2019-2050 Bay Area Seaport Forecast

Prepared for
SF Bay Conservation and Development Commission

The Tioga Group ♦ Hackett Associates

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Overview

The *San Francisco Bay Area Seaport Plan* (Seaport Plan), prepared by the San Francisco Bay Conservation and Development Commission (BCDC), guides the development and use of the Bay Area's seaport land. The Seaport Plan focuses on the lands designated for "port priority use" in the *San Francisco Bay Plan*. The general goal of the Seaport Plan is to ensure that the Bay Area retains sufficient seaport capacity to serve its foreseeable waterborne cargo needs. The Seaport Plan covers five generic cargo types:

- Containerized cargo
- Roll-on/Roll-off (Ro-Ro) cargo (formerly classified as "neo-bulk")
- Dry bulk cargo
- Break-bulk cargo (not currently handled)
- Non-petroleum liquid bulk cargo

The composition of SF Bay Area cargo flows has changed over time, and will continue to shift in response to demand, trade conditions, and competitive alternatives. Exhibit 1 shows the commodities moving through Bay Area ports as of early 2019.

Exhibit 1: Current 2019 Bay Area Cargo Flows

Commodity	Seaport Plan Public Ports					Private Terminals	
	Oakland	Richmond	Benicia	Redwood City	San Francisco	Levin Richmond	Others
Containerized Imports	X	-	-	-	-	-	-
Containerized Exports	X	-	-	-	-	-	-
Containerized Domestic IB	X	-	-	-	-	-	-
Containerized Domestic OB	X	-	-	-	-	-	-
Import Autos	-	X	X	-	X	-	-
Export Autos	-	X	X	-	X	-	-
Export Scrap Metal	-	-	-	X	-	X(2)	X(1)
Import Veg Oils	-	X	-	-	-	-	-
Import Chemicals	-	-	-	-	-	-	X
Import Gypsum	-	-	-	X	-	-	X
Export Pet Coke	-	-	X	-	-	X	-
Export Coal	-	-	-	-	-	X	-
Import Sand & Gravel	-	-	-	X	X	X	X
Harvested Bay Sand	-	-	-	-	X	-	-
Import Slag	-	-	-	X	-	-	-
Import Bauxite	-	-	-	X	-	-	-

(1) Schnitzer Steel (2) From SIMS Richmond

This report provides 2050 forecasts for the relevant cargo types, and a high-level review of marine terminal capacity and expansion potential. Future cargo volumes through Bay Area seaports will be determined by economic activity in the Bay Area itself, and in the broader Central and Northern California market. Available near-term forecasts identified in this section share a common view that growth in California over the coming three to five years will be slower than in the pre-recession years, and that the West Coast economy in general will grow more slowly than in the rest of the nation. The limited number of long-term forecasts available tend to focus on population and expect steady growth over the long term, but again at a slower rate than previously seen in California.

Containerized Cargo

The previous containerized cargo forecasts prepared for BCDC were developed by Tioga in 2009 to assist BCDC in evaluating the proposed use of Richmond's Port Potrero site for Ro-Ro cargo rather than for containers. That forecast was prepared toward the end of the 2008-2009 recession, and reflected widespread expectations for a relatively strong recovery. Post-recovery trade growth deviated from those expectations, and cargo has grown more slowly than expected.

Container Cargo Forecast. The international TEU forecasts for imports and exports are driven by projections of economic growth developed by Moody's and Caltrans, including sub-components of national-level Gross Domestic Product, industrial output, and Gross Metro Product. The Moderate Growth scenario assumes that:

- Trade disputes are resolved, and most trade flows return to their recent growth patterns;
- Exporters affected by trade disputes either regain those former markets or find new markets;
- Long-term exports rebound as foreign markets recover economically;
- Refrigerated container trade grows due to the development of the recently completed CoolPort facility at the Port of Oakland; and
- Imports of automobile parts increase as Tesla increases production.

Exhibit 2 shows the elements of the Moderate Growth container cargo forecast. The Slow Growth and Strong Growth scenarios have alternative assumptions documented in the report. The empty TEU forecast is built upon the loaded TEU forecast and the relationship between empty containers and loaded container movements. Domestic container volumes between the Port of Oakland and Hawaii are more opaque, and likely are driven primarily by market share shifts rather than economic growth.

Exhibit 2: Bay Area Moderate Growth Containerized Cargo Forecast, 2010-2050

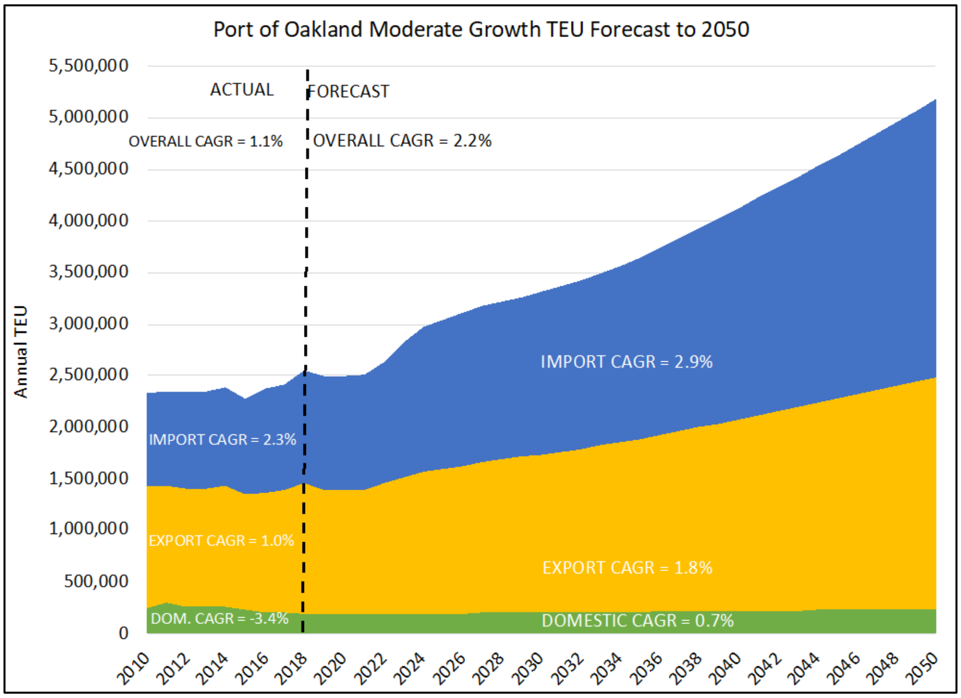
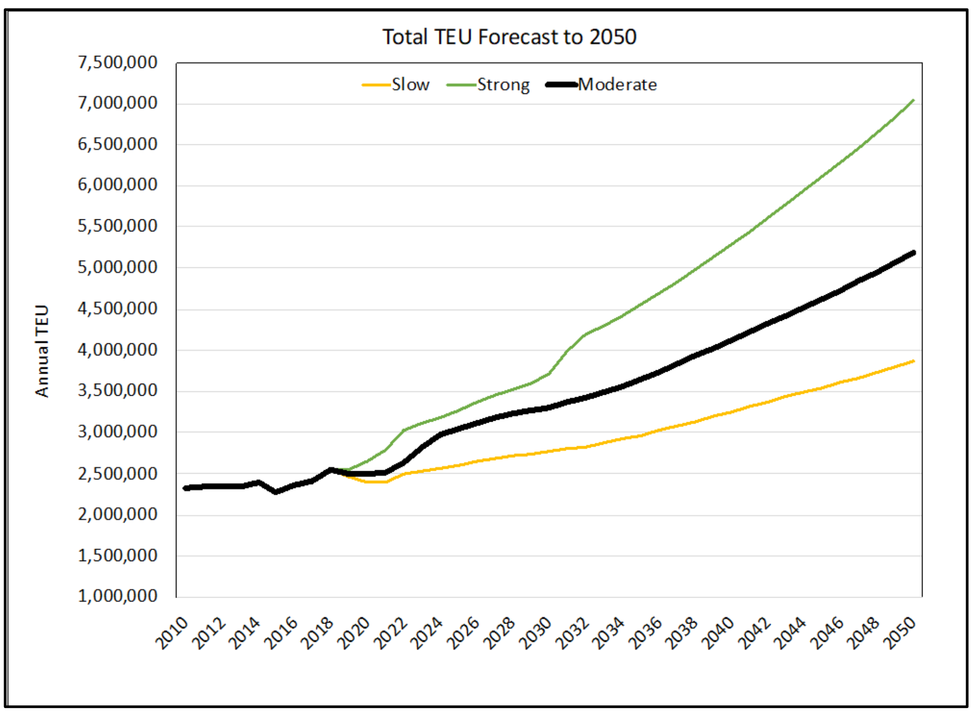


Exhibit 3 displays the three TEU forecast scenarios.

Exhibit 3: Total TEU Forecast to 2050



Container Terminal Capacity. Exhibit 4 shows the Port of Oakland's acreage in terminals and major off-dock parcels. The post-electrification acreages allow for a two-acre battery exchange complex or equivalent to support electrically powered, zero-emissions container handling equipment.

Exhibit 4: Port of Oakland Terminals and Acreages

Site	Acres	2019 Acres in Use	Potential Terminal Acres	Build-out Acres	Post-Electrification Acres
Ben Nutter	75	75	0	**95**	**93**
Berths 33-34	20	-	20		
OICT 55-56	120	120	0	**290**	**288**
OICT 57-59	170	170	0		
TraPac	123	123	0	**123**	**121**
Matson	75	75	0	**101**	**99**
Roundhouse	26	-	26		
Berths 20-21**	20	-	150	**150**	**148**
Berths 22-24	130	-			
Howard*	50	-	50	**40**	**38**
Subtotal	**809**	**563**	**246**	**799**	**787**
Off-Dock Staging***	30	30	0	0	0
Total	**839**	**593**	**246**	**799**	**787**

* Assumes 10 acres will be used for Inner Harbor Turning Basin
** 20 acres may become dry bulk terminal for 15 years (in negotiation)
**Not usable as long-term terminal space

The Port of Oakland container terminals currently average about 4,279 annual TEU per acre. The consultant team estimated maximum current capacity at 6,061 annual TEU per acre based on current OICT performance, and long-term sustainable capacity at 7,112 annual TEU per acre based on achieving high terminal productivity in line with industry benchmarks. The forecast thus allows for a 66% productivity increase over the present average throughput. Container terminals can be expected to expand horizontally where possible, and then invest in productivity improvements to accommodate further cargo growth.

Ancillary Service Needs. As of early 2019, there were approximately 314 acres of land in the immediate Port area either already in an ancillary use (e.g. CoolPort or the two cargo facilities on Union Pacific Land); under development for an ancillary use (e.g. CenterPoint Phase 1 or Prologis Buildings 2 and 3); or available for long-term ancillary use. Estimated acres required for all ancillary uses range from 167 in the Slow Growth scenario to 269 in the Strong Growth scenario. These comparisons suggest that there is adequate space within the Port of Oakland complex, including Port, City of Oakland, and Union Pacific land, for the identified ancillary services to support projected cargo growth in all three scenarios.

Container Cargo Growth vs. Terminal Capacity. Exhibit 5 shows that the Port of Oakland would be at or near capacity under the Moderate Growth forecast, and at estimated maximum terminal capacity under high productivity assumptions. The Port currently plans to use about 20 acres at Berths 20-21 for dry bulk cargo for the next 15 years. If that land is not returned to container cargo use, the Port would be at about 95% of capacity by 2050 under Moderate Growth assumptions. If Howard Terminal were unavailable for container cargo handling but Berths 20-21 were available, the Port would be at about 98% of capacity in 2050. If both Howard and Berths 20-21 were unavailable for container cargo use, the port would be slightly over capacity by 2050. The Slow Growth forecast would leave Oakland at 69%-75% of capacity by 2050, while the Strong Growth forecast would exceed the port's estimated maximum capacity by 26% to 36%.

Exhibit 5: Container Cargo Growth vs. Annual Terminal Capacity

Estimated Annual Sustainable TEU Capacity for:	Phase VI: High Productivity at all Terminals	2050 Moderate Growth TEU and Maximum Capacity Utilization		2050 Slow Growth TEU and Maximum Capacity Utilization		2050 Strong Growth TEU and Maximum Capacity Utilization	
All Potential Terminal Acres	5,597,348	5,187,588	93%	3,862,435	69%	7,038,560	126%
Potential Terminal Acres w/o Howard	5,312,858	5,187,588	98%	3,862,435	73%	7,038,560	132%
Potential Terminal Acres w/o Berths 20-21	5,455,103	5,187,588	95%	3,862,435	71%	7,038,560	129%
Potential Terminal Acres w/o Howard or Berths 20-21	5,170,613	5,187,588	100%	3,862,435	75%	7,038,560	136%

A more stringent requirement, capacity to handle the 8.4% average August monthly peaking, would lead to somewhat more serious or earlier shortfalls, as explained in the report body.

To facilitate comparisons between cargo types, Exhibit 6 shows terminal acres available and required under the maximum productivity assumption.

Exhibit 6: Container Cargo Growth and Acreage Requirements

Container Terminal Acres	2050 Acres Available*	Moderate Growth		Slow Growth		Strong Growth	
		Required	Reserve	Required	Reserve	Required	Reserve
All Potential Terminal Acres	787	729	58	543	244	990	(203)
Potential Terminal Acres w/o Howard	747	729	18	543	204	990	(243)
Potential Terminal Acres w/o Berths 20-21	767	729	38	543	224	990	(223)
Potential Terminal Acres w/o Howard or Berths 20-21	727	729	(2)	543	184	990	(263)

* Post-electrification

Berth Requirements. Container vessel size and the associated need for greater berth length are both increasing. The consultant team developed multiple scenarios for future vessel sizes and vessel calls, and checked their implications for berth length as an annual average and for the peak weekday (Exhibit 7). Utilization in excess of 65% would likely result in berth congestion at the terminal. The Port would exceed 70% peak day utilization under the Moderate Growth scenario based on the existing, active container berths, regardless of whether vessel size was limited to 14,000 TEU, to 25,000 TEU, or not limited at all. Limiting vessel size to 14,000 TEU would likely exceed the standard of 65% utilization in each of the three future berth availability alternatives under the moderate growth scenario. Limiting vessel size to 25,000 TEU or not restricting vessel size would likely exceed the standard of 65% utilization only in the most restrictive of the berth availability alternatives (i.e. without Berths 20-21 or Howard Terminal) under the Moderate Growth scenario.

Exhibit 7: Port of Oakland Forecast Berth Utilization on Peak Weekday

Berth Capacity				2050 Berth Required Peak* Daily Foot-Hours					
				Moderate Growth Case					
Berth Dimensions	Nominal Berths	Total Berth Feet	Daily Berth Foot-Hours	No Vessel Cap	Peak Ute.	14,000 TEU Cap	Peak Ute.	25,000 TEU Cap	Peak Ute.
Existing Terminal Berth Dimensions (feet)	14	21,484	365,832	265,165	72%	341,974	93%	268,267	73%
Future Terminal Berth Dimensions (feet) with Expanded Turning Basin	18	19,094	458,256	265,165	58%	341,974	**75%**	268,267	59%
Future Terminal Berth Dimensions (feet) with Turning Basin & Howard Dolphin	18	19,594	470,256	265,165	56%	341,974	**73%**	268,267	57%
Future Terminal Berth Dimensions (feet) with Turning Basin w/o Howard	16	16,007	384,168	265,165	**69%**	341,974	**89%**	268,267	**70%**

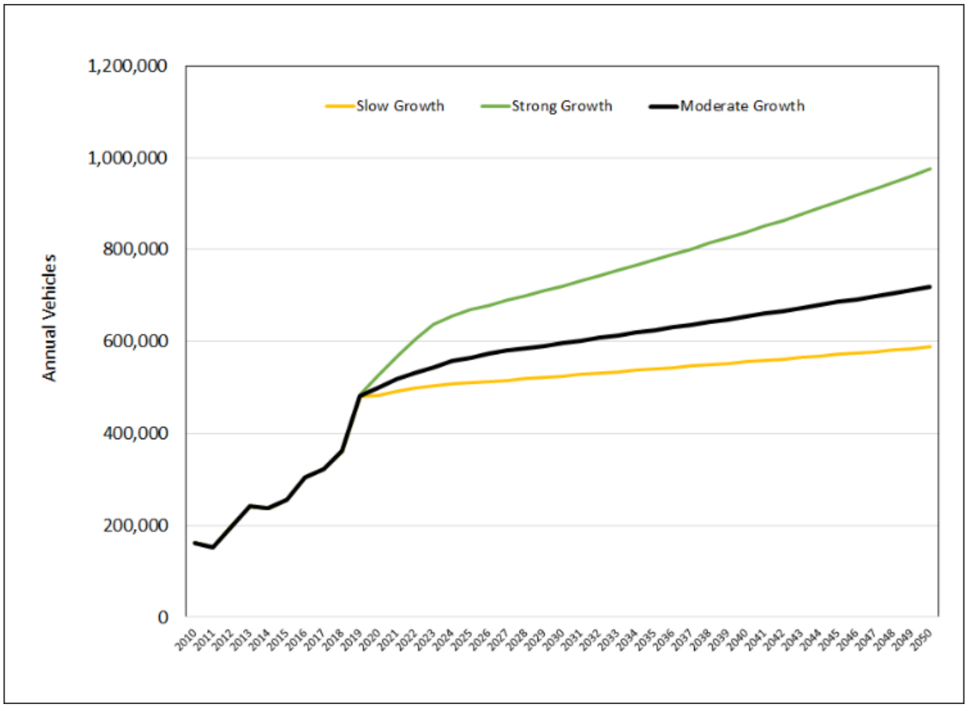
*Peak Utilization reflects 23% of weekly capacity at berth on Wednesday

Ro-Ro (Neo-Bulk) Cargo

The Seaport Plan has used the term "neo-bulk" to describe cargos that are neither containerized nor bulk, but do not require the traditional piece-by-piece handling of break-bulk cargo. Roll-on roll-off (Ro-Ro) shipment of autos and other vehicles has come to dominate this cargo segment, and is the only active "neo-bulk" category at SF Bay Area ports. The analysis therefore uses the "Ro-Ro" nomenclature for clarity and consistency with industry terminology.

The outlook for Ro-Ro cargo through San Francisco Bay depends on the growth in import and export auto volume, and on how many vehicles can be stored, processed, and moved through Bay Area facilities. The compound annual growth rate between 2018 and 2050 is projected to be 2.2 % in the Moderate Growth scenario, 1.5% in the Slow Growth scenario, and 3.2% in the Strong Growth scenario (Exhibit 8).

Exhibit 8: Ro-Ro Cargo Forecast to 2050



The Ports of Richmond, Benicia, and San Francisco are currently handling import and export autos in Ro-Ro vessels. Exhibit 9 shows that existing Ro-Ro terminals total about 215 acres, which compares closely to the estimate of 207 acres currently required under the team's base productivity estimates. This comparison is also consistent with the observations by port officials that the Richmond and Benicia terminals are operating at or near capacity at present.

Exhibit 9: Bay Area Ro-Ro Terminals and Scenario Capacities

Terminal	Acres	Low Capacity	Base Case Capacity	High Capacity
Weighted Annual Units per Acre		**1,444**	**1,976**	**2,903**
Existing	**215**	**310,465**	**424,875**	**624,178**
Benicia	75	108,302	148,212	217,737
Richmond Port Potrero	80	115,522	158,093	232,252
SF Pier 80	60	86,641	118,570	174,189
Potential	**162**	**233,932**	**320,138**	**470,311**
SF Pier 96 & Other	67	96,750	132,403	194,511
Richmond T-3	20	28,880	39,523	58,063
Benicia Short-Term Lease	35	50,541	69,166	101,610
Oakland Howard Terminal*	40	57,761	79,046	116,126
Total	**357**	**544,397**	**745,013**	**1,094,489**

*Assumes turning basin widening

The table in Exhibit 10 displays the combined Ro-Ro forecast and capacity analysis. Nine scenario combinations are presented. The Moderate Growth forecast and base case productivity scenario together suggest that 375 acres of Ro-Ro terminal space would be required to handle 718,863 vehicles in 2050, and about 160 additional acres of Ro-Ro terminal space would be needed. The Slow Growth scenario would require about 98 additional acres with base case productivity. The Strong Growth forecast would require 281 acres of additional space under the base case productivity, or 148 additional acres with higher productivity.

Exhibit 10: Ro-Ro Cargo Summary

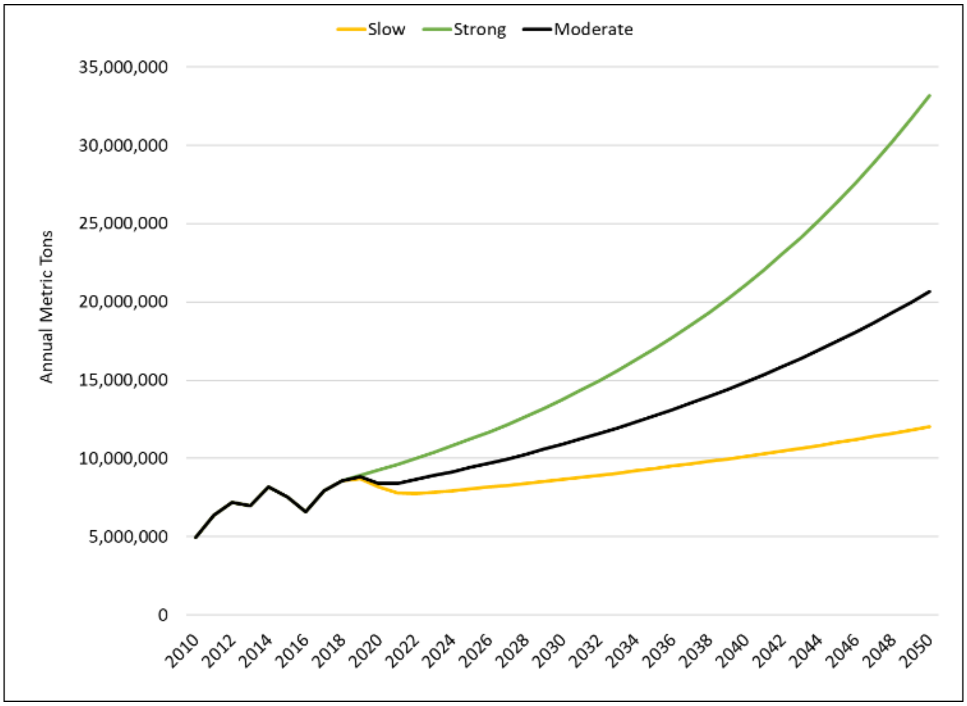
Combined Scenarios		2018	2020	2030	2040	2050	CAGR	Existing Acres	New Acres	Available	% Used
Slow Growth		**360,671**	**483,345**	**524,940**	**555,546**	**587,949**	**1.5%**				
Low Prod. Acre s	L/L	207	270	365	387	409	2.1%	215	194	377	109%
Base Prod. Acres	L/B	207	258	279	296	**313**	1.3%	215	98	377	83%
High Prod. Acres	L/H	207	246	209	221	234	0.4%	215	19	377	62%
Moderate Growth		**360,671**	**500,252**	**596,110**	**654,616**	**718,863**	**2.2%**				
Low Prod. Acres	B/L	207	278	411	452	496	2.8%	215	281	377	132%
Base Prod. Acres	**B/B**	**207**	**266**	**311**	**341**	**375**	**1.9%**	**215**	**160**	**377**	**99%**
High Prod. Acres	B/H	207	253	230	253	278	0.9%	215	63	377	74%
Strong Growth		**360,671**	**526,081**	**721,128**	**838,446**	**974,850**	**3.2%**				
Low Prod. Acres	H/L	207	290	492	572	665	3.7%	215	450	377	176%
Base Prod. Acres	H/B	207	277	367	427	**496**	2.8%	215	281	377	132%
High Prod. Acres	H/H	207	263	268	312	363	1.8%	215	148	377	96%

Dry Bulk Cargo

The dry bulk imports handled through Bay Area ports have long been dominated by construction industry needs. The major commodities have included, and continue to include, aggregates (sand and gravel), bauxite and slag (used as concrete additives), and gypsum (used in wallboard). Outbound dry bulk cargos include scrap metal, petroleum coke (pet coke, a refinery by-product), and coal.

Dry Bulk Forecast. Exhibit 11 displays the combined tonnage forecast for dry bulk commodities, including imports, exports, and harvested bay sand. The main drivers are growing demand for sand and gravel and a dwindling regional supply, leading to increased imports.

Exhibit 11: Bay Area Total Dry Bulk Cargo Forecast, 2010-2050



Dry Bulk Capacity. The current (2012) Bay Area Seaport Plan includes a dry bulk terminal size benchmark of 13 acres, with one berth for a dry bulk terminal and an average throughput capability of 1,037,000 metric tons per berth. As Exhibit 12 shows, Bay Area dry bulk terminals in 2018 average about 50,256 annual metric tons per acre and 696,460 metric tons per berth. The productivity forecast considers a spectrum of efficiency improvements that increase the number of metric tons handled per acre at varying rates by scenario, either by gradually introducing denser storage or by moving the product through the terminal and out to the customer faster. combines these productivity scenarios to estimate terminal requirements under Moderate, Slow, and Strong Growth forecasts. The Moderate Growth scenario anticipates an average of 113,379 annual metric tons per acre, a bit more than double the current average and in line with new terminal proposals. Moderate Growth would likely require the equivalent of 30 additional acres and 1 additional berth to handle the expected volume.

Exhibit 12: Bay Area Estimated Dry Bulk Terminal Requirements for 2050

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	8,575,119	**20,654,319**	12,025,443	33,183,607
Tonnage increase	na	**139%**	44%	274%
MT/Acre	56,452	**113,379**	79,167	146,295
Increase over 2018	na	**101%**	40%	159%
Acres	**152**	**182**	**152**	**227**
Additional Acres	na	**30**	**-**	**75**
Terminals	**12**	**13**	**12**	**15**
Berths	**12**	**13**	**12**	**15**
Additional Berths	na	**1**	**(0)**	**3**

Other Cargo Types

Bay Area Seaport facilities at Richmond continue to handle some non-refinery liquid bulk cargo, including imported vegetable oils and chemicals. These are single-purpose terminals, however, and most are under private ownership. Cargo movements may rise or fall on a commodity-by-commodity basis without strong long-term trends. Accordingly, the consultant did not analyze these flows or terminals in detail.

Some Bay Area seaport terminals previously handled break-bulk or project cargo. None handle such cargoes at present, and there is no specific projection for future demand. As the need for break-bulk or project cargo shipments (e.g. windmill parts) could arise in the future, there may be a purpose in maintaining break-bulk capability for the Bay Area, perhaps within container or Ro-Ro terminals.

Summary Findings

The Bay Area's seaports can expect long-term cargo growth in three sectors that could stress capacity: containerized cargo, Ro-Ro vehicle cargo, and import dry bulk cargo. There are three basic strategies for accommodating the expected growth: increased throughput at existing facilities; horizontal expansion onto vacant land or land in other uses within seaport complexes; and use of dormant marine terminals.

Increased throughput at existing terminals is generally the least costly, most efficient, and least disruptive means of accommodating growth. Terminal operators can be expected to expand throughput to the point at which the terminal becomes congested or when substantial capital investment is needed to increase capacity. At that point, economic and financial tradeoffs will determine the preferred expansion path. Horizontal expansion onto available seaport land is often less costly and easier to implement than expansion via capital investment on existing footprints.

Exhibit 13 provides estimates of total seaport terminal acreage requirements under the three forecast scenarios. There are many possible variations. The three cargo types will not necessarily follow similar growth scenarios, although all will be affected by the same underlying regional economic growth trends. Also, different terminals may follow different productivity strategies. The general implication of Exhibit 13, however, is clear:

- Under moderate cargo growth assumptions, the Bay Area will need more active terminal space, estimated at about 327 acres by 2050.

- Under slow cargo growth assumptions, the Bay Area will need about 98 acres more active terminal space by 2050.
- Under strong growth assumptions across the three cargo types, the Bay Area will need substantially more seaport terminal space, about 753 more acres than is now active (and will need to activate additional berth space for larger container vessels).

Exhibit 13: Estimated Seaport Acreage Requirements

Forecast Scenario	Container Cargo Terminal Acres			Ro-Ro Cargo Terminal Acres			Dry Bulk Cargo Terminal Acres			Combined Cargo Terminal Acres		
	Existing*	2050**	Additional	Existing	2050***	Additional	Existing	2050***	Additional	Existing	2050	Additional
Moderate Growth	**593**	**729**	**136**	**215**	**375**	**160**	**152**	**182**	**30**	**960**	**1,286**	**327**
Slow Growth	593	543	-	215	313	98	152	152	-	**960**	**1,008**	**98**
Strong Growth	593	990	397	215	496	281	152	227	75	**960**	**1,712**	**753**

* In-use acreage at Port of Oakland
** At high productivity Phase VI
***Under base productivity assumptions

Available Terminal Expansion Sites

Within the Bay Area seaports there are a few dormant or under-utilized terminal sites.

- San Francisco's Pier 96, formerly part of the Pier 94-96 container terminal, is currently partially vacant and partially in non-cargo uses. There is also usable land between Pier 92 and Pier 94.
- Oakland's Berth 20-21 area is used for ancillary services at present, although there is an active proposal to develop a dry bulk terminal there.
- Oakland's Berth 22-24 area, formerly part of the Ports America complex, is currently used for ancillary port functions.
- Oakland's Berth 33-34 area, between the Ben E. Nutter and TraPac terminals, is currently used for ancillary port functions.
- Oakland's Howard Terminal is also currently used for ancillary services.
- Oakland's Roundhouse parcel, although not on the water, is adjacent to active container terminals.
- Benicia has an estimated 35 acres under short-term lease for non-cargo uses that could be added to Ro-Ro terminal capacity.
- Richmond's Terminal 3, formerly a small container terminal, is currently being used to load logs into containers for export through Oakland, but is not handling any cargo over the wharf.

Exhibit 14 lists these sites, their size, and their potential uses. The table also illustrates some inherent tradeoffs.

Exhibit 14: Bay Area Seaport Expansion Sites

Site	Acres	Potential Use		
		Container	Ro-Ro	Dry Bulk
SF Pier 96 & Other	67	-	X	X
Oakland Berths 20-21	20	X	-	X
Oakland Berths 22-24	130	X	-	-
Oakland Berths 33-34	20	X	-	-
Oakland Roundhouse	26	X	-	-
Oakland Howard*	38	X	X	X
Benicia Short-Term Lease	35	-	X	-
Richmond Terminal 3	20	-	X	X
Available Acres	**356**	**176-234**	**35-162**	**0-147**
Moderate Growth Needs	**327**	**136**	**160**	**30**
Slow Growth Needs	98	0	98	0
Strong Growth Needs	753	397	281	75

* Post turning basin expansion: 38 acres container, 40 acres Ro-Ro or dry bulk

- San Francisco's Pier 96 was most recently used to handle containers. Its limited draft, however, would make it less suitable for container handling than the Oakland locations. Moreover, the container shipping industry previously consolidated at the Oakland terminals, and an isolated terminal across the Bay at San Francisco is unlikely to be attractive to container shipping lines in the future. Pier 96 also lacks access to active rail intermodal facilities. Trucks connecting Pier 96 with inland customers would add to congestion on the bay bridges. Pier 96 and adjacent land would therefore most likely be suitable for Ro-Ro or dry bulk cargos.
- Oakland's Berth 22-24 site is expected to be used for container cargo in the long run. The consultant team's analysis suggests that the Berth 22–24 capacity will be required under any container forecast scenario, and there have been no proposals to use this space for other cargos.
- Oakland's Berths 20-21 may be used for dry bulk cargo, either as an interim use or in the long term. If so, available container berth space would be reduced as well, increasing the need to either boost productivity or expand container operations to Howard Terminal.
- Oakland's Roundhouse site has no berth access, and can only function as added backland space for adjacent container terminals.
- Oakland's Howard Terminal capacity may be required for container handling under the forecast scenarios, depending on what degree of other productivity improvement is implemented at other terminals. In addition to its terminal acreage, Howard's berth capacity may be required to handle larger vessels or additional services under a Strong Growth scenario, particularly if Berths 20-21 are used for dry bulk cargo. Howard Terminal may also be a logical expansion site for Ro-Ro vehicle handling. Howard could also handle dry bulk cargo under some circumstances, and Schnitzer Steel has expressed interest in using a portion of Howard to expand its adjacent operations.
- Richmond's Terminal 3 has limited space, as the terminal totals about 20 acres. With such limited backland, 35' of draft, and isolation from the Oakland terminals, T3 is not a viable location for container handling. T3 would most likely serve as auxiliary parking for the Pt. Potrero Ro-Ro terminal. It could also handle dry bulk or break-bulk cargos.

- As Exhibit 13 indicates, moderate container cargo growth through 2050 could probably be handled at Oakland without Howard Terminal, but as Exhibit 5 shows, Oakland would have little or no room for future growth. Strong container cargo growth would exhaust Oakland's total capacity unless terminals can boost productivity to higher levels than anticipated.
- Dry cargo growth may conflict with the availability of SF Pier 96, Oakland's Berth 20-21, or Howard Terminal for Ro-Ro or container cargo.

Overall, utilizing most or all of Pier 96 and Howard Terminal would probably be required for sufficient capacity under the Moderate Growth scenario. The Bay Area should have sufficient capacity in the Slow Growth Scenario through 2050. Available space would be insufficient under the Strong Growth scenario even if all available terminals were utilized.

1. Introduction

Background

The *San Francisco Bay Area Seaport Plan*, prepared by the San Francisco Bay Conservation and Development Commission (BCDC), guides the development and use of the Bay Area's seaport land. The Seaport Plan focusses on the lands designated as "port priority use". The Seaport Planning Advisory Committee (SPAC), composed of industry and planning agency representatives, oversees Seaport Plan development and updates.

The general goal of the Seaport Plan is to ensure that the Bay Area retains sufficient seaport capacity to serve its foreseeable waterborne cargo needs. To do so, the Seaport Plan must be periodically updated to reflect the best available information on expected cargo growth and marine terminal capacities. Waterfront land is a finite resource, and selected portions have been designated for port priority use. Most of that designated land is already being used to handle waterborne cargo, and there are only a few sites idle or developable to handle cargo growth.

The Seaport Plan covers five generic cargo types:

- Containerized cargo.
- Roll-on/Roll-off (Ro-Ro) cargo (formerly classified as "neo-bulk").
- Dry bulk cargo.
- Break-bulk cargo (not currently handled).
- Non-refinery liquid bulk cargo

Applicable liquid bulk cargos consist primarily of chemicals and other commodities handled at specialized port and private marine terminals. Crude petroleum and petroleum products handled at refineries are outside the Seaport Plan scope.

The container cargo forecast and terminal capacity estimates were last updated in 2009, and the bulk cargo forecast was last updated in 2011. While some of the trends documented in those updates have continued, there have since been numerous shifts in both economic development and trade conditions.

This report provides 2050 forecasts for the relevant cargo types, and a high-level review of marine terminal capacity and expansion potential. The approach taken was cargo-specific and commodity-specific, as opposed to applying a high-level econometric forecast across types. Bay Area seaports handle containerized cargo and just a few other commodities, and these flows respond to a variety of outside factors. This report also examines the need for ancillary services to support the full functionality of container terminals, and the land requirements of those services.

Current Cargo Flows

The composition of SF Bay Area cargo flows has changed over time, and will continue to shift in response to demand, trade conditions, and competitive alternatives. Exhibit 15 shows the commodities moving through Bay Area ports as of early 2019.

Exhibit 15: Current 2019 Bay Area Cargo Flows

Commodity	Seaport Plan Public Ports					Private Terminals	
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Containerized Imports	X	-	-	-	-	-	-
Containerized Exports	X	-	-	-	-	-	-
Containerized Domestic IB	X	-	-	-	-	-	-
Containerized Domestic OB	X	-	-	-	-	-	-
Import Autos	-	X	X	-	X	-	-
Export Autos	-	X	X	-	X	-	-
Export Scrap Metal	-	-	-	X	-	X(2)	X(1)
Import Veg Oils	-	X	-	-	-	-	-
Import Chemicals	-	-	-	-	-	-	X
Import Gypsum	-	-	-	X	-	-	X
Export Pet Coke	-	-	X	-	-	X	-
Export Coal	-	-	-	-	-	X	-
Import Sand & Gravel	-	-	-	X	X	X	X
Harvested Bay Sand	-	-	-	-	X	-	-
Import Slag	-	-	-	X	-	-	-
Import Bauxite	-	-	-	X	-	-	-

(1) Schnitzer Steel (2) From SIMS Richmond

- The Port of Oakland itself handles containerized cargo almost exclusively. The exception is a small volume of non-containerized autos handled by Matson.
- Schnitzer Steel, a private terminal within the Oakland Harbor but not part of the Port of Oakland, exports scrap metal in bulk.
- The Port of Richmond handles autos in Ro-Ro service at its Point Potrero terminal and vegetable oil imports at the AAK terminal. The Port's Terminal 3 is being used to stage and containerize logs that are then exported through the Port of Oakland.
- The Benicia Port Terminal Company (BPTC), at Benicia, handles autos and trucks in Ro-Ro service (predominantly imports). BPTC is developing a supplementary terminal at Pittsburg, beyond the Seaport Plan scope. BPTC also exports petroleum coke in bulk from a nearby refinery.
- The Port of Redwood City is currently exporting scrap metal in bulk and importing sand and gravel, slag, bauxite, and gypsum in bulk.
- The Port of San Francisco is currently handling autos in Ro-Ro service (primarily Tesla exports) at Pier 80, import aggregates at Pier 94, and harvested bay sand at two locations.
- Levin Richmond Terminal (LRT) is a private multi-purpose port facility adjacent to the Port of Richmond. LRT has handled multiple commodities in the past and is currently handling export coal and petroleum coke. LRT also handles scrap metal exports from the adjacent Sims site.

- There are private terminals handling aggregates (Eagle Rock), gypsum (National Gypsum), and chemicals at Richmond.
- Sand “harvested” (dredged) from the bay floor is not a “cargo” in the usual sense. Bay sand does, however, occupy port facilities, and if bay sand production declines it may be necessary to increase sand imports.
- There are multiple refineries handling liquid bulk petroleum products in the Bay Area. Those terminals and commodities, however, are excluded from the Seaport Plan.

The narrowing range of cargoes and cargo types being handled at SF Bay Area ports allowed the consultant team to focus on the following demand factors:

- For international containerized trade: regional demand for imports and foreign demand for California exports.
- For domestic containerized cargo: the future of shipments to and from Hawaii, Guam, etc. and Oakland’s market share.
- Ro-Ro autos: U.S. demand for imports and foreign demand for U.S. production, specifically Teslas.
- For export dry bulks: foreign demand for scrap metal, and local refinery production of petroleum coke.
- For import dry bulks: Northern California construction activity and local supply of sand and gravel.

2. Relevant Economic and Trade Trends

Economic Trends

Future volume through Bay Area seaports will be determined by economic activity in the Bay Area itself, and in the broader Central and Northern California market. Some exports move through Oakland from Oregon and Nevada, and occasionally beyond. Some import flows extend from California distribution centers (DCs) to markets in other Western states, and some import containers cross the Nevada border to distribution centers in Sparks.

The primary focus of this analysis is therefore the Bay Area and Northern and Central California, but the team's analysis must also take the overall western state context into account.

Near-term Forecasts

The forecasts identified in this section share a common view that growth in California over the coming three to five years will be slower than before the recession, and that the West Coast in general will grow at a slower pace than the rest of the nation (Exhibit 16).

Exhibit 16: Near-Term Forecast Summaries

Forecast	Outlook
Governor's Budget	California growth is projected to be steady, but at a slower pace than was typical of the pre-recession years
ComericA Bank State Economic Outlook	California growth is forecast to be steady at moderate rates, although there are increased downside risks in the near term
UCLA Anderson Forecast	Statewide outlook for slower economic growth in 2019 and in coming years
Center for Business and Policy Research at the University of the Pacific Eberhardt School of Business, 2019-2022 California & Metro Forecast	Real gross state product is forecast to grow at a reduced pace as recession risks grow
City of San Jose Economic Forecast	San Jose development outlook is increasing in 2019 to 2023
Wells Fargo Western Economic Outlook	West Coast outlook remains bright but growth is anticipated to moderate relative to the rest of the country
Bank of the West California Economic Outlook	California job growth peaked in 2015 and slower growth is expected to continue through 2020 due to weaker global growth and tighter financial conditions. Bay Area job growth is held down by the low unemployment rate, meaning that fewer unemployed workers are available to fill new jobs.

Most available forecasts of economic activity cover only 1–4 years out. The value of these forecasts is establishing that no near-term changes from existing patterns are expected.

Governor's Budget Summary — 2019-20 Economic Outlook

The Governor’s Budget Summary includes a section on the economic outlook. The indicators in Exhibit 17 compare the U.S. and California outlooks through 2022. The state forecast indicates that, from 2017 to 2022:

- Personal income will grow by 25.7% (compared to growth of 24.6% at the national level).
- Annual housing permits will increase by 55% (perhaps linked to an aggressive affordable housing policy).
- The civilian labor force will grow by 3.6% (compared to growth of 4.5% at the national level).

These projections are consistent with an overall picture of steady, but slower growth than was typical of the pre-recession years.

Exhibit 17: Governor's Budget Summary - Selected Indicators

	ACTUAL		FORECAST				
United States	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Nominal gross domestic product, $ billions	$18,707	$19,485	$20,504	$21,555	$22,537	$23,472	$24,420
Real gross domestic product, percent change	1.6%	2.2%	2.9%	2.7%	2.1%	1.6%	1.5%
Contributions to real GDP growth							
Personal consumption expenditures	1.9%	1.7%	1.8%	1.9%	1.6%	1.5%	1.3%
Gross private domestic investment	-0.2%	0.8%	1.0%	0.9%	0.6%	0.4%	0.3%
Net exports	-0.3%	-0.3%	-0.2%	-0.5%	-0.3%	-0.3%	-0.2%
Government purchases of goods and services	0.3%	0.0%	0.3%	0.5%	0.2%	0.0%	0.0%
Personal income, $ billions	$16,125	$16,831	$17,585	$18,378	$19,284	$20,131	$20,974
Corporate profits, percent change	-0.2%	2.4%	0.0%	6.8%	2.3%	3.2%	3.2%
Housing permits, thousands	1,207	1,282	-	-	-	-	-
Housing starts, thousands	1,177	1,208	1,263	1,318	1,424	1,435	1,437
Median sales price of existing homes	$235,500	$248,800	-	-	-	-	-
Federal funds rate, percent	0.4%	1.0%	1.8%	2.8%	3.4%	3.4%	3.4%
Consumer price index, percent change	1.3%	2.1%	2.5%	2.5%	2.0%	2.1%	2.1%
Unemployment rate, Percent	4.9%	4.4%	3.9%	2.4%	3.4%	3.6%	3.8%
Civilian labor force, millions	159.2	160.3	162.0	163.5	165.3	166.4	167.5
Nonfarm employment, millions	144.3	146.6	149.0	151.3	153.0	153.8	154.5
California							
Personal Income, $ billions	$2,259	$2,364	$2,494	$2,619	$2,740	$2,857	2,972.0
California exports, percent change	-1.2%	5.2%	-	-	-	-	-
Housing permits, thousands	101.0	114.0	125.0	139.0	154.0	166.0	177.0
Housing unit net change, thousands	89.0	85.0	-	-	-	-	-
Median sales price of existing homes	$502,930	$537,860	-	-	-	-	-
Consumer price index, percent change	2.3%	2.9%	3.7%	3.7%	3.2%	3.0%	2.8%
Unemployment rate, percent	5.5%	4.8%	4.3%	4.3%	4.3%	4.3%	4.3%
Civilian labor force, millions	19.1	19.3	19.5	19.6	19.8	19.9	20.0
Nonfarm employment, millions	16.5	16.8	17.2	17.4	17.5	17.7	17.8
Percent of total nonfarm employment							
Mining and logging	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Construction	4.7%	4.8%	5.0%	5.3%	5.6%	5.9%	6.2%
Manufacturing	8.0%	7.8%	7.7%	7.6%	7.5%	7.5%	7.4%
Trade, transportation, and utilities	18.1%	18.1%	17.9%	17.8%	17.7%	17.7%	17.6%
Information	3.2%	3.2%	3.2%	3.2%	3.2%	3.2%	3.1%
Financial activities	5.0%	5.0%	4.9%	4.9%	4.9%	4.9%	4.9%
Professional and business services	15.3%	15.3%	15.4%	15.4%	15.4%	15.3%	15.2%
Educational and health services	15.4%	15.7%	15.8%	15.8%	15.8%	15.9%	16.0%
Leisure and hospitality	11.5%	11.6%	11.5%	11.5%	11.5%	11.5%	11.4%
Other services	3.4%	3.4%	3.3%	3.3%	3.3%	3.3%	3.3%
Government	15.3%	15.2%	15.0%	15.0%	14.9%	14.8%	14.8%

Forecast based on data available as of November 2018.
Percent changes calculated from unrounded data.

ComericA Bank State Economic Outlook

This forecast expects the California economy to continue expanding in the near term. The forecast notes increased downside risks, and that there are fewer possible accelerators. A resolution to the U.S./China trade dispute would boost demand for California exports and increase shipping volumes through California ports. Job growth is expected to be moderate. Recent declines in mortgage rates and moderating house price growth across California's major metropolitan areas are expected to help affordability in the short term. Exhibit 18 summarizes the forecast through 1Q20. Here too, the picture is of steady growth at moderate rates.

Exhibit 18: ComericA California Outlook

		Actual		Forecast						Actual	Forecast	
		2Q'18	3Q'18	4Q'18	1Q'19	2Q'19	3Q'19	4Q'19	1Q'20	2017	2018	2019
State GDP	Real GDP (Chained 2009 Millions $)	2,652,488	2,678,432	2,702,426	2,721,884	2,740,193	2,755,797	2,767,719	2,778,408	2,576,223	2,665,519	2,746,398
	Percent Change Annualized	**3.7**	**4.0**	**3.6**	**2.9**	**2.7**	**2.3**	**1.7**	**1.6**	**3.0**	**3.5**	**3.0**
Labor and Demographics	Payroll Jobs (Thousands)	17,096	17,179	17,262	17,343	17,411	17,478	17,538	17,597	16,819	17,148	17,443
	Percent Change Annualized	**1.0**	**2.0**	**2.0**	**1.9**	**1.6**	**1.5**	**1.4**	**1.3**	**2.1**	**2.0**	**1.7**
	Unemployment Rate (Percent)	4.2	4.2	4.1	3.9	3.8	3.7	3.6	3.5	4.8	4.2	3.7
	Population (Thousands)	39,557	39,605	39,656	39,708	39,762	39,815	39,866	39,917	39,419	39,584	39,788
	Percent Change Annualized	**0.4**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**	**0.4**	**0.5**
	Net Migration (Thousands)	-9.7	-9.4	-9.5	-8.1	-8.5	-8.4	-8.6	-9.2	-31.7	-38.5	-33.7
Personal Income	Total Personal Income (Nom., Millions $)	2,465,197	2,490,789	2,521,959	2,548,972	2,578,814	2,610,955	2,642,783	2,674,075	2,364,129	2,477,807	2,595,381
	Percent Change Annualized	**5.4**	**4.2**	**5.1**	**4.4**	**4.8**	**5.1**	**5.0**	**4.8**	**4.6**	**4.8**	**4.7**
Housing	Housing Starts (Total, Ann. Rate)	117,929	111,259	109,821	110,926	111,385	111,604	111,987	112,157	103,335	117,322	111,475
	Percent Change Annualized	**-32.9**	**-20.8**	**-5.1**	**4.1**	**1.7**	**0.8**	**1.4**	**0.6**	**8.2**	**13.5**	**-5.0**
	SF Housing Starts (# of Units, Ann Rate)	66,312	66,006	64,470	65,410	65,766	65,943	66,180	66,312	59,131	67,233	65,825
	MF Housing Starts (# of Units, Ann Rate)	51,617	45,253	45,351	45,516	45,620	45,661	45,807	45,845	44,204	50,089	45,651
	Existing Home Sales (000 Units/yr)	453	429	427	429	431	432	433	433	473	444	431
	House Prices, FHFA (1991 Q1=100, SA)	281	284	287	290	293	296	299	302	263	282	295
	Year/Year Percent Change	**7.5**	**6.5**	**5.7**	**4.3**	**4.6**	**4.5**	**4.2**	**4.1**	**8.2**	**7.2**	**4.4**
Bankruptcies	Total Business (12 Months Ending)	2,828	2,819	2,813	2,728	2,698	2,656	2,636	2,619	2,974	2,860	2,680
	Total Personal (12 Months Ending)	66,624	66,041	65,855	65,328	63,664	62,729	61,936	61,450	69,956	66,437	63,414

UCLA Anderson Forecast

The economic forecast for the United States (and specifically California) prepared by the UCLA Anderson project predicts slower economic growth in 2019 and in coming years.

> *"In his outlook for the national economy, UCLA Anderson Senior Economist David Shulman says that 'growth will gradually taper off in all of the major sectors of the economy.' While consumer spending has been strong, peaking at 4% in the second quarter, it is expected to decrease to 2% by the fourth quarter of 2019 and to 1.5% by the fourth quarter of 2020."*
>
> *"In his latest essay, UCLA Anderson Forecast Director Jerry Nickelsburg says that the California forecasts for 2018 and 2019 have not changed much from the June 2018 outlook. He anticipates that California's economy in 2020 will be slightly weaker, compliments of changes in fiscal policy that also will affect the national outlook. While the state's economy has been evolving as expected, the risk of a trade war with China remains a concern, as it could adversely affect the logistics industry, one of the fastest growing sectors in California this past year."*

Center for Business and Policy Research at the University of the Pacific Eberhardt School of Business, 2019-2022 California & Metro Forecast, February 2019

This forecast covers both California as a whole and selected metro areas.

- Overall, real gross state product is forecast to grow at 2.9%, and drop below 2% growth by 2021 as recession risks grow.
- A slight slowdown in construction job growth is expected in 2019, about 30,000 new jobs compared to as much as 50,000 in recent years. Job growth may be limited by worker availability and limited new residential construction in 2019. Single family housing starts are projected at 66,000 in 2019, about the same as 2018. Multi-family starts are also projected to be flat in 2019 between 45,000 and 50,000 new units. After 2019, total new housing starts gradually grow another 10% and stabilize at 125,000 per year.
- California's population growth is projected at about 0.5% for the next several years, at or near a record Slow Growth rate. California's population is still on track to reach 40 million this year prior to the 2020 census, and should add about 200,000 new residents per year.

As Exhibit 19 shows, the Central Valley economy is expected to grow somewhat faster than in the Bay Area. One reason is that current unemployment rates are higher in the Central Valley, implying a large margin for employment growth.

Exhibit 19: 2019-2022 Metro Area Forecast Summaries

Central Valley Metro Forecast Summary

Metro Area	Non-Farm Payroll Employment (% Change)					Unemployment Rate (%)				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
Sacramento	2.1	2.0	2.4	2.0	1.2	4.5	3.7	3.5	3.4	3.6
Stockton	3.9	3.2	2.1	1.3	1.2	7.0	6.0	5.6	5.5	5.7
Modesto	1.7	2.0	1.5	1.1	0.7	7.5	6.3	6.1	6.2	6.4
Merced	3.3	3.5	1.9	1.7	1.4	9.3	8.1	7.7	7.8	8.1
Fresno	2.6	2.8	1.9	1.1	0.6	8.5	7.3	6.8	6.8	7.0
California	**2.1**	**1.9**	**1.5**	**1.3**	**0.7**	**4.8**	**4.2**	**4.0**	**4.0**	**4.2**

Note: Sacramento MSA includes Sacramento, El Dorado, Placer, and Yolo Counties. Stockton, Merced, Fresno, and Modesto MSAs correspond to San Joaquin, Merced, Fresno, and Stanislaus Counties

Bay Area Metro Forecast Summary

Metro Area	Non-Farm Payroll Employment (% Change)					Unemployment Rate (%)				
	2017	2018	2019	2020	2021	2017	2018	2019	2020	2021
San Francisco	2.2	1.9	2.3	2.0	0.8	2.8	2.3	2.2	2.1	2.1
San Jose	2.5	3.1	2.3	1.6	1.1	3.3	2.6	2.5	2.4	2.4
Oakland	2.3	1.9	1.3	1.2	0.8	3.7	3.1	3.0	3.1	3.2
California	**2.1**	**1.9**	**1.5**	**1.3**	**0.7**	**4.8**	**4.2**	**4.0**	**4.0**	**4.2**

Note: San Francisco MSA includes San Francisco and San Mateo Counties. Oakland MSA includes Contra Costa and Alameda Counties. San Jose MSA includes Santa Clara and San Benito Counties.

Exhibit 20 shows the state-level summary, calling for:

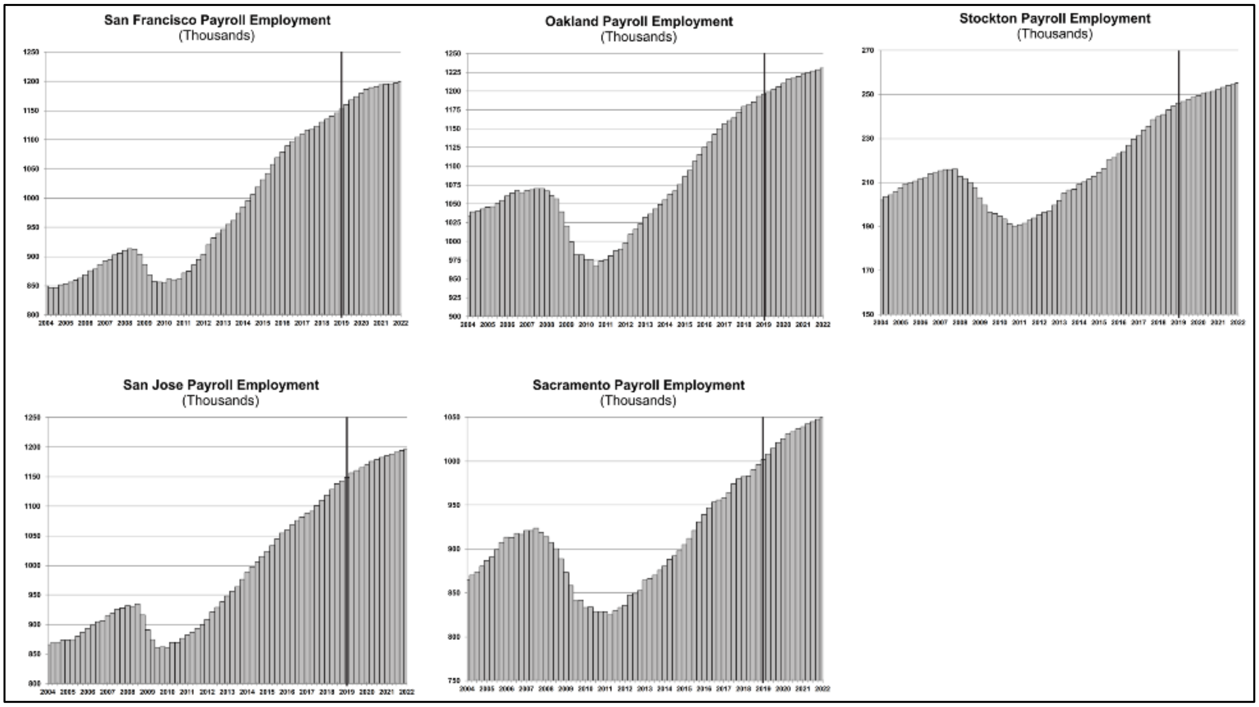
- Tapering GSP growth rates in 2020–2022.
- A gradual increase in the labor force.
- Increasing housing starts.
- Steady new vehicle registrations.

Exhibit 20: 2019-2022 California & Metro State Forecast

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Personal Income and Gross State Product												
Personal Income (Bil. $)	1,738	1,854	1,886	2,022	2,173	2,259	2,364	2,468	2,583	2,720	2,848	2,974
Calif. (%Ch)	6.8	6.6	1.8	7.2	7.5	4	4.6	4.4	4.6	5.3	4.7	4.4
Gross State Product (Bil. $)	2,050	2,145	2,263	2,397	2,557	2,665	2,798	2,952	3,108	3,259	3,394	3,521
Calif. (%Ch)	3.8	4.6	5.5	5.9	6.7	4.2	5	5.5	5.3	4.9	4.2	3.7
Real GSP (Bil. 2009$)	2,092	2,145	2,221	2,310	2,425	2,501	2,576	2,664	2,744	2,814	2,861	2,899
Calif. (%Ch)	1.6	2.5	3.6	4	5	3.1	3	3.4	3	2.6	1.7	1.3
Employment and Labor Force (Household Survey % Change)												
Employment	1	2.1	2.2	2.3	2.2	1.8	1.9	1.1	1.7	0.9	0.4	0.3
Labor Force	0.4	0.6	0.5	0.7	0.7	1	1.1	0.5	1.5	0.9	0.6	0.5
CA Unemployment Rate (%)	11.7	10.4	8.9	7.5	6.2	5.5	4.8	4.2	4	4	4.2	4.4
Non-Farm Employment (Payroll Survey % Change)												
Total Non-Farm California	1.1	2.2	2.6	2.8	3	2.7	2.1	1.9	1.5	1.3	0.7	0.5
Mining	8.5	6.2	-0.1	3.4	-9.6	-15.4	-1.4	0.5	1	1.2	0.8	0.7
Construction	0.2	5.1	8.1	5.8	8.5	6	4.4	5.6	2.7	4.2	5.1	3.9
Manufacturing	0.5	0.4	0.2	1.4	1.7	0.5	0.1	0.5	0.8	-0.3	-0.7	-0.1
Nondurable Goods	-0.4	0.3	0.5	1.1	1.1	1	-0.5	-1.8	0	-0.2	-0.3	0
Durable Goods	1.1	0.4	0	1.6	2.1	0.2	0.4	1.8	1.3	-0.3	-1	-0.1
Trans. Warehs. & Utility	1.8	2.7	3.2	4.1	6.2	6.7	5.5	3.7	2.2	0.1	-0.1	-0.2
Wholesale Trade	2.1	2.4	2.5	2.1	1.2	0.6	0.8	0.3	0.9	0.8	0.5	0.4
Retail Trade	1.9	1.5	1.6	2.2	2	1.1	0.8	0.5	-0.4	-0.6	-0.5	-0.8
Financial Activities	0.2	1.5	1.2	-0.1	2.5	2.6	1.1	0.5	1.5	1.7	0.2	-0.3
Prof. and Business Services	2.8	5	4.4	3.4	2.7	1.7	1.8	2.6	4.1	4.6	1.6	1.1
Edu & Health Services	1.5	3.2	3.3	3	3.6	3.5	3.8	3	1.6	0.3	0.6	0.5
Leisure & Hospitality	2.3	4.1	4.9	4.8	4.1	4	2.7	2.7	1.1	0.9	0.6	0.3
Information	0.6	1	3	3	5.2	7.8	0.5	1.9	1.9	2.1	2.3	0.8
Federal Gov't.	-4.6	-1.9	-1.9	-1.3	0.7	1.4	0.3	-1.1	-0.1	4.5	-3.5	0
State & Local Gov't.	-1.3	-1.2	0.1	2	2.2	2.2	1.7	1.4	0.6	0.5	0.6	0.6
Other Indicators												
Population (000)	37,716	38,059	38,393	8,741	39,061	39,325	39,569	39,810	39,983	40,170	40,369	40,578
(%Ch)	0.9	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.4	0.5	0.5	0.5
Housing Starts Tot. Private (Annual Rate, 000)	45.8	56.0	72.6	79.2	92.5	96.5	103.5	113.3	113.2	125.6	127.4	127.4
Housing Starts Single Family	23.9	28.8	36.6	41.8	47	50.9	59.7	66.2	66	73.1	74.1	73.8
Housing Starts Multi-Family	21.9	27.2	36	37.4	45.4	45.6	43.8	47.1	47.3	52.4	53.3	53.6
New Passenger Car & Truck Registrations	1,223	1,529	1,712	1,848	2,054	2,089	2,048	1,992	2,006	1,997	1,994	1,905
Retail Sales (Billions $)	462	493	509	532	551	570	600	632	668	690	716	744

As Exhibit 21 suggests, the major metro areas in the Bay Area seaports' market area all have similar near-term employment outlooks, although from different starting points.

Exhibit 21: Metro Area Employment Growth



City of San Jose Economic Forecast

The City of San Jose Department of Planning, Building, and Code Enforcement prepared a construction forecast (Exhibit 22). It predicts an increase in development for San Jose over the 2019-2023 period:

> *"Construction valuation in fiscal year 2017/2018 is expected to exceed the previous five-year average, aided by a particularly strong year in new commercial and residential construction, and industrial alterations. Future development is predicted to be driven by mixed-use residential projects, and certain commercial and industrial sectors as described above. San José is poised to capitalize on on-going demand for office and warehouse space for expanding companies that has led to low vacancy rates and high rents in neighboring cities."*

Exhibit 22: San Jose Construction Forecast

Residential Units and Non-Residential Square Footage: FY 12/13 to FY 22/23

	Actual					Projected					
Fiscal Year	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**	**19/20**	**20/21**	**21/22**	**22/23**
Residential (Units)											
Single-Family	284	341	254	152	201	275	275	275	275	275	275
Multi-Family	2,418	4,383	2,987	1,540	2,511	2,900	2,600	2,450	2,450	2,450	2,450
Total	**2,702**	**4,724**	**3,241**	**1,692**	**2,712**	**3,175**	**2,875**	**2,725**	**2,725**	**2,725**	**2,725**
Non-Residential ('000s sqft)											
Commercial	500	1,400	2,000	1,854	1,911	3,500	2,000	1,800	1,400	1,400	1,400
Industrial	790	1,200	1,000	2,068	1,452	2,400	1,000	1,000	1,000	1,000	1,000
Total	**1,290**	**2,600**	**3,000**	**3,922**	**3,363**	**5,900**	**3,000**	**2,800**	**2,400**	**2,400**	**2,400**

Note: Data on residential units based on the Building Division's Permit Fee Activity Report
Data on non-residential square footage estimated based on construction valuation in the Building Division's Permit Fee Activity Report

Wells Fargo Western Economic Outlook

The Wells Fargo report provides an economic forecast for the United States, based on the performance of major economic indicators. With regard to the western states, the forecast says:

"While the outlook for the West remains bright, we expect growth to moderate relative to the rest of the country."

The forecast includes a specific section for California, noting that the continued outperformance of the State compared to the nation could be at risk due to the threats to global trade and the affordability of housing.

- *"The California economy continues to outperform the rest of the nation. Real GDP grew 3.5 percent on a year-to-year basis in Q1 and has now outpaced the country as a whole for nearly six years. While the tech sector remains the primary driver of growth, most other major industries are performing well.*

- *Employment growth has been more modest over the past year, with nonfarm payrolls rising 2.0 percent in July. Even that more moderate pace still slightly exceeds the nation, however, and the unemployment rate has fallen to a modern-era low of 4.2 percent. Every metro area in the state and nearly every major industry added jobs over the past year. Construction posted the largest year-over-year gains, reflecting a ramp-up in home construction and continued gains in commercial development.*

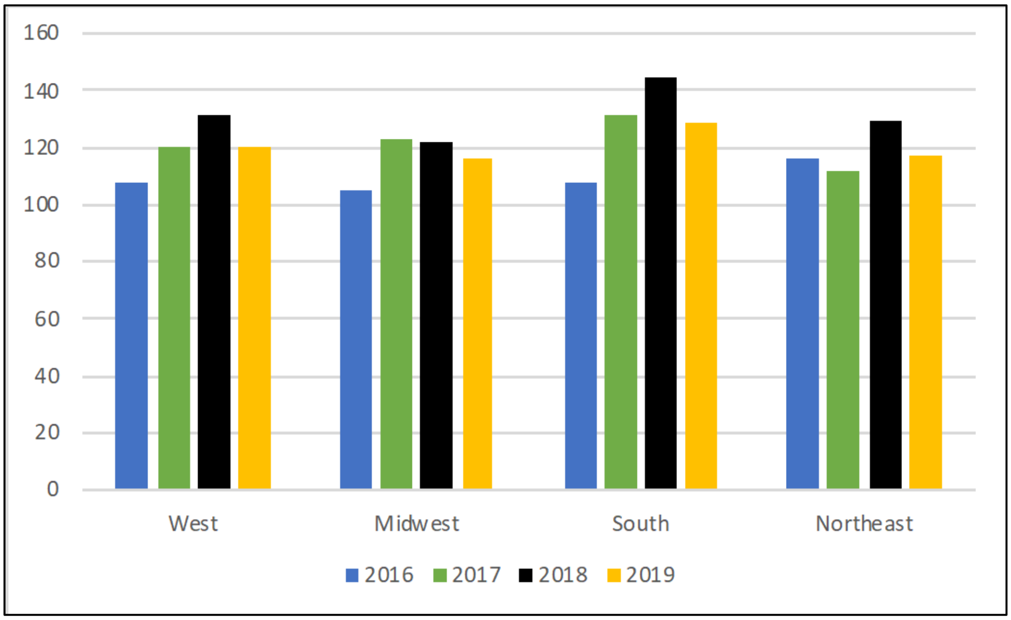
- *New housing supply should come as a welcome relief for Californians. Affordability remains a significant risk to the Golden State economy, as businesses are increasingly seeking more affordable options outside of the state. New supply has been slow to come back on track, which has helped drive home prices up much faster than income growth. The lack of affordable housing is causing younger workers to seek out alternative areas, such as Denver and Dallas.*

- *Trade disputes also pose a risk as California is home to some of the nation's busiest ports and is the second largest exporter behind Texas. NAFTA partners and China combined account for 34.9 percent of California's 2017 exports."*

Wells Fargo Construction Industry Forecast 2019

Wells Fargo uses an "Optimism Quotient" (Exhibit 23) to predict growth or contraction in the construction industry. Values over 100 are considered optimistic, and a positive sign for the construction industry. While the quotient for the west has declined from 131 (2018) to 120 (2019), Wells Fargo still considers the 2019 outlook positive.

Exhibit 23: Wells Fargo Optimism Quotient



Bank of the West California Economic Outlook

Bank of the West provides a report and forecast for California's economy, including jobs, housing, and trade. The executive summary notes:

- *"Job creation in California has outpaced that of the nation since March 2012. But California job growth peaked at 3.0% in 2015 and has been decelerating annually since then. This trend is expected to continue with growth forecast to slow from 1.8% this year to 1.2% in 2019 and just 0.5% in 2020 due to weaker global growth and tighter financial conditions.*

- *Among the four regions job growth in the Bay Area is expected to be the strongest this year at (2.0%) followed by the Central Valley (1.9%), the Central Coast (1.8%) and Southern California (1.4%).*

- *Job growth is expected to decelerate in all four regions of California in 2019 and 2020, while Bay Area is expected to become an under-performer in job creation as high costs of living and doing business weigh more heavily, net-migration turns negative and Silicon Valley faces new headwinds from trade protectionism and regulatory oversight.*

- *The California unemployment rate fell to an all-time low in April of this year and has remained there. As job growth slows in 2019 the unemployment rate is projected to rise from 4.2% in 2018 to 4.7% in 2020."*

- *"Net migration across all four regions and the state is projected to turn negative in 2019 and remain there in 2020 due to deterioration in the state's relative economic performance, the high cost of living, and congested freeways. This will weigh on housing demand, especially in Southern California.*

- *The Trump Administration's protectionist measures thus far have focused mainly on China, an important destination for California exports and driver of California port activity. This is an evolving downside risk to the California economy in 2019.*

- *An analysis by the Brookings Institution reveals that California employs 287,000 workers in those industries targeted by China's initial $50 billion in retaliatory tariffs.*

- *Brookings also determined that the counties in the state most impacted by the tariffs have higher-than-average unemployment rates. Therefore, the protectionist policies are more likely to result in increased economic insecurity for communities that are already struggling."*

The report also discusses how job growth has been strongest in construction, with a 4.7% increase in 2017-2018.

Exhibit 24 displays summary statistics for the Bay Area. In common with other forecasts, Bank of the West expects slower, but positive growth in many aspects. In particular, Bay Area job growth is held down by the low unemployment rate, meaning that fewer unemployed workers are available to fill new jobs.

