang Ming	PS3	Nhava Sheva - Pipavav - Colombo - Port Kelang - Singapore - Laem Chabang - Cai Mep - LONG BEACH - Oakland - Pusan - Ningbo - Shekou - Singapore - Port Kelang - Nhava Sheva
International Transportation Services (ITS) Pier G	THE Alliance	THE Alliance ONE Hapag-Lloyd Yang Ming	AL5	Southampton - Le Havre - Rotterdam - Hamburg - Antwerp - Savannah - Cartagena -Balboa - Los Angeles - Oakland - Seattle - Vancouver - LONG BEACH - Balboa - Cartagena - Caucedo - Savannah - Southampton
Pacific Container Terminal (PCT) Pier J	Independent	PIL WHL COSCO YML OOCL	ACS - CP2 - AAC3 - AAC - PCC2	Lianyungang - Shanghai - Ningbo - LONG BEACH - Seattle - Lianyungang
Pacific Container Terminal (PCT) Pier J	Independent	PIL WHL COSCO CMA CGM APL	AC5 - CP1 - SEA - PSX Pacific South Express - SC3	Haiphong - Nansha - Hong Kong - Yantian/Shenzhen - LONG BEACH - Oakland - Yantian/Shenzhen - Haiphong
Total Terminals Inc. (TTI) Pier T	2M+H	Maersk MSC HSD HMM	TP2 - Jaguar - UPAS2 - PS3	Singapore - Cai Mep - Yantian/Shenzhen - Ningbo - Shanghai - LONG BEACH - Oakland - Vostchny - Busan - Ningbo - Shekou/Chiwan - Singapore
Total Terminals Inc. (TTI) Pier T	2M+H	Maersk MSC HSD HMM	TP8 - New Orient - UPAS1 -PS4	Xingang - Qingdao - Ningbo - Shanghai - Busan - Yokohama - Prince Rupert - LONG BEACH - Oakland - Vostochniy - Xingang
Total Terminals Inc. (TTI) Pier T	Independent	MSC	CEX	Gioia Tauro - Civitavecchia - La Spezia - Valencia - Sines - Cristobal - Balboa - Manzanillo - LONG BEACH - Oakland - Vancouver - Seattle - Oakland - LONG BEACH - Balboa - Cristobal - Gioia Tauro
Total Terminals Inc. (TTI) Pier T	2M+H	HMM Maersk MSC	PS2 - TP7 - Lotus	Laem Chabang - Cai Mep - Kaohsiung - Busan - LONG BEACH - Oakland - Busan - Kaohsiung - Hong Kong - Laem Chabang
Total Terminals Inc. (TTI) Pier T	Independent	Maersk Hamburg Sud Sealand Alianca APL CMA CGM	WCCA2 - WC2	Balboa - Corinto - Acajutla - Lazaro Cardenas - LONG BEACH - Oakland - Lazaro Cardenas - Corinto - Puerto Caldera - Arrijan- Balboa

*Source: Port of Long Beach Website

2.3.3 TEU Weight per Containers

Data was collected from the POLB to determine weight per TEU. **Table 2-4** provides the weight per TEU by trade route. Generally, exports are heavier than imports, as noted in the data.

Table 2-4: Average Weight per Loaded TEU by Trade Lane

Route Group	Description	Import Weight/TEU (Metric Tons)	Export Weight/TEU (Metric Tons)	Imports and Exports Weight/TEU (Metric Tons)
NEA-WCUS	Northeast Asia Container Route	5.7	9.7	6.8
SEA-WCUS	Southeast Asia + ISCME Container Route	5.8	9.4	6.9
EU-NA-LA-WCUS	Europe/North America/Latin America/ WCUS	8.3	9.1	8.5
OCEANIA-WCUS	New Zealand/Australia/Pacific Island/Hawaii	8.6	8.5	8.5

2.4 Historical Commerce

In 2019 , 7.63 million loaded TEUs were reported, including items from clothing, shoes, toys, furniture, and electronics. **Figure 2-4**Figure 2-4: illustrates the total container throughput (TEUs) for the port, from 2010 through 2019. During this time frame, throughput increased by approximately 1.4 million TEUs, which is an increase by about 19%.

Figure 2-4: Port of Long Beach Historical Container Throughput

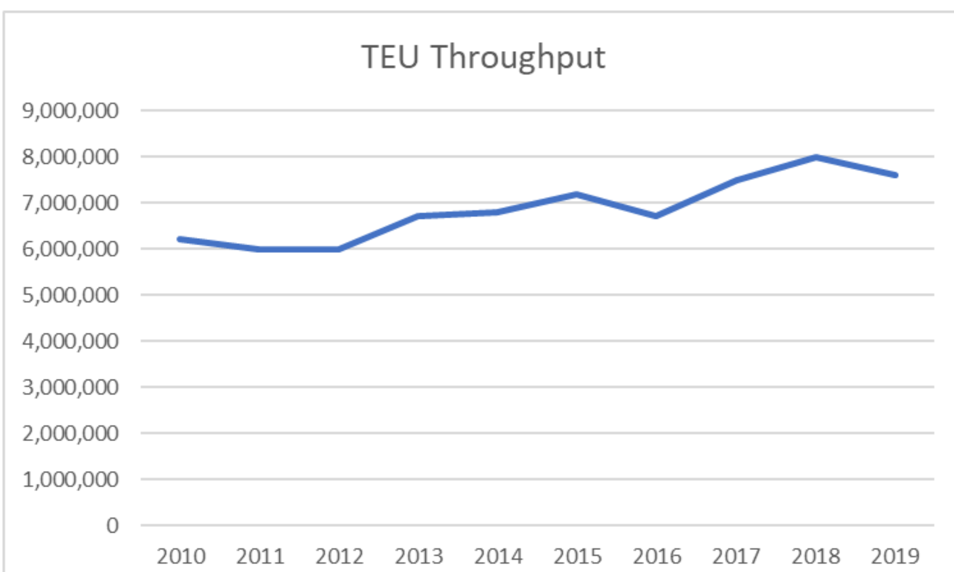


Figure 2-5 illustrates the historic tonnage of crude oil, the primary liquid bulk commodity for the POLB. From 2011 through 2019, there was no discernable trend in tonnage. In 2019, crude oil tonnage was above 25 million tons.

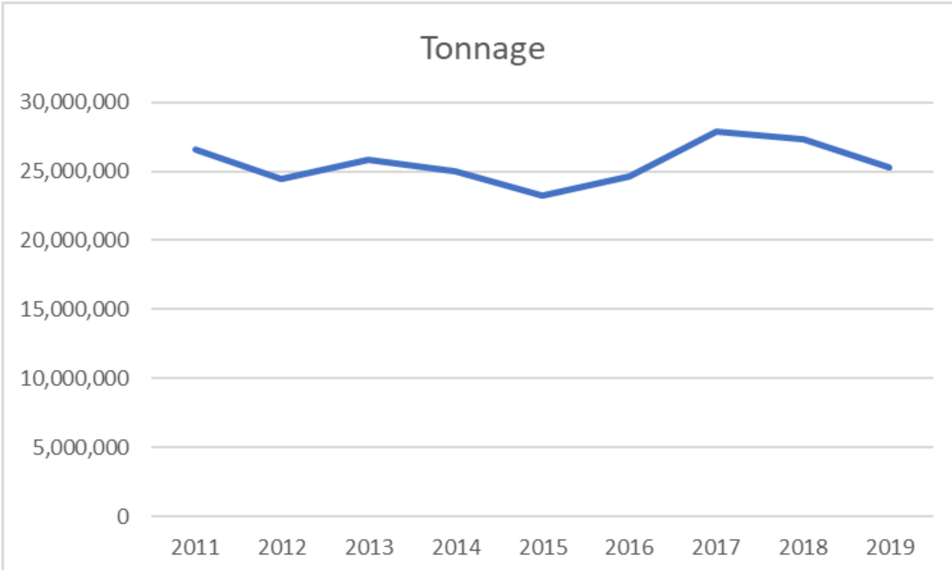
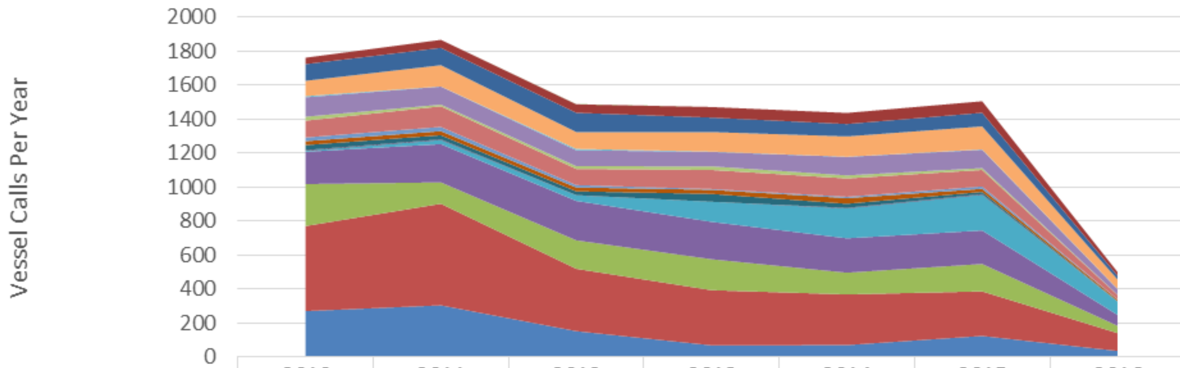


Figure 2-5: Port of Long Beach Historical Crude Oil Tonnage

In 2020, the Port of Long Beach moved more than 8.1 million container units, with 6.3% more TEUs handled than in 2019. Imports increased 6.6% while exports increased 0.2%, even with the Covid-19 pandemic in 2020.

2.5 Existing Fleet

Data for the existing fleet was obtained from the POLB and a variety of tanker and container ships called to the port between 2010 and 2016. Container ships are classified as sub-Panamax (SPX), Panamax (PX), Post-Panamax Generation 1 (PPX Gen 1), Post-Panamax Generation II (PPX Gen 2), Post-Panamax Generation III (PPX Gen 3), and Post-Panamax Generation IV (PPX Gen 4) depending on their capacity. Tanker vessels are classified as Handymax (HX), Medium Range 1 (MR1) or 2 (MR2), Panamax (PX), Aframax (AX), Suezmax (SX), or Very Large Crude Carriers (VLCC) depending on their capacity as well. The vessels are distinguished based on their physical and operation characteristics, including lengths overall (LOA), design draft, beam, speed, and TEU capacity. It is common practice to separate the containership fleet in TEU bands or classes to analyze the supply within the industry. However, due to the evolution of vessel design over time, these TEU bands do not correspond to a breakdown of the fleet by dimensions, such as beam or draft. **Figure 2-6** shows the vessel calls at the POLB from 2010 - 2016, broken down by vessel class and tanker capacity. Detailed vessel call information was provided by the Port. At the time it was provided, Data was the latest available.



	2010	2011	2012	2013	2014	2015	2016
400K DWT Tanker	0	0	1	0	0	0	0
300K DWT Tanker	38	47	50	62	65	68	22
200K DWT Tanker	98	102	113	85	73	80	22
100K DWT Tanker	90	125	99	115	119	135	55
80K DWT Tanker	7	1	8	2	1	2	2
70K DWT Tanker	114	106	94	85	109	108	32
60K DWT Tanker	23	10	16	21	18	11	2
50K DWT Tanker	99	121	95	112	108	97	25
40K DWT Tanker	22	25	14	5	8	14	2
30K DWT Tanker	23	24	23	24	33	18	8
20K DWT Tanker	29	24	22	46	24	13	3
10K DWT Tanker	5	4	1	0	3	4	0
PPX4	0	0	0	0	0	0	1
PPX3	5	24	33	118	176	210	78
PPX2	190	225	232	220	202	197	64
PPX1	247	126	167	182	128	161	43
PX	500	597	367	324	298	262	105
SPX	271	305	153	70	71	125	37

Figure 2-6: POLB Vessel Calls by Class, 2010 - 2016

Table 2-5: POLB Existing Fleet Vessel Characteristics

Vessel Fleet Subdivision (Containerships)		**From**	**To**
Sub Panamax (SPX) (MSI size brackets: 0.1-1.3, 1.3-2.9 k TEU)	**Beam**	55	98
	Draft	8.2	38.1
	LOA	222	813.3
Panamax (PX) (MSI size brackets: 1.3-2.9, 2.9-3.9, 3.9-5.2, 5.2-7.6 k TEU)	**Beam**	98	106
	Draft	30.8	44.8
	LOA	572	970
Post-Panamax (PPX1) (MSI size brackets: 2.9-3.9, 3.9-5.2, 5.2-7.6, 7.6-12 k TEU)	**Beam**	106	138
	Draft	35.4	47.6
	LOA	661	1045
Super Post-Panamax (PPX2) (MSI size brackets: 5.2-7.6, 7.6-12 k TEU)	**Beam**	138	144
	Draft	39.4	49.2
	LOA	911	1205
Ultra Post-Panamax (PPX3) (MSI size brackets: 5.2-7.6, 7.6-12, 12 k + TEU)	**Beam**	144	168
	Draft	Up to	55
	LOA	Up to	1220
Post-Panamax (PPX4) (MSI size brackets: 12 k + TEU)	**Beam**	168	200
	Draft	Up to	55
	LOA	1000	1300
Vessel Fleet Subdivision (Tankers)		**From**	**To**
Handymax (HX) (DWT size brackets: 10,000 – 26,999 DWT)	**Beam**	65	136
	Draft	27.7	52.8
	LOA	405	868
Medium Range 1 (MR1) (DWT Size brackets: 27,000 – 39,999 DWT)	**Beam**	83	190
	Draft	25.5	85.3
	LOA	540	1092
Medium Range 2 (MR2) (DWT Size brackets: 40,000 – 54,999 DWT)	**Beam**	62.5	122
	Draft	13.3	302
	LOA	577	748
Panamax (PX) (DWT Size brackets: 55,000 – 79,999 DWT)	**Beam**	104	106
	Draft	40	49
	LOA	601	820
Aframax (AX) (DWT Size brackets: 80,000 – 122,000 DWT)	**Beam**	104	197
	Draft	21.5	55
	LOA	748	1092
Suezmax (SX) (DWT Size brackets: 123,000 – 193,000 DWT)	**Beam**	137	518
	Draft	46.5	59
	LOA	799	925
Very Large Crude Carrier (VLCC) (DWT Size brackets: 265,000 – 400,000 DWT)	**Beam**	164	229
	Draft	30.5	70
	LOA	942	1115

2.6 Shipping Operations

2.6.1 Underkeel Clearance

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

Evaluation of all movements renders a distribution of UKC requirements. Evaluation of minimal clearance (i.e., some level of clearance below which operators or pilots will not move a vessel due to concerns for insufficient safety) helps to quantify the period of time each day, within a tide cycle; a given vessel with a specified immersed draft can be moved relative to tide.

Given the general evaluation of practices for UKC at most coastal ports in the U.S., minimal clearances for all vessel types are often 2.0 to 3.0 feet measured in the static condition for many historical fleets having Panamax or lesser service. The average UKC for vessels of sub-Panamax up through Post-Panamax Gen IV is approximately 4.5 feet. It is important to consider, however, that most coastal ports have comparatively limited distances between ocean approaches and dock facilities (i.e., less than 20 miles).

Regarding vessel sizes under with-project conditions, it is understood that most Post-Panamax vessels need more clearance depending on blockage factors, currents, and relative confinement of the waterway. As such, most Post-Panamax containerships need about 4 to 5 feet for vessels with breadths of 120 to nearly 200 feet, LOA approaching 1,300 feet, and summer loadline drafts of 46.0 to approximately 55.0 feet. **Table 2-6** displays the UKC requirements for the Sub-Panamax through the Post-Panamax Generation IV.

Table 2-6: Vessel Underkeel Clearance

Vessel Class	Total Underkeel Clearance (feet)
Sub-Panamax (SPX)	4.0
Panamax (PX)	4.0
Post-Panamax Gen I (PPX1)	4.0
Post-Panamax Gen II (PPX2)	4.5
Post-Panamax Gen III (PPX3)	4.5
Post-Panamax Gen IV (PPX4)	5.0
40k dwt	3.0
50k dwt	3.5
60k dwt	3.5
70k dwt	3.5
80k dwt	4.0
90k dwt	4.3
100k dwt	4.5
200k dwt	6.2
300k dwt	7.9

2.6.2 Tidal Range

The variability of sea level must also be considered when determining the level of water needed for navigation. According to the 2019 NOAA tidal data, the POLB experienced an average tide range of approximately 3.9 feet MLLW. **Table 2-7** summarizes the High Tide and Low Tide data for the Port of Long Beach in 2019. **Table 2-8** presents the tidal data through the tidal epoch relative the MLLW. **Figure 2-7** depicts a tide prediction table for NOAA. The solid blue line depicts a curve fit between the high and low values.

Table 2-7: Tide Statistics Summary (feet MLLW)

	Low Tide	High Tide	Low and High Tide
Min	3.4	2.9	-1.9
Max	-1.9	7.3	7.3
Mean	0.9	4.8	2.9

Table 2-8: Tidal Data at Port of Long Beach Station 9410660 (1983-2001 Tidal Epoch)

Datum	Value (feet)	Description
MHHW	5.49	Mean Higher-High Water
MHW	4.75	Mean High Water
MTL	2.84	Mean Tide Level
MSL	2.82	Mean Sea Level
MLW	0.94	Mean Low Water
MLLW	0	Mean Lower-Low Water

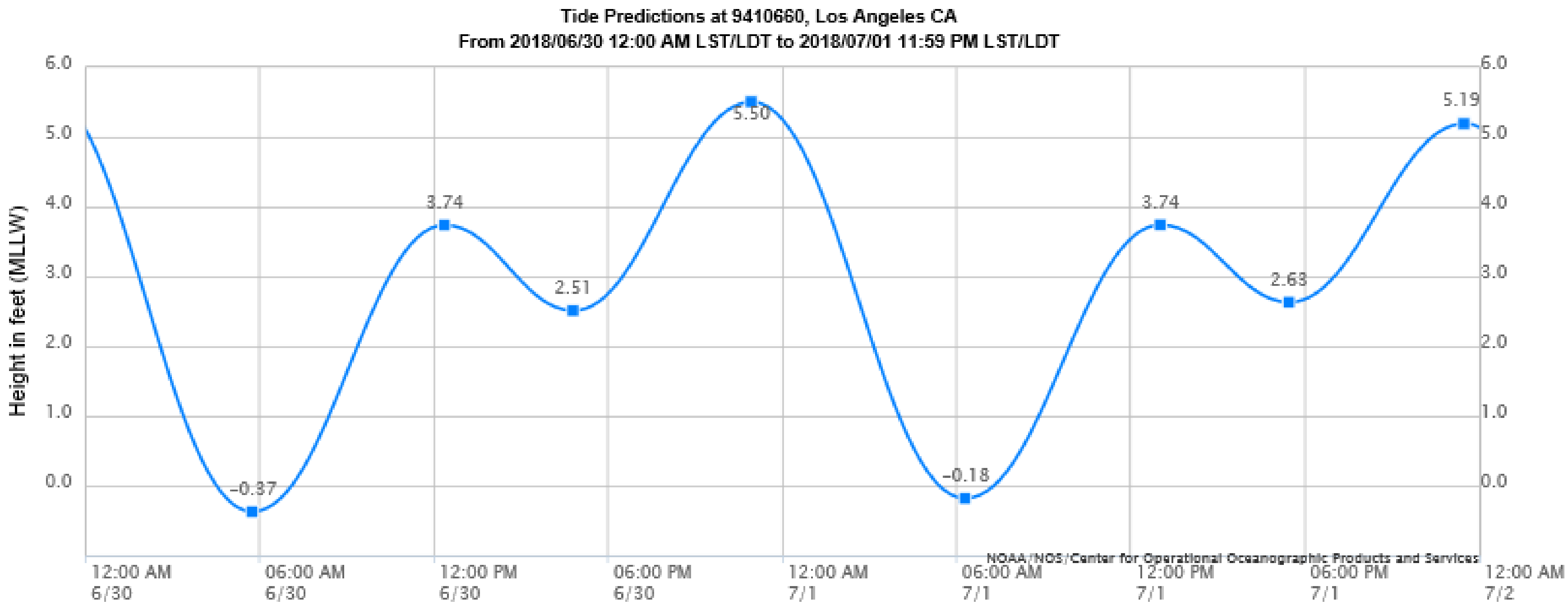


Figure 2-7: Tide predictions for Port of Long Beach (Feet MLLW)

2.7 Design Vessel

"For deep-draft projects, the design ship or ships is/are selected on the basis of economic studies of the types and sizes of the ship fleet expected to use the proposed channel over the project life. The design ship is chosen as the maximum or near maximum size ship in the forecasted fleet" (USACE 1984, 1995, 1999).