Exhibit 24: Bank of the West California Bay Area Outlook

	2016	2017	2018	2019	2020
Labor Market					
Employment Growth	3.4%	2.3%	2.0%	1.1%	0.3%
Unemployment Rate	4.0%	3.4%	3.0%	3.2%	3.7%
Income and Spending Trends					
Personal Income Growth	5.0%	4.7%	4.7%	4.5%	4.0%
Median HH Income ($)	88,211	91,296	94,128	97,936	101,888
Retail Sales Growth	3.6%	5.5%	5.5%	4.7%	2.0%
Housing Market					
Total Housing Starts Growth	6.7%	13.1%	9.6%	-2.0%	-3.7%
Med. Existing 1-Unit Home Price	6.3%	12.3%	9.0%	5.6%	5.1%
Demographics					
Population Growth	0.8%	0.5%	0.5%	0.5%	0.4%
Net Migration (000's)	26.6	7.0	5.8	-4.0	-6.0

The Bay Area includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma counties

Long-term Forecasts

The limited number of long-term forecasts available tend to focus on population. Long-term population growth is a useful proxy for consumer demand, which in turn drives import flows of consumer goods, foods, and beverages, and industrial imports.

The forecasts (Exhibit 25) depict steady growth over the long term that falls short of the recent strength seen in California.

Exhibit 25: Long-Term Forecast Summaries

Forecast	Outlook
Federal Reserve Federal Open Market Committee Forecast, March 2019	National real GDP growth of about 1.9% annually over the long run, with a slight rise in the unemployment rate as the current tight labor market eases
Caltrans California County-Level Economic Forecast 2018-2050	County and statewide forecast of population, housing permits, income, and other factors.
ABAG Planning/Research Forecasts and Projections, 2016	Bay Area forecast of population and employment, with employment increasing by 1.0% annually between 2010 and 2035.
Plan Bay Area 2040, 2017	Bay Area forecast of population and employment, with employment increasing by 1.1% annually between 2010 and 2040.

Federal Reserve Federal Open Market Committee Forecast, March 2019

The most recent FOMC release (Exhibit 26) provides both annual forecasts through 2021 and a longer-term growth rate range. The long-run projections are the rates of growth, unemployment, and inflation to which the economy is expected to converge over time "in the absence of further shocks and under appropriate monetary policy." Overall, the FOMC expects long-run real GDP growth at about 1.9%, with a slight rise in the unemployment rate as the current tight labor market eases.

Exhibit 26: FOMC March 2019 Forecasts

Variable	Median[1]				Central Tendency[2]				Range[3]			
	2019	2020	2021	Longer run	2019	2020	2021	Longer run	2019	2020	2021	Longer run
Change in real GDP	2.1	1.9	1.8	1.9	1.9 - 2.2	1.8 - 2.0	1.7 - 2.0	1.8 - 2.0	1.6 - 2.4	1.7 - 2.2	1.5 - 2.2	1.7 - 2.2
December projection	2.3	2	1.8	1.9	2.3 - 2.5	1.8 - 2.0	1.5 - 2.0	1.8 - 2.0	2.0 - 2.7	1.5 - 2.2	1.4 - 2.1	1.7 - 2.2
Unemployment rate	3.7	3.8	3.9	4.3	3.6 - 3.8	3.6 - 3.9	3.7 - 4.1	4.1 - 4.5	3.5 - 4.0	3.4 - 4.1	3.4 - 4.2	4.0 - 4.6
December projection	3.5	3.6	3.8	4.4	3.5 - 3.7	3.5 - 3.8	3.6 - 3.9	4.2 - 4.5	3.4 - 4.0	3.4 - 4.3	3.4 - 4.2	4.0 - 4.6
PCE inflation	1.8	2	2	2	1.8 - 1.9	2.0 - 2.1	2.0 - 2.1	2	1.6 - 2.1	1.9 - 2.2	2.0 - 2.2	2
December projection	1.9	2.1	2.1	2	1.8 - 2.1	2.0 - 2.1	2.0 - 2.1	2	1.8 - 2.2	2.0 - 2.2	2.0 - 2.3	2
Core PCE inflation[4]	2	2	2	-	1.9 - 2.0	2.0 - 2.1	2.0 - 2.1	-	1.8 - 2.2	1.8 - 2.2	1.9 - 2.2	-
December projection	2	2	2	-	2.0 - 2.1	2.0 - 2.1	2.0 - 2.1	-	1.9 - 2.2	2.0 - 2.2	2.0 - 2.3	-
Memo: Projected appropriate policy path												
Federal funds rate	2.4	2.6	2.6	2.8	2.4 - 2.6	2.4 - 2.9	2.4 - 2.9	2.5 - 3.0	2.4 - 2.9	2.4 - 3.4	2.4 - 3.6	2.5 - 3.5
December projection	2.9	3.1	3.1	2.8	2.6 - 3.1	2.9 - 3.4	2.6 - 3.1	2.5 - 3.0	2.4 - 3.1	2.4 - 3.6	2.4 - 3.6	2.5 - 3.5

Note: Projections of change in real gross domestic product (GDP) and projections for both measures of inflation are percent changes from the fourth quarter of the previous year to the fourth quarter of the year indicated. PCE inflation and core PCE inflation are the percentage rates of change in, respectively, the price index for personal consumption expenditures (PCE) and the price index for PCE excluding food and energy. Projections for the unemployment rate are for the average civilian unemployment rate in the fourth quarter of the year indicated. Each participant's projections are based on his or her assessment of appropriate monetary policy. Longer-run projections represent each participant's assessment of the rate to which each variable would be expected to converge under appropriate monetary policy and in the absence of further shocks to the economy. The projections for the federal funds rate are the value of the midpoint of the projected appropriate target range for the federal funds rate or the projected appropriate target level for the federal funds rate at the end of the specified calendar year or over the longer run. The December projections were made in conjunction with the meeting of the Federal Open Market Committee on December 18-19, 2018. One participant did not submit longer-run projections for the change in real GDP, the unemployment rate, or the federal funds rate in conjunction with the December 18-19, 2018, meeting, and one participant did not submit such projections in conjunction with the March 19-20, 2019, meeting.

(1) For each period, the median is the middle projection when the projections are arranged from lowest to highest. When the number of projections is even, the median is the average of the two middle projections.

(2) The central tendency excludes the three highest and three lowest projections for each variable in each year.

(3) The range for a variable in a given year includes all participants' projections, from lowest to highest, for that variable in that year.

(4) Longer-run projections for core PCE inflation are not collected.

Exhibit 27 provides greater detail on the GDP forecast.

- The "longer-run" real GDP growth forecast ranges from a high of 2.2% to a low of 1.7%.
- The "longer-run" expected range ("central tendency") is from 1.8% to 2.0%, with a median of 1.9%.

Exhibit 27 FOMC Change in Real GDP (Annual %), March 2019

	Actual 2014	2015	2016	2017	2018	Forecast 2019	2020	2021	Longer Run
Actual	2.7	2.0	1.9	2.5	3.1	-	-	-	-
Upper End of Range						2.4	2.2	2.2	2.2
Upper End of Central Tendency						2.2	2.0	2.0	2.0
Median						2.1	1.9	1.8	1.9
Lower End of Central Tendency						1.9	1.8	1.7	1.8
Lower End of Range						1.6	1.7	1.5	1.7

California County-Level Economic Forecast 2018-2050

This county-by-county forecast through 2050 uses data from the UCLA Anderson Forecast:

- *"The UCLA Anderson Forecast makes projections of state and national economic indicators several times each year, and we have relied on these forecasts to influence the regional forecasts. UCLA Anderson's June 2018 U.S. and California economic projections were used for the county forecasts presented in this report."*
- *"The County level forecasts are updated annually to incorporate (1) substantially revised historical data and (2) changes in the U.S. and California economic forecasts, which influence the direction of the regional economies. Consequently, in explaining the forecast, greater attention is directed at the near term, principally the next three years. However, a growth forecast for economic indicators is presented (for comparison purposes) for the 2018 to 2023 period for every county".*
- *"The longer term forecasts, from 2024 to 2050, are based on the extrapolation of near term forecast results. These long term "trend" forecasts respond to how the economic indicators might grow (or change) over time, consistent with reasonable assumptions about population and housing growth, and the growth of the U.S. and California economies. They are also created in a manner that is consistent with historical trends."*

For the near term, the California County Level Economic Forecast that extends through 2050 has a similar outlook as the UCLA Anderson Forecast, which influences the regional forecasts. At the State level:

- The forecast projects a slowdown in construction job growth. After 2018 the growth of annual new housing permits is forecast to slow, with an average of 131,000 per year between 2018 and 2022.
- California's population growth is projected at about 0.7% for the next several years through 2022, with about 280,000 new residents projected per year.

The County Level forecast includes a near-term forecast specifically for Alameda County with the following highlights:

- In 2018, total employment will increase by 1.7 percent. From 2018 to 2023, employment growth is expected to average 0.8 percent per year.

- The largest employment gains will be observed in professional services, education, healthcare, and leisure services. Together, these sectors will account for 67 percent of net job creation during the 2018-2023 period.
- We are near the peak of the current building cycle, and job losses may be observed in the construction industry during the forecast period.
- Average salaries are currently well above the California average, and will remain so over the foreseeable future. In Alameda County, inflation-adjusted salaries are expected to rise by an average of 1.4 percent per year between 2018 and 2023.
- Over the forecast period, an average of 6,300 homes will be authorized per year. The most prominent area for development will be the Oakland Waterfront, where several thousand apartments and condos could be built over the next decade.

The population is expected to increase by 0.7 percent annually through 2023. Net migration will slow, with an average of 2,100 net migrants entering the county each year. Exhibit 28 was developed by the consultant team from the County Level forecast to summarize the outlook for the 19 major counties in the California market served by the Bay Area ports.

The 19 counties shown vary in character from large urban clusters to less populous agricultural areas. Combined, they have:

- A population of about 13 million, expected to grow at an annual average compound rate of 0.7%, adding 3 million people by 2048.
- A total of 37,071[i] new home permits in 2017, declining to 30,432 by 2048, but adding 1+ million homes over 30 years.
- About $16 trillion in real personal income in 2017, rising at 1.7% to $27 trillion in 2048.
- About $27 billion in annual farm crop value rising at 0.8% to $35 billion in 2048.
- Roughly $140 billion in annual industrial production, rising at 1.9% to reach $254 billion in 2048.

[i] This total was adjusted to avoid large year-to-year fluctuations.

Exhibit 28: Nineteen-County Forecast

County	County	Metrics						Compound Annual Growth Rates					
		Population	New Homes Permitted*	Real Per Capita Income	Real Personal Income - Billions	Real Farm Crop value - Billions	Real Industrial Production - Billions	Population CAGR	Annual Homes CAGR	Real Per Capital Income CAGR	Real Personal Income CAGR	Real Farm Crop Value CAGR	Real Industrial Production CAGR
Alameda	2017	1,650,818	*5,500*	$69,350.00	$114.5	0.0	22.6	na	na	na	na	na	na
	2048	1,990,314	4,118	$93,588.00	$186.3	0.0	46.5	0.6%	-0.9%	1.0%	1.6%	NA	2.4%
Contra Costa	2017	1,138,039	*2,800*	$74,731.00	$85.0	0.1	5.6	na	na	na	na	na	na
	2048	1,419,039	3,156	$96,197.00	$136.5	0.1	10.3	0.7%	0.4%	0.8%	1.5%	0.0%	2.0%
Fresno	2017	999,929	3,050	$40,612.00	$40.6	6.3	8.5	na	na	na	na	na	na
	2048	1,351,570	3,154	$52,109.00	$70.4	8.0	17.8	1.0%	0.1%	0.8%	1.8%	0.8%	2.4%
Madera	2017	157,472	436	$38,158.00	$6.0	1.9	1.0	na	na	na	na	na	na
	2048	223,842	527	$48,563.00	$10.9	2.3	2.1	1.1%	0.6%	0.8%	1.9%	0.6%	2.4%
Marin	2017	262,545	104	$121,715.00	$32.0	0.1	1.4	na	na	na	na	na	na
	2048	274,104	30	$174,442.00	$47.8	0.1	2.9	0.1%	-3.9%	1.2%	1.3%	0.0%	2.4%
Merced	2017	276,275	670	$37,034.00	$10.2	3.5	2.9	na	na	na	na	na	na
	2048	369,356	788	$47,040.00	$17.4	4.6	5.8	0.9%	0.5%	0.8%	1.7%	0.9%	2.3%
Monterey	2017	442,806	648	$53,901.00	$23.9	4.6	2.1	na	na	na	na	na	na
	2048	504,643	561	$73,267.00	$37.0	5.6	4.4	0.4%	-0.5%	1.0%	1.4%	0.6%	2.4%
Napa	2017	141,624	183	$70,186.00	$9.9	0.7	3.5	na	na	na	na	na	na
	2048	160,635	199	$106,199.00	$17.1	1.7	8.4	0.4%	0.3%	1.3%	1.8%	2.9%	2.9%
Sacramento	2017	1,519,381	4,915	$50,052.00	$76.0	0.5	7.2	na	na	na	na	na	na
	2048	1,923,180	4,149	$71,556.00	$137.6	0.6	14.2	0.8%	-0.5%	1.2%	1.9%	0.6%	2.2%
San Benito	2017	58,416	599	$48,960.00	$2.9	0.4	0.6	na	na	na	na	na	na
	2048	83,311	175	$56,629.00	$4.7	0.4	1.2	1.2%	-3.9%	0.5%	1.6%	0.0%	2.3%
San Francisco	2017	880,418	4,736	$114,181.00	$100.5	0.0	5.9	na	na	na	na	na	na
	2048	1,040,980	2,712	$180,251.00	$187.6	0.5	11.9	0.5%	-1.8%	1.5%	2.0%	NA	2.3%
San Joaquin	2017	749,092	2,545	$41,522.00	$31.1	2.5	9.0	na	na	na	na	na	na
	2048	983,053	2,026	$54,038.00	$53.1	3.1	8.6	0.9%	-0.7%	0.9%	1.7%	0.7%	-0.1%

County	County	Metrics						Compound Annual Growth Rates					
		Population	New Homes Permitted*	Real Per Capita Income	Real Personal Income - Billions	Real Farm Crop value - Billions	Real Industrial Production - Billions	Population CAGR	Annual Homes CAGR	Real Per Capital Income CAGR	Real Personal Income CAGR	Real Farm Crop Value CAGR	Real Industrial Production CAGR
San Mateo	2017	772,900	1,759	$110,949.00	$85.8	0.1	11.8	na	na	na	na	na	na
	2048	935,164	1,613	$152,099.00	$142.2	0.0	25.7	0.6%	-0.3%	1.0%	1.6%	-100.0%	2.5%
Santa Clara	2017	1,945,465	*5,500*	$92,544.00	$180.0	0.3	37.3	na	na	na	na	na	na
	2048	2,297,042	3,563	$141,996.00	$326.2	0.4	44.8	0.5%	-1.4%	1.4%	1.9%	0.9%	0.6%
Santa Cruz	2017	276,801	322	$61,809.00	$17.1	0.7	1.9	na	na	na	na	na	na
	2048	309,007	208	$78,994.00	$24.4	0.8	3.7	0.4%	-1.4%	0.8%	1.2%	0.4%	2.2%
Solano	2017	437,309	995	$48,368.00	$21.2	0.4	3.8	na	na	na	na	na	na
	2048	526,012	967	$61,237.00	$32.2	0.4	7.8	0.6%	-0.1%	0.8%	1.4%	0.0%	2.3%
Sonoma	2017	504,671	876	$59,023.00	$29.8	0.9	6.3	na	na	na	na	na	na
	2048	550,296	569	$87,021.00	$47.9	1.1	12.8	0.3%	-1.4%	1.3%	1.5%	0.6%	2.3%
Stanislaus	2017	551,557	939	$42,190.00	$23.3	3.2	6.5	na	na	na	na	na	na
	2048	735,806	1,410	$56,256.00	$41.4	5.3	12.3	0.9%	1.3%	0.9%	1.9%	1.6%	2.1%
Yolo	2017	219,468	492	$50,681.00	$11.1	0.7	2.6	na	na	na	na	na	na
	2048	288,042	597	$70,694.00	$20.4	0.8	5.4	0.9%	0.6%	1.1%	2.0%	0.4%	2.4%
19-County Market Area	**2017**	**12,984,986**	**37,069**	**1,225,966**	**$15,919.2**	**26.9**	**140.5**	na	na	na	na	na	na
	2048	**15,965,396**	**30,522**	**1,702,176**	**$27,175.9**	**35.8**	**246.6**	**0.7%**	**-0.6%**	**1.1%**	**1.7%**	**0.9%**	**1.8%**

* Housing permits in italics normalized to avoid atypical values

ABAG Planning/Research Forecasts and Projections, 2016

The Association of Bay Area Governments (ABAG) has prepared a 2035 Bay Area forecast for population and employment by industry. These forecasts are part of Plan Bay Area 2040 discussed below.

The forecast (Exhibit 29) predicts that population will increase from 7,150,739 in 2010 to 8,889,000 in 2035. It also predicts that employment will grow from 3,268,680 to 4,198,400 in the same period (1.0% CAGR). The forecast also includes figures for the construction industry, which is expected to grow from 142,350 to 217,080 employees during this time (1.5% CAGR).

Exhibit 29: ABAG Population and Employment Projections

Demographics	2010	2015	2020	2025	2030	2035	2040
Population	7,150,739	7,461,400	7,786,800	8,134,000	8,496,800	8,889,000	9,299,100
Household Population	7,003,059	7,307,400	7,623,700	7,961,900	8,313,900	8,690,400	9,084,800
Households	2,608,023	2,720,410	2,837,680	2,952,910	3,072,920	3,188,330	3,308,090
Persons Per Household	2.69	2.69	2.69	2.70	2.71	2.73	2.75
Employed Residents	3,268,680	3,547,310	3,849,790	3,949,620	4,052,020	4,198,400	4,350,070

Jobs	2010	2015	2020	2025	2030	2035	2040
Agriculture & Natural Resources	24,640	25,180	25,690	24,800	23,940	23,330	22,750
Construction	142,350	168,380	197,560	203,280	209,150	217,080	225,290
Manufacturing & Wholesale	460,170	473,360	486,720	476,580	467,010	461,330	456,080
Retail	335,930	352,550	370,260	372,210	374,060	379,210	384,420
Transportation & Utilities	98,710	108,320	119,080	120,650	122,090	124,760	127,360
Information	121,070	134,550	149,640	150,890	152,130	154,720	157,330
Financial & Leasing	186,070	204,730	225,520	226,770	227,680	230,880	233,790
Professional & Managerial Services	596,740	678,230	771,560	814,300	859,260	914,710	973,640
Health & Educational Services	447,720	497,070	553,680	584,230	616,620	656,290	698,610
Arts, Recreation & Other Services	472,930	519,020	570,160	589,000	608,420	633,960	660,570
Government	498,970	508,600	517,280	526,610	536,220	550,550	565,390
Total Jobs	**3,385,300**	**3,669,990**	**3,987,150**	**4,089,320**	**4,196,580**	**4,346,820**	**4,505,230**

Sources: 2010 demographic data are taken directly from the U.S. Census. 2010 employment data are from California County-Level Economic Forecast, 2011-2040, California Department of Transportation; Job Growth to 2040: Projections and Analysis, Center for Continuing Study of the California Economy; National Establishment Times-Series (NETS) Database, Walls & Associates using Dun and Bradstreet labor force data from U.S. Bureau of Labor Statistics and the U.S. Census Bureau's 2005-2009 America Community Survey.

Plan Bay Area 2040, 2017

Plan Bay Area was developed by MTC and ABAG in cooperation as a general forecast of economics and population for the nine-county San Francisco Bay Area region through 2040:

"The forecast for Plan Bay Area is a cooperative effort between the ABAG research program, the Metropolitan Transportation Commission (MTC) modeling team, and local jurisdiction planning staff. ABAG develops regional totals for population, households, employment, output, and income. Geographic distribution of the forecast within the region is accomplished through efforts of ABAG and MTC modeling and planning staff with input at several stages from local jurisdictions. MTC then uses the information from the geographic distribution of the forecast for detailed travel demand analysis and estimates of greenhouse gas production."

Plan Bay Area forecasts that between 2010 and 2040, Bay Area employment will grow from 3.4 to 4.7 million jobs, while the population is projected to grow from 7.2 to 9.6 million people. This population will live in almost 3.4 million households, an increase of nearly 800,000 households over 2010 levels. Specifically, Plan Bay Area estimates (Exhibit 30):

- An increase of 1.3 million jobs between 2010 and 2040. Almost half of those jobs – over 600,000 – were already added between 2010 and 2015.

- An increase of 2.4 million people between 2010 and 2040. Almost one fourth of the projected growth already occurred between 2010 and 2015.

Exhibit 30: Plan Bay Area Forecasts

	2010	2040
Employment	3.4 million	4.7 million
Population	7.2 million	9.6 million
Households	2.6 million	3.4 million

The employment and population projections are slightly more aggressive than the earlier ABAG forecasts.

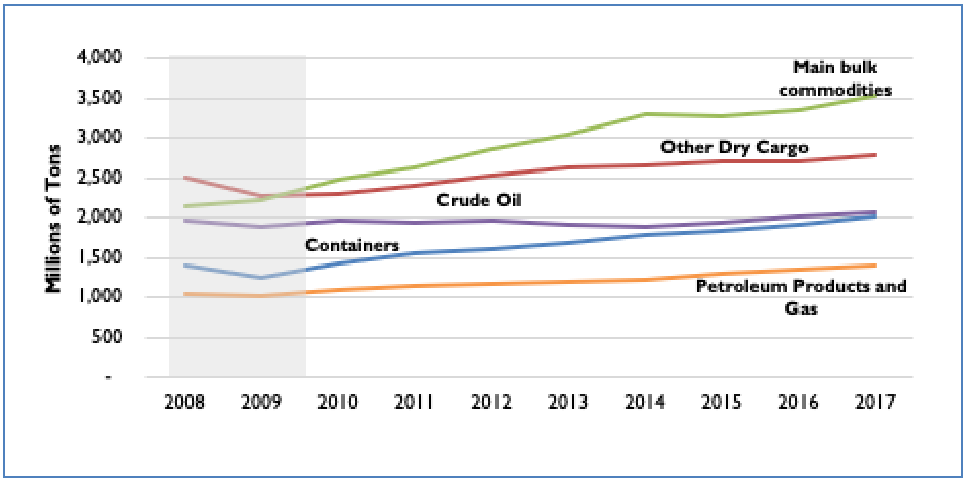
Trade Trends

Global Maritime Trade

As Exhibit 31 shows, global maritime trade began to grow again after the recession. Different commodity groups had different growth patterns.

- Container cargo grew moderately but steadily.
- Other dry cargo, which includes commodities such as cement, aggregates, and gypsum handled at Bay Area ports, also grew moderately.
- "Main bulk" commodities, of which only coal moves through Bay Area ports, have grown more dramatically.
- Liquid bulk crude oil, petroleum products, and gas grew more slowly, although the growth of U.S. fracking and oil production has resulted in increased exports of crude oil and liquefied natural gas in recent years. Some of these commodities are handled at private refinery terminals and are outside the scope of the Seaport Plan.

Exhibit 31: Global Maritime Trade in Tons



NOTES: Main bulk commodities include iron ore, coal, and grain. Other dry cargo includes bauxite/alumina, phosphate, forestry and steel products, cement, etc. Shaded gray box indicates period of global recession, which the National Bureau of Economic Research details as starting in December 2007 and ending in June 2009 in the United States.
SOURCE: United Nations Conference on Trade and Development (UNCTAD), Review of Maritime Transport: 2018, available at http://unctadstat.unctad.org/ as of October 2018.

The short-term outlook for world merchandise trade is for slower growth than in recent years. The World Trade Organization projects growth of 2.6% in 2019 and 3.0% in 2020, compared to growth of 4.6% in 2017 and 3.0% in 2018.

IMO 2020. One change that will affect all types of shipping is the “IMO 2020” requirement for use of low-sulfur fuel. Starting in January 2020, the IMO will cap the sulfur content of marine diesel fuel used in international trade at 0.5%, down from the current 3.5%. Vessels operating in the Emissions Control Areas (ECAs) along the U.S. coasts are already required to use low sulfur fuel (0.1%). Vessel operators can comply with IMO 2020 in three ways:

- Using ultra-low sulfur fuel oil (ULSFO).
- Installing vessel exhaust scrubbers to reduce sulfur emissions from existing diesel fuels.`
- Converting to LNG as a fuel supply in addition to or instead of diesel fuel.

All of these options are costly and it is not obvious how or if the shipping industry will meet the IMO 2020 requirement. Among other factors, there is an insufficient supply of ULSFO, and refineries require costly and lengthy modifications to increase production.

The cost of meeting IMO 2020 requirements will increase shipping costs by some amount as yet unknown, although several shipping alliances have developed surcharge formulas based on potential bunker fuel prices. The impact on relatively high-value cargo such as containerized consumer imports, high-value exports, or Ro-Ro automobiles, is likely to be minor as shipping costs for those goods are a small part of total delivered price. IMO 2020 costs are more likely to affect flows of low-value containerized and bulk commodities, where shipping costs account for a larger share of delivered price and are more likely to affect demand. Examples of affected commodities could include bulk export scrap metal or containerized export waste paper. Some imports, such as sand, aggregates, and gypsum to Redwood City, are already arriving in "clean" vessels and will be minimally affected.

Trade Disputes and Tariffs. The trade initiatives launched by the current U.S. administration, the enacted and proposed tariffs on imports to the U.S., and the tariffs on U.S. exports enacted and proposed by foreign governments in response, will all have mixed impacts on Bay Area trade.

- Threats of tariffs on imports, particularly imports from China, have led to an import surge due to "frontloading," as explained in more detail below.
- Tariffs and uncertainty have reduced some recent U.S. exports. Those most affected, however, such as soybeans, are not major Bay Area commodities.
- For the near term, volatile and unpredictable trade conditions will likely constrain overall trade growth, but with impacts varying by commodity and trading partner.
- In the long run, tariffs and non-tariff barriers will slow the growth of trade.

The administration's focus on trade with China is also leading manufacturers and importers to shift production and sourcing to other countries, notably Vietnam. This trend can have two impacts:

- Increased vessel service between Vietnam and other Asian nations and the U.S. West Coast. For example, a new service between Vietnam and Oakland began in early 2019.
- For inland U.S. destinations, a shift between transpacific intermodal routes through the West Coast, and Suez Canal all-water or intermodal routes via the East Coast (potentially counter-balanced by higher shipping costs due to IMO 2020).

The second trend is more likely to affect Southern California ports, which depend far more on intermodal connections than Oakland.

3. Containerized Forecast and Capacity Analysis

Containerized Cargo Forecast Review

Cargo that is not moved in bulk or roll-on/roll-off vehicle service now typically moves in international containers. International containers are most often 40' long, but also come in 20' and 45' lengths (53' containers are used within the U.S., and do not ordinarily travel on oceangoing vessels). Container volumes and capacities are usually measured in "twenty-foot equivalent units" (TEU). A 20' container is one TEU, and a 40' container would be two TEU. There is usually a ratio of about 1.8 TEU per container to account for the mix of 20', 40', and 45' units.

The previous containerized cargo forecasts prepared for BCDC were developed by Tioga in 2009 to assist BCDC in evaluating the proposed use of Richmond's Port Potrero site for Ro-Ro cargo rather than for containers. The forecast is shown in Exhibit 32 below. That forecast was prepared toward the end of the 2008-2009 recession, and reflected widespread expectations for a relatively strong recovery. As the comparison in Exhibit 32 suggests, post-recovery trade growth deviated from those expectations.

Exhibit 32: 2009 Port of Oakland Containerized Cargo Forecast Comparison

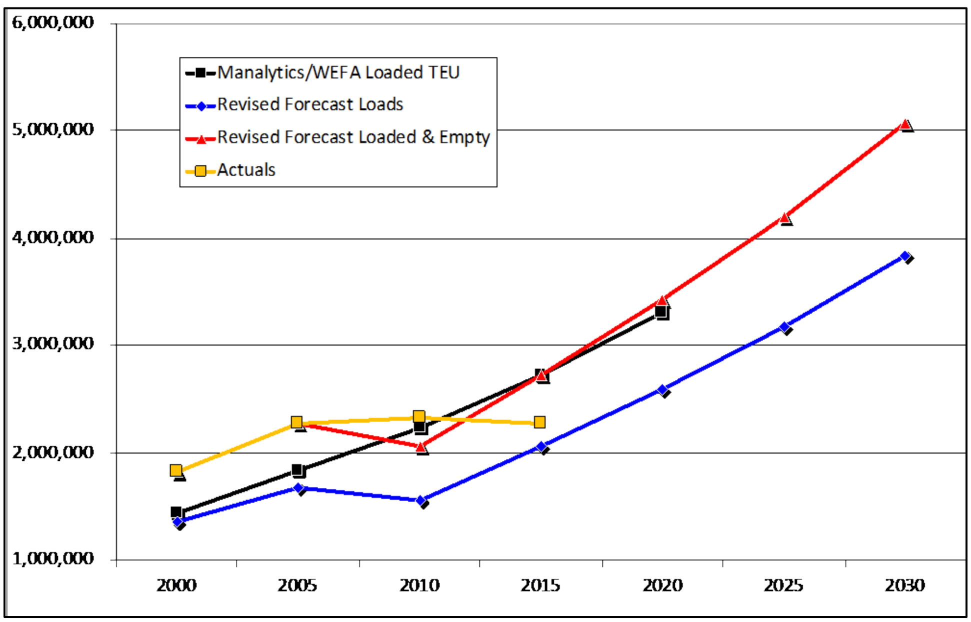


Exhibit 33 displays 1998-2018 annual Port of Oakland TEU counts and the 2009 forecast shown in Exhibit 32.

Exhibit 33: Port of Oakland Annual Total TEU, 1998-2018

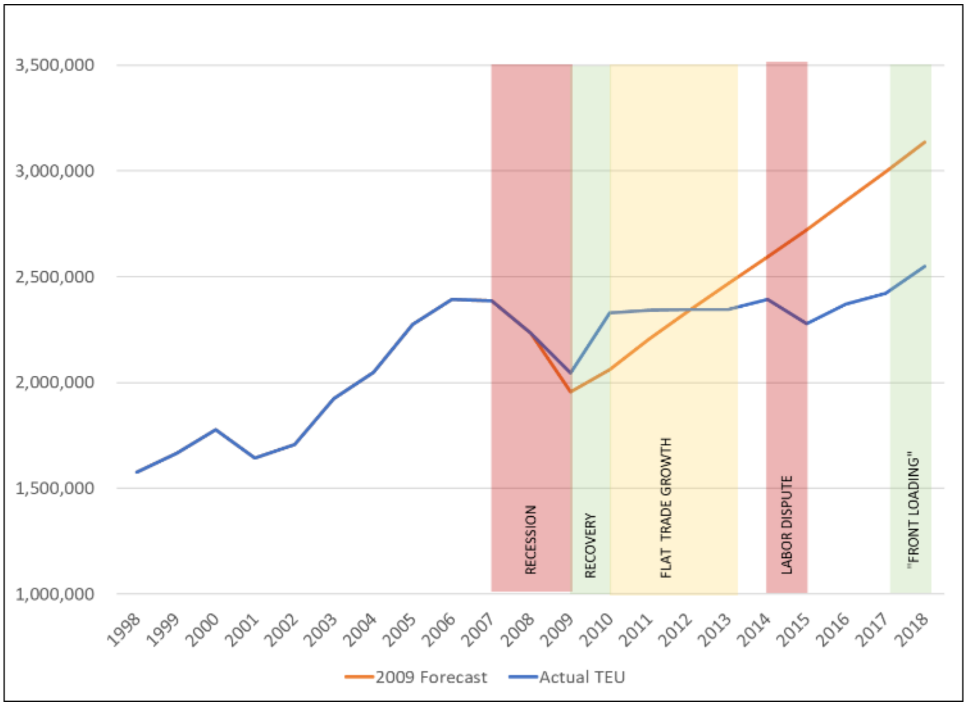
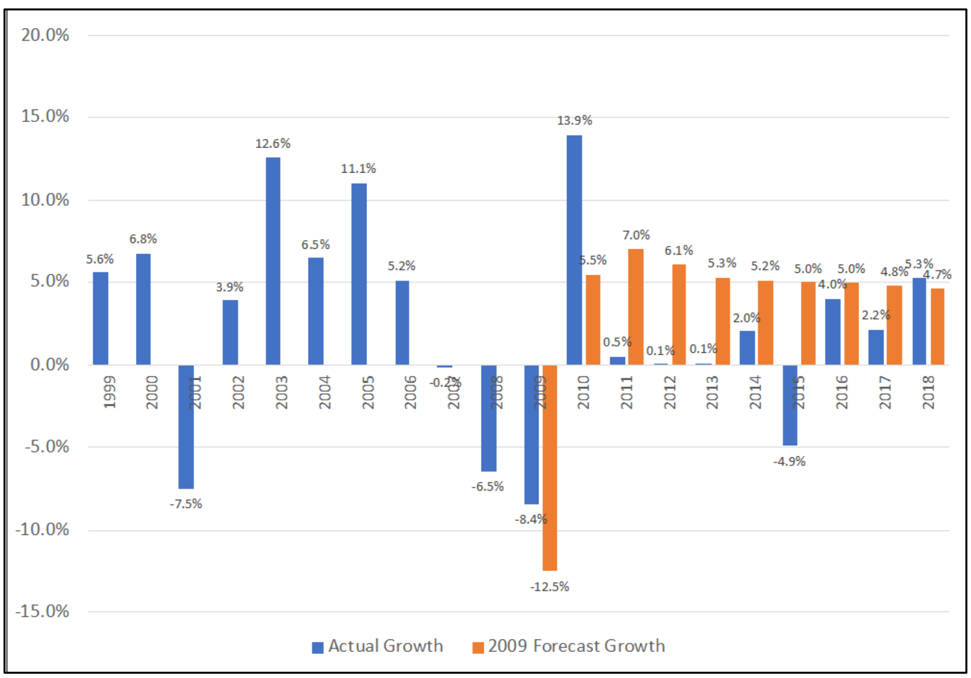


Exhibit 34 shows the corresponding growth rates.

Exhibit 34: Port of Oakland Annual Total TEU Growth Rates, 1999-2018



- The 2009 forecast was developed during the 2007–2009 recession, and anticipated a more severe 2008–2009 decline (-12.5%) than actually occurred (-8.4%).

- The 2009 forecast called for relatively steady growth at 4.7–5.3% after a moderate recovery in 2010–2012.
- Actual 2010 recovery was stronger (13.9%), but then the recovery "stalled" and Oakland's TEU volume was nearly flat in 2011–2013. The forecast was almost exactly equal to the actual in 2012.
- After a moderate increase at the start of 2014, the PMA-ILWU contract dispute that began in November 2014 lead to a net volume loss in 2015.
- Recovery in 2016 and moderate growth in 2017 put the Port of Oakland "back on track," but from a lower starting point.
- In 2018, import inventory buildup in advance of proposed tariffs (termed "frontloading") contributed to stronger growth than forecast.

Overall, the 2009 forecast called for 3,136,317 TEU in 2018, while Oakland was actually at 2,548,837. Exhibit 35 below breaks the 1998-2018 period into three segments:

- 1998-2008, in which Oakland TEU grew at a CAGR of 3.6%.
- 2008-2015, in which the forecast anticipated an overall CAGR of 2.9% but flat post-recession trade and the 2014-2015 dispute held the actual CAGR to 0.3%.
- 2015-2018, in which 3.8% growth approximated the pre-recession average, but was still lower than the forecast CAGR of 4.8%.

Exhibit 35: Port of Oakland Total TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Actual TEU	3.6%	0.3%	3.8%	2.4%
2009 Forecast	3.6%	2.9%	4.8%	3.5%

The near lack of any net growth in 2008-2015 thus held down the overall 1998-2018 CAGR to 2.4% versus the 3.5% forecast in 2009. However, as noted below, some of the slower-than-expected growth in recent years is attributable to a decline in domestic container trade.

Oakland Import TEU

Oakland's import record (Exhibit 36 and Exhibit 37) is less volatile than export or overall TEU. After flat post-recession growth and a loss of momentum in the 2014-2015 trade dispute, imports have grown much more in line with the 2009 forecast.

Exhibit 36: Port of Oakland Annual Loaded Import TEU, 1998-2018

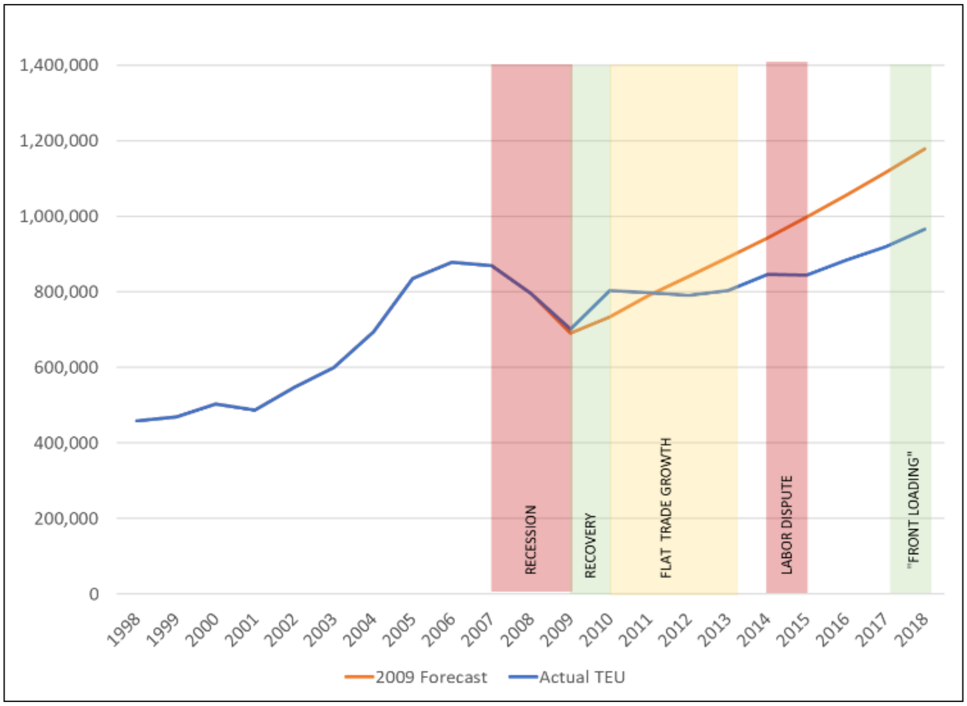
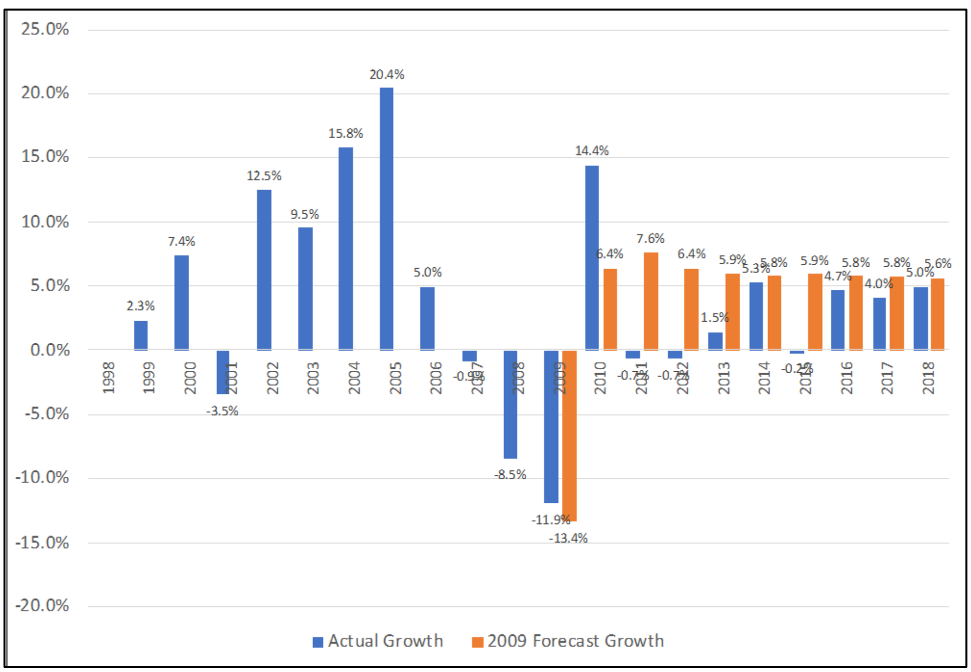


Exhibit 37: Port of Oakland Annual Loaded Import TEU Growth Rates, 1999-2018



As

Exhibit 38 shows, import actuals lagged forecasts by about one percentage point in 2015–2018 and in 1998–2018 overall.

Exhibit 38: Port of Oakland Loaded Import TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Import TEU				
Actual Growth	5.7%	0.8%	4.6%	3.8%
2009 Forecast Growth	5.7%	3.3%	5.7%	4.8%

Oakland Export TEU

Exhibit 39 shows that Oakland's export TEU were affected much less by the recession and grew modestly post-recession, but have been on a downward trend since 2013. Exhibit 40 shows the volatility of Oakland's export growth. The CAGRs in Exhibit 41 show that the 2009 forecast was 2.5 to 3.1 percentage points above actuals.

Exhibit 39: Port of Oakland Annual Loaded Export TEU, 1998-2018

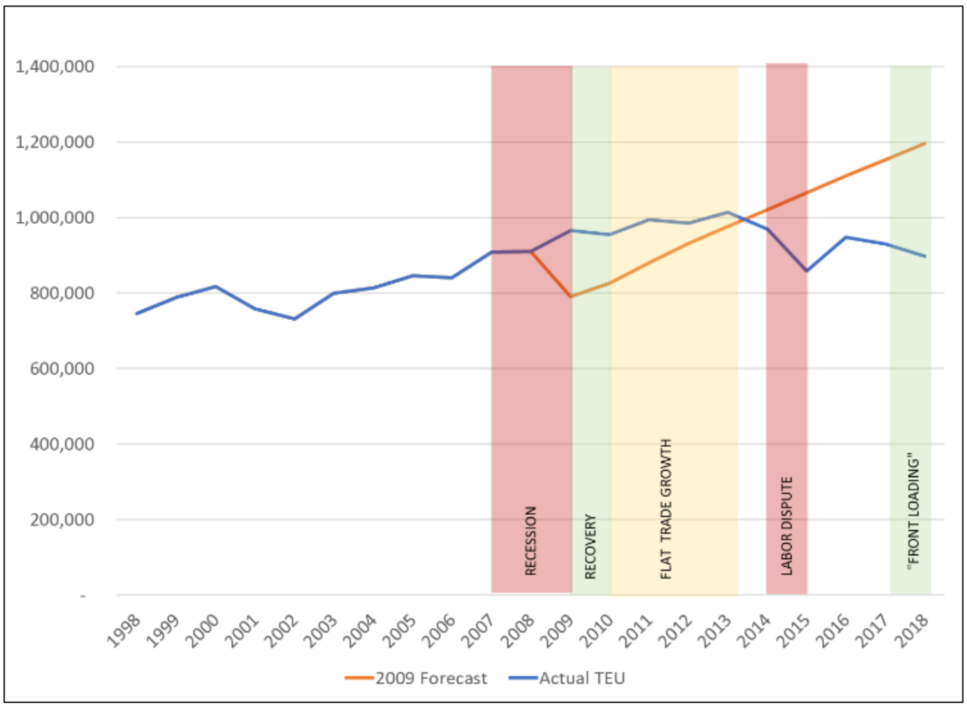
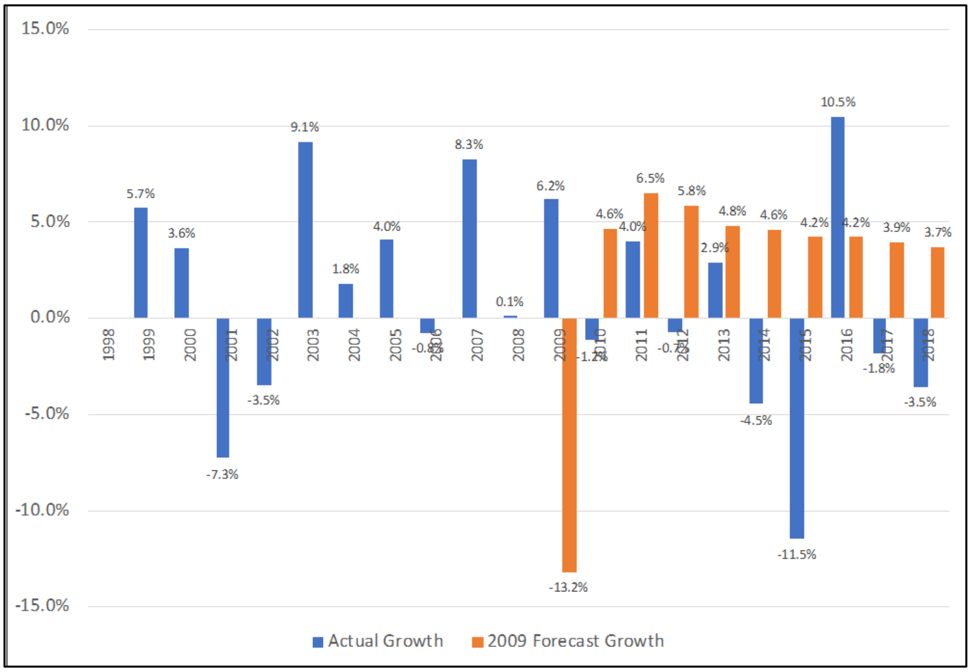


Exhibit 40: Port of Oakland Annual Loaded Export TEU Growth Rates, 1999-2018



In Exhibit 41, the substantial disparity between export forecast and export actuals is apparent. The 2014–2015 labor dispute brought export TEU down below the 2008 level after a high point in 2013. Growth since 2015 has been positive, but slow.

Exhibit 41 Port of Oakland Loaded Export TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Export TEU				
Actual Growth	2.0%	-0.8%	1.5%	0.9%
2009 Forecast Growth	2.0%	2.3%	4.0%	2.4%

Oakland Empty TEU

The Port of Oakland is unusual on the West Coast as having substantial volumes of both inbound and outbound empty containers.

- As with most West Coast ports, Oakland terminals load outbound empties to offset the overall U.S. excess of import over export containers.
- Oakland terminals also discharge a significant volume of empties, notably refrigerated containers, to fill the needs of exporters in California and other Western states.

As Exhibit 42 shows, empty movements dropped sharply during the recession as ocean carriers saw no purpose in returning empties to Asia if there were no U.S.-bound loads to fill them. Empty movements rose sharply in 2010 as the recovery pulled those empty containers back into circulation. There was little net increase in empty TEU volume between 2010 and 2017 (as also shown in Exhibit 43), but a strong uptick in 2018 due to import "frontloading" and subsequent generation of empties to be repositioned westbound.

Exhibit 42: Port of Oakland Annual Empty TEU, 1998-2018

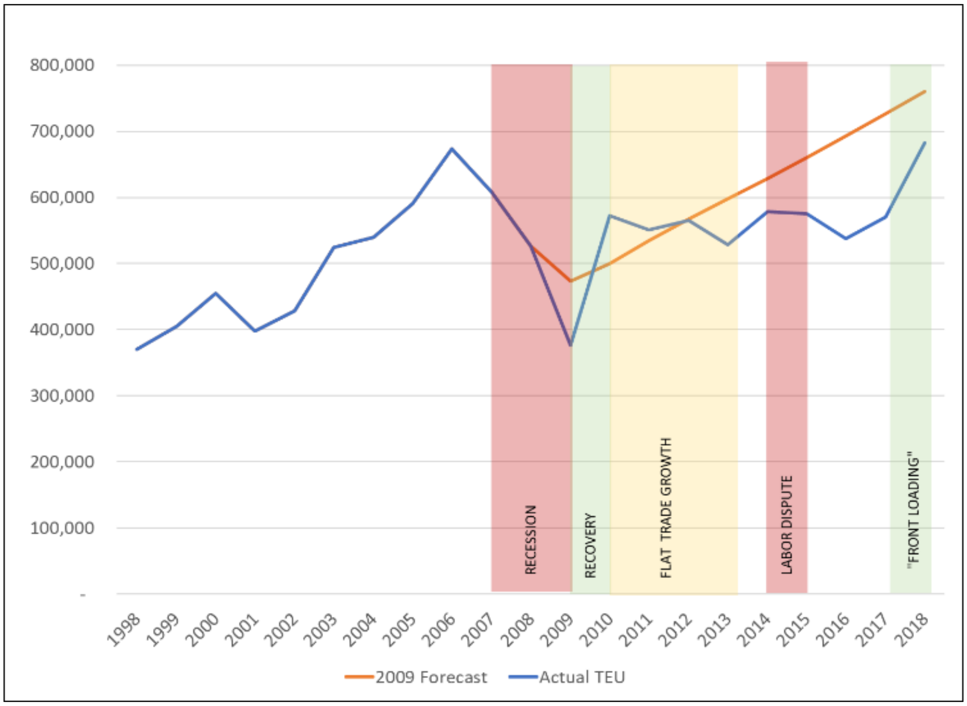
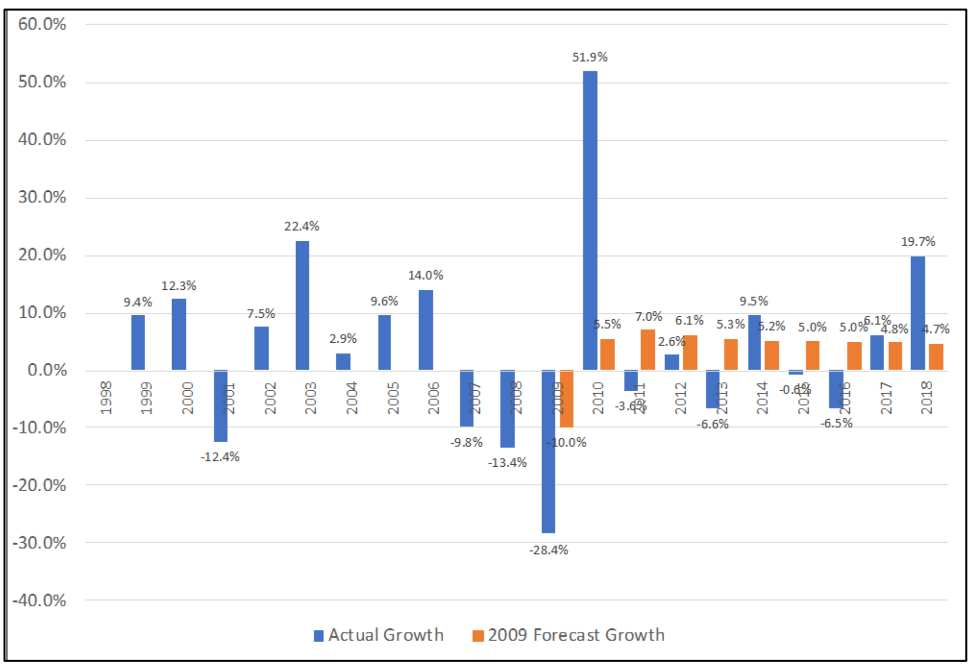


Exhibit 43: Port of Oakland Annual Empty TEU Growth Rates, 1999-2018



As Exhibit 44 indicates, Oakland's empty TEU volumes ran both ahead and behind forecast, depending on the era.

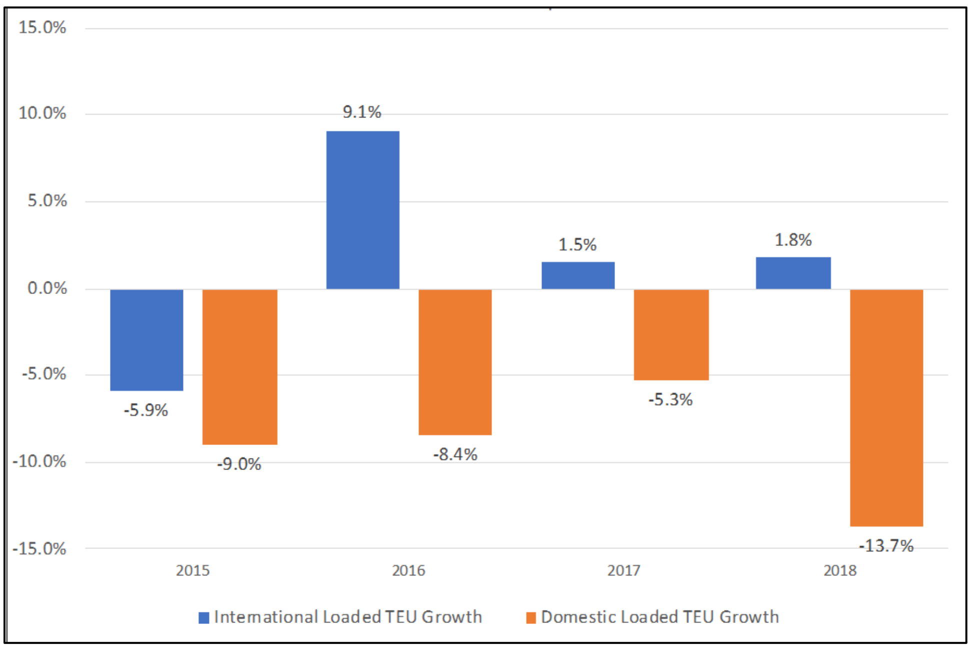
Exhibit 44: Port of Oakland Empty TEU CAGRs by Era

Actual TEU and Forecast	1998-2008 CAGR	2008-2015 CAGR	2015-2018 CAGR	1998-2018 CAGR
Empty TEU				
Actual Growth	3.6%	1.3%	5.9%	3.1%
2009 Forecast Growth	3.6%	3.3%	4.8%	3.7%

International vs. Domestic TEU

Discussions with the Port of Oakland have determined that domestic TEU (e.g. the Hawaiian and Guam trades) have declined noticeably in recent years, as shown in Exhibit 45. The domestic drop-off has therefore concealed some of the underlying international growth.

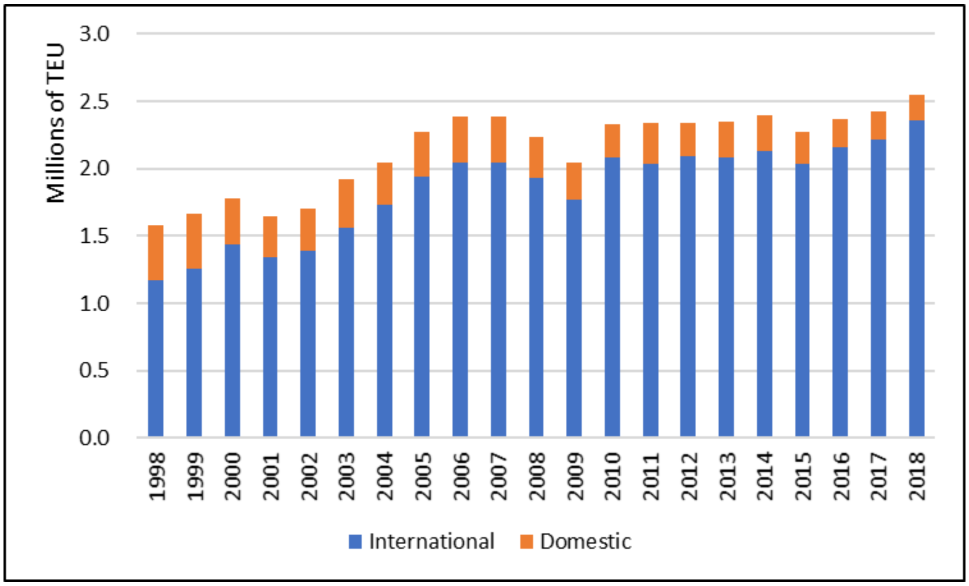
Exhibit 45: Port of Oakland International vs. Domestic Loaded TEU Growth, 2015-2018



Recent Container Cargo Flows

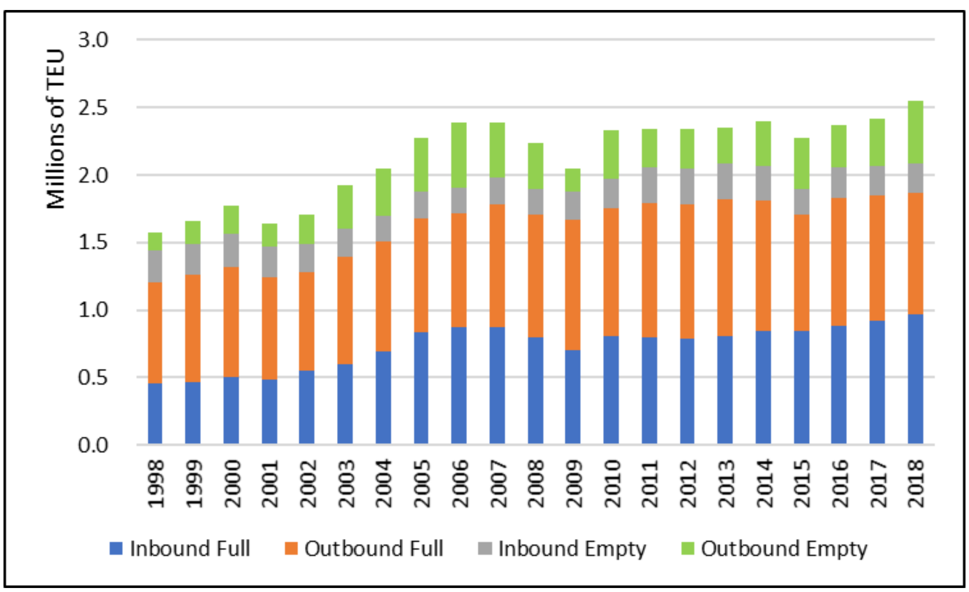
The Port of Oakland moved a total of 2.55 million TEU in 2018, comprised of 2.36 million international TEU and 189,443 domestic TEU. The share of the total containers handled at the Port of Oakland that are international has increased in all but three of the past 20 years, growing from 75.7% in 1999 to 92.6% in 2018 (Exhibit 46). The total number of TEU handled has increased at an annual rate of 1.1% since 2010, with international TEU increasing at an annual rate of 1.6% compared to an annual 3.4% decrease in domestic TEU.

Exhibit 46: Port of Oakland Container Trade by Type, 1998-2018



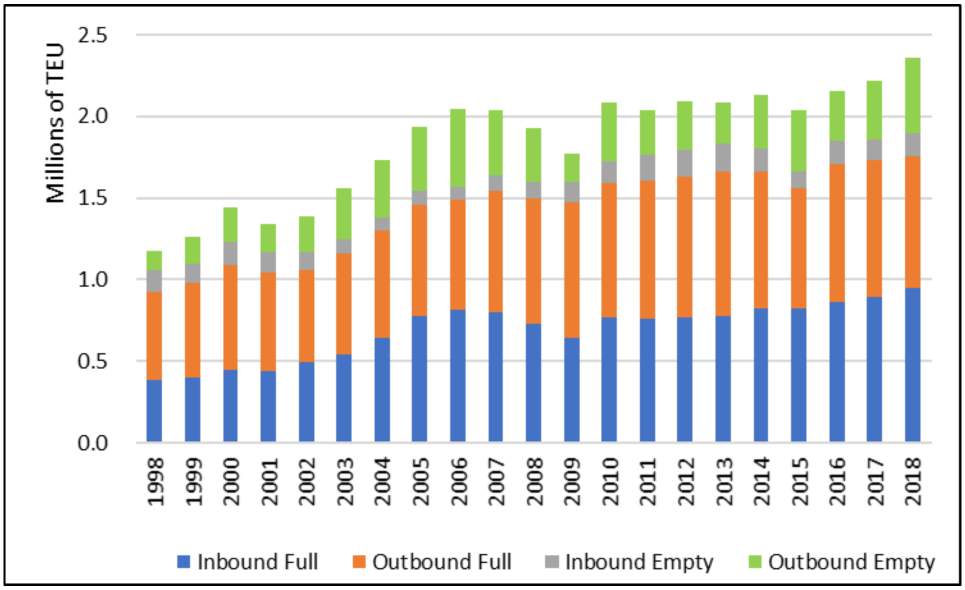
The mix of loaded and empty containers handled by the port varies by the direction of trade. The Port of Oakland handled 1.86 million loaded TEU in 2018 and 682,995 empty TEU, which equates to a 73% to 27% split (Exhibit 47). Loaded containers were almost evenly split between inbound and outbound moves, with 52% of loaded containers inbound compared to 48% that were outbound. The same was not true with empty containers, with just 32% of the total inbound compared to 68% that were outbound. Inbound loaded TEU have increased at an annual rate of 2.3% since 2010, while outbound loaded TEU have decreased at an annual rate of 0.8%. In contrast, inbound empty TEU have increased at an annual rate of 0.5% since 2010, while outbound empty TEU have increased at an annual rate of 3.1%.

Exhibit 47: Port of Oakland Total Container Trade by Direction, 1998-2018



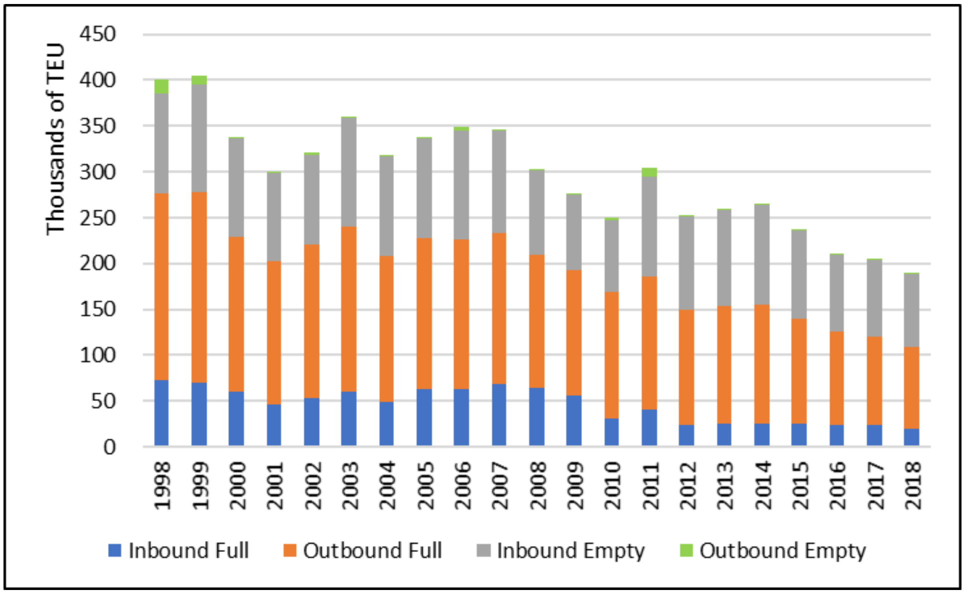
The Port of Oakland handled 1.75 million loaded international TEU in 2018 and 602,409 empty international TEU, which equates to a 74% to 26% split, with 54% of loaded containers inbound compared to 46% that were outbound (Exhibit 48). Empty containers were again dominated by the outbound trade: 77% were outbound compared to just 23% inbound. Inbound loaded TEU have increased at an annual rate of 2.6% since 2010, while outbound loaded TEU have decreased at an annual rate of 0.2%. In contrast, inbound empty TEU have increased at an annual rate of 0.7% since 2010, while outbound empty TEU have increased at an annual rate of 3.2%.

Exhibit 48: Port of Oakland International Container Trade by Direction, 1998-2018



Total domestic volumes at the Port of Oakland have decreased in 12 of the last 20 years. The Port handled 108,857 loaded domestic TEU in 2018 and 80,586 empty domestic TEU, which equates to a 57% to 43% split (Exhibit 49). The direction of trade had a major impact on the percentage of containers that are loaded. For domestic loaded containers, 17% of TEU were inbound compared to 83% that were outbound, while for empty containers 98% of TEU were inbound compared to just 2% that were outbound. Inbound loaded TEU have decreased at an annual rate of 6.0% since 2010, while outbound loaded TEU have decreased at an annual rate of 5.2%. In contrast, inbound empty TEU have increased at an annual rate of 0.2% since 2010, although outbound empty TEU have decreased at an annual rate of 6.9%.

Exhibit 49: Port of Oakland Domestic Container Trade by Direction, 1998-2018



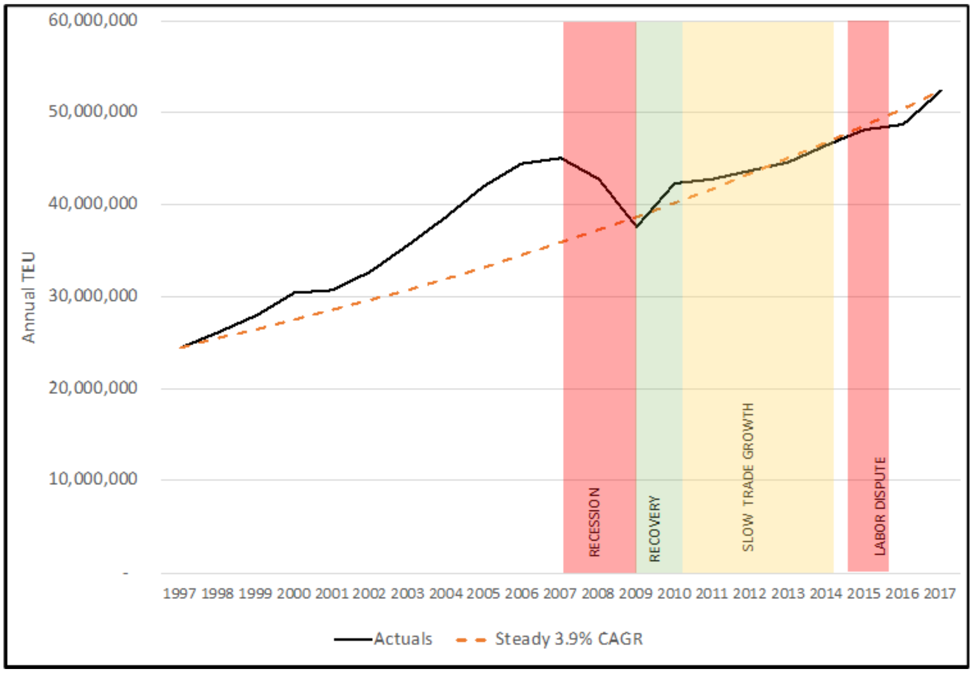
Containerized Shipping Trends

Overall U.S. Container Trade Growth

Overall U.S. container trade grew at an average compound annual growth rate (CAGR) of 3.9% since 1997. As Exhibit 50 shows, that growth has been uneven.

- After the brief "dot com" recession in 2001 U.S. container trade grew rapidly, reaching a new peak in 2007.
- The 2008–2009 recession led to a drastic drop in container trade.
- Post-recession recovery in 2010 was initially dramatic, but contrary to widespread expectations growth thereafter was much slower than before the recession. The 2007 peak was not regained until 2014.
- In late 2014 and early 2015, a prolonged dispute between management and labor at West Coast ports slowed trade growth.
- Recent industry forecasts anticipate that near-term growth will be slower than the long-term average.

Exhibit 50: U.S. Containerized Trade Growth, 1997-2018



"Frontloading" Imports

Late 2018 saw a strong influx of Asian imports due to import "frontloading" – increasing inventory in advance of announced or potential tariff actions. This short-term trend affected Southern California ports more than Oakland, although TEU imports to Oakland posted year-on-year growth of 15% and 11% respectively.

"Frontloading" has apparently abated in 2019. The tariff situation remains volatile, even unpredictable as of spring 2019. "Frontloading" is intrinsically a short-term trend, limited by the ability of the U.S. distribution system to absorb inventory and inventory cost.

Within the forecast context, frontloading can best be viewed as a shift of trade from later to earlier dates. This view assumes that the inventory amassed in late 2018 is a substitute for imports that would otherwise have arrived in 2019. Thus, while trade policy shifts will affect long-term cargo trends, the practice of frontloading should not.

Frontloading did, however, create a short-term cargo surge at the California ports that stressed port capacity. In that regard frontloading can be considered one source of potential surges in the future.

Empty Container Trends

Containers move both loaded and empty. Many trade forecasts include only loaded (full) container cargo movements, as those moves generate revenue for ocean carriers and tend to grow with overall economic development and demand.

For the Seaport Plan, however, it is necessary to forecast empty container movements as well. Empty containers require just as much space on vessels, in terminals, and on highways and railroads. Although the rates charged may be lower, the work involved in moving empty containers through marine terminals is similar to the work required for loaded containers.

While loaded container movements are driven by the need to move goods between origin and destination and by routing choices in between, empty container movements typically reflect:

- Imbalances between inbound and outbound cargo flows.
- Need for specialized container types (notably refrigerated containers) in specific export regions.
- Demand for container capacity at overseas origin points.
- Space available on vessels.
- The relative cost of re-positioning empty containers by various routes.
- Strategies and policies of container fleet owners (ocean carriers and leasing companies).