The selection of vessel specifications for fleet service forecasts and waterway engineering evaluations sometimes poses unique concerns given the requirements to evaluate design and improvements for waterway systems over time. Generally, waterway improvements should be designed to be optimized across the entire fleet forecast regime or structure. Typically, it may include service by several sizes and types of vessels (i.e., bulk carriers, containerships, tankers, etc.). Where vessel designs are relatively mature (tankers and dry bulk carriers), the task is comparatively straightforward. However, where consideration is to include fully cellular containership services, associated hull designs are still evolving. On a world fleet basis, containership designs continue to change with respect to size and cargo carrying capacity, and have not reached an absolute limiting threshold for rated carrying capacity as measured by weight (deadweight tonnage) or nominal intake for standard-unit slot capacity (i.e., nominal TEUs).

With respect to current and projected fleet service for deep-draft harbors, such as the POLB, post and new Panamax designs are divided into three (3) general groupings, largely separated by beam or extreme breadth and capacity for nominal TEU intake. Building trends for the first two groupings (Generation I and Generation II, with beams typically less than 150 to 152 feet) are reasonably well established with respect to typical physical dimensions and size relative to displacement, associated deadweight capacity, and typical homogeneous and nominal TEU ratings. What can be termed the Generation III class of containership (beams exceeding 150 feet through 168 feet) has only recently become better defined in terms of typical dimensions that a project analyst would expect to encounter due in large part to announcement of the specifications for maximum hull size to be accommodated by the new locks currently nearing completion of construction for the Panama Canal. This class has dimensions designed with an emphasis of consideration for specifications of the new locks under construction for the Panama Canal expansion. The length and beam limitations of the new locks for the Panama Canal are now known and these parameters are considered fixed. Conversely, while the specification for draft typically does have a limit, as with employment of the existing lock system, actual immersed draft can be adjusted or allowed to vary based on variability in cargo density, loading, and utilization of weight carrying capacity of the hull.

Table 2-9 shows the containerized design vessel specification that were recommended by the Economics team in collaboration with the USACE's Institute for Water Resources (IWR). **Table 2-10** shows the liquid bulk design vessel specifications.

Table 2-9: Containerized Design Vessel

Post Panamax Gen IV	
Maximum Draft:	52 ft
LOA:	1,300 ft
Beam:	193 ft
DWT:	188,000
TEUs:	18,000 - 19,000

Table 2-10: Liquid Bulk Design Vessel

VLCC	
Maximum Draft:	70 ft
LOA:	1,100 ft
Beam:	200-210 ft
DWT:	325,000

In addition to new or evolving Panamax specification, fleet service for harbors on the west of the United States such as the POLB have the potential to be serviced by the new Post-Panamax class(es) of ships, especially where concerns for depth and limitation on air draft of little concern. The primary issue for these carriers is a matter of timing or when they will initiate service, frequency of service, and applicable load factor specifications applicable to the trades involved. These vessels fall within the classification of what could be called Generation IV (and above) Post-Panamax (with the definition of Post-Panamax based on the original or lock specifications of the Canal) or new Post-Panamax based on the new locks expected to be placed into service by 2015. The Generation IV Post-Panamax class of containership have beams exceeding 168 feet through 185 to nearly 190 feet and accordingly this class of ship represent hulls that are considered to clearly exceed the margins for accommodation of the new lock system of the Panama canal and as previously described fall into the realm of what may be considered to the “new” Post-Panamax standard once the new lock system is commissioned into service.

2.8 Liquid Bulk Services

Liquid forms of bulk cargo include crude oil, gasoline, and miscellaneous chemicals. The primary liquid bulk commodity for the port is crude oil imports. Current liquid bulk facilities include Marathon Petroleum, Petro-Diamond Terminal Co., Chemoil Marine Terminal, and Vopak Terminal Long Beach (**Table 2-11**). These facilities are located on piers F, B, C, and S. As shown previously in **Figure 2-5**, crude oil imports have varied with no discernable trend from 2011 through 2019. Projected imports are not anticipated to be significantly different from historical volumes.

Table 2-11: Liquid Bulk Facilities

Terminal Operator	Petro-Diamond Terminal Co.	Chemoil Marine Terminal	Marathon Petroleum	Marathon Petroleum	Marathon Petroleum	Vopak Terminal Long Beach
Terminal Location	Pier B Berths B82, B83	Pier F Berth F209; Pier G Berth G211A	Pier B Berths B76-B80	Pier B Berths B84-B87	Pier T Berth 121	Pier S Berth S101
Cargoes Served	Gasoline, ethanol, gasoline blend stocks, diesel, biodiesel	Petroleum products and bunker fuel	Petroleum products: i.e., gasoline, blending stocks, MTBE, diesel, naphtha jet fuel, nonenes tetramers, fuel oils, carbon black, crude oil.	Crude oil, petroleum products, bunker fuel.	Crude oil and petroleum products	Miscellaneous bulk liquid chemicals
Total Terminal Area	6 ac. | 2.43 ha.	5 ac. | 2.02 ha.	18 ac. | 7.28 ha.	11 ac. | 4.45 ha.	6 ac. | 2.43 ha.	10 ac. | 4 ha.
Length of Berths	1,060 ft. | 323 m	800 ft. | 244 m	2,200 ft. | 671 m	1,980 ft. | 604 m	1,140 ft. | 347 m	700 ft. | 213.4 m
Wharf Height	14.4 ft. | 4.4 m	19.1 ft. | 5.8 m	14.4 ft. | 4.4 m	16.8 ft. | 5.1 m	22.4 ft. | 6.8 m	15.5 ft. | 4.7 m
Special Equipment & Facilities	Terminal has pipeline connections which allow petroleum products to be shipped to most L.A. Basin refiners and common carrier pipelines. Two 8-inch dock hoses connecting into two 10-inch dock lines capable of receiving up to 12,000 BBLS per hour. Truck rack at the terminal is capable of loading 150 trucks per twenty-four hour period. Permits are available for DSP and bonded storage. Capacity for petroleum products: 590,000 BBLS.	Storage capacity: 425,000 BBLS. Pipeline system to handle ships, barges, trucks and railcars. Pipeline connection to Carson tank farm, which supplies petroleum products to most L.A. Basin refiners and terminals. Rail served.	Capacity for storage: 1,800,000 BBLS. Terminal has several pipeline connections to other companies. Loading arms on dock are 8" Chiksan and are capable of loading rates of 10,000 to 15,000 BBLS per hour. Three vessels can be loaded or discharged simultaneously.	Discharge capacity: 32,000 BBLS per hour, 24-inch pipeline to storage and tank farm. Storage capacity: 245,000 BBLS	Four 16-inch diameter articulated crude unloading arms and one 8" dia. articulated bunker/diesel loading arm; 275 psi max. working pressure; designed to accommodate tankers from 50,000 to 265,000 dwt; Storage tankage available at ARCO facilities in Carson and the inner harbor via 42" and 24" pipelines.	Dedicated pump and piping systems to transfer products to and from ships, barges, railcars, and tank trucks. Storage capacity: 15 million gallons.

3 FUTURE CONDITIONS

3.1 Terminal Expansions

The Port's ability to accommodate large container ships and handle additional cargo is a key objective of the POLB. In preparation of the next generation of vessels, the POLB has a 10 year, $4.0 billion capital program to update their infrastructure and facilities to improve the efficiency of cargo operations. The program has a plan for projected spending of $2.3 billion over the next 10 years. This includes the Middle Harbor Redevelopment Project, the Gerald Desmond Bridge Replacement, the Pier B Rail Support Facility, the Pier G and J modification project, and berth deepening.

3.1.1 Existing Container Terminal Facilities and Infrastructure

Figure 2-3 outlines the existing container terminal facilities and infrastructure. These facilities include:

- Pier A: SSA terminals
- Pier C: SSA Terminal
- Pier E: Long Beach Container Terminal Inc.
- Pier G: International Transportation Service
- Pier J: Pacific Container Terminal
  Pier T: Total Terminals International

As aforementioned, the POLB has an improvement plan of $2.3 billion projected capital spends over the next 10 years. This includes the following improvements:

- Middle Harbor Redevelopment Project: $1.5 billion to combine and modernize two aging shipping terminals. The project will quintuple dock rail capacity and is expected to be completed in 2021.

- Gerald Desmond Bridge Replacement: A $1.5 billion project to build a new bridge that spans the port's main channel. This will allow for better traffic management and was completed in 2020.

- Pier B Rail Support Facility: The Pier B support facility will provide a more efficient transfer of cargo between marine terminals and Class 1 railroads.

- Pier G and Pier J modernization: Berth and rail facility improvements.

- Berth deepening

Additionally, the Port is currently updating their master plan. This includes improvements to Pier G, which would allow the design vessel to call on that berth, and the infill of Pier J South, which would allow greater landside terminal facilities and capacity for Pier J North.

3.2 Operations

3.2.1 Container Terminal Use Plan

The POLB's future container use plan will generally conform to its historical practices, however, as ships get larger, terminal operators globally are looking for ways to handle higher densities of cargo more efficiently and in a cost effective manner. The Long Beach City Council recently directed the city's harbor department to study the economic implications of automation on the city. Construction for the Middle Harbor Terminal Redevelopment Project began in 2011 and is creating one of the world's greenest container shipping terminals. The 311 acre facility will be able to handle twice as much cargo and will be nearly fully electric with zero emissions. The first phase (170 acres) of the project opened in 2016 with Orient Overseas Container Line agreeing in 2012 to a 40 year lease to operate the new terminal.

3.3 Commodity Forecast

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

3.3.1 Baseline

To minimize the impact of potential anomalies in trade volumes on long-term forecasts, seven years of data were employed to establish the baseline for the commodity forecast. Empirical data from 2010 to 2016 were used to develop a baseline, allowing the forecast to capture both economic prosperity and downturn which occurred over that timeframe. The year 2015 was used as the baseline for the forecast. While this study was underway, two additional years of data (2016 and 2017) became available. Those data were evaluated, and no significant changes were found; therefore, the baseline condition was not changed.

Containerized Imports

Table 3-1 illustrates the historical import TEUs for the POLB from 2008 – 2019.

Table 3-1: Historical Containerized TEU Imports

Fiscal Year	Loaded	Empty	Total
2019	3,758,438	74,706	3,833,144
2018	4,097,377	91,364	4,188,741
2017	3,863,187	75,710	3,938,897
2016	3,442,575	99,349	3,541,924
2015	3,625,264	101,560	3,726,824
2014	3,517,512	89,184	3,606,696
2013	3,455,331	71,760	3,527,091
2012	3,062,301	82,605	3,144,906
2011	3,024,964	107,441	3,132,405
2010	3,128,859	95,907	3,224,766
2009	2,461,137	82,399	2,543,536
2008	3,189,363	112,911	3,302,274

Containerized Exports

Table 3-2: illustrates the historical containerized TEU exports for POLB from 2008 – 2019.

Table 3-2: Historical Containerized TEU Exports

Fiscal Year	**Loaded**	**Empty**	**Total**
2019	1,472,802	2,326,087	3,798,889
2018	1,523,008	2,379,274	3,902,282
2017	1,470,514	2,135,096	3,605,610
2016	1,529,497	1,703,750	3,233,247
2015	1,525,561	1,939,684	3,465,245
2014	1,604,395	1,609,716	3,214,111
2013	1,704,924	1,498,558	3,203,482
2012	1,540,179	1,360,579	2,900,758
2011	1,506,702	1,421,995	2,928,697
2010	1,562,398	1,476,334	3,038,732
2009	1,352,052	1,094,547	2,446,599
2008	1,687,052	1,498,491	3,185,543

3.3.2 Trade Forecast

The preceding section describes the methodology that was used to develop the import and export baseline. The following sections discuss the methodology employed to develop the import and export long-term trade forecasts. While the forecasts presented in the following sections are truncated in the year 2040, the Port will in all likelihood continue to grow. However, due to the substantial uncertainty of developing projections past 2040, benefits are assumed to remain constant for the remainder of the period of analysis (2027-2076).

The long-term trade forecast for the POLB study combined data obtained from the Mercator International LLC and empirical data obtained from the POLB. The Cargo Forecast from the Mercator Report identifies the economic factors that drive future performance of commodities and uses an Econometric model to provide a forecast of volumes by commodity and direction.

First, a baseline was established from historical trade information, as discussed in Section 3.3.1. Next, a long-term trade forecast for the POLB was obtained from the Mercator Report. In the following sections, the methodology to develop a long-term containerized trade forecast for the Port of Long Beach is discussed.

Mercator Report

The Mercator Report was released in February 2016 and provides a 25-year volume forecast for container and non-container cargo for the Ports of Long Beach and Los Angeles, collectively referred to as the San Pedro Bay Ports (SPB). The Port of Long Beach comprises approximately 50% of SPB values. The forecast is conducted by separating volumes by direction, commodity, and major segments. Economic factors are identified that may influence the performance of each commodity by direction to create a 25-year forecast. These forecasted economic variables are used as inputs for an Econometric model to create a 25-year forecast of both the SPB ports and national volumes by commodity and direction. This is combined with the quantified risk of cargo diversion to other ports based on changes to the SPB ports over the 25 year time frame. This analysis is done with three macro-economic assumptions to produce three separate volume forecasts: High, Expected, and Low. Additional analysis was conducted on cargo types that had the potential of diversion that quantified the risk of diversion based on three sets of assumptions: Upside, Base case, and Downside. These are defined by the amount of volume that is diverted, with Base case being the most likely volume diverted, Upside being the least volume diverted, and downside with the greatest volume diverted. The analysis therefore produced nine forecast scenarios, with the Expected economic assumptions and Base Case risk diversion assumption resulting in the most likely outcome. We only reference the results of the Expected-Base case results in this appendix. It is noted that the analysis is unconstrained and actual future volumes will be constrained by physical and operation capacities of the SPB ports.

Oxford Economics and Haver Analytics provided data and models for trade forecasts. This includes information on macroeconomic factor effects from the Oxford Economic's Global Scenarios Service that was combined to build import/export change scenarios for the U.S. and the Port of Long Beach.

Mercator Trade Forecast

a. Mercator Containerized Imports

The relationship between imports into SPB ports and the nation as a whole were analyzed for each commodity and region combination. Two important factors when performing this analysis were the SPB port's changing structure through time and the SPB port's importance to the national economy. Structural economic factors (population growth, manufacturing and service sector growth) imply that the SPB port's share of US container imports are set to grow over the 25-year forecast period. Average container growth from 2015-2020 is 5.7% and 3.75% from 2021-2041.

SPB import arrivals are shown to be comprised of higher densities from the Asia-Pacific region (79%) than the national average. Because the imports from regions other than Northeast Asia (NEA) grew faster than that of NEA, we would expect the proportion of imports from the NEA region to decrease comparatively, while the share of imports from other regions are expected to increase throughout the overall analysis period. **Figure 3-1** and **Figure 3-2** show container imports for the SPB region over the analysis period by source region.

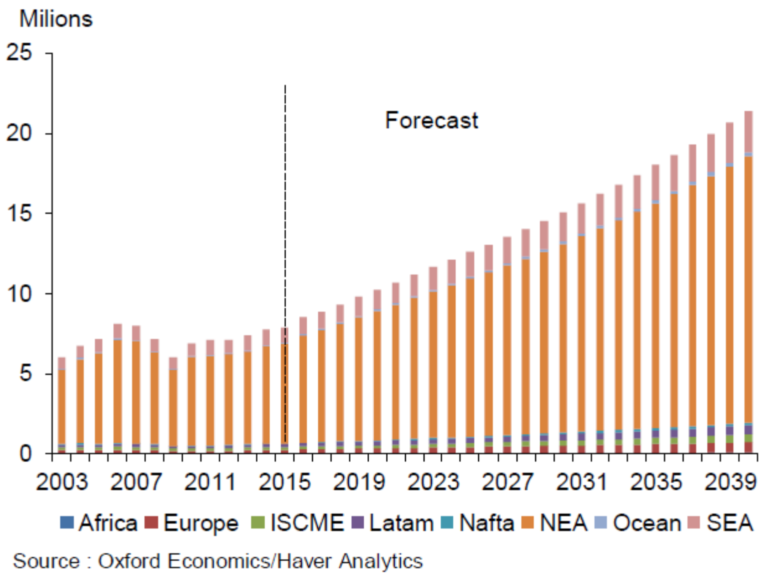


Figure 3-1: SPB Container Imports by Source Region

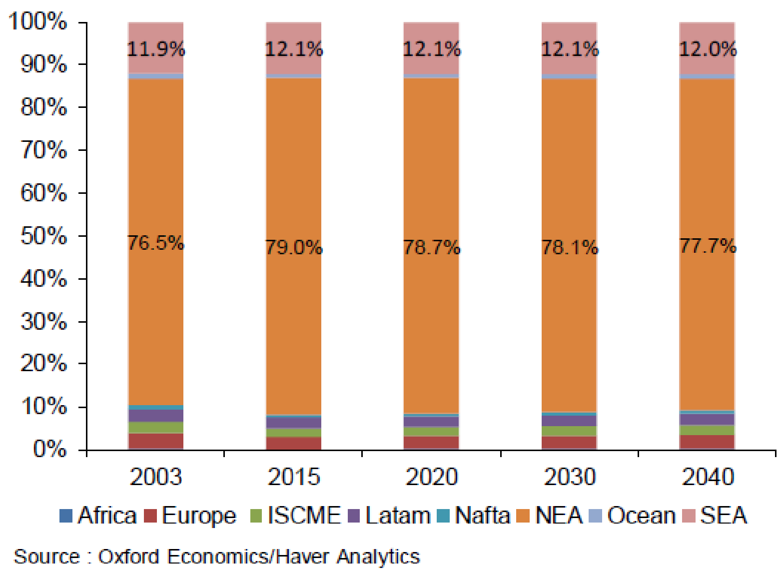


Figure 3-2: SPB Container Imports by Region

b. Mercator Containerized Exports

A similar analysis was performed as with the containerized imports in the Mercator Report. National TEU container exports are expected to rise 4.7% per year from 2015-2020. Energy products (Chemicals and machinery) are expected to be an increase proportion of the US export, as well as wood products through the analysis period. Europe is expected to have a decreasing share of US exports compared to that of emerging markets. The most rapid growth is seen in the Indian Sub-Continent and Middle East region, as well as growth in NEA and SEA. It is estimated that SPB port's exports of TEU's will increase 5.5% per annum from 2016-2020. Machinery and waste are expected to be an increasing portion of the exports from SPB, with NEA having an increasing portion of SPB exports. **Figure 3-3** and **Figure 3-4** show container exports for the SPB region over the analysis period by destination region.

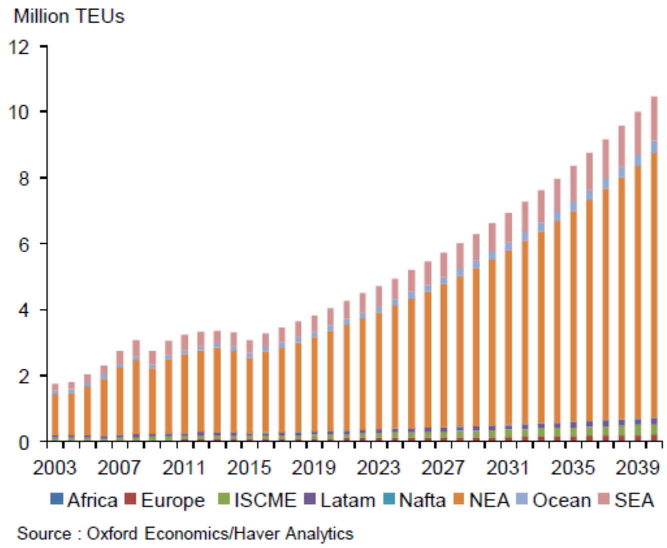


Figure 3-3: SPB Ports Exports by Destination Region

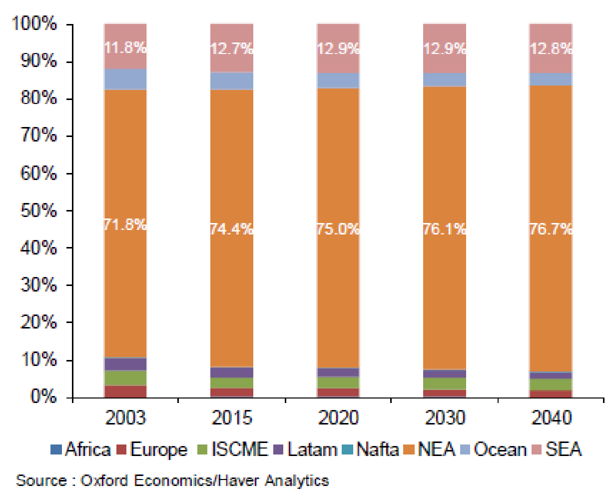


Figure 3-4: SPB Ports Exports by Region

3.3.3 Port of Long Beach Long-Term Trade Forecast – Methodology

Numerous container services call on the POLB, which have trade routes that originate all of the world. **Table 3-3** displays the trade routes used for the analyses in this study. Distances of the services included in the route group were evaluated to determine the minimum, most likely, and maximum sailing distances in nautical miles to the prior port, next port, and remaining sailing distance.

Table 3-3: Trade Routes

Route Group Name	Description
NEA-WCUS	Northeast Asia Container Route
SEA-WCUS	Southeast Asia + ISCME Container Route
EU-NA-LA-WCUS	Europe/North America/Latin America/ WCUS
OCEANIA-WCUS	New Zealand/Australia/Pacific Island/Hawaii
WCSA-WCUS	West Coast South America / WCUS
LATAM-WCUS	Latin America / WCUS
AL-WCUS-MEX	Alaska / WCUS /Mexico / Crude Oil

Table 3-4 presents the total growth rates that were developed by generating the route groups to represent all world regions. It should be noted that each trade route contains unique characteristics, such as cargo volume, cargo weight, ports of call, vessel types, mix of vessels, etc., and are therefore evaluated separately before being combined as part of the National Economic Development (NED) analysis presented in the next chapter.

Table 3-4: Port of Long Beach Forecast (Import and Export) - Total Rate of Change (%)

Year	EU-NA-LA-WCUS	NEA-WCUS	OCEANIA-WCUS	SEA-WCUS
2015	-	-	-	-
2016	5.74%	5.74%	5.74%	5.74%
2017	5.43%	5.43%	5.43%	5.43%
2018	5.15%	5.15%	5.15%	5.15%
2019	4.90%	4.90%	4.90%	4.90%
2020	4.67%	4.67%	4.67%	4.67%
2021	4.46%	4.46%	4.46%	4.46%
2022	4.75%	4.75%	4.75%	4.75%
2023	4.54%	4.54%	4.54%	4.54%
2024	4.34%	4.34%	4.34%	4.34%
2025	4.16%	4.16%	4.16%	4.16%
2026	3.99%	3.99%	3.99%	3.99%
2027	3.84%	3.84%	3.84%	3.84%
2028	3.70%	3.70%	3.70%	3.70%
2029	3.57%	3.57%	3.57%	3.57%
2030	3.44%	3.44%	3.44%	3.44%
2031	4.68%	4.68%	4.68%	4.68%
2032	4.47%	4.47%	4.47%	4.47%
2033	4.28%	4.28%	4.28%	4.28%
2034	4.11%	4.11%	4.11%	4.11%
2035	3.94%	3.94%	3.94%	3.94%
2036	3.80%	3.80%	3.80%	3.80%
2037	3.66%	3.66%	3.66%	3.66%
2038	3.53%	3.53%	3.53%	3.53%
2039	3.41%	3.41%	3.41%	3.41%
2040	3.29%	3.29%	3.29%	3.29%

Containerized Import Trade

The respective world region route import rates of change were applied to the 2015 baseline to estimate the POLB long-term import forecast, as shown in **Table 3-5**. Port capacity is not forecasted to be reached before 2040. The forecast to 2040 was included in the economic analysis presented in the next chapter of this appendix given the expectation that port capacity will not be exceeded by 2040 with benefits being held constant throughout the remaining period of analysis.

Table 3-5: Port of Long Beach Containerized Trade Forecasts - Import Tonnes

Year	EU-NA-LA-WCUS	NEA-WCUS	OCEANIA-WCUS	SEA-WCUS	Total
2015	4,280,121	9,431,645	2,178,759	5,994,495	21,885,020
2021	5,754,179	12,679,869	2,929,115	8,058,978	29,422,142
2030	8,215,775	18,104,223	4,182,169	11,506,549	42,008,716
2040	12,063,948	26,584,032	6,141,049	16,896,084	61,685,113

Containerized Export Trade

Table 3-6: Port of Long Beach Containerized Trade Forecasts - Export Tonnes

Year	EU-NA-LA-WCUS	NEA-WCUS	OCEANIA-WCUS	SEA-WCUS	Total
2015	2,599,801	5,728,903	1,323,406	3,641,134	13,293,245
2021	3,495,163	7,701,917	1,779,183	4,895,128	17,871,391
2030	4,990,368	10,996,740	2,540,304	6,989,227	25,516,639
2040	7,327,799	16,147,486	3,730,152	10,262,900	37,468,337

Using the containerized trade forecast for imports and exports and the average weight per loaded container (in terms of twenty-foot equivalent units, or TEUs), a loaded container forecast was developed. **Table 3-7** provides the weight per loaded container for the four route groups. Additionally, **Table 3-8** provides the loaded import and export TEU forecast for the four route groups.

Table 3-7 Port of Long Beach Containerized Trade Weight per TEU

Year	EU-NA-LA-WCUS	NEA-WCUS	OCEANIA-WCUS	SEA-WCUS
2015	8.47	6.78	8.52	6.87
2021	8.44	6.81	8.44	6.81
2030	8.47	6.90	8.36	6.83
2040	8.50	7.01	8.32	6.81

Table 3-8: Port of Long Beach TEU Forecast

Route Group	2015	2021	2030	2040
EU-NA-LA-WCUS	517,787	696,100	982,611	1,427,312
NEA-WCUS	1,646,550	2,226,954	3,199,399	4,693,378
OCEANIA-WCUS	254,273	346,424	499,958	733,858
SEA-WCUS	1,038,691	1,427,687	2,054,473	3,073,389
Total Imports	**3,457,301**	**4,697,166**	**6,736,442**	**9,927,937**
Route Group	**2015**	**2021**	**2030**	**2040**
EU-NA-LA-WCUS	287,368	388,727	565,307	846,502
NEA-WCUS	593,749	796,727	1,138,080	1,675,691
OCEANIA-WCUS	155,802	211,033	304,166	449,892
SEA-WCUS	386,455	520,833	749,937	1,114,428
Total Exports	**1,423,373**	**1,917,320**	**2,757,490**	**4,086,514**

Crude Oil Import Trade

Table 3-9 shows the forecasted crude oil imports for POLB through year 2040. As shown, crude oil shows a decrease after years 2021, through 2030 and 2040. Improvements in energy efficiency is expected to drive the easing of oil import demand. The compounded annual growth rate (CAGR) from 2015-2021 was 0.66%. The CAGR from 2021 to 2030 is -0.56%. The CAGR from 2030 to 2040 is -.057%.

Table 3-9: Forecasted Crude Oil Imports

Year	Crude Oil Imports
2015	22,985,501
2021	23,917,152
2030	22,751,027
2040	22,494,704

The crude oil import and export forecast was defined by a 2020 IHS Markit analysis. This analysis includes a forecasted recession due to the Covid 19 pandemic, followed by a recovery period starting in 2022. The growth in petroleum product demand will be driven by the increase in refinery utilization and increase crude oil demand from the economic recovery. The U.S. is expected to remain a heavy importer of heavy crude, with increasing volumes of Canadian barrels via pipeline. The increased import from Canada is expected to cause a decrease in the volumes of offshore imports (**Figure 3-5**).

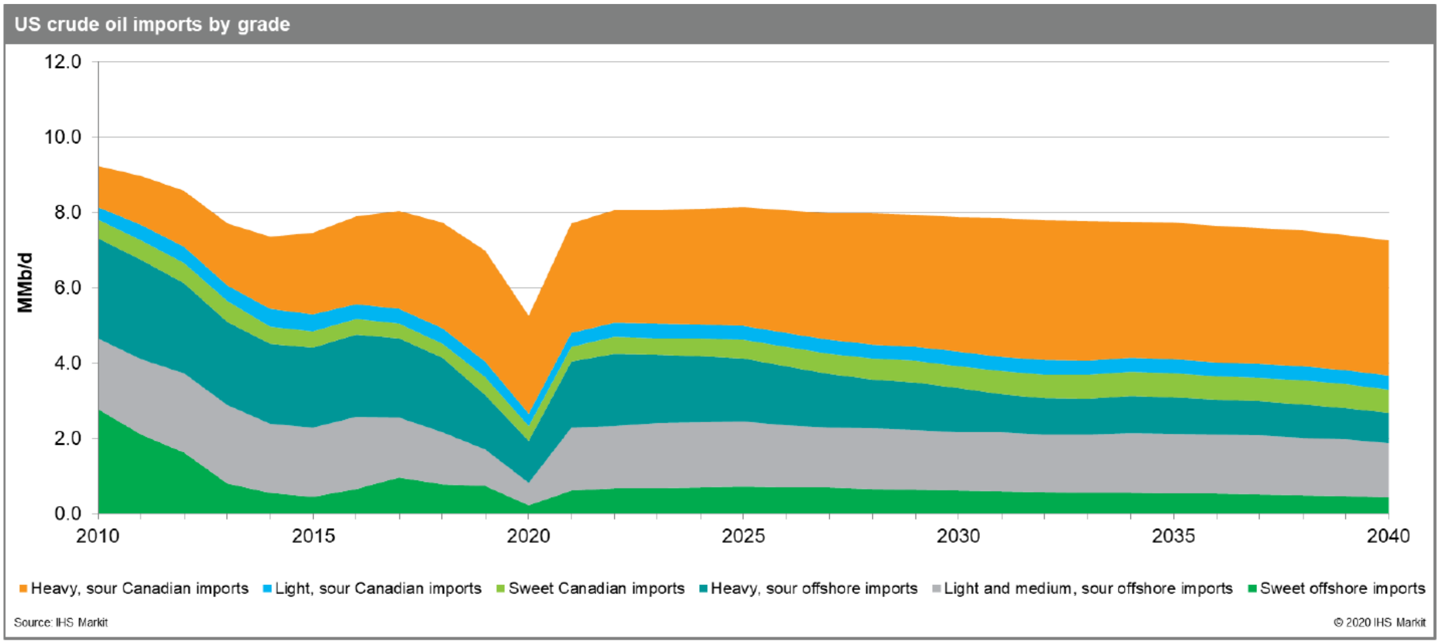


Figure 3-5: U.S. Crude Oil Imports by Grade

3.4 Vessel Fleet

3.4.1 World Fleet

In addition to a commodity forecast, a forecast of the future fleet is required when evaluating navigation projects. To develop projections of the future fleet calling at the POLB, the study team obtained a World Fleet forecast of containerships developed by Maritime Strategies Inc. (MSI), which forecasted the total capacity calling at the POLB and provided a breakdown of that capacity calling into the containership size and TEU classes.

The methodology developed by MSI was then linked to the IHS commodity forecast data for U.S. West Coast and the Mercator Report for Long Beach. The commodity forecasts were unconstrained forecasts, and consequently MSI's model was similarly unconstrained with respect to the inter-port competition on the U.S. West Coast. Furthermore, MSI did not consider land-based infrastructure as a limiting factor in its approach to forecasting the world fleet. **Table 3-10** shows the fleet subdivision using the common vessel labeling terminology and vessel specifications for design draft, beam, and length overall (LOA).

Table 3-10: Fleet Subdivisions on Draft, Beam, and LOA (feet)

Vessel Fleet Subdivision (Containerships)		From	To
Sub Panamax (SPX) (MSI size brackets: 0.1-1.3, 1.3-2.9 k TEU)	**Beam**	55	98
	Draft	8.2	38.1
	LOA	222	813.3
Panamax (PX) (MSI size brackets: 1.3-2.9, 2.9-3.9, 3.9-5.2, 5.2-7.6 k TEU)	**Beam**	98	106
	Draft	30.8	44.8
	LOA	572	970
Post-Panamax (PPX1) (MSI size brackets: 2.9-3.9, 3.9-5.2, 5.2-7.6, 7.6-12 k TEU)	**Beam**	106	138
	Draft	35.4	47.6
	LOA	661	1045
Super Post-Panamax (PPX2) (MSI size brackets: 5.2-7.6, 7.6-12 k TEU)	**Beam**	138	144
	Draft	39.4	49.2
	LOA	911	1205
Ultra Post-Panamax (PPX3) (MSI size brackets: 5.2-7.6, 7.6-12, 12 k + TEU)	**Beam**	144	168
	Draft	44	55
	LOA	950	1220
Post-Panamax (PPX4) (MSI size brackets: 12 k + TEU)	**Beam**	168	200
	Draft	52.5	55
	LOA	1000	1300

By combining information from the commodity forecast with MSI's forecasted fleet capacity and the POLB's average share of cargo on a containerized vessel, the study team was able to allocate a number of Post-Panamax, Panamax, and sub-Panamax vessels calls to the POLB fleet. The number of transits, particularly those made by larger vessels, is a key variable in calculating the transportation costs. MSI's forecasting technique begins with performing a detailed review of the current world fleet and how it is deployed throughout various trade routes of the world. Forecasting of the world fleet was made possible through MSI's proprietary Container Shipping Planning Service (CSPS) model (**Figure 3-6**), which applies the historical and forecasted time series data from 1980 to 2035 for:

- Macroeconomic indicators
- Global container trade and movements by region
- TEU lifts by type (primary/transshipment and full/empty) and by region
- Bilateral trade data for major routes
- Containership supply and fleet developments by vessels size range
- Explicit scrapping, cancellation and slippage assumptions
- Time-charter rates, freight rates and operating costs by segment
- Newbuilding, secondhand (by age) and scrap prices by segment

Data sources for the CSPS model include:

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

World Trade history is provided by UNCTAD, Drewry Shipping Consultants and Containerization International. MSI's forecast for trade in dry goods, including containerized trade, are derived from a series of constantly evolving econometric relationships between trade volumes and macroeconomic drivers. The latter drivers are country/regional specific and form the proprietary core of MSI's business.

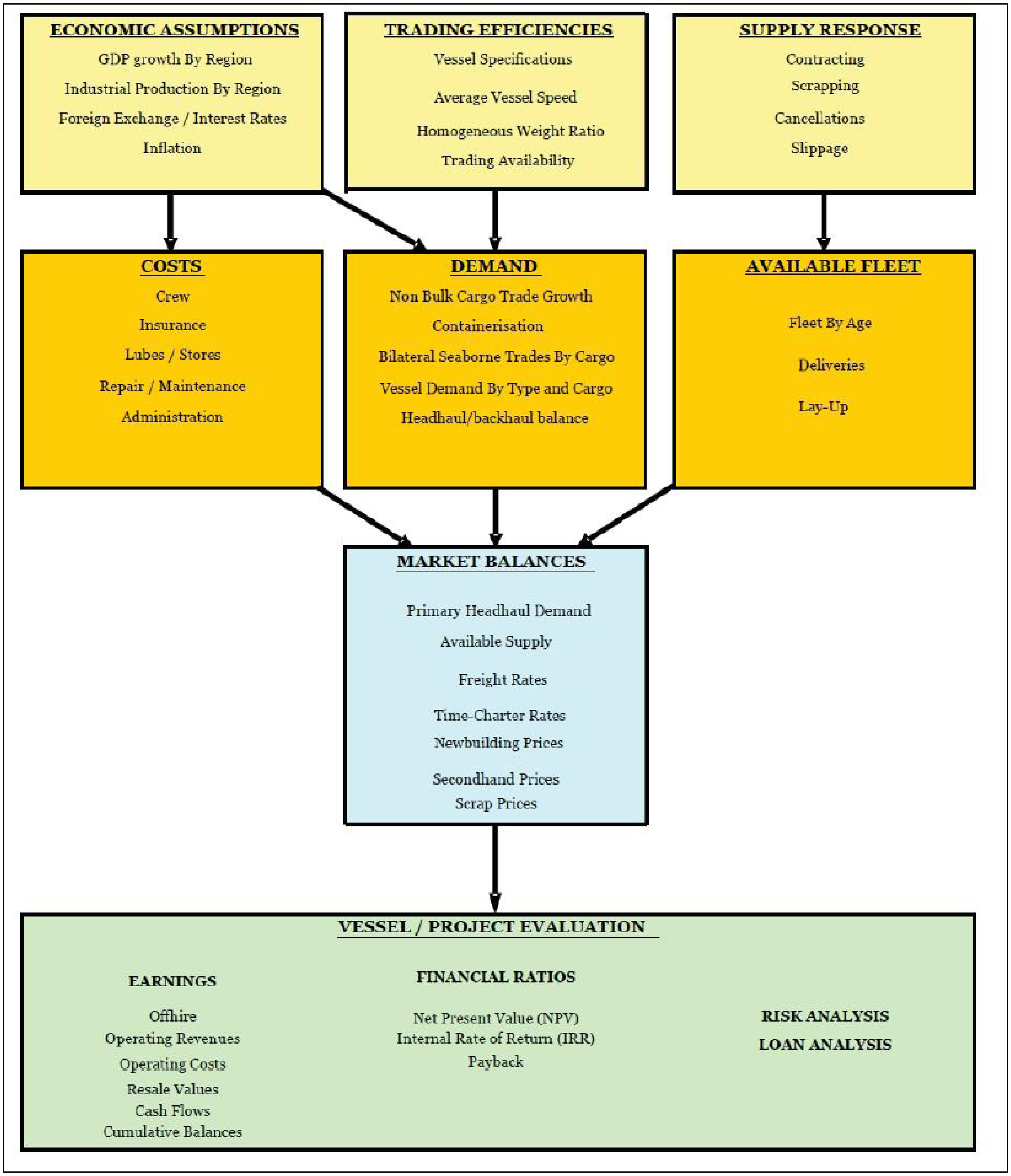


Figure 3-6: Schematic Overview of MSI's CSPS Model

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

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

World Fleet

A projection of the world fleet provides the necessary background for evaluating the future fleet forecast for the POLB. The starting point for this projection was the world fleet by vessel class extracted from the Lloyd's Register (LR)-Fairplay database for the years 2013, 2014, and 2017[1]. As shown in **Table 3-11**, larger vessels are quickly becoming a higher percentage of the world fleet. In 2013, container vessels larger than 12,000 TEUs made up just under 3 percent of the world fleet while vessels greater than 7,600 TEUs totaled around 10.5 percent. As of 2017, 12,000 TEU vessels have increased to about 7.6 percent of the world fleet and vessels greater than 7,600 TEUs now make up about 20 percent.