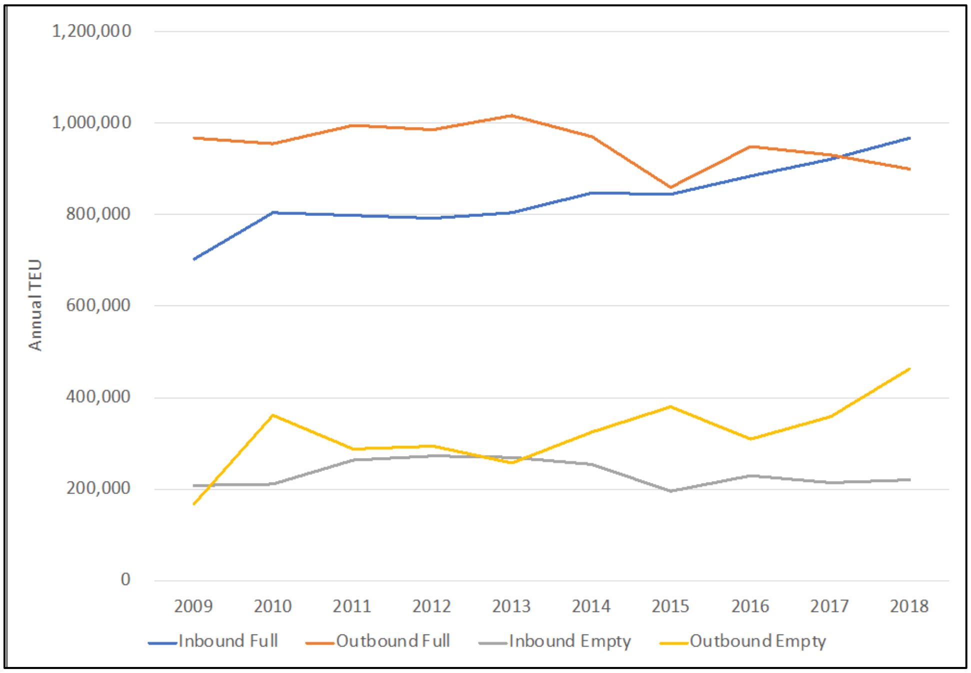
Oakland has substantial flows of both inbound and outbound empty containers (Exhibit 51). The Southern California ports, in contrast, have massive outbound empty container movements due to their import/export imbalance, and minimal inbound empties.

Exhibit 51: Port of Oakland Loaded and Empty TEU, 2009-2018

		Annual Total TEU			
Year	**Inbound Full**	**Outbound Full**	**Inbound Empty**	**Outbound Empty**	**Total**
2009	701,501	966,882	209,258	167,570	2,045,211
2010	802,657	955,579	209,878	362,343	2,330,457
2011	797,272	993,826	264,471	286,957	2,342,526
2012	791,672	986,452	271,068	294,711	2,343,903
2013	803,314	1,014,796	270,535	257,919	2,346,564
2014	845,810	969,378	254,636	324,245	2,394,069
2015	844,234	858,146	196,677	378,464	2,277,521
2016	883,748	947,968	227,816	310,044	2,369,576
2017	919,524	930,826	213,381	357,105	2,420,837
2018	965,552	897,804	218,968	464,027	2,546,351
2010-2018 CAGR	**2.3%**	**-0.8%**	**0.5%**	**3.1%**	**1.1%**

The growth rates in Exhibit 51 and the patterns in Exhibit 52 imply a complex relationship between loaded and empty container moves.

Exhibit 52: Port of Oakland Total Loaded and Empty TEU Chart, 2009-2018



International Loads and Empties

Oakland's domestic and international cargo flows have different growth patterns, as noted earlier. Accordingly, the consultant team split the international and domestic empty flows for separate analysis. Exhibit 53 shows the international containerized data for 2009–2018. The 2009 recession data, grayed out in the tables, would artificially boost the apparent growth rate and has been left out of the CAGR calculations, but has been shown in the trend graphs to illustrate the post-recession changes.

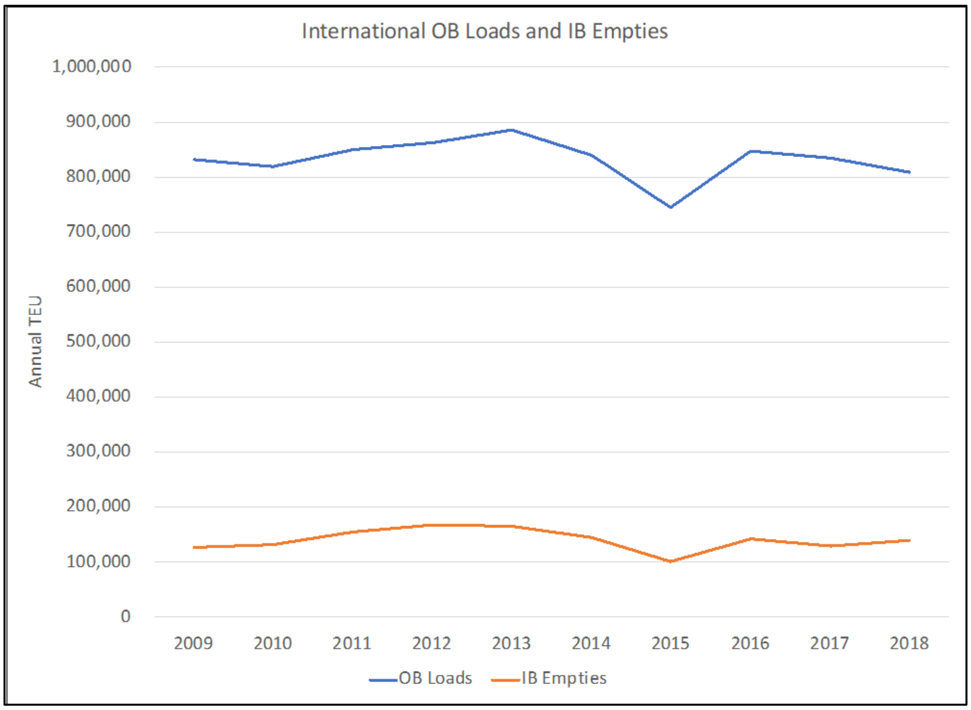
Exhibit 53: Port of Oakland International Loaded and Empty TEU, 2009-2018

	Annual International TEU				
Year	**Inbound Full**	**Outbound Full**	**Inbound Empty**	**Outbound Empty**	**Total**
2009	644,904	830,297	127,288	165,931	1,768,420
2010	771,343	817,822	131,614	359,979	2,080,758
2011	756,338	849,162	155,045	278,023	2,038,568
2012	767,152	861,502	169,169	293,302	2,091,125
2013	778,523	886,062	165,243	256,833	2,086,661
2014	820,975	838,686	146,141	323,419	2,129,221
2015	819,406	743,282	100,327	376,706	2,039,721
2016	860,432	846,051	143,540	308,556	2,158,579
2017	896,172	833,616	129,705	355,476	2,214,969
2018	946,524	807,975	139,719	462,690	2,356,908
2010-2018 CAGR	**2.6%**	**-0.2%**	**0.7%**	**3.2%**	**1.6%**

The growth rates for inbound loads and outbound empties are similar, as are those for the outbound loads and inbound empties.

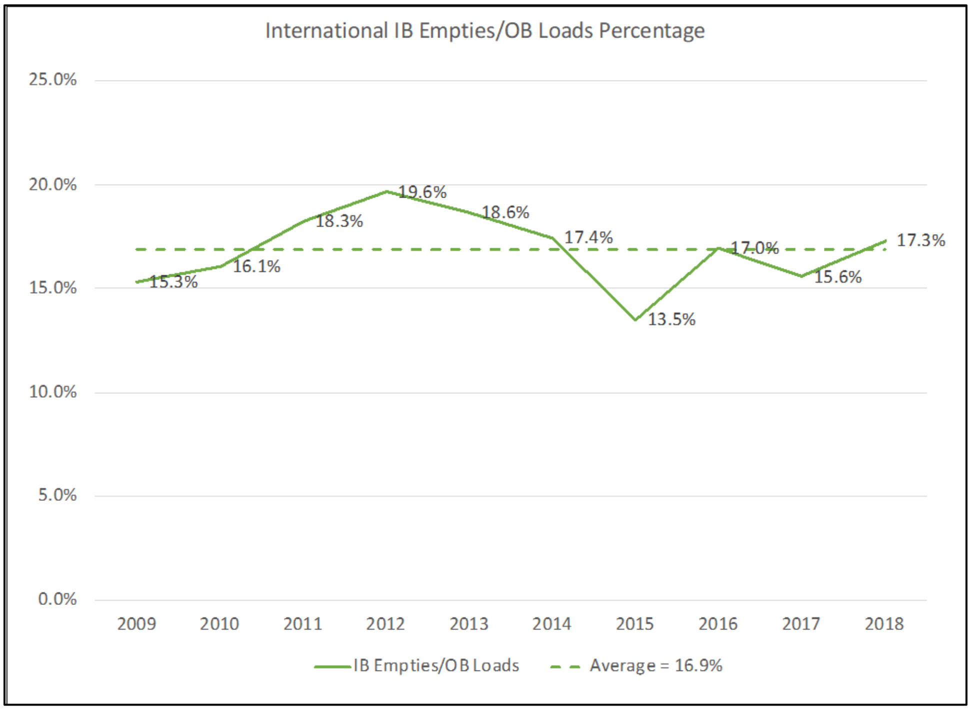
Isolating the inbound empties and the outbound loads in Exhibit 54 highlights that pattern and suggests that empties are moved inbound to supply the needs of outbound shippers – exporters. Most of the exporters' requirements are met by empty containers available locally from import loads. There are a number of reasons why an exporter may not be able to use an empty import container for an outbound load, including ownership, location, size, type, and timing. One reason for bringing in empties is to supply refrigerated containers for California exporters.

Exhibit 54: Port of Oakland International Outbound Loads and Inbound Empties, 2009-2018



The ratio of inbound international empties to outbound loads averaged 16.9% between 2009 and 2018. Exhibit 55 shows that the ratio has moved back and forth in a fairly narrow range, with only a slight upward trend (due in part to the low, recession-era value in 2009).

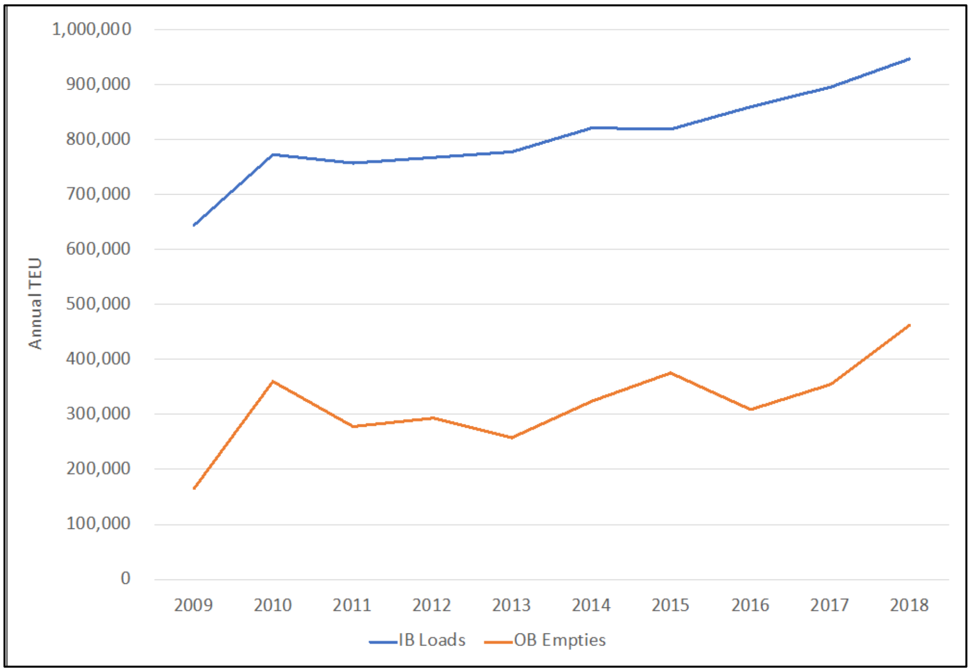
Exhibit 55: Port of Oakland Relationship of International Inbound Empties to Outbound Loads, 2009-2018



International outbound empty volumes tend to move with international inbound loaded volumes (Exhibit 56). In most ports, outbound empties are generated by the excess of imports over exports. In Oakland there are two reasons:

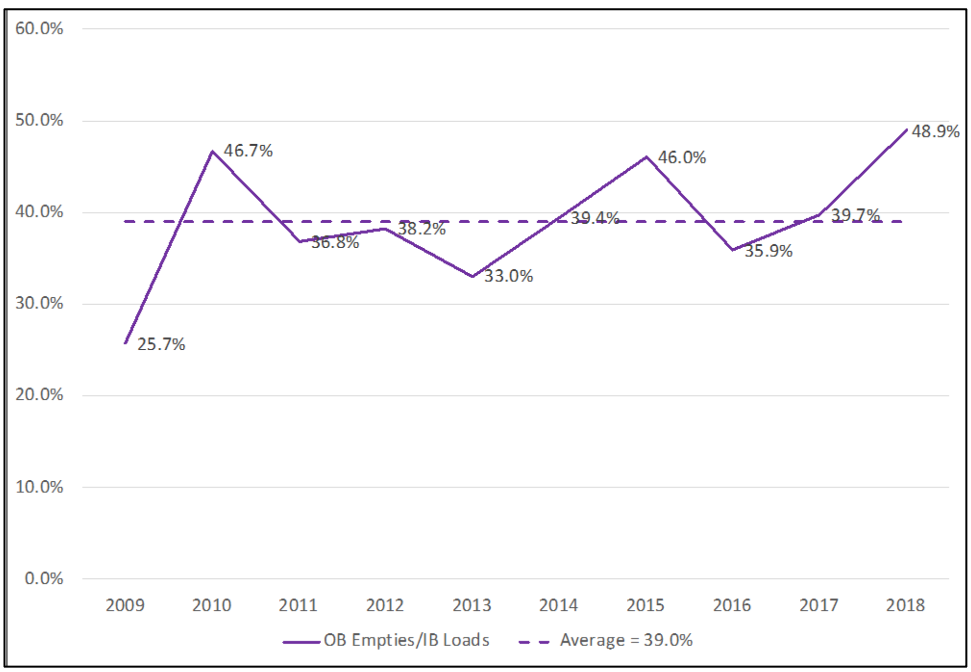
- Exporters cannot always use empty import containers for export loads, and the excess empties are returned to origin.
- Oakland is often the last West Coast port of call before vessels return to Asia, so ocean carriers return excess empty containers from other areas through Oakland. At the start of March 2019, 16 of the 17 services between the Far East and Oakland had Oakland as the final West Coast call.

Exhibit 56: Port of Oakland International Inbound Loads and Outbound Empties, 2009-2018



Outbound empties averaged 39.0% of inbound loads between 2009 and 2018. Exhibit 57 again shows a slight upward trend, due mostly to inclusion of the low 2009 value.

Exhibit 57: Relationship of International Outbound Empties to Inbound Loads at Port of Oakland, 2009-2018



The net outbound international empty movement in Exhibit 58 means that Oakland has been "exporting" an average of 202,581 TEU, or an estimated 115,761 containers each year. Based on contacts with ocean carriers and other stakeholders, the consultant team confirmed that at least some ocean carriers reposition empty containers from inland regions by rail to take advantage of Oakland's "last port of call" position.

Exhibit 58: Port of Oakland International Container Imbalance, 2009-2018

		International Container	Trade	
Year	**Inbound Loaded & Empty**	**Outbound Loaded & Empty**	**Net Outbound TEU**	**Est. Net Outbound Containers @ 1.75**
2009	772,192	996,228	224,036	128,021
2010	902,957	1,177,801	274,844	157,054
2011	911,383	1,127,185	215,802	123,315
2012	936,321	1,154,804	218,483	124,847
2013	943,766	1,142,895	199,129	113,788
2014	967,116	1,162,105	194,989	111,422
2015	919,733	1,119,988	200,255	114,431
2016	1,003,972	1,154,607	150,635	86,077
2017	1,025,877	1,189,092	163,215	93,266
2018	1,086,243	1,270,665	184,422	105,384
Average	**946,956**	**1,149,537**	**202,581**	**115,761**

Domestic Loads and Empties

Exhibit 59 shows the domestic containerized data for 2009–2018. As was the case with the international data in Exhibit 53, the 2009 recession data is grayed out and has been left out of the CAGR calculations. Domestic service from Oakland is primarily offered by two U.S. flag carriers (Pasha and Matson) and serves the Hawaiian market. In 2018 the two lines together offered three calls per week. The number of loaded domestic containers handled at Oakland has decreased markedly in both directions over the last ten years, with the reduced rates for inbound loads (full) and outbound loads similar to outbound empties; only inbound empties posted growth since 2010 (although there have been declines in each of the past four years). This decrease is primarily due to an apparent loss of market share to Southern California.

Exhibit 59: Port of Oakland Domestic Loaded and Empty TEU, 2009-2018

Year	Inbound Full	Outbound Full	Inbound Empty	Outbound Empty	Total
		Annual Domestic TEU			
2009	56,597	136,585	81,970	1,639	276,791
2010	31,314	137,757	78,264	2,364	249,699
2011	40,934	144,664	109,426	8,934	303,958
2012	24,520	124,950	101,899	1,409	252,778
2013	24,791	128,734	105,292	1,086	259,903
2014	24,835	130,692	108,495	826	264,848
2015	24,828	114,864	96,350	1,758	237,800
2016	23,316	101,917	84,276	1,488	210,997
2017	23,353	97,210	83,676	1,629	205,868
2018	19,028	89,829	79,249	1,338	189,443
2010-2018 CAGR	**-6.0%**	**-5.2%**	**0.2%**	**-6.9%**	**-3.4%**

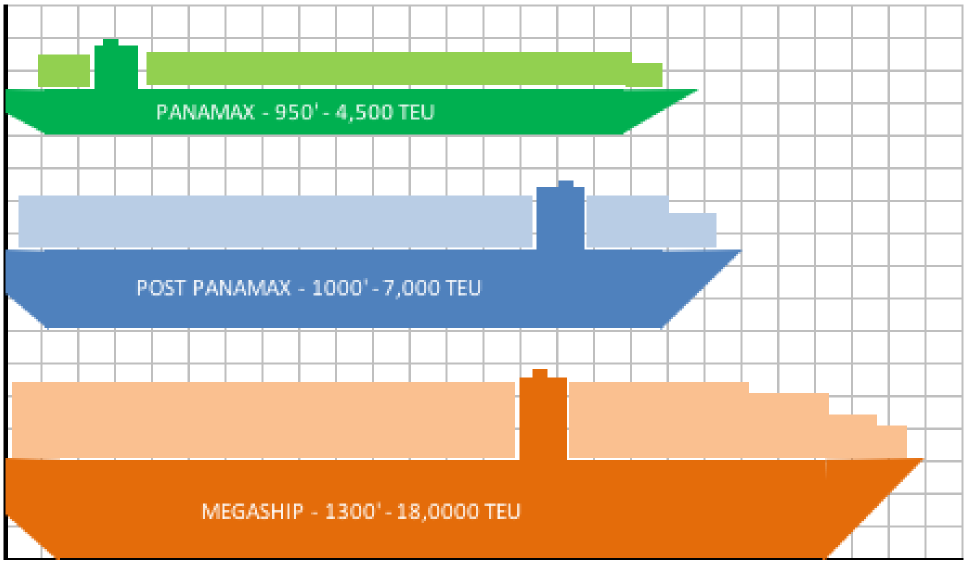
Container Vessel Size

Average and maximum container ship sizes are both increasing due to the introduction of "megaships" with capacity of up to 22,000 TEU. Exhibit 60 shows the progression of vessel sizes, and Exhibit 61 provides a graphical comparison.

Exhibit 60: Container Vessel Sizes

Vessel Class	Capacity (TEU)	Containers Across	Draft (feet)	Beam (feet)	Length Overall (feet)	Air Draft (feet)	LOA Feet	Berth Feet
Panamax	4,000	15	40	105	950	117	950	1,055
Post-Panamax	7,000	17	49	141	1,000	138	1,000	1,141
Super Post-Panamax	9,000	19	50	158	1,200	159	1,200	1,358
Neo Panamax	13,000	20	50	160	1,200	164	1,200	1,361
Megaship	18,000	23	52	193	1,300	187	1,300	1,493

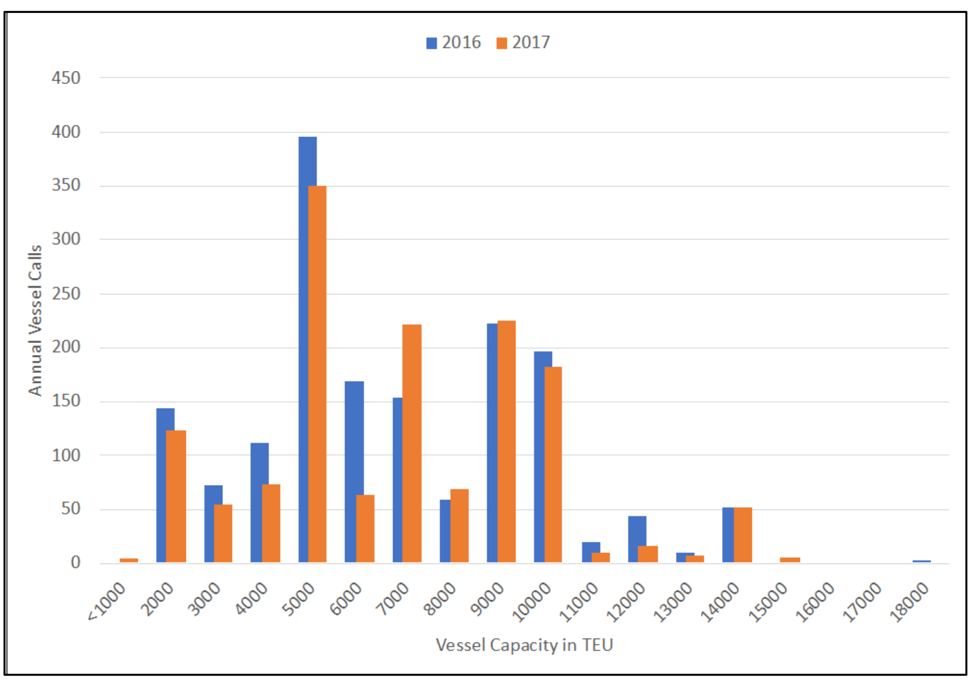
Exhibit 61: Vessel Size Graphics



The push toward larger container ships is driven by ocean carrier pursuit of scale economies in an era of low profit margins. Thus far the largest container vessels have been deployed in Asia-Europe trades, where the very long voyages can best exploit scale economies.

Exhibit 62 shows the distribution of container vessel sizes calling at Oakland in 2016 and 2017, based on data available from the federal AIS system. Because of the large number of vessels and vessel calls, the average size grows slowly - from 6,179 TEU in 2016 to 6,333 TEU in 2017. At the start of March 2019, Oakland had seven services to/from the Far East that utilized vessels with a capacity of at least 10,000 TEU, of which five utilized at least one vessel with a capacity of 13,000 TEU or more.

Exhibit 62: 2016-2017 Oakland Container Vessel Sizes



The larger vessels need greater berth length. The industry rule of thumb is that a vessel requires berth space equal to its own length plus its breadth (Exhibit 63). A 1300-foot, 18,000 TEU vessel, for example, would require about 1,493 feet of berth space.

Exhibit 63: Container Vessel Berth Requirements

Vessel Class	TEU Capacity	Vessel LOA Feet	Vessel Beam Feet	Berth Feet
Panamax	4,000	950	105	1,055
Post-Panamax	7,000	1,000	141	1,141
Megaship	18,000	1,300	193	1,493

In 2017, the average length of vessels calling Oakland was 962 feet, up about 1% from 957 feet in 2016.

The *APL Florida* (Exhibit 64) made three Oakland calls in 2017 and is typical of the average container vessel at 6,350 TEU with a length of 961 feet, beam of 131 feet, and design draft of 40.4 feet. This vessel would require 1,092 feet of berth space (vessel length plus vessel beam).

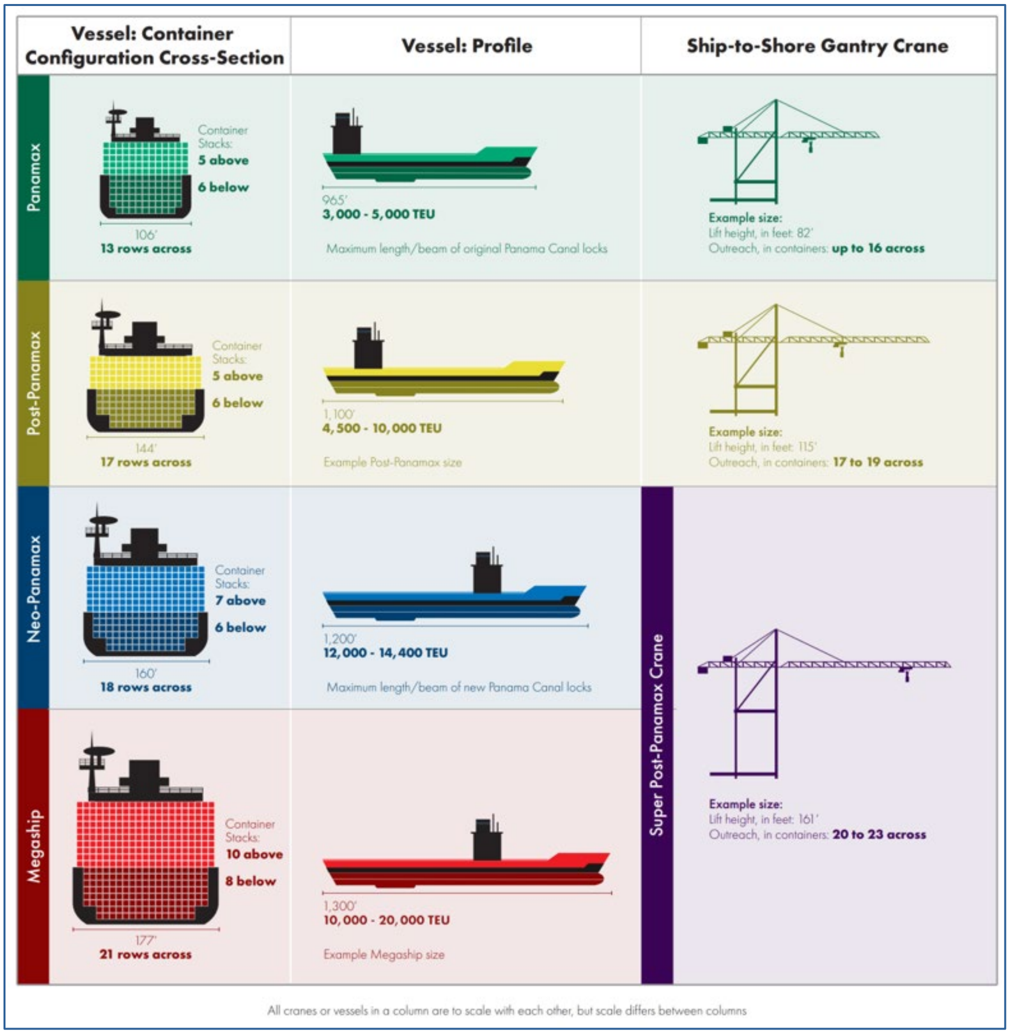
Exhibit 64: APL Florida: Typical of Oakland Vessel Calls

The largest vessel calling at Oakland in 2017 was the *COSCO Himalayas*, at 14,568 TEU with length of 1200 feet, beam of 168 feet, and design draft of 51 feet (Exhibit 65). This vessel would require 1,368 feet of berth space (vessel length plus vessel beam).

Exhibit 65: COSCO Himalayas, Largest 2017 Vessel at Oakland

Larger vessels also need more cranes, and larger cranes. As shown in Exhibit 66, so-called "super post-Panamax" cranes that serve megaships must be higher and have greater outreach.

Exhibit 66: Vessel and Crane Dimensions



Oakland's current (early 2019) crane inventory is shown in Exhibit 67.

Exhibit 67: Port of Oakland Ship-to-Shore Cranes

	Crane Type		
Terminal	**Panamax**	**Post-Panamax**	**Super Post-Panamax**
OICT	-	-	10
TraPac	-	5	2
Ben E. Nutter	-	1	3
Matson	-	4	-
Berth 20-24	-	4	-
Howard	3	1	-
Total	**3**	**15**	**15**

As of late 2019, there were 3 super post-Panamax cranes on order to replace three older cranes at OICT.

Marine terminals typically use more cranes to discharge and load larger ships within the scheduled port call. Port terminals that discharge or load a large proportion of the vessel's capacity may use 6-7 cranes on the largest vessels. Terminals can use fewer cranes if they are handling less of the vessel's capacity or have a longer vessel call.

Larger container ships also tend to create cargo surges. The larger vessels are operated and shared by ocean carrier alliances. Megaship deployment may thus concentrate cargo that was formerly handled on different days, or different vessels, at different terminals, in a single call at one terminal. As the data in Exhibit 68 and the chart in Exhibit 69 show, the number of vessel calls at Oakland has been decreasing despite cargo growth, and the average vessel size and container volume handled per vessel call have been rising.

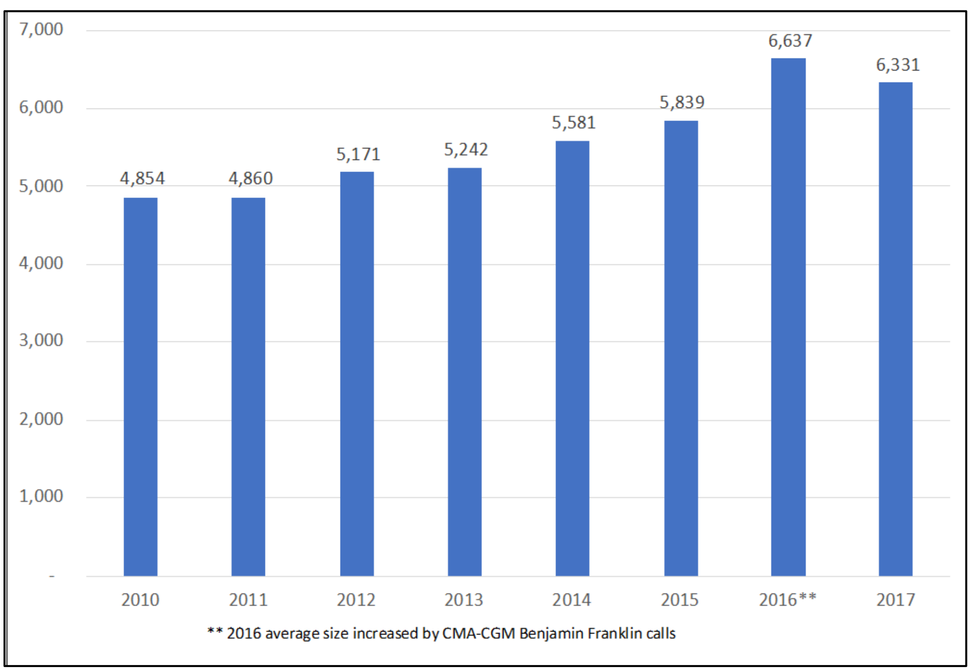
Exhibit 68: Oakland Vessel Calls and Average Cargo Volumes

Year	Container Vessel Calls	Average Vessel TEU*	Port TEU	TEU/Call
2010	1,741	4,854	2,330,457	1,339
2011	2,187	4,860	2,342,526	1,071
2012	1,635	5,171	2,343,903	1,434
2013	1,780	5,242	2,346,564	1,318
2014	1,659	5,581	2,394,069	1,443
2015	1,371	5,839	2,277,521	1,661
2016**	1,735	6,637	2,369,576	1,366
2017	1,458	6,331	2,420,837	1,660

* Vessel TEU estimated from vessel deadweight tons in 2013-2015

** 2016 average size increased by CMA-CGM Benjamin Franklin calls

Exhibit 69: Average Container Vessel Size in TEU at Port of Oakland



The largest vessels handled are much larger than the averages shown. Maximums are not readily available for all years. The largest vessels in recent years were:

- 2016: *CMA-CGM Benjamin Franklin* at 17,859 TEU
- 2017: *COSCO Himalayas* at 14,568 TEU (Exhibit 65)
- 2018: *CMA-CGM Thomas Jefferson* at 14,414 TEU

Cargo surges create container volume peaks that can stress terminal capacity:

- Export and outbound empties are typically received and staged in the container yard before the vessel arrives, and as it is being discharged.
- Inbound loaded containers are discharged and typically spend 1–5 days in the yard before being delivered to customers.

The number of containers in the terminal thus tends to peak as the vessel is being discharged.

Larger vessels also require more space to maneuver, specifically in turning basins. When the 1,310 foot Benjamin Franklin called at Oakland's OICT in 2016, the vessel required extra tug assist to be turned outside the Estuary. The Port has planned to widen the Inner Harbor Turning Basin to accommodate larger vessels.

Terminal Efficiency

There is a worldwide trend toward greater automation and reliance on information technology in container terminals. The trend, however, is far from uniform in either its application or its implications.

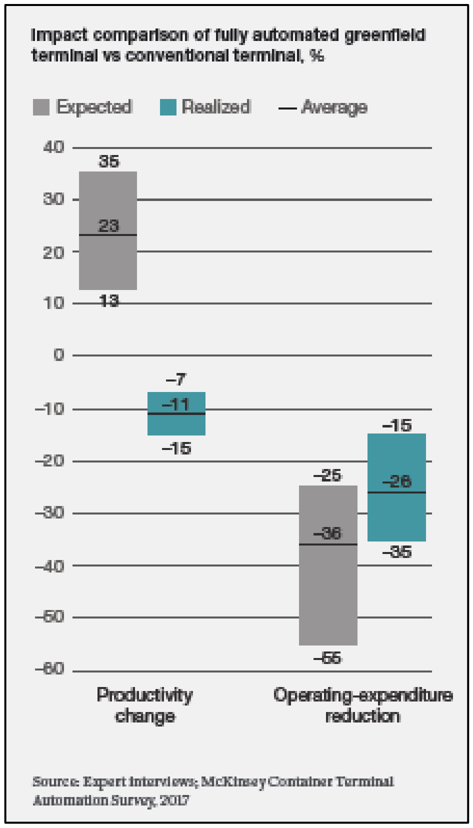
Automation

"Automation" can vary from common applications such as optical character recognition (OCR) at entry gates to fully automated container yard operations with automated vehicles transferring containers to and from wharf-side gantries.

There are two "automated" terminals in the U.S.: the Long Beach Container Terminal (LBCT) at Long Beach, and the TraPac terminal at Los Angeles. Both terminals use automated stacking cranes (ASCs) in the container yard, and automated guided vehicles (AGVs) to shuttle containers between the container yard and the manually operated container cranes. This approach to automation requires a completely new terminal (or a complete rebuild of an existing terminal) to provide tracks for the ASCs and guidance sensors embedded in the pavement for the AGVs. The total cost of the 311-acre LBCT is expected to be about $2.1 billion, including equipment, or about $6.75 million per acre. At full buildout LBCT is expected to have a capacity of 3.3 million annual TEU, or about 10,600 TEU per acre.

There are growing concerns within the industry, however, that extensive terminal automation is not generating the expected benefits. A recent report by McKinsey documented these concerns in survey responses (Exhibit 70). Respondents reported less-than-expected productivity improvements (productivity losses, actually) and less than expected cost savings.

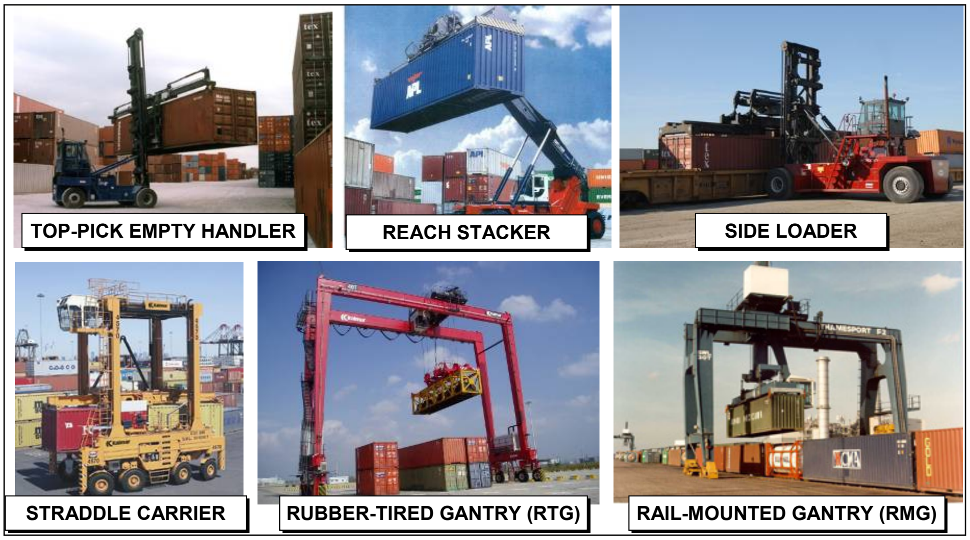
Exhibit 70: McKinsey Terminal Automation Survey Results



Perhaps as a consequence of lower-than-expected benefits there has been a slowdown in new automation initiatives and renewed interest in less costly approaches.

Marine container terminal operators adjust container yard (CY) storage density and stacking height by reconfiguring the CY, changing handling equipment, and varying container storage practices. Typical handling equipment types ("lift machines") are shown in Exhibit 71.

Exhibit 71: Container Yard Handling Equipment Types



APM Terminals in Los Angeles has proposed employing automated straddle carriers (auto-strads) in part of its terminal. Auto-strads do not require embedded sensors and can operate on existing pavement. However, straddle carrier operations, either automated or manned, have lower unit storage capacities than stacking cranes (Exhibit 72). Using auto-strads rather than the ASC/AGV approach at LBCT and TraPac at Los Angeles lowers capital costs and should yield many of the same cost savings, but accepts reduced terminal storage density in exchange.

Exhibit 72: Typical CY Storage Densities

CY Storage Method	TEU Slots per Acre
Wheeled Chassis	80
Grounded Straddle Carrier	160
Grounded Stacked	200
Grounded RTG	300
Grounded RMG	360

The auto-strad strategy relies on reduced container dwell time to improve velocity and achieve comparable throughput with lower storage capacity than ASCs. Auto-strad systems require advanced information systems to inform drayage operators of container availability as soon as possible after vessel arrival. This information should, in turn, allow draymen to begin pulling import containers earlier than in other systems. The favorable results, however, still rely on the availability of sufficient drayage capacity and the ability and willingness of importers to receive the cargo. The auto-strad technology is not yet used in North America. The leading examples are at Brisbane and Sydney, Australia. This less capital-intensive approach, however, requires greater terminal acreage – more land – to achieve the same end capacity.

The more comprehensive automation approaches, as at LBCT, increase capacity while reducing unit cost. The capacity increase comes from denser storage patterns and, it is hoped, reduced container dwell times. The cost reductions are achieved largely through reduced manning.

It is notable that the recent expansion and upgrade of the Oakland TraPac terminal did not include significant automation, unlike the TraPac terminal in Los Angeles.

The degree of terminal automation eventually implemented will likely depend on cargo volume. The McKinsey report found that full automation could yield substantial benefits for a "medium-sized" terminal of 6-8 million annual TEU. In 2018, Oakland's largest volume was at OICT, with 1.6 million TEU.

Information Technology

The application of advanced information technology (IT) solutions is an integral part of increased container terminal productivity. The "paperwork" required to ship, clear, transfer, and receive containers is now almost completely electronic. Yet containers cannot move, operators cannot manage terminals, and drayage firms cannot retrieve and deliver containers until the electronic "paperwork" chain is complete.

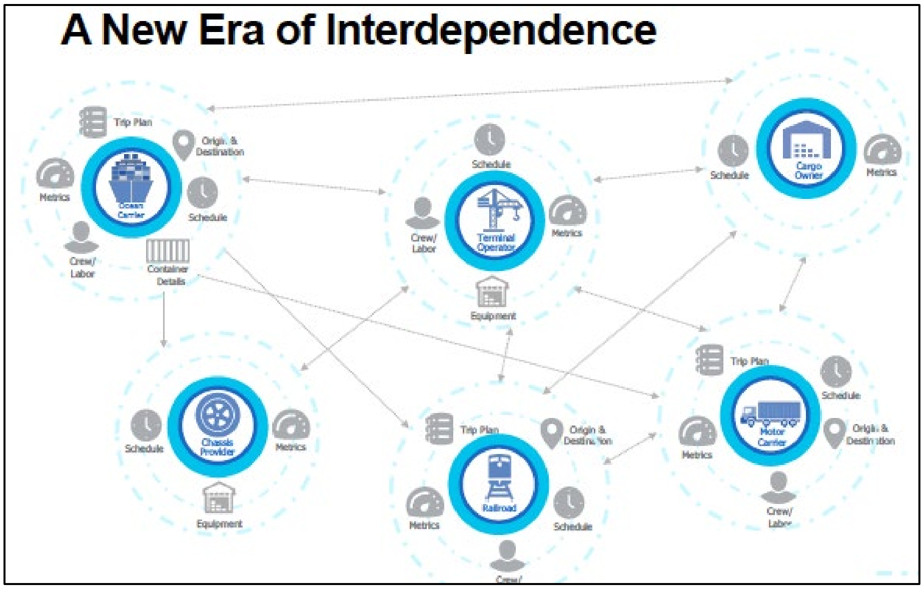
Ports and terminals around the world are looking to advanced IT applications to digitalize container shipping transactions and communications. Among the relevant goals are:

- Accelerating import container availability after vessel arrival. The faster availability can be established and communicated, the faster draymen can pick up containers and the higher the terminal throughput.
- Reducing errors. Previous studies have established that processing errors and failed transactions that result in "trouble tickets" account for about 5% of all moves, but consume about 15% of overall truck turn time.
- Supporting terminal and drayage operating plans. Both terminal operators and trucking firms make daily plans, but those plans are routinely disrupted by unpredictable conditions. By providing a more accurate and reliable information source IT solutions encourage better planning and better adherence to plans.
- Reducing double-handling and "digging". The post-recession shift from wheeled to stacked terminals has led to extra container handling when equipment operations must "dig" through stacks of containers to locate the right unit. Re-handling in this manner raises costs, extends drayage turn times, raises container dwell times, and reduces terminal throughput.
- Increased use of appointment systems. Terminal operators are increasingly requiring draymen to make appointments to pick up import containers. Appointment systems assist in leveling truck arrivals over terminal idle hours and between day and evening shifts. Appointment systems are far from perfect, however, and will need additional development.

IT initiatives are being pursued at both the terminal and port levels.

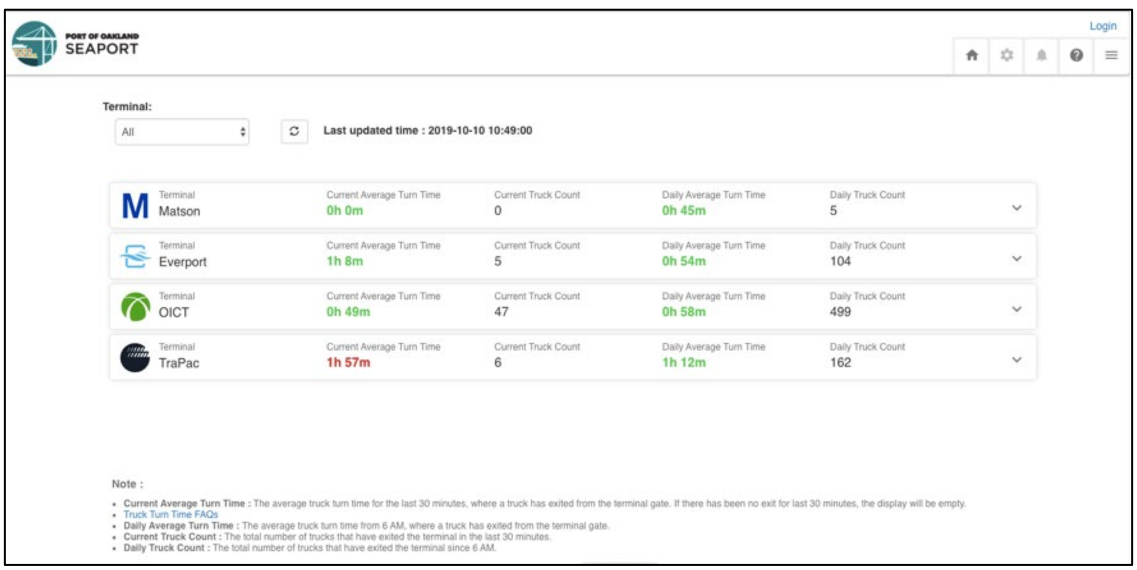
- Terminal IT solutions include advanced terminal management information systems (TMIS) that incorporate IT advances in successive versions. Navis, a part of Cargotec Corporation headquartered in Oakland, is the leading independent provider. Some terminal operators develop their own systems, such as the Forecast System developed by Tideworks, an affiliate of SSA.
- Port authority systems include both terminal systems (where an operating port authority also operates terminals) and higher level systems that cross terminal boundaries (where a landlord port does not directly operate terminals). The Port of Vancouver's truck turn time system is one example, as is the Port of New York-New Jersey's Terminal Information Portal System (TIPS).
- Port Community Systems overlap and link terminal, port, and stakeholder systems. The NYNJ TIPS system performs some community functions, but the most prominent such system is Port Optimizer initiated by the Port of Los Angeles and expanding to cover the port of Long Beach. As Exhibit 73 shows, this system attempts to facilitate communication and data exchange between the participants in container shipping. Port Optimizer includes Automated Programming Interfaces (APIs) to integrate with stakeholder systems.

Exhibit 73: Port Optimizer Linkages



The Port of Oakland and the Oakland terminal operators have moved in this direction. Oakland terminal operators have implemented new TMIS versions and features, and as of mid-2019 all use the eModal truck appointment system. The Port itself contracted with eModal to develop the Oakland Portal, which has begun providing terminal information and truck turn time data (Exhibit 74). The Port intends to add functionality to the Oakland Portal in the future.

Exhibit 74: Port of Oakland Portal



The Port of Oakland's GoPort program will use funding from the Alameda County Transportation Commission and federal sources to develop and deploy a Freight Intelligent Transportation System (FITS) and a Technology Master Plan (TMP). The FITS/TMP initiative covers smart traffic signals, changeable message signs, incident response, truck parking management, and other measures to improve the flow and reliability of truck movements to and from Oakland terminals.

Container Port Competition

There has been a recent downward trend in U.S. West Coast shares of total U.S. container trade and of transpacific container trade.

The Port of Oakland handles nearly all containerized imports and exports for Northern California, as well as some intermodal cargo moving to and from inland points. Oakland competes for different trade flows in different ways.

California container ports compete with other U.S. and North American ports in two ways:

- California ports compete for "discretionary" container traffic that can move by rail to other regions through any one of several ports. For example, Oakland competes for Asian imports to Midwestern consumer markets with the ports of Los Angeles, Long Beach, Vancouver, Prince Rupert, New York-New Jersey, Baltimore, and Virginia.
- California ports compete with other regions for the location of import distribution centers (DCs) and their inbound trade flows. For example, San Joaquin County might compete with Georgia for a new import DC that would bring in goods through either Oakland or Savannah.

In the case of discretionary cargo, economic activity and employment at the port and in the transportation network are at risk due to competition with other ports. In the case of an import DC location, economic activity and employment at the DC itself are also at risk, due to competition with other regions.

For exports, Oakland's geographic position near California agricultural production gives it an advantage. Oakland is also often the last port of call before vessels return to Asia, providing a later and faster shipping option for exporters. As a result, Oakland is one of few U.S. ports where containerized exports often exceed imports.

The large local and regional markets in Southern California draw many first inbound vessel calls to Los Angeles and Long Beach. Inland importers use these vessel schedules to get the fastest service from Asia. However, Pacific Northwest and British Columbia ports have faster sailing times from ports in North Asia (e.g. Korea, Japan, Northern China), giving these ports a transit time advantage over California ports for discretionary intermodal imports. Some services call at ports in British Columbia ahead of Southern California, combining the shorter transit time with the faster vessel schedule.

There is overlap between the Oakland, Los Angeles, and Long Beach markets in the Central and Southern San Joaquin Valley. There, importers and exporters may choose ports based on relative trucking costs, ocean shipping costs, and timing of vessel schedules.

As

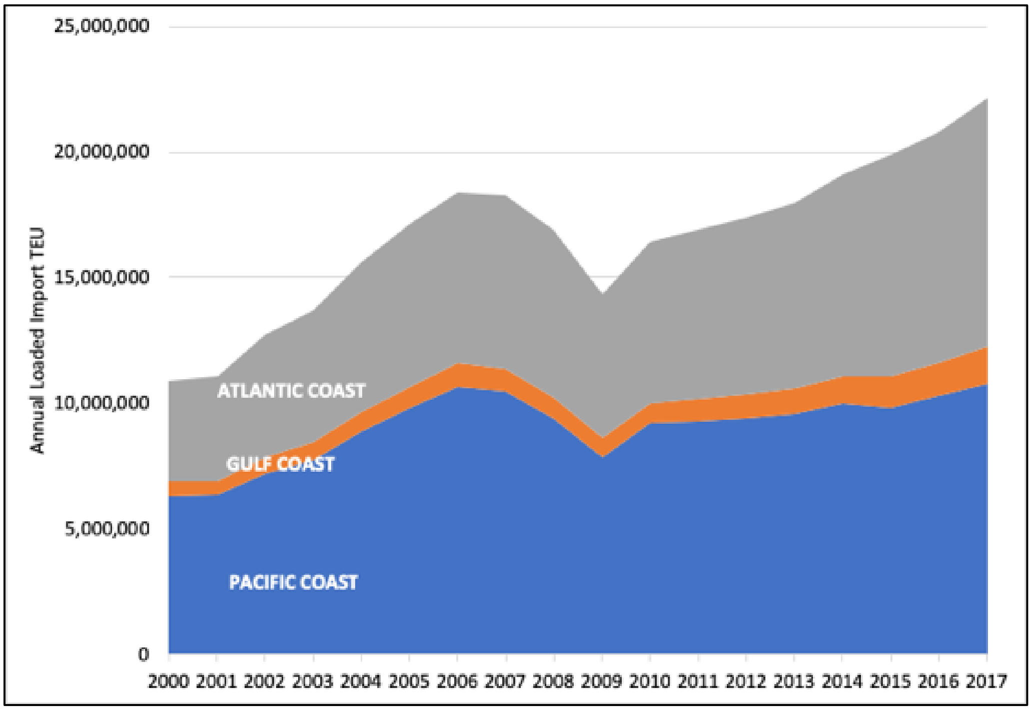
Exhibit 75 shows, the Pacific Coast ports combined had a 55 to 58 percent share of the loaded U.S. import container trade in 2000 through 2012. That share declined to 49 percent by 2017. This loss of market share has prompted concerns over the competitiveness of California's container ports.

Exhibit 75: Coastal Shares of Loaded Import TEU, 2000-2017

Coast	Pacific	Atlantic	Gulf
2000	58%	37%	5%
2001	57%	38%	5%
2002	57%	38%	5%
2003	56%	38%	5%
2004	57%	38%	5%
2005	57%	38%	5%
2006	58%	37%	5%
2007	57%	38%	5%
2008	55%	39%	5%
2009	55%	40%	5%
2010	56%	39%	5%
2011	55%	40%	5%
2012	54%	40%	5%
2013	53%	41%	6%
2014	52%	42%	6%
2015	50%	44%	6%
2016	50%	44%	6%
2017	49%	45%	7%

As Exhibit 76 reveals, however, the market share shift did not result from net cargo loss at California or Pacific Coast ports, but from faster growth at Atlantic and Gulf Coast ports. Imports on all three coasts grew rapidly up to the peak in 2006-2007, then fell off during the 2008-2009 recession. After the recession, growth resumed on all coasts (although interrupted on the West Coast by the labor-management dispute of late 2014 and early 2015).

Exhibit 76: U.S. Loaded Import TEU by Coast, 2000-2017



There was faster growth on the Atlantic and Gulf coasts for several reasons identified in the literature and trade press:

- Strong growth in the transatlantic/European and Caribbean/South American trades served by the Atlantic and Gulf ports.
- Increased use of Suez Canal routings from Southeast Asia to the U.S., driven in part by a shift of manufacturing and sourcing from China to Southeast Asia and the Indian subcontinent.
- Increased adoption of "three corner"[ii] and "four corner"[iii] logistics strategies by large importers (notably large retail chains), which dispersed import flows from the major Southern California gateway.
- A reduction in Southern California import transloading.
- Rate increases on rail intermodal service, leading ocean carriers to replace rail movements from Southern California to some inland markets with truck or rail moves from other ports.
- Rising costs of locating and operating distribution and manufacturing facilities in California, versus aggressive economic development efforts in other states such as Texas and Alabama.
- Modernization and increased capacity at Atlantic and Gulf ports.
- New Panama Canal locks permitting larger, more efficient vessels on that route.
- Increased cost at California ports due to "clean truck" requirements, PierPass/Off-Peak fees, and rising drayage costs from port and highway congestion.
- Concern over West Coast labor relations stability after the lengthy 2014-2015 dispute and accompanying shipping disruption.

Of these factors, only the last two are specific to California ports; the others are shifts in trade patterns and in the economic context in which California ports must compete.

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ii Using three import ports, such as Los Angeles, Savannah, and New York-New Jersey
iii Using four import ports, such as Los Angeles, Seattle, Savannah, and New Yok-New Jersey

Exhibit 77 provides a key perspective on the relative growth of California's container port volumes. In the rapid growth era of 1990-2007, Southern California ports outperformed the nation. Much of the cargo and share growth in that period was attributable to the rapid expansion of rail intermodal container movements through San Pedro Bay in response to the introduction and adoption of double-stack rail cars. This period also saw an increase in the practice of import transloading: bringing in international containers of imported merchandise and transferring the goods to domestic containers or trailers in Southern California. Finally, this period also saw dramatic growth in U.S. imports from China, with Southern California as the leading gateway. The Port of Oakland did not benefit as much from the expansion of intermodal traffic or transloading, and Northern California[iv] TEU totals did not grow as quickly.

Exhibit 77: Container Port Cargo Growth Rates 1990-2017

Compound Annual Growth Rate (CAGR)	1990-2007	2007-2009	2009-2017
U.S.	6.4%	-6.1%	4.4%
California	**7.9%**	**-8.4%**	**4.3%**
Southern California	8.9%	-8.9%	4.6%
Northern California	3.8%	-5.0%	2.1%
Pacific Northwest	3.6%	-8.1%	1.4%
British Columbia	11.7%	-1.3%	7.1%

U.S. container ports were hit hard by the 2008-2009 recession. Oakland's volume dropped by 14 percent during the recession, but did not grow as quickly as expected after partial recovery in 2010. The labor-management issues in late 2014 and early 2015 hampered recovery for all U.S. West Coast ports.

Exhibit 77 also highlights one other critical factor: the rapid growth of the British Columbia ports as an intermodal gateway to both Canadian and U.S. markets. Much of the market share gained by the British Columbia ports has come at the expense of U.S. Pacific Northwest ports (as suggested by their slow post-recession growth in Exhibit 77 and the loss of regular international container service at the Port of Portland in Oregon), but the success of Vancouver and Prince Rupert has restrained Oakland's discretionary cargo growth as well. Prior to the recession, the Port of Oakland added the BNSF-served Oakland International Gateway (OIG) to increase capacity for expected growth in discretionary cargo. That growth was slower than had been hoped, in part due to persistent competition from Southern California ports and new competition from British Columbia ports.

Scenario Overview

The complex mix of international and domestic containers combined with the varied ratio of loaded and empty containers requires separate modeling of the international and domestic forecasts.

International Loaded Containers

The loaded (full) container forecast from 2020 onward utilizes separate models for imports and exports that are driven by forecast data purchased from Moody's. The 2019 projection is based on the short-term model that drives the Global Port Tracker forecast, which has separate sub-models for each direction of trade on the Port's primary trade routes.

[iv] The Port of San Francisco also handled containers until 2013.

Short-term growth adjustments

The forecast scenarios incorporate adjustments for the first five years of the forecast (2019-2025).

The Moderate Growth forecast anticipates that the Port of Oakland would add three “first call” services (i.e. the Port of Oakland would be the first North American port of call) in 2022-2024 to provide a first call service for each of the three major vessel sharing alliances. These first call services would decrease the transit time for cargo coming from Asia and reduce the impact of late vessel arrivals caused by delays at previous ports. The impact of these new services is spread across a three-year period, in part due to the timing of shipping line schedule changes and in part due to the associated ramp-up in volume that would likely occur.

The Slow Growth forecast anticipates that the current slowdown in economic growth is more pronounced than in the Moderate case. Total volumes in the Slow Growth scenario reach a low in 2021, while the Moderate scenario reaches a low in 2020.

The Strong Growth forecast anticipates that any slowdown is offset by the Port of Oakland acquiring three first call services earlier than in the Moderate Case, in 2020-2022. An additional three first call services are acquired between 2030 and 2032 in the Strong Growth scenario.

Discussions with Port of Oakland officials suggested that a first call service would increase import volumes by 50,000 to 100,000 TEU. Based on a detailed comparison of vessel call volumes and average vessel sizes, the import/export mix, and the share moved inland via rail at Los Angeles, Long Beach, and Oakland, the consultant team estimated that each first call schedule that replaced an existing schedule would add 74,151 annual TEU (roughly the average of the Port staff estimate).

- The Moderate Growth scenario allows for introduction of first call services in 2022-2024, timed roughly to coincide with projected ramp-up of Tesla vehicle production passing 300,000 annual vehicles.

- The Strong Growth forecast included the introduction of first call vessels earlier, in 2020-2022, and a second wave in 2030-2032.

An event such as the Tesla production ramp-up is likely to markedly increase demand for first call delivery of high-priority imports – auto parts, in Tesla’s case. When New United Motors Manufacturing, Inc. (NUMMI, Tesla’s predecessor at the Fremont plant) was operating near capacity, there was at least one first call vessel service (APL) to serve that business, and likely others. The projected Tesla ramp-up is not necessarily a “make or break” event for first-call service; it is representative of the type of demand likely to receive first call service.

Long-term growth adjustments

The growth rates in the Moderate Growth case serve as the basis of the forecast in the Slow Growth and Strong Growth scenarios, but these are modified to represent the combination of variables that may affect container volumes in the long term (2024-2050). Factors in the Slow Growth and Strong Growth scenarios include:

- Slower/faster population growth in the U.S.;
- Slower/faster economic growth in the U.S.;
- Major infrastructure investment by the U.S. Government;
- Lower value of the U.S. dollar resulting in increased export growth;

- High value of the U.S. dollar resulting in decreased export growth;
- Changes in trade policies that increase/decrease tariffs resulting in reduced/increased import volume;
- Increased/decreased market share compared to other West Coast ports in the U.S. and Canada, resulting in increased/reduced import and export volume (which could be driven by infrastructure spending/underfunding, regional economic performance, improved/reduced port productivity, etc.); and
- Increased/decreased market share at West Coast ports compared to East Coast ports, resulting in increased/reduced import and export volume (which could be driven by geopolitical events, changes in transportation costs due to fuel prices or emission requirements, improving/slowing economic growth in trade partners, etc.).

Import volumes at container ports are significantly affected by development of new distribution centers, especially if they are designed to process and distribute imports to other smaller distribution centers. Walmart, for example, has five such facilities located near major ports including the Ports of Los Angeles and Long Beach, Houston, Savannah, and Virginia. New Northern California distribution centers designed to serve Northern California stores or other regional distribution centers would likely increase imports to the Port of Oakland. For example:

- Target has major distribution centers in both Northern California (Woodland) and Southern California (Inland Empire). The addition of a first call vessel at Oakland might shift some cargo from the Ports of Los Angeles and Long Beach to the Port of Oakland as the company decides to serve more of their central California stores from Northern rather than Southern California.
- Walmart has California DCs in Mira Loma (Inland Empire) and Porterville (SE of Fresno). Porterville is almost exactly equidistant between the Ports of Los Angeles and Long Beach and the Port of Oakland. Most intact Walmart imports come through the Southern California ports, while a separate stream of imports is transloaded at DAMCO in South Gate, north of Long Beach. Walmart might decide to import more cargo via Oakland to establish a gateway option.

The Moderate Growth scenario assumes that:

- The trade disputes with China, the European Union, Canada, and Mexico are resolved amicably without punitive long-term tariffs, and most trade flows return to their pre-dispute growth patterns;
- California exporters already affected by the trade dispute with China or other events either regain those former markets or instead find new markets for the same output (perhaps at a lower price);
- Long-term exports rebound as foreign markets recover economically;
- A positive impact on refrigerated container trade due to the development of the Cool Port facility; and
- A moderate increase in the import of automobile parts as Tesla increases production.

The Moderate Growth international TEU forecasts for imports and exports are driven by projections of economic growth developed by Moody's and Caltrans, including sub-components of national-level Gross Domestic Product, industrial output, and Gross Metro Product.

The Slow Growth scenario assumes that some of the following occur, thereby slowing growth in international container trade:

- Slower import demand in line with the low end of relevant economic and trade forecasts, starting from a resumption of 2017 levels rather than from the late 2018 peak that was supported by retailers bringing in cargo ahead of feared tariffs;
- A permanent loss of a portion of the U.S. and California export markets as other suppliers capture market share during protracted trade wars;
- Global economic growth slows at the higher end of relevant economic and trade forecasts or recovers at the lower end of those forecasts; or
- There is only a small increase in the import of automobile parts as Tesla increases production.

The Strong Growth scenario assumes that some of the following occur, thereby increasing growth in international container trade:

- Import demand in line with the high end of relevant economic and trade forecasts, starting from a resumption of 2017 levels rather than from the late 2018 peak that was supported by retailers bringing in cargo ahead of feared tariffs;
- Trade disputes are resolved in a way that greater international trade is encouraged;
- New distribution centers are built that rely on imports through the Port of Oakland;
- Global economic growth slows at the lower end of relevant economic and trade forecasts or recovers at the higher end of those forecasts; or
- There is a large increase in the import of automobile parts as Tesla increases production.

Exhibit 78 compares the Moderate, Slow, and Strong Growth scenarios for the forecasts for loaded containerized imports and exports.

Exhibit 78: Projected International Loaded Imports and Exports to the Port of Oakland by Scenario

Year	Imports			Exports			Total International Loads		
	Moderate	Slow	Strong	Moderate	Slow	Strong	Moderate	Slow	Strong
2010	771,343	771,343	771,343	817,822	817,822	817,822	1,589,165	1,589,165	1,589,165
2018	946,524	946,524	946,524	807,975	807,975	807,975	1,754,499	1,754,499	1,754,499
2020	972,705	934,088	1,024,188	804,645	780,666	861,775	1,777,349	1,714,755	1,885,962
2030	1,407,818	1,068,308	1,531,287	964,799	935,225	1,129,131	2,372,618	2,003,534	2,660,418
2040	1,855,070	1,338,879	2,407,678	1,108,241	1,021,749	1,363,333	2,963,311	2,360,627	3,771,011
2050	2,493,437	1,711,630	3,401,708	1,236,308	1,084,096	1,598,657	3,729,745	2,795,726	5,000,365
2018-2050 CAGR	**3.1%**	**1.9%**	**4.1%**	**1.3%**	**0.9%**	**2.2%**	**2.4%**	**1.5%**	**3.3%**

International Empty Containers

The empty TEU forecast is built upon the loaded TEU forecast and the concept that the volume of empty containers is related to the volume of loaded containers moving in the opposite direction. For example, as loaded *inbound* containers increase, empty *outbound* containers also increase, and vice versa. The model maintains a constant loaded/empty ratio that is based on the Oakland average ratios of outbound loaded containers to inbound empty containers and inbound loaded containers to outbound empty containers over the past 10 years.

This ratio equates to approximately 17 inbound empty containers for every 100 outbound loaded containers, and 39 outbound empty containers for every 100 inbound loaded containers.

The Slow and Strong Growth empty container scenarios use the same ratios as the Moderate Case scenario, and the decrease or increase in volume is directly related to the same shift projected in the loaded container scenarios.

Exhibit 79 compares the Moderate, Slow, and Strong Growth scenarios for the forecasts for empty containerized imports and exports.

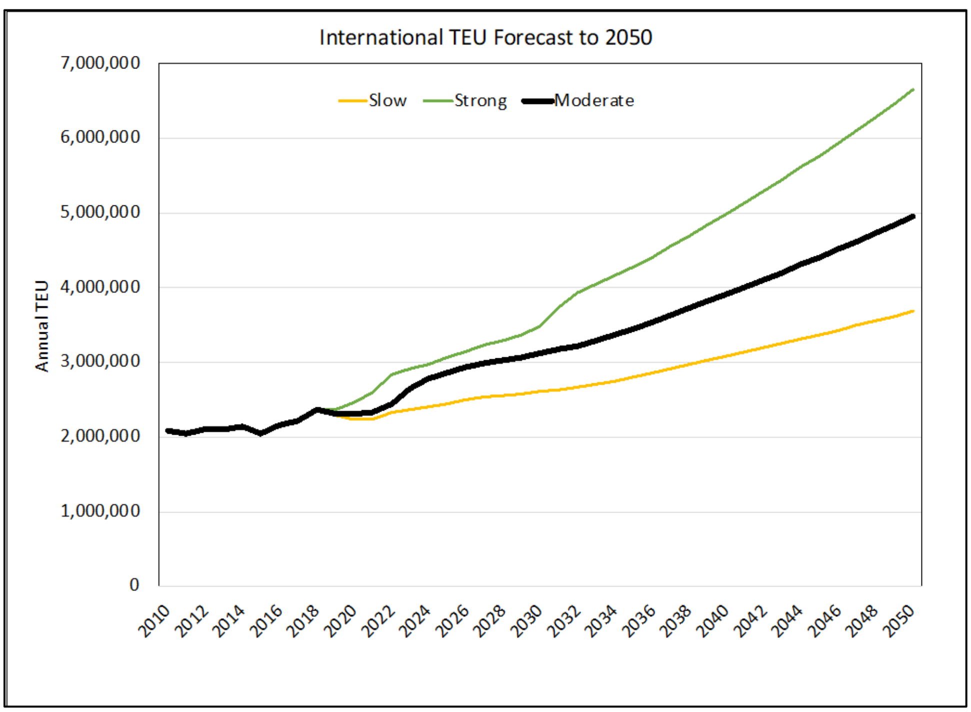
Exhibit 79: Projected International Empty Imports and Exports to the Port of Oakland by Scenario

Year	Imports			Exports			Total International Empties		
	Moderate	Slow	Strong	Moderate	Slow	Strong	Moderate	Slow	Strong
2010	131,614	131,614	131,614	359,979	359,979	359,979	491,593	491,593	491,593
2018	139,719	139,719	139,719	462,690	462,690	462,690	602,409	602,409	602,409
2020	137,128	133,041	146,864	393,867	378,231	414,714	530,995	511,272	561,578
2030	164,421	159,381	192,427	570,054	432,579	620,048	734,475	591,960	812,475
2040	188,866	174,126	232,339	751,155	542,139	974,917	940,021	716,265	1,207,256
2050	210,692	184,752	272,443	1,009,642	693,073	1,377,419	1,220,334	877,825	1,649,862
2018-2050 CAGR	**1.3%**	**0.9%**	**2.1%**	**2.5%**	**1.3%**	**3.5%**	**2.2%**	**1.2%**	**3.2%**

Total Containerized Cargo

Exhibit 80 shows the annual growth rates for the three forecasts for total containerized cargo.