Table 3-11: World Fleet by TEU Band – 2013, 2014 and 2017

TEU Band	2013	2014	2017
0.1 - 1.3 k TEU	1,600	1,557	1,553
1.3 - 2.9 k TEU	1,352	1,333	1,476
2.9 - 3.9 k TEU	303	295	271
3.9 - 5.2 k TEU	762	750	656
5.2 - 7.6 k TEU	519	536	468
7.6 - 12 k TEU	379	438	670
12 k TEU +	151	193	422
TOTAL	**5,066**	**5,102**	**5,516**

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

The "Order Book"

The "order book" is shorthand for the vessels that have been contracted to be built by ship builders around the world. Vessel deliveries are primarily the function of new building contracting. These contracts can take several forms. There are firm contracts for vessels that are under construction. There are also option contracts that secure the capacity of the shipyard but do not require the buyer to exercise the option to construct the vessel. Some contracts have financing that is committed; others do not. There are several other nuances that pose possible challenges in translating the number of vessels and types of contracts into future vessels coming online at a specific time. This requires knowledge and expertise of this market and this process. Forecasts must be made for future contracts, vessel scrapping, and vessel deliveries[2]. Over the long term, new building investment tends to equate to the incremental demand for new tonnages to meet cargo growth or replacement of aged or obsolete ships.

A historical breakdown of contracting by TEU band was accomplished using a widely recognized fleet database provided by LR-Fairplay. The breakdown was expressed as a percentage of ships for each TEU band size. These percentages were used as a baseline for forecasting future contracting. **Figure 3-7** depicts historical and future forecasted contracting by TEU bands for fully cellular container (FCC) vessels[3] for years 2000 to 2035.

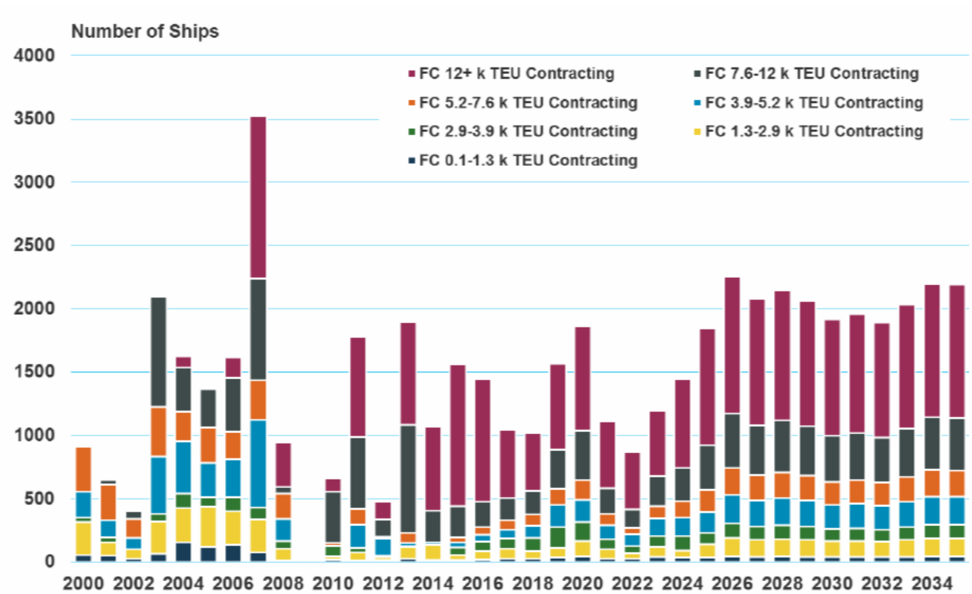


Figure 3-7: Container Contracting, 2000-2035 (Source: MSI)

Deliveries and Scrapping Assumptions

MSI modeled the relationship between annual contracting and annual deliveries by TEU band. The forecast of deliveries by TEU band are depicted in **Figure 3-8**. The number of new vessel deliveries is expected to increase each year until a 2030 peak, and then taper off to the end of the forecast period, with an upward bounce in 2034.

[2] Factors such as economic conditions, price of steel, exchange rates, and a host of others can influence the forecasted world fleet.
[3] The term "fully cellular" refers to vessels that are purposely built to carry ocean containers. The containers are generally stored in vertical slots on the ship.

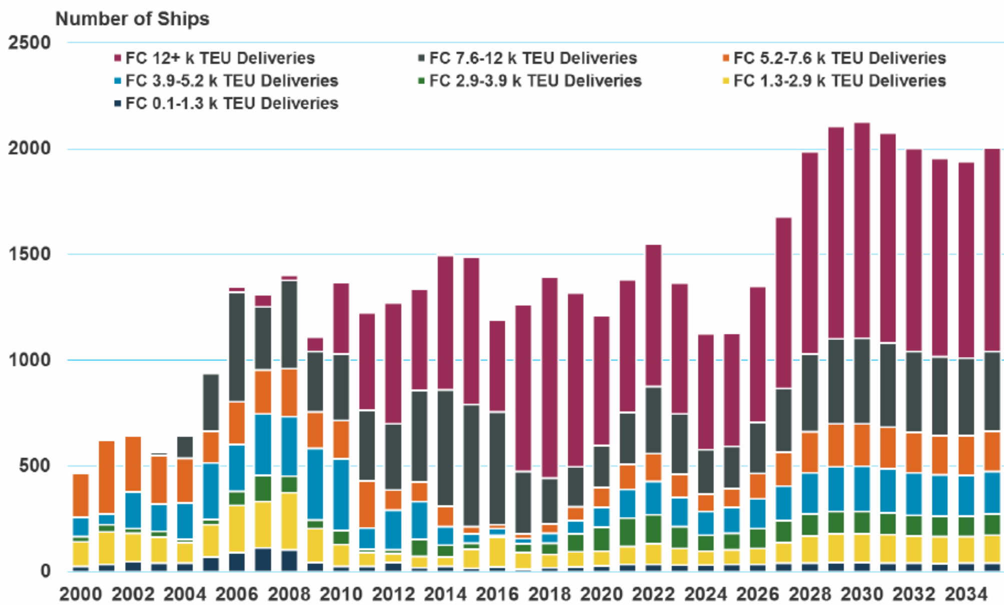


Figure 3-8: Containership Deliverables. 2000-2035 (Source: MSI)

An estimate of annual scrapping was accomplished by examining the LR-Fairplay database for the world fleet each year and noting which vessels drop out each year. This was done by TEU band and transformed into a scrapping profile for each band. **Figure 3-9** shows the estimated scrapping by TEU band class.

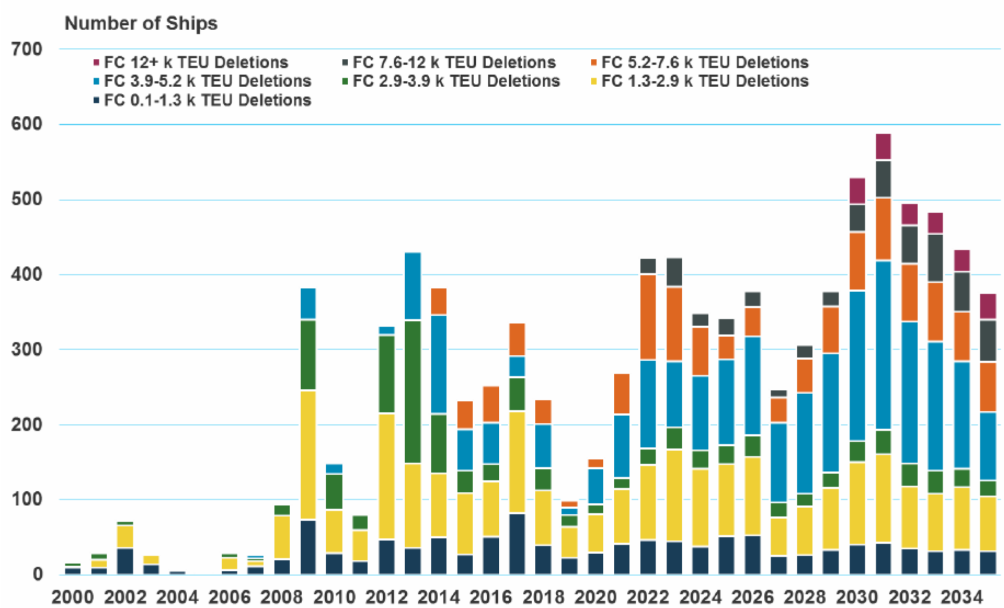


Figure 3-9: Containership Deletions, 2000-2035 (Source MSI)

World Fleet Forecast

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

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

Figure 3-10 displays the world FCC forecast by TEU band through 2035.

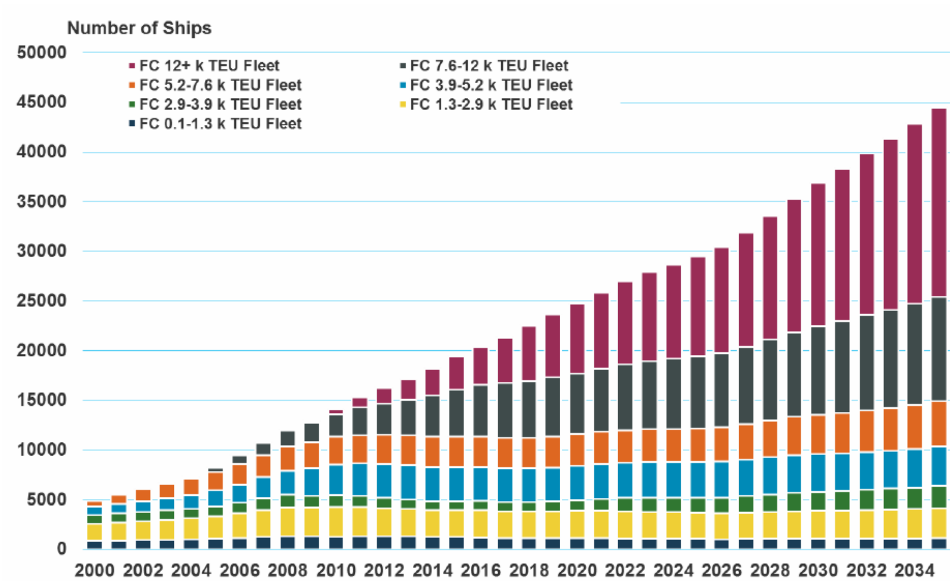
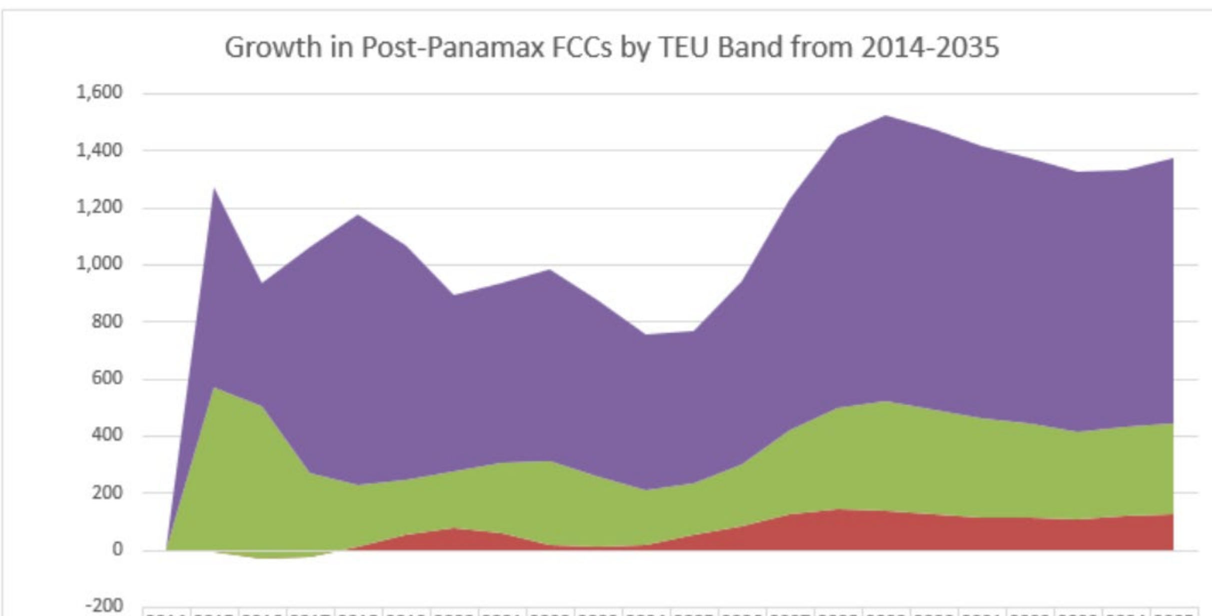


Figure 3-10: World Fleet, Historical and Forecasted FCC by TEU Band, 2000-2035 (Source: MSI)

Figure 3-11 shows the net growth in selected Post-Panamax TEU bands from the 2014 fleet. The figure shows the additional vessels added to the fleet. These types of vessels are a key factor in the evaluation of port deepening studies such as the POLB.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
12+ k	0	698	432	791	950	823	616	627	677	617	547	536	644	815	956	1006	987	956	931	910	900	927
7.6-12 k	0	576	534	296	217	187	198	244	293	248	192	178	218	291	350	380	367	347	331	307	313	319
5.2-7.6 k	0	-4	-32	-22	11	57	81	63	17	10	17	56	82	128	147	141	125	115	114	108	121	126

Figure 3-11: World Fleet Net Growth Forecast of Selected TEU Bands

4 TRANSPORTATION COST SAVINGS BENEFIT ANALYSIS

The purpose of this analysis is to describe the benefits associated with the deepening and widening at the Port of Long Beach channels. NED benefits were estimated by calculating the reduction in transportation cost for each project depth using the HarborSym Model (HSM), developed by IWR. The HSM incorporates USACE guidance on transportation cost savings analysis. Within this section, the HSM is described in detail and its application in this study.

4.1 Methodology

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

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

To begin, HarborSym was setup with the basic required variables. To estimate Origin- Destination (OD) cost saving benefits, a tool was used to generate a vessel call list based on the commodity forecast at the POLB for particular, defined years and available channel depth under the various examined depth alternatives. The resulting vessel traffic was simulated using HarborSym, producing an average annual vessel OD transportation cost. The transportation costs saving benefits were then calculated from the existing channel depths for each additional project depth. The NED Plan was identified by considering the highest net benefit based on the OD transportation cost saving benefits.

Preliminary benefits were calculated using the 2019 deep-draft vessel operating costs developed by the Institute for Water Resources and published for use by analysts of the US Army Corps of Engineers for assessment of potential economic benefits associated with waterway improvement projects. Vessel operating costs were updated in July 2020. The updated vessel operating costs were used to calculate benefits in the final alternative analysis. Per EGM 20-04, "Recent years have seen dramatic fluctuations in oil prices that have had remarkable effects on the VOCs." This was mitigated by a year to year cap of 5% per year.

4.1.1 HarborSym Model

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

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

Model Behavior

HarborSym is an event driven model. Vessel calls are processed individually and the interactions with other vessels are taken into account. For each iteration, the vessel calls for an iteration that fall within the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all of the docks in the vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route.

Potential conflicts with other vessels that have previously entered the system are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If a rule activation occurs, such as no passing allowed in a given reach, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. Vessels move from reach to reach, eventually arriving at the dock that is the terminus of the leg.

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

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

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

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

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

Either all or a portion of the at-sea costs are associated with the subject port, depending on whether the vessel call is a partial or full load. The at-sea cost allocation procedure is implemented within the HarborSym Monte-Carlo processing kernel and utilizes the estimate total trip cargo (ETTC) field from the vessel call information along with import tonnage and export tonnage. In all cases the ETTC is the user's best estimate of total trip cargo.

Data Requirements

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

Simulation Parameters

Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay. These inputs were included in the model runs for this study. For this analysis, detailed forecasts were developed for years 2021, 2030, and 2040. After 2040 the forecasted number of TEUs and liquid bulk were held constant throughout the period of analysis.

Physical and Descriptive Harbor Characteristics: These data inputs include the specific network of the POLB, such as the node location and type, reach length, width, and depth, in addition to tide and current stations. This also includes information about the docks in the harbor, such as length and maximum number of vessels the dock can accommodate at any given time. **Figure 4-1** displays the Node network used for Long Beach Harbor.

General Information

General information used as inputs to the model include: specific vessel and commodity classes, route groups **(Table 4-1),** commodity transfer rates at each dock **(Table 4-2),** specifications of turning area usage at each dock, and specifications of anchorage use within the harbor. Distances between the route groups were developed by evaluating the 9 trade routes calling on the Port of Long Beach in 2015. The route group distance included in the analysis for each trade lane is calculated from the average distance for each trade route that was identified.