Exhibit 80: Port of Oakland International TEU Forecast to 2050



As the chart indicates, a near-term divergence is expected due to:

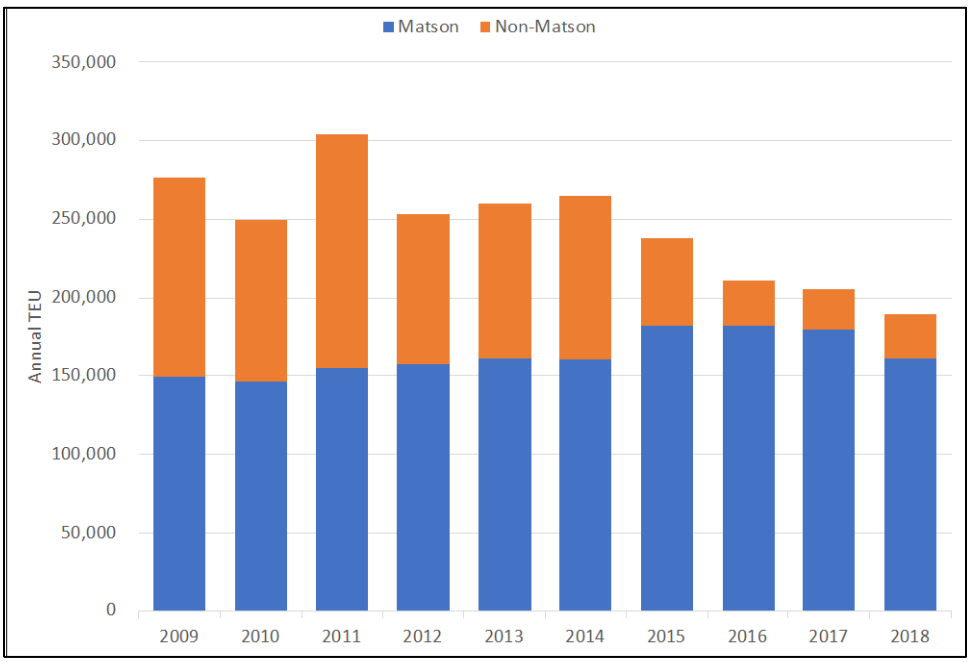
- Gradual introduction of first call services in the Moderate Case.
- More rapid introduction of first call services in the Strong Case.
- No first call services and adverse impacts of trade conditions in the Slow Case.

Thereafter, each forecast case grows at an appropriate long-term rate, although as previously noted the Strong Growth scenario benefits from a second round of first call services in the mid-term.

Domestic Containers

Domestic container volumes between the Port of Oakland and Hawaii are more opaque and likely are driven primarily by market share shifts than economic growth. As previously noted, overall domestic TEU volume has decreased since 2010. However, Matson has experienced growth in its loaded outbound container volumes and empty container volumes over the same period (Exhibit 81).

Exhibit 81: Port of Oakland Domestic TEU 2009-2018



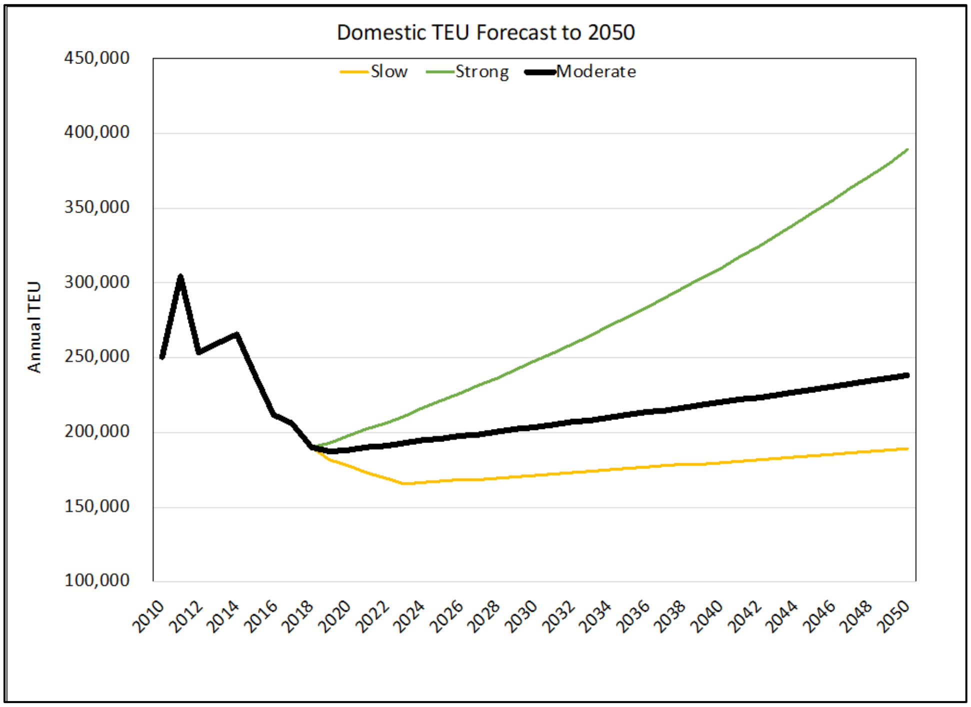
The domestic Moderate Growth forecast assumes that Matson continues to expand its trade volumes at the same pace as it has since 2010 while other carriers remain at the same level as 2018.

The Slow Growth forecast projects that Matson's cargo volume expands at the slower pace than in the Moderate Case, but that container levels at other carriers continue to decrease until Matson is the sole domestic carrier by 2023.

The Strong Growth forecast projects that Matson's cargo volume expands at a faster pace than the Moderate Case, using the growth the carrier experienced between 2010 and 2017 as a basis for future growth. Other domestic carriers also increase at a faster pace than in the Moderate Case and are able to capture 15% of the total domestic market each year.

Exhibit 82 charts the domestic TEU forecast.

Exhibit 82: Port of Oakland Domestic TEU Forecast to 2050



Total Containerized Cargo Forecast

Annual TEU Forecast

The combined international and domestic forecasts are summarized at five-year intervals in Exhibit 83 and graphed in Exhibit 84. Exhibit 86 displays projected TEU by trade direction and load/empty status by decade and the long-term compound annual growth rates.

The projected 2050 totals are:

- Slow Growth forecast: 3.86 million TEU at a CAGR of 1.3%
- Moderate Growth forecast: 5.19 million TEU at a CAGR of 2.2%
- Strong Growth forecast: 7.04 million TEU at a CAGR of 3.2%

The Moderate Growth 2018-2050 CAGR at 2.2% is slightly higher than the past average of about 2.1% due to expected long-term increase in Northern California manufacturing and distribution, and to the introduction of first call vessels to serve that increase. Exhibit 85 shows the components of the Moderate Growth scenario. Each of the three components allow for somewhat faster growth than the 2010-2018 record, but the slower growth of the export and domestic sectors keeps the overall rate below expected import growth. Exhibit 86 provides additional forecast detail.

Exhibit 83: Port of Oakland Annual TEU Forecast

Annual Forecast	2020	2025	2030	2035	2040	2045	2050	CAGR
International TEU								
Moderate Growth	2,308,344	2,847,701	3,107,092	3,436,849	3,903,333	4,401,425	4,950,079	**2.3%**
Slow Growth	2,226,027	2,437,039	2,595,494	2,792,677	3,076,892	3,367,347	3,673,551	**1.4%**
Strong Growth	2,447,540	3,051,118	3,472,893	4,270,618	4,978,267	5,761,075	6,650,228	**3.3%**
Domestic TEU								
Moderate Growth	188,082	195,442	203,133	211,169	219,566	228,341	237,509	**0.7%**
Slow Growth	177,159	166,741	170,952	175,269	179,694	184,232	188,884	**0.0%**
Strong Growth	197,064	220,652	247,062	276,634	309,746	346,820	388,332	**2.3%**
Total TEU								
Moderate Growth	2,496,427	3,043,144	3,310,226	3,648,018	4,122,899	4,629,766	5,187,588	**2.2%**
Slow Growth	2,403,186	2,603,781	2,766,446	2,967,946	3,256,587	3,551,579	3,862,435	**1.3%**
Strong Growth	2,644,604	3,271,770	3,719,955	4,547,252	5,288,013	6,107,895	7,038,560	**3.2%**

Exhibit 84: Port of Oakland Total Containerized TEU Forecast to 2050

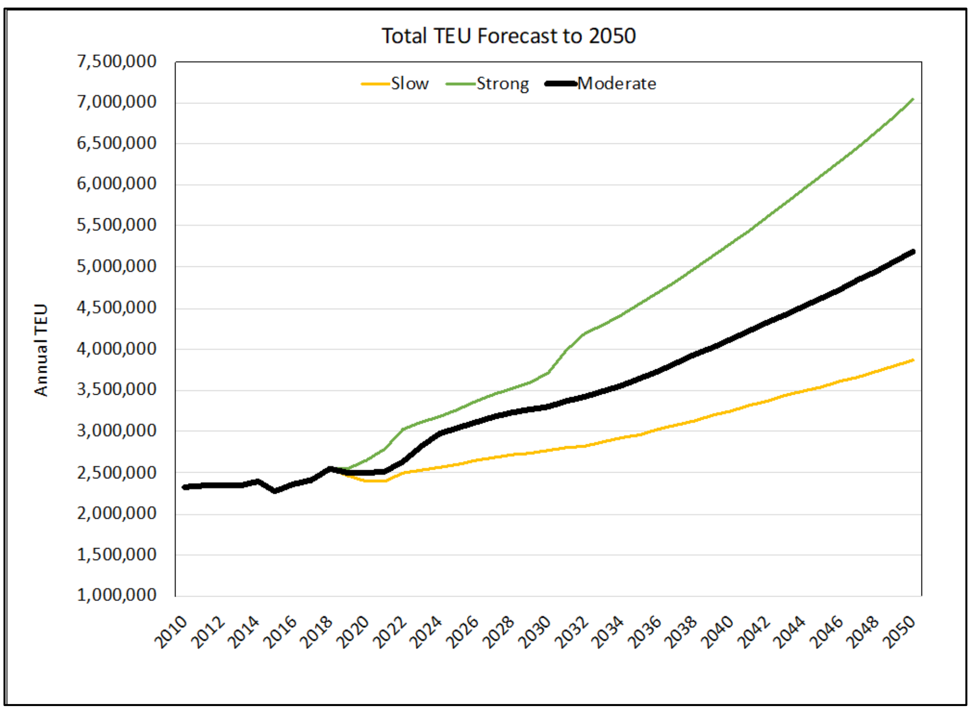


Exhibit 85: Port of Oakland Moderate Growth Container Forecast Components

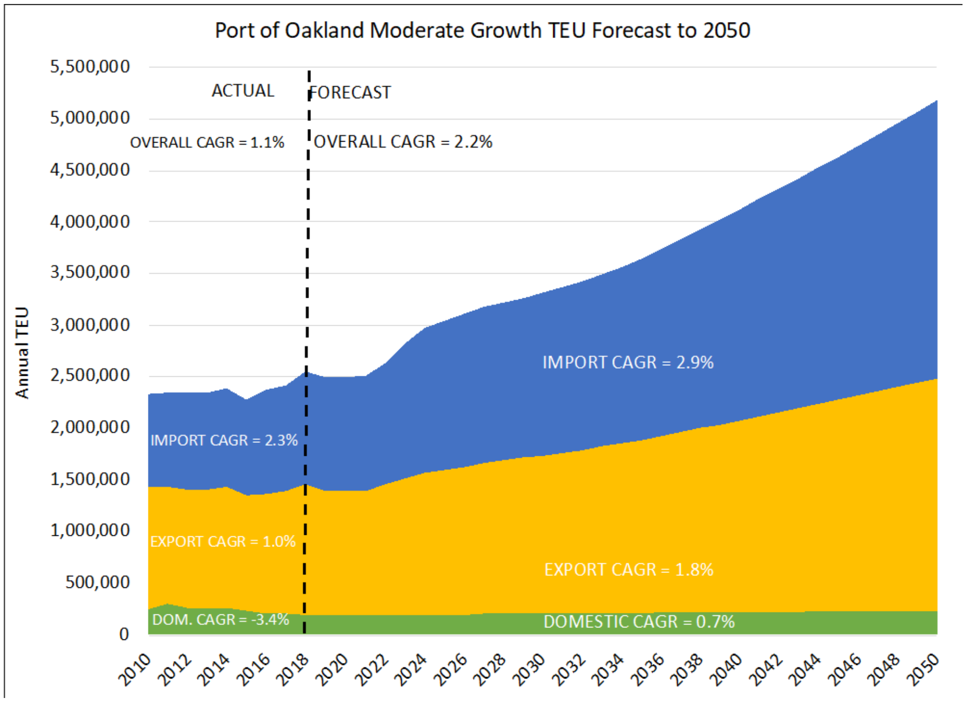


Exhibit 86: Port of Oakland Containerized TEU Forecast by Decade to 2050

Moderate	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	972,705	137,128	804,645	393,867	19,250	76,289	91,249	1,294	2,496,427
2030	1,407,818	164,421	964,799	570,054	20,423	82,615	98,737	1,358	3,310,226
2040	1,855,070	188,866	1,108,241	751,155	21,703	89,523	106,912	1,428	4,122,899
2050	2,493,437	210,692	1,236,308	1,009,642	23,101	97,064	115,839	1,505	5,187,588
2018-2050 CAGR	**3.1%**	**1.3%**	**1.3%**	**2.5%**	**0.6%**	**0.6%**	**0.8%**	**0.4%**	**2.2%**

Slow	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	934,088	133,041	780,666	378,231	16,561	72,804	86,744	1,050	2,403,186
2030	1,068,308	159,381	935,225	432,579	13,319	71,855	85,050	728	2,766,446
2040	1,338,879	174,126	1,021,749	542,139	14,000	75,529	89,400	765	3,256,587
2050	1,711,630	184,752	1,084,096	693,073	14,716	79,392	93,972	805	3,862,435
2018-2050 CAGR	**1.9%**	**0.9%**	**0.9%**	**1.3%**	**-0.8%**	**0.0%**	**0.1%**	**-1.6%**	**1.3%**

Strong	International				Domestic				Total
	Loaded Imports	Empty Imports	Loaded Exports	Empty Exports	Loaded Inbound	Empty Inbound	Loaded Outbound	Empty Outbound	
2010	771,343	131,614	817,822	359,979	31,314	78,264	137,757	2,364	2,330,457
2018	946,524	139,719	807,975	462,690	19,028	79,249	89,829	1,338	2,546,351
2020	1,024,188	146,864	861,775	414,714	15,442	82,086	98,606	931	2,644,604
2030	1,531,287	192,427	1,129,131	620,048	19,359	102,913	123,624	1,167	3,719,955
2040	2,407,678	232,339	1,363,333	974,917	24,271	129,023	154,989	1,463	5,288,013
2050	3,401,708	272,443	1,598,657	1,377,419	30,429	161,758	194,312	1,834	7,038,560
2018-2050 CAGR	**4.1%**	**2.1%**	**2.2%**	**3.5%**	**1.5%**	**2.3%**	**2.4%**	**1.0%**	**3.2%**

Monthly Peaking

Cargo volumes are not even during the year, and peak periods place additional demands on port infrastructure. Cargo peaks can be driven by multiple factors, including holiday and back-to-school shopping and seasonal agricultural production. August has typically been the peak volume month for the Port of Oakland, and as Exhibit 87 indicates August peaks have averaged 8.4% over the annual monthly average.

Exhibit 87: Port of Oakland August Peaking

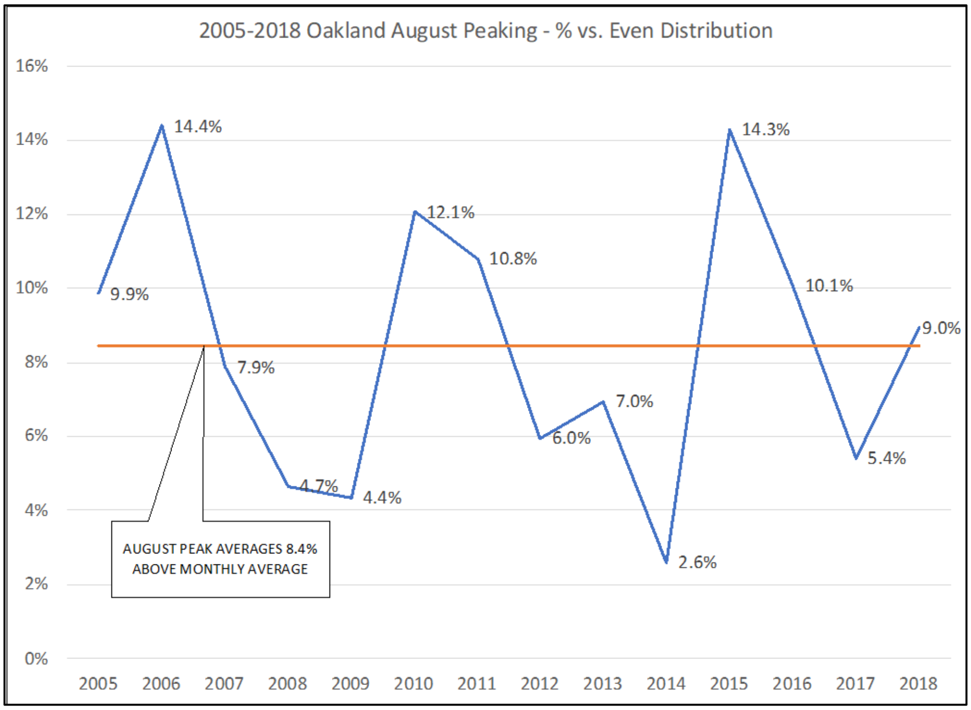


Exhibit 88 applies the 8.4% monthly peaking factor to the forecast in Exhibit 86, to derive a monthly peak TEU forecast.

Exhibit 88: Port of Oakland Monthly Peak TEU Forecast

Monthly Peak Forecast	2020	2025	2030	2035	2040	2045	2050	CAGR
International TEU								
Moderate Growth	208,604	257,345	280,786	310,586	352,742	397,754	447,336	**2.3%**
Slow Growth	201,165	220,234	234,553	252,373	278,057	304,305	331,977	**1.4%**
Strong Growth	221,183	275,728	313,843	385,933	449,883	520,625	600,977	**3.3%**
Domestic TEU								
Moderate Growth	16,997	17,662	18,357	19,083	19,842	20,635	21,464	**0.7%**
Slow Growth	16,010	15,068	15,449	15,839	16,239	16,649	17,069	**0.0%**
Strong Growth	17,809	19,940	22,327	24,999	27,992	31,342	35,093	**2.3%**
Total TEU								
Moderate Growth	225,601	275,007	299,143	329,669	372,584	418,389	468,799	**2.2%**
Slow Growth	217,174	235,302	250,002	268,211	294,296	320,954	349,046	**1.3%**
Strong Growth	238,991	295,668	336,170	410,932	477,875	551,967	636,070	**3.2%**

Container Terminal Capacity

Productivity Benchmarks

Exhibit 89 shows an overall comparison of average TEU/acre for major U.S. container ports. Oakland's current productivity is high, right behind New York-New Jersey.

Exhibit 89: 2017 Port Productivity Comparison

Port	Container Terminal Acres	TEU	TEU/Acre
Los Angeles	1,704	9,343,192	5,483
Long Beach	1,399	7,544,507	5,393
New York & New Jersey	1,496	6,710,817	4,486
Oakland (2018)	**593**	**2,537,400**	**4,279**
Charleston	597	2,177,550	3,647
Seattle/Tacoma	1,011	3,665,329	3,625
Mobile	90	318,889	3,543
Savannah	1,200	4,046,212	3,372
Baltimore	294	962,484	3,274
Virginia	896	2,841,016	3,171
Houston	811	2,459,107	3,032
Boston	90	270,881	3,010
12-port Total	**10,181**	**42,877,384**	**4,212**

There are many variations in marine container terminal operations and capacities.

- **Wheeled.** "Wheeled" operations, in which containers are placed on chassis and parked, have the lowest capacity per acre but also the lowest operating cost. West Coast terminals were mostly wheeled until ocean carriers began withdrawing from chassis supply, starting in 2010. Most terminals retain a portion of their wheeled operations for special handling, such as for refrigerated cargo.

- **Stacked.** Most U.S. container terminals are now largely stacked, using a variety of lift equipment to handle containers without chassis and storing the chassis separately. Stacked terminals have higher throughput per acre than wheeled terminals, but also higher operating cost due to the additional handling.

Conventional terminals, as discussed in this analysis, include wheeled, stacked, and mixed terminals, including all existing Oakland terminals. These terminals may include some aspects of automation such as the use of optical character recognition (OCR) at entry gates, but all container operations are performed with manually operated equipment.

High productivity terminals also come in multiple variations, depending on the type and extent of automation.

- **Semi-automated terminals.** Some terminals, such as the Virginia International Gateway at Portsmouth, VA, combine automated and manned operations throughout the terminal. Others, such as TraPac at Los Angeles, have sections of the terminal automated and other sections manned.

- **Auto-strad terminals.** "Auto-strads" are automated straddle carriers. This type of automation is used in Australia and is receiving increased industry attention for its lower capital cost and its capability of deployment in existing, rather than newly built terminals. APM Terminals has proposed deploying auto-strads in a portion of its Los Angeles terminal.

These less-than-complete automation approaches are viewed by many observers as being more cost-effective than more elaborate automation, especially for improving existing terminals. For this analysis we have grouped these approaches as "high productivity."

- **Complete automation.** The more aggressive automation approaches are often referred to as "complete automation," although the label is a misnomer. In all North American examples to date, such as the Long Beach Container Terminal (LBCT) at Long Beach, the shipside container cranes are manned. The actual automation is in the container yard, where Automated Guided Vehicles (AGVs) move containers to and from stacks served by automated stacking cranes (ASCs). Automation on this scale, however, requires building a new terminal or completely replacing an existing terminal, requiring heavy capital investment and a long development time.

Exhibit 90 compares claimed capacities and throughput per acre for benchmark terminals in each group. Few terminals post their capacities, so the available data are limited.

Exhibit 90: Terminal Productivity Benchmarks

Terminal	Acres	Published Capacity Annual TEU*	Max TEU/Acre**	Sustainable @ 80%**	Average
Conventional Terminals					
Oakland OICT	**290**	**1,600,440**	**8,335**	**6,668**	**6,676**
OICT Off-dock	**30**				
TTI Long Beach	385	3,000,000	7,792	6,234	
GCT Deltaport	210	1,800,000	8,571	6,857	
APM Los Angeles	507	4,400,000	8,679	6,943	
High Productivity					
VIG Portsmouth	291	2,000,000	6,873	5,498	**7,112**
TraPac Los Angeles	220	1,600,000	7,273	5,818	
Sydney Auto-strad	156	1,600,000	10,282	8,226	
Brisbane Auto-strad	99	1,100,000	11,134	8,907	
"Complete" Automation					
LBCT Long Beach	170	3,100,000	18,235	14,588	**11,366**
GCT Bayonne	167	1,700,000	10,180	8,144	

* OICT is actual TEU
** Assumes current average is 95% of sustainable max
Source: Industry publications and terminal websites

OICT currently has Oakland's highest throughput and throughput per acre. Multiple industry and study sources describe OICT as being near maximum capacity.

Exhibit 91: 2018 Port of Oakland Productivity

Oakland & OICT 2018 Average TEU/Acre	
Oakland 2018 TEU	2,537,400
Oakland Acres in Use	593
Oakland Avg TEU/Acre	**4,279**
OICT 2018 TEU	1,600,400
OICT Acres in Use	290
STE Off-dock Staging	30
OICT Avg TEU/Acre	**5,001**

Exhibit 91 shows that OICT's 2018 volume was 1,600,400 TEU over 320 acres (290 terminal acres and 30 off-dock acres), a *current* average of 5,001 annual TEU/acre.

- Based on multiple opinions that OICT is operating near capacity, the consultant team assumed that the terminal is at 75% of a *sustainable capacity* of 6,668 TEU/acre.
- The industry rule of thumb is that a terminal's *sustainable throughput is 80% of its maximum capacity* (Exhibit 90), which yields a current *maximum* capacity of 8,335 TEU per acre.
- On this basis, if all 593 acres of Oakland terminals and off-dock staging currently in use reached OICT's estimated annual *sustainable* capacity per acre, the Port as a whole would have a *maximum* capacity of 4,942,655 annual TEU and a *sustainable* capacity of 3,954,322 annual TEU (80% of the maximum capacity).

As Exhibit 90 shows, this estimate puts OICT's productivity comparable to GCT Deltaport at Vancouver, TTI at Long Beach, and APM at Los Angeles. Exhibit 90 calculates that the *sustainable* average for conventional terminals is 6,676 TEU/acre, for high productivity terminals is 7,112 (17% higher), and for aggressive automation is 17,088 TEU/acre (181% higher than the conventional average). It should be noted that the claims for high throughputs at completely automated terminals have not yet been proven in practice.

The container capacity estimated in this report therefore use the *sustainable* Oakland capacity estimates of 6,668 annual TEU/acre for conventional terminals and 7,112 annual TEU/acre for high productivity terminals .

Port of Oakland Container Terminals

Exhibit 92 provides a summary of the Port's acreage in terminals and off-dock staging. The locations are also shown in Exhibit 93. As the discussion below indicates, there is a distinction between:

- Sites and acreage currently used as operating marine terminals.
- Other sites and acres that could potentially be incorporated in marine terminals, but may be idle or in ancillary uses at present, such as Berths 20-21, Berths 22-25, the Roundhouse parcel, and the Howard Terminal.
- Sites suitable for ancillary use but which cannot be incorporated in marine terminals, such as the 30 acres being used for off-dock staging by Shipper's Transport Express (STE).

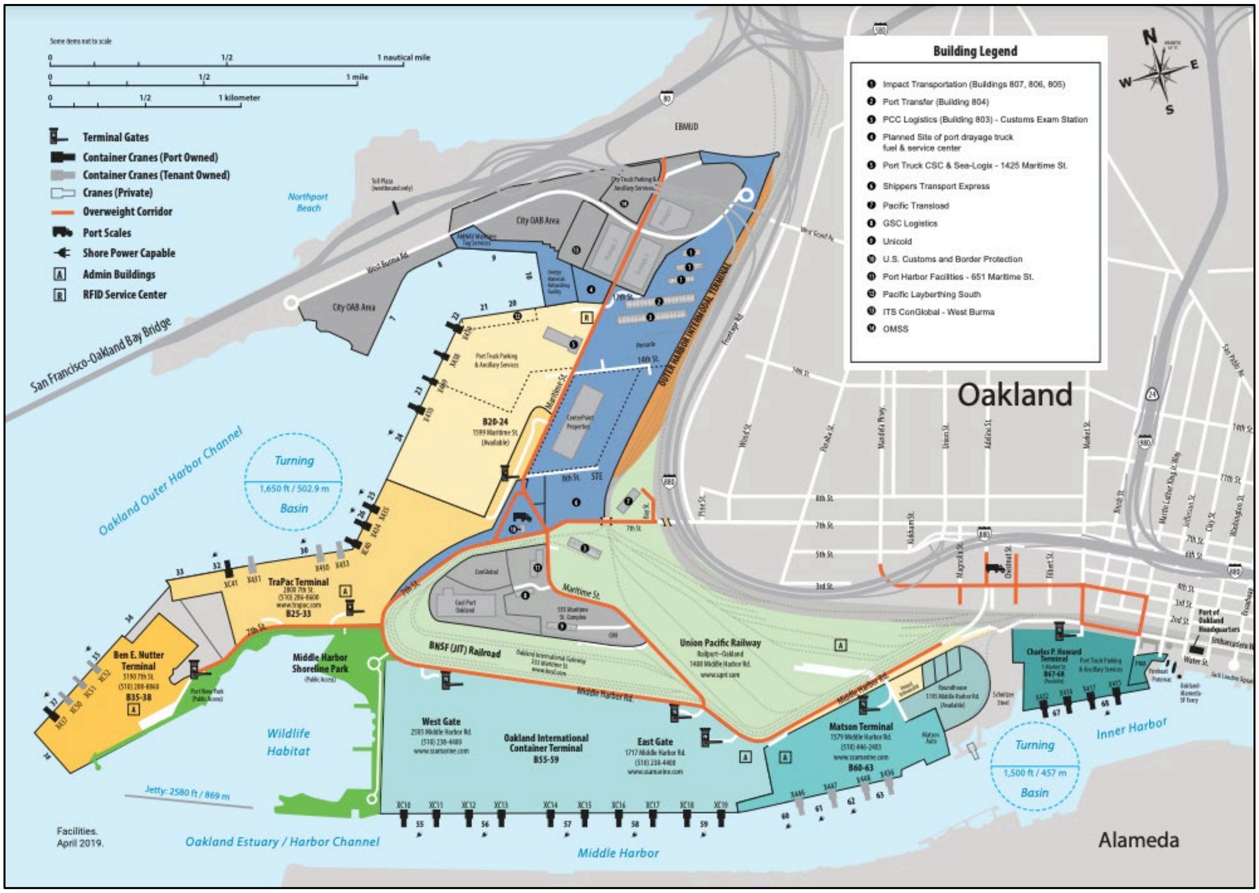
The report focuses on the existing terminal acres and the acres and sites that could be functionally incorporated into marine terminals as "All Potential Terminal Acres".

Exhibit 92: Port of Oakland Marine Terminals and Acreages

Site	Acres	2019 Acres in Use	Potential Terminal Acres	Build-out Acres	Post-Electrification Acres
Ben Nutter	75	75	0	**95**	**93**
Berths 33-34	20	-	20		
OICT 55-56	120	120	0	**290**	**288**
OICT 57-59	170	170	0		
TraPac	123	123	0	**123**	**121**
Matson	75	75	0	**101**	**99**
Roundhouse	26	-	26		
Berths 20-21**	20	-	150	**150**	**148**
Berths 22-24	130	-			
Howard*	50	-	50	**40**	**38**
Subtotal	**809**	**563**	**246**	**799**	**787**
Off-Dock Staging***	30	30	0	0	0
Total	**839**	**593**	**246**	**799**	**787**

* Assumes 10 acres will be used for Inner Harbor Turning Basin
** 20 acres may become dry bulk terminal for 15 years (in negotiation)
**Not usable as long-term terminal space

Exhibit 93: Port of Oakland Map



The Ben E. Nutter Terminal is located on a peninsula, and has limited expansion potential without bay fill.

OICT is effectively fully built out at 290 acres, sharing its eastern boundary with the Matson terminal. OICT is also currently using 30 acres of off-dock land for container staging, operated by sister company Shippers' Transport Express (STE). The full working area of OICT is therefore 320 acres at present. STE also operates an 11-acre facility at French Camp, which acts as a "reliever" for OICT. That facility, however, is well outside the Port area, and could be replaced by other space in the inland region.

The TraPac terminal has recently been rebuilt and expanded to 123 acres. It is adjacent to the vacant Outer Harbor Terminal (OHT, former Ports America) site. Because TraPac has recently been expanded and because the 150-acre OHT site is large enough for a separate terminal, this analysis limits TraPac to 123 acres.

The Matson terminal presently occupies 75 acres.

The Howard Terminal, presently used for ancillary support functions, covers 50 acres. There are no significant expansion options for Howard, and the Inner Harbor Turning Basin could reduce the available land to 40 acres.

The Port has three parcels of land contiguous with marine terminals and potentially usable as parts of those terminals.

- **Berths 33–34.** The unused area at Berths 33–34, between the Ben E. Nutter and TraPac terminals, totals 23 acres. This is the only possible expansion space for the Nutter terminal, and as Exhibit 92 shows, the consultant team has treated it as part of a full build-out for that facility. The area at Berth 34 is not usable as a vessel berth due to the presence of BART's Transbay Tube about 20' below water level.
- **Roundhouse Site.** The adjacent Roundhouse site of 39 acres could be used to extend Matson's terminal to a total of 95 acres, although it does not provide additional berth length.
- **Berths 20-21 and 22-24.** The Berth 22–24 Outer Harbor Terminal (OHT) site is what remains of the former Ports America terminal after a portion was used to expand TraPac. The site covers 150 acres, and this analysis treats it as a separate terminal. Based on the Port's September 2019 release of a *Notice of Preparation of a Draft Supplemental Environmental Impact Report* to develop a dry bulk terminal on 20 acres of land at Berths 20-21, that land may not be available for near-term container terminal use, leaving 130 usable acres. The Port intends to use the Berth 20-21 land for dry bulk over the next 15 years, with potential reversion to container use thereafter.

Current CARB emission goals call for zero emissions or near-zero emissions at marine terminals by 2030. With current and foreseeable technologies, achieving these goals requires electrification. Existing electrification technologies place two additional requirements on terminal land:

- Space for a battery exchange and servicing building. At LBCT in Long Beach, this function consumes about 1 acre.
- Additional electric service, potentially including a local substation. The consultant team has allowed an additional acre for this function.

The post-electrical acres in Exhibit 92 therefore reduce the available size of each terminal by 2 acres. Since automation effectively requires electrification, the capacity estimates below reduce the working acres of each terminal according to Exhibit 92 as automation is added.

The Port also has about 126 acres of undeveloped off-dock space, part of the former Oakland Army Depot. About 30 acres is currently being used by OICT and STE for supplementary staging of containers on chassis. All existing planning documents anticipate this land being used for ancillary support uses, rail infrastructure, or commercial development similar to the CenterPoint and CoolPort projects. This analysis therefore excludes this site from the terminal capacity estimates.

It should be noted that whether the Berth 33–34 site becomes part of the Nutter terminal or the TraPac terminal does not make a difference in the planning-level capacity estimates. Nor does it matter whether OHT becomes a separate terminal or part of TraPac. The only relevant size distinction is that automation strategies favor larger terminal sizes. While that factor may influence the sequence in which terminals are automated under some scenarios, the long-term potential capacity is a function of the total acres available.

Expansion Scenarios

Existing marine terminals typically expand incrementally to relieve congestion and accommodate trade growth. Marine terminal expansion is costly and time consuming. Ports and terminals therefore tend to expand existing facilities as needed rather than adding large increments of capacity that may not be utilized for several years.

New terminals, or complete replacements for existing terminals, may on the other hand build capacity for a more distant future. They may also be built in stages, with rising utilization of the first stage triggering construction of the next.

Oakland's terminal acreage has been almost completely built out, but as noted above, three significant expansion opportunities remain:

- 20 acres at Berths 33–34, which this analysis treats as expansion room for the Ben E. Nutter terminal.
- 26 acres at the Roundhouse property, which this analysis treats as expansion room for the Matson terminal.
- 150 acres at the Outer Harbor Terminal (OHT) site (120 acres excluding Berths 20-21), which this analysis treats as an opportunity to replace and upgrade the former Ports America infrastructure, or to rebuild as a new terminal.

A review of Port of Oakland planning documents, former terminal configurations, industry literature, and practices at other ports suggests the following conceptual path for Port of Oakland terminal expansion and capacity increases.

Phase I: Low-Cost Horizontal Expansion on Available Terminal Acres

Horizontal expansion onto contiguous, available land is the quickest and least costly means of increasing capacity, and offers the greatest flexibility.

- The space at Berths 33–34 is paved and was part of a former container terminal configuration. Only temporary fencing and barriers separate this space from the Ben E. Nutter terminal.
- The Roundhouse[v] property is paved and has been used for truck staging and empty container storage. It is separated from the Matson terminal by fencing and temporary barriers.
- The OHT site is more complex, as it includes multiple structures and has been used for a variety of trucking operations. It is paved, and includes multiple berths and cranes.
- The Howard Terminal was last used for container operations in 2014. It contains structures and four cranes.

The Phase 1 expansion scenario would involve progressive reactivation of these sites and either incorporating them in expanded terminals (Berths 33–34 into Ben E. Nutter, the Roundhouse site into Matson) or operating them as separate terminals (OHT and Howard).

Exhibit 94 provides a capacity estimate for the 2018 configuration and for the Phase 1 horizontal expansion, including adjustments for electrification (reduction of 2 acres per terminal). Under the assumptions documented here, this expansion would raise total sustainable capacity from about 3.95 million annual TEU in 2018 to 5.33 million annual TEU when complete. *This estimate also assumes that all Oakland terminals would have the capability to equal OICT's estimated sustainable capacity of 6,668 annual TEU per acre under conventional operations.*

[v] The property is the site of the former Western Pacific Railroad roundhouse.

Phase II: Enhanced Efficiency on 150 Acres at OICT

Phase II is representative of partial automation or other productivity improvements in response to trade growth. OICT has essentially no expansion room, is reportedly close to maximum capacity, and would be the most likely candidate for partial automation (148 acres) or other methods of significantly increasing throughput per acre. Exhibit 94 shows the estimated capacity increase using the 7,112 TEU/acre average for sustainable throughput at high productivity (Exhibit 90). This approach would increase capacity from 5.33 million TEU in Phase I to 5.38 million TEU in Phase II.

Phase III: Enhanced Efficiency at OICT and OHT

Phase III would extend high productivity operation to the remaining areas of OICT and OHT in response to trade growth. As noted above OICT is reportedly close to capacity, and automation would likely be easier in reactivating OHT than retrofitting TraPac or Ben E. Nutter. Matson and Howard are small relative to the usual suggested minimums for effective automation. Phase III as outlined here and shown in Exhibit 94 would increase sustainable throughput capacity from 5.38 million to 5.49 million annual TEU.

Phase IV: Enhanced Efficiency at OICT, OHT, and Ben E. Nutter

Phase IV expansion would extend automation to the expanded 95-acre Ben E. Nutter terminal, raising the high productivity area to a total of 529 acres (Exhibit 94). The remaining 264 acres at TraPac, Matson, and Howard would remain under conventional operation. This extension of high productivity operations would raise total capacity from 5.49 million to 5.52 million annual TEU.

Phase V: Enhanced Efficiency at OICT, OHT, Ben E. Nutter, and TraPac

The TraPac terminal might be the last to increase productivity as it was the most recently expanded and updated and likely has the most reserve capacity as of 2019. This Phase would add TraPac's 123 acres to the high productivity total and raise Port capacity from 5.52 million to 5.56 million annual TEU.

Phase VI: Enhanced Efficiency at All Terminals

Extending high productivity capability to all terminals, including Matson and Howard, would raise sustainable port capacity from 5.56 million to 5.60 million annual TEU.

Expansion Beyond Phase VI

Capacity increases beyond "high productivity" at all terminals could conceivably come from:

- More aggressive automation (e.g. ASCs and AGVs).
- Improved information flow and operational optimization to reduce container dwell times.
- Use of off-dock space for "relief" container storage capacity.
- Moving empty storage off-dock.

Expansion Progression

Exhibit 95 shows the estimated sustainable capacity in TEU in four scenarios: with Howard and Berths 20-21, without Howard, without Berths 20-21, and with neither Howard nor Berths 20-21. (Berths 20-21 are presently under consideration for dry bulk use.)

Exhibit 94: Scenario Capacity Estimates: All Potential Terminal Acres: 799 Current/787 Post-Electrification

All Potential Terminal Acres: 799 Current 787 Post-Electrification	Port Capacity Estimates						
	2018 Capacity Estimate	Phase 1: Horizontal Expansion on Available Terminal Acres	Phase II: 150 Acres High Productivity at OICT	Phase III: High Productivity at OICT & OHT	Phase IV: High Productivity at OICT, OHT, Ben Nutter	Phase V: High Productivity at OICT, OHT, Ben Nutter, TraPac	Phase VI: High Productivity at all Terminals
Total Terminal Acres	799	799	799	799	799	799	799
Terminal Acres in Conventional Use	563	799	649	359	264	141	0
Terminal Acres in High Productivity Use	0	0	148	436	529	650	787
Terminal Acres in Electrification Support	0	0	2	4	6	8	12
Total Off-dock Acres	126	126	126	126	126	126	126
Off-Dock Acres in Conventional Use	30	0	0	0	0	0	0
Available Off-Dock Acres	96	126	126	126	126	126	126
Total Port Acres	593	799	797	795	793	791	787
Total Acres in Conventional Use	593	799	649	359	264	141	0
Total Acres in High Productivity Use	0	0	148	436	529	650	787
Conventional Annual TEU/Acre (OICT 2018)	6,668	6,668	6,668	6,668	6,668	6,668	6,668
Conventional Capacity	3,954,322	5,327,998	4,327,748	2,393,932	1,760,440	940,235	-
High Productivity Annual TEU/Acre	7,112	7,112	7,112	7,112	7,112	7,112	7,112
High Productivity Capacity	-	-	1,052,614	3,100,945	3,762,385	4,622,969	5,597,348
Total Sustainable Capacity	3,954,322	5,327,998	5,380,363	5,494,877	5,522,825	5,563,204	5,597,348

Exhibit 95: Estimated Sustained Capacity at Port of Oakland by Port Configuration Scenario

Estimated Annual Sustainable TEU Capacity for:	2018 Capacity Estimate	Phase 1: Low-Cost Horizontal Expansion on Available Terminal Acres	Phase II: 150 Acres High Productivity at OICT or OHT	Phase III: High Productivity at OICT & OHT	Phase IV: High Productivity at OICT, OHT, Ben Nutter	Phase V: High Productivity at OICT, OHT, Ben Nutter, TraPac	Phase VI: High Productivity at all Terminals
All Potential Terminal Acres	3,954,322	5,327,998	5,380,363	5,494,877	5,522,825	5,563,204	5,597,348
Potential Terminal Acres w/o Howard	3,954,322	5,061,265	5,113,629	5,228,144	5,256,092	5,296,470	5,312,858
Potential Terminal Acres w/o Berths 20-21	3,954,322	5,194,632	5,246,996	5,352,632	5,380,580	5,420,959	5,455,103
Potential Terminal Acres w/o Howard or Berths 20-21	3,954,322	4,927,898	4,980,263	5,085,898	5,113,847	5,154,225	5,170,613

Annual Capacity Comparisons

Based on the capacity estimates in the previous section, Exhibit 96 shows the progression of capacity increases needed to handle the forecast cargo growth. The various capacity phases are color-coded to match the Phase depicted in Exhibit 95. Cells that are shaded dark orange indicate years in which projected volume exceeds maximum capacity.

- All Potential Terminal Acres, 799 Current/787 Post-Electrification:
    - with Moderate Growth, a succession of capacity increases is required through Phase I, providing capacity of 5.33 million TEU to accommodate 5.19 million TEU in 2050.
    - with Slow Growth, the volume reaches 3.86 million TEU, requiring no expansion for a capacity of 3.95 million TEU.
    - with Strong Growth, the Port would have to reach the Phase VI capacity level (full productivity upgrades) of 5.60 million TEU in 2041, and would have a capacity shortfall by 2042.
- Potential Terminal Acres w/o Howard, 759 Current/747 Post-Electrification:
    - with Moderate Growth, a succession of capacity increases is required through Phase III, providing capacity of 5.23 million TEU to accommodate 5.19 million TEU in 2050.
    - with Slow Growth, the volume reaches 3.86 million TEU, requiring no expansion for a capacity of 3.95 million TEU.
    - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.31 million TEU in 2040, and would have a capacity shortfall by 2041.
- Potential Terminal Acres w/o Berths 20-21, 779 Current/767 Post-Electrification:
    - with Moderate Growth, a succession of capacity increases is required through Phase I, providing capacity of 5.19 million TEU to accommodate 5.19 million TEU in 2050.
    - with Slow Growth, the volume reaches 3.86 million TEU, requiring no expansion for a capacity of 3.95 million TEU.
    - with Strong Growth, the Port would have to reach the Phase VI capacity level (full productivity upgrades) of 5.46 million TEU in 2041, and would have a capacity shortfall by 2042.
- Potential Terminal Acres w/o Howard or Berths 20-21, 739 Current/727 Post-Electrification:
    - with Moderate Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.17 million TEU in 2050, but would still have a capacity shortfall in 2050.
    - with Slow Growth, the volume reaches 3.86 million TEU, requiring no expansion for a capacity of 3.95 million TEU.
    - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 5.17 million TEU in 2039, and would have a capacity shortfall by 2040.

Exhibit 96: Annual TEU Forecast and Capacity (millions of TEU)

Productivity Color Code:	Existing	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI

Scenario	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50
All Potential Terminal Acres: 799 Current 787 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.49	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60
Potential Terminal Acres w/o Howard: 759 Current 747 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.11	5.23
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.23	5.30	5.31	5.31	5.31	5.31	5.31	5.31	5.31	5.31	5.31	5.31
Potential Terminal Acres w/o Berths 20-21: 779 Current 767 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.35	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46	5.46
Potential Terminal Acres w/o Berths 20-21 or Howard: 739 Current 727 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.98	5.09	5.17
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	4.93	4.93	4.93	4.93	4.93	4.93	4.93	5.09	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17

Limits to Productivity

Some industry contacts question whether high-productivity strategies and investments are practical or productive for smaller terminals, notably those under 100 acres – which would include Matson, Ben E. Nutter, and Howard, and leave TraPac and a future OHT site on the margin. (If TraPac absorbed the OHT space at Berths 20-24, it would be well over 100 acres.) For the volumes handled, the productivity improvements may not justify the investment. Moreover, the limited dimensions and sub-optimal configurations of those smaller terminals may eliminate some automation strategies.

Inability to shift the smaller terminals to higher productivity would cap the progression at Phase III (Exhibit 95), and limit Oakland's capacity to 5.09 to 5.49 million annual TEU, depending on total acres in use.

Exhibit 97: Impact of Limited Productivity Increases (millions of TEU)

Productivity Color Code:	Existing	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI

Scenario	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50
All Potential Terminal Acres: 799 Current / 787 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.33	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
Potential Terminal Acres w/o Howard: 759 Current / 747 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.11	5.23
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23	5.23
Potential Terminal Acres w/o Berths 20-21: 779 Current / 767 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	4.15	4.15	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.19	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35	5.35
Potential Terminal Acres w/o Berths 20-21 or Howard: 739 Current / 727 Post-Electrification																																	
Moderate Growth	2.55	2.50	2.50	2.51	2.63	2.83	2.98	3.04	3.11	3.18	3.23	3.27	3.31	3.37	3.42	3.49	3.57	3.65	3.74	3.83	3.93	4.03	4.12	4.22	4.33	4.42	4.53	4.63	4.73	4.84	4.95	5.07	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.98	5.09	5.09
Slow Growth	2.55	2.47	2.40	2.40	2.50	2.53	2.56	2.60	2.65	2.69	2.72	2.74	2.77	2.80	2.83	2.87	2.92	2.97	3.02	3.08	3.14	3.20	3.26	3.32	3.38	3.43	3.49	3.55	3.61	3.67	3.73	3.80	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong growth	2.55	2.55	2.64	2.80	3.03	3.11	3.18	3.27	3.37	3.45	3.53	3.59	3.72	3.98	4.19	4.30	4.42	4.55	4.69	4.83	4.98	5.14	5.29	5.45	5.61	5.77	5.94	6.11	6.28	6.46	6.65	6.84	7.04
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95	4.93	4.93	4.93	4.93	4.93	4.93	4.93	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09	5.09

Monthly Peak Capacity Comparisons

Monthly cargo peaking creates greater short-term demands for marine container terminals, and is a more stringent test of capacity. Based on the capacity estimates in the previous section and the monthly peak forecast in Exhibit 88, Exhibit 98 shows the progression of capacity increases needed to handle the forecast peak August volumes. The various capacity phases are again color-coded to match the Phase depicted in Exhibit 95. Cells that are shaded dark orange indicate years in which projected volume exceeds maximum capacity.

- All Potential Terminal Acres, 799 Current/787 Post-Electrification:
  - with Moderate Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) providing monthly capacity of 466 thousand TEU in 2050, but would still have a peak capacity shortfall in 2050.
  - with Slow Growth, the peak volume reaches 349 thousand TEU, requiring only Phase I expansion for a capacity of 444 thousand TEU.
  - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 466 thousand TEU in 2040, but would still have a peak capacity shortfall by 2040.
- Potential Terminal Acres w/o Howard, 759 Current/747 Post-Electrification:
  - with Moderate Growth, a succession of capacity increases is required through Phase VI (full efficiency upgrades), providing monthly capacity of 443 thousand TEU in 2048, but would still have a peak capacity shortfall by 2048.
  - with Slow Growth, the peak volume reaches 349 thousand monthly TEU, requiring only Phase I expansion for a capacity of 422 thousand TEU.
  - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 443 thousand TEU in 2038, but would still have a peak capacity shortfall by 2038.
- Potential Terminal Acres w/o Berths 20-21, 779 Current/767 Post-Electrification:
  - with Moderate Growth, a succession of capacity increases is required through Phase VI (full efficiency upgrades), providing monthly capacity of 455 thousand TEU by 2049, but would still have a peak capacity shortfall by 2049.
  - with Slow Growth, the volume reaches 349 thousand monthly TEU, requiring Phase I expansion for a capacity of 433 thousand TEU.
  - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 455 thousand TEU in 2039, but would still have a peak capacity shortfall by 2039.
- Potential Terminal Acres w/o Howard or Berths 20-21, 739 Current/727 Post-Electrification:
  - with Moderate Growth, a succession of capacity increases is required through Phase VI (full efficiency upgrades), providing monthly capacity of 431 thousand TEU by 2047, but would still have a peak capacity shortfall by 2047.
  - with Slow Growth, the volume reaches 349 thousand monthly TEU, requiring Phase I expansion for a capacity of 411 thousand TEU.
  - with Strong Growth, the Port would have to reach the Phase VI capacity level (full efficiency upgrades) of 431 thousand TEU by 2037, but would still have a capacity shortfall by 2037.

Exhibit 98: Monthly Peak TEU Forecast and Capacity (thousands of TEU)

Productivity Color Code: Existing | Phase I | Phase II | Phase III | Phase IV | Phase V | Phase VI

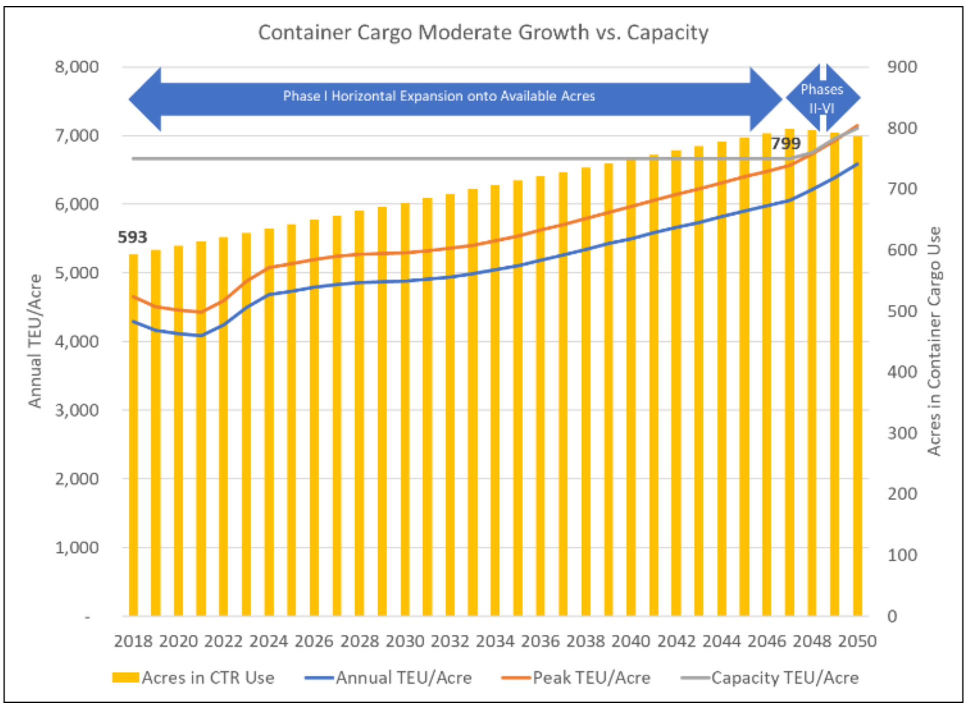
Scenario	'18	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50
All Potential Terminal Acres: 799 Current / 787 Post-Electrification																																	
Moderate Growth	230	226	226	227	238	256	269	275	281	287	292	295	299	304	309	315	322	330	338	346	355	364	373	382	391	400	409	418	428	437	448	458	469
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	444	444	444	444	444	444	444	444	444	444	444	444	448	460	466
Slow Growth	230	223	217	217	226	228	231	235	240	243	246	248	250	253	256	259	264	268	273	278	284	289	294	300	305	310	316	321	326	332	337	343	349
Available Capacity	346	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	444	444	444	444
Strong Growth	230	230	239	253	274	281	288	296	304	312	319	325	336	360	379	388	399	411	424	436	450	464	478	492	507	521	537	552	567	584	601	618	636
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	444	444	444	444	444	444	444	444	458	466	466	466	466	466	466	466	466	466	466	466	466
Potential Terminal Acres w/o Howard: 759 Current / 747 Post-Electrification																																	
Moderate Growth	230	226	226	227	238	256	269	275	281	287	292	295	299	304	309	315	322	330	338	346	355	364	373	382	391	400	409	418	428	437	448	458	469
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	422	422	422	422	422	422	422	422	422	422	436	438	443	443	443
Slow Growth	230	223	217	217	226	228	231	235	240	243	246	248	250	253	256	259	264	268	273	278	284	289	294	300	305	310	316	321	326	332	337	343	349
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	422	422	422	422
Strong Growth	230	230	239	253	274	281	288	296	304	312	319	325	336	360	379	388	399	411	424	436	450	464	478	492	507	521	537	552	567	584	601	618	636
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	346	422	422	422	422	422	426	438	443	443	443	443	443	443	443	443	443	443	443	443	443
Potential Terminal Acres w/o Berths 20-21: 779 Current / 767 Post-Electrification																																	
Moderate Growth	230	226	226	227	238	256	269	275	281	287	292	295	299	304	309	315	322	330	338	346	355	364	373	382	391	400	409	418	428	437	448	458	469
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	346	346	433	433	433	433	433	433	433	433	433	446	448	455	455
Slow Growth	230	223	217	217	226	228	231	235	240	243	246	248	250	253	256	259	264	268	273	278	284	289	294	300	305	310	316	321	326	332	337	343	349
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	433	433	433	433
Strong Growth	230	230	239	253	274	281	288	296	304	312	319	325	336	360	379	388	399	411	424	436	450	464	478	492	507	521	537	552	567	584	601	618	636
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	433	433	433	433	433	433	433	437	452	455	455	455	455	455	455	455	455	455	455	455	455
Potential Terminal Acres w/o Berths 20-21 or Howard: 739 Current / 727 Post-Electrification																																	
Moderate Growth	230	226	226	227	238	256	269	275	281	287	292	295	299	304	309	315	322	330	338	346	355	364	373	382	391	400	409	418	428	437	448	458	469
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	411	411	411	411	411	411	411	411	411	424	430	431	431	431	431
Slow Growth	230	223	217	217	226	228	231	235	240	243	246	248	250	253	256	259	264	268	273	278	284	289	294	300	305	310	316	321	326	332	337	343	349
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	411	411	411	411
Strong Growth	230	230	239	253	274	281	288	296	304	312	319	325	336	360	379	388	399	411	424	436	450	464	478	492	507	521	537	552	567	584	601	618	636
Available Capacity	330	330	330	330	330	330	330	330	330	330	330	330	411	411	411	411	411	415	424	431	431	431	431	431	431	431	431	431	431	431	431	431	431

Container Terminal Expansion Paths

The complex interaction between container cargo demands, available terminals acres, and productivity per acre can be illustrated by a set of conceptual expansion paths between 2018 and 2050.

Exhibit 99 illustrates a conceptual container terminal expansion path corresponding to the capacity scenarios in Exhibit 94 and the cargo forecast in Exhibit 84. The chart displays the terminal acres available each year, and the corresponding average annual TEU per acre, peak TEU per acre (reflecting the average 8.44% monthly peaking factor in August), and the estimated annual TEU capacity per acre. With all usable acres available, the container terminals could expand from their present 593 acres to 799 acres before losing some acres to electrification infrastructure.

Exhibit 99: Conceptual Container Terminal Expansion Path – All Acres



For sake of simplicity the expansion path shown in Exhibit 99 assumes that terminals would add acres and capacity in steady increments. In reality the expansion path will more likely be stepwise, with terminals adding acres and capacity in larger, less frequent increments. While the capacity scenarios in Exhibit 94 attempt to anticipate likely increments, the detailed expansion path will depend on demand, available capital, and terminal operator strategies that cannot be predicted with confidence.

As Exhibit 99 implies, the Port of Oakland currently has substantial reserve capacity due to:

- 2018 throughput averaging about 4,279 annual TEU/acre compared to the estimated sustainable capacity of 6,688 annual TEU per acre under conventional operations.
- The availability of 200+ acres of land that could be added to existing terminal capacity.

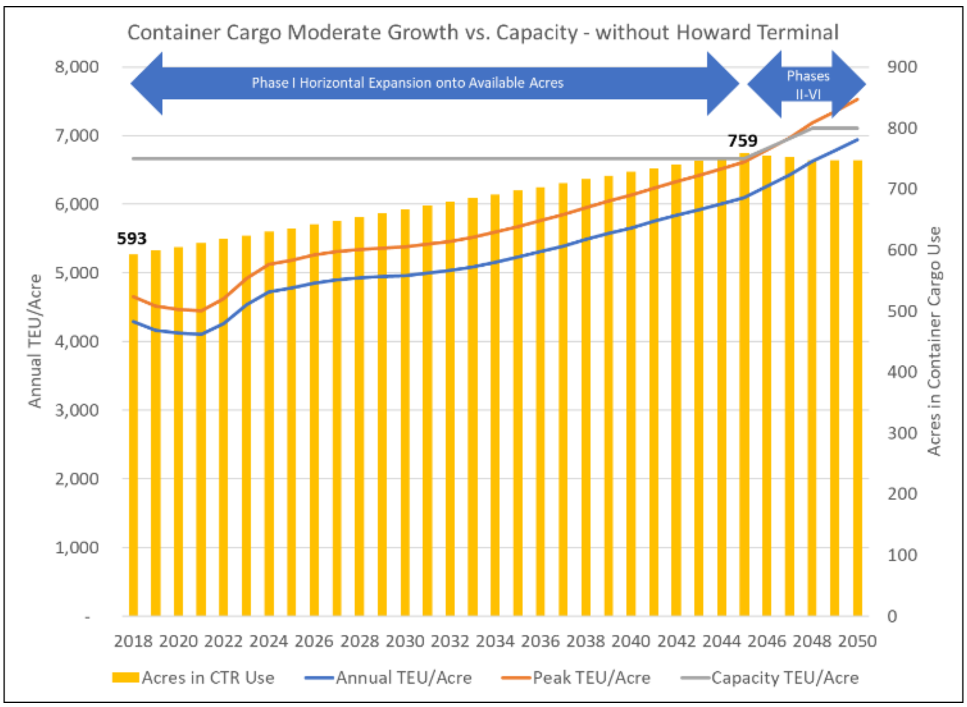
Fully exploiting these capabilities by building out horizontally and gradually bringing throughputs up to the conventional sustainable limit of 6,668 TEU/acre would allow Oakland terminals to handle growth through about

2047 before peak month volumes exceeded capacity. At that point the Port would be able to handle an estimated 4.8 million annual TEU with an 8.44% monthly peak (equivalent to 5.2 million annual TEU on Exhibit 99) on 799 acres at 6,668 average annual TEU per acre.

From that point forward the container terminals would have to densify, building up rather than out, to increase capacity. In 2050, they would reach the maximum capacity of 7,112 average annual TEU per acre on 787 acres against an average annual demand of 6,592 annual TEU per acre and a peak demand equivalent to 7,148 annual TEU per acre.

Exhibit 100 displays the same comparisons for the Port of Oakland without Howard Terminal. The space could grow to 759 acres instead of 799 before the terminals had to densify, and the need to densify would be triggered in about 2045 instead of 2047. In 2050, the 747 net acres after electrification could handle 5.3 million annual TEU at an annual average of 6,945 per acre. The equivalent peak demand would be 7,531 TEU per acre against a sustainable capacity of 7,112 annual TEU per acre, suggesting a potential shortfall in peak shipping season.

Exhibit 100: Conceptual Container Terminal Expansion Path – without Howard Terminal



Port of Oakland Container Terminal and Capacity Findings

The forecasts and capacity scenarios indicate that the Port of Oakland has sufficient estimated capacity and reserve acreage at present to accommodate cargo growth through as late as 2046, depending on the cargo growth pattern.

Starting in the 2030-2035 period, cargo growth in the Moderate and Strong Growth scenarios will trigger a need for additional capacity beyond that provided by current terminal footprints. That additional capacity is likely to be obtained first by horizontal expansion on available land (Phase I), and then through investment in automation or equivalent productivity improvements (Phases II-VI), as shown in Exhibit 99. It should be noted that many of the benefits obtained by semi-automated and "fully" automated terminals are generated by improved terminal configurations, equipment, and information systems, not by automation *per se*.

- With Moderate Growth and with all potential terminal acres in use, the Port is likely to have some reserve annual capacity by 2050, but would require minor productivity increases (i.e. to Phase I). Major productivity increases would be required in order to meet peak month capacity, with Phase II required by 2048, although a shortfall is forecast by 2050. An annual capacity shortfall is projected by 2050 without the capacity provided by Berth 20-21, and Howard Terminal even with major productivity increases (i.e. Phase VI).
- With Slow Growth suppressed by continuing adverse trade conditions and persistently sluggish economic growth, the Port will likely have adequate annual and peak capacity for the forecast period without any productivity increases, even without capacity provided by Berth 20-21 and Howard Terminal. Minor productivity increases would be required in order to meet peak month capacity, with Phase II forecast to be required by 2046 or 2047 depending on the terminal acres in use.
- The Strong Growth forecast will lead to annual capacity shortfalls by 2042 with all potential terminal acres in use, even after major productivity increases. The shortfall is forecast to occur by 2040 without the capacity provided by Berth 20-21 and Howard Terminal. A peak month capacity shortfall when all potential terminal acres are in use is forecast to occur in 2040.

If the Berth 20-21 acreage is kept or returned for container cargo, the Port can go longer without capacity shortfalls or be less aggressive with productivity improvements, as shown in Exhibit 99. If neither Berths 20-21 nor Howard Terminal are available for container cargo, the capacity shortfalls will hit sooner and require more aggressive productivity improvements.

It is not certain that the productivity investments envisioned in high productivity scenarios would be economically justified and financially feasible. Recent adverse financial trends in the container shipping industry have handicapped terminal owners in attempting to recover the cost of added capacity from their carrier clients.

The scenario of progressive capacity increases envisioned in this analysis relies on high productivity operations to enable upgrades of existing facilities while they remain largely operational. While more aggressive and costly automation approaches may be able to yield even higher throughputs, those approaches require enough near-term excess capacity to take terminals out of service for complete rebuilding. In the Southern California case, additional space was available during the recession years and fill was used to expand the terminal area – an approach that will probably not be available in the Bay Area.

The productivity and capacity increases would likely include a mix of horizontal expansion, greater storage density, semi-automation, and IT measures to increase throughput on the available acreage. In general:

- Horizontal expansion and CY storage densification will increase static storage capacity – the ability of the terminals to accept import and export cargo surges from large vessel calls.
- Increased automation of handling equipment, starting with CY elements, could speed container stowage and retrieval and facilitate CY "grooming" to anticipate coming needs.
- IT applications would support automated features, but would also facilitate faster truck turn and container dwell times and increase container velocity through the terminal.

The tables below summarize these comparisons. Exhibit 101 shows that the Port of Oakland would be at or near capacity by 2050 under the Moderate Growth forecast and with estimated maximum terminal capacity under high productivity assumptions. If both Howard and Berths 20-21 were withdrawn from container cargo use, the port would be at full capacity by 2050. The Slow Growth forecast would leave Oakland at 69% to 75% of capacity by 2050, while the Strong Growth forecast would exceed the port's estimated maximum capacity by 26% to 36%.

Exhibit 101: Container Cargo Growth Versus Annual Terminal Capacity

Estimated Annual Sustainable TEU Capacity for:	Phase VI: High Productivity at all Terminals	2050 Moderate Growth TEU and Maximum Capacity Utilization		2050 Slow Growth TEU and Maximum Capacity Utilization		2050 Strong Growth TEU and Maximum Capacity Utilization	
All Potential Terminal Acres	5,597,348	5,187,588	93%	3,862,435	69%	7,038,560	126%
Potential Terminal Acres w/o Howard	5,312,858	5,187,588	98%	3,862,435	73%	7,038,560	132%
Potential Terminal Acres w/o Berths 20-21	5,455,103	5,187,588	95%	3,862,435	71%	7,038,560	129%
Potential Terminal Acres w/o Howard or Berths 20-21	5,170,613	5,187,588	100%	3,862,435	75%	7,038,560	136%

Exhibit 102 offers a second perspective: the terminal container productivity increases required to accommodate expected cargo growth under different terminal acreage scenarios. The results reflect the values shown in Exhibit 96 and Exhibit 98:

- On an annual basis, Oakland's terminals will have to significantly increase productivity to accommodate Moderate Growth, especially if fewer acres are available than at present. Slow Growth would demand little in the way of productivity increases, while Strong Growth would exhaust the Port’s capacity.
- As expected, on the basis of peak monthly volumes productivity demands are greater, and the Port may not be able to accommodate Moderate Growth if Berths 20-21 or Howard Terminal are used for other purposes.

Exhibit 102: Required Container Terminal Productivity

Annual Productivity Increase Requirements*	Moderate Growth	Slow Growth	Strong Growth
All Potential Terminal Acres	Phase I	Existing	Phase VI+
Potential Terminal Acres w/o Howard	Phase III	Existing	Phase VI+
Potential Terminal Acres w/o Berths 20-21	Phase I	Existing	Phase VI+
Potential Terminal Acres w/o Howard or Berths 20-21	Phase VI	Existing	Phase VI+

* Required productivity Phase to accommodate cargo growth by 2050

Peak Month Productivity Increase Requirements*	Moderate Growth	Slow Growth	Strong Growth
All Potential Terminal Acres	Phase VI+	Phase I	Phase VI+
Potential Terminal Acres w/o Howard	Phase VI+	Phase I	Phase VI+
Potential Terminal Acres w/o Berths 20-21	Phase VI+	Phase I	Phase VI+
Potential Terminal Acres w/o Howard or Berths 20-21	Phase VI+	Phase I	Phase VI+

* Required productivity Phase to accommodate cargo growth by 2050

These observations imply that Oakland would reach capacity limits in different years depending on acres in use and productivity increases. Exhibit 103 shows the "limit" years - the last years in which capacity would exceed volume - for different acreage, growth, and productivity stage combinations. Only productivity Phases I, III, and VI are shown - the other phases would yield limit years between those in the tables. Here too, the peak monthly volume is a more stringent test of capacity.

Exhibit 103: Port of Oakland Container Capacity Limit Years

Port of Oakland Average Container Capacity Limit Year*	Moderate Growth				Slow Growth				Strong Growth			
	Existing	Phase			Existing	Phase			Existing	Phase		
	0	I	III	VI	0	I	III	VI	0	I	III	VI
All Potential Terminal Acres	**2038**	**2050+**	**na**	**na**	2050+	na	na	na	2030	2040	2041	2041
Potential Terminal Acres w/o Howard	**2038**	**2048**	**2050+**	**na**	2050+	na	na	na	2030	2038	2039	2040
Potential Terminal Acres w/o Berths 20-21	**2038**	**2050+**	**na**	**na**	2050+	na	na	na	2030	2039	2040	2041
Potential Terminal Acres w/o Howard or Berths 20-21	**2038**	**2047**	**2049**	**2049**	2050+	na	na	na	2030	2037	2038	2039

* Last year before estimated volume exceeds estimated capacity

Port of Oakland Peak Container Capacity Limit Year*	Moderate Growth				Slow Growth				Strong Growth			
	Existing	Phase			Existing	Phase			Existing	Phase		
	0	I	III	VI	0	I	III	VI	0	I	III	VI
All Potential Terminal Acres	**2034**	**2047**	**2048**	**2049**	2046	2050+	na	na	2029	2037	2038	2039
Potential Terminal Acres w/o Howard	**2034**	**2045**	**2046**	**2047**	2046	2050+	na	na	2029	2035	2036	2037
Potential Terminal Acres w/o Berths 20-21	**2034**	**2046**	**2047**	**2048**	2046	2050+	na	na	2029	2036	2037	2037
Potential Terminal Acres w/o Howard or Berths 20-21	**2034**	**2044**	**2045**	**2046**	2046	2050+	na	na	2029	2034	2035	2036

* Last year before estimated peak monthly volume exceeds estimated capacity

To facilitate comparisons between cargo types, Exhibit 104 shows terminal acres needed and available under the maximum productivity assumption (Phase VI) of 7,112 annual TEU/acre.

Exhibit 104: Container Cargo Annual Growth and Acreage Requirements

Container Terminal Acres	2050 Acres Available*	Moderate Growth		Slow Growth		Strong Growth	
		Required	Reserve	Required	Reserve	Required	Reserve
All Potential Terminal Acres	787	729	58	543	244	990	(203)
Potential Terminal Acres w/o Howard	747	729	18	543	204	990	(243)
Potential Terminal Acres w/o Berths 20-21	767	729	38	543	224	990	(223)
Potential Terminal Acres w/o Howard or Berths 20-21	727	729	(2)	543	184	990	(263)

* Post-electrification

Port of Oakland Berth Capacity

Existing Oakland Container Berths

Exhibit 105 shows the existing (2019) terminals at the Port of Oakland, and the location of berths and container cranes. There are basically two berthing areas:

- The Outer Harbor: Berths 20-37 (TraPac and Ben E. Nutter Terminals)
- The Inner Harbor: Berths 55-68 (OICT, Matson, and Howard Terminals)

Exhibit 105 also shows the berth lengths.