Figure 4-1: POLB HarborSym Node Network

Table 4-1: HarborSym Route Groups

Route Group Name	Description	Sea Distance (nautical miles)
NEA-WCUS	Northeast Asia Container Route	14,000
SEA-WCUS	Southeast Asia + ISCME Container Route	16,000
EU-NA-LA-WCUS	Europe/North America/Latin America/ WCUS	17,000
OCEANIA-WCUS	New Zealand/Australia/Pacific Island/Hawaii	13,000
WCSA-WCUS	West Coast South America / WCUS	7,000
LATAM-WCUS	Latin America / WCUS	7,000
AL-WCUS-MEX	Alaska / WCUS /Mexico / Crude Oil	2,800
FE-WCUS	Far East / WCUS / Crude Route	12,500

Table 4-2: HarborSym Transfer Rates

Dock Name	Loading/Unloading Rate for Containerized Commodities (tonnes/hour)		
	Min	Most Likely	Max
Pier J North TEUs	880	1,936	2,816
Pier J South TEUs	880	1,936	2,816
Pier T TEUs	950	1,000	1,200
Pier T-Crude MT	5,400	6,000	6,600

Vessel Speeds

The speed at which vessels operate in the harbor, by vessel class both loaded and light loaded, were determined for each channel segment by evaluating pilot logs and port records as well as by verifying the data with the pilots. Vessel speed inputs are provided in **Table 4-3** for each reach of the node network for containerized vessels.

Table 4-3: HarborSym Vessel Speed in Reaches (knots)

Reach	Sub-Panamax		Panamax		PPX1		PPX2		PPX3 & PPX4		Tankers	
	Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded	Light	Loaded
All Reaches	12	10	12	10	12	10	12	10	12	10	12	10

Vessel Operations

Hourly operating costs while in-port and at-sea were determined for both domestic and foreign flagged containerized vessels. Sailing speeds at-sea were also determined. These values are entered as a triangular distribution. The inputs are shown in **Table 4-4**.

Table 4-4: Vessel Operations

Description	Panamax	PPX 1	PPX 2	PPX 3	PPX4	Sub Panamax	Tankers
Vessel Speed at Sea, Min (knots)	19.0	20.0	20.0	20.0	20.0	16.0	13.0
Vessel Speed at Sea, Most Likely (knots)	20.0	21.0	21.0	21.0	21.0	17.0	14.0
Vessel Speed at Sea, Max (knots)	21.0	22.0	22.0	22.0	22.0	18.0	15.0

Reach Transit Rules

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

Vessel Calls

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

4.1.2 Vessel Call List

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

In order to successfully utilize this tool on a planning study, users provide extensive data describing containership loading patterns and services frequenting the study port. The user provides a vessel fleet forecast by vessel class, season, and service, and a commodity forecast by dock, season, and region.

Container Loading Practice Changes

A load factor analysis (LFA) was done to determine the maximum practicable draft and the maximum practicable cargo capacity for each trade unit. A load factor analysis is used to account for the physical components that determine the vessel draft. Combining these factors allows the analyst to determine whether the vessel will reach its volumetric capacity before it reaches its deadweight capacity. Once the vessel reaches its volumetric cargo capacity, the vessel is said to have "cubed out", meaning it can carry no more cargo no matter how much additional channel depth is available. **Table 4-5** provides details on the vessel subclasses, which is used by the LFA to create vessels to satisfy the commodity forecast. The user provides the linkage between the HarborSym vessel class and the IWR-defined vessel subclass.

Table 4-5: Vessel Class Inputs

Service	Vessel Class	AVG Loading Weight Per Loaded TEU (tonnes)	AVG Container Weight Per TEU (tonnes)	Empty TEU Allotment	Vacant Slot Allotment	Operation Allowance (% of DWT)	Variable Ballast (% of DWT)	Import Shipment Size Proportion	Export Shipment Size Proportion
NEA-WCUS	PX	7.28	2	22.3%	6.2%	7.1%	14.9%	23%	15%
NEA-WCUS	PPX 1	7.28	2	19.2%	6.2%	7.1%	14.9%	28%	12%
NEA-WCUS	PPX 2	7.28	2	24.9%	6.2%	7.1%	14.9%	46%	28%
NEA-WCUS	PPX 3	7.28	2	21.2%	6.2%	7.1%	14.9%	49%	36%
NEA-WCUS	PPX 4	7.28	2	21.2%	6.2%	6.1%	13.0%	44%	25%
NEA-WCUS	SPX	7.28	2	21.2%	6.2%	6.1%	11.5%	32%	18%
SEA-WCUS	PX	7.22	2	22.3%	6.2%	7.1%	14.9%	23%	15%
SEA-WCUS	PPX 1	7.22	2	19.2%	6.2%	7.1%	14.9%	29%	12%
SEA-WCUS	PPX 2	7.22	2	24.9%	6.2%	7.1%	14.9%	46%	29%
SEA-WCUS	PPX 3	7.22	2	21.2%	6.2%	7.1%	14.9%	49%	36%
SEA-WCUS	PPX 4	7.22	2	21.2%	6.2%	6.1%	13.0%	44%	25%
SEA-WCUS	SPX	7.22	2	21.2%	6.2%	6.1%	11.5%	32%	18%
EU-NA-LA-WCUS	PX	8.86	2	22.3%	6.2%	7.1%	14.9%	20%	13%
EU-NA-LA-WCUS	PPX 1	8.86	2	19.2%	6.2%	7.1%	14.9%	26%	11%
EU-NA-LA-WCUS	PPX 2	8.86	2	24.9%	6.2%	7.1%	14.9%	43%	27%
EU-NA-LA-WCUS	PPX 3	8.86	2	21.2%	6.2%	7.1%	14.9%	47%	35%
EU-NA-LA-WCUS	PPX 4	8.86	2	21.2%	6.2%	6.1%	13.0%	44%	24%
EU-NA-LA-WCUS	SPX	8.86	2	21.2%	6.2%	6.1%	11.5%	32%	18%
OCEANIA-WCUS	PX	8.79	2	29.6%	6.2%	7.1%	14.9%	21%	14%
OCEANIA-WCUS	PPX 1	8.79	2	22.3%	6.2%	7.1%	14.9%	26%	11%
OCEANIA-WCUS	PPX 2	8.79	2	9.7%	6.2%	7.1%	14.9%	43%	27%
OCEANIA-WCUS	PPX 3	8.79	2	9.7%	6.2%	7.1%	14.9%	46%	34%
OCEANIA-WCUS	PPX 4	8.79	2	12.4%	6.2%	6.1%	13.0%	44%	24%

The percentage share of each subclass was defined by historical data provided by the Port. **Table 4-6** provides additional detail on the shipment sizes per trade unit. The table illustrates the average combined imported and exported shipment per vessel call for each alternative depth evaluated. The additional cargo transported on each call was developed by taking into account the additional cargo capacity available with deeper channel depths, the probability of a vessel utilizing the additional capacity, and the tons per inch calculated by IWR to quantify the tonnage needed to achieve that depth. **Table 4-7** provides detail on the annual cargo tonnage projected for 2021.

Table 4-6: Mean Shipment Size by Trade Unit & Alternative Depth

	Class	50 feet (Existing Condition)	53 feet	55 feet	57 feet
NEA-WCUS	SPX	4,690	4,690	4,690	4,690
	PX	11,973	11,973	11,973	11,973
	PPX1	24,510	24,510	24,510	24,510
	PPX2	39,096	39,096	39,096	39,096
	PPX3	45,711	46,174	46,174	46,174
	PPX4	45,711	50,648	50,781	50,781
SEA-WCUS	SPX	4,690	4,690	4,690	4,690
	PX	11,973	11,973	11,973	11,973
	PPX1	24,510	24,510	24,510	24,510
	PPX2	39,096	39,096	39,096	39,096
	PPX3	45,711	46,147	46,147	46,147
	PPX4	45,711	50,648	50,781	50,781
EU-NA-LA-WCUS	SPX	4,690	4,690	4,690	4,690
	PX	11,973	11,973	11,973	11,973
	PPX1	24,510	24,510	24,510	24,510
	PPX2	39,096	39,096	39,096	39,096
	PPX3	45,711	46,269	46,269	46,269
	PPX4	45,711	50,648	50,781	50,781
OCEANIA-WCUS	SPX	4,690	4,690	4,690	4,690
	PX	11,973	11,973	11,973	11,973
	PPX1	24,510	24,510	24,510	24,510
	PPX2	39,096	39,096	39,096	39,096
	PPX3	45,711	46,269	46,269	46,269
	PPX4	45,711	50,648	50,781	50,781

Table 4-7: Annual Container Cargo by Trade Unit and Measure Depth (metric tonnes)

	Class	50 feet (Existing Condition)	53 feet	55 feet	57 feet
NEA-WCUS	SPX	135,748	135,748	135,748	135,748
	PX	1,970,127	1,909,795	1,908,616	1,908,616
	PPX1	2,091,005	2,045,756	2,044,872	2,044,872
	PPX2	3,955,982	3,925,816	3,925,227	3,925,227
	PPX3	3,495,291	3,532,299	3,532,299	3,532,299
	PPX4	1,031,716	1,130,455	1,133,108	1,133,108
SEA-WCUS	SPX	75,476	75,476	75,476	75,476
	PX	439,033	407,399	406,810	406,810
	PPX1	778,189	754,464	754,022	754,022
	PPX2	3,604,218	3,588,401	3,588,106	3,588,106
	PPX3	2,498,072	2,519,878	2,519,878	2,519,878
	PPX4	663,990	713,360	714,686	714,686
EU-NA-LA-WCUS	SPX	486,255	486,255	486,255	486,255
	PX	1,483,844	1,456,945	1,456,355	1,456,355
	PPX1	627,063	606,888	606,446	606,446
	PPX2	1,653,618	1,640,168	1,639,873	1,639,873
	PPX3	1,035,202	1,046,357	1,046,357	1,046,357
	PPX4	468,197	517,567	518,893	518,893
OCEANIA-WCUS	SPX	495,560	495,560	495,560	495,560
	PX	1,009,372	1,009,372	1,009,372	1,009,372
	PPX1	949,456	949,456	949,456	949,456
	PPX2	474,728	474,728	474,728	474,728
	PPX3	-	-	-	-
	PPX4	-	-	-	-

Vessel Calls

Vessel calls by vessel class for containerized vessels are shown in **Table 4-8**. Vessel calls by vessel class for bulker vessels are shown in **Table 4-9**. These are a result of the containerized trade forecast for the POLB, the available vessel fleet by service, and the LFA data inputs.

Table 4-8: Containerized Vessel Calls by Class and Channel Depth

Vessel Class	50 feet (Existing Condition)	53 feet	55 feet	57 feet
2021				
SPX	252	252	252	252
PX	408	399	398	398
PPX 1	180	180	180	180
PPX 2	248	244	244	244
PPX 3	150	150	150	150
PPX 4	40	40	40	40
Total	**1,278**	**1,265**	**1,264**	**1,264**
2030				
SPX	212	212	212	212
PX	328	296	296	296
PPX 1	212	199	199	199
PPX 2	332	327	327	327
PPX 3	280	280	280	280
PPX 4	130	130	130	130
Total	**1,494**	**1,444**	**1,444**	**1,444**
2040				
SPX	188	188	188	188
PX	116	102	102	102
PPX 1	192	159	159	159
PPX 2	288	255	254	254
PPX 3	490	490	490	490
PPX 4	450	450	450	450
Total	**1,724**	**1,644**	**1,643**	**1,643**

Table 4-9: Tanker Vessel Calls by Vessel Class and Channel Depth

Vessel Class	76 feet (Existing Condition)	78 feet	80 feet	83 feet
2021				
10K DWT Tanker	1	1	1	1
20K DWT Tanker	46	46	46	46
30K DWT Tanker	35	35	35	35
40K DWT Tanker	4	4	4	4
50K DWT Tanker	217	217	217	217
60K DWT Tanker	18	18	18	18
70KDWT Tanker	155	151	147	147
80K DWT Tanker	5	5	5	5
100K DWT Tanker	179	178	177	177
200K DWT Tanker	167	167	167	167
300K DWT Tanker	105	105	105	105
Total	**932**	**927**	**922**	**922**
2030				
10K DWT Tanker	1	1	1	1
20K DWT Tanker	46	46	46	46
30K DWT Tanker	34	34	34	34
40K DWT Tanker	4	4	4	4
50K DWT Tanker	213	213	213	213
60K DWT Tanker	18	18	18	18
70K DWT Tanker	151	147	146	146
80K DWT Tanker	5	5	5	5
100K DWT Tanker	176	175	173	173
200K DWT Tanker	167	167	167	167
300K DWT Tanker	101	101	101	101
Total	**916**	**911**	**908**	**908**
2040				
10K DWT Tanker	1	1	1	1
20K DWT Tanker	43	43	43	43
30K DWT Tanker	33	33	33	33
40K DWT Tanker	4	4	4	4
50K DWT Tanker	213	213	213	213
60K DWT Tanker	18	18	18	18
70K DWT Tanker	151	147	145	145
80K DWT Tanker	5	5	5	5
100K DWT Tanker	176	174	173	173
200K DWT Tanker	167	167	167	167
300K DWT Tanker	101	101	101	101
Total	**912**	**906**	**903**	**903**

Table 4-10 displays the average load for crude oil imports by channel depth for all tanker classes. The additional cargo transported on each call was developed by taking into account the additional cargo capacity available with deeper channel depths, the probability of a vessel utilizing the additional capacity, and the tons per inch calculated by IWR to quantify the tonnage needed to achieve that depth. The trend shows that as depth increases, the average load increases until a depth of 80 feet.

Table 4-10: Crude Oil Average Load by Channel Depth (metric tons)

Year	76 feet (Existing Condition)	78 feet	80 feet	81 -83 feet*
2021	25,156	25,354	25,478	25,478
2030	24,418	24,585	24,714	24,714
2040	24,498	24,617	24,766	24,766

*81-83 feet does not load deeper, but has additional tide delay reduction

Sailing Draft Distribution Changes

Table 4-11 provides details on the change to the average arrival draft for PPX3 and PPX4 container vessels. **Figures 4-2 – 4-5** provide tanker sailing draft changes by channel depth.

Table 4-11: Container Sailing Draft Changes by Channel Depth

	Vessel Class	50 feet	53 feet	55 feet	57 feet
NEA-WCUS	PPX3	37.48	37.86	37.86	37.86
	PPX4	37.48	41.53	41.64	41.64
SEA-WCUS	PPX3	37.48	37.84	37.84	37.84
	PPX4	37.48	41.53	41.64	41.64
EU-NA-LA-WCUS	PPX3	37.48	37.94	37.94	37.94
	PPX4	37.48	41.53	41.64	41.64
OCEANIA-WCUS	PPX3	37.48	37.48	37.48	37.48
	PPX4	37.48	37.48	37.48	37.48