Exhibit 105: Port of Oakland Berth Lengths

Not all of the existing berths have container cranes. Berths 35 (Ben E. Nutter Terminal) and 67 (Howard Terminal) have extensions of the wharf face known as "dolphins", with mooring line attachments but not cargo handling capabilities. These dolphins allow the full use of the berth length for cargo handling.

Exhibit 106 shows the container and berth lengths in active use as of September 2019. Cranes at Berths 20–21 are scheduled for removal. Berth 34 is unusable due to the underwater presence of the BART Transbay Tube. Berth 38 no longer has container cranes, and there are no plans to accommodate vessel calls there. As of September 2019, Oakland has 21,484 feet of working berth length spread over 14 active berths.

Exhibit 106: Existing Active Container Berths

Existing Terminal Berth Dimensions (feet)								
Terminal	**Berth**	**Depth**	**Length**	**Dolphin**	**Total**	**Active Nominal Berths**	**Available Weekly Berth Foot-Hours**	**Daily Berth Foot-Hours**
Inactive	20-21*	42	1,355	-	1,355	-	-	-
Inactive	22-24	50	2,870	-	2,870	-	-	-
TraPac	25-26	50	1,393	-	1,393	2	234,024	33,432
TraPac	30-33	50	2,850	-	2,850	3	478,800	68,400
Unusable	34*	37	-	-		-	-	-
Ben E. Nutter	35-37	50	2,157	100	2,257	2	379,176	54,168
Unusable	38***	50	-	-		-	-	-
OICT	55-59	50	6,000	-	6,000	5	1,008,000	144,000
Matson	60-63	42	2,743	-	2,743	2	460,824	65,832
Howard	67-68	42	1,946	70	2,016	-	-	-
Total			**21,314**	**170**	**21,484**	**14**	**2,560,824**	**365,832**

* Container cranes scheduled for removal.
** Limited by BART Tube.
*** Cranes removed prior to 2000, not expected to receive vessel calls.

In September 2019, the Port recently released a *Notice of Preparation of a Draft Supplemental Environmental Impact Report* for development of the proposed Eagle Rock Aggregate Terminal at Berths 20-21. The project would also occupy Berth 22, but would enable other vessels to use that berth when not used by Eagle Rock vessels or barges. Accordingly, Berths 20-21 are not considered to be available for future container cargo but Berth 22 is included in the analysis scenarios. The proposed use for dry bulk has a fifteen-year life, and that Berths 20-21 may eventually return to container handling.

Exhibit 107 shows the future available berths and berth length, assuming that widening the Inner Harbor Turning Basin as planned will result in the shortening of the Howard Terminal berth by 965 feet and the removal of the 70-foot dolphin from the west end. Under those circumstances, the Port of Oakland would have 19,094 feet of container berth spread over 18 active berths.

Exhibit 107: Container Berths With Expanded Turning Basin

Future Terminal Berth Dimensions (feet) with Expanded Turning Basin								
Terminal	**Berth**	**Depth**	**Length**	**Dolphin**	**Total**	**Active Nominal Berths**	**Available Weekly Berth Foot-Hours**	**Daily Berth Foot-Hours**
Eagle Rock	20-21*	42	-	-	-	-	-	-
TraPac/Other	22-26	50	4,263	-	4,263	4	716,184	102,312
TraPac	30-33	50	2,850	-	2,850	3	478,800	68,400
Unusable	34*	37	-	-	-	-	-	-
Ben E. Nutter	35-37	50	2,157	100	2,257	2	379,176	54,168
Unusable	38***	50	-	-		-	-	-
OICT	55-59	50	6,000	-	6,000	5	1,008,000	144,000
Matson	60-63	42	2,743	-	2,743	2	460,824	65,832
Howard	67-68****	42	981	-	981	2	164,808	23,544
Total			**18,994**	**100**	**19,094**	**18**	**3,207,792**	**458,256**

* Container cranes scheduled for removal.
** Limited by BART Tube.
*** Cranes removed prior to 2000, not expected to receive vessel calls.
**** Turning basin expansion removes 70' dolphin and 965 feet of berth.

Discussions with Port of Oakland staff confirmed the conceptual feasibility of adding a dolphin to the east end of the Howard Terminal wharf, as indicated in the Appendix. A 500-foot dolphin at the east end of the Howard Terminal wharf (or an equivalent expansion of the wharf itself) would raise the Port total berth length to 19,594 feet over 18 nominal berths.

Exhibit 108: Container Berths With Howard Terminal Extension

Future Terminal Berth Dimensions (feet) with Turning Basin & Howard Dolphin								
Terminal	**Berth**	**Depth**	**Length**	**Dolphin**	**Total**	**Active Nominal Berths**	**Available Weekly Berth Foot-Hours**	**Daily Berth Foot-Hours**
Eagle Rock	20-21*	42	-	-	-		-	-
TraPac/Other	22-26	50	4,263	-	4,263	4	716,184	102,312
TraPac	30-33	50	2,850	-	2,850	3	478,800	68,400
Unusable	34*	37	-	-	-	-	-	-
Ben E. Nutter	35-37	50	2,157	100	2,257	2	379,176	54,168
Unusable	38***	50	-	-	-	-	-	-
OICT	55-59	50	6,000	-	6,000	5	1,008,000	144,000
Matson	60-63	42	2,743	-	2,743	2	460,824	65,832
Howard	67-68****	42	981	500	1,481	2	248,808	35,544
Total			**18,994**	**600**	**19,594**	**18**	**3,291,792**	**470,256**

* Container cranes scheduled for removal.
** Limited by BART Tube.
*** Cranes removed prior to 2000, not expected to receive vessel calls.
**** Turning basin expansion removes 70' dolphin and 965 feet of berth.

Exhibit 109 shows available berths and lengths without Howard Terminal. The Port would then have 16,007 feet over 16 active berths.

Exhibit 109: Container Berths Without Howard Terminal

Future Terminal Berth Dimensions (feet) with Turning Basin w/o Howard								
Terminal	Berth	Depth	Length	Dolphin	Total	Active Nominal Berths	Available Weekly Berth Foot-Hours	Daily Berth Foot-Hours
Eagle Rock	20-21*	42	-	-	-		-	-
TraPac/Other	22-26	50	2,157	-	2,157	4	362,376	51,768
TraPac	30-33	50	2,850	-	2,850	3	478,800	68,400
Unusable	34*	37	-	-	-	-	-	-
Ben E. Nutter	35-37	50	2,157	100	2,257	2	379,176	54,168
Unusable	38***	50	-	-	-	-	-	-
OICT	55-59	50	6,000	-	6,000	5	1,008,000	144,000
Matson	60-63	42	2,743	-	2,743	2	460,824	65,832
Howard	67-68****	42	-	-	-	-	-	-
Total			**15,907**	**100**	**16,007**	**16**	**2,689,176**	**384,168**

* Container cranes scheduled for removal
** Limited by BART Tube
*** Cranes removed prior to 2000, not expected to receive vessel calls.
**** Turning basin expansion removes 70' dolphin and 965 feet of berth.

Vessel Berthing Requirements

Vessel berthing requirements are determined by vessel length and the requirement for mooring lines (Exhibit 110). Mooring lines from adjacent vessels can overlap, but common practice is to maintain spacing between the vessels roughly equal to their beam (width).

Exhibit 110: Vessel and Mooring Lines

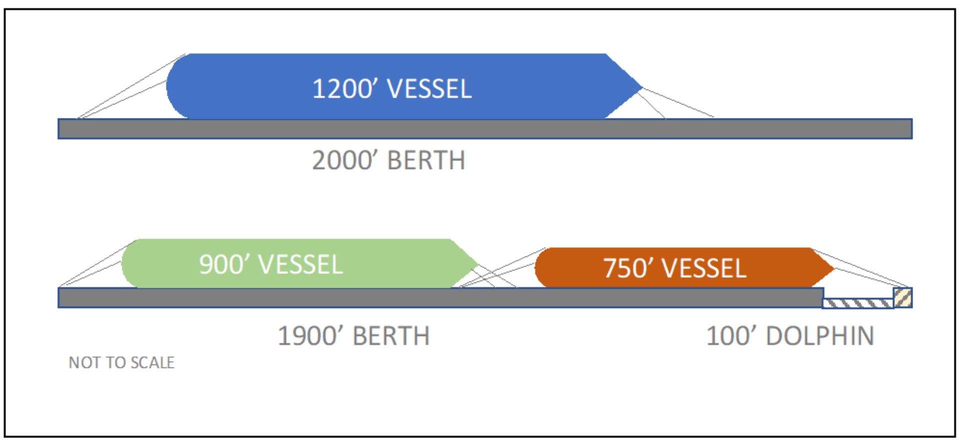
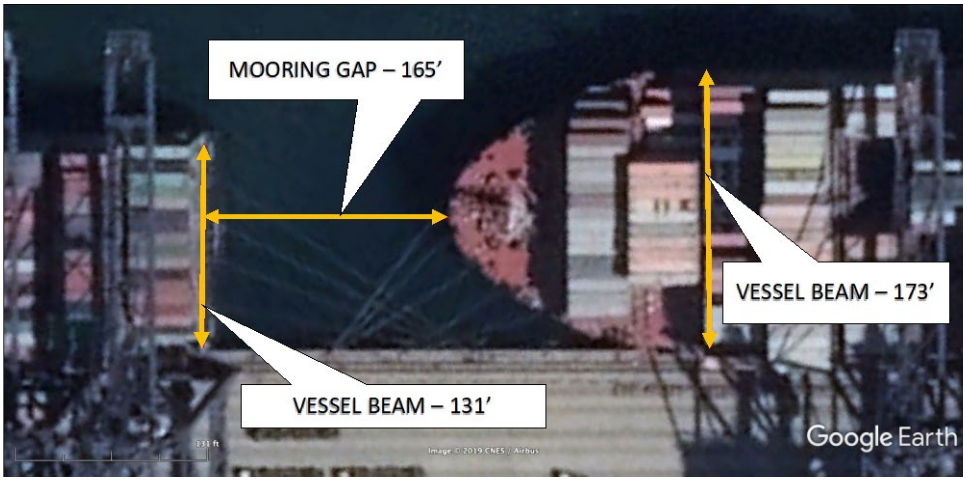


Exhibit 111 and Exhibit 112 provide examples of this practice. For purposes of this berthing analysis, the study team has allowed 150 feet beyond the vessel length for multiple vessels at the same berth expanse.

Exhibit 111: Vessel Mooring Line Span

Exhibit 112: Example of Vessel Mooring Gap



Existing Vessel Services

As of early 2019, Oakland is served by 28 container vessel services, with 29 weekly calls because one service calls semi-weekly (Exhibit 113). As Exhibit 113 shows, most vessel calls are alliance services, but there are still individual carrier calls as well as the domestic services of Matson and Pasha.

Exhibit 113: Early 2019 Oakland Container Services

Terminal	Operator	Service	Frequency	Schedule Call Day	2019 Vessel Example	2019 Vessel Size TEU
Matson	Matson	Hawaii 2	Weekly	Mon	Kaimana Hila	3,600
	Matson	Hawaii 1	Weekly	Wed	Daniel Inouye	3,600
Nutter	Ocean Alliance	CPS/CC5/AAC2/HBB	Weekly	Sat	NAVARINO	8,530
	Ocean Alliance	HTW/AAS3/GEX	Weekly	Sun	EVER SMART	7,024
	Ocean Alliance	TPS/Jade Express/AAS4/SC8	Semi-weekly	Sun/Wed	THALASSA ELPIDA	13,800
OICT	2M Alliance	TP8/Orient/PS4/UPAS1	Weekly	Fri	MAERSK ALGOL	9,580
	2M Alliance	TP2/Jaguar/PS3/UPAS 2	Weekly	Tue	MAERSK ELBA	13,100
	ANL	PSW1/PANZ-PSW/WAS/AOS/Oceania Loop 1	Weekly	Sat	ANL WARRNAMBOOL	4,563
	APL	EX1	Weekly	Fri	PRESIDENT WILSON	5,780
	Hamburg Sud	WAMS/WCCA2/AZTEC1/WC2	Weekly	Fri	CAP PALLISER	1,841
	Hamburg Sud	SSEA/Polynesia	Biweekly	Thu	Polynesia	1,304
	Hapag-Lloyd	MPS/MCPS/MPS	Semi-weekly	Sun/Wed	Kobe Express	4,612
	Hyundai	PS2/TP7/Lotus	Weekly	Fri	Hyundai Long Beach	6,350
	MSC	California Express	Weekly	Wed	MSC Siliva	9,400
	Ocean Alliance	Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3	Weekly	Fri	CMA-CGM T Jefferson	14,414
	Ocean Alliance	Columbus JAX/PE1/SEA2/PE1/SEAP-PSW	Weekly	Mon	CMA-CGM Chennai	10,100
	Ocean Alliance	CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	Weekly	Sun	CSCL South China Sea	10,036
	Pasha	CHX	Weekly	Wed	HORIZON PACIFIC	2,325
	THE Alliance	PS6	Weekly	Sun	NYK ALTAIR	9,582
	THE Alliance	AL5 WB/California Bridge/ECX	Semi-weekly	Sun/Wed	NYK ROMULUS	4,888
	THE Alliance	FP1	Weekly	Tue	Hamburg Bridge	8,212
	COSCO/PIL/Wan Hai	AC5	Weekly	Sat	Kota Panjang	11,900
	THE Alliance	PS5	Weekly	Wed	YM UNICORN	8,636
TraPac	THE Alliance	PS4	Weekly	Fri	YM Maturity	6,572
	THE Alliance	PS7	Weekly	Mon	MOL BRILLIANCE	10,000
	THE Alliance	PS3	Weekly	Mon	NYK Athena	6,492
	THE Alliance	PS2/JPSW/PS2	Weekly	Tue	Brussels Bridge	4,432
	THE Alliance	EC1 WB	Weekly	Wed	MOL MATRIX	6,724

These services are complex, and carriers and alliances periodically change vessel rotations and service names, so it is difficult to make year-to-year comparisons. Exhibit 113 provides examples of vessels recently used in the Oakland services. Because many services operate with a mix of vessels and changes can occur at any time, the vessel specifications should be taken as indicative rather than definitive.

The largest vessels built to date are between 23,000 and 24,000 TEU, as shown in Exhibit 114. As the data reveal, the largest vessels have overall lengths of 400 meters (1,312 feet), beams of about 59.0 to 61.5 meters (193-202 feet), and design drafts of 16.0 to 16.5 meters (52.5 to 54.1 feet). These vessels would require about 1,462 feet of berth when moored adjacent to others (about 1,612 if moored separately). Sailing drafts are typically limited to about 90% of the maximum design draft. With 4 feet of underkeel clearance, as required by San Francisco Bay pilots, these vessels would require up to 51-53 feet of draft, about Oakland's current maximum. In practice, if these vessels call first at Los Angeles-Long Beach and discharge most of their import cargo, they would not use this full draft while calling at Oakland.

Exhibit 114: Largest Container Vessels as of Mid-2019

	MSC Gulsun	OOCL Hong Kong	COSCO Shipping Universe	CMA CGM Antoine de St Exupery	Madrid Maersk	Ever Golden	MOL Truth
TEU Capy	23,756	21,413	21,237	20,954	20,568	20,150	20,182
Length (m)	400	400	400	400	399	400	400
Beam (m)	61.5	58.8	58.6	59.0	58.8	58.8	58.5
Design Draft (m)	>16.0	16.0	16.0	16.0	16.5	14.5	16.0
Length (ft)	1,312	1,312	1,312	1,312	1,309	1,312	1,312
Beam (ft)	202	193	192	194	193	193	192
Design Draft (ft)	>52.5	52.5	52.5	52.5	54.1	47.6	52.5
Avg. Max Sailing Draft (ft)	>47.2	47.2	47.2	47.2	48.7	42.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	**>51.2**	**51.2**	**51.2**	**51.2**	**52.7**	**46.8**	**51.2**
Length (ft)	1,312	1,312	1,312	1,312	1,309	1,312	1,312
Mooring Allowance	150	150	150	150	150	150	150
Berth Required	**1,462**	**1,462**	**1,462**	**1,462**	**1,459**	**1,462**	**1,462**

As of mid-2019, there are approved plans for a 25,000 TEU container ship, but none have yet been ordered. There have been proposed conceptual designs for vessels up to 32,000 TEU and speculation on what vessels of up to 50,000 TEU would be like. There are doubts, however, whether vessels of over 36,000 TEU are either technically or economically feasible. Recent analyses indicate that vessel sizes over 20,000 TEU have diminishing returns as size increases. It is fair to point out, however, that all previous estimates of the largest feasible vessel size have been exceeded in practice.

The Bay Area is limited by Oakland's channel and berth depth (currently a nominal 50 feet at most berths), and by the air draft (vertical clearance) under the bridges. The vessels shown in Exhibit 114 have already reached the maximum draft and air draft, so without relaxing those constraints future vessels must be longer and wider to increase capacity further.

Exhibit 115 presents typical examples of the vessel classes calling at Oakland. The largest vessels currently calling at Oakland are 1,200 feet long and require 1,350 feet of berth length (1,500 feet if moored separately). These vessels correspond to the 1,200-foot vessels shown in Exhibit 111 and Exhibit 123. As Exhibit 122 indicates, the longest dwell times for these vessels are around 36 hours.

Exhibit 115: 2019 Vessel Classes Calling Oakland

Class Vessel Example	1,000 Polynesia	2,000 Cap Palliser	3,000 Cap Capricorn	4,000 Kota Ekspres	5,000 NYK Romulus	6,000 Hyundai Long Beach	7,000 Ever Smart
TEU Capacity	1,304	1,841	2,824	3,600	4,888	6,350	7,024
Design Draft (ft)	32	37	41	33	44	46	47
Avg. Max Sailing Draft (ft)	29.2	33.4	36.9	30.1	39.9	41.3	41.9
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	**33.2**	**37.4**	**40.9**	**34.1**	**43.9**	**45.3**	**45.9**
LOA	529	611	748	854	964	961	984
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	**679**	**761**	**898**	**1,004**	**1,114**	**1,111**	**1,134**

Class Vessel Example	8,000 OOCL London	9,000 Gerner MAERSK	10,000 MOL Brilliance	11,000 Cape Kortia	12,000 MSC Beryl	13,000 MAERSK Elba	14,000 CMA-CGM Thomas Jefferson
TEU Capacity	8,063	9,038	10,000	11,010	12,400	13,100	14,414
Length (ft)	1,102	1,092	1,105	1,082	1,200	1,202	1,200
Design Draft (ft)	46	48	49	52	51	51	52
Avg. Max Sailing Draft (ft)	41.3	42.8	44.3	47.2	45.8	45.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	**45.3**	**46.8**	**48.3**	**51.2**	**49.8**	**49.8**	**51.2**
LOA	1,102	1,092	1,105	1,082	1,200	1,202	1,200
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	**1,252**	**1,242**	**1,255**	**1,232**	**1,350**	**1,352**	**1,350**

Exhibit 116 provides comparable data on larger vessel classes in use elsewhere (primarily in the Asia-Europe trades) but not yet calling at Oakland or on the U.S. West Coast.

Exhibit 116: Larger Vessel Classes in Use

Class Vessel Example	15,000 Ebba Maersk	16,000 CMA CGM Jules Verne	17,000 APL Singapura	18,000 CMA CGM Benjamin Franklin	19,000 CSCL Globe	20,000 Ever Golden	21,000 OOCL Hong Kong
TEU Capacity	14,770	16,022	17,292	17,859	19,100	20,150	21,413
Length (ft)	1,304	1,299	1,305	1,309	1,311	1,312	1,312
Design Draft (ft)	51	52	52	52	52	48	52
Avg. Max Sailing Draft (ft)	45.8	47.2	47.2	47.2	47.2	42.8	47.2
Underkeel Clearance (ft)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Draft Required (ft)	**49.8**	**51.2**	**51.2**	**51.2**	**51.2**	**46.8**	**51.2**
Length (ft)	1,304	1,299	1,305	1,309	1,311	1,312	1,312
Mooring Allowance	150	150	150	150	150	150	150
Berth Required (ft)	**1,454**	**1,449**	**1,455**	**1,459**	**1,461**	**1,461**	**1,462**

Exhibit 117 shows the berth occupancy implied by the schedules in Exhibit 113 and typical or estimated dwell times for the various vessel sizes.

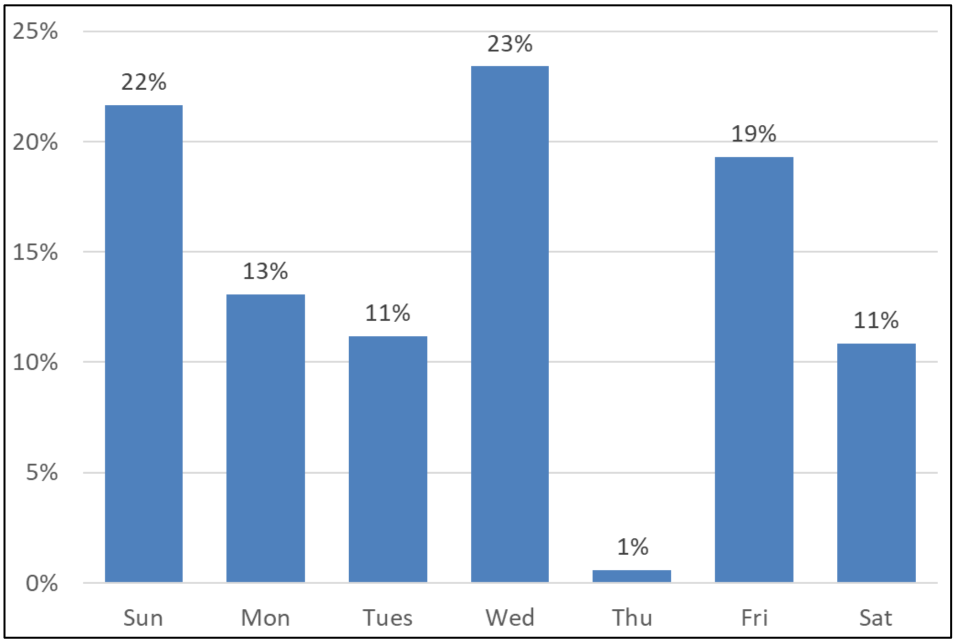
Exhibit 117: 2019 Estimated Berth Occupancy

Day of Week	Sunday			Monday			Tuesday			Wednesday			Thursday			Friday			Saturday		
Shift	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
OICT		AC5		Columbus JAX/PE1/SEA2/PE1/SEA						PS5						Pearl River Express/SC1/PR				AC5	
OICT	CEN/BOHAI/CC2/CEN/PCN1/CEN/						TP2/Jaguar/PS3/UP/			CHX			SSEA/Polynes			WAMS/WCCA			PSW1/PANZ-		
OICT	PS6						FP1			California Exp						TP8/Orient/PS4/UP/					
OICT	MPS/MCPS/N									MPS/MCPS/N						PS2/TP7/Lotus					
OICT	AL5 WB/Calif															EX1					
TraPac				PS7						EC1 WB						PS4					
TraPac				PS3			PS2/JPSW/PS2														
Ben E. Nutter										TPS/Jade Express/A											
Ben E. Nutter	HTW/AAS3/GEX																				
Ben E. Nutter	CPS																		CPS/CC5/AAC2/HBB		
Matson				Hawaii 2						Hawaii 1											

On this basis, OICT, with five (nominal) berths, appears to be fully occupied Sundays and Fridays. TraPac has four (nominal) berths, two of which are occupied Monday and Tuesday. Ben E. Nutter Terminal has two berths, and would appear to have overlapping occupancy on Sundays. The Matson terminal has two berths, only one of which appears to be occupied at a time. Based on AIS data, however, some Matson vessels spend extended time in port. As Exhibit 117 implies and Exhibit 118 documents, Sunday, Wednesday, and Friday are the peak days for vessel arrivals at the Port of Oakland.

Exhibit 117 also illustrates the need for "slack" in berth capacity to deal with late vessel arrivals or delays in terminal handling. For example, if the TP2 or FP1 services arrive late at OICT on Tuesday, they may be occupying a berth needed for the five vessels scheduled to arrive on Wednesday.

Exhibit 118: Daily Port of Oakland Capacity Arrival Shares, 2019



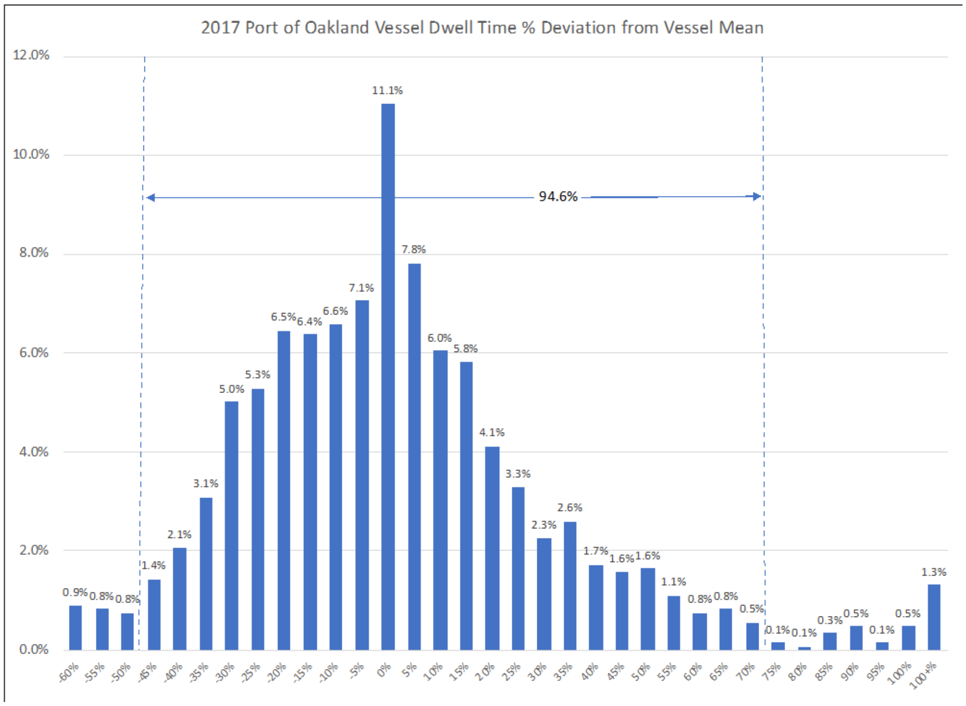
As both Exhibit 117 and Exhibit 118 imply, vessel arrivals and berth utilization are uneven. This unevenness is driven by:

- Sailing times from ports before or after Oakland in the service rotations.
- Market timing preferences of ocean carriers and their customers.
- The commercial relationship between ocean carriers and marine terminal operators.

While berth and terminal congestion *might* encourage some leveling across days and terminals in the long run, the pattern remains uneven at most ports after more than four decades of container shipping.

Exhibit 119 shows the distribution of 2017 Oakland dwell times around the mean for each vessel. To capture 94.6% of the dwell time, scheduled calls and available berth time would have to be 70% longer than the mean. The Oakland mean was about 24.9 hours, so the required average berth occupancy window would have to be approximately 42.3 hours, and average berth utilization for such a call would be 59%.

Exhibit 119: 2017 Oakland Vessel Dwell Time Distribution



An UNCTAD study set thresholds for utilization to avoid vessel queuing:

- 55% for single berths
- 60% for two berths
- 65% for three or more berths

Higher utilization would risk frequent disruption. The approach taken in this report uses the 65% threshold, which would be suitable for the OICT, TraPac, and future OHT multi-berth terminals. Ben E. Nutter, Matson, and Howard could be either single or multi-berth terminals depending on vessel size.

2050 Vessel Call Scenarios

In principle there are two ways in which vessel calls can change to accommodate cargo growth:

- Increased vessel sizes within existing services and schedules, or
- New services with additional vessel calls.

In practice, the future will probably see a mix of strategies that cannot be predicted with any confidence. Vessel call expectations through 2035 are based on a confidential 2018 analysis prepared for the Port of Oakland. That analysis took service details and expected ocean carrier and alliance strategies into account, and predicted a progression of vessel size increases. Beyond 2035, the study team extrapolated vessel calls and sizes based on projected trade growth and increased vessel sizes.

Exhibit 120 shows the scenario developed for increased vessels sizes under the Moderate Growth case. The 2018 analysis did not cover all of the existing Oakland services, so those that were not covered were extended through

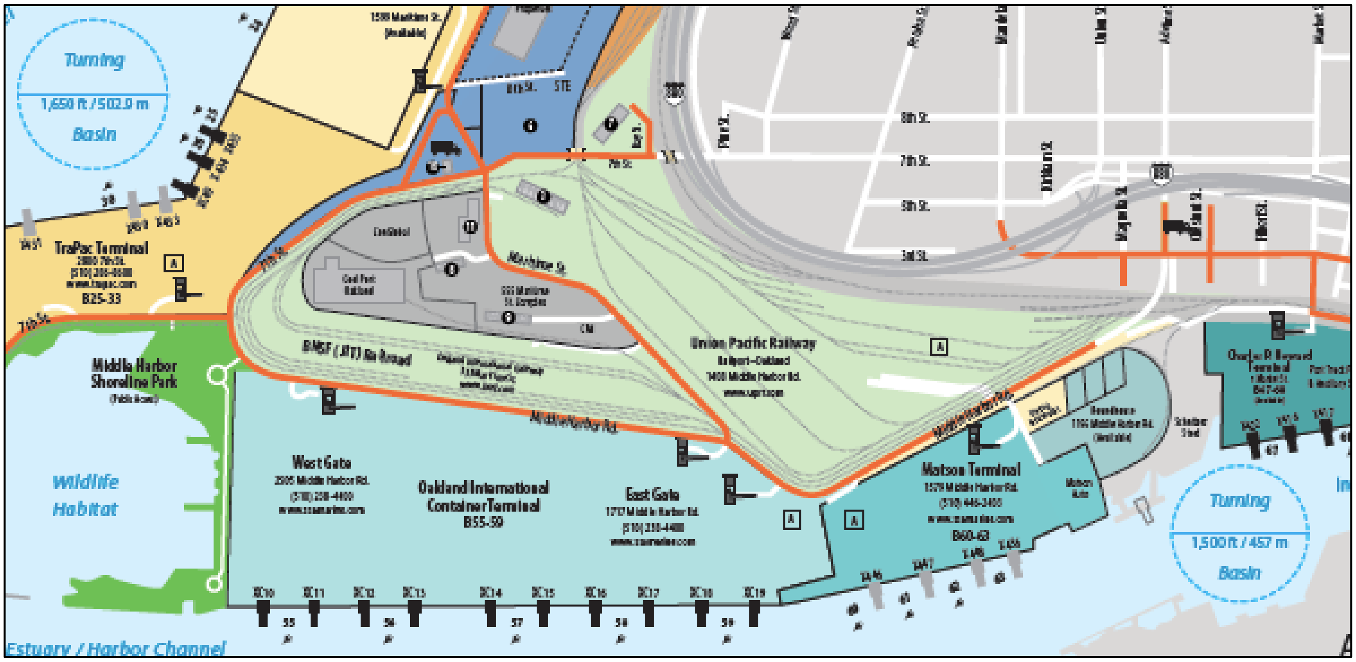
2035 at existing or slightly increased growth rates. Some services have already increased vessel size beyond what the analysis predicted for 2020.

Exhibit 120: Moderate Growth Scenario for Increased Vessel Size

Moderate Case		No Vessel Cap		14000 TEU Vessel Cap		25000 TEU Vessel Cap	
Service	**2019 Vessel Size TEU**	**2018 Study/ Tioga 2020**	**Tioga 2050**	**2018 Study/ Tioga 2020**	**Tioga 2050**	**2018 Study/ Tioga 2020**	**Tioga 2050**
Hawaii 2 - Domestic	3,600	3,600	4,499	3,600	4,499	3,600	4,499
Hawaii 1 - Domestic	3,600	3,600	4,499	3,600	4,499	3,600	4,499
CHX - Domestic	2,325	2,325	2,615	2,325	2,615	2,325	2,615
CPS/CC5/AAC2/HBB	8,530	11,500	17,284	11,500	14,000	11,500	17,284
HTW/AAS3/GEX	7,024	8,500	20,164	8,500	14,000	8,500	20,164
TPS/Jade Express/AAS4/SC8	13,800	13,800	25,925	13,800	14,000	13,800	25,000
TP8/Orient/PS4/UPAS1	9,580	13,250	31,687	13,250	14,000	13,250	25,000
TP2/Jaguar/PS3/UPAS 2	13,100	13,700	23,045	13,700	14,000	13,700	23,045
PSW1/PANZ-PSW/WAS/AOS/Oceania Loop 1	4,563	4,563	9,785	4,563	9,785	4,563	9,785
EX1	5,780	7,000	14,403	7,000	14,000	7,000	14,403
WAMS/WCCA2/AZTEC1/WC2	1,841	1,841	3,948	1,841	3,948	1,841	3,948
SSEA/Polynesia	1,304	1,304	2,796	1,304	2,796	1,304	2,796
MPS/MCPS/MPS	4,612	4,612	9,890	4,612	9,890	4,612	9,890
PS2/TP7/Lotus	6,350	8,500	15,843	8,500	14,000	8,500	15,843
California Express	9,400	9,400	20,158	9,400	14,000	9,400	20,158
Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3	14,414	14,414	30,102	14,000	14,000	14,414	25,000
Columbus JAX/PE1/SEA2/PE1/SEAP-PSW	10,100	10,100	24,485	10,100	14,000	10,100	24,485
CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	10,036	13,500	27,366	13,500	14,000	13,500	25,000
PS6	9,582	9,582	21,604	9,582	14,000	9,582	21,604
AL5 WB/California Bridge/ECX	4,888	4,888	10,482	4,888	10,482	4,888	10,482
FP1	8,212	8,212	17,610	8,212	14,000	8,212	17,610
AC5	11,900	11,900	25,519	11,900	14,000	11,900	25,000
PS5	8,636	8,750	14,403	8,750	14,000	8,750	14,403
PS4	6,572	6,500	14,403	6,500	14,000	6,500	14,403
PS7	10,000	10,000	21,604	10,000	14,000	10,000	21,604
PS3	6,492	6,600	18,724	6,600	14,000	6,600	18,724
PS2/JPSW/PS2	4,432	4,500	10,802	4,500	10,802	4,500	10,802
EC1 WB	6,724	6,724	14,419	6,724	14,000	6,724	14,419
Required Weekly Vessel Capacity in TEU		**223,165**	**458,064**	**223,165**	**458,064**	**223,165**	**458,064**
Existing Services (with vessel size cap) - Starting in 2021		223,165	458,064	223,165	325,316	223,165	442,466
Additional Service Capacity Required		-	-	-	132,747	-	15,598
Average Vessel Capacity in TEU		7,970	16,359	7,955	11,618	7,970	15,802
Additional Average Vessel Calls		-	-	-	11	-	-
Additional Average Vessel Capacity		-	-	-	127,803	-	-
Additional Other Vessel Service		-	-	-	4,945	-	15,598
Total Weekly Capacity		223,165	458,064	223,165	458,064	223,165	458,064
Total Weekly Vessel Calls		**28**	**28**	**28**	**40**	**28**	**29**

The Port of Oakland has two designated vessel turning basins, the Outer Harbor Turning Basin (OHTB) and the Inner Harbor Turning Basin (IHTB). As shown in Exhibit 121, the OHTB is 1,650 feet across, but the IHTB is 1,500 feet. The IHTB is therefore limited to vessels of 13,000-14,000 TEU. Accordingly, the consultant team created a scenario limiting vessel calls to 14,000 TEU.

Exhibit 121: Port of Oakland Turning Basins



As noted, there are no vessels in operation over 24,000 TEU. While some increase over the existing maximum is expected, questions have been raised regarding the advantages of still larger vessels. Accordingly, the consultant team created a second scenario limiting vessel size to 25,000 TEU.

Exhibit 120 shows that capping the vessel sizes at 14,000 or 25,000 TEU limits the capacity of the largest volume services. The analysis therefore allows for additional services at the average 2050 vessel size, and then one additional service at less than average size to provide the required total weekly capacity.

This approach does not attempt to predict where the additional services would call or which carriers and alliances would operate them. While a service-specific approach was used in the 2018 projections out to 2035, such an approach would not be reliable out to 2050.

Exhibit 120 shows, the chosen approach yields 2050 Moderate Growth scenarios of:

- 40 weekly calls at an average vessel capacity of 11,618 TEU under a 14,000 TEU size cap.
- 29 weekly calls at an average vessel capacity of 15,802 TEU under a 25,000 TEU size cap.
- 28 weekly calls at an average vessel capacity of 16,359 TEU with no vessel cap.

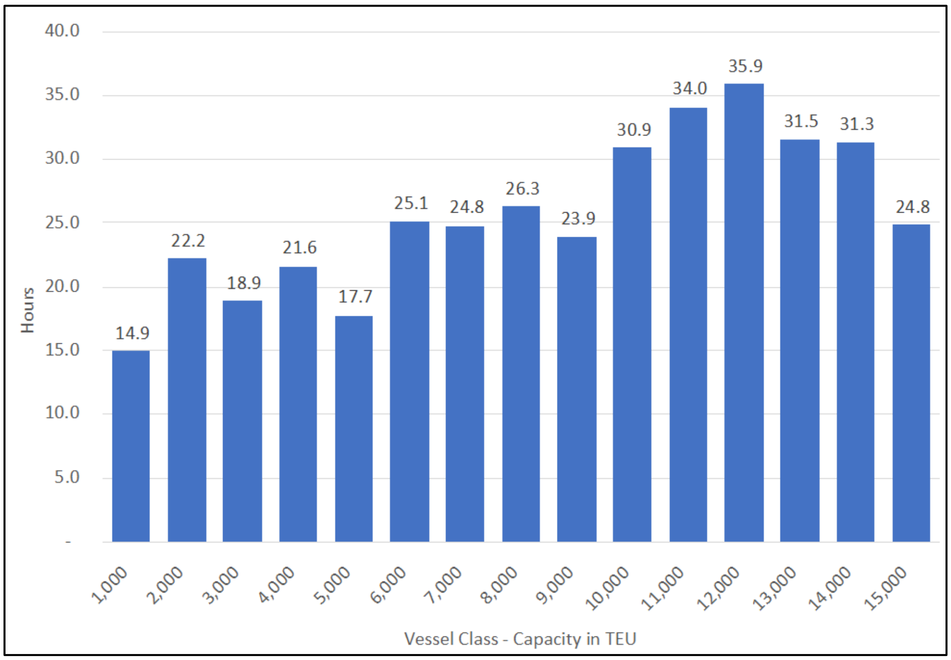
This approach follows observed industry practice by introducing new services rather than expanding existing services indefinitely. Between 2019 and 2050 the structure of vessel services and port rotations is likely to change completely. The consultant team's approach effectively assumes that vessel sizes on Oakland services would grow as the trades they serve grow, and applies the projected domestic and international growth rates separately to estimate the vessel size growth in each segment, and the total vessel capacity required. This approach also assumes that vessel utilization will not change significantly. Vessel strings that reached the size cap would be supplemented by additional services using vessels typical of the current fleet mix (e.g. vessels cascaded from other services).

Relying only on vessel size increase to accommodate trade growth would require some services to use vessels of over 30,000 TEU in the Moderate Growth case and over 34,000 TEU by 2050 in the Strong Growth case.

Vessel Handling Rates and Dwell Times

Vessels at berth take up both space and time. As Exhibit 122 shows, larger vessels typically, but not inevitably, stay longer at berth to handle the greater cargo volumes they usually carry. Containerships of up to 9,000 TEU typically stay in port for up to one full day, allowing two shifts (e.g. one day shift and one evening shift) to work the vessel if required. Vessels of 10,000 TEU and above typically spend 30-36 hours in port, allowing for a third shift (e.g. a day shift, an evening shift, and a second day shift) to work the vessel.

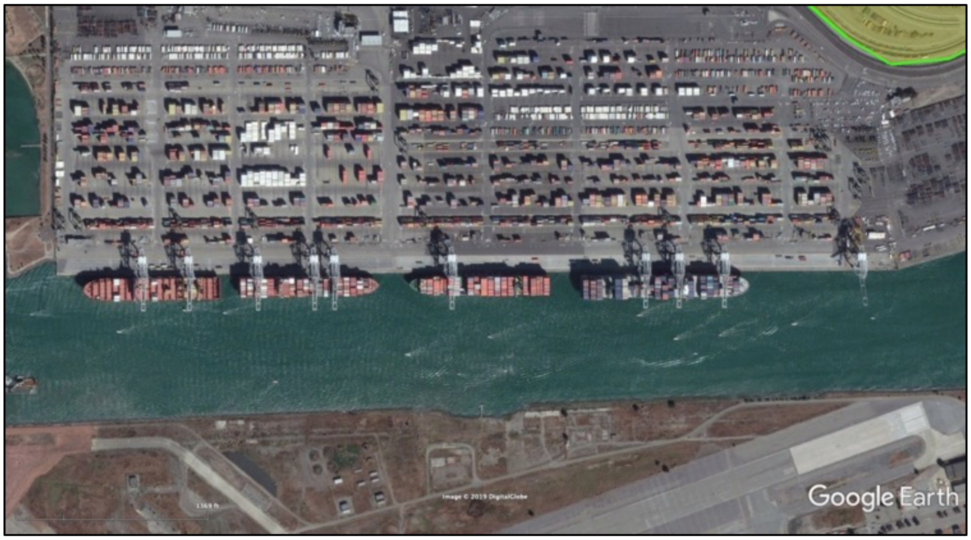
Exhibit 122: 2017 Port of Oakland Average Vessel Class Dwell Times



The dwell time needed to handle a vessel and its import and export containers depends in part on the number of cranes assigned to handle the ship. Most vessels are worked with 2-4 cranes as required, while up to 6 may be used on the very largest ships. Industry participants indicate that terminals typically assign enough cranes to each vessel to meet the vessel schedule. Expectations for the number of cranes available for a given service may be set in discussion between terminal operators and carriers, and may even be specified in contractual agreements. The aerial photograph in Exhibit 123, for example, shows nine cranes deployed across four vessels at OICT. The largest vessel, with three cranes, is a 1,200 ft ship.

The use of additional cranes to speed up vessel handling is limited by the supply of cranes (which can be adjusted to some extent in the long run), the spacing needed between cranes, and the ocean carrier's willingness to incur additional costs. The common practice appears to be assigning additional cranes as needed to keep larger vessels on schedule rather than allowing dwell time to rise with cargo volume. Only for the very largest vessel and call volumes (e.g. megaships calling Los Angeles or Long Beach) have scheduled port calls been increased to a third day. There is, however, a physical limit on how many cranes can be used for a single vessel. As the crane legs are wider than a single container cargo bay, they can at most be used only on alternate bays.

Exhibit 123: Crane Use at OICT



Vessel dwell time at marine container terminals is a function of:

- Time required to secure the vessel on arrival and prepare for container transfer.
- Time required to discharge import and inbound empty containers.
- Time required to load export and outbound empty containers.
- Time required to prepare for departure and release the vessel.

Discussions with Oakland marine terminal operators suggested an allowance of 2 hours for line handling and other operations at arrival and departure.

The time required to discharge and load containers is a function of:

- TEU per vessel call.
- Average crane moves per hour (33–35 at Oakland).
- Average TEU/container (about 1.8 at Oakland).
- The number of cranes assigned.

For the Port of Oakland, 2017 statistics show an average vessel call utilization of 25.9% (Exhibit 124). In other words, Port of Oakland terminals typically discharge and load 25.9% of the average vessel capacity[vi].

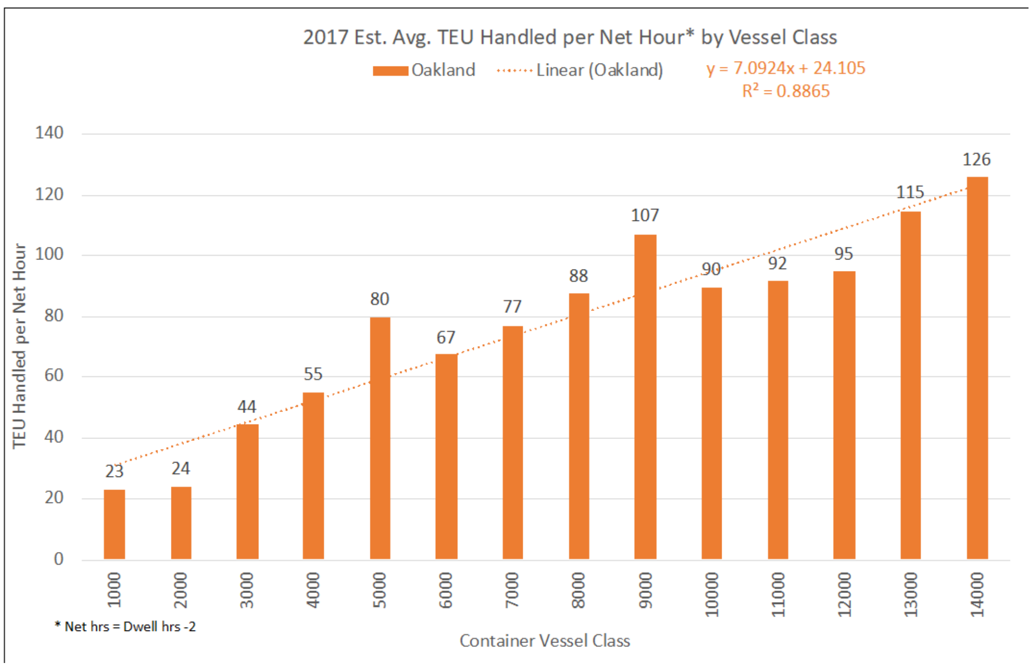
[vi] The maximum would be 200% – 100% discharge and 100% load.

Exhibit 124: Port Comparisons

2017	LALB	Oakland
Total Dwell Hours	104,157	34,157
Total Vessel Capy TEU	11,643,847	9,347,112
Annual TEU	16,887,698	2,420,837
TEU/hr	162	71
Vessel TEU capy/hr	112	274
Calls	1,810	1,471
TEU/call	9,330	1,646
Avg vessel capy TEU	6,433	6,354
Avg vessel ute	**145.0%**	**25.9%**
Avg Dwell Hours	**57.5**	**23.2**

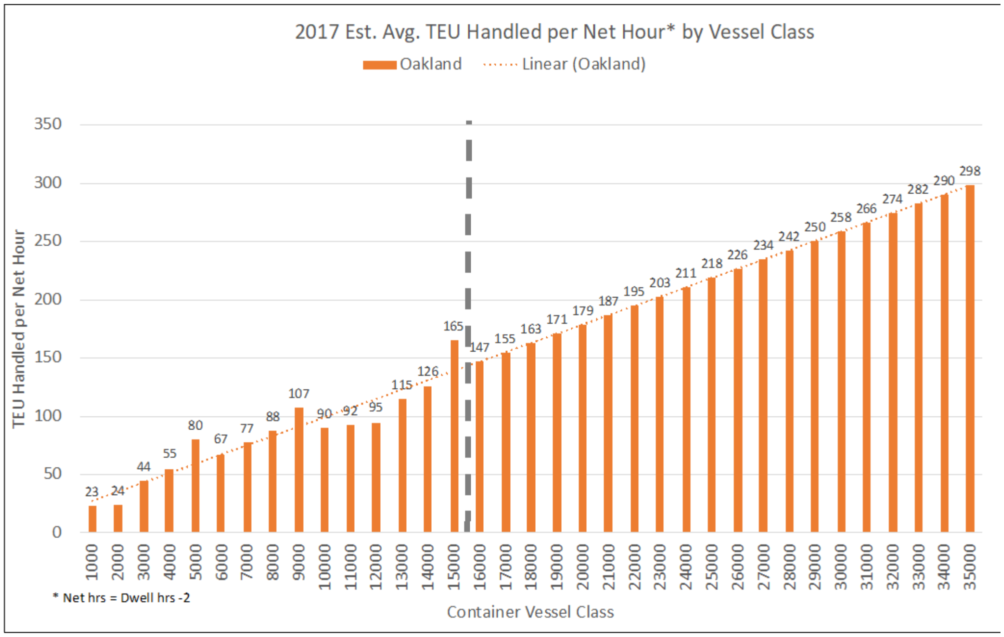
This factor and 2017 AIS dwell time data yield the relationship between vessel size and average handling rates in Exhibit 125. As indicated, there is a strong linear approximation (R^2 = 0.8865).

Exhibit 125: Vessel Size and Handling Rates



This linear approximation yields, in turn, projected handling rates in TEU per hour for the average vessel sizes and classes expected through 2050 (Exhibit 126).

Exhibit 126: Projected Vessel Handling Rates



These handling rates correspond to the cranes typically assigned to various vessel sizes, from a minimum of 1 to 2 cranes for vessels under 5,000 TEU to 2 to 3 cranes for vessels up to 14,000 TEU and projected at 4 to 5 cranes for vessels over 25,000 TEU. The projected handling rates were then used to estimate vessel dwell times.

Vessel Berthing Requirements

Estimating the berthing requirements incorporates the forecast vessel demands (Exhibit 120 displays the Moderate Growth scenario) with the estimated handling times of those vessels. Exhibit 127 shows the approach to estimating weekly and peak day berthing requirements under the Moderate Growth case.

Exhibit 127: Moderate Growth Vessel Berth Requirements

Moderate Case	No Vessel Cap			14,000 TEU Vessel Cap			25,000 TEU Vessel Cap		
Service	2018 Study/ Tioga 2020	Tioga 2050	Vessel Berth Req. in Feet	2018 Study/ Tioga 2020	Tioga 2050	Vessel Berth Req. in Feet	2018 Study/ Tioga 2020	Tioga 2050	Vessel Berth Req. in Feet
Required Weekly Vessel Capacity in TEU	**223,165**	**458,064**		**223,165**	**458,064**		**223,165**	**458,064**	
Existing Services (with vessel size cap) - Starting in 2021	223,165	458,064		223,165	325,316		223,165	442,466	
Additional Service Capacity Required	-	-		-	132,747		-	15,598	
Average Vessel Capacity in TEU	7,970	16,359	1,462	7,955	11,618	1,350	7,970	15,802	1,462
Additional Average Vessel Calls	-	-		-	11		-	-	
Additional Average Vessel Capacity	-	-		-	127,803		-	-	
Additional Other Vessel Service	-	-		-	4,945	1,150	-	15,598	1,462
Total Weekly Capacity	223,165	458,064		223,165	458,064		223,165	458,064	
Total Weekly Vessel Calls	**28**	**28**		**28**	**40**		**28**	**29**	
Average Vessel Capacity in TEU	**7,970**	**16,359**		**7,970**	**11,452**		**7,970**	**15,795**	
Avg. TEU/call	2,064	4,237		2,064	2,966		2,064	4,091	
Avg. Handling Rate TEU/Net Hour	83	150		83	111		83	145	
Avg. Dwell Time	26.9	30.3		26.9	28.8		26.9	30.2	
Weekly Vessel Dwell Hours	753	848		753	1,152		753	875	
Avg. Daily Vessel Hours		121			165			125	
Avg. Vessel Berth Length (including mooring)			1,359			1,290			1,333
Weekly Vessel Foot-Hours			1,152,891			1,486,845			1,166,377
Avg. Daily Berth Foot-Hours			164,699			212,406			166,625
Wednesday Peak Foot-Hours at 23%			265,165			341,974			268,267

The average dwell times were estimated from the data and relationships in Exhibit 126. Two additional hours were added for vessel handling at arrival and departure. The result is an estimate of the expected handling time (not of vessel call schedule).

The average vessel length was estimated by utilizing average values for vessels of a similar size class and length, derived from data similar to that in Exhibit 115 and Exhibit 116. This provides a measure of how much berth space would be required.

The average berth length requirements combined with the dwell time yield the total weekly berth foot-hours needed to accommodate the expected vessel mix and dwell times.

Exhibit 127 then estimates the average daily berth foot-hours required over seven days and a peak day requirement (based on the current 23% share of the weekly total scheduled for Wednesday, per Exhibit 110).

Exhibit 128, Exhibit 129, and Exhibit 130 show the complete analysis spreadsheets for the Moderate, Slow, and Strong Growth forecast scenarios.

Exhibit 128: Moderate Growth Vessel Call and Berth Analysis

Service	2019 Vessel Size TEU	No Vessel Cap: 2018 Study/ Tioga 2020	No Vessel Cap: 2018 Study/ Tioga 2035	No Vessel Cap: Tioga 2050	No Vessel Cap: Vessel Berth Req. in Feet	14,000 TEU Vessel Cap: 2018 Study/ Tioga 2020	14,000 TEU Vessel Cap: 2018 Study/ Tioga 2035	14,000 TEU Vessel Cap: Tioga 2050	14,000 TEU Vessel Cap: Vessel Berth Req. in Feet	25,000 TEU Vessel Cap: 2018 Study/ Tioga 2020	25,000 TEU Vessel Cap: 2018 Study/ Tioga 2035	25,000 TEU Vessel Cap: Tioga 2050	25,000 TEU Vessel Cap: Vessel Berth Req. in Feet
Hawaii 2 - Domestic	3,600	3,600	4,000	4,499	1,050	3,600	4,000	4,499	1,050	3,600	4,000	4,499	1,050
Hawaii 1 - Domestic	3,600	3,600	4,000	4,499	1,050	3,600	4,000	4,499	1,050	3,600	4,000	4,499	1,050
CHX - Domestic	2,325	2,325	2,325	2,615	900	2,325	2,325	2,615	900	2,325	2,325	2,615	900
CPS/CC5/AAC2/HBB	8,530	11,500	12,000	17,284	1,462	11,500	12,000	14,000	1,350	11,500	12,000	17,284	1,462
HTW/AAS3/GEX	7,024	8,500	14,000	20,164	1,462	8,500	14,000	14,000	1,350	8,500	14,000	20,164	1,462
TPS/Jade Express/AAS4/SC8	13,800	13,800	18,000	25,925	1,600	13,800	14,000	14,000	1,350	13,800	18,000	25,000	1,450
TP8/Orient/PS4/UPAS1	9,580	13,250	22,000	31,687	1,650	13,250	14,000	14,000	1,350	13,250	22,000	25,000	1,450
TP2/Jaguar/PS3/UPAS 2	13,100	13,700	16,000	23,045	1,450	13,700	14,000	14,000	1,350	13,700	16,000	23,045	1,450
PSW1/PANZ-PSW/WAS/AOS/Oceania Loop 1	4,563	4,563	6,794	9,785	1,250	4,563	6,794	9,785	1,250	4,563	6,794	9,785	1,250
EX1	5,780	7,000	10,000	14,403	1,350	7,000	10,000	14,000	1,350	7,000	10,000	14,403	1,350
WAMS/WCCA2/AZTEC1/WC2	1,841	1,841	2,741	3,948	1,050	1,841	2,741	3,948	1,050	1,841	2,741	3,948	1,050
SSEA/Polynesia	1,304	1,304	1,942	2,796	900	1,304	1,942	2,796	900	1,304	1,942	2,796	900
MPS/MCPS/MPS	4,612	4,612	6,867	9,890	1,250	4,612	6,867	9,890	1,250	4,612	6,867	9,890	1,250
PS2/TP7/Lotus	6,350	8,500	11,000	15,843	1,462	8,500	11,000	14,000	1,350	8,500	11,000	15,843	1,462
California Express	9,400	9,400	13,995	20,158	1,462	9,400	13,995	14,000	1,350	9,400	13,995	20,158	1,462
Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3	14,414	14,414	20,900	30,102	1,650	14,000	14,000	14,000	1,350	14,414	20,900	25,000	1,450
Columbus JAX/PE1/SEA2/PE1/SEAP-PSW	10,100	10,100	17,000	24,485	1,450	10,100	14,000	14,000	1,350	10,100	17,000	24,485	1,450
CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	10,036	13,500	19,000	27,366	1,600	13,500	14,000	14,000	1,350	13,500	19,000	25,000	1,450
PS6	9,582	9,582	15,000	21,604	1,462	9,582	14,000	14,000	1,350	9,582	15,000	21,604	1,462
AL5 WB/California Bridge/ECX	4,888	4,888	7,278	10,482	1,250	4,888	7,278	10,482	1,250	4,888	7,278	10,482	1,250
FP1	8,212	8,212	12,227	17,610	1,462	8,212	12,227	14,000	1,350	8,212	12,227	17,610	1,462
AC5	11,900	11,900	17,718	25,519	1,600	11,900	14,000	14,000	1,350	11,900	17,718	25,000	1,450
PS5	8,636	8,750	10,000	14,403	1,350	8,750	10,000	14,000	1,350	8,750	10,000	14,403	1,350
PS4	6,572	6,500	10,000	14,403	1,350	6,500	10,000	14,000	1,350	6,500	10,000	14,403	1,350
PS7	10,000	10,000	15,000	21,604	1,462	10,000	14,000	14,000	1,350	10,000	15,000	21,604	1,462
PS3	6,492	6,600	13,000	18,724	1,462	6,600	13,000	14,000	1,350	6,600	13,000	18,724	1,462
PS2/JPSW/PS2	4,432	4,500	7,500	10,802	1,250	4,500	7,500	10,802	1,250	4,500	7,500	10,802	1,250
EC1 WB	6,724	6,724	10,011	14,419	1,350	6,724	10,011	14,000	1,350	6,724	10,011	14,419	1,350
Required Weekly Vessel Capacity in TEU		**223,165**	**320,297**	**458,064**		**223,165**	**320,297**	**458,064**		**223,165**	**320,297**	**458,064**	
Existing Services (with vessel size cap) - Starting in 2021		223,165	320,297	458,064		223,165	285,679	325,316		223,165	320,297	442,466	
Additional Service Capacity Required		-	-	-		-	34,618	132,747		-	-	15,598	
Average Vessel Capacity in TEU		7,970	11,439	16,359	1,462	7,955	10,203	11,618	1,350	7,970	11,439	15,802	1,462
Additional Average Vessel Calls		-	-	-		-	3	11		-	-	-	
Additional Other Vessel Service		-	-	-		-	4,009	4,945	1,150	-	-	15,598	1,462
Total Weekly Vessel Calls		**28**	**28**	**28**		**28**	**32**	**40**		**28**	**28**	**29**	
Average Vessel Capacity in TEU		**7,970**	**11,439**	**16,359**		**7,970**	**10,009**	**11,452**		**7,970**	**11,439**	**15,795**	
Avg. TEU/call		2,064	2,963	4,237		2,064	2,592	2,966		2,064	2,963	4,091	
Avg. Handling Rate TEU/Net Hour		83	111	150		83	99	111		83	111	145	
Avg. Dwell Time		26.9	28.8	30.3		26.9	28.1	28.8		26.9	28.8	30.2	
Weekly Vessel Dwell Hours		753	806	848		753	901	1,152		753	806	875	
Avg. Daily Vessel Hours				**121**				**165**				**125**	
Avg. Vessel Berth Length (including mooring)					**1,359**				**1,290**				**1,333**
Weekly Vessel Foot-Hours					**1,152,891**				**1,486,845**				**1,166,377**
Avg. Daily Berth Foot-Hours					**164,699**				**212,406**				**166,625**
Wednesday Peak Foot-Hours at 23%					**265,165**				**341,974**				**268,267**

Exhibit 129: Slow Growth Vessel Call and Berth Analysis

		No Vessel Cap				14,000 TEU Vessel Cap				25,000 TEU Vessel Cap			
Service	**2019 Vessel Size TEU**	**2018 Study/ Tioga 2020**	**2018 Study/ Tioga 2035**	**Tioga 2050**	**Vessel Berth Req. in Feet**	**2018 Study/ Tioga 2020**	**2018 Study/ Tioga 2035**	**Tioga 2050**	**Vessel Berth Req. in Feet**	**2018 Study/ Tioga 2020**	**2018 Study/ Tioga 2035**	**Tioga 2050**	**Vessel Berth Req. in Feet**
Hawaii 2 - Domestic	3,600	3,600	4,000	4,311	1,050	3,600	4,000	4,311	1,050	3,600	4,000	4,311	1,050
Hawaii 1 - Domestic	3,600	3,600	4,000	4,311	1,050	3,600	4,000	4,311	1,050	3,600	4,000	4,311	1,050
CHX - Domestic	2,325	2,325	2,325	2,506	900	2,325	2,325	2,506	900	2,325	2,325	2,506	900
CPS/CC5/AAC2/HBB	8,530	11,500	12,000	16,049	1,462	11,500	12,000	14,000	1,350	11,500	12,000	16,049	1,462
HTW/AAS3/GEX	7,024	8,500	14,000	18,724	1,462	8,500	14,000	14,000	1,350	8,500	14,000	18,724	1,462
TPS/Jade Express/AAS4/SC8	13,800	13,800	18,000	24,074	1,450	13,800	14,000	14,000	1,350	13,800	18,000	24,074	1,450
TP8/Orient/PS4/UPAS1	9,580	13,250	22,000	29,424	1,600	13,250	14,000	14,000	1,350	13,250	22,000	25,000	1,450
TP2/Jaguar/PS3/UPAS 2	13,100	13,700	16,000	21,399	1,462	13,700	14,000	14,000	1,350	13,700	16,000	21,399	1,462
PSW1/PANZ-PSW/WAS/AOS/Oceania Loop 1	4,563	4,563	6,794	9,086	1,250	4,563	6,794	9,086	1,250	4,563	6,794	9,086	1,250
EX1	5,780	7,000	10,000	13,374	1,350	7,000	10,000	13,374	1,350	7,000	10,000	13,374	1,350
WAMS/WCCA2/AZTEC1/WC2	1,841	1,841	2,741	3,666	1,050	1,841	2,741	3,666	1,050	1,841	2,741	3,666	1,050
SSEA/Polynesia	1,304	1,304	1,942	2,597	900	1,304	1,942	2,597	900	1,304	1,942	2,597	900
MPS/MCPS/MPS	4,612	4,612	6,867	9,184	1,250	4,612	6,867	9,184	1,250	4,612	6,867	9,184	1,250
PS2/TP7/Lotus	6,350	8,500	11,000	14,712	1,462	8,500	11,000	14,000	1,350	8,500	11,000	14,712	1,462
California Express	9,400	9,400	13,995	18,718	1,462	9,400	13,995	14,000	1,350	9,400	13,995	18,718	1,462
Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3	14,414	14,414	20,900	27,953	1,600	14,000	14,000	14,000	1,350	14,414	20,900	25,000	1,450
Columbus JAX/PE1/SEA2/PE1/SEAP-PSW	10,100	10,100	17,000	22,737	1,450	10,100	14,000	14,000	1,350	10,100	17,000	22,737	1,450
CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	10,036	13,500	19,000	25,411	1,450	13,500	14,000	14,000	1,350	13,500	19,000	25,000	1,450
PS6	9,582	9,582	15,000	20,062	1,462	9,582	14,000	14,000	1,350	9,582	15,000	20,062	1,462
AL5 WB/California Bridge/ECX	4,888	4,888	7,278	9,733	1,250	4,888	7,278	9,733	1,250	4,888	7,278	9,733	1,250
FP1	8,212	8,212	12,227	16,352	1,462	8,212	12,227	14,000	1,350	8,212	12,227	16,352	1,462
AC5	11,900	11,900	17,718	23,696	1,450	11,900	14,000	14,000	1,350	11,900	17,718	23,696	1,450
PS5	8,636	8,750	10,000	13,374	1,350	8,750	10,000	13,374	1,350	8,750	10,000	13,374	1,350
PS4	6,572	6,500	10,000	13,374	1,350	6,500	10,000	13,374	1,350	6,500	10,000	13,374	1,350
PS7	10,000	10,000	15,000	20,062	1,462	10,000	14,000	14,000	1,350	10,000	15,000	20,062	1,462
PS3	6,492	6,600	13,000	17,387	1,462	6,600	13,000	14,000	1,350	6,600	13,000	17,387	1,462
PS2/JPSW/PS2	4,432	4,500	7,500	10,031	1,250	4,500	7,500	10,031	1,250	4,500	7,500	10,031	1,250
EC1 WB	6,724	6,724	10,011	13,389	1,350	6,724	10,011	13,389	1,350	6,724	10,011	13,389	1,350
Required Weekly Vessel Capacity in TEU		**223,165**	**320,297**	**425,696**		**223,165**	**320,297**	**425,696**		**223,165**	**320,297**	**425,696**	
Existing Services (with vessel size cap) - Starting in 2021		223,165	223,165	320,297	425,696		223,165	285,679	318,937		223,165	320,297	417,909
Additional Service Capacity Required		-	-	-		-	34,618	106,759		-	-	7,788	
Average Vessel Capacity in TEU		7,970	11,439	15,203	1,462	7,955	10,203	11,391	1,250	7,970	11,439	14,925	1,462
Additional Average Vessel Calls		-	-	-		-	3	9		-	-	-	
Additional Other Vessel Service		-	-	-		-	4,009	4,244	1,050	-	-	7,788	1,250
Total Weekly Vessel Calls		**28**	**28**	**28**		**28**	**32**	**38**		**28**	**28**	**29**	
Average Vessel Capacity in TEU		7,970	11,439	15,203		7,970	10,009	11,203		7,970	11,439	14,679	
Avg. TEU/call		2,064	2,963	3,938		2,064	2,592	2,901		2,064	2,963	3,802	
Avg. Handling Rate TEU/Net Hour		83	111	141		83	99	109		83	111	136	
Avg. Dwell Time		26.9	28.8	30.0		26.9	28.1	28.7		26.9	28.8	29.9	
Weekly Vessel Dwell Hours		753	806	841		753	901	1,091		753	806	867	
Avg. Daily Vessel Hours				**120**				**156**				**124**	
Avg. Vessel Berth Length (including mooring)						**1,340**				**1,261**			
Weekly Vessel Foot-Hours					**1,126,194**				**1,375,102**				**1,149,409**
Avg. Daily Berth Foot-Hours					**160,885**				**196,443**				**164,201**
Wednesday Peak Foot-Hours at 23%					**259,025**				**316,273**				**264,364**

Exhibit 130: Strong Growth Vessel Call and Berth Analysis

		No Vessel Cap				14,000 TEU Vessel Cap				25,000 TEU Vessel Cap			
Service	**2019 Vessel Size TEU**	3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150
Hawaii 2 - Domestic	3,600	3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150
Hawaii 1 - Domestic	3,600	2,325	2,325	3,264	900	2,325	2,325	3,264	900	2,325	2,325	3,264	900
CHX - Domestic	2,325	11,500	12,000	19,008	1,462	11,500	12,000	14,000	1,350	11,500	12,000	19,008	1,462
CPS/CC5/AAC2/HBB	8,530	8,500	14,000	22,176	1,462	8,500	14,000	14,000	1,350	8,500	14,000	22,176	1,462
HTW/AAS3/GEX	7,024	13,800	18,000	28,512	1,600	13,800	14,000	14,000	1,350	13,800	18,000	25,000	1,450
TPS/Jade Express/AAS4/SC8	13,800	13,250	22,000	34,849	1,650	13,250	14,000	14,000	1,350	13,250	22,000	25,000	1,450
TP8/Orient/PS4/UPAS1	9,580	13,700	16,000	25,344	1,450	13,700	14,000	14,000	1,350	13,700	16,000	25,000	1,450
TP2/Jaguar/PS3/UPAS 2	13,100	4,563	6,794	10,761	1,250	4,563	6,794	10,761	1,250	4,563	6,794	10,761	1,250
PSW1/PANZ-PSW/WAS/AOS/Oceania Loop 1	4,563	7,000	10,000	15,840	1,462	7,000	10,000	14,000	1,350	7,000	10,000	15,840	1,462
EX1	5,780	1,841	2,741	4,342	1,050	1,841	2,741	4,342	1,050	1,841	2,741	4,342	1,050
WAMS/WCCA2/AZTEC1/WC2	1,841	1,304	1,942	3,075	900	1,304	1,942	3,075	900	1,304	1,942	3,075	900
SSEA/Polynesia	1,304	4,612	6,867	10,877	1,250	4,612	6,867	10,877	1,250	4,612	6,867	10,877	1,250
MPS/MCPS/MPS	4,612	8,500	11,000	17,424	1,462	8,500	11,000	14,000	1,350	8,500	11,000	17,424	1,462
PS2/TP7/Lotus	6,350	9,400	13,995	22,169	1,462	9,400	13,995	14,000	1,350	9,400	13,995	22,169	1,462
California Express	9,400	14,414	20,900	33,106	1,650	14,000	14,000	14,000	1,350	14,414	20,900	25,000	1,450
Pearl River Express/SC1/PRX/AAS2/PCS1/AC6/CP3	14,414	10,100	17,000	26,928	1,600	10,100	14,000	14,000	1,350	10,100	17,000	25,000	1,450
Columbus JAX/PE1/SEA2/PE1/SEAP-PSW	10,100	13,500	19,000	30,097	1,650	13,500	14,000	14,000	1,350	13,500	19,000	25,000	1,450
CEN/BOHAI/CC2/CEN/PCN1/CEN/AC3	10,036	9,582	15,000	23,760	1,450	9,582	14,000	14,000	1,350	9,582	15,000	23,760	1,450
PS6	9,582	4,888	7,278	11,528	1,350	4,888	7,278	11,528	1,350	4,888	7,278	11,528	1,350
AL5 WB/California Bridge/ECX	4,888	8,212	12,227	19,367	1,462	8,212	12,227	14,000	1,350	8,212	12,227	19,367	1,462
FP1	8,212	11,900	17,718	28,065	1,600	11,900	14,000	14,000	1,350	11,900	17,718	25,000	1,450
AC5	11,900	8,750	10,000	15,840	1,462	8,750	10,000	14,000	1,350	8,750	10,000	15,840	1,462
PS5	8,636	6,500	10,000	15,840	1,462	6,500	10,000	14,000	1,350	6,500	10,000	15,840	1,462
PS4	6,572	10,000	15,000	23,760	1,450	10,000	14,000	14,000	1,350	10,000	15,000	23,760	1,450
PS7	10,000	6,600	13,000	20,592	1,462	6,600	13,000	14,000	1,350	6,600	13,000	20,592	1,462
PS3	6,492	4,500	7,500	11,880	1,350	4,500	7,500	11,880	1,350	4,500	7,500	11,880	1,350
PS2/JPSW/PS2	4,432	6,724	10,011	15,858	1,462	6,724	10,011	14,000	1,350	6,724	10,011	15,858	1,462
EC1 WB	6,724	**223,165**	**320,297**	**505,497**		**223,165**	**320,297**	**505,497**		**223,165**	**320,297**	**505,497**	
Required Weekly Vessel Capacity in TEU		223,165	320,297	505,497		223,165	285,679	332,958		223,165	320,297	473,596	
Existing Services (with vessel size cap) - Starting in 2021		223,165	-	-	-		-	34,618	172,539		-	-	31,902
Additional Service Capacity Required		7,970	11,439	18,053	1,462	7,955	10,203	11,891	1,350	7,970	11,439	16,914	1,462
Average Vessel Capacity in TEU		-	-	-		-	3	14		-	-	1	
Additional Average Vessel Calls		-	-	-		-	4,009	6,060	1,150	-	-	14,988	1,462
Additional Other Vessel Service		**28**	**28**	**28**		**28**	**32**	**43**		**28**	**28**	**30**	
Total Weekly Vessel Calls		7,970	11,439	18,053		7,970	10,009	11,756		7,970	11,439	16,850	
Average Vessel Capacity in TEU		2,064	2,963	4,676		2,064	2,592	3,045		2,064	2,963	4,364	
Avg. TEU/call		83	111	163		83	99	113		83	111	154	
Avg. Handling Rate TEU/Net Hour		26.9	28.8	30.7		26.9	28.1	28.9		26.9	28.8	30.4	
Avg. Dwell Time		753	806	858		753	901	1,244		753	806	912	
Weekly Vessel Dwell Hours				**123**				**178**				**130**	
Avg. Daily Vessel Hours					**1,395**				**1,304**				**1,365**
Avg. Vessel Berth Length (including mooring)						**1,197,553**				**1,621,979**			
Weekly Vessel Foot-Hours					**171,079**				**231,711**				**177,868**
Avg. Daily Berth Foot-Hours					**275,437**				**373,055**				**286,368**
Wednesday Peak Foot-Hours at 23%		3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150	3,600	4,000	5,615	1,150

Exhibit 131 summarizes the implications for Port-wide berth capacity utilization. The table is color-coded to indicate where peak utilization exceeds 65% (and where congestion and delays become more likely). The rows display the existing terminal berth dimensions as well as the three previously discussed scenarios, as follows:

- **Current conditions,** based on the existing, active container berths (Exhibit 106). This scenario incorporates 14 berths with a combined length of 21,484 feet. In this scenario, the Port would exceed 70% peak day utilization under all three container volume growth scenarios and reach a peak day utilization of 102% in the Strong Growth case with a 14,000 TEU vessel size cap.
- **Expanded IHTB** and the resulting shortening of Howard Terminal without a replacement dolphin (Exhibit 107). This scenario incorporates 18 berths with a combined length of 19,094 feet. This scenario would exceed 70% peak day utilization in the Moderate and Strong Growth scenarios with a 14,000 TEU vessel cap. With the expanded turning basin, however, the 14,000 TEU cap would not be necessary. All three container growth scenarios have peak day utilization under 65% with the 25,000 TEU vessel cap.
- **Expanded IHTB with a new 500-foot dolphin** at the east end of the Howard Terminal wharf (Exhibit 108). This scenario incorporates 18 berths with a combined length of 19,594 feet. This would reduce peak day utilization to 73% in the Moderate case and to 79% in the Strong Growth case. As with Scenario 2, the 14,000 TEU restriction should be lifted with an expanded turning basin. All three container growth scenarios have peak day utilization under 65% with the 25,000 TEU vessel cap.
- **No use of Howard Terminal** (Exhibit 109). This scenario incorporates 16 berths with a combined length of 16,007 feet. By 2050, peak day utilization would exceed 65% under all three growth scenarios. Here again, widening the IHTB would remove the 14,000 TEU vessel size cap. Even with the improved utilization from 25,000 TEU cap, however, the peak day utilization remains above 65% under all three growth scenarios.

Exhibit 131: 2050 Peak Day Berth Utilization

Berth Capacity				2050 Berth Required Peak* Daily Foot-Hours																	
				Moderate Growth Case						Slow Growth Case						Strong Growth Case					
Berth Dimensions	Nominal Berths	Total Berth Feet	Daily Berth Foot-Hours	No Vessel Cap	Peak Ute.	14,000 TEU Cap	Peak Ute.	25,000 TEU Cap	Peak Ute.	No Vessel Cap	Peak Ute.	14,000 TEU Cap	Peak Ute.	25,000 TEU Cap	Peak Ute.	No Vessel Cap	Peak Ute.	14,000 TEU Cap	Peak Ute.	25,000 TEU Cap	Peak Ute.
Existing Terminal Berth Dimensions (feet)	14	21,484	365,832	265,165	72%	341,974	93%	268,267	73%	259,025	71%	316,273	86%	264,364	72%	275,437	75%	373,055	102%	286,368	78%
Future Terminal Berth Dimensions (feet) with Expanded Turning Basin	18	19,094	458,256	265,165	58%	341,974	**75%**	268,267	59%	259,025	57%	316,273	69%	264,364	58%	275,437	60%	373,055	**81%**	286,368	62%
Future Terminal Berth Dimensions (feet) with Turning Basin & Howard Dolphin	18	19,594	470,256	265,165	56%	341,974	**73%**	268,267	57%	259,025	55%	316,273	67%	264,364	56%	275,437	59%	373,055	**79%**	286,368	61%
Future Terminal Berth Dimensions (feet) with Turning Basin w/o Howard	16	16,007	384,168	265,165	**69%**	341,974	**89%**	268,267	**70%**	259,025	**67%**	316,273	**82%**	264,364	**69%**	275,437	**72%**	373,055	**97%**	286,368	**75%**

*Peak Utilization reflects 23% of weekly capacity at berth on Wednesday

Berth Requirement Implications

The consultant team's analysis illustrates the impact of cargo growth, longer vessel dwell times, and greater vessel size on berth occupancy at Oakland terminals.

- Moderate or Slow Growth in vessel sizes through 2050 could likely be accommodated with minor increased risk of congestion without Berths 20-21 or Howard Terminal, if an expanded turning basin allows vessels to grow to 25,000 TEU.
- A 14,000 TEU vessel size cap would create high utilization and the potential for berth congestion under Moderate or Strong Growth cases. The expansion of the Inner Harbor Turning Basin, however, should remove that vessel cap and improve berth utilization.
- Strong Growth would require Howard Terminal's berth space, and potentially a dolphin extension, to supplement berths at OICT, TraPac, Ben E. Nutter, and Matson.
- Without Howard Terminal's berth length and a 25,000 TEU vessel size cap, Oakland's peak day berth utilization is expected to reach 70% under Moderate Growth, 69% under Slow Growth, and 75% under Strong Growth.

All of these findings assume long-term fungibility among the Port's terminals and berths. That fungibility may not always be available, especially in the short-term.

Ancillary Services Land Use

Need for Ancillary Services

As established in BCDC's consideration of the Oakland Army Base redevelopment project, efficient operation of container ports requires services that are not provided by or within the marine terminals. While the full range of ancillary functions can be very large, in the context of the Seaport Plan the relevant functions are those with strong reasons to be located in the immediate port facility.

Exhibit 132 shows the Port of Oakland parcels designated for port priority and available for ancillary functions and facilities:

- The Seaport Logistics Complex, at about 140 acres.
- The complex around 555 Maritime St., at about 78 acres.
- The "CBP Triangle," at about 7 acres.
- The "Outer Harbor Extension," at about 20 acres.

Exhibit 132: Port of Oakland Ancillary Use Sites

2001 Ancillary Services Study

In connection with development plans for the former Oakland Army Base (OAB), the Port of Oakland engaged a consultant team lead by Tioga to determine the need for ancillary services in the immediate port area, and their land requirements, out to 2020. The *Port Services Location Study* was completed in 2001.

The consultant team identified a narrow range of functions and facilities that should preferably be located in the immediate vicinity of the Port:

- **Overnight parking for drayage tractors and staging for containers on chassis and bare chassis.** Lacking parking in the port area, many more tractors and chassis would be left in the residential or commercial neighborhoods surrounding the port, and would incur additional miles of travel and generate additional emissions moving back and forth.
- **Short-term truck parking.** Truck drivers need a safe, legal place to stop for rest breaks or while waiting for their next assignment. Here too, lack of parking space in the port area would tend to push trucks into adjacent neighborhoods.
- **Truck services.** Wherever possible, truck drivers should be able to access fuel, charging facilities, scales, food service, and other necessities without driving to and through adjacent neighborhoods.
- **Heavy Cargo Facilities.** The need for heavy cargo facilities identified in the 2001 study included transloading and container freight stations to shift cargo between truck, rail, and marine modes. The Port of Oakland has long handled substantial volumes of heavy commodities, particularly agricultural products. Many of those commodities would exceed highway weight limits if loaded to the full ocean-going capacity of a marine container. It is thus common practice to move these commodities to and from the Port area in smaller truckloads or in rail cars, and make the transfer to and from marine containers at or near the port along so-called "overweight corridors". This strategy minimizes moving heavy containers and other cargo to and from the port on public roads.

- **Reefer Container Depots.** The Port of Oakland is a major export point for California produce, Midwestern meat and poultry, and other commodities that need refrigerated containers. These "reefer" containers may need inspection, cleaning, and refueling between trips; pre-cooling before loading; and calibration and temperature checks after being loaded. Locating these functions at or near the port minimizes the need for drayage firms to shuttle them back and forth over public streets.

Exhibit 133 summarizes the land requirements estimated in the 2001 study.

Exhibit 133: 2001 Estimate of Ancillary Land Requirements

Year	Drayage Tractor Parking	Container/ Chassis Staging	Short-Term Staging	Truck Services	Heavy Cargo Facilities	Working Reefer Depots	Total Core Service Acres	Port Land	Est. Usable Port Land (90%)	Gap
2000	5	7	1	4	36	18	71	125	113	-
2005	7	8	2	4	44	24	88	180	162	-
2010	9	10	2	7	56	30	114	155	140	-
2015	12	12	5	7	70	38	143	130	117	26
2020	16	14	8	8	85	47	178	105	95	84

For this study, the consultant team re-examined the need for each facility type and the land available to locate them within the immediate Port of Oakland area.

Truck Services

The Port of Oakland has had a truck service center under development for several years. The project, currently described as the "Oakland Energy & Truck Travel Center," would include:

- Truck fueling and charging.
- Truck scales
- Convenience store/travel center
- Limited maintenance/ testing facilities.
- Limited truck parking.

The most recent proposed plan would cover about 8.26 acres, as shown in Exhibit 134. The proposed site is within the "Outer Harbor Extension" area, as indicated in Exhibit 135. Exhibit 135 also shows the location of Oakland Marine Support Services (OMSS) on roughly 10 acres of City of Oakland land outside the port priority area. OMSS offers truck parking and a range of truck support services.

Exhibit 134: Oakland Energy & Truck Travel Center

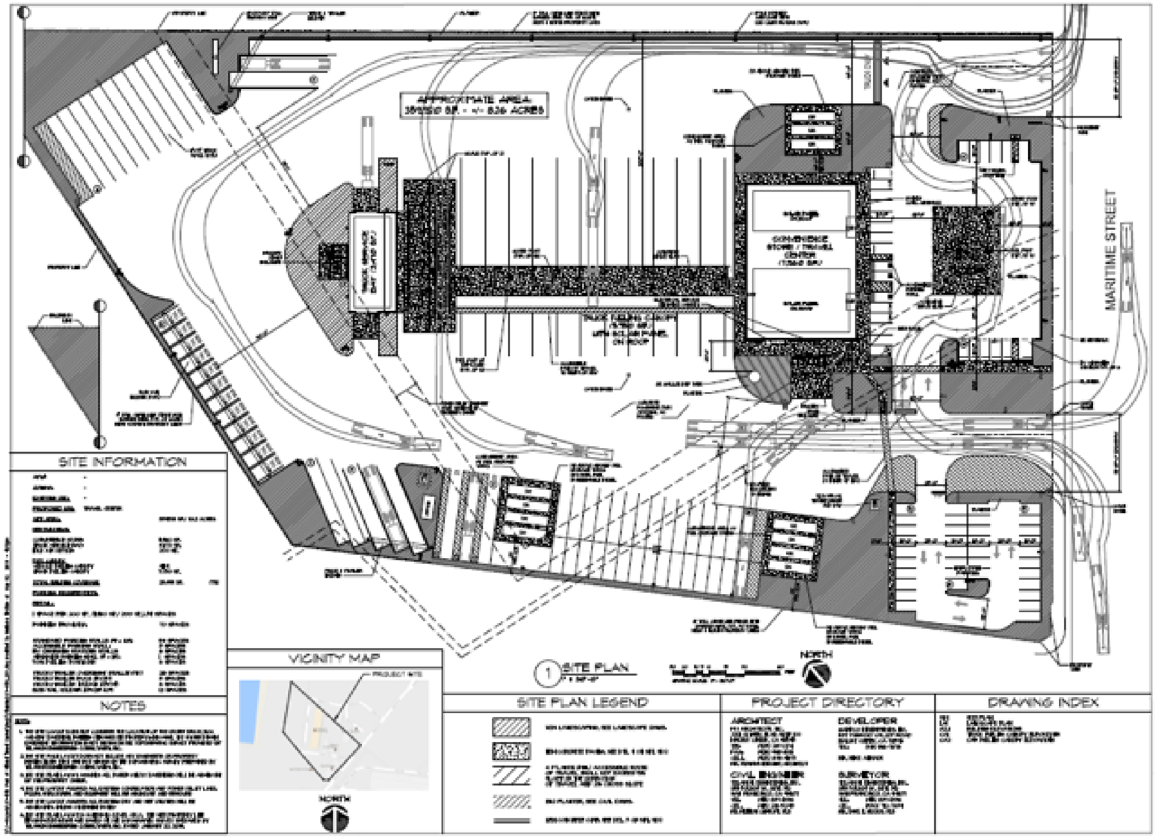
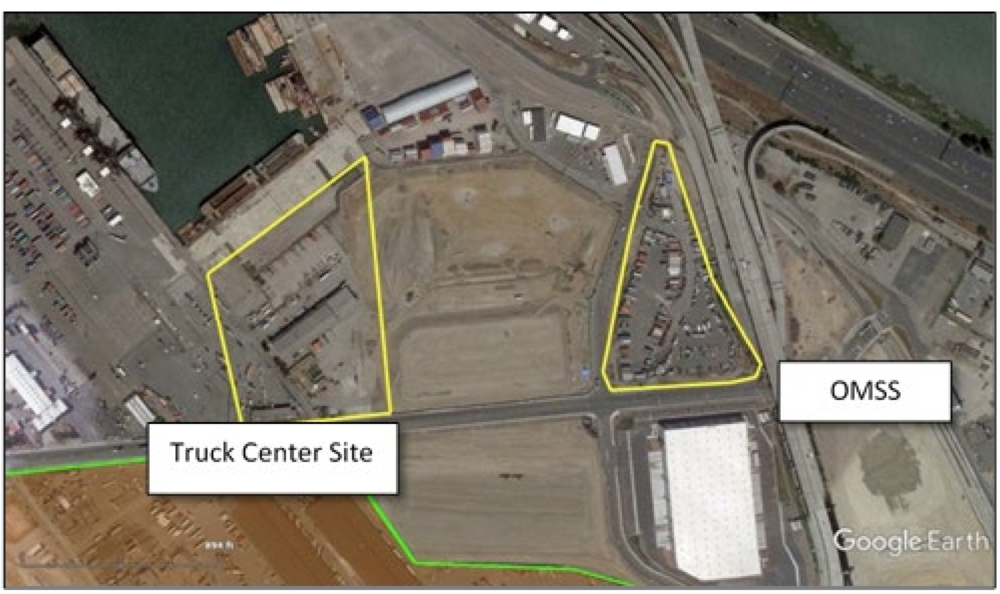


Exhibit 135: Location of Proposed Truck Service Center and OMSS



The proposed truck service center and OMSS together would effectively fulfill the need for truck services identified in the 2001 study, which are largely independent of cargo volume.

Heavy Cargo Facilities and Reefer Container Depots

The 2001 study estimated the required space for heavy cargo facilities at 85 acres (Exhibit 133). Using the same model with cargo growth extended to 2050 yields a long-term estimate of 109 acres for the Moderate Growth scenario, 82 acres for Slow Growth, and 147 acres for Strong Growth. The study also identified a need for 47 acres of reefer depot facilities. Extending the model to 2050 implies a need for 59 acres with Moderate Growth, 45 acres with Slow Growth, or 80 acres with Strong Growth.

The need for such facilities is being met by development on Port-owned seaport priority land, on City of Oakland land, and on private, non-priority land.

555 Maritime St Complex

The overall port-owned 555 Maritime St. Complex (Exhibit 136) covers about 79 acres. Besides CoolPort itself at 25 acres, the land is currently used by GSC Logistics and Unicold for cargo transfer, and by ConGlobal for container depot operations. The Port's current plan is to continue developing the remaining site acreage for ancillary services, as the site's physical and operational separation surrounded by rail lines prevents efficient integration with marine terminal operations.

Exhibit 136: 555 Maritime St Complex

CoolPort. CoolPort at the Port of Oakland is a 275,000 square foot, state-of-the-art refrigerated transload and distribution facility with supporting rail infrastructure on approximately 25 acres centrally located within the Port complex (Exhibit 137).

Exhibit 137: Oakland CoolPort

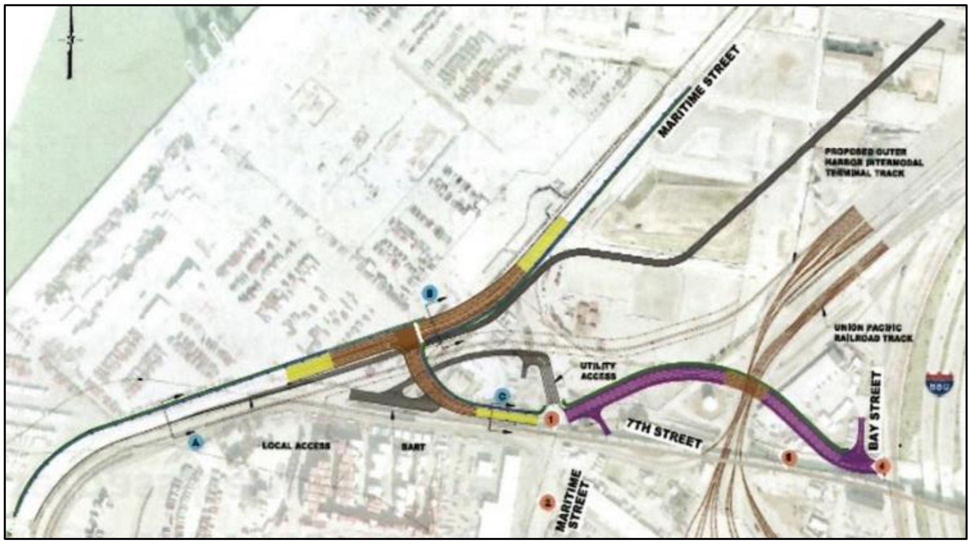
Phase I construction started in April/May of 2017, and the facility opened on November 1, 2018. CoolPort LLC has the option to expand on 15 acres of adjacent land. If Phase 2 is approved, work would start sometime in 2024.

Seaport Logistics Complex/CenterPoint

A large portion of the total Port land available for ancillary uses is the former Oakland Army Base, as shown in Exhibit 138. Designated as the "Seaport Logistics Complex," the site comprises about 140 acres, all in port priority land. As indicated in Exhibit 139, a small portion of the acreage will be occupied by the 7th Street Grade Separation realignment of Maritime and 7th Streets.

Exhibit 138: Oakland Army Base/Seaport Logistics Complex

Exhibit 139: 7th Street Grade Separation Project



As of early 2019, the first phase of the Seaport Logistics Complex is under construction in cooperation with CenterPoint. This will be a 460,000 square foot distribution and transloading center on a 27-acre site. The Port expects that the remaining space will be developed in a similar fashion over multiple phases.

Portions of the site are currently (early 2019) in use by:

- Shipper's Transport Express, as an off-dock container staging area for OICT.
- Impact Transportation, engaged in cargo transloading and truck drayage.
- Port Transfer, Inc., engaged in cargo transloading.
- Pacific Coast Container, also enaged in transloading.

"CBP Triangle"

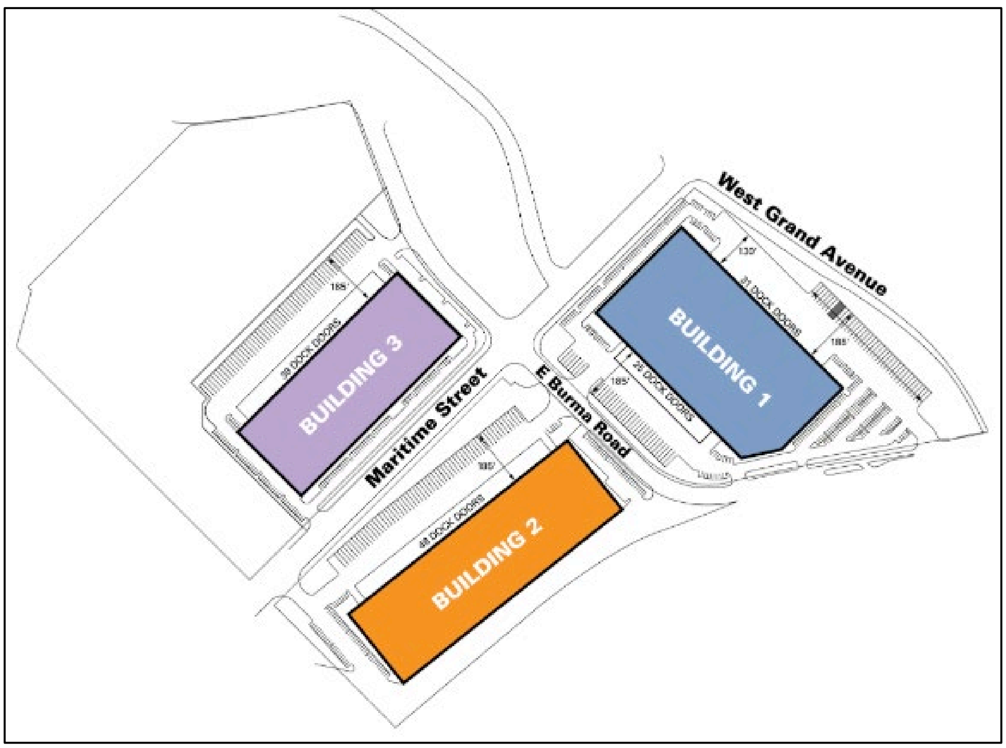
The "CBP" Triangle shown in Exhibit 132 is about 7 acres, and is currently used by Customs and Border Protection (CBP). As Exhibit 139 implies, however, significant use of the site for ancillary uses will be pre-empted by the 7th Street Grade Separation Project.

City of Oakland/ProLogis

The City of Oakland portion of OAB (Exhibit 140) is being developed in a multi-phase program in cooperation with ProLogis. The completed Building 1 is shown in Exhibit 138. Exhibit 141 displays the build-out plan for all three buildings. The overall ProLogis site in Exhibit 140 is about 63 acres.

Exhibit 140: City of Oakland/ProLogis Site

Exhibit 141: City of Oakland/ProLogis Development



Outer Harbor Extension

Much of the Outer Harbor Extension may be used for the truck service center. The remaining portions of the 20-acre site include:

- A dredging material re-handling site, which is critical to the Port's ability to conduct maintenance dredging and is not suitable for other ancillary uses.
- AMNAV Maritime Tug Service, which has provided Bay Area tug services since 1976. This 5-acre portion of the property is thus in a critical ancillary use that requires water access.

The Outer Harbor Extension will thus have about 13 acres in ancillary use – 5 acres for AMNAV and 8 acres for the truck center.

Union Pacific

Union Pacific has two sites being used for ancillary port services. They are currently used by PCC Logistics and Pacific Transload, both for transloading cargo and related services. The two parcels total about 17 acres (Exhibit 142).

Exhibit 142: Union Pacific Ancillary Sites

Truck Parking

2001 Estimate

The 2001 Tioga report estimated a 2020 need for 16.0 acres of overnight tractor parking and 14.0 acres of overnight container and chassis staging, forming the basis for the combined Port/city commitment of 30.0 acres in the OAB EIR. No separate commitment was made for short-term truck parking.

2016 Truck Parking Update

In view of changing cargo volumes and circumstances, the Port asked Tioga to revisit the parking requirement estimates in 2016. There was ongoing concern within the Oakland community, particularly in West Oakland, that drayage tractors and containers would be parked on city streets or at other undesirable locations. Tioga selectively revised and updated the truck parking model to reflect survey and interview findings regarding the need for short-term and overnight truck and container chassis parking, and the ways in which that parking need was being filled.

The earlier estimate was based on 2001 expectations of cargo growth, rail intermodal share, parking practice, and turn times. Many of those factors had changed by 2016. Some of those factors are expected to reduce parking and staging needs

- Slower cargo growth is expected to result in lower overall cargo volume, fewer truck trips, and reduced parking needs.
- Greater use of company yards and locations outside of Oakland, as revealed in a trucker survey, is expected to materially reduce the need for overnight tractor parking in the Port area.
- A greater percentage of rail intermodal moves should also reduce the required truck fleet and parking needs, because rail intermodal moves typically have more daily turns.

The Port and port terminals operators also introduced a number of practices in 2016 that should reduce the long-term need to park tractors or container on chassis:

- Terminal appointment systems for truck drivers will reduce turn times, increase the productivity of each truck, reduce the number of trucks needed, and improve the ability of trucking companies to schedule their operations.
- "Extended gates" open during the night and evening will allow truckers to extend their working day and reduce the need to pre-pull and park containers on chassis or stage returned containers for the next morning.

The main factor that was previously expected to increase the truck fleet requirement, and thus overnight parking needs, was a reduction in estimated daily turns. Tioga's 2016 trucker survey reported about half as many daily average turns as were assumed in the 2001 study.

As Exhibit 143 shows, the net effect of these factors discussed was to reduce the estimated 2020 overnight tractor parking requirement from 16.0 acres to 11.5 acres, and the overnight container and chassis staging requirement from 14.0 acres to 10.6 acres. The reduction in daily turns was expected to require a 64% larger truck fleet, but the larger fleet size should have been more than offset by the reduced use of on-port parking by companies with their own yards or based out of Oakland.

Exhibit 143: 2020 Overnight Truck Parking and Container/Chassis Staging Requirements

Year	Drayage Tractors	Container & Chassis	Tractor & Chassis	Total
2001 Summary Acreage Requirements				
2000	4.8	6.6	na	11
2005	7.2	8.1	na	15
2010	9.4	9.8	na	19
2015	12.1	11.8	na	24
2020	**16.0**	**14.0**	**na**	**30.0**
Updated Scenario Summary Acreage Requirements				
2020	**11.5**	**10.6**	**na**	**22.1**
Daily Tractors Needed:			4,108	
2001 Estimate			2,070	

At the Port's request, Tioga also used the model to create three other scenarios:

- Baseline: current 2015 numbers and intermodal share of 15%.
- Future (2020): 3.2M TEU with a 27% intermodal share (as projected in the 2012 OAB EIR Addendum).

- Future (2035 Full Build-out): 4.05M TEU with a 40% intermodal share.

The results suggested that the 30-acre Port/city commitment for overnight tractor parking space would be adequate for "foreseeable conditions," which at that time extended through 2035. The sensitivity analysis indicated that the only circumstance under which the demand for overnight tractor parking is likely to exceed 30 acres would be high trade volumes, combined with a resurgence in Oakland-based drayage firms without their own yards.

Updated Truck Parking Forecast to 2050

Both the cargo growth outlook and the truck operating conditions have changed since 2016.

While trade volumes in excess of 4 million annual TEU are forecast by 2050, a resurgence in Oakland-based drayage is counter to both industry trends at the time and industry trends at present. There is an ongoing industry trend towards company yards for security and logistics reasons.

At present, as it was in 2016, overnight tractor parking is concentrated at sites out of Oakland, at company yards, and at the ABM (AMPCO) and OMSS lots. Overnight chassis or container on chassis parking is likewise concentrated in company yards and at ABM. Daytime tractor parking is only needed for driver breaks, waiting for gate openings, or waiting for appointments. Daytime chassis and container staging is mostly confined to ABM, with no reported use of city streets in the 2016 study.

Tioga re-ran the truck parking model to determine the impact of new cargo forecasts extending to 2050, and to determine what other factors that could change between 2019 and 2050 would have a significant impact on truck parking needs.

Exhibit 144: BCDC Forecast Ancillary Services Truck/Container Model: 2050 Scenarios

Inputs Scenario	Annual TEU	% Rail	Day Gates	Night Gates	Night Gate Ute %	Total Equivalent Gates	Space Utilization
2001 Estimate for 2020	3,939,575	42%	250	0	0%	250	80%
2016 Update to 2020	2,283,942	15%	260	0	0%	260	80%
Moderate Growth	5,187,588	15%	300	300	10%	330	80%
Slow Growth	3,862,435	15%	250	125	5%	256	80%
Strong Growth	7,038,560	17%	300	300	25%	375	85%

Outputs Scenario	Drayage Fleet Tractors	Overnight Acres			Day Use Acres		
		Drayage Tractors	Container & Chassis	Total	Drayage Tractors	Tractor & Chassis	Total
2001 Estimate for 2020	2,070	16.0	14.0	30.0	2.9	5.2	8.1
2016 Update to 2020	4,761	13.5	13.3	26.8	1.7	1.0	2.7
Moderate Growth	6,773	14.4	15.3	29.7	2.1	1.2	3.3
Slow Growth	6,494	13.8	14.6	28.4	2.0	1.1	3.1
Strong Growth	6,450	13.4	17.1	30.5	2.3	1.3	3.7

The modeling results showed that the increased need for trucking and truck parking from cargo growth tends to be offset by the measures terminals take to accommodate that growth. Notably, extending gate hours into night shifts reduces the number of trucks that would otherwise be needed and keeps them busy more and parked less. The Port's FITS program will include a parking information system that should increase utilization of available space. The result is that overnight parking requirements remain at roughly 30 acres. Day use parking needs rise slightly, but are limited for the same reasons. Day use parking is typically accommodated in the same lots that provide overnight space.

Summary of Ancillary Service Needs

A comparison of the acreage required for ancillary services in the Port area and the acres estimated to be required under the three container cargo growth scenarios is provided in Exhibit 145.

Exhibit 145: Summary Ancillary Acreage Needs

Acres Required	Truck Services	Overnight Tractor Parking	Short-Term Container Staging	Heavy Cargo Transloading	Reefer Depots	Total
Moderate Growth	8	30	3	109	59	**209**
Slow Growth	8	28	3	82	45	**167**
Strong Growth	8	30	4	147	80	**269**
Acres in Ancillary Use and Available	**Seaport Logistics Complex**	**555 Maritime St Complex**	**Outer Harbor**	**City of Oakland**	**Union Pacific**	**Total**
As of Early 2019	140	78	13	63	11	**305**

As of early 2019, there were about 305 acres of land in the immediate Port area either already in an ancillary use (e.g. CoolPort or the two facilities on Union Pacific Land); under development for an ancillary use (e.g. CenterPoint Phase 1); or available for long-term ancillary use (e.g. Prologis Buildings 2 and 3).

Estimated acres required for all ancillary uses range from 167 in the Slow Growth scenario to 269 in the Strong Growth scenario.

The comparisons in Exhibit 145 suggest that there is adequate space within the Port of Oakland complex for ancillary services to support projected cargo growth in all three scenarios. The Port of Oakland plans to eventually develop all the Port-owned land listed in Exhibit 145 in functions that will encourage and support marine cargo growth. The City of Oakland is on a path to do the same.

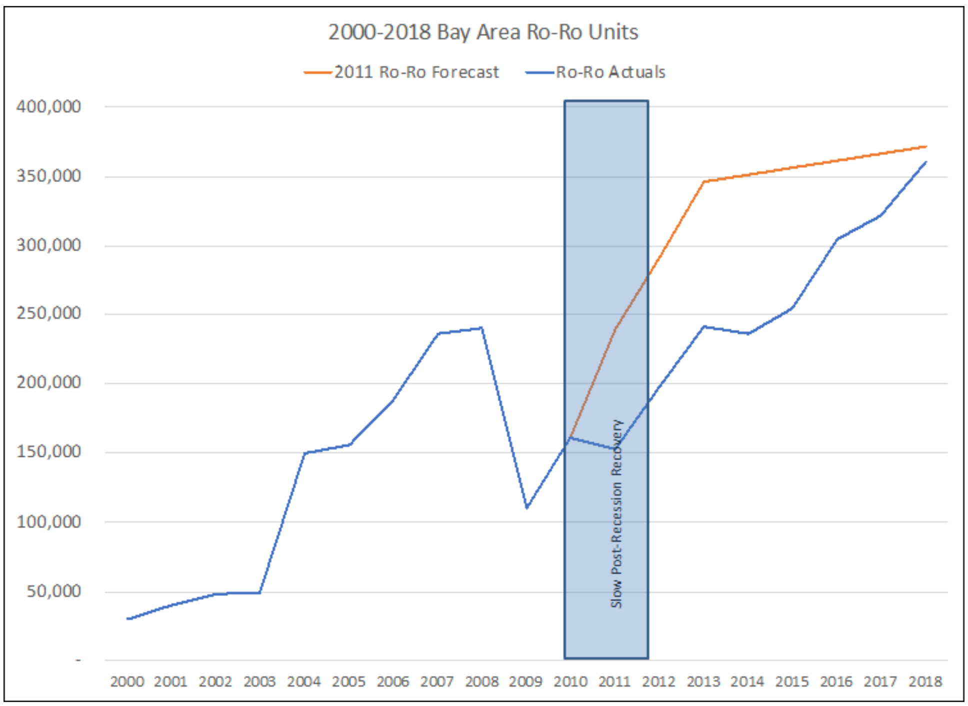
4. Ro-Ro Cargo Forecast and Capacity Analysis

Ro-Ro (Neo-Bulk) Cargo Review

The Seaport Plan has used the term "neo-bulk" to describe cargoes that are neither containerized nor bulk, but do not require the traditional piece-by-piece handling of break-bulk cargo. Roll-on roll-off (Ro-Ro) shipment of autos and other vehicles have come to dominate this cargo segment, and is the only active "neo-bulk" category at SF Bay Area ports. The analysis therefore uses the Ro-Ro nomenclature for clarity and consistency with industry terminology.

As shown in Exhibit 146, the import and export auto trades did not recover as strongly as expected from the recession, but have since grown to near the predicted volume by 2018.

Exhibit 146: Ro-Ro Auto Trade Forecasts

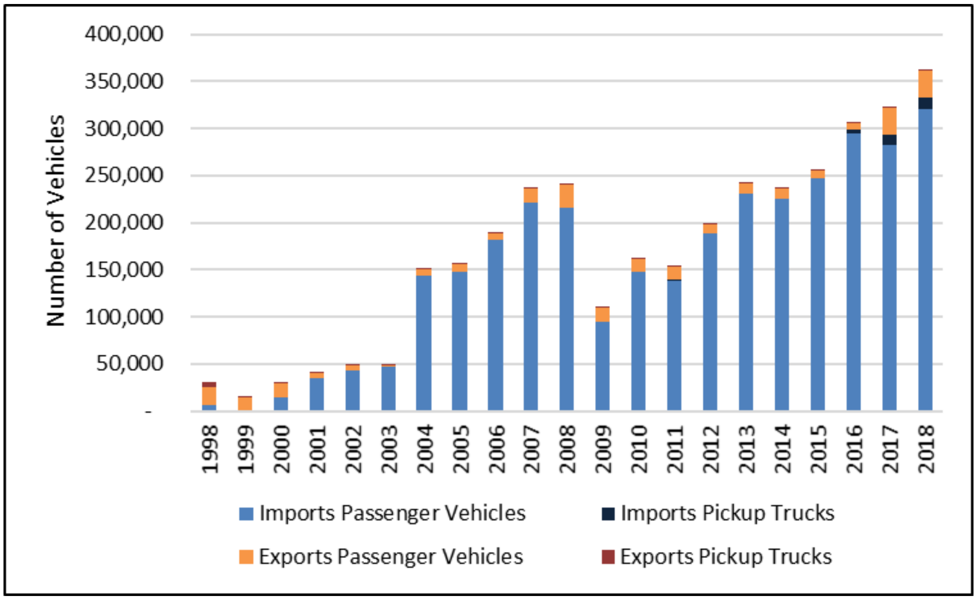


Current Ro-Ro Cargo Flows

The Ports of Richmond, Benicia, and San Francisco import and export automobiles in Ro-Ro vessels. Passenger vehicle counts for the Bay Area were obtained from the Office of Transportation and Machinery at the International Trade Administration (a bureau within the U.S. Department of Commerce) as port-provided data were inconsistently recorded in units and tons.

Exhibit 147 shows the import and export vehicle counts between 1998 and 2018. The data show the dominance of imported vehicles and, in particular, the importance of passenger vehicles, which accounted for 93 percent of the total light-vehicle movements over the past decade.

Exhibit 147: Bay Area Ro-Ro Vehicle Trade by Type, 1998-2018



The compound annual growth rate between 2010 and 2018 was 9.5% for imports, 8.2% for exports, and 9.3% total.

Two factors have begun to decrease the dominance of passenger vehicle imports in Bay Area Ro-Ro activity:

- Pickup truck imports that began in 2016 accounted for almost four percent of total vehicle imports in both 2017 and 2018 (Exhibit 148).
- Passenger vehicle exports, which averaged around 12,400 per year between 2008 and 2016, but increased to around 28,000 per year in both 2017 and 2018, in large part due to the export of Tesla vehicles (Exhibit 149).

Exhibit 148: Pickup Truck (under 5 tons) Imports and Exports, 2009-2018

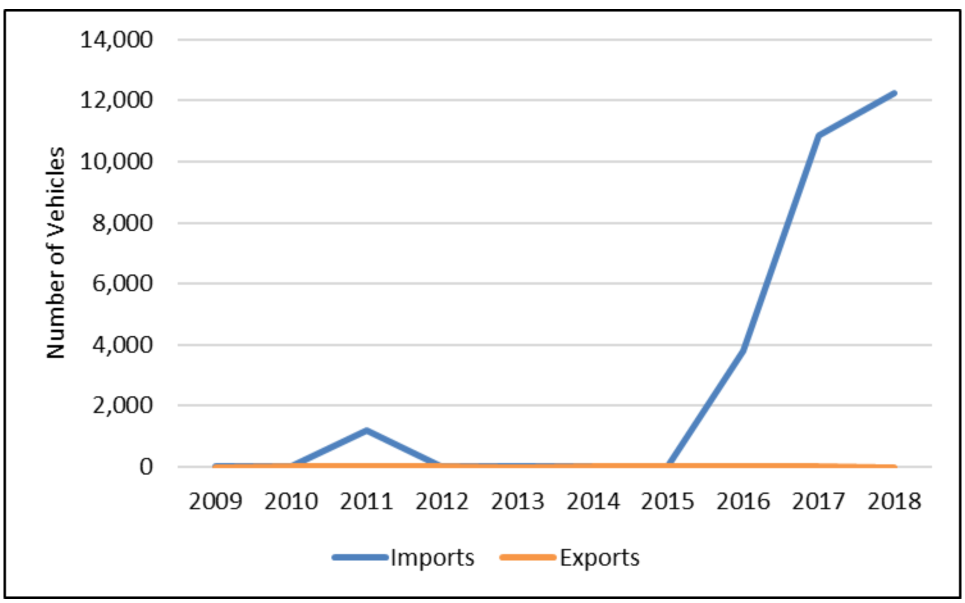
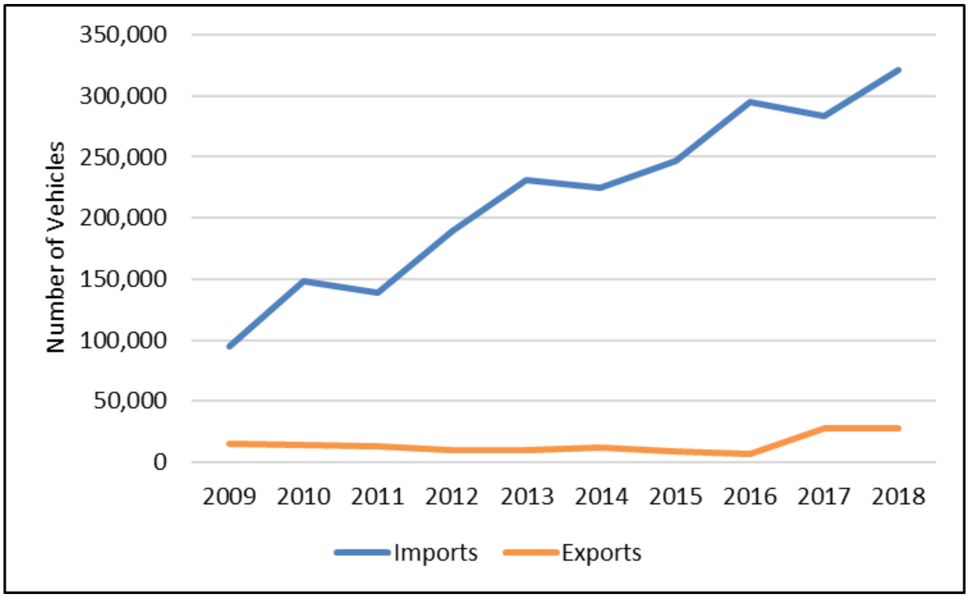


Exhibit 149: Passenger Vehicle Imports and Exports, 2009-2018



Ro-Ro Shipping Trends

For roll-on/roll-off (Ro-Ro) trade, mainly automobiles and vehicles, the Ports of San Diego, Long Beach, Hueneme, Benicia, San Francisco, and Richmond all participate and compete. Ro-Ro facilities are principally of two types: brand-linked (such as the Toyota import facility at Long Beach) and operator-based (such as the Pasha facilities at San Diego and San Francisco). Ports and terminal operators compete for multi-year contracts with major auto importers, and on a shipment-by-shipment basis for other flows. The key factors in this competition are:

- Fit within the importer's international market strategy.
- Access to major consumer markets.
- Costs of ocean shipment, port handling, and vehicle processing.
- Trucking costs to local and regional markets.
- Rail access, service, and cost to intrastate markets.

From the above factors, geography and market access are most often the primary factors, and transportation cost is a secondary factor.

The Ports of Richmond and Benicia are entry and distribution points for imported autos, and Pasha has recently commenced auto operations at the Port of San Francisco. Each manufacturer/importer tends to choose one or more ports as entry points for multi-year commitments. Ports and auto terminal operators, therefore, tend to compete for these long-term commitments. To the extent that one importer may bring in autos to more than one port, the port terminal operators may compete for volume and territory, as do distributors of other goods.

Ro-Ro shipping handles vehicles and other cargo (e.g. industrial equipment) that can be rolled on and off specialized vessels. A moderate-sized Ro-Ro auto carrier, such as the *K. Asian Beauty*, which called at Richmond and Benicia in 2019 (Exhibit 150), is about 600 feet long and 100 feet wide, with a design draft of 30 feet and a typical sailing draft of about 26 feet. Fully loaded, such a vessel would require about 34 feet of draft (with 4 feet of underkeel clearance), and as typically loaded would require about 30 feet.

Exhibit 150: K. Asian Beauty, Moderate-Sized Ro-Ro Vessel

A large Ro-Ro auto carrier vessel, such as the *Glovis Condor*, which called at Benicia in early 2019 (Exhibit 151), is about 650 feet long and 105 feet wide, with a design draft of 40 feet and a typical sailing draft of about 32 feet. Fully loaded, such a vessel would require about 44 feet of draft (with 4 feet of underkeel clearance), and as typically loaded would require about 36 feet.

Exhibit 151: Glovis Condor, Large Ro-Ro Vessel

Ro-Ro vessels are essentially floating parking lots (Exhibit 152), and are loaded and discharged via ramps (Exhibit 153).

Exhibit 152: Ro-Ro Vessel

Exhibit 153: Ro-Ro Vessel Discharge

The Bay Area has three active Ro-Ro terminals:

- BPTC at Benicia (auto processing is done by Amports).
- Port Potrero, operated by AWC, at Richmond.
- Pier 80, operated by Pasha, at San Francisco.

The primary market for Ro-Ro operations has long been import autos and trucks. Both Richmond and Benicia have also handled much smaller volumes of export vehicles. The Pasha operation at Pier 80 is an exception, as it mostly handles Teslas for export to China and Europe.

Growth of import vehicle shipments has been tempered by the tendency of foreign manufacturers to build U.S. assembly plants for their most popular vehicles in the U.S. market. For example:

- Toyota has assembly plants in Kentucky, Indiana, Texas, and Mississippi.
- Honda has assembly plants in Ohio, Alabama, and Indiana.
- Nissan has assembly plants in Tennessee and Mississippi.
- Subaru has an assembly plant in Indiana.
- Hyundai has an assembly plant in Alabama.

- Kia has an assembly plant in Georgia.
- Volkswagen has an assembly plant in Tennessee.
- Volvo has an assembly plant in South Carolina.
- Daimler (Mercedes) has assembly plants in Alabama and South Carolina.
- BMW has an assembly plant in South Carolina.

Many industry observers have predicted that the U.S. would eventually begin importing Chinese autos from manufacturers such as Chery. This predicted trend has not yet resulted in significant imports of Chinese brands. If Chinese makers gain a significant foothold in U.S. markets, they may follow other manufacturers in establishing U.S. assembly plants.

There are also autos and auto components made in China for the U.S. market by non-Chinese manufacturers. Buick, Cadillac, and Volvo, all produce vehicles in China for export to the U.S. Those imports have been curtailed due to the current (2019) trade dispute with China. Instead, these manufacturers have reportedly imported vehicles and components from European plants.

The volume of imported passenger vehicles has increased rapidly over the past decade, substantially outpacing population growth in the 19-county region. In 2018, the United States International Trade Commission reported that the San Francisco district imported a total of 320,873 light vehicles and 12,259 pickup trucks (Exhibit 148). Passenger vehicle imports have increased consistently over the past decade, with an annual growth rate of 10.2 percent between 2010 and 2018 (2009 is excluded due to the impact of the recession). In contrast, pickup truck imports were minimal until 2016. In both cases this is markedly different from the growth rates experienced at the national level. Between 2010 and 2018, the number of passenger vehicles imported nationally increased by 4.0% per year, while pickup trucks increased by 13.2% per year.

The U.S. Census Bureau reported that 2.4 million passenger vehicles were imported from Mexico to the U.S. in 2017, a 71% increase from 2012. This is anticipated to increase to nearly 5 million vehicles by 2020 (Automotive News). Pickup imports faced high tariffs until NAFTA encouraged production in Mexico. Benicia receives substantial volumes of Toyota pickups assembled in Mexico.

Imports accounted for 92% of the total international movement of passenger vehicles and pickup trucks in 2018, as just 27,537 passenger vehicles and 2 pickup trucks were exported (Exhibit 149). Passenger vehicle exports increased by 9.2% annually between 2010 and 2018, although exports increased over threefold between 2016 and 2018, likely due to Tesla, as 39,234 electric vehicles were exported in 2017 and 2018. The growth rate in exports at the national level is once again different; between 2010 and 2018, the number of passenger vehicles exported increased by 1.8% per year, while pickup trucks increased by 1.9% per year.

Discussions with Ro-Ro terminal operators and port staff reveal that different manufacturers have different import and processing strategies.

- Some manufacturers import "plain vanilla" vehicles and move them to dealers with minimal processing. Accessories are then added by the dealers. The dwell time at the port depends on whether they are moving in volume by rail (3-5 days at port) or in smaller lots by truck (7-15 days).
- Other manufacturers process "plain vanilla" vehicles and add options and accessories at the port before movement inland. This strategy leads to longer port dwell times, a range of roughly 7-30 days.

Manufacturers tend to adjust their strategies back and forth over time, so a terminal handling multiple vehicle lines will experience an average dwell of around 15 days and a throughput averaging about 1,700 vehicles per acre per year.

The growing size of vehicles, particularly the size of dual-cab pickups, reduces annual throughput capacity per acre. Autos can be parked at about 250 per acre for rail shipping or 120 per acre for shipping by truck. Large trucks can be parked at 70-100 units per acre.

Richmond. Auto handling at the Port of Richmond is currently managed by Auto Warehousing Co. (AWC). AWC also operates auto terminals at Portland, Vancouver, Tacoma, and multiple East and Gulf Coast ports, as well as at inland rail hubs. Subaru, Honda, and Ford autos are currently imported through Richmond.

- Hondas and Fords pass through the terminal with minimal processing, spending 2-4 days at Richmond.
- Subarus undergo extensive processing and accessory installation, and typically spend several days at the port.

The Port Potrero Ro-Ro terminal is currently operating near capacity, sometimes receiving as many as four vessels in 10 days. The Port is seeking ways to expand Ro-Ro operations, including the use of off-terminal parking.

Benicia. In a late 2018 interview, the Amports CEO noted that Amports is developing a new terminal about 15 miles east of its dedicated auto terminal in Benicia after signing a long-term lease on a 100-acre former paper mill site in Antioch. Mr. Taylor said Benicia is at capacity, on pace for 250,000 vehicles, and the new development will have room to move 150,000 to 175,000 vehicles per year.

The Volkswagen Group of America opened a new processing facility at Benicia in February 2018, and expects to process 40,000 VW, Bentley, Audi, and Porsche cars annually. BPTC actually moved 203,928 vehicles through Benicia in 2018, suggesting that the auto facility[vii] is operating at roughly 82% of capacity. The previous peak was 200,608 annual units in 2008, on the brink of the recession.

Since volumes recovered from the recession in 2013, the volume through Benicia has grown at a CAGR of 8.7%. At that rate, the Benicia facility will have reached capacity in 2021. The combined Benicia and Antioch capacity will have been reached by about 2028, even if the Antioch facility is not used for other purposes (such as domestic auto processing).

San Francisco. Pier 80 is a 66-acre facility[viii] with two warehouses and four berths. Pasha, a major vessel operator and auto handling organization, signed a 15-year lease for Pier 80 in 2016. Pasha moved 43,204 export autos, primarily Teslas, through SF Pier 80 in 2018, up from 24,688 in 2017. In Fiscal 2018-2019, Pasha moved about 77,000 Tesla exports, and the 2019 total is expected to exceed 100,000 vehicles.

Reportedly, part of the attraction of Pier 80 for Pasha was its underutilization compared to Benicia and Richmond, which are already operating near capacity. Pasha believes that when Pier 80 is completely renovated, it will be able to handle 150,000 vehicles a year and around 100 ships[ix]. On that basis, Pier 80 was operating at about 29% of capacity in 2018, and at about 75% of capacity as of mid-2019.

[vii] The entire Benicia facility is roughly 640 acres, but portions are leased out for other uses.
[viii] Exact acreage to be determined for the final report.
[ix] American Journal of Transportation - 6/12/17

Both Pier 80 and Pier 96 (now dormant) are usable as Ro-Ro terminals. They may be limited to export and local movements by truck, however, as the Potrero Hill railroad tunnels lack the necessary clearances for the tri-level railcars used to move vehicles by rail (Exhibit 154).

Exhibit 154: Tri-level Auto Rack Cars

Ro-Ro Outlook

The outlook for Ro-Ro cargo through San Francisco Bay depends on the growth in import and export auto volume, on competition with other East Coast, Gulf Coast, and West Coast ports, and on how many vehicles can be stored, processed, and moved through Bay Area facilities.

Growth in import and export vehicle flows depends on:

- Demand for foreign-built vehicles in the U.S., and for U.S.-built vehicles in foreign countries.
- Tariffs, quotas, and other trade barriers.
- Auto industry sourcing decisions.
- Location of new foreign-brand assembly plants in the U.S. and U.S.-brand assembly plants in foreign countries.
- The demand for personal versus hired vehicles over the next decades.

In the short term, the major risks to vehicle import and export growth are automobile tariffs that could be levied in both trade directions as part of a trade dispute with China and the E.U. Drewry reported that if tariffs were implemented in the second quarter of 2019, the most negative effect would be expected between 2020 and 2021. Although Canada and Mexico may be exempted from any vehicle-related tariffs, the impact of reduced imports from Japan, China, and Europe on the Bay Area's ports would be significant. If tariffs on vehicles are avoided it is possible in the mid-term that imports from China will increase as the manufacturing of Chinese brands (as opposed to European and American brands built in China) matures.

In the long term, any significant transition to autonomous driving vehicles may have an impact on the number of vehicles that households own, with numerous companies exploring the possibility of providing driverless fleets that can be summoned as needed. The outlook for the production of autonomous vehicles varies to a large degree. In 2018, Credit Suisse predicted that by 2040 just 14% of global car production will be comprised of self-driving vehicles. Industry sources, however, have noted that the greater annual mileage incurred by taxis or other hired vehicles leads to accelerated wear and more frequent replacement. New York City taxis, for example, average 60,000–70,000 miles annually compared to private vehicles at 13,000–14,000. The more frequent replacement of hired vehicles is therefore likely to offset any reduction in private vehicle ownership.

The volume through the Bay Area also depends on market share shifts. For inland delivery by rail, Bay Area ports compete with ports such as Baltimore and Portland. Specific import brands could change ports, either to or from the Bay Area. While the consultant team did not attempt to forecast such shifts, they should be recognized as one factor that could push future volumes higher or lower.

The ability of Bay Area Ro-Ro terminals to accommodate the expected flows will depend on the number of vehicles that can be stored and processed through an acre of land, currently averaging about 1,700 vehicles annually.

- The mix of vehicle sizes will affect the space required. More imports of large SUVs and double-cab trucks, for example, will increase space requirements and decrease throughput.
- The average time each vehicle spends at the port (dwell time).
- The share of rail versus truck moves; rail-destined vehicles can be parked closer together and typically have shorter dwell times.

The forecast and capacity analyses that follow attempt to capture these influences in a series of representative scenarios.

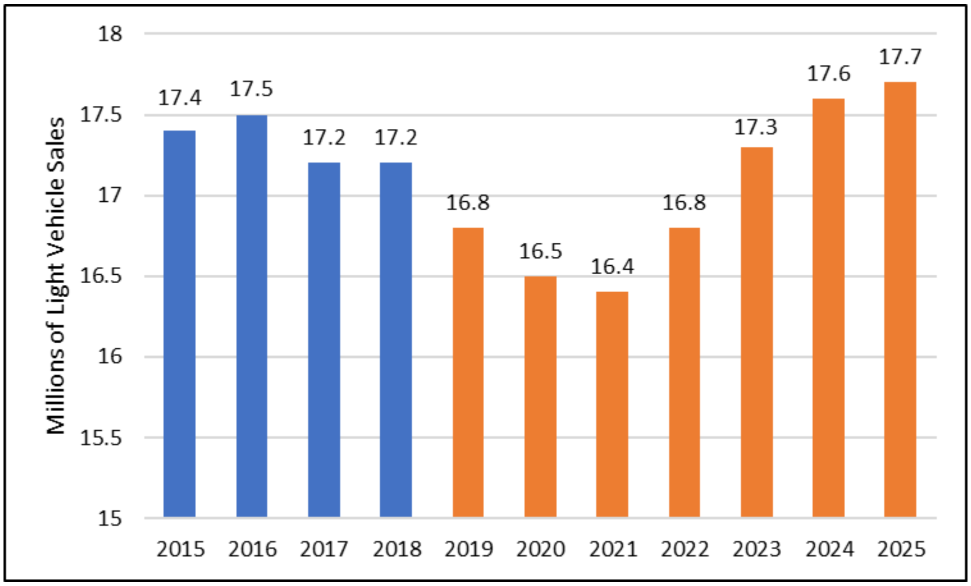
Scenario Overview

Imports

Projecting vehicle imports is complicated by the advent of new technologies, changes in societal urbanization and consumer spending trends, and an uncertain trade environment. This forecast examined a number of factors and trends in an effort to develop a range of scenarios suitable for seaport planning. As vehicles imported to the Bay Area are destined for dealerships throughout the nation and not just the local market, the import forecast is driven by national growth and demand factors.

The Center for Automotive Research (CAR) has forecast that light vehicle sales will decrease in each of the three coming years before slow growth returns in 2022 (Exhibit 155).

Exhibit 155: U.S. Light Vehicle Sales Forecast



While this forecast does not differentiate between passenger vehicles, sports utility vehicles, and pickup trucks, there has been a shift between the classes over the past decade. The National Automobile Dealers Association (NADA) stated that in 2018 light trucks accounted for approximately 70% of sales compared to 30% for cars. In contrast, NADA noted that the split was almost balanced about a decade ago, when light trucks accounted for 48% of sales and cars accounted for 52%. This shift has been less pronounced with imports to the Bay Area due to the dominance of U.S. truck manufacturers. The increased share of pickup truck imports to the Bay Area over the past three years is anticipated to continue, however, and even if the number of vehicles imported were to remain unchanged over the next 30 years the transitions from light passenger vehicles to SUVs and pickup trucks would still affect space utilization.

The future role of shared or hired vehicles has been the subject of wide speculation, and is far from clear. The degree to which the population will shift to alternative modes of ownership (such as trip-based fees or annual subscription-based models) is highly debated. McKinsey and Company has predicted that by 2030 10% of new cars would be "shared vehicles", increasing to as many as 33% by 2050. Deloitte has a more aggressive outlook that suggests that by 2040 just 10% of new vehicle sales in urban areas will be personally owned driver-driven vehicles, with over 70% of new sales falling into the category of shared autonomous vehicles. However, household vehicle ownership is already lower in urban areas than in suburban or rural zones. To date there has been little evidence to support that a shift to shared mobility vehicles is underway despite the proliferation of shared vehicle and ride-hailing services. Recent surveys also suggest there is an ongoing generational shift in attitudes to car ownership, although the pace of that shift is debated. For example, AAA's most recent driving survey showed a decrease in the percentage of those who "drive at least occasionally" in the 16-19, 20-24, and 25-34 age groups between 2014-15 and 2016-17. While the degree to which that shift is occurring and the reasons behind it are beyond the scope of this effort, the forecast reflects the fact that there will be an impact on sales relative to population growth due to this transition.

The consultant team compared forecasts of household size to the number of vehicles owned per household. The number of automobiles per household has grown consistently since 1950 according to CAR, with the average crossing the two-vehicle-per-household threshold in the 1990s. Household ownership of vehicles has reportedly reached a saturation point, however, and CAR anticipates that ownership levels will plateau at 2.07 vehicles per household beyond 2025. The Harvard Joint Center for Housing Studies forecasts that household formation will slow over the next 20 years. Taken together, if households continue to own cars at the same rate while households are not formed as quickly, the result would be slower growth in new car sales. The final approach examined was to utilize the Federal Highway Authority's (FHWA) forecast of Vehicle Miles Travelled (VMT). The forecast of VMT growth is based upon national economic performance, population and employment growth, and gasoline and diesel prices, with baseline, pessimistic, and optimistic economic growth scenarios. The projected annual growth rate for light-duty vehicle VMT over the 2017-2047 year period is 0.7% for the baseline scenario, 0.6% in the pessimistic scenario, and 0.9% in the optimistic scenario. This is a lower growth rate than the average 1.6% annual gain over the past five years and the 1.3% average gain over the past 25 years. The use of VMT to estimate new vehicle requirements is based on the concept that vehicles will have to be replaced due to use regardless of who owns the vehicle, or if it is operated by a human or computer. This approach also smooths out the impact of taxis or fleet-owned vehicles, as these would need to be replaced more often, offsetting reduced vehicle sales to individuals or households.

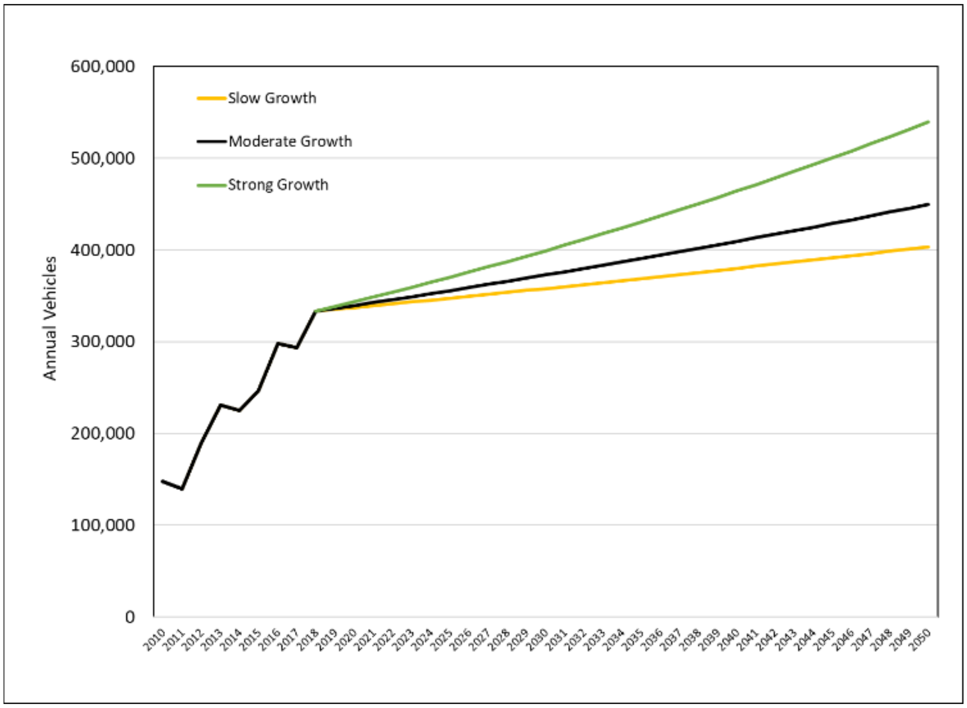
The import of new passenger vehicles and light trucks over the past year has increased by an average annual rate of 2.7%. As a ratio of VMT to new vehicle imports, a 1% increase in VMT over the past 5 years has been accompanied by a 1.7% increase in imports. The strong economic performance of the country over the past five years suggests that the 1.7% increase in imports for every 1% increase in VMT is more indicative of an upper limit and is therefore utilized in the Strong Growth scenario, while a Slow Growth scenario utilizes only the growth in VMT (a 1% increase in imports for every 1% increase in VMT). The Moderate Case forecast is based on the midpoint growth rate, or a 1.34% increase in imports for every 1% increase in VMT.

The import forecast (Exhibit 156) does not attempt to predict the percentage of vehicle sales that will be autonomous and/or shared, nor does it attempt to predict the pace of change in vehicle ownership levels. Instead it acknowledges that the impact of technology and the shifting nature of vehicle ownership will result in a slowing pace of vehicle imports over time relative to population growth and VMT.

The Moderate Growth import forecast growth rate incorporates the FHWA VMT baseline forecast and the mid-point in the calculated ratio of imports to VMT growth rates. The Strong Growth scenario follows FHWA's optimistic economic scenario for VMT growth and the Strong Growth ratio of vehicle imports to VMT, and the Slow Growth scenario utilizes FHWA's pessimistic economic scenario for VMT growth and the Slow Growth ratio of vehicle imports to VMT.

The compound annual growth rate between 2019 and 2050 is projected to be 0.94% in the Moderate Case scenario, 0.60% in the Slow Growth scenario, and 1.52% in the Strong Growth scenario.

Exhibit 156: Projected Vehicle Imports to the Bay Area by Scenario



Exports

Barring no major shakeup in the automotive industry, Ro-Ro export figures for the Bay Area will be driven primarily by Tesla volumes, which makes projecting future export numbers highly speculative. At present the only facility producing Tesla models is located in Fremont, although work has commenced on a second factory in China. While this second facility would reduce the demand for Tesla models in that country, it is assumed that there is adequate demand in the rest of the world to sustain Tesla exports at some level. It was reported that Tesla hoped to export 3,000 vehicles a week to Europe from February 2019 on. Port of San Francisco data suggest that Tesla is approaching that volume as of mid-2019. The current capacity at Fremont is supposedly 300,000 vehicles per year, although Tesla has stated that capacity will reach 500,000 vehicles per year. The first vessels to carry Tesla Model 3s to Europe in the first quarter of 2019 reportedly moved 1,400 vehicles per voyage. The Port of San Francisco has stated that it is on track for 100,000 vehicles to be exported in 2019, although this growth rate is not sustainable in the long-run.

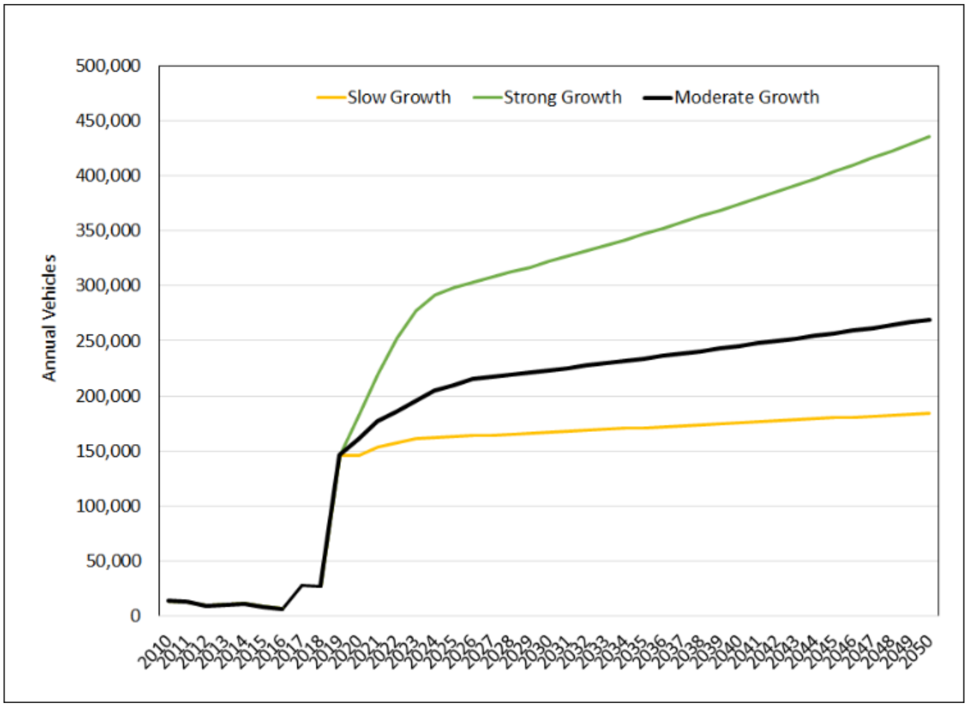
As of September 2019, Tesla is constructing an assembly plant in China, with production of the Model 3 set to commence in late 2019 or early 2020. The stated production target of the facility is 250,000 vehicles per year initially and thereafter increasing to 500,000 vehicles per year. While other Tesla models would still be exported from the Fremont plant, it is therefore unlikely that significant numbers of the more affordable Model 3 will be exported to China. Instead, recent Tesla export growth has been in the European market.