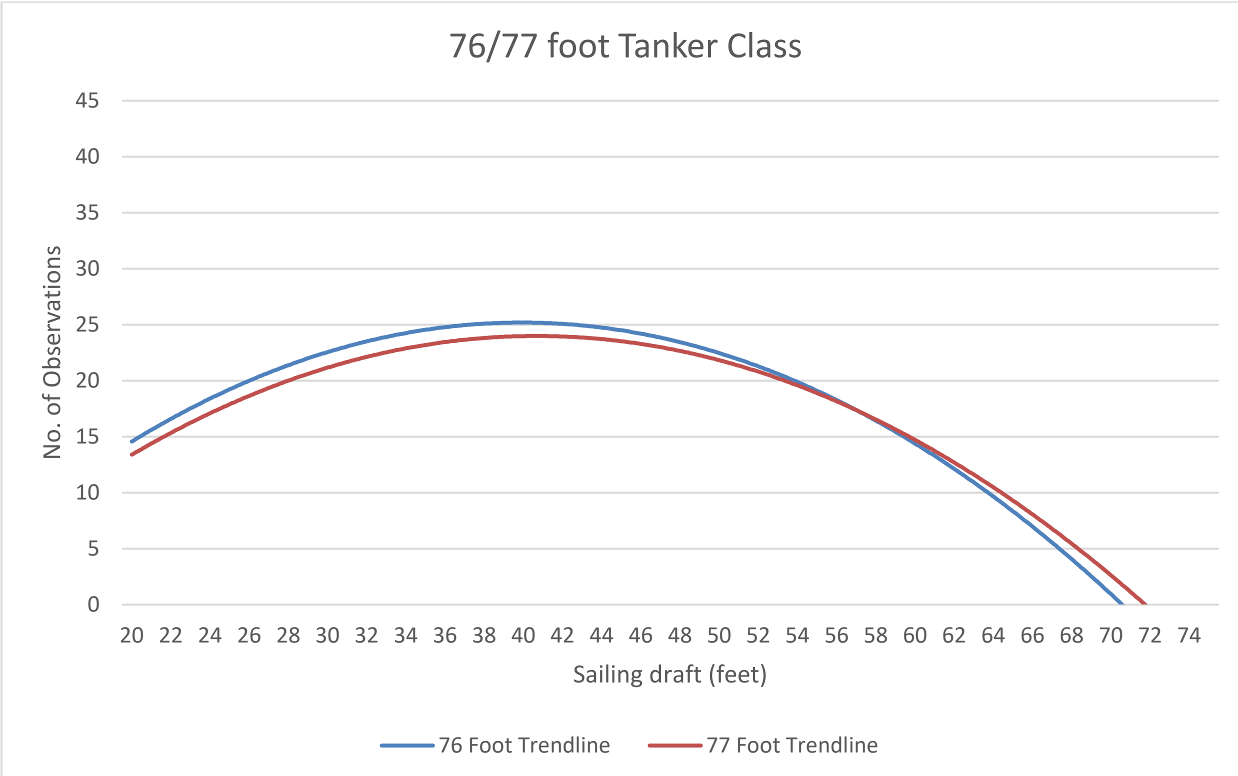


Figure 4-2: 76 ft vs 77 ft Tanker Class Sailing Drafts

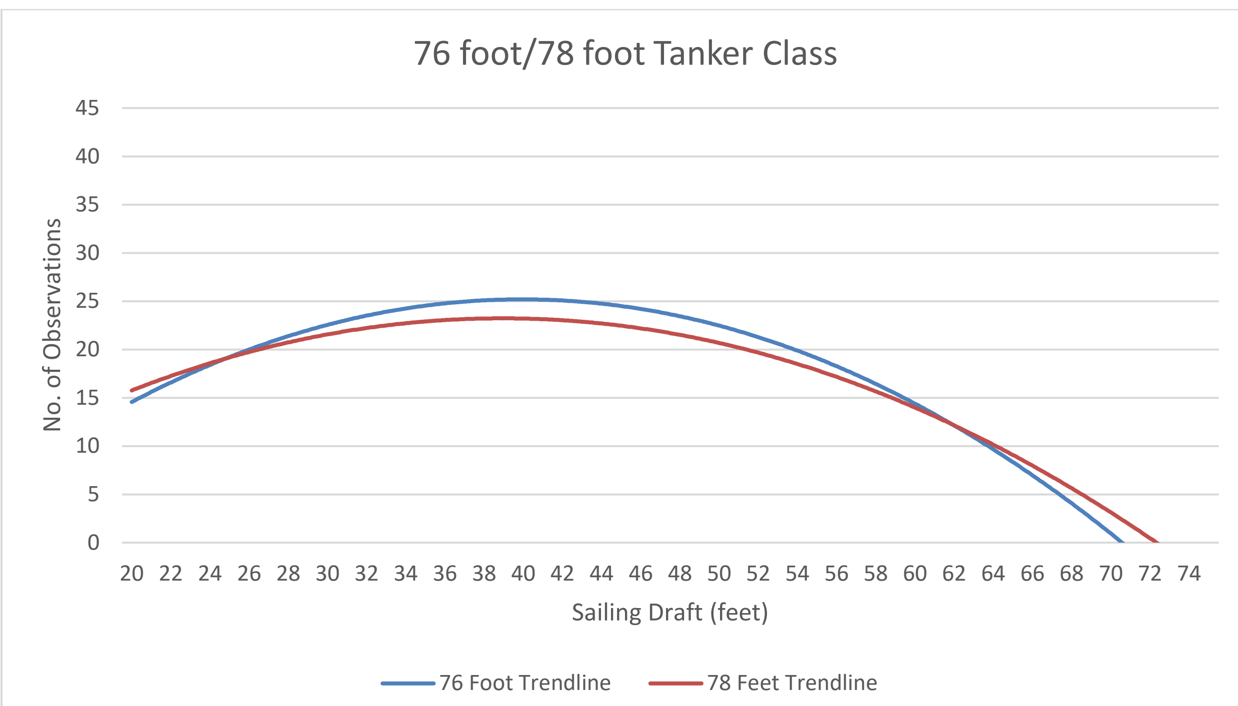


Figure 4-3: 76 ft vs 78 ft Tanker Class Sailing Drafts

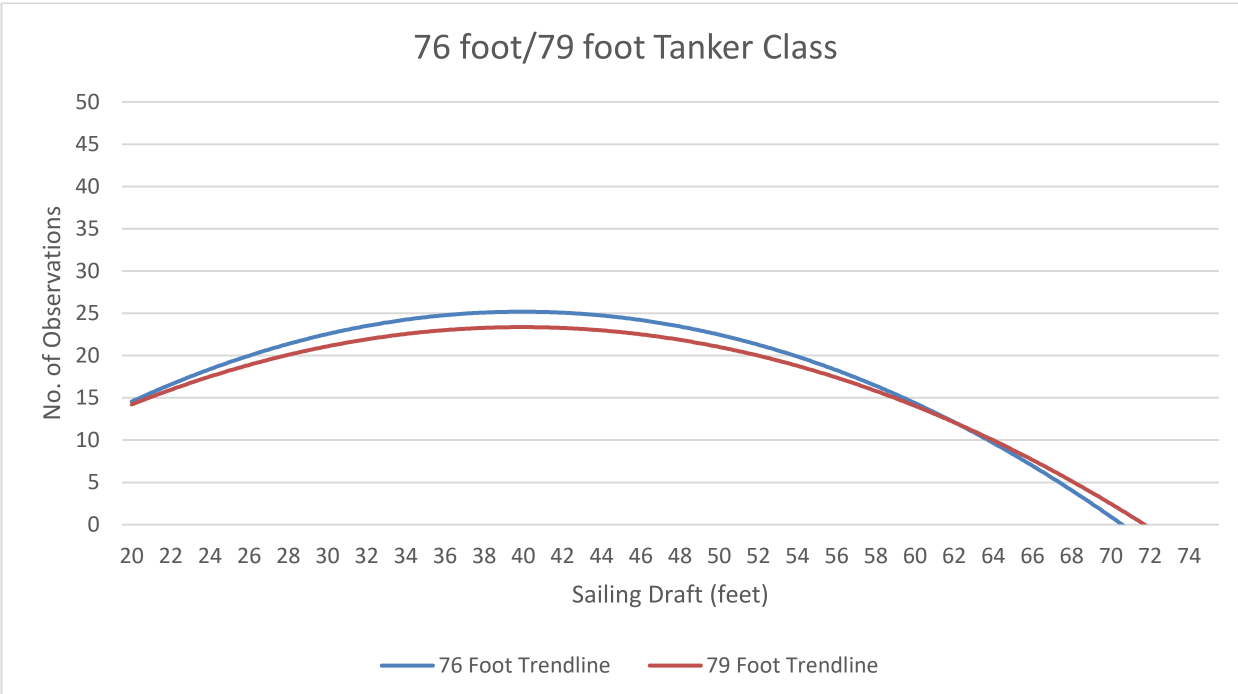


Figure 4-4: 76 ft vs 79 ft Tanker Class Sailing Drafts

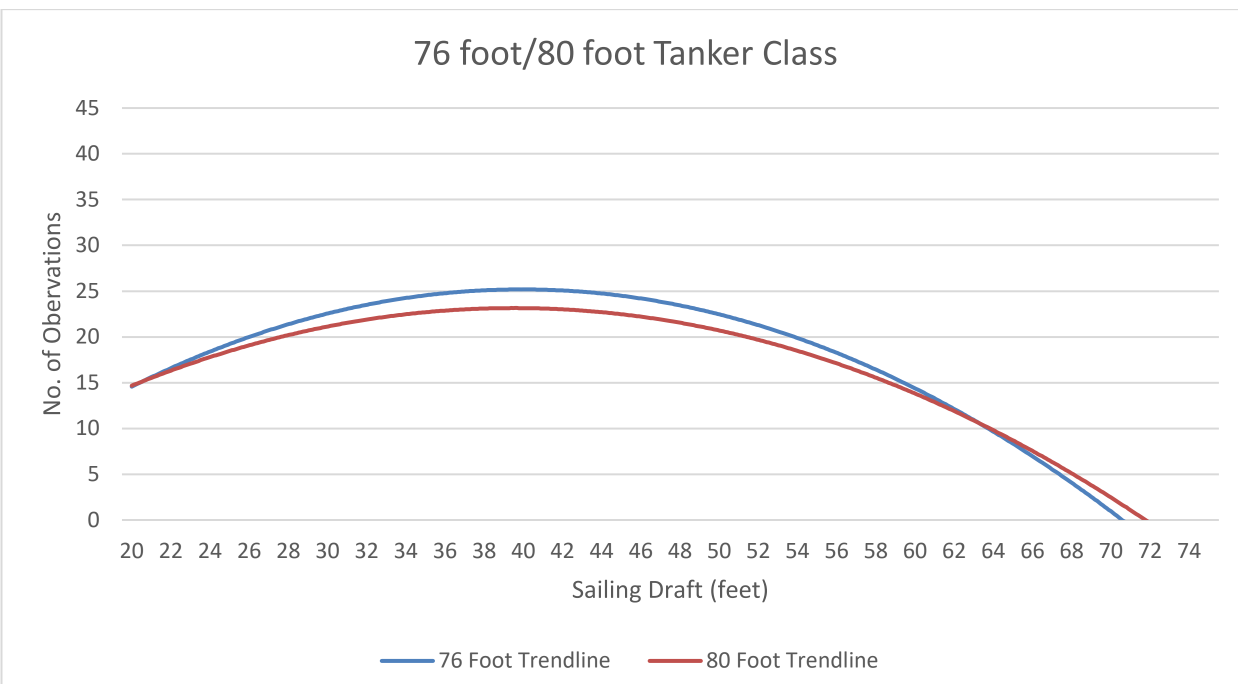


Figure 4-5: 76 ft vs 80 ft Tanker Class Sailing Drafts

4.2 Origin-Destination (OD) Transportation Cost Savings Benefit by Project Depth

From the onset of this analysis, the alternatives considered—primarily deepening scenarios but also a potential stand-by area—acknowledged that there were three "separable elements" (independent beneficial measures that must be economically justified) to be analyzed. The first separable element would address depths needed to allow calls by Post–Panamax container ships that are becoming the norm in international maritime shipping and are already calling on West Coast ports, albeit not fully loaded. With the existing depth for container Piers T and J being 53' and 50' respectively, team economists discussed anticipated future operational needs and decided to examine scenarios of 53', 55', and 57' depths.

Additionally, POLB officials were interested in the benefits accruing to each facility separately (Pier J South vs Pier T West Basin). Also, the Port indicated that their long-term plans are to implement modifications that would fill in and therefore eliminate Pier J South by about 20 years after the Base Year (approximately 2047). Thus, the economic model runs and results incorporated these issues. Benefits and costs were separated out for the two container piers and the benefiting stream for Pier J South was truncated to year 2046 (rather than the full period of analysis end year of 2076).

The next element that was addressed was liquid bulk tankers, primarily for crude oil shipments. The approach and Main Channel currently have a draft of 76', making it necessary for tankers to arrive into POLB particularly light-loaded due to pilots rules concerning safety underkeel clearances of 10% design draft for these classes of vessels (thus translating to underkeel clearance safety factors to upwards of 8'). Large crude/liquid bulk vessels use the west side of Pier T abutted against the Main Channel. Meetings with Port officials and pilots resulted in the decision to analyze deeper depths of 78', 80', and 83' to accommodate vessels to transit the harbor with crude amounts closer to their capacity. Tidal delays rather than vessel design draft lead to analyzing depths greater than 80'.

Finally, the Port and pilots expressed an interest in providing a stand-by area for vessels waiting to dock and providing some degree of safety coverage by being within the harbor breakwater rather than in open water. Based upon design drafts of both design vessel classes, the team decided to analyze stand-by area depth of 67', 68', 71', 72', and 73'. Primarily, this stand-by area would accommodate tankers waiting to load at the single Pier T crude facility. The analysis did not analyze two-way traffic, only queuing needs which, per guidance, did not result in an incremental economic justification.

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

Transportation costs were estimated for a 50-year period of analysis for the years 2027 through 2076. Transportation costs were calculated using the Corps certified HarborSym model for the years 2021, 2030, and 2040 and are shown in **Table 4-12** and **Table 4-13**. Results for the base year 2027 are calculated by interpolating between the 2021 and 2030 results. This was due to a change in the anticipated base year (2027 from 2021) during the study phase of the analysis. Also, due to the risk and uncertainty associated with forecasting beyond 2040, along with time frame any additional benefits would be discounted back to the base year 2027, transportation costs were held constant beyond 2040. Transportation costs were then determined for each alternative project depth.

In the following cost-benefit tables, all calculations of transportation cost savings used the FY 2019 Federal Discount Rate of 2.875% (including figures estimated by interpolating between the modeled years and calculating Net Present Value). All cost estimates provided by Cost Estimating are in FY 2019 (Oct 2018) Price Levels and were annualized using the same Federal Discount rate and amortized over 50 years. **Table 4-13** shows decreasing transportation costs to the recommended depth of 80 feet. **Table 4-17** demonstrates a decrease in net benefits as depths deeper than 80 feet. Therefore, detailed costs are not provided in **Table 4-13**.

Table 4-12: Container Vessel Transportation Costs

Model Year	Class	FWOP	53 feet	55 feet	57 feet
2021	SPX	$ 114,794,282	$ 114,794,282	$ 114,794,282	$ 114,794,282
	PX	$ 482,202,619	$ 479,677,998	$ 473,997,601	$ 473,366,446
	PPX1	$ 500,201,662	$ 500,201,662	$ 498,534,323	$ 496,866,984
	PPX2	$ 900,189,684	$ 900,189,684	$ 900,189,684	$ 900,189,684
	PPX3	$ 681,907,102	$ 681,907,102	$ 681,907,102	$ 681,907,102
	PPX4	$ 161,407,340	$ 161,407,340	$ 161,407,340	$ 161,407,340
2030	SPX	$ 98,038,353	$ 98,038,353	$ 98,038,353	$ 98,038,353
	PX	$ 389,637,859	$ 387,107,743	$ 378,252,338	$ 377,619,809
	PPX1	$ 588,838,317	$ 588,838,317	$ 582,295,669	$ 582,295,669
	PPX2	$ 1,203,256,658	$ 1,203,256,658	$ 1,203,256,658	$ 1,203,256,658
	PPX3	$ 1,283,963,703	$ 1,283,963,703	$ 1,283,963,703	$ 1,283,963,703
	PPX4	$ 476,025,237	$ 476,025,237	$ 476,025,237	$ 476,025,237
2040	SPX	$ 87,822,491	$ 87,822,491	$ 87,822,491	$ 87,822,491
	PX	$ 144,545,910	$ 143,277,964	$ 139,474,124	$ 138,840,151
	PPX1	$ 571,267,073	$ 558,848,223	$ 552,638,799	$ 552,638,799
	PPX2	$ 1,075,974,124	$ 1,075,974,124	$ 1,075,974,124	$ 1,075,974,124
	PPX3	$ 2,164,422,412	$ 2,164,422,412	$ 2,164,422,412	$ 2,164,422,412
	PPX4	$ 1,612,179,964	$ 1,612,179,964	$ 1,612,179,964	$ 1,612,179,964

Table 4-13: Tanker Vessel Transportation Cost

Model Year	Class	FWOP	78 feet	79 feet	80 feet
2021	10K DWT Tanker	$250,900	$250,900	$250,900	$250,900
	20K DWT Tanker	$19,434,426	$19,434,426	$19,434,426	$19,434,426
	30K DWT Tanker	$17,432,431	$17,432,431	$17,432,431	$17,432,431
	40K DWT Tanker	$2,635,599	$2,635,599	$2,635,599	$2,635,599
	50K DWT Tanker	$154,512,012	$154,512,012	$154,512,012	$154,512,012
	60K DWT Tanker	$8,487,067	$8,487,067	$8,487,067	$8,487,067
	70K DWT Tanker	$104,871,066	$102,164,716	$100,811,540	$99,458,365
	80K DWT Tanker	$1,667,498	$1,667,498	$1,667,498	$1,667,498
	100K DWT Tanker	$64,654,526	$64,293,328	$63,932,129	$63,932,129
	200K DWT Tanker	$73,381,804	$73,381,804	$73,381,804	$73,381,804
	300K DWT Tanker	$31,392,999	$31,392,999	$31,392,999	$31,392,999
2030	10K DWT Tanker	$249,660	$249,660	$249,660	$249,660
	20K DWT Tanker	$18,043,291	$18,043,291	$18,043,291	$18,043,291
	30K DWT Tanker	$16,813,147	$16,813,147	$16,813,147	$16,813,147
	40K DWT Tanker	$2,547,115	$2,547,115	$2,547,115	$2,547,115
	50K DWT Tanker	$147,125,724	$147,125,724	$147,125,724	$147,125,724
	60K DWT Tanker	$7,461,248	$7,461,248	$7,461,248	$7,461,248
	70K DWT Tanker	$91,938,429	$89,502,974	$89,502,974	$88,894,110
	80K DWT Tanker	$1,448,981	$1,448,981	$1,448,981	$1,448,981
	100K DWT Tanker	$55,194,292	$54,880,688	$54,253,480	$54,253,480
	200K DWT Tanker	$64,588,626	$64,588,626	$64,588,626	$64,588,626
	300K DWT Tanker	$28,514,713	$28,514,713	$28,514,713	$28,514,713
2040	10K DWT Tanker	$250,424	$250,424	$250,424	$250,424
	20K DWT Tanker	$14,990,002	$14,990,002	$14,990,002	$14,990,002
	30K DWT Tanker	$16,310,580	$16,310,580	$16,310,580	$16,310,580
	40K DWT Tanker	$2,640,507	$2,640,507	$2,640,507	$2,640,507
	50K DWT Tanker	$151,631,922	$151,631,922	$151,631,922	$151,631,922
	60K DWT Tanker	$9,115,057	$9,115,057	$9,115,057	$9,115,057
	70K DWT Tanker	$85,467,452	$83,203,414	$83,203,414	$82,071,394
	80K DWT Tanker	$1,653,664	$1,653,664	$1,653,664	$1,653,664
	100K DWT Tanker	$62,260,526	$61,553,020	$61,199,267	$61,199,267
	200K DWT Tanker	$68,926,301	$68,926,301	$68,926,301	$68,926,301
	300K DWT Tanker	$34,845,677	$34,845,677	$34,845,677	$34,845,677

Table 4-14 through Table 4-18 presents the preliminary economic benefit summaries using the FY 2019 Federal Discount Rate of 2.875% by measure for each of the two container terminals, then separately for containers and tankers, and finally for a stand-by area**.** The preliminary economic benefits were calculated before the release of the EGM 20-04 updated guidance for vessel operating costs. The benefit cost analysis for the final analysis was performed using the methodology in the EGM 20-04. An estimated 7.4 million cubic yards of material would be dredged. Proposed disposal sites include LA-2, LA-3, surfside borrow pits off Huntington Beach/Seal Beach, and Port fill sites (nearshore). LA -2 disposal site is located at the upper southern wall of San Pedro Sea Valley, about 6.8 miles south-southwest of the Queens Gate entrance to Los Angeles and Long Beach Harbor. LA -3 disposal site is located on the continental slope near the Newport Submarine Canyon about 5.4 miles southwest of the entrance of Newport Harbor.

Container annualized benefits were calculated separately for Pier J (for 20 years, as previously described per Port master plans) and Pier T/West Basin. Cost Estimating figures were allocated appropriately between each and subsequently annualized. As the table shows, each pier is economically justified as a separable element of subsequent alternatives. Moreover, each pier shows maximized annual net benefits at a project improvement depth of -55-ft.

Table 4-14: Preliminary Economic Benefit Summary for Pier J

Alternative	Avg Annual Benefits Pier J	Avg Annual Costs Pier J	Net Annual Benefits	Benefit-Cost Ratio
Containers 53 Offshore	$2,752,936.08	$2,015,000	$737,936	1.4
Containers 55 Offshore	$6,184,171.13	$2,557,000	$3,627,171	2.4
Containers 57 Offshore	$6,468,887.54	$3,569,000	$2,899,888	1.8
Containers 53 Nearshore	$2,752,936.08	$1,832,000	$920,936	1.5
Containers 55 Nearshore	$6,184,171.13	$2,283,000	$3,901,171	2.7
Containers 57 Nearshore	$6,468,887.54	$3,267,000	$3,201,888	2.0

Table 4-15: Preliminary Economic Benefit Summary for Pier T

Alternative	Avg Annual Benefits Pier T	Avg Annual Costs Pier T	Net Annual Benefits	Benefit-Cost Ratio
Containers 53 Offshore	$6,076,565	$685,000	$5,391,565	8.9
Containers 55 Offshore	$13,650,343	$846,000	$12,804,343	16.1
Containers 57 Offshore	$14,278,798	$1,778,000	$12,500,798	8.0
Containers 53 Nearshore	$6,076,565	$623,000	$5,453,565	9.8
Containers 55 Nearshore	$13,650,343	$755,000	$12,895,343	18.1
Containers 57 Nearshore	$14,278,798	$1,628,000	$12,650,798	8.8

Once both container terminals were shown to be incrementally justified, annualized costs were updated (thus, they may not match exactly the costs presented in the previous table) and combined to show that the overall container analysis was also economically justified. **Table 4-16** documents that the combined elements of Nearshore sediment placement and a channel depth of -55-ft maximizes container annual net benefits at just shy of $16.8M and results in a containers Benefit-Cost ratio of 6.5.

Table 4-16: Preliminary Container Economic Benefit Summary

Alternative	Avg Annual Benefits Pier J	Avg Annual Benefits Pier T	Avg Annual Benefits	Avg Annual Costs	Net Annual Benefits	Benefit-Cost Ratio
Containers 53 Offshore	$2,753,000	$6,077,000	$8,830,000	$2,700,000	$ 6,130,000	3.3
Containers 54 Offshore	$4,460,000	$9,863,000	$14,332,000	$3,048,000	$11,284,000	4.7
Containers 55 Offshore	$6,184,000	$13,650,000	$19,835,000	$3,402,000	$16,432,000	5.8
Containers 56 Offshore	$6,327,000	$13,965,000	$20,291,000	$4,417,000	$15,874,000	4.6
Containers 57 Offshore	$6,469,000	$14,279,000	$20,748,000	$6,961,000	$13,787,000	3.0
Containers 53 Nearshore	$2,753,000	$6,077,000	$8,830,000	$2,455,000	$6,375,000	3.6
Containers 54 Nearshore	$4,469,000	$9,863,000	$14,332,000	$2,743,000	$11,590,000	5.2
Containers 55 Nearshore	**$6,184,000**	**$13,650,000**	**$19,835,000**	**$3,038,000**	**$16,797,000**	**6.5**
Containers 56 Nearshore	$6,327,000	$13,965,000	$20,291,000	$4,388,000	$15,903,000	4.6
Containers 57 Nearshore	$6,469,000	$14,279,000	$20,748,000	$6,509,000	$14,239,000	3.2

Table 4-17 displays the same analysis of the Pier T liquid bulk terminal. Annual benefits were calculated for project depths of -78-ft through -83-ft, considering both Nearshore and Offshore placement site cost estimates. Annual net benefits top out at approximately $2.2M and at an improved project depth of -80 feet. The tanker vessel class, which drives the benefits, is not able to load deeper beyond 80', therefore benefits beyond 80' are associated with reductions in tide delays Model results for the 81' alternative demonstrated net benefits were decreasing. The 83' alternative was run to confirm this trend.

Table 4-17: Preliminary Tanker Economic Benefit Summary

Alternative	Avg Annual Benefits	Avg Annual Costs	Net Annual Benefits	Benefit-Cost Ratio
Tankers 78 Offshore	$2,928,000	$1,972,000	$956,000	1.5
Tankers 79 Offshore	$3,584,000	$2,441,000	$1,142,000	1.5
Tankers 80 Offshore	$4,613,000	$2,919,000	$1,694,000	1.6
Tankers 81 Offshore	$4,713,000	$3,547,000	$1,166,000	1.3
Tankers 82 Offshore	$4,763,000	$4,100,000	$663,000	1.2
Tankers 83 Offshore	$4,763,000	$4,679,000	$84,000	1.0
Tankers 78 Nearshore	$2,928,000	$1,677,000	$1,251,000	1.7
Tankers 79 Nearshore	$3,584,000	$1,995,000	$1,589,000	1.8
Tankers 80 Nearshore	**$4,613,000**	**$2,375,000**	**$2,238,000**	**1.9**
Tankers 81 Nearshore	$4,713,000	$2,797,000	$1,916,000	1.7
Tankers 82 Nearshore	$4,762,700	$3,164,000	$1,598,000	1.5
Tankers 83 Nearshore	$4,762,700	$3,554,000	$1,209,000	1.3

Finally, the results of the stand-by measure are displayed in **Table 4-18**. The tanker vessel class drives the benefits of increasing the depths of the stand-by area. Therefore, the NED depth alternative of 80' was used in the HarborSym analysis to calculate the decrease in transportation costs with channel improvements made to the stand-by area. This was completed by altering the stand-by area depth of the 80' alternative from 67' to 73'. Benefits were generated by comparing the transportation costs to the future with project 80' scenario. None of the proposed depths for the stand-by area for either material placement option proved to be economically justified. Nearshore material placement at -67 and -68-ft come close to reaching unity.

Table 4-18: Preliminary Economic Benefit Summary for Standby Area

Alternative	Avg Annual Benefits	Avg Annual Costs	Net Annual Benefits	Benefit-Cost Ratio
Standby Area 67 Nearshore Clamshell	$650,000	$1,781,000	$(1,131,000)	0.4
Standby Area 68 Nearshore Clamshell	$776,000	$1,809,000	$(1,033,000)	0.4
Standby Area 71 Nearshore Clamshell	$1,030,000	$2,283,000	$(1,253,000)	0.5
Standby Area 72 Nearshore Clamshell	$1,093,000	$2,519,000	$(1,426,000)	0.4
Standby Area 73 Nearshore Clamshell	$1,155,000	$2,756,000	$(1,601,000)	0.4
Standby Area 67 Nearshore Hopper	$650,000	$671,000	$(21,000)	0.97
Standby Area 68 Nearshore Hopper	$776,000	$818,000	$(42,000)	0.95
Standby Area 71 Nearshore Hopper	$1,030,000	$1,413,000	$(383,000)	0.7
Standby Area 72 Nearshore Hopper	$1,093,000	$1,631,000	$(538,000)	0.7
Standby Area 73 Nearshore Hopper	$1,155,000	$1,853,000	$(698,000)	0.6

4.3 Preliminary Transportation Cost Savings Benefit Analysis Summary for Final Array Plans

Based upon the analysis results shown on Tables 4-16 through 4-18, it was determined that net benefits maximized at a depth of -55' for container alternatives and -80' for liquid bulk alternatives for both disposal options/scenarios. However, dredging to depths of -53' to -57' for containers and -78' to -83' for liquid bulk vessels were also economically justified. Based upon these results, three scales of combined container/liquid bulk alternatives were selected for more detailed analysis as Final Array plans. These included a smaller scale plan of -53'/-78', the tentative NED scale of -55'/-80', and a larger scale plan of -57'/-83', representing the depths of deepening for container and liquid bulk vessels, respectively. In addition, an additional plan is being carried forward into the Final Array, that is based upon the NED scale of -55'/-80' for container and liquid bulk vessels, plus a -67' Standby Area measure. Although the Standby Area was not economically justified, it is being included as a Final Array plan option as it may be considered as a locally preferred plan by the non-Federal sponsor.

Table 4-19 below provides the Origin-Destination benefit cost analysis for these alternatives based upon rough order cost analysis.

As shown, the 55'/80' depth provides the greatest total net benefits.

Table 4-19 Origin-Destination Benefit Cost Analysis (Million $)

Project Depth	Total AAEQ Costs	O-D AAEQ Benefits	Total Net Benefits	Incremental Net Benefits	Benefit/Cost Ratio
53/78	$4.10	$11.80	$7.70	-	2.9
55/80	$5.40	$24.40	$19.00	$11.30	4.5
57/83	$10.10	$25.50	$15.40	($3.60)	2.5
55/80/67*	$6.10	$25.10	$19.00	$0	4.1

**Net benefits slightly lower for 55/80/67 Plan*

4.4 Economic Cost Analysis (Refined Costs for Final Array Plans)

This section presents the evaluation of costs based upon refined costs for the Final Array Plans identified in the prior section. These costs also incorporate contingencies based upon an abbreviated cost risk analysis. Interest during construction (IDC) was calculated for the Federal Costs assuming that the schedule may vary depending on the time required to obtain congressional authorization and funding. Other areas of project uncertainties include the dredging industry execution of bid and contract requirements, availability of contractors' dredging equipment to comply with environmental windows and delays due to unexpected weather conditions. Based on these uncertainties, the construction duration for the project may vary from 24 to 60 months. **Table 4-20**, **Table 4-21**, **Table 4-22, and Table 4-23** show the initial project costs for each alternative, including the federal and non-federal portions.

Table 4-20: Alternative 2 Initial Costs (2.875% Fed Discount Rate)

Alternative 2 - 53 feet / 78 feet				
	PED	Navigation	Construction Management	Total Initial Cost
Local Service Facilities	$2,206,000	$11,234,000	$2,068,000	$15,508,000
General Navigation Features	$11,625,000	$77,507,000	$5,193,000	$94,325,000
Total	$13,831,000	$88,741,000	$7,261,000	$109,833,000
Interest during Construction (2 Years at 2.875% Fed Discount Rate) - $3,180,000				

Table 4-21 Alternative 3 Initial Costs

Alternative 3 - 55 feet / 80 feet				
	PED	Navigation	Construction Management	Total Initial Cost
Local Service Facilities	$2,297,000	$14,998,000	$2,153,000	$19,448,000
General Navigation Features	$16,177,000	$107,853,000	$7,226,000	$131,256,000
Total	$18,474,000	$122,851,000	$9,379,000	$150,704,000
Interest during Construction (3 Years at 2.875% Fed Discount Rate) - $6,604,000				

Table 4-22 Alternative 4 Initial Costs

Alternative 4 - 57 feet / 83 feet				
	PED	Navigation	Construction Management	Total Initial Cost
Local Service Facilities	$11,585,000	$76,106,000	$10,861,000	$98,552,000
General Navigation Features	$28,490,000	$189,909,000	$12,724,000	$231,123,000
Total	$40,075,000	$266,015,000	$23,585,000	$329,675,000
Interest during Construction (5 years at 2.875% Fed Discount Rate) - $24,529,000				

Table 4-23 Alternative 5 Initial Costs

Alternative 5 - 55 feet / 80 feet / 67 feet				
	PED	Navigation	Construction Management	Total Initial Cost
Local Service Facilities	$2,297 ,000	$14,998,000	$10,861,000	$2,153,000
General Navigation Features	$21,579,000	$143,845,000	$9,637,000	$175,061,000
Total	$40,075,000	$266,015,000	$23,585,000	$194,509,000
Interest during Construction (4 Years at 2.875% Fed Discount Rate) - $11,469,000				

The cost benefit analysis for the Final Array Plans based upon the refined and updated costs is shown in **Table 4-24**, with the NED plan highlighted in yellow. The NED plan has approximately $15 million average annual net benefits, about $0.9 million more than Alternative 5. Alternative 3 was identified as the Tentatively Selected Plan (FY 2016 vessel operating costs). Following the TSP milestone, the costs for the TSP (Alternative 3) were refined and updated to reflect the FY 21/ Oct 20; 2.5% Discount Rate).

Table 4-24: Alternative Cost - Benefit Analysis

Alternative	Total Initial cost	Total Investment Cost	Annualized Investment Cost	Annual O&M	Total Annual Economic Cost	Average Annual Benefits	Net Average Annual Benefits	Incremental Benefits	B/C
1 - No Action	-	-	-	-	-	-	-	-	
2 - 53/78	$109,833,000	112,596,000	$3,987,000	$101,000	$4,088,000	$10,081,000	$5,990,000	($9,102,000)	2.5
3 - 55/80*	**$155,749,000**	**$163,576,000**	**$5,767,000**	**$101,000**	**$5,868,000**	**$20,960,000**	**$15,092,000**	**-**	**3.6**
4 - 57/83	$329,675,000	$350,908,000	$12,389,000	$101,000	$12,490,000	$21,872,000	$9,379,000	($5,713,000)	1.8
5 - 55/80/67	$194,509,000	$204,449,000	$7,215,000	$101,000	$7,326,000	$21,518,000	$14,189,000	($903,000)	2.9

***Total initial cost includes Local Service Facilities and Aids to Navigation Costs including cost contingencies**

5 MULTIPORT ANALYSIS

Multiport competition was assessed qualitatively for this study as it relates to shifting of cargo from one port to another port based on factors such as deepening of a harbor. The recommended plan includes a deeper channel to more efficiently operate larger containerships and crude oil tankers. Larger ships alone do not drive growth for the harbor. Many factors may influence the growth of a particular harbor: landside development and infrastructure, location of distribution centers for imports, source locations for exports, population and income growth and location, port logistics and fees, business climate and taxes, carrier preferences, labor stability and volatility, and business relationships. Harbor depth is just one of many factors involved in determining growth and market share for a particular port. The economic analysis was conducted with the historical cargo share at the POLB remaining the same in both the future without-project and future with-project conditions. Cargo may vary in the future as investments are made in port facilities and supporting infrastructure, and long-term leases are renewed or changed at individual terminals; however, the POLB's share of cargo is expected to remain relatively consistent with growth in the future being attributed to GDP growth for the U.S. West Coast and associated hinterland based on the information provided in the Mercator Report's commodity forecast conducted for this study in 2016. To restate the multiport considerations in another way, justification of the recommendation for this study is not based on an assumption that cargo will shift to the POLB based on deepening alone. It does take into account an evaluation of historical cargo data along the West Coast, including changes in growth when other harbor improvements have been made at various other West Coast ports. Based on that evaluation, the analysis takes into account that the POLB will receive a relatively similar share of regional cargo volumes with or without navigation improvements.

Two other deep water reports were considered for this study: the Ports of Los Angeles (adjacent to POLB) and Oakland. With rail transport being the preferred transportation mode for both exports and imports across the United States, rail services to these ports were examined. As the map below illustrates, both Oakland and LA/LB areas are served by major rail lines. Oakland is served by Union Pacific via major distribution cities of Reno, Salt Lake City, and Denver before reaching the markets of the Midwest. LA/LB is served by both Union Pacific and BNSF which provide access to Phoenix, Tucson, and El Paso before reaching the major southwest markets of Dallas/Fort Worth, Houston, and Memphis. While there may inevitably be some overlap in the areas served, these rail routes and their demand for goods would not be shifted from Northern to Southern CA due to the Federal project.

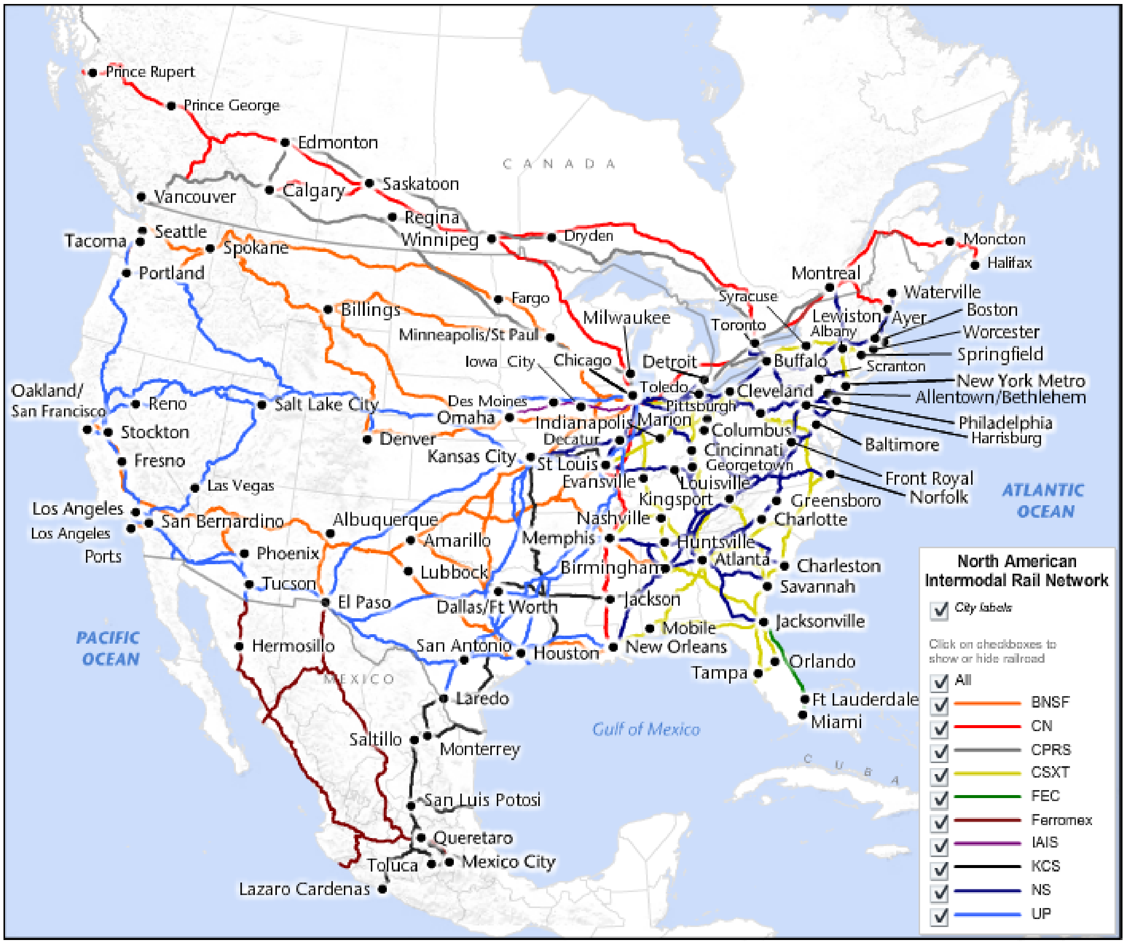


Figure 5-1: North American Intermodal Network

Next, the overall economic health of the potentially impacted ports was considered. According to the Port of Oakland, it recognizes that it is one of the three Pacific Coast gateways for cargo, along with Seattle & Tacoma and LA/LB. In 2018, 78% of its trade was with Asia, 11% with Europe, and 2% with Australia/New Zealand/Oceana. Its container history has grown from approximately 1.7M TEUs in 2002 to 2.6M TEUs in 2018, which amounts to around 2.7% growth per year.

The Port of Los Angeles also reports robust activity. In 2018, it handled about 9.5M TEUs and has a main channel water depth of 53'. It has ranked as the number one container port in the US since the year 2000. Its Top Five Trade Routes in 2018 were Northeast Asia (73%), Southeast Asia (21%), the Indian Subcontinent (2%), Northern Europe (1%) and the Middle East (1%).

Finally, the trade routes of the POLB were examined vis-à-vis Los Angeles and Oakland. East Asian trade already accounts for upwards of 90% of POLB shipments. Their top trading partners are China, South Korea, Japan, Hong Kong, Taiwan, Vietnam, Iraq, Australia, Ecuador, and Indonesia. So, while there definitely are some overlapping trade lanes to the other two ports, all three are already heavily invested in Asia, while Oakland also has a sizable market with Europe and Los Angeles has had a deeper channel for some time. These factors, as well as contracts and established business partnerships lend to the unlikelihood of the recommended Federal project substantially shifting cargo from either LA or Oakland to the POLB.

6 REGIONAL ECONOMIC DEVELOPMENT ANALYSIS

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

6.1 Regional Analysis

The USACE online Regional Economic System (RECONS), a regional economic impact modeling tool developed by the USACE Institute for Water Resources, the Louis Berger Group, and Michigan State University, is a system designed to provide estimates of regional, state, and national contributions of federal spending associated with Civil Works and American Recovery and Reinvestment Act ARRA Projects. It also provides a means for estimating the forward linked benefits (stemming from effects) associated with non-federal expenditures sustained, enabled, or generated by USACE Recreation, Navigation, and Formally Utilized Sites Remedial Action Program (FUSRAP). Contributions are measured in terms of economic output, jobs, earnings, and/or value added. The system was used to perform the following regional analysis for the proposed Long Beach Harbor, CA improvement project.

This RECONS report provides estimates of the economic impacts of Civil Works Budget Analysis for Long Beach Harbor, CA. It provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Work program spending and stem-from effects for Ports, Inland Water Way, FUSRAP and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations. These multipliers were then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. The tool will be used as a means to evaluate project and program expenditures associated with the annual expenditure by the USACE.