Exhibit 157 compares the three export scenarios for Ro-Ro cargo. The Moderate Growth export scenario is based on the assumption that Tesla exports grow at a diminishing rate as production in China starts late this year or early next, but export growth occurs in other markets. By 2027 the pace of growth slows to match the Moderate Growth import rate (0.94%) as Tesla expands into new markets.

The Strong Growth export scenario assumes that Tesla will be able to sustain faster growth over the same period, after which the growth rate matches the Strong Growth import rate (1.52%). The Slow Growth export scenario incorporates a near-term decline due to the impact of further trade restrictions followed by limited market expansion before returning to the Slow Growth import rate (0.60%).

The compound annual growth rate between 2019 and 2050 is projected to be 2.0% in the Moderate Growth scenario, 0.8% in the Slow Growth scenario, and 3.6% in the Strong Growth scenario.

Exhibit 157: Projected Vehicle Exports from the Bay Area by Scenario, 2000-2050



Total Ro-Ro Activity

Exhibit 158 compares the three growth forecasts for Ro-Ro cargo comprised of the base import/base export, low import/low export, and high import/high export scenarios. Exhibit 159 shows these volumes in select years. The compound annual growth rate between 2018 and 2050 is projected to be 2.2 % in the Moderate Growth scenario, 1.5% in the Slow Growth scenario, and 3.2% in the Strong Growth scenario.

Exhibit 158: Chart of Projected Total Ro-Ro Counts in the Bay Area by Scenario, 2000-2050

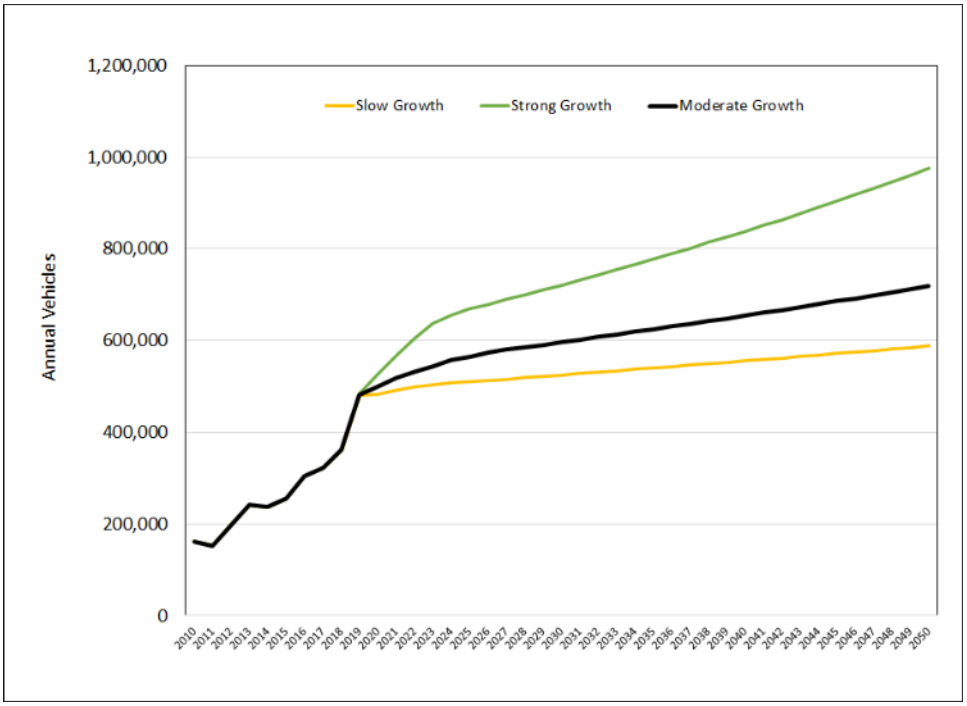


Exhibit 159: Projected Total Ro-Ro Activity in the Bay Area by Scenario

Scenario	2018	2022	2026	2030	2034	2038	2042	2046	2050	CAGR
Slow Growth Vehicles	360,671	481,334	483,345	510,280	524,940	540,025	555,546	571,516	587,949	1.5%
Moderate Growth Vehicles	360,671	482,469	500,252	565,606	596,110	624,678	654,616	685,988	718,863	2.2%
Strong Growth Vehicles	360,671	484,394	526,081	668,777	721,128	777,578	838,446	904,079	974,850	3.2%

Ro-Ro Terminal Capacity

Ro-Ro terminals are a mix – most include a full range of functions on-site (e.g. Richmond), but others are part of a multi-site complex (e.g. Benicia). The consultant team's analysis assumes that existing organizational patterns will continue, and that future terminal space requirements are a function of volume growth.

Estimating the terminal space required to handle the auto and truck volumes shown above requires constructing scenarios for vehicle mix and dwell time, and then tracing the implications for terminal space.

Vehicle Size Mix

Average vehicle size has been growing with the popularity of SUVs, trucks, and especially double-cab trucks. The most recent data indicates that around 70% of new vehicles sold in the U.S. are trucks, primarily pickup trucks. The 10 largest-selling vehicles in the U.S. in 2018 were:

1. Ford F-Series pickup 909,330 units
2. Chevrolet Silverado pickup 585,581 units

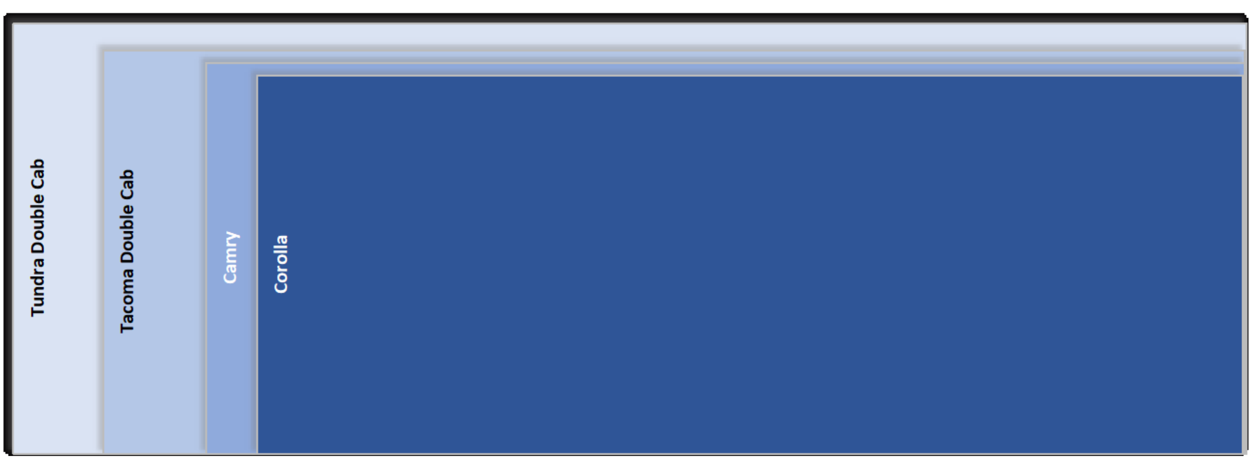
3. Dodge Ram pickup 536,980 units
4. Toyota RAV4 compact SUV 427,170 units
5. Nissan Rogue compact SUV 412,110 units
6. Honda CRV compact SUV 397,813 units
7. Toyota Camry mid-size auto 343,439 units
8. Chevrolet Equinox compact SUV 332,618 units
9. Honda Civic compact auto 325,760 units
10. Toyota Corolla compact auto 303,732 units

Using familiar Toyota models as examples, Exhibit 160 shows the "footprint" of various types in square feet. The differences are illustrated in Exhibit 161. Exhibit 160 also shows Tesla models for comparison, because Teslas are the dominant export brand.

Exhibit 160: Sizes of Selected 2019 Toyota and Tesla Models

Model	Size			Estimated Annual Units per Acre
	Length Inches	Width Inches	Area SF	
Corolla	182.5	70.1	88.8	1,849
RAV4	180.9	73.0	91.7	1,578
Camry	192.7	72.2	96.6	1,700
Tacoma Double Cab	212.3	74.4	109.7	1,497
Sequoia	205.1	79.9	113.8	1,443
Tundra Double Cab	228.9	79.9	127.0	1,293
Tesla Model 3	184.8	76.1	97.7	1,682
Tesla Model S	196	77.3	105.2	1,561
Tesla Model X	198.3	81.5	112.2	1,463

Exhibit 161: Vehicle Space Needs Comparison



Under the assumption that the "mid-size" sedan (Camry) in Exhibit 160 reflects the current average vehicle size at the average throughput of 1,700 per acre, Exhibit 160 also shows the impact of vehicle size on throughput. As larger vehicles enter the mix, throughput per acre drops. A shift toward smaller vehicles, particularly small urban "robo-taxis" envisioned by some observers, would increase throughput per acre.

Productivity Scenarios

Exhibit 162 combines variations in dwell time and vehicle mix to develop moderate, low, and high import, export, and combined productivity scenarios for Ro-Ro terminal space. The numbers used in Exhibit 162 are not intended to reflect the current experience or performance of specific terminals or operators, but to illustrate the range of outcomes from variations in dwell time and vehicle size mix. As Exhibit 162 indicates, the Port of San Francisco's recent experince with Tesla exports through Pier 80 yield much lower average dwell times and annual throughputs for exports.

Shifting the mix toward more trucks (or large SUVs) and increasing import dwell time would both reduce working throughput. The size mix shown would reduce annual average vehicles per acre by about 24%. Factors in such a shift could include:

- Increased production of trucks and large SUVs in foreign countries (i.e. the current production of double-cab Toyota Tacomas in Mexico).
- Popularity of mid-size rather than compact vehicles in ride-hailing applications (a Tesla 3 is 185" long and 76" wide, closer to a mid-size Camry than to a compact Corolla).
- Low gas prices, favoring larger cars.
- Import and export strategies favoring more processing at the port and favoring truck delivery over rail.

Shifting the mix toward more compact cars or compact SUVs and reducing average import dwell time from 15 to 12 days could reduce occupancy and space requirements by about 22 percent, and increase annual throughput per acre. Factors in such a shift could include:

- Concentration of future truck and large SUV production in the U.S.
- Increased popularity of compact electric cars and SUVs, and use of compact vehicles in ride-hailing.
- Rising fuel prices.
- Import strategies favoring minimal processing at the port and maximum use of rail.

The export case shows the reported 2019 throughput for Pier 80, which averaged 2,437 annual units per acre with a 3.5 day average dwell time. The table envisions lower productivity with a 5.3 day dwell and higher productivity with a 2.3 day dwell corresponding to lower or higher vessel call frequency.

Exhibit 162 also presents a combined weighted average using the 2050 shares of imports and exports.

Exhibit 162: Ro-Ro Productivity Scenarios

Import Case	Average Dwell Days	Unit Size Distribution - Square feet				Occupancy Index	% Change	Annual Units per Acre
		Compact 88.8	Mid-Size 96.6	Truck 109.7	Average			
Low Productivity	18.0	25%	50%	25%	97.9	1,763	24%	**1,371**
Base Case	15.0	40%	50%	10%	94.8	1,422	na	**1,700**
High Productivity	12.0	50%	50%	0%	92.7	1,113	-22%	**2,173**

Export Case	Average Dwell Days	Unit Size Distribution - Square feet				Occupancy Index	% Change	Annual Units per Acre
		Compact 88.8	Mid-Size 96.6	Truck 109.7	Average			
Low Productivity	5.3	25%	50%	25%	97.9	514	52%	**1,603**
Base Case (SF 2019)	3.5		100%		96.6	338	na	**2,437**
High Productivity	2.3	50%	50%	0%	92.7	216	-36%	**3,809**

Combined Case	Average Dwell Days	Import Units per Acre	Import Share	Export Units per Acre	Export Share	Occupancy Index	% Change	Annual Units per Acre
Low Productivity	14.0	1,371	69%	1,603	31%	1,371	-27%	**1,444**
Base Case (SF 2019)	10.7	1,700	63%	2,437	37%	1,033	-	**1,976**
High Productivity	7.7	2,173	55%	3,809	45%	713	47%	**2,903**

The shifts contemplated in Exhibit 162 are likely to take place over several years rather than all at once. Exhibit 163 spreads the changes out over 10 years to provide a plausible progression of Ro-Ro terminal productivity.

Exhibit 163: Ro-Ro Productivity Shifts to 2030

Import Productivity Scenario	2018	2019	2020	2025	2030
Low Productivity Units/Acre	1,700	1,670	1,640	1,500	1,371
Base Productivity Units/Acre	1,700	1,700	1,700	1,700	1,700
High Productivity Units/Acre	1,700	1,735	1,771	1,962	2,173

Export Productivity Scenario	2018	2019	2020	2025	2030
Low Productivity Units/Acre	2,437	2,353	2,273	1,908	1,603
Base Productivity Units/Acre	2,437	2,437	2,437	2,437	2,437
High Productivity Units/Acre	2,437	2,529	2,625	3,162	3,809

Ro-Ro Terminal Needs

Discussions with the Ports of Richmond and Benicia indicate that those facilities are approaching capacity. For Ro-Ro facilities capacity is determined primarily by 1) parking space, and 2) the average dwell time of vehicles in the parking space. Capacity is further affected by peaking, with closely spaced vessel arrivals or seasonal sales variations leading to periodic surges. The Port of San Francisco is handling Tesla exports at Pier 80, which have grown rapidly in the last 2-3 years.

The chart in Exhibit 164 and the table in Exhibit 165 display the combined Ro-Ro forecast and capacity analysis. Nine scenario combinations are presented. Productivity is held constant after the 10-year phase-in shown in Exhibit 163.

- The Moderate Growth forecast and base case productivity scenario together suggest that 375 acres of Ro-Ro terminal space would be required to handle 718,863 vehicles in 2050.
- At the lower extreme, the Slow Growth forecast and the high productivity scenario together call for 234 acres to handle 587,949 vehicles in 2050.
- The Strong Growth forecast and low productivity scenario together would require 665 acres to handle 974,850 vehicles in 2050.

As both the table and the chart indicate, the scenario combinations overlap. The combination of a high forecast and high productivity, for example, would require 363 acres versus 375 acres for the base/base combination.

Exhibit 164: Ro-Ro Terminal Acreage Requirements to 2050

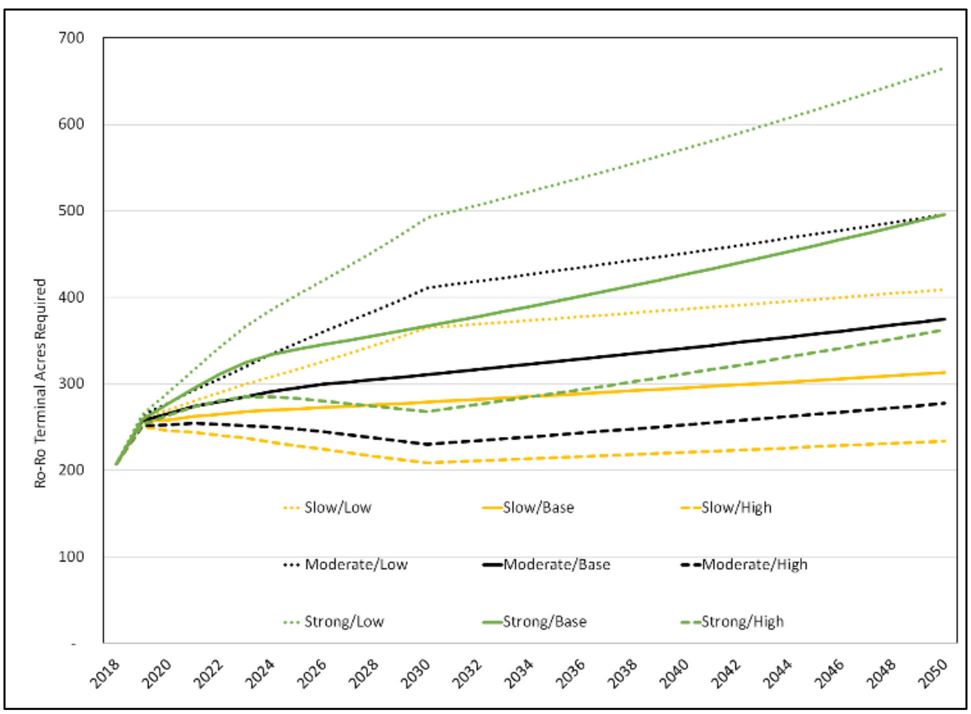


Exhibit 165: Ro-Ro Cargo Summary

Scenario		2018	2019	2020	2025	2030	2035	2040	2045	2050	CAGR	Existing Acres	New Acres	Available	% Used
Slow Growth		**360,671**	**481,334**	**483,345**	**510,280**	**524,940**	**540,025**	**555,546**	**571,516**	**587,949**	**1.5%**				
Low Prod. Acres	L/L	207	263	270	317	365	376	387	398	409	2.1%	215	194	377	109%
Base Prod. Acres	L/B	207	257	258	271	279	287	296	304	**313**	1.3%	215	98	377	83%
High Prod. Acres	L/H	207	251	246	229	209	215	221	227	234	0.4%	215	19	377	62%
Moderate Growth		**360,671**	**482,469**	**500,252**	**565,606**	**596,110**	**624,678**	**654,616**	**685,988**	**718,863**	**2.2%**				
Low Prod. Acres	B/L	207	264	278	347	411	431	452	473	496	2.8%	215	281	377	132%
Base Prod. Acres	**B/B**	**207**	**258**	**266**	**295**	**311**	**326**	**341**	**358**	**375**	**1.9%**	**215**	**160**	**377**	**99%**
High Prod. Acres	B/H	207	252	253	248	230	241	253	265	278	0.9%	215	63	377	74%
Strong Growth		**360,671**	**484,394**	**526,081**	**668,777**	**721,128**	**777,578**	**838,446**	**904,079**	**974,850**	**3.2%**				
Low Prod. Acres	H/L	207	265	290	403	492	530	572	617	665	3.7%	215	450	377	176%
Base Prod. Acres	H/B	207	259	277	340	367	396	427	460	**496**	2.8%	215	281	377	132%
High Prod. Acres	H/H	207	253	263	283	268	289	312	336	363	1.8%	215	148	377	96%

Exhibit 166 shows that existing Ro-Ro terminals total about 215 acres, which compares closely to the estimate of 207 acres currently required under the base case in Exhibit 165. This comparison is also consistent with the observations by port officials that the Richmond and Benicia terminals are operating at or near capacity at present.

Exhibit 166: Bay Area Ro-Ro Terminals and Scenario Capacities

Terminal	Acres	Low Capacity	Base Case Capacity	High Capacity
Annual Units per Acre		**1,444**	**1,976**	**2,903**
Existing	**215**	**310,465**	**424,875**	**624,178**
Benicia	75	108,302	148,212	217,737
Richmond Port Potrero	80	115,522	158,093	232,252
SF Pier 80	60	86,641	118,570	174,189
Potential	**162**	**233,932**	**320,138**	**470,311**
SF Pier 96 & Other	67	96,750	132,403	194,511
Richmond T-3	20	28,880	39,523	58,063
Benicia Short-Term Lease	35	50,541	69,166	101,610
Oakland Howard Terminal*	40	57,761	79,046	116,126
Total	**377**	**544,397**	**745,013**	**1,094,489**

*Assumes turning basin widening

Ro-Ro Cargo Capacity Findings

Based on the consultant team's analysis, additional Ro-Ro terminal space will be required to accommodate any of the forecast scenarios. The most acreage would be required for higher growth and lower productivity, as expected. The base case capacity for the existing 215 acres is estimated at 424,875 annual units, about 20% over the 360,671 units reported for 2018 (Exhibit 165). At the higher productivity of 2,903 units per acre the existing terminals could handle an estimated 624,178 annual units, which would be approximately sufficient through 2050 in the Slow Growth scenario, 2035 for the Moderate Growth forecast, and 2025 in the Strong Growth scenario, as shown in Exhibit 165. These estimates are consistent with reports from Benicia and Richmond that they are near or at capacity, and from San Francisco that Pier 80 is at about 75% of capacity.

Within the Bay Area, the larger unused marine terminal spaces suitable for Ro-Ro operations (either as-is or with minor improvements) are Pier 96 at San Francisco and Howard Terminal at Oakland. Terminal 3 at Richmond might also provide additional space for the Point Potrero terminal. The Amports Antioch site is also discussed below. The final possibility is conversion of other terminal sites (e.g. dry bulk sites) to Ro-Ro use, or adding capacity by building multi-deck parking structures.

- **Benicia Short-Term Lease.** BPTC at Benicia has about 75 acres in use for imports and exports, and could probably make another 35 acres available from land currently in other uses.
- **Pier 96.** The Pier 96 site at San Francisco is roughly 67 acres at a former container terminal, including land between Piers 92 and 94. The site appears to have 9 acres of usable wharf face and is paved, with several structures that may or may not be usable for auto processing. Pier 96 has on-dock rail trackage and access to additional rail facilities at a nearby site originally intended for intermodal operations, but nearby tunnels do not have sufficient clearances for tri-level autorack cars. Recent NOAA charts show a 39-foot nominal draft at Pier 96, sufficient for typical Ro-Ro auto carrier vessels.

- **Howard Terminal.** Howard Terminal is a dormant container terminal of about 50 acres (potentially reduced to 40 acres with turning basin expansion) on the Oakland Estuary. The terminal is paved and appears to have a usable wharf face for Ro-Ro operations. Recent NOAA charts show a nominal 42-foot draft for Howard Terminal, sufficient for most Ro-Ro auto carriers. Howard has potential access for on-dock rail, and is roughly one mile from the UP or BNSF intermodal facilities at Oakland.
- **Richmond Terminal 3.** Richmond's Terminal 3 is a dormant container/break-bulk site of about 20 acres. The site could conceivably be used for overflow storage from the Port Potrero terminal.
- **Antioch Site.** The Amports site at Antioch, outside of San Francisco Bay, is roughly 110 acres. The existing pier and wharf have a nominal draft of about 35 feet, which would likely require dredging to accommodate loaded Ro-Ro vessels. This facility is not yet fully operational, and will not necessarily be used to handle imports and exports, as Amports also handles domestic vehicles. As the Antioch site is not covered by the Seaport Plan and is not part of the Port Priority area, there is no certainty that it will be used for maritime Ro-Ro cargo in the future.
- **Conversion of Other Sites.** One alternative would be converting dry bulk terminals to Ro-Ro cargo. The Port of Redwood City, for example, has considered development of a multi-purpose terminal that could include Ro-Ro capability. Air draft limitations under the Hayward Bridge could, however, limit the vessels calling Redwood City.
- **Parking Structures.** Some Ro-Ro terminals in other countries (e.g. Shanghai) have multi-level parking structures, and the Port of Hueneme is reportedly investigating the possibility of multi-level parking. This approach would require substantial capital investment and raise costs compared to terminals elsewhere, and it is not clear whether multi-level parking would be economically or technically feasible at Bay Area ports.

There would be sufficient capacity in the Slow Growth scenario through 2050 if the available space either at Pier 96 or Howard Terminal were utilized, while utilizing both terminals would provide sufficient capacity for the Moderate Growth scenario. The Strong Growth scenario would require all available space as well as higher productivity per acre. As noted earlier, the Bay Area ports compete with others for inland deliveries by rail. If Bay Area Ro-Ro terminals reach capacity, some trade may be lost to other ports and regions.

5. Dry Bulk Cargo Forecast and Capacity Analysis

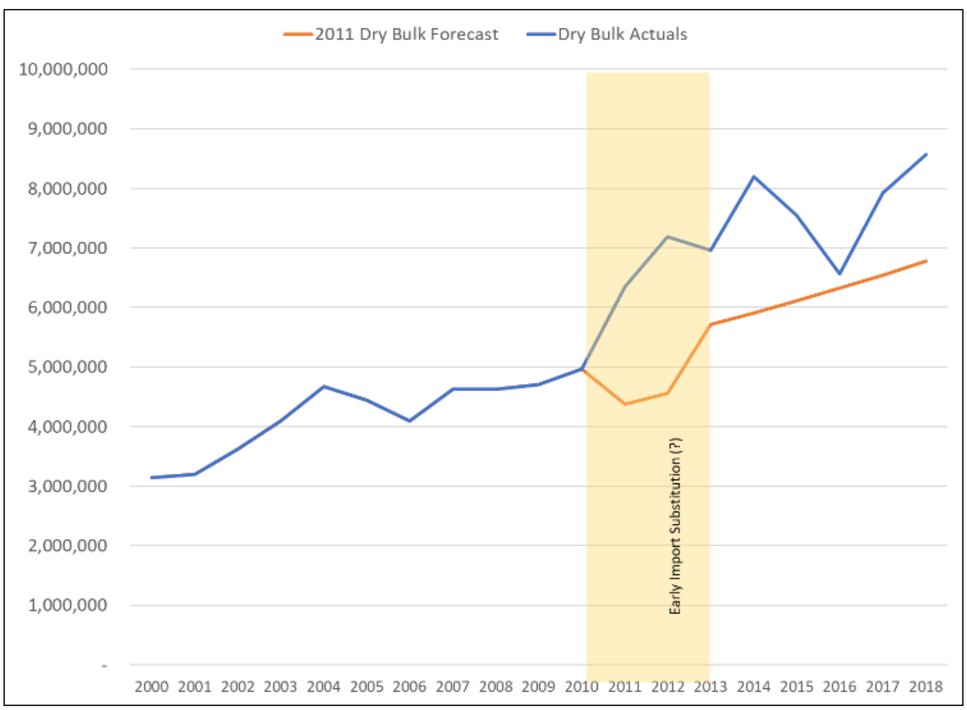
Dry Bulk Cargo Review

The Bay Area ports handle a variety of bulk cargo, including:

- Import sand and gravel at Redwood City, Richmond, and San Francisco
- Harvested bay sand at San Francisco
- Import bauxite and slag at Redwood City
- Import gypsum at Richmond and Redwood City
- Export scrap metal at Redwood City, Richmond, and Schnitzer Steel in Oakland Harbor
- Export petroleum coke at Benicia and Levin Richmond Terminal
- Export coal at Levin Richmond Terminal

The dry bulk import cargoes handled through Bay Area ports have long been dominated by construction industry needs. The major commodities have included, and continue to include, aggregates (sand and gravel), bauxite and slag (used as concrete additives), and gypsum (used in wallboard). Outbound dry bulk cargoes include scrap metal, petroleum coke (pet coke, a refinery by-product), and coal. Exhibit 167 shows the 2011 forecast.

Exhibit 167: 2011 Dry Bulk Forecast vs. Actuals



The strong increase predicted between 2012 and 2013 reflected then-current industry expectations for import substitution. As Exhibit 167 shows, dry bulk cargo volumes have varied from the 2011 forecast as economic development and construction activity have varied. The 2011 forecast anticipated increased imports of aggregates as Northern California production declined. The consultant team revisited this issue in developing a new forecast.

The 2011-2016 actuals also reflect substantial iron ore shipments through Levin Richmond Terminal in 2011-2013, and coal shipments in 2013-2016.

There is limited competition between regional ports for bulk commodity exports. The Port of Stockton and Levin Richmond Terminals have handled export coal and iron ore movements, primarily from Utah to China. These movements might have been handled through the bulk export terminal at the Port of Long Beach.

Exhibit 168 shows recent volumes and growth.

Exhibit 168: Bay Area Dry Bulk Cargo

Commodity	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	CAGR
Bay Sand*	1,053,558	718,931	725,711	604,139	500,847	175,290	167,542	282,772	453,173	602,315	-3.1%
Import Sand	76,248	44,586	280,680	145,909	328,249	179,544	448,480	822,230	792,497	1,320,834	17.2%
Import Aggregates	-	727,128	985,252	903,641	934,071	1,011,510	2,026,074	2,225,628	1,701,734	2,057,698	20.7%
Sand & Gravel Subtotal	**1,129,806**	**1,490,645**	**1,991,643**	**1,653,689**	**1,763,167**	**1,366,344**	**2,642,095**	**3,330,630**	**2,947,404**	**3,980,847**	**7.2%**
Import Gypsum	231,393	230,711	301,653	294,833	189,710	159,301	198,202	180,501	108,166	380,820	2.8%
Import Bauxite & Slag	165,664	82,068	195,418	83,551	121,727	53,348	74,992	92,675	53,410	145,437	-0.7%
Imports	**1,526,863**	**1,803,424**	**2,488,714**	**2,032,093**	**2,025,758**	**1,578,993**	**2,915,290**	**3,603,806**	**3,108,980**	**4,289,501**	**6.6%**
Export Scrap	1,473,600	1,433,219	1,976,601	1,766,486	2,241,777	3,060,480	3,632,256	2,654,650	2,481,437	2,506,842	3.0%
Export Pet Coke	306,156	450,929	315,325	298,536	363,435	327,976	646,868	603,860	599,253	562,112	3.4%
Export Coal	-	-	-	-	-	-	-	1,334,725	377,883	999,061	20.7%
Exports	**1,779,756**	**1,884,148**	**2,291,926**	**2,065,022**	**2,605,213**	**3,388,456**	**4,279,125**	**4,593,235**	**3,458,573**	**4,068,015**	**4.7%**
Total Dry Bulk	**3,306,619**	**3,687,572**	**4,780,640**	**4,097,115**	**4,630,971**	**4,967,449**	**7,194,414**	**8,197,042**	**6,567,554**	**8,575,119**	**5.4%**

* Bay sand data include SF Pier 92 import aggregates prior to 2010.

All of the dry bulk imports are tied to the construction industry. Sand and gravel have multiple uses, as well as being components of concrete. Bauxite and slag are used in concrete. Gypsum is primarily used in manufacturing drywall (e.g. Sheetrock).

Forecast Commodity Flows

The different commodities require different approaches to a forecast.

Sand & Gravel (Aggregates)

Import aggregate volumes are determined by demand and local supply. The 2009 forecast update noted that Northern California production of aggregates was not keeping up with growing demand:

- Northern California quarries were being depleted or could not expand.
- Environmental and community concerns severely restricted new production sites.
- Import sources in British Columbia and elsewhere could compete effectively with domestic sources outside of Northern California.
- Northern California supply of specific aggregate types used in high grade concrete for infrastructure projects was particularly tight.

A 2018 study by the California Geological Survey found that the state's permitted aggregate resources increased by 88% between 2011 and 2017. As Exhibit 169 indicates, California has only about 69% of the aggregate resources needed to meet demand over the next 50 years. Most areas served by the Bay Area ports have a 21-30 year supply, suggesting that the need to import aggregates will rise sharply in that timeframe.

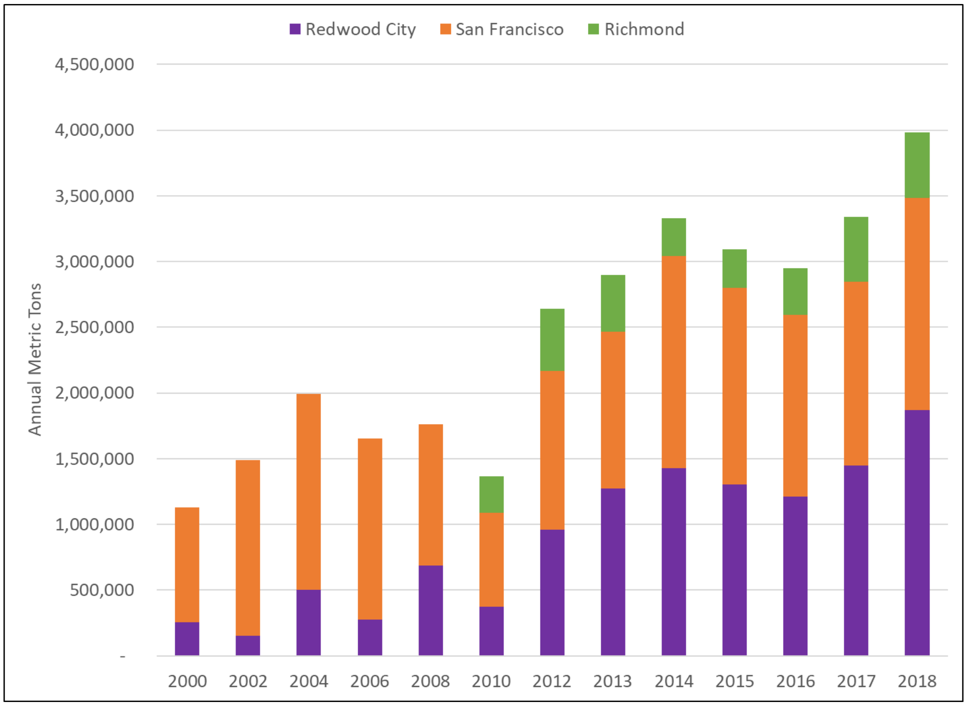
Exhibit 169: California Geological Survey 50-year Aggregate Supply Outlook as of January 1, 2017

AGGREGATE STUDY AREA[1]	50-Year Demand (million tons)	Permitted Aggregate Reserves (million tons)	Permitted Aggregate Reserves Compared to 50-Year Demand (percent)	Projected Years Remaining
Bakersfield P-C Region	338	1,708	505	More than 50
Barstow-Victorville P-C Region	163	117	72	31 to 40
Claremont-Upland P-C Region	202	90	45	21 to 30
El Dorado County	82	15	18	11 to 20
Fresno P-C Region	305	556	182	More than 50
Glenn County	41	22	54	21 to 30
Merced County	154	61	40	21 to 30
Monterey Bay P-C Region	333	297	89	41 to 50
Nevada County	41	52	127	More than 50
North San Francisco Bay P-C Region	492	263	53	21 to 30
Palmdale P-C Region	569	163	29	11 to 20
Palm Springs P-C Region	238	163	68	31 to 40
Placer County	188	387	206	More than 50
Sacramento County	724	327	45	21 to 30
Sacramento-Fairfield P-C Region	295	109	37	21 to 30
San Bernardino P-C Region	939	156	17	11 to 20
San Fernando Valley/ Saugus-Newhall[2]	**387**	**17**	**4**	**10 or fewer**
San Gabriel Valley P-C Region	751	297	40	21 to 30
San Luis Obispo-Santa Barbara P-C Region	226	58	26	11 to 20
Shasta County	82	49	60	31 to 40
South San Francisco Bay P-C Region	1,320	506	38	21 to 30
Stanislaus County	160	39	24	11 to 20
Stockton-Lodi P-C Region	409	203	50	21 to 30
Tehama County	49	30	61	31 to 40
Temescal Valley-Orange County[2]	1,079	862	80	41 to 50
Tulare County	130	53	41	21 to 30
Ventura County[2]	241	84	35	11 to 20
Western San Diego County P-C Region	763	265	35	11 to 20
Yuba City-Marysville P-C Region	344	679	197	More than 50
Total	**11,045**	**7,628**	**69**	-

1 Aggregate study areas follow either a Production-Consumption (P-C) region boundary or a county boundary. A P-C region includes one or more aggregate production districts and the market area that those districts serve. Aggregate resources are evaluated within the boundaries of the P-C Region. County studies evaluate all aggregate resources within the county boundary.
2 Two P-C regions have been combined into one study area.
Bold = study area with ten or fewer years of permitted reserves.

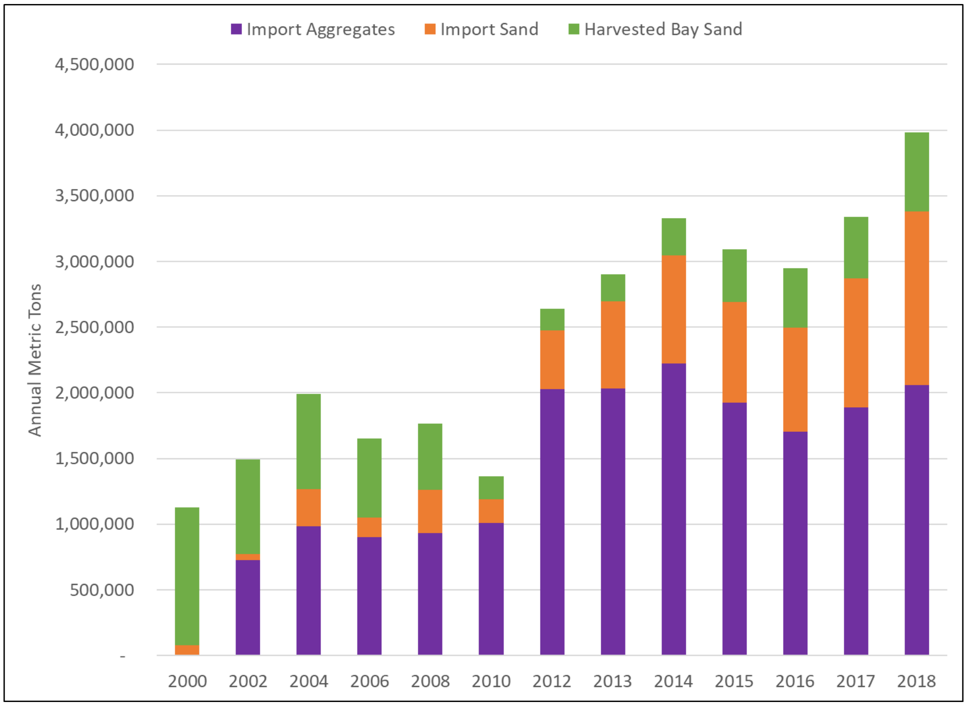
Exhibit 170 shows the recent history, with strong growth picking up after the recession.

Exhibit 170: Bay Area Sand and Gravel Tonnage, 2000-2018



Sand "harvested" from the bay floor through dredging is not a cargo *per se*, but is included for land use planning purposes. The data show the dominance of imported aggregate materials and bay sand in 2018, with 88% of the total imports (Exhibit 171). Gypsum accounted for 8% of the total, and slag and bauxite together 3%. Cement and limestone have not been imported since 2009, at least in part because rail imports have taken their place. (Richmond data began in 2010)

Exhibit 171: Bay Area Aggregate Imports and Bay Sand by Commodity, 2000-2018



Growth since 2010 showed an annual growth rate of 13.9% for imported aggregates and sand, 16.7% for bay sand, 11.5 % for gypsum, and 13.4% for bauxite. The growth rate of bay sand since 2014 averaged 20.8%, while imported sand grew at 12.6%. Gypsum meanwhile increased at an annual rate of 20.5% over the past five years.

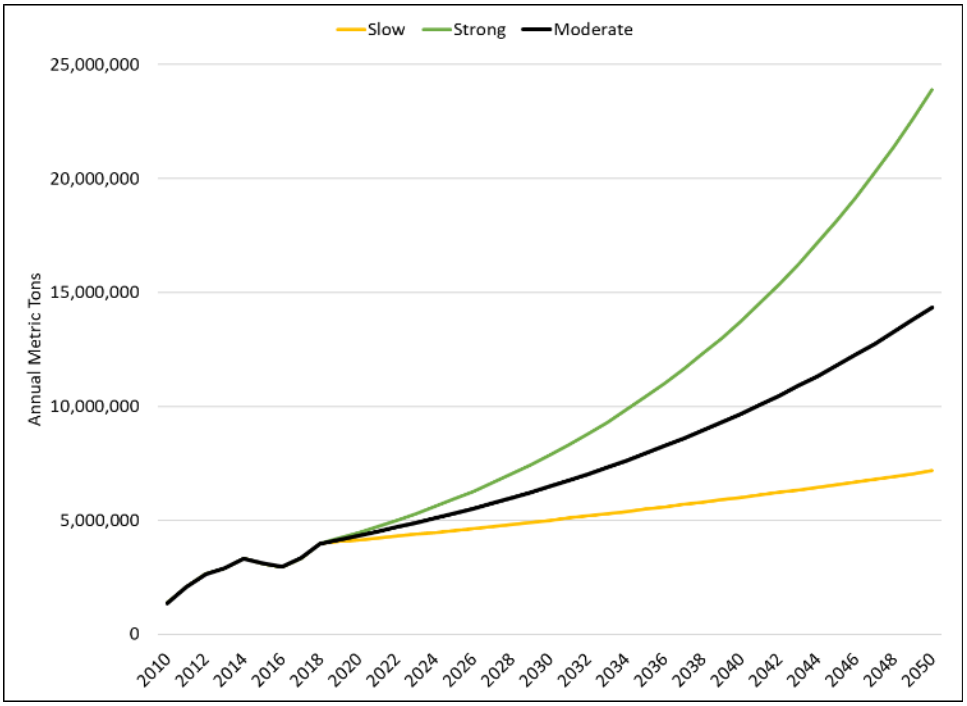
The amount of construction-related dry bulk cargo delivered to the Bay Area ports is a factor of the construction needs of the region, as well as the production capacity of regional and national sources. Research suggests that the rule of thumb for calculating aggregate demand (including sand and gravel) is to use a stable long-term per capita consumption per person. Demand growth was based on the population forecast for the nine-county Bay Area. The Caltrans population projections were used to estimate demand growth out to 2050.

The consultant team did not attempt to distinguish demand for harvested bay sand from demand for import sand. Different grades and types of sand are produced locally, harvested from the bay, or imported for a wide variety of end uses that will change over time.

The forecast takes into account the reports that the State of California is facing a shortfall in permitted reserves of sand and gravel, although estimates regarding the extent of the remaining supply vary. In 2018 it is estimated that imported and harvested sand and gravel met 9.4% of the annual demand. The Moderate Growth scenario assumes that due to mining limitations the share of imported and harvested sand and gravel will increase to 30% by 2050; the Slow Growth scenario increases the imported share to 15% by 2050, and the Strong Growth scenario import share reaches 50% by 2050.

Exhibit 172 shows the Moderate Growth, Slow Growth, and Strong Growth scenario forecasts through 2050 for imported aggregates and bay sand.

Exhibit 172: Bay Area Sand and Gravel Forecast, 2010-2050

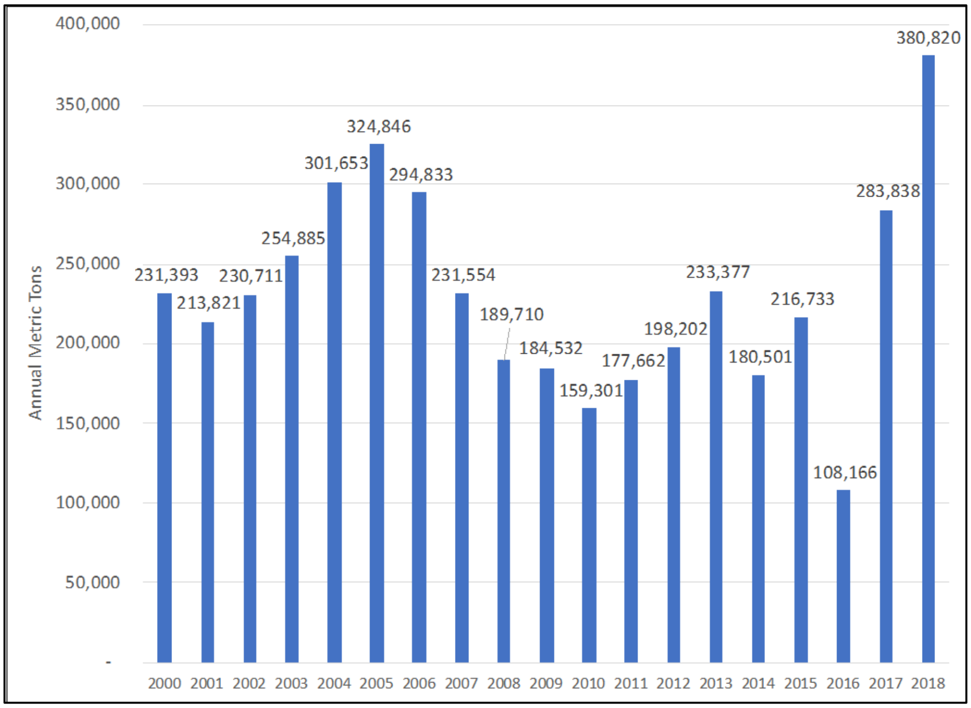


The compound annual growth rate for aggregates and bay sand between 2018 and 2050 is projected to be 4.1% in the Moderate Growth scenario, 1.9% in the Slow Growth scenario, and 5.8% in the Strong Growth scenario.

Gypsum

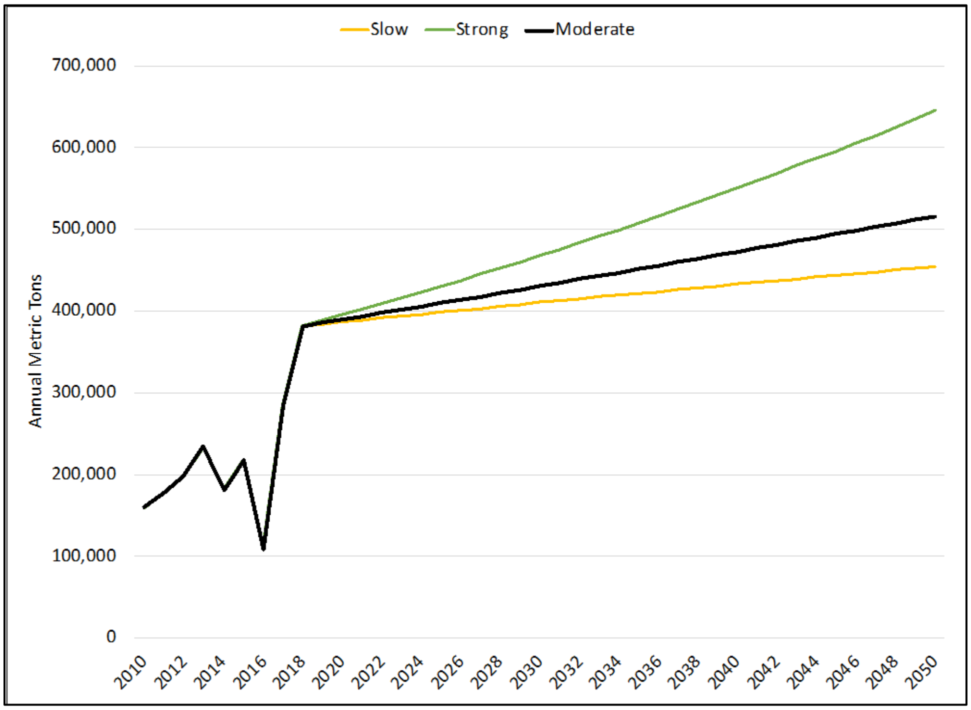
Bay Area gypsum imports dropped off sharply during the recession and have grown unevenly since (Exhibit 173). The U.S. as a whole remains the world's leading producer of gypsum, but imports have none the less grown. Part of U.S. demand is filled by synthetic gypsum derived from byproducts of coal-fired powerplants. This source is likely to diminish as coal-fired plants close and are replaced with natural gas powerplants, leading to a greater demand for imports.

Exhibit 173: Bay Area Gypsum Imports, 2000-2018



The volume of imported gypsum also tends to be a function of population. The gypsum forecast uses the same population growth factors for the nine-county area. In 2018 it is estimated that imported gypsum met 52.8% of the annual demand. The Moderate Growth scenario assumes that the share of imported gypsum will increase to 60% by 2050; the Slow Growth scenario remains at 52.8%, and the Strong Growth scenario reaches 75% by 2050. The compound annual growth rate for gypsum imports between 2019 and 2050 is projected to be 1.0% in the Moderate Growth scenario, 0.6% in the Slow Growth scenario, and 1.7% in the Strong Growth scenario. Exhibit 174 depicts the scenarios for gypsum imports through 2050.

Exhibit 174: Bay Area Import Gypsum Forecast, 2010-2050

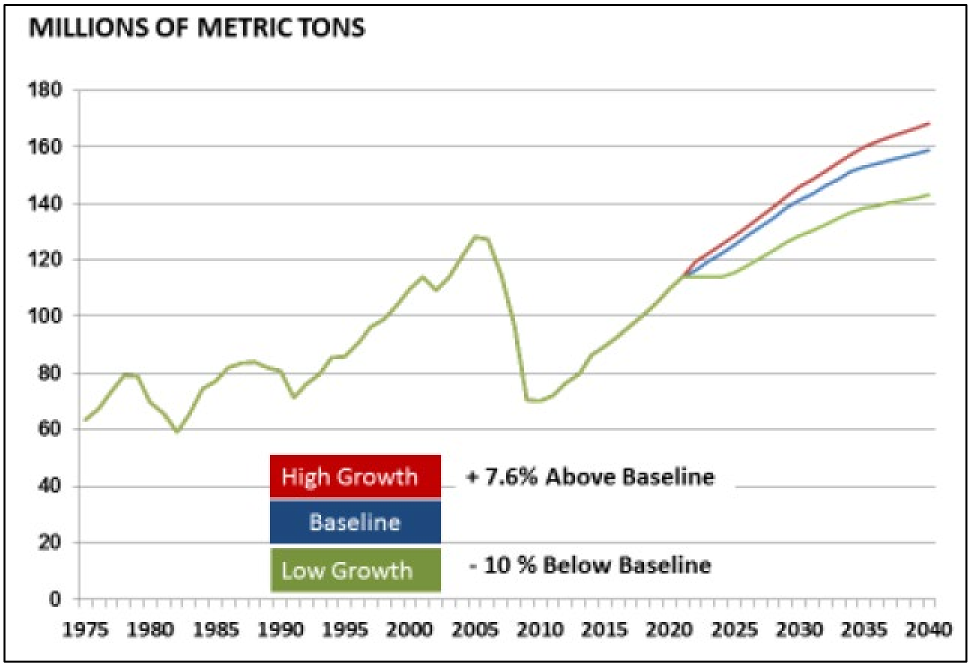


Bauxite & Slag

Bauxite and slag are imported for use in domestic cement production (some portion of the gypsum is used in cement production as well). The amount of bauxite and slag imported will vary with the amount of cement demanded and produced. The consultant team assumed that the current volume of bauxite and slag imported reflects the share of cement demand being filled by domestic production, and did not alter that implicit share. Bauxite and slag imports will therefore grow with cement consumption regardless of the cement source.

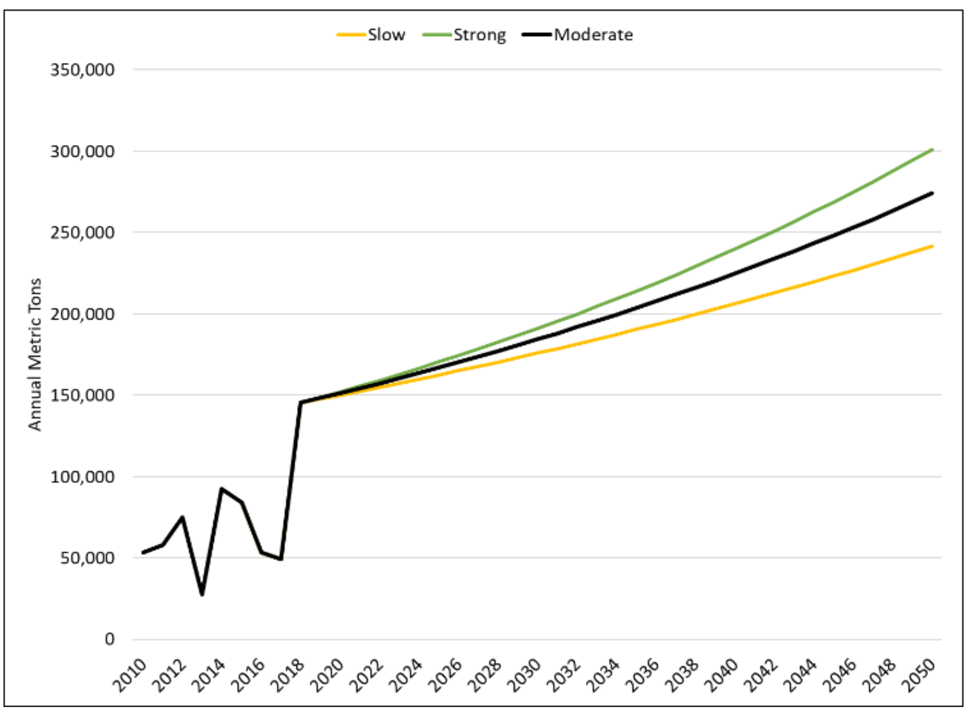
The Portland Cement Association (PCA) found that per capita cement consumption rises with GDP. A 1% increase in GDP growth yields a 0.7% increase in per capita consumption. Accounting for both rising GDP and rising per capita consumption, PCA sees cement consumption rising at a CAGR of 2.0% from 2018 to 2040 (Exhibit 175) for a base case forecast. The Slow Growth forecast uses a 1.6% CAGR, and the Strong Growth case uses a 2.3% CAGR.

Exhibit 175: PCA Cement Consumption Forecast



These growth rates were applied to Bay Area bauxite and slag imports (Exhibit 176), and would likely apply to cement and limestone imports if and when they resume.

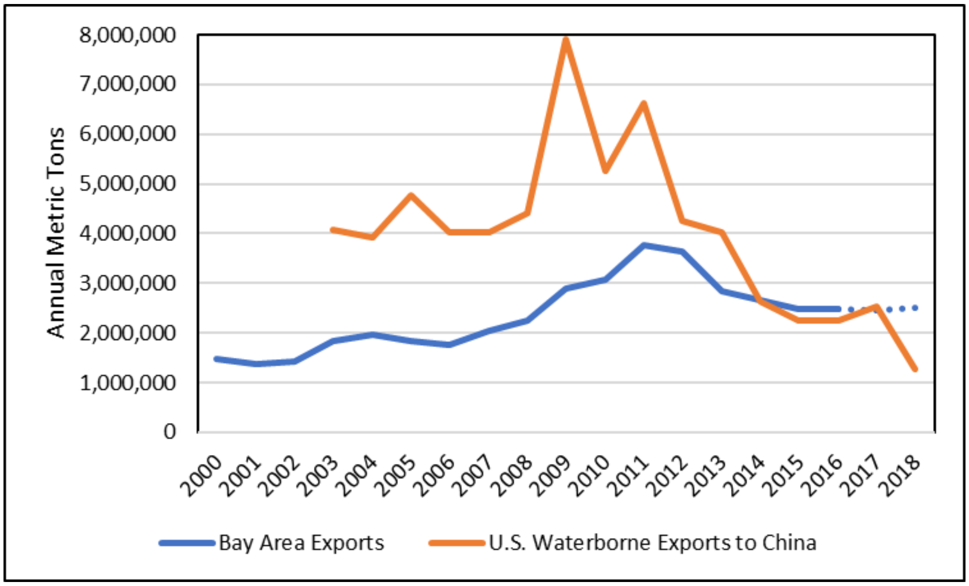
Exhibit 176: Bay Area Bauxite & Slag Import Forecast, 2010-2050



Scrap Metal

Bay Area scrap metal exports peaked in 2011 and have fallen since, largely due to changes in world market conditions. Exhibit 177 shows that the decline in Bay Area exports starting in 2011 coincides with the decline in overall U.S. scrap metal exports to China.

Exhibit 177: Scrap Metal Exports, 2000-2018



China has been the largest customer for U.S. scrap exports, but is buying less for two reasons:

- Tighter controls on the quality and purity of imported scrap.
- Greater domestic supply of scrap metals.

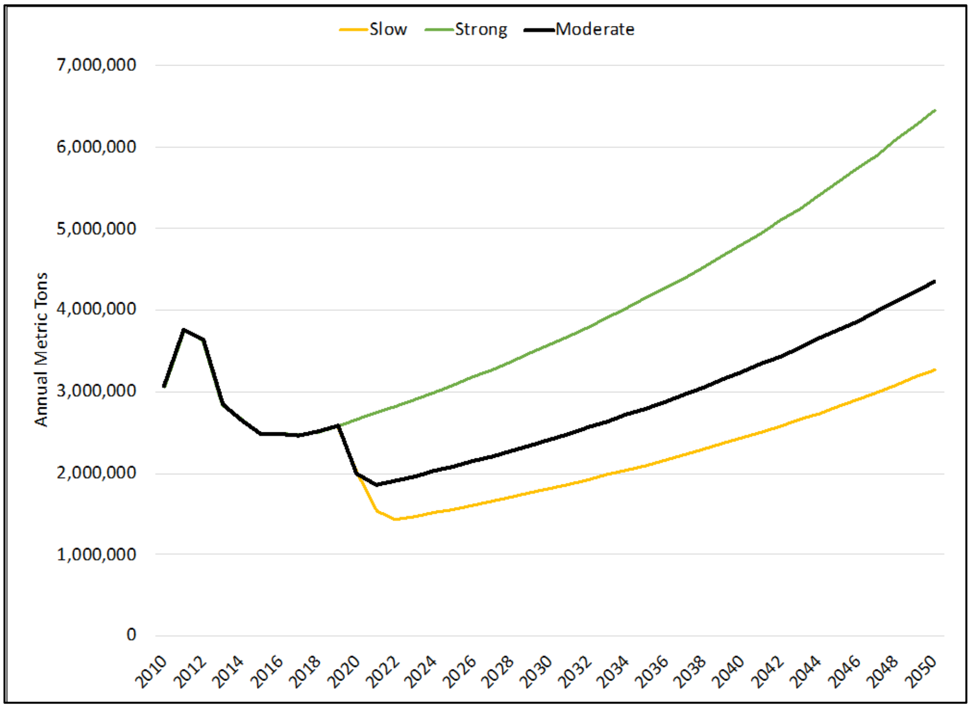
The administration's proposed tariffs on imported metals will likely increase U.S. consumption of scrap as well, leaving less to export.

The outlook for export scrap metal is uncertain, due in part to impending closure or drastic reduction in Chinese imports. Recent Bay Area export growth has averaged about 3.0%, and industry sources call for continued growth at similar rates. Long-term, a 3.0% CAGR was used for the scrap metal forecast (Exhibit 178).

China has been the main foreign market for West Coast scrap metal exports. China has placed strict requirements on imports of waste and recycled materials, and has announced intentions to ban such imports after 2020. Overall growth is expected in the global market for ferrous and non-ferrous scrap metals, as the use of recycled metals is generally more efficient than producing metals from original ores.

Loss of the Chinese market is included in both the Moderate Growth and Slow Growth scrap metal scenarios. The Moderate Growth scenario allows for more rapid recovery, i.e. selling to different foreign markets, than the Slow Growth scenario. The Strong Growth scenario allows for continuation of recent growth assuming either that a portion of the Chinese market is retained or that the Chinese demand is replaced seamlessly with demand from other nations. As a result of the short-term adjustments, the compound annual growth rate for scrap metal exports between 2019 and 2050 is projected to be 1.7% in the Moderate Growth scenario, 0.8% in the Slow Growth scenario, and 3.0% in the Strong Growth scenario.

Exhibit 178: Bay Area Export Scrap Metal Forecast, 2010-2050

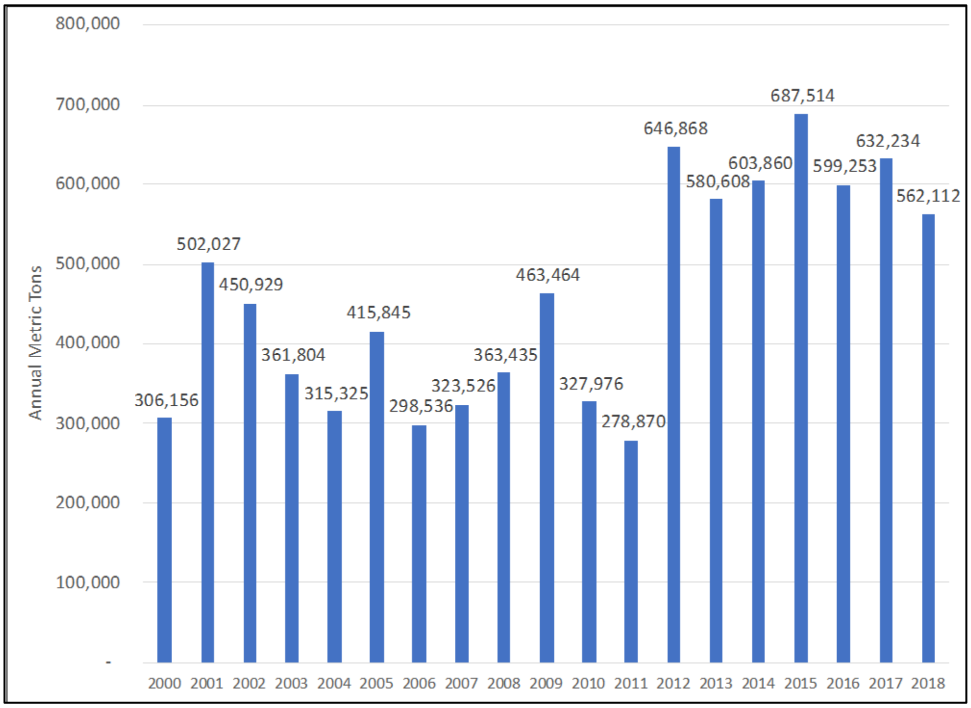


Petroleum Coke

Petroleum coke (pet coke) is a by-product of petroleum refining, and Bay Area production of pet coke is therefore driven by refinery activity. Pet coke is used as a fuel for energy production, and some grades are also used in steelmaking and chemical production. Demand for pet coke is largely foreign. As of 2013 the U.S. was exporting about 80% of the pet coke produced; essentially all of the Bay Area production is exported through Benicia or Levin Richmond. Due to heightened environmental concerns, there is strong community pressure to stop pet coke exports from Levin Richmond.

Exhibit 179 shows pet coke exports since 2000. The volume increased noticeably in 2011-2012 after the recession, but has remained relatively stable since.

Exhibit 179: Bay Area Petroleum Coke Exports



Available information indicates that refineries processing heavy oils cannot easily or economically switch from producing petroleum coke as a byproduct to producing asphalt or some other byproduct. For this reason, the Bay Are refineries producing petroleum coke will do so as long as they continue processing heavy crude.

U.S. refineries are not expected to increase production for the foreseeable future. Exhibit 180, from the DOE Annual Energy Outlook 2019, indicates that U.S. petroleum consumption is expected to decline somewhat from a peak in 2019-2020, and then resume gradual growth in 2030-2040. Exhibit 181, from the same source, indicates that U.S. refinery capacity is also expected to decline slightly from the current level, and then stay relatively steady through 2050.

Assuming Bay Area refineries reflect the U.S. norm, the available forecast indicates that refinery activity, and therefore pet coke output, will decline somewhat from recent levels, but then remain at nearly the same level for the foreseeable future.

Exhibit 180: U.S. Energy Consumption by Fuel (AEO 2019)

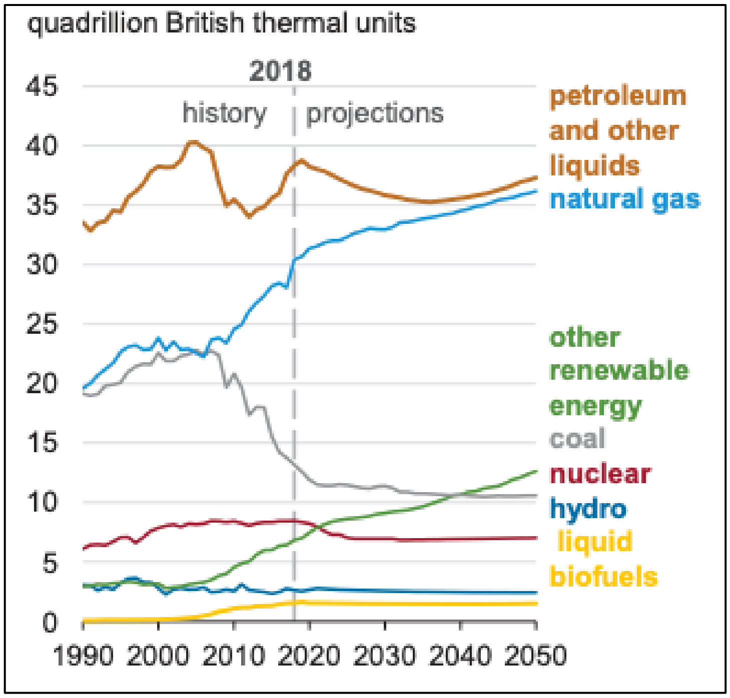
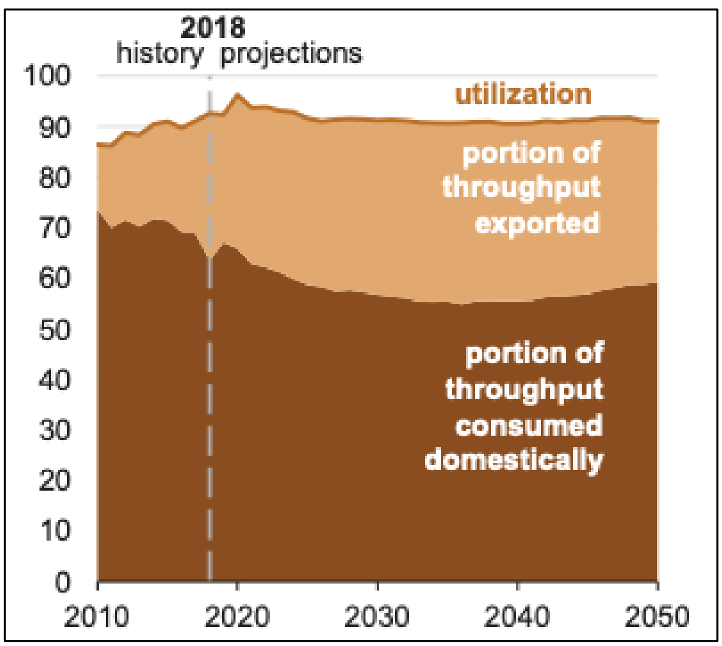


Exhibit 181: U.S. Refinery Utilization (AEO 2019)



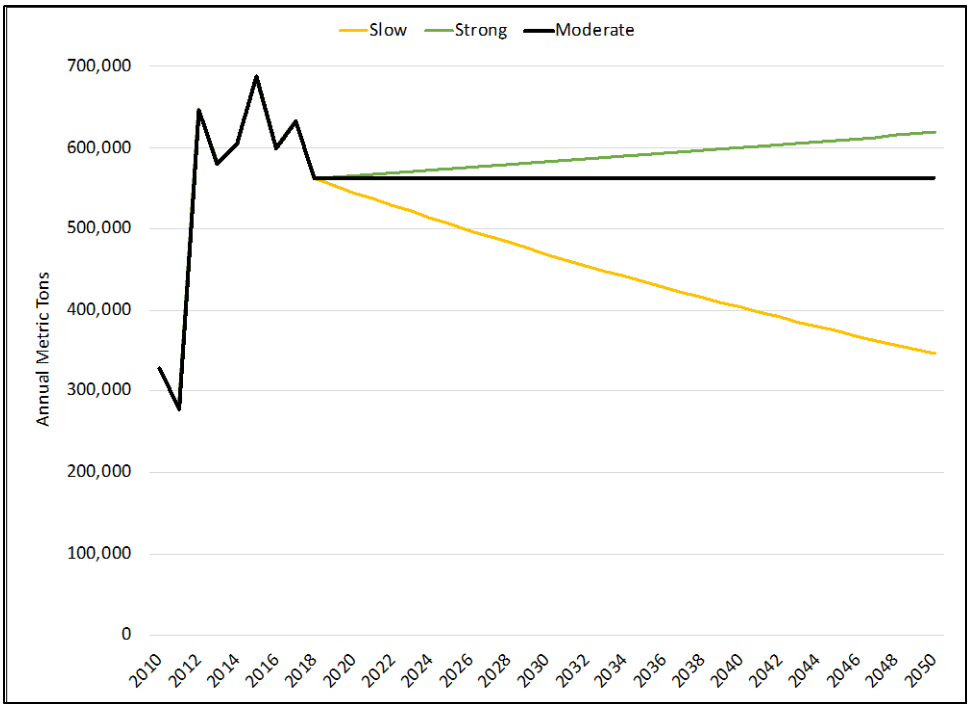
As nearly all pet coke is exported, export volumes will therefore be a function of heavy crude refining at Bay Area refineries. Based on data from the U.S. Energy Information Administration (EIA), Bay Area refineries have recently averaged utilization of around 95%, basically full capacity. There is no anticipation of either retiring or significantly expanding Bay Area refineries, making their capacity effectively constant. Assuming they continue to use heavy crude as a feedstock and stay at or near capacity, the volume of pet coke produced and exported would be level for the indefinite future.

The consultant team used projections from the *Annual Energy Outlook 2019* to define scenarios:

- The Slow Growth scenario was based on the outlook for gasoline production, which is expected to have a negative 1.5% CAGR through 2050.
- The Strong Growth scenario was based on the outlook for diesel (distillate fuel) production, which is expected to have a 0.3% CAGR through 2050.