Table 6-1: Project Information

Project Name:	LONG BEACH HARBOR CHANNEL DEEPENING, CA
Project ID:	
Division:	SPD
District:	LOS ANGELES DISTRICT
Type of Analysis:	Civil Works Budget Analysis
Business Line:	Navigation
Work Activity:	CWB - Navigation

Table 6-2: Economic Impact Regions

Regional Impact Area:	Los Angeles Long Beach Santa Ana CA MSA
Regional Impact Area ID:	24
Counties included	Los Angeles/Orange/
State Impact Area:	California
National Impact:	Yes

6.2 Results of the Economic Impact Analysis

The RED impact analysis was evaluated at three geographical levels: Local, State, and National. The local represents the Los Angeles/Long Beach/Santa Ana MSA impact area which encompasses the area included in about a 50-mile radius around the project area. The State level will include the State of California. The National level will include the 48 contiguous United States.

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

Table 6-3: Input Assumptions (Spending and LPC)

Category	Spending (%)	Spending Amount	Local LPC (%)	State LPC (%)	National LPC (%)
Dredging Fuel	6%	$9,272,000	87%	87%	90%
Metals and Steel Materials	4%	$6,536,000	45%	55%	90%
Textiles, Lubricants, and Metal Valves and Parts (Dredging)	2%	$3,192,000	44%	45%	65%
Pipeline Dredge Equipment and Repairs	5%	$7,904,000	48%	51%	100%
Aggregate Materials	3%	$4,408,000	57%	78%	97%
Switchgear and Switchboard Apparatus Equipment	0%	$456,000	38%	42%	80%
Hopper Equipment and Repairs	2%	$2,888,000	1%	10%	97%
Construction of Other New Nonresidential Structures	14%	$20,672,000	100%	100%	100%
Industrial and Machinery Equipment Rental and Leasing	7%	$11,096,000	100%	100%	100%
Planning, Environmental, Engineering and Design Studies and Services	5%	$6,992,000	100%	100%	100%
USACE Overhead	7%	$10,032,000	71%	71%	100%
Repair and Maintenance Construction Activities	4%	$6,232,000	100%	100%	100%
Industrial Machinery and Equipment Repair and Maintenance	11%	$15,960,000	100%	100%	100%
USACE Wages and Benefits	13%	$20,216,000	75%	100%	100%
Private Sector Labor or Staff Augmentation	15%	$23,256,000	100%	100%	100%
All Other Food Manufacturing	2%	$2,888,000	58%	75%	90%
Total	**100%**	**$152,000,000**	**-**	**-**	**-**

The USACE is planning on expending approximately $152,000,000 on the project. Of this total project expenditure about $127 million will be captured within the regional impact area. The rest will be leaked out to the state or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity in that can be measured in jobs, income, sales and gross regional product as summarized in the following table and includes impacts to the region, the State impact area, and the Nation. **Table 6-4** is the overall economic impacts for this analysis.

The labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income. The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. An interesting note is that in the local geography one job averages an annual wage of $59,908, the state equivalent is $61,636 and the National equivalent is $60,951 (labor income/job). The total impact, direct and secondary, yields a local average wage of $56,700, state $56,862 and $54,818 nationally.

Table 6-4: Overall Summary Economic Impacts

Impacts	Impact Areas	Regional	State	National
Total Spending		$152,000,000	$152,000,000	$152,000,000
Direct Impact				
	Output	$127,067,481	$134,731,844	$148,665,586
	Job	1,261.91	1,314.77	1,411.64
	Labor Income	$75,598,302	$81,037,070	$86,040,213
	GRP	$88,396,051	$94,569,662	$100,883,443
Total Impact				
	Output	$252,273,259	$278,942,389	$395,725,178
	Job	2,113.21	2,292.96	3,040.36
	Labor Income	$119,819,949	$130,382,377	$166,667,393
	GRP	$164,766,600	$180,573,851	$240,533,691

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

Table 6-5: Economic Impact at Regional Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$6,816,525	0.87	$208,791	$1,052,790
171	Steel product manufacturing from purchased steel	$1,972,786	4.30	$355,146	$435,289
198	Valve and fittings other than plumbing manufacturing	$989,594	3.00	$269,434	$505,167
201	Fabricated pipe and pipe fitting manufacturing	$2,277,084	9.02	$523,865	$911,247
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$692,165	4.55	$326,450	$390,521
268	Switchgear and switchboard apparatus manufacturing	$97,465	0.29	$24,953	$47,315
290	Ship building and repairing	$5,967	0.03	$1,836	$2,276
319	Wholesale trade businesses	$3,324,767	18.61	$1,467,856	$2,590,822
322	Retail Stores - Electronics and appliances	$14,563	0.10	$7,407	$9,666
323	Retail Stores - Building material and garden supply	$601,950	6.81	$293,442	$420,493
324	Retail Stores - Food and beverage	$20,168	0.30	$10,191	$14,760
326	Retail Stores - Gasoline stations	$212,996	1.36	$87,237	$148,445
332	Transport by air	$7,731	0.03	$2,245	$3,857
333	Transport by rail	$124,717	0.36	$45,419	$70,997
334	Transport by water	$50,463	0.11	$8,282	$21,314
335	Transport by truck	$2,087,600	16.59	$994,114	$1,177,760
337	Transport by pipeline	$47,135	0.05	$23,315	$22,307
36	Construction of other new nonresidential structures	$20,672,000	127.53	$8,542,519	$10,695,378
365	Commercial and industrial machinery and equipment rental and leasing	$11,096,000	37.55	$2,937,481	$6,202,534
375	Environmental and other technical consulting services	$6,987,778	69.95	$4,779,851	$4,797,617
386	Business support services	$7,086,144	111.02	$4,796,089	$4,748,826
39	Maintenance and repair construction of nonresidential structures	$6,225,445	42.84	$2,793,596	$3,526,921
417	Commercial and industrial machinery and equipment repair and maintenance	$15,960,000	128.48	$9,843,672	$11,851,481
439	* Employment and payroll only (federal govt, non-military)	$15,162,000	119.99	$13,797,729	$15,162,000
5001	Labor	$23,256,000	554.34	$23,256,000	$23,256,000
69	All other food manufacturing	$1,278,438	3.79	$201,382	$330,268
	Total Direct Effects	$127,067,481	1,261.91	$75,598,302	$88,396,051
	Secondary Effects	$125,205,779	851.30	$44,221,647	$76,370,549
	Total Effects	**$252,273,259**	**2,113.21**	**$119,819,949**	**$164,766,600**

Table 6-6: Economic Impact at State Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$6,816,525	0.87	$208,791	$1,052,790
171	Steel product manufacturing from purchased steel	$2,562,457	5.59	$464,297	$568,247
198	Valve and fittings other than plumbing manufacturing	$989,594	3.00	$269,434	$505,167
201	Fabricated pipe and pipe fitting manufacturing	$2,413,581	9.56	$555,267	$965,871
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$1,505,798	10.13	$710,189	$849,574
268	Switchgear and switchboard apparatus manufacturing	$115,261	0.34	$29,509	$55,955
290	Ship building and repairing	$241,847	1.08	$83,529	$100,383
319	Wholesale trade businesses	$3,486,199	19.52	$1,539,127	$2,716,618
322	Retail Stores - Electronics and appliances	$14,563	0.10	$7,407	$9,666
323	Retail Stores - Building material and garden supply	$687,724	7.80	$335,256	$480,411
324	Retail Stores - Food and beverage	$20,168	0.30	$10,191	$14,760
326	Retail Stores - Gasoline stations	$248,964	1.59	$102,183	$173,623
332	Transport by air	$7,731	0.03	$2,245	$3,857
333	Transport by rail	$138,610	0.40	$50,478	$78,906
334	Transport by water	$50,463	0.11	$8,282	$21,314
335	Transport by truck	$2,147,403	17.09	$1,022,592	$1,211,498
337	Transport by pipeline	$48,218	0.06	$23,885	$22,855
36	Construction of other new nonresidential structures	$20,672,000	127.53	$8,542,519	$10,695,378
365	Commercial and industrial machinery and equipment rental and leasing	$11,096,000	37.55	$2,937,481	$6,202,534
375	Environmental and other technical consulting services	$6,988,323	69.96	$4,780,224	$4,797,991
386	Business support services	$7,086,144	111.02	$4,796,089	$4,748,826
39	Maintenance and repair construction of nonresidential structures	$6,225,445	42.84	$2,793,596	$3,526,921
417	Commercial and industrial machinery and equipment repair and maintenance	$15,960,000	128.48	$9,843,672	$11,851,481
439	* Employment and payroll only (federal govt, non-military)	$20,208,380	160.26	$18,390,038	$20,208,380
5001	Labor	$23,256,000	554.34	$23,256,000	$23,256,000
69	All other food manufacturing	$1,744,447	5.21	$274,788	$450,655
	Total Direct Effects	$134,731,844	1,314.77	$81,037,070	$94,569,662
	Secondary Effects	$144,210,546	978.18	$49,345,306	$86,004,189
	Total Effects	**$278,942,389**	**2,292.96**	**$130,382,377**	**$180,573,851**

Table 6-7: Economic Impact at National Level

IMPLAN No.	Industry Sector	Sales	Jobs	Labor Income	GRP
	Direct Effects				
115	Petroleum refineries	$6,942,381	0.89	$213,872	$1,075,828
171	Steel product manufacturing from purchased steel	$4,734,505	10.40	$866,356	$1,057,996
198	Valve and fittings other than plumbing manufacturing	$1,636,838	5.15	$445,657	$835,573
201	Fabricated pipe and pipe fitting manufacturing	$6,242,182	24.72	$1,480,489	$2,576,557
26	Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals	$2,177,380	14.74	$1,026,931	$1,228,482
268	Switchgear and switchboard apparatus manufacturing	$285,109	0.87	$72,994	$138,950
290	Ship building and repairing	$2,762,848	12.39	$956,643	$1,148,924
319	Wholesale trade businesses	$3,533,468	19.81	$1,559,995	$2,753,452
322	Retail Stores - Electronics and appliances	$14,592	0.10	$7,422	$9,685
323	Retail Stores - Building material and garden supply	$816,060	9.52	$397,818	$570,060
324	Retail Stores - Food and beverage	$20,216	0.30	$10,215	$14,795
326	Retail Stores - Gasoline stations	$250,338	1.86	$102,755	$174,585
332	Transport by air	$8,835	0.03	$2,566	$4,408
333	Transport by rail	$180,288	0.53	$65,656	$102,632
334	Transport by water	$50,760	0.11	$8,343	$21,447
335	Transport by truck	$2,277,650	18.20	$1,084,615	$1,284,980
337	Transport by pipeline	$101,957	0.13	$52,182	$50,082
36	Construction of other new nonresidential structures	$20,672,000	127.53	$8,542,519	$10,695,378
365	Commercial and industrial machinery and equipment rental and leasing	$11,096,000	37.55	$2,937,481	$6,202,534
375	Environmental and other technical consulting services	$6,991,073	69.99	$4,782,137	$4,799,911
386	Business support services	$10,028,833	164.27	$6,787,778	$6,720,888
39	Maintenance and repair construction of nonresidential structures	$6,230,223	42.88	$2,795,740	$3,529,628
417	Commercial and industrial machinery and equipment repair and maintenance	$15,960,000	128.48	$9,843,672	$11,851,481
439	* Employment and payroll only (federal govt, non-military)	$20,215,998	160.32	$18,396,971	$20,215,998
5001	Labor	$23,256,000	554.34	$23,256,000	$23,256,000
69	All other food manufacturing	$2,180,050	6.53	$343,405	$563,188
	Total Direct Effects	$148,665,586	1,411.64	$86,040,213	$100,883,443
	Secondary Effects	$247,059,593	1,628.72	$80,627,180	$139,650,248
	Total Effects	**$395,725,178**	**3,040.36**	**$166,667,393**	**$240,533,691**

The total economic impact from the improvements made at the POLB on the State of California, as shown in **Table 6-6,** is just under $279 million in sales, around 2,300 jobs equating to about $130 million in labor income, and a contribution of $180.5 million to GRP.

Table 6-8 displays the impact region profile for 19 selected sectors. It displays the geographical capture amounts for the Los Angeles/Long Beach/Santa Ana CA MSA, which is that portion of USACE spending that is captured in the impact area. The labor income represents all forms of employment earnings. In IMPLAN's regional economic model, it is the sum of employee compensation and proprietor income. The Gross Regional Product (GRP) which is also known as value added, is equal to gross industry output (i.e., sales or gross revenues) less its intermediate inputs (i.e., the consumption of goods and services purchased from other U.S. industries or imported). The number of jobs equates to the labor income. The total Long Beach Harbor project economic impact for the metropolitan statistical area is composed of $1.3 trillion in output (sales), 7.7 million in employment, $450 billion in labor income and a contribution of $721 billion to GRP. An interesting note is that in the MSA one job averages an annual wage of $57,955 (labor income/employment).

Table 6-8: Impact Region Profile (2019)

Regional Impact Area ID:	24			
Regional Impact Area Name:	Los Angeles Long Beach Santa Ana CA MSA			
Impact Area Type	Metropolitan Impact Area			
State Impact Region::	California			
Section	**Output (millions)**	**Labor Income (millions)**	**GRP (millions)**	**Employment**
Accommodations and Food Service	$34,802	$12,634	$19,394	506,670
Administrative and Waste Management Services	$36,818	$19,270	$24,621	559,124
Agriculture, Forestry, Fishing and Hunting	$974	$480	$502	12,122
Arts, Entertainment, and Recreation	$29,510	$12,142	$18,228	246,606
Construction	$55,939	$24,103	$26,420	362,746
Education	$32,654	$25,051	$28,196	480,559
Finance, Insurance, Real Estate, Rental and Leasing	$176,324	$46,865	$119,045	815,966
Government	$54,465	$39,280	$44,929	482,253
Health Care and Social Assistance	$63,661	$35,073	$41,503	641,159
Imputed Rents	$90,657	$12,833	$58,782	500,434
Information	$121,758	$32,480	$55,129	305,431
Management of Companies and Enterprises	$19,459	$8,784	$11,785	86,388
Manufacturing	$269,098	$49,317	$71,290	633,174
Mining	$7,887	$1,771	$4,942	12,415
Professional, Scientific, and Technical Services	$127,029	$58,047	$76,317	761,141
Retail Trade	$62,231	$26,340	$42,944	735,704
Transportation and Warehousing	$30,287	$13,148	$18,379	221,871
Utilities	$20,803	$3,943	$11,364	17,165
Wholesale Trade	$73,293	$27,959	$47,838	375,410
Total	**$1,307,649**	**$449,521**	**$721,610**	**7,756,338**

The following table shows the top ten industries that typically benefit from the types of expenditures made for this project by the USACE. This analysis was conducted at the national level and thus it cannot be guaranteed that these industries would be present in the regional impact area as analyzed.

Table 6-9: Top Ten Industries Affected by Work Activity (2019)

Project:	LONG BEACH HARBOR, CA		
Business Line:	Navigation		
Work Activity:	CWB - Navigation		
Rank	**Industry (millions)**	**IMPLAN No.**	**% of Total Employment**
1	* Employment and payroll only (federal govt, non-military)	439	8 %
2	Business support services	386	7 %
3	Construction of other new nonresidential structures	36	6 %
4	Food services and drinking places	413	5 %
5	Commercial and industrial machinery and equipment repair and maintenance	417	4 %
6	Real estate establishments	360	3 %
7	Wholesale trade businesses	319	3 %
8	Employment services	382	3 %
9	Maintenance and repair construction of nonresidential structures	39	3 %
10	Offices of physicians, dentists, and other health practitioners	394	2 %
			43 %

7 SENSITIVITY ANALYSIS

The Principle & Guidelines and subsequent ER 1105-2-100 recognize the inherent variability to water resources planning. Navigation projects and container studies in particular are fraught with uncertainty about future conditions. Therefore, a sensitivity analysis with changes to key quantitative assumptions and computations is required to assess their effect on the final outcome. The sensitivity analysis for this study was a repeat of the primary analysis, substituting commodity and fleet forecasts with a range of values that were projected to be below the base scenario. The HarborSym model used in the baseline evaluation included variations or ranges for many of the variables involved in the vessel operating costs, loading practices, trade lane distances, etc. However, it used only one base line commodity forecast, a key area of potential uncertainty. This sensitivity analysis presents the results of multiple forecasts of future commodity traffic at Long Beach Harbor.

For the analysis, the impact of Pier J going offline in 15 years, as opposed to 20 years, was analyzed. The change in timeline for Pier J resulted in a drop in incremental benefits of approximately 7%, from $6.2 million to $5.8 million. The costs amortized over a 5 year shorter timeframe would rise by approximately 26%, from $2.3 million to $2.8 million. The incremental Benefit-Cost ratio would be 2.0, down from 2.7, but would remain economically justified.

7.1 Inputs for Sensitivity Analysis

Benefits are a function of projected cargo and fleet forecasts, vessel operating costs, vessel itineraries, and changes in the overall economy, including the balance of trade between nations – for Long Beach, Asia in particular. There are also uncertainties regarding changes in port operations and infrastructure. To evaluate the uncertainty in the calculated benefits for the proposed project, multiple commodity and vessel fleet forecasts were developed for lower growth scenarios based on the baseline forecast presented in Section 3.3.3. The focus of these sensitivity scenarios are changes in the anticipated number of containers handled at the POLB. Crude oil imports were not included in the scenarios because the annual throughput is not anticipated to significantly change during the period of analysis.

Three lower growth scenarios were developed to assess the risk in Federal Investment of the proposed channel modifications at the Port of Long Beach. Scenario 1 assumed that commodity growth would occur from the baseline tonnage (2015) through 2021, at the same rate as the NED analysis. Then, from 2022 through the period of analysis the benefits were held constant. Scenario 2 assumed a lower growth rate of 2 percent annually from the baseline tonnage, 2015, to the base year that would continue throughout the period of analysis. Scenario 3 assumed a growth rate of 1.2 percent from the baseline tonnage through 2076. **Table 7-1** displays the total TEU forecast for each scenario.

Table 7-1: Total TEUs for Sensitivity Scenarios

Total TEU Throughput (million)				
Year	NED Analysis	Scenario 1	Scenario 2	Scenario 3
2015	4.9	4.9	4.9	4.9
2021	6.6	6.6	5.7	5.4
2030	9.5	6.6	6.6	6.0
2040	14.0	6.6	8.1	6.6

7.2 Sensitivity Results

HarborSym was run with changes in commodities imported and exported from base year tonnage. The results of the three sensitivity analyses are provided in the table below. As with the "most likely" scenario, the results for 2027 are calculated using the detailed model runs from 2021 and 2030. The results are compared to both the nearshore and offshore placement areas. As shown in each scenario the 55 foot recommended channel depth remains justified.

Table 7-2: Benefit/Cost for Sensitivity Scenarios

	Scenario 1	Scenario 2	Scenario 3
Average Annual Benefit	$ 10,045,000	$ 11,067,000	$ 9,472,000
Average Annual Cost (Nearshore)	$ 3,038,000	$ 3,038,000	$ 3,038,000
Net Benefits	$ 7,007,000	$ 8,029,000	$ 6,434,000
BC Ratio	3.3	3.6	3.1
Average Annual Cost (Offshore)	$ 3,402,000	$ 3,402,000	$ 3,402,000
Net Benefits	$ 6,643,000	$ 7,665,000	$ 6,070,000
BC Ratio	3.0	3.3	2.8

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