The compound annual growth rate for pet coke exports between 2019 and 2050 was therefore projected to be 0.0% (constant volume) in the Moderate Growth scenario, -1.5% in the Slow Growth scenario, and 0.3% in the Strong Growth scenario (Exhibit 182).

Exhibit 182: Bay Area Export Pet Coke Forecast, 2010-2050

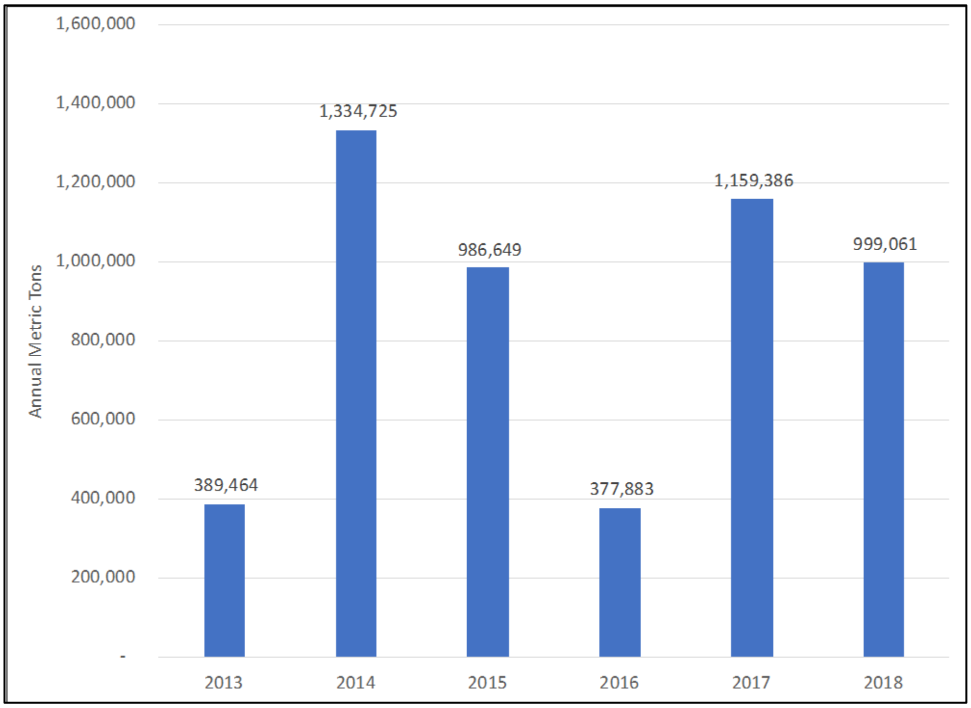


Coal

Coal exports are currently split between the Port of Stockton and Levin Richmond terminal. The vessels in use cannot move to and from Stockton fully loaded due to draft restrictions. In current operations, vessels are partially loaded at Stockton and topped off at Levin Richmond. As Exhibit 183 indicates annual volume has varied with market conditions.

The future of coal handling in the Bay Area is controversial. There is an on-going dispute over a proposed coal terminal at Oakland (on City of Oakland property, not at the Port of Oakland), and escalating community opposition to operations at Levin Richmond.

Exhibit 183: Levin Richmond Coal Exports 2013-2018

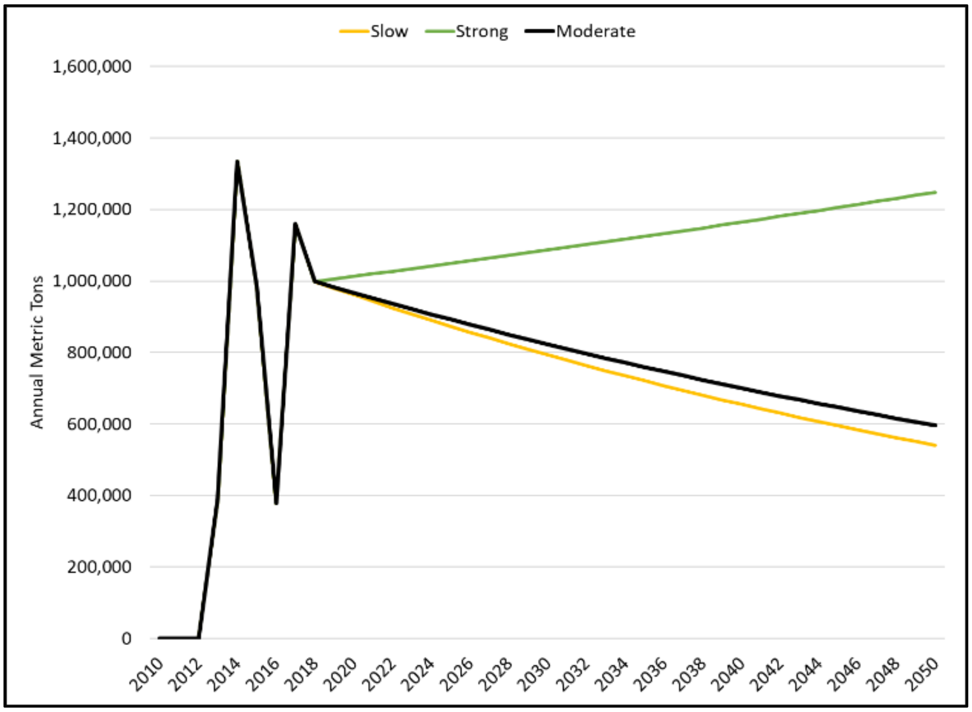


The export coal market remains uncertain, as it depends on U.S. production, U.S. demand, foreign demand, and environmental restrictions. The consultant team used three projections from the *Annual Energy Outlook 2019* to define scenarios:

- The "reference case" for coal exports at a CAGR of -1.6% for the Moderate Growth scenario.
- The "high oil price" case for coal exports at -1.9% for the Slow Growth scenario.
- The "low oil price" case for coal exports at 0.7% for the Strong Growth scenario.

Exhibit 184 shows the forecast. Regardless of economic demand, export coal movements could be eliminated through community or city legal action.

Exhibit 184: Bay Area Export Coal Forecast, 2010-2050



Summary Dry Bulk Forecast

Exhibit 185 displays the combined tonnage forecast for dry bulk commodities, including imports, exports, and harvested bay sand, while Exhibit 186 shows the tonnage by commodity type by decade and the long-term compound annual growth rates.

Exhibit 185: Bay Area Total Dry Bulk Cargo Forecast, 2010-2050

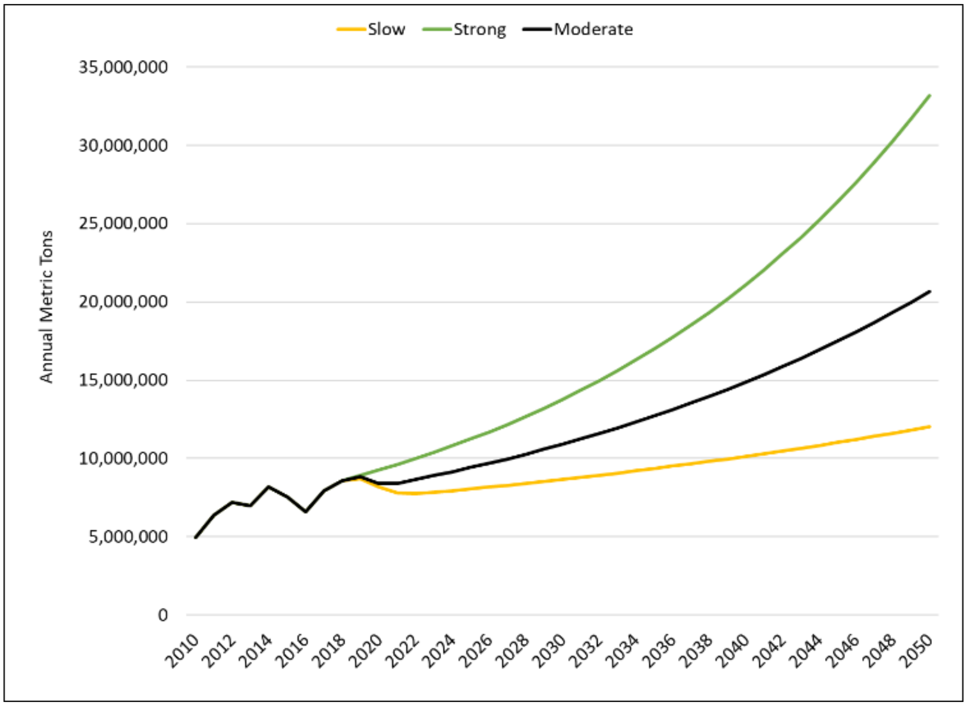


Exhibit 186: Bay Area Total Dry Bulk Cargo Forecast by Commodity by Scenario, 2010-2050

Moderate Growth	Gypsum	Aggregates	Bauxite & Slag	Export Scrap	Export Pet Coke	Export Coal	Total Dry Bulk
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	**4,967,449**
2018	380,820	3,980,847	145,437	2,506,842	562,112	999,061	**8,575,119**
2020	389,332	4,326,501	151,312	1,994,631	562,112	967,347	**8,391,236**
2030	430,140	6,489,853	184,449	2,412,556	562,112	823,253	**10,902,363**
2040	472,248	9,673,929	224,842	3,242,274	562,112	700,623	**14,876,028**
2050	515,913	14,348,832	274,082	4,357,345	562,112	596,259	**20,654,319**
2018-2050 CAGR	**1.0%**	**4.1%**	**2.0%**	**1.7%**	**0.0%**	**-1.6%**	**2.8%**
Slow Growth	**Gypsum**	**Aggregates**	**Bauxite & Slag**	**Export Scrap**	**Export Pet Coke**	**Export Coal**	**Total Dry Bulk**
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	**4,967,449**
2018	380,820	3,980,847	145,437	2,506,842	562,112	999,061	**8,575,119**
2020	386,234	4,143,072	150,128	1,994,631	545,375	961,457	**8,180,897**
2030	410,007	5,004,360	175,954	1,809,417	468,876	793,634	**8,662,248**
2040	432,516	6,006,822	206,222	2,431,705	403,107	655,104	**10,135,476**
2050	454,003	7,174,416	241,698	3,268,008	346,563	540,755	**12,025,443**
2018-2050 CAGR	**0.6%**	**1.9%**	**1.6%**	**0.8%**	**-1.5%**	**-1.9%**	**1.1%**
Strong Growth	**Gypsum**	**Aggregates**	**Bauxite & Slag**	**Export Scrap**	**Export Pet Coke**	**Export Coal**	**Total Dry Bulk**
2010	159,301	1,366,344	53,348	3,060,480	327,976	-	**4,967,449**
2018	380,820	3,980,847	145,437	2,506,842	562,112	999,061	**8,575,119**
2020	394,800	4,466,860	152,204	2,659,509	565,490	1,013,097	**9,251,959**
2030	467,683	7,860,101	191,065	3,574,157	582,685	1,086,290	**13,761,981**
2040	550,549	13,744,340	239,849	4,803,368	600,404	1,164,770	**21,103,281**
2050	644,891	23,914,720	301,089	6,455,325	618,661	1,248,921	**33,183,607**
2018-2050 CAGR	**1.7%**	**5.8%**	**2.3%**	**3.0%**	**0.3%**	**0.7%**	**4.3%**

As

Exhibit 187 shows, the three scenarios could have dramatically different implications for Bay Area ports.

Exhibit 187: Bay Area Forecast Dry Bulk Growth to 2050

Year	Moderate	Slow	Strong
2010	4,967,449	4,967,449	4,967,449
2018	8,575,119	8,575,119	8,575,119
2020	8,391,236	8,180,897	9,251,959
2030	10,902,363	8,662,248	13,761,981
2040	14,876,028	10,135,476	21,103,281
2050	20,654,542	12,025,443	33,183,607
2018-2050 CAGR	**2.8%**	**1.1%**	**4.3%**
2018-2050 Growth	**140.9%**	**40.2%**	**287.0%**

- The Moderate Growth scenario calls for total Bay Area bulk cargo to approach triple the volume handled in 2018 by 2050. The primary driver of this growth is import substitution for domestic supplies of sand and gravel, with economic development and consumption growth secondary factors.
- The Slow Growth scenario, with minimal import substitution and cargo growth, would almost double existing volumes. This case, however, implicitly assumes increased regional production of aggregates, which is contrary to estimates of permitted supply. Moreover, this case assumes minimal growth in every commodity.
- The Strong Growth scenario would increase existing flows more than four-fold, maximizing import substitution coupled with high growth in every commodity.

Dry Bulk Terminals

The terminals currently handling dry bulk cargoes are a mix of public and private facilities.

Aggregates

Aggregates (sand and gravel) are handled at:

- San Francisco Pier 94 (Hanson imports), open pile (Exhibit 188)
- San Francisco Pier 92 aggregates, open pile (Exhibit 189)
- San Francisco Pier 92 (Hanson bay harvest sand), open pile (Exhibit 190)
- Redwood City (Cemex imports), open pile (Exhibit 191)
- Richmond (Eagle Rock/Orca, private), covered storage (Exhibit 192)

Of the five locations, only Eagle Rock/Orca in Richmond has a clear capacity limit. The facility's operating permit limits it to 1.5 million short tons annually, although discussions with Eagle Rock management place the feasible annual throughput at about 1 million short tons (907,029 metric tons).

Exhibit 188: Hanson Pier 94 Aggregate Terminal, San Francisco

Exhibit 189: Pier 92 Aggregate Terminal, San Francisco

Exhibit 190: Hanson Bay Sand Terminal, San Francisco

Exhibit 191: Cemex Import Aggregate Terminal, Redwood City

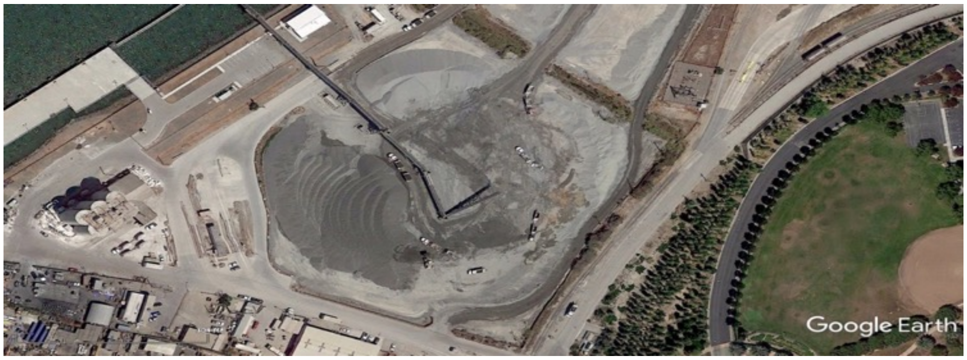
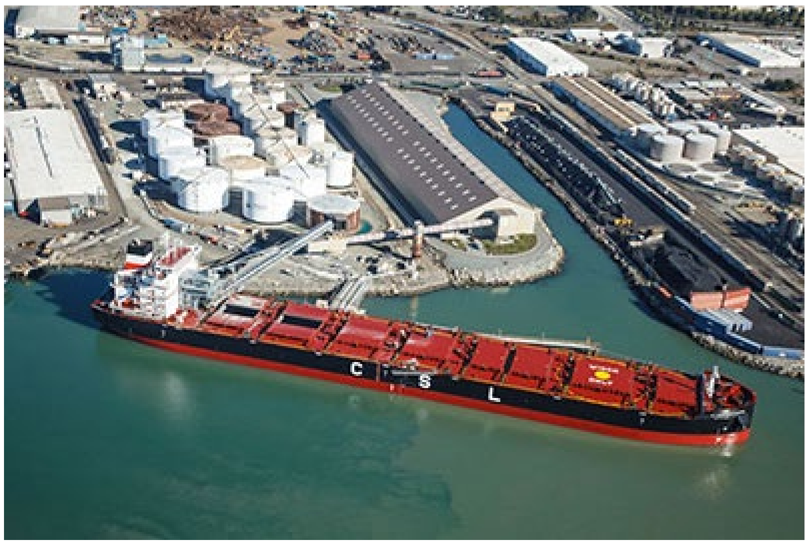


Exhibit 192: Eagle Rock Terminal, Richmond



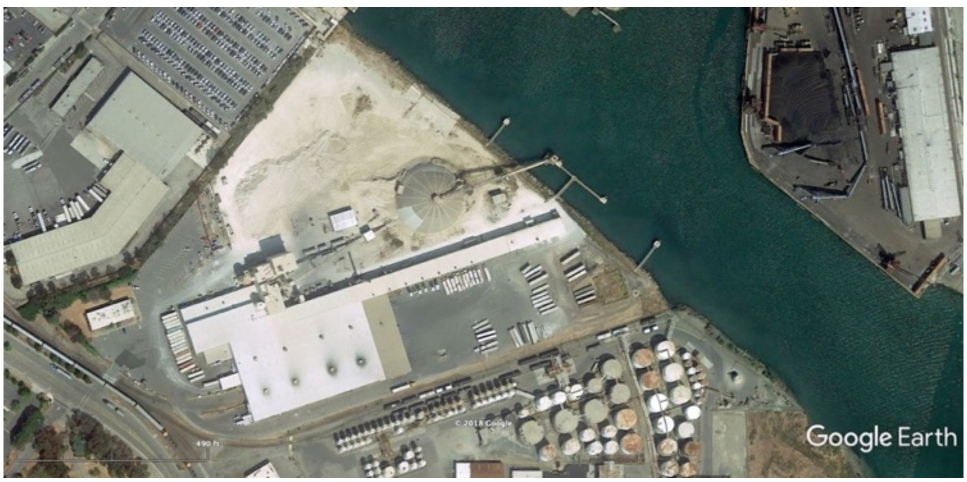
Gypsum

Gypsum is imported through two private terminals:

- Pabco at Redwood City, open pile (Exhibit 193)
- National Gypsum at Richmond, open pile, serving a wallboard plant (Exhibit 194)

Exhibit 193: Pabco Gypsum, Redwood City

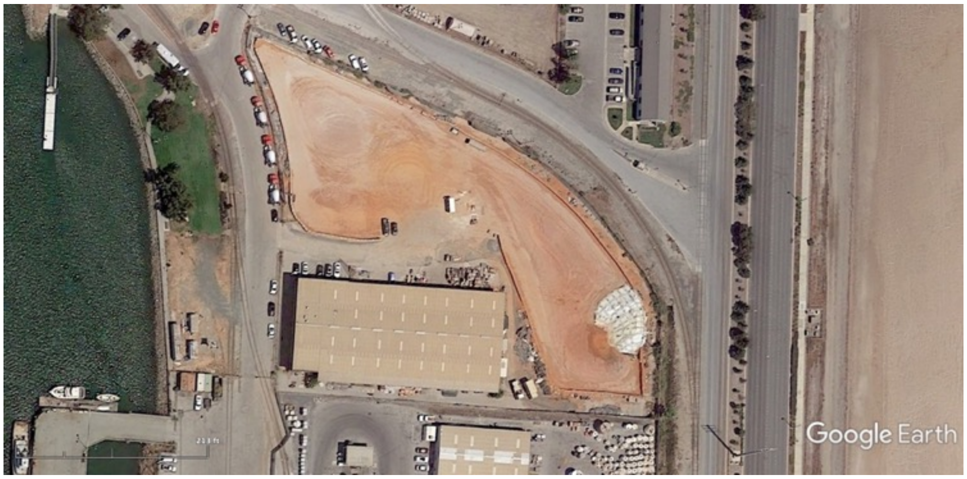
Exhibit 194: National Gypsum, Richmond



Bauxite

Bauxite is presently imported through the International Materials, Inc. (IMI) terminal at Redwood City, an open pile terminal (Exhibit 195).

Exhibit 195: IMI Bauxite, Redwood City



Scrap Metal

The three Bay Area export scrap metal terminals are at the ports of Oakland (Exhibit 196), Redwood City (Exhibit 197), and Richmond (Exhibit 198), and each has substantial material-handling infrastructure that could not be readily moved or duplicated. Should existing terminals reach capacity, there are limited expansion opportunities within port complexes.

Exhibit 196: Schnitzer Steel, Oakland

Exhibit 197: Sims Scrap Metal Terminal, Redwood City

Exhibit 198: SIMS Scrap Metal, Richmond

Petroleum Coke

Pet coke is exported through a silo/bin and conveyor system at Benicia (Exhibit 199), and from open piles at Levin Richmond (Exhibit 200).

Exhibit 199: Pet Coke Terminal, Benicia

Exhibit 200: Levin Richmond Terminal, Richmond

Coal

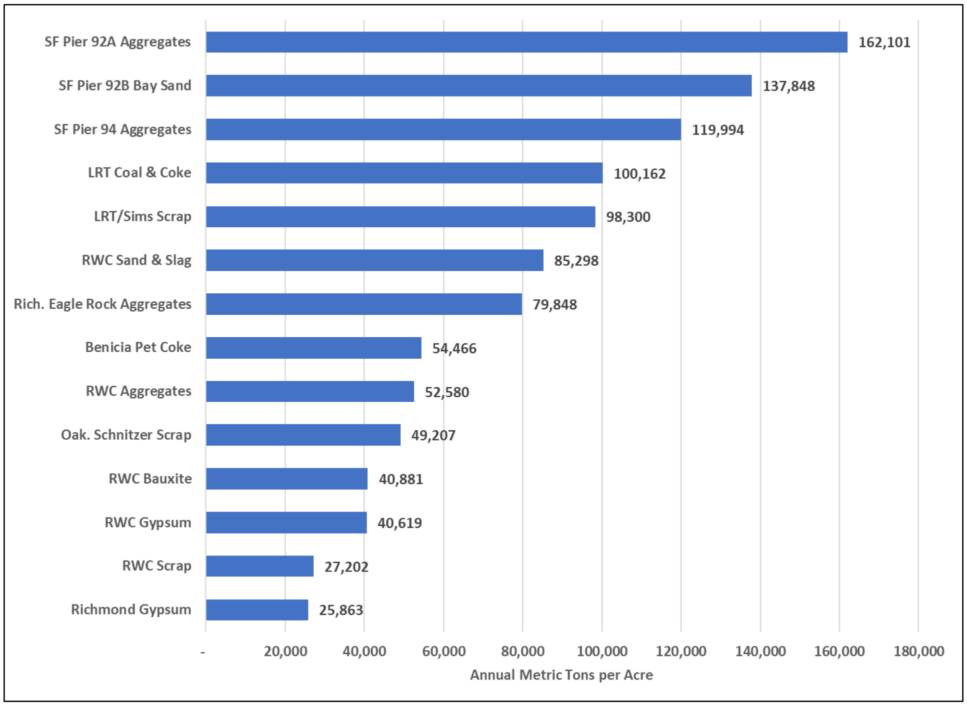
The coal exports are handled at Levin Richmond via open piles (Exhibit 200).

Capacity Estimate

The current (2012) Bay Area Seaport Plan includes a planning requirement of 13 acres for a dry bulk terminal (Exhibit 202) and an average throughput capability of 1,037,000 metric tons per berth. In 2018, Bay Area bulk terminals averaged 12.7 acres and 714,593 metric tons per berth, suggesting significant room for growth.

Examining recent peak throughput for each terminal (Exhibit 201) yields additional insight into capacity. As of 2018 Bay Area dry bulk terminals together averaged 56,452 metric tons per acre. As Exhibit 201 shows, however, there has been a wide range of throughput rates in recent years. Terminal throughputs have not all peaked in the same years as different commodity volumes rise and fall. The peaks in Exhibit 201 yield an average of 72,679 metric tons per acre, 29% higher than the 2018 average. The maximum throughput located in recent statistics was for the Pier 92A aggregate terminals at San Francisco, at 162,101 metric tons per acre.

Exhibit 201: Recent Maximum Throughput per Acre



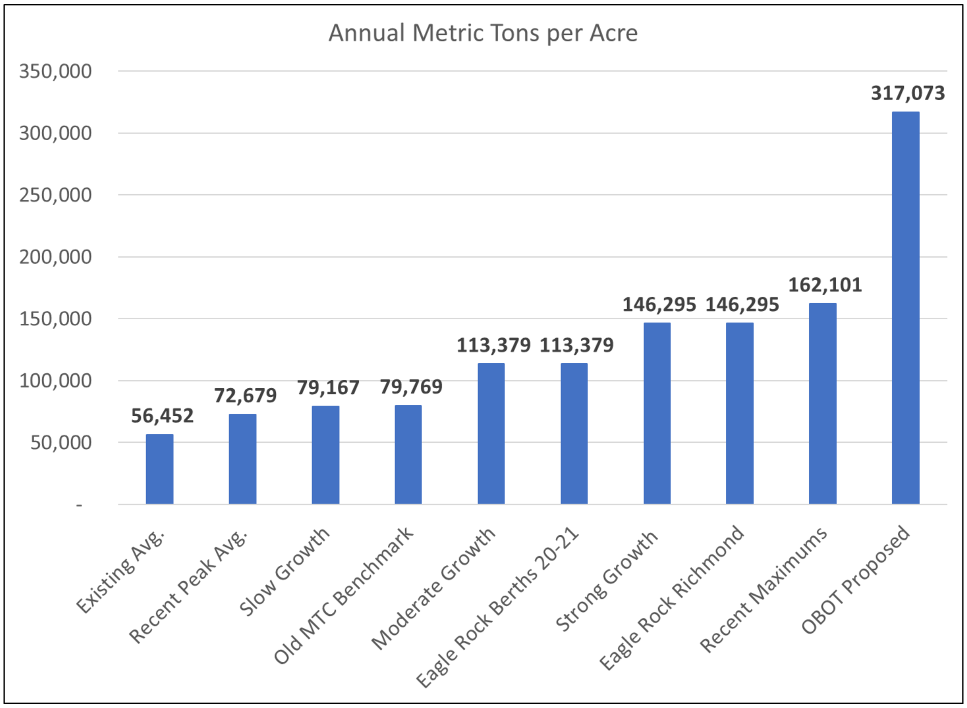
The productivity forecast utilizes a spectrum of efficiency improvements that increase the number of metric tons handled per acre at varying rates by scenario. Slow Growth productivity is halfway between the existing average and the old MTC benchmark, and anticipates a 40% increase over the 2018 average. Moderate Growth productivity is set equal to the proposed Eagle Rock facility at the Port of Oakland, and is 101% higher than the 2018 average. Strong Growth productivity is set to the current feasible maximum at the Eagle Rock covered facility in Richmond, 159% higher than the 2018 average. This progression represents the terminals becoming progressively more productive as needed either by gradually introducing denser storage or by moving the product through the terminal and out to the customer faster. The average of recent peaks and the highest recent peak throughput are included for comparison.

Exhibit 202: Dry Bulk Terminal Productivity Scenarios

Metric	Existing Avg.	Recent Peak Avg.	Slow Growth	Old MTC Benchmark	Moderate Growth	Eagle Rock Berths 20-21	Strong Growth	Eagle Rock Richmond	Recent Maximums	OBOT Proposed
Acres per terminal	12.7	12.7	12.8	13.0	13.8	20.0	14.9	6.2	3.5	20.5
MT per Acre	56,452	72,679	79,167	79,769	113,379	113,379	146,295	146,295	162,101	317,073
Increase over 2018	na	29%	40%	41%	101%	101%	159%	159%	187%	462%
MT per Berth	714,593	919,995	875,797	1,037,000	1,583,300	2,267,574	2,402,750	907,029	2,074,136	6,500,000

As Exhibit 203 indicates, the forecast scenarios all anticipate higher throughput per acre than the current average, in line with discussions between the consultant team and port staffs. Those discussions indicated that existing terminals were not generally operating at capacity, and could expand throughput on existing footprints. The Moderate Growth scenario anticipates a 101% increase in throughput per acre, roughly double the 2018 average.

Exhibit 203: Dry Bulk Terminal Productivity Comparison



On this basis the dry bulk forecasts imply a need for the terminal and berth infrastructure shown in Exhibit 204.

Exhibit 204: Bay Area Estimated Dry Bulk Terminal Requirements for 2050

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	8,575,119	**20,654,319**	12,025,443	33,183,607
Tonnage increase	na	**139%**	44%	274%
MT/Acre	56,452	**113,379**	79,167	146,295
Increase over 2018	na	**101%**	40%	159%
Acres	**152**	**182**	**152**	**227**
Additional Acres	na	**30**	**-**	**75**
Terminals	**12**	**13**	**12**	**15**
Berths	**12**	**13**	**12**	**15**
Additional Berths	na	**1**	**(0)**	**3**

The acreage estimates in Exhibit 204 prorate existing throughput per acre with Seaport Plan throughput per berth to derive a corresponding standard for planning. The Moderate Growth scenario of around 113,000 metric tons per acre corresponds roughly with port estimates of existing terminal capacities (e.g. 2 million metric tons for a 20-acre terminal). The Eagle Rock terminal proposed for Oakland's Berths 20-21 would handle about 2.3 million metric tons (2.5 million short tons) on 20 acres, or about 113,379 metric tons per acre. The Eagle Rock/Orca terminal at Richmond can reportedly handle up to 907,029 metric tons (1 million short tons) on its 6.2 acres, corresponding to an average of 146,295 metric tons per acre, taken as the Strong Growth benchmark

On this basis, there is a need for 30-75 additional acres and 1-3 additional berths for dry bulk terminals, even allowing for substantial increases in throughput per acre. The Moderate Growth scenario allows for throughput per acre to more than double over the current average, and the Strong Growth scenario allows for a nearly three-fold increase.

Open pile terminals are, to a large extent, interchangeable in the long run. Dry bulk commodities suitable for uncovered storage are handled with conveyor systems and mobile equipment that are rarely commodity-specific. Some of these terminals have handled different commodities in the past and could shift commodities over time. Moreover, the annual capacity is a factor of stockpile turnover as well as stockpile size.

Various covered storage systems such as silos, domes, or covered sheds (as in Exhibit 192) may have higher storage capacities per acre than open piles. The capacities of such structures, however, would be site-specific and terminal-specific, and the consultant team was unable to locate general guidelines. Accordingly, the consultant team used the maximum productivity of the existing Eagle Rock covered terminal at Richmond as a benchmark.

Dry Bulk Capacity Options

Besides using existing terminals for additional throughput, there are a few options for additional dry bulk capacity.

- The SF Pier 96 terminal space is adjacent to the active Pier 94 Hanson Aggregate terminal, and is actually part of the overall Pier 94-96 complex that formerly handled containers and other cargoes. With Pier 96 and land between Pier 92 and Pier 94, the Port could make approximately 67 additional acres available for marine terminal space. Pier96 has rail access, although rail service may be difficult to manage due to competing line use by Caltrains.
- Howard Terminal at Oakland is technically capable of handling dry bulks, and has rail access.
- Richmond's Terminal 3 could handle dry bulk cargo under some circumstances.
- Local concerns over coal and pet coke exports through Levin Richmond Terminal might eventually halt or curtail those flows. If so, Levin’s capacity could be released for other suitable dry bulk commodities. However, loss of existing cargo could lead Levin Richmond Terminal’s ownership to consider other uses for the site[x].
- There is an active proposal to use 20 acres of Oakland’s Pier 20-21 area for dry bulk aggregates.
- Dry bulk handling, specifically export coal, has been proposed for the former Oakland Army Base “Gateway Development Area” by a private developer as the Oakland Bulk and Oversize Terminal (OBOT) The coal export project faces strong local opposition. However, some capacity for more acceptable commodities, such as aggregates, might be developed there. This area is not designated for port priority.

[x] Based on contacts with LRT

6. Liquid Bulk Cargo

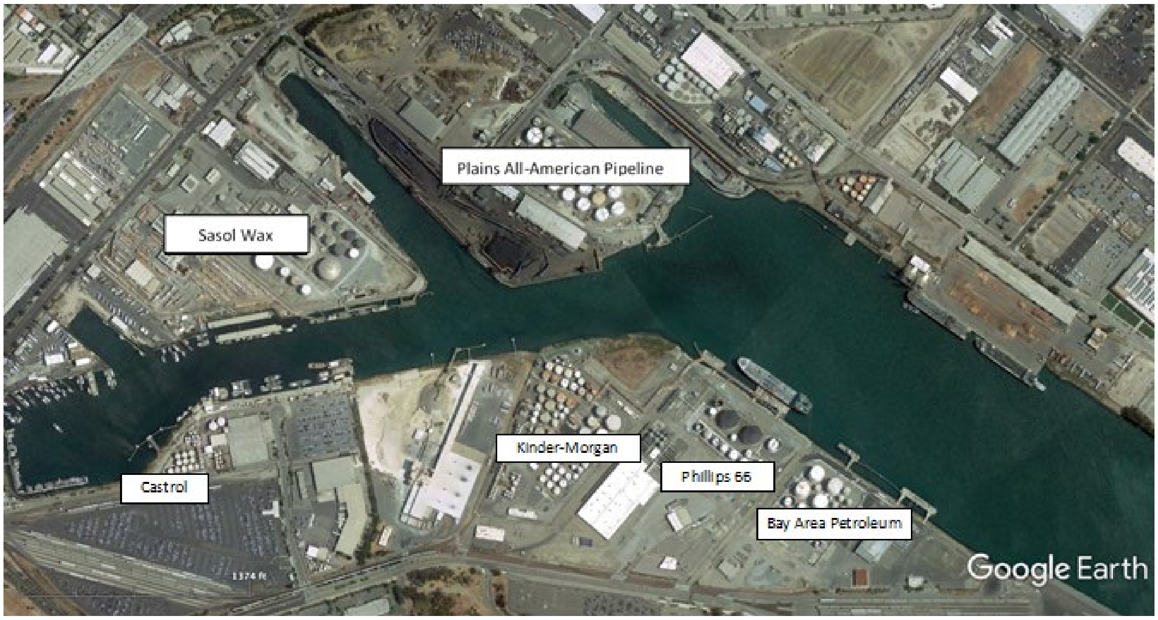
Liquid Bulk Cargo Review

There are large volumes of liquid bulk cargo handled at Bay Area marine facilities. Most of that cargo is petroleum and petroleum products moving through private refinery facilities, and outside the Seaport Plan scope. Within the Seaport Plan scope there are the following terminals and cargo flows:

- Port of Richmond Terminal 2, an import vegetable oil facility operated by AAK (Exhibit 205).
- Port of Richmond privately owned chemical terminals, terminals and tank storage facilities operated by Safety-Kleen, Castrol, IMTT, Kinder-Morgan, Sascol, and Plains All-American Pipeline (Exhibit 206).

Exhibit 205: Port of Richmond Terminal 2

Exhibit 206: Port of Richmond Private Liquid Bulk Terminals



Note that company and terminal names do not always correspond.

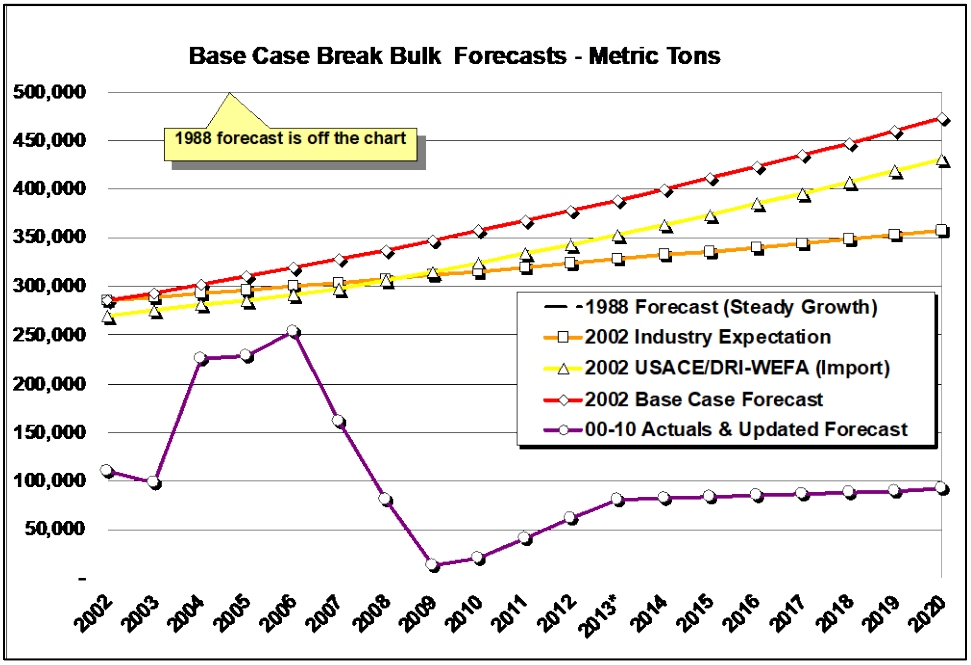
These are single-purpose terminals, however, and most are under private ownership. Cargo movements may rise or fall on a commodity-by-commodity basis without strong long-term trends. Accordingly, the consultant team did not analyze these flows or terminals.

7. Break-Bulk Cargo

Break-Bulk Cargo Review

Exhibit 207 below shows the 2011 and previous break-bulk forecasts. The dramatic difference was attributable to progressive containerization of what had been break-bulk cargo,

Exhibit 207: 2011 Base Case Break-Bulk Forecast, 2002-2020



Industry expectations for slow but continuing growth in break-bulk cargo were based on a history of steel, lumber, newsprint, and project cargo flows that eventually ended or were containerized.

Break-Bulk Trade Trends

The Bay Area ports do not currently handle any break-bulk cargo, but have done so in the past and may be needed to do so in the future. Previous flows have either ceased or been containerized. The remaining Northern California break-bulk cargo, such as imported windmill parts, is being handled at Stockton and West Sacramento. While there is no basis for forecasting future break-bulk tonnage, there may be a public interest in retaining break-bulk capabilities in the Bay Area to handle project cargo or a resurgence of past flows.

Break-bulk trade, also called "general cargo," includes non-bulk, non-containerized commodities such as structural steel, lumber, and machinery. "Project cargo" is a key subcategory of break-bulk trade, and includes goods such as bridge components, refinery assemblies, subway car shells, and other goods requiring special handling to support a near-term local or regional project. Wind farm generator towers and blades are an important project cargo at many ports.

Project cargo and break-bulk cargo in general have recently been handled at multi-purpose terminals at Stockton or West Sacramento. Handling and inland transport costs are high for items such as windmill blades, steel shapes, or transit cars, so shipments typically move through the closest port. California ports would thus compete with other California ports. The only significant area of overlap may be Northern California and Southern Oregon.

Break-Bulk Outlook and Options

The outlook for break-bulk cargo will likely depend on the future of major infrastructure projects, and on trade conditions for specific commodities such as structural steel. As the discussion of dry bulk construction commodities suggests, the future of infrastructure projects will depend in turn on the availability of public funding and the use of public-private partnerships.

The Bay Area seaports have the latent capability to accommodate break-bulk or project cargo should the need arise. Several Bay Area marine terminals have handled break-bulk shipments. At other ports, a significant share of break-bulk and project cargo is handled in Ro-Ro service, and the Ro-Ro terminals at Richmond and Benicia have the capability to do so. San Francisco's Piers 80 and 96 have handled break-bulk cargo in the past, as has Howard Terminal in Oakland and Terminal 3 at Richmond. Levin Richmond also has capability to handle some types of break-bulk. Occasional project cargo shipments may move via special stowage on container vessels and be handled at container terminals.

There may thus be no need to make separate provisions for future break-bulk cargo in the Seaport Plan.

8. Cargo and Capacity Findings

Pressure on Seaport Terminal Capacity

The Bay Area's seaports can expect long-term cargo growth in three sectors that could stress terminal and berth capacity:

- Containerized cargo
- Ro-Ro vehicle cargo
- Import aggregate dry bulk cargo

Exhibit 208 provides estimates of total seaport terminal acreage requirements under the three forecast scenarios. There are many possible variations. The three cargo types will not necessarily follow similar growth scenarios, although all will be affected by the same underlying regional economic growth trends. Also, different terminals may follow different productivity strategies. The general implication of Exhibit 208, however, is clear:

- Under Moderate Growth assumptions the Bay Area will need more active terminal space, estimated at about 326 acres by 2050.
- Under Slow Growth assumptions the Bay Area will need about 98 acres more active terminal space by 2050.
- Under Strong Growth assumptions across the three cargo types, the Bay Area will need substantially more seaport terminal space, about 753 more acres than are now active, and will need to activate additional berth space for larger container vessels.

Exhibit 208: Estimated Seaport Acreage Requirements

Forecast Scenario	Container Cargo Terminal Acres			Ro-Ro Cargo Terminal Acres			Dry Bulk Cargo Terminal Acres			Combined Cargo Terminal Acres		
	Existing*	2050**	Additional	Existing	2050***	Additional	Existing	2050***	Additional	Existing	2050	Additional
Moderate Growth	**593**	**729**	**136**	**215**	**375**	**160**	**152**	**182**	**30**	**960**	**1,286**	**327**
Slow Growth	593	543	-	215	313	98	152	152	-	**960**	**1,008**	**98**
Strong Growth	593	990	397	215	496	281	152	227	75	**960**	**1,712**	**753**

* In-use acreage at Port of Oakland
** At high productivity Phase VI
***Under base productivity assumptions

There are three basic strategies for accommodating the expected growth:

- Increased throughput at existing facilities.
- Horizontal expansion onto vacant land or land in other uses within seaport complexes.
- Use of dormant marine terminals.

Increased throughput at existing terminals is generally the least costly, most efficient, and least disruptive means of accommodating growth. Terminal operators can be expected to expand throughput to the point at which the terminal becomes congested or when substantial capital investment is needed to increase capacity. At that point, economic and financial tradeoffs will determine the preferred expansion path. Horizontal expansion onto available seaport land is often less costly and easier to implement than expansion via capital investment on existing footprints.

Available Terminal Expansion Sites

Within the Bay Area seaports there are a few dormant or under-utilized terminal sites.

- San Francisco's Pier 96, formerly part of the Pier 94-96 container terminal, is currently partially vacant and partially in non-cargo uses and could be combined with space between Piers 92 and 94 to make about 67 additional acres available.
- Oakland's Berth 20-21 area is used for ancillary services at present, although there is an active proposal for a dry bulk terminal there.
- Oakland's Berth 22-24 area, formerly part of the Ports America complex, is currently used for ancillary port functions.
- Oakland's Howard Terminal is also currently used for ancillary services.
- Oakland's Roundhouse parcel, although not on the water, is adjacent to active container terminals.
- Benicia has an estimated 35 acres under short-term lease for non-cargo uses that could be added to Ro-Ro terminal capacity.
- Richmond's Terminal 3, formerly a small container terminal, was recently used to load logs into containers for export through Oakland, but was not handling any cargo over the wharf as of late 2019.

Exhibit 209 lists these sites, their size, and their potential uses. The table also illustrates some inherent tradeoffs.

Exhibit 209: Bay Area Seaport Expansion Sites

Site	Acres	Potential Use		
		Container	Ro-Ro	Dry Bulk
SF Pier 96 & Other	67	-	X	X
Oakland Berths 20-21	20	X	-	X
Oakland Berths 22-24	130	X	-	-
Oakland Berths 33-34	20	X	-	-
Oakland Roundhouse	26	X	-	-
Oakland Howard*	38	X	X	X
Benicia Short-Term Lease	35	-	X	-
Richmond Terminal 3	20	-	X	X
Available Acres	**356**	**176-234**	**35-162**	**0-147**
Moderate Growth Needs	**327**	**136**	**160**	**30**
Slow Growth Needs	98	0	98	0
Strong Growth Needs	753	397	281	75

* Post turning basin expansion: 38 acres container, 40 acres Ro-Ro or dry bulk

- San Francisco's Pier 96 was most recently used to handle containers. Its limited draft, however, would make it less suitable for container handling than the Oakland locations. Moreover, the container shipping industry previously consolidated at the Oakland terminals, and an isolated terminal across the Bay at San Francisco is unlikely to be attractive to container shipping lines in the future. Pier 96 also lacks access to active rail intermodal facilities, and access for double-stack or tri-level rail cars is constrained by tunnel clearances. Trucks connecting Pier 96 and additional Port of San Francisco land with inland customers would add to congestion on the bay bridges. Pier 96 would therefore most likely be suitable for export Ro-Ro or dry bulk cargoes.

- Oakland's Berths 20-21 may be used for dry bulk cargo as an interim use under a 15-year lease. The Port expects to return the space to container terminal use in the long run.
- Oakland's Berth 22-24 site is expected to be used for container cargo in the long run. The consultant team's analysis suggests that the Berth 22-24 capacity will be required under any container forecast scenario, and there have been no proposals to use this space for other cargoes.
- Oakland's Roundhouse site has no berth access, but can function as added space for adjacent container terminals.
- Oakland's Howard Terminal capacity may be required for container handling under the forecast scenarios, depending on what productivity improvement is achieved at other terminals. Howard's berth capacity may be required to handle additional vessel services under a Strong Growth scenario, particularly if Berths 20-21 are used for dry bulk cargo. Howard Terminal may also be a logical expansion site for Ro-Ro vehicle handling. Howard could also handle dry bulk cargo, and Schnitzer Steel has expressed interest in using a portion of Howard to expand its adjacent operations.
- Richmond's Terminal 3 has limited space, as the terminal totals about 20 acres. With such limited backland, 35' of draft, and isolation from the Oakland terminals, T3 is not a viable location for container handling. T3 would most likely serve as auxiliary parking for the Port Potrero Ro-Ro terminal. It could also handle dry bulk cargoes.

As Exhibit 209 indicates, moderate container cargo growth through 2050 might be handled at Oakland without Howard Terminal or without Berths 20-21, but not without both, and not without some risk of capacity shortfall in peak periods. As Exhibit 101 shows, Oakland would then be at 95-98% of capacity with little or no room for future growth. Strong container cargo growth would exhaust Oakland's total capacity unless terminals can boost productivity to higher levels than anticipated.

The Bay Area could probably meet moderate Ro-Ro cargo growth needs at SF Pier 96 and Richmond's Terminal 3, but Strong Growth would introduce a conflicting demand for Howard Terminal's acreage.

Dry cargo growth may conflict with the availability of SF Pier 96, Oakland's Berth 20-21, or Howard Terminal for Ro-Ro or container cargo.

Appendix: Potential Role of Oakland's Howard Terminal

Howard Terminal Background

Howard Terminal (technically Charles P. Howard Terminal) is located in Oakland's Inner Harbor on the Alameda Estuary. Howard Terminal began operations importing coal and exporting grain in about 1900 (Exhibit 210).

Exhibit 210: Howard Terminal, Circa 1900

The terminal operated independently until purchased by the Port of Oakland in 1978. Existing "finger" berths were filled in to develop a more modern terminal. Under the Port, Howard Terminal was rebuilt as a combination container and break-bulk terminal with two cargo sheds (Exhibit 211).

Exhibit 211: Howard Terminal, Circa 1993

These cargo sheds were removed by 2000, and Howard assumed essentially its present configuration (Exhibit 212).

- 50 acres
- 1,946-foot berth with a 70-foot dolphin, 2,016 total feet
- 42-foot depth
- 4 container cranes: 1 post-Panamax, 3 Panamax

Exhibit 212: Howard Terminal, Circa 2018

Between 2005 and 2013, Howard Terminal was used by Matson to support its domestic container service. In 2014, Matson moved to the former APL terminal at berths 60-63.

Interim Uses

Starting in 2014 and through the present, Howard has been used for a mix of ancillary uses, including:

- Longshore worker training.
- Truck parking and staging.
- Container and chassis storage.
- Cargo transloading.
- Layberthing.
- Tug boat docking.

These interim uses are valuable to the shipping industry as a whole and the Port's tenants in particular, and create revenue for the Port. In the long run, however, the Port's commitment to ancillary service space will be met on non-terminal sites, as discussed in the report. The possible exception is layberthing, for which the need is difficult to predict despite periodic inquiries received by the Port.

Some Port scenarios for terminal development and increased productivity entail temporary operations at Howard while other terminals are being upgraded or renovated, or the relocation of smaller vessel services not ideally accommodated at the largest terminals. Here too, the need is difficult to predict.

Container Cargo Use

Howard is the smallest of the Oakland terminals, but also the largest idle port terminal on San Francisco Bay and the best available site for an additional active container terminal. At 50 acres and with 42 feet of depth, Howard Terminal is small by current West Coast container terminal standards. Exhibit 213 compares Howard with other U.S. container terminals in the 40-acre to 75-acre range. Significantly, SSA/Pier C at Long Beach and Terminal 25/30 at Seattle are Matson terminals, as was Howard until 2014. Midport at Port Everglades also handles domestic cargo.

Exhibit 213: Container Terminals of 40-75 Acres

Terminal	Port	2017 Acres	2017 Berth Length
Midport	Port Everglades	40	800
Hooker's Point	Tampa	40	3,000
Howard Terminal	Oakland	50	2,016
East Sitcum Terminal	Tacoma	54	1,100
Napoleon Avenue Container Terminal	New Orleans	61	2,000
SSA / Pier C	Long Beach	70	1,800
Terminal 25/30	Seattle	70	2,700
Ben E. Nutter Terminal	Oakland	74	2,157

Howard Terminal could presently accommodate most of the container vessels that called Oakland in 2017. Howard Terminal has a reported draft of 42 feet. With 4 feet of underkeel clearance, Howard can accept vessels with a sailing draft of up to 38 feet. Vessels are rarely loaded to their full design draft. Ordinarily, the mix of empty and loaded containers and full and vacant slots limits vessels to a maximum of about 90% of their design draft. A vessel with a 42.2 foot design draft would therefore usually operate at a sailing draft of 38 feet or less. Of the 1,457 container vessel calls at Oakland in 2017, 1,167 (80%) had design drafts of 42.2 feet or less, aggregating 6.7 million TEU, 72% of the total capacity.

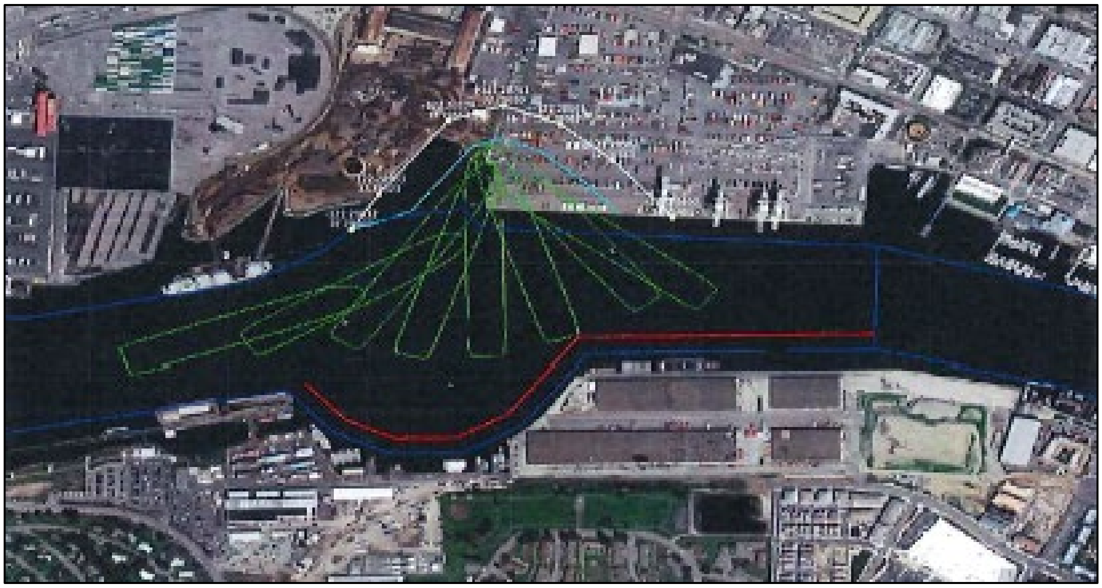
Howard Terminal currently has a 2,016-foot berth (including the 70-foot dolphin), adequate for vessels with design drafts of up to 43.3 feet, which are typically 1,200 feet long and require a 1,350-foot berth. A 2,016-foot berth could also accept two smaller vessels of up to around 2,000 TEU each, typical of those used in domestic trades (e.g. Pasha or Matson vessels).

The existing basin adjacent to Howard Terminal is 1,500 feet in diameter, sufficient to turn a vessel of up to 1,210 feet in length. This length corresponds closely to the largest vessel size that could currently be handled with Howard's berth length and draft.

Howard Terminal served Matson vessels as recently as 2014. The current cranes are capable of handling vessels of up to around 4,500 TEU ("Panamax"). Oakland had 360 calls from vessels of 4,500 TEU or smaller in 2017.

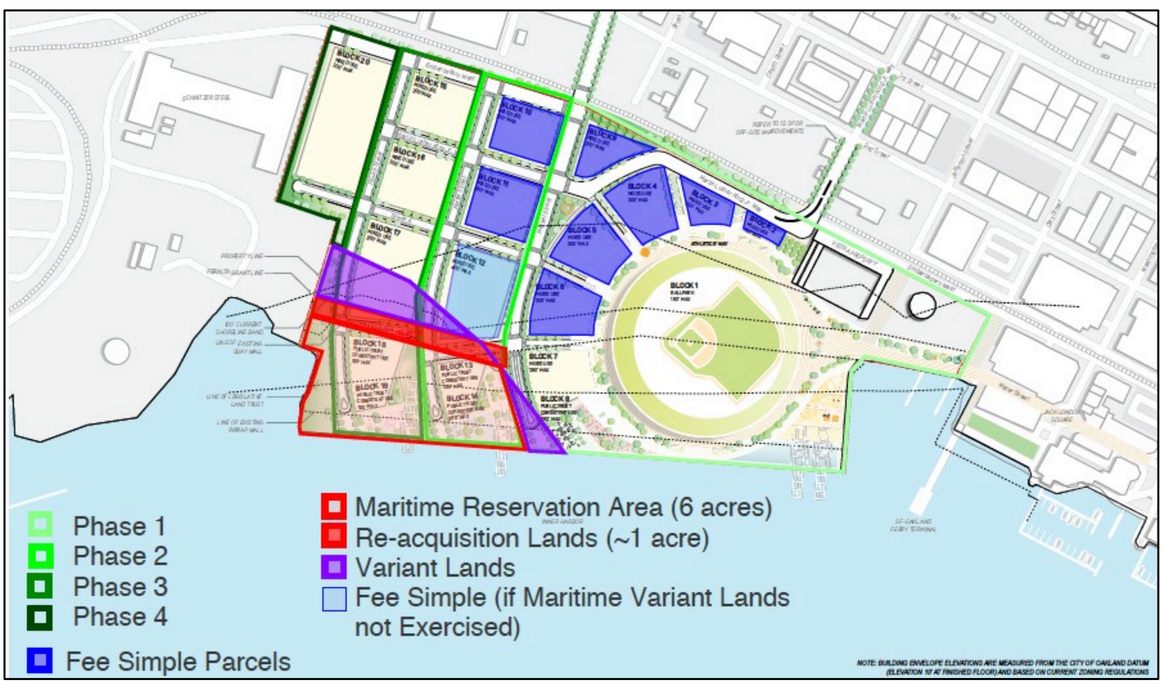
Under current plans, expansion of the turning basin to accommodate larger vessels of up to 1,300 feet would require truncating Howard's berth. Available preliminary studies suggest that turning basin expansion would take about 965 feet from Howard's berth length, plus the existing dolphin, leaving Howard with a 981-foot berth. With a truncated berth of 981 feet, Howard could accept few of the vessels projected to call at Oakland by 2050 without modifications (e.g. extending the berth or adding a dolphin on the east end).

Exhibit 214: Preliminary Turning Basin Expansion Plan



Expanding the turning basin would also reduce Howard's area by about 10 acres, as shown in Exhibit 214 and Exhibit 215. Exhibit 215 shows approximately 9 acres set aside as the Marine Reservation Area, Re-acquisition Lands, and Variant Lands for expansion of the turning basin. Post-expansion, Howard Terminal would be about 40 acres (38 post-electrification if used for containers), comparable to the smallest terminals in Exhibit 213.

Exhibit 215: Proposed Howard Terminal Stadium Plan with Marine Reservation



While Howard could accommodate smaller vessels essentially "as is", long-term use for container cargo would require upgrades. The Howard Terminal berth would have to be dredged to 50 feet (nominal) to accommodate larger vessels. In a 2013 study for the Port of Oakland, Moffat & Nichol estimated the cost of dredging at $3.8

million. Howard would likely need at least four new super-Post-Panamax cranes, at a cost of around $15 million each, for a total of $60 million. The Moffat & Nichol study also identified a need for wharf strengthening, paving, and other improvements totaling around $13 million to upgrade Howard.

Fifty acres is below the current standard for new container terminals, but may be a necessary increment to seaport capacity under the Moderate or Strong cargo growth scenarios. Howard Terminal's role in Bay Area container cargo capacity would depend on multiple factors, as illustrated in Exhibit 216.

Exhibit 216: Port of Oakland Container Cargo Scenarios (millions of TEU)

Productivity Color Code:	Existing	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI

Scenario	2018	2020	2025	2030	2035	2040	2045	2050
All Potential Terminal Acres: 799 Current / 787 Post-Electrification								
Moderate Growth	2.55	2.50	3.04	3.31	3.65	4.12	4.63	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	5.33	5.33	5.33
Slow Growth	2.55	2.40	2.60	2.77	2.97	3.26	3.55	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.64	3.27	3.72	4.55	5.29	6.11	7.04
Available Capacity	3.95	3.95	3.95	3.95	5.33	5.33	5.60	5.60
Potential Terminal Acres w/o Howard: 759 Current / 747 Post-Electrification								
Moderate Growth	2.55	2.50	3.04	3.31	3.65	4.12	4.63	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	5.06	5.06	5.23
Slow Growth	2.55	2.40	2.60	2.77	2.97	3.26	3.55	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.64	3.27	3.72	4.55	5.29	6.11	7.04
Available Capacity	3.95	3.95	3.95	3.95	5.06	5.30	5.31	5.31
Potential Terminal Acres w/o Berths 20-21: 779 Current / 767 Post-Electrification								
Moderate Growth	2.55	2.50	3.04	3.31	3.65	4.12	4.63	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	5.19	5.19	5.19
Slow Growth	2.55	2.40	2.60	2.77	2.97	3.26	3.55	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.64	3.27	3.72	4.55	5.29	6.11	7.04
Available Capacity	3.95	3.95	3.95	3.95	5.19	5.35	5.46	5.46
Potential Terminal Acres w/o Berths 20-21 or Howard: 739 Current / 727 Post-Electrification								
Moderate Growth	2.55	2.50	3.04	3.31	3.65	4.12	4.63	5.19
Available Capacity	3.95	3.95	3.95	3.95	3.95	4.93	4.93	5.17
Slow Growth	2.55	2.40	2.60	2.77	2.97	3.26	3.55	3.86
Available Capacity	3.95	3.95	3.95	3.95	3.95	3.95	3.95	3.95
Strong Growth	2.55	2.64	3.27	3.72	4.55	5.29	6.11	7.04
Available Capacity	3.95	3.95	3.95	3.95	4.93	5.17	5.17	5.17

- With all 799 Oakland post-electrification acres available for container terminal operations the port would have adequate capacity under the Slow and Moderate scenarios and would be over capacity with Strong Growth.
- Without Howard, at 759 acres, the port would have adequate capacity under the Slow and Moderate scenarios and would be over capacity with Strong Growth.
- Without Berths 20-21 (but with Howard) at 779 acres, the port would have adequate capacity under the Slow and Moderate scenarios and would be over capacity with Strong Growth.
- Without either Howard or Berths 20-21, Oakland would be over capacity with Moderate Growth, and well over capacity with Strong Growth.

If Howard's truncated berth were too small for any of the vessels calling Oakland in 2050, the site would not be fully functional as a standalone container terminal. The Port would then have a choice of using Howard for off-dock parking, or extending the berth to the east.

Productivity Growth. Under the high productivity growth scenario shown in Exhibit 95, Howard Terminal's long-term capacity at 38 acres after turning basin expansion is estimated at 270,256 annual TEU. More aggressive productivity increases would reduce the need for Howard's acreage. As noted in the container cargo analysis section, the lowest cost strategy to increase capacity is to expand horizontally, using more land. With less land to work with, the Oakland terminals would need to invest in other means of increasing capacity sooner.

Cargo Growth. Under a Moderate Growth scenario with sufficient productivity increases, the Bay Area could have sufficient container cargo capacity through 2050 without Howard Terminal, but would be at or near capacity (estimated at 99.8%) with little or no room for future growth. Under a Strong Growth scenario Oakland is expected to need Howard's acreage by around 2042.

Use of Berths 20–21. If, as currently proposed, the Port of Oakland develops a dry bulk cargo terminal at Berths 20–21, the available Outer Harbor container terminal space would be reduced by about 20 acres as long as that use continues. At the high productivity average of 7,112 annual TEU per acre, that development would reduce the Port's long-term container capacity by about 142,240 annual TEU. As Exhibit 216 shows, that development would either:

- Accelerate the need for Howard's capacity, or
- Result in a capacity shortfall by 2050 under the Moderate Growth scenario if Howard Terminal is not available, assuming bulk operations were to continue indefinitely.

Alternatively, the Port of Oakland could give priority to container use and end the dry bulk tenant lease when the capacity was needed for containers as an alternative to using Howard. The current proposal envisions an initial 15-year commitment to dry bulk cargo.

Berth Requirements. To accommodate cargo growth Oakland terminals will need to accommodate larger vessels, more vessel calls, or a mix of larger and more frequent calls. As the berth analysis showed, additional berth space would be required for one or more weekly calls under Strong Growth scenarios if cargo growth is accommodated by increasing vessel size. The role of Howard will change if the turning basin is expanded as currently envisioned.

- **Existing Howard Berth Length.** If cargo growth is accommodated by increasing sailings and holding vessels to a maximum of 25,000-26,000 TEU, either Berths 20-21 or Howard's existing berths, but not both, would be required under Strong Growth scenarios. If Berths 20-21 are used for dry bulk operations, Howard's existing berth would be needed under any Strong Growth scenario. Under Moderate Growth scenarios, some berth congestion would be expected at TraPac, Ben E. Nutter, and OICT unless either Berths 20-21 or Howard were available as an alternative.

- **Reduced Howard Berth Length.** With the berth reduced to 981 feet after the proposed turning basin expansion, Howard would be unable to handle the vessels expected by 2050 without modifications. This scenario would necessitate the use of Berths 20-21 for containers.
- **Extended Berth Length.** It appears conceptually feasible to extend the Howard Terminal berth to the east via a dolphin, fill, or a combination. As Exhibit 217 shows, there is space for a dolphin of up to 500 feet, and fill behind part of that length. This extension would entail relocating the ferry pier, which is not considered a barrier over the 30-year forecast horizon. This option would create a new Howard Terminal berth of up to 1,481 feet and enable Howard to accommodate the larger vessels expected out to 2050.

Exhibit 217: Howard Terminal: East End of Wharf

Ro-Ro Cargo Use

A second potential use for Howard Terminal is Ro-Ro cargo. Exhibit 164 notes the need for up to 160 additional acres of Ro-Ro terminal capacity in the Moderate Growth/base productivity case, and correspondingly higher requirements for faster growth. Howard's 50 acres would have capacity for about 99,000 annual vehicles in the base capacity case. At 40 acres, Howard could handle about 79,000 annual vehicles.

As discussed in the Ro-Ro cargo analysis section, typical Ro-Ro vessels are around 650 feet long, with a 40-foot design draft. These vessels would typically sail at a draft of about 36 feet. With 4 feet of underkeel clearance these vessels would require 40 feet of draft, which is within Howard's current specifications. These vessels would also fit in a truncated 981-foot berth after turning basin expansion.

Although Howard Terminal does not have active rail service at present, the rail access right-of-way and trackage at the terminal's northwest corner are intact as of June 2019. Exhibit 218 superimposes an image of the rail loading facility at Richmond's Port Potrero terminal on an aerial photo of Howard Terminal, at approximately the same scale. This informal comparison suggests that it may be possible to add rail loading capabilities to Howard if access trackage can be rebuilt as required past Schnitzer Steel.

Exhibit 218: Ro-Ro Rail Facilities Superimposed on Howard Terminal

There has been at least one inquiry to the Port of Oakland regarding Ro-Ro operations at Howard. That inquiry was ended due to the presence, at the time, of airborne fibrous material from the adjacent Schnitzer Steel operation. According to Port staff that problem has since been remedied by enclosing the relevant portion of the Schnitzer machinery.

A 2013 Moffat & Nichol study for the Port of Oakland estimated the cost of updating Howard for Ro-Ro auto and vehicle processing at $16.6 million, including rail track work (at the adjacent Roundhouse site, in the Moffat & Nichol study) and structures for vehicle processing.

The need for rail connections and processing facilities is tied to import vehicle flows. A terminal that distributes nationally (as do Benicia and Richmond) will need rail capabilities on or adjacent to the terminal, and processing facilities to support accessory installation as well as washing and minor preparation. Export flows will not require such elaborate facilities. It is noteworthy that Howard is the closest marine terminal to the Tesla plant in Fremont.

Dry Bulk Cargo Use

The cargo forecast also implies a need for additional Bay Area capacity for dry bulk cargo, specifically imported sand and gravel to replace a dwindling regional supply in the greater Bay Area. The dry cargo analysis identified Howard Terminal as a potential site for dry bulk cargo, as well as Oakland Berths 20–21, and San Francisco's Pier 96.

The dry bulk forecast and capacity analysis, repeated below as Exhibit 219, anticipates a need for three new dry bulk terminals with total of 30 acres by 2050 under the Moderate Growth scenario. The Slow Growth scenario would not require any additional acreage, while the Strong Growth scenario would require an additional 75 acres, about half of which could be supplied by the 40 post-turning basin expansion acres at Howard.

Exhibit 219: Dry Bulk Cargo Forecast and Terminal Requirements

Factor	Existing	Moderate Growth	Slow Growth	Strong Growth
Annual Metric Tons	8,575,119	**20,654,319**	12,025,443	33,183,607
Tonnage increase	na	**139%**	44%	274%
MT/Acre	56,452	**113,379**	79,167	146,295
Increase over 2018	na	**101%**	40%	159%
Acres	**152**	**182**	**152**	**227**
Additional Acres	na	**30**	**-**	**75**
Terminals	**12**	**13**	**12**	**15**
Berths	**12**	**13**	**12**	**15**
Additional Berths	na	**1**	**(0)**	**3**

As the dry bulk cargo section of the main report discusses in more detail, the throughput capacity of a dry bulk terminal is a function of both on-site storage capacity and product turnover. Storage capacity may, however, limit the volume that can be transferred to or from a single vessel call. The proposed 2.5 million ton annual throughput for the conceptual 20-acre Berth 20-21 facility implies an average of about 125,000 annual tons per acre, or 5.0 million tons for the 40 long-term acres at Howard Terminal, similar to the Moderate Growth average in Exhibit 219.

Use of Howard Terminal for bulk cargo would thus likely satisfy the Bay Area requirements under the Moderate Growth scenario, and part of the requirements under the Strong Growth scenario.

The 2013 Moffat & Nichol report estimated a cost of $61.1 million to develop a dry bulk terminal at Howard, but noted that truck transportation could cause impacts to local roads that are not included, and that the final investment would depend on the exact tenant and operation. That estimate included enclosed storage and handling equipment, but not rail access. Rail access may or may not be necessary, although the existing trackage could likely form the basis of upgraded rail facilities if needed.

Summary

The role that Howard Terminal could play in overall Bay Area seaport capacity and commerce depends on growth and productivity improvements in the container, Ro-Ro, and dry bulk trades. Although Howard is currently used for ancillary needs, those needs should be accommodated on other sites (Exhibit 145) in the long term.

- **Container Cargo.** For container cargo, the Moderate cargo growth scenario may not require Howard's acreage, depending on terminal productivity improvements. A Slow Growth scenario could likely be accommodated without Howard. A Strong Growth scenario would definitely require Howard's acreage. Use of Berths 20–21 for dry bulk cargo would increase the need for Howard's terminal space. A truncated berth after turning basin expansion, however, may limit Howard's utility as a stand-alone container terminal without an extension to the east.
- **Ro-Ro Cargo.** Howard Terminal could handle Ro-Ro cargo and fill some of the need for additional Bay Area capacity under a Moderate Growth scenario, especially for exports (e.g. Teslas or another maker). The configuration of a Ro-Ro terminal at Howard would depend on the mix of import and export vehicles and the need for rail connections and processing facilities. Pier 96 at San Francisco is the other potential site for a Ro-Ro terminal.

- **Dry Bulk Cargo.** Howard could serve as a dry bulk cargo terminal. There may be dust and heavy truck impacts on surrounding streets. The use of Berths 20–21 and the development of OBOT for dry bulk would reduce the need for dry bulk cargo at Howard (although OBOT is not designated as port priority, is on City-owned rather than Port land, and is under litigation as of early 2019). San Francisco's Pier 96 is the other possible site, and LRT at Richmond may have capacity available if coal and pet coke decline.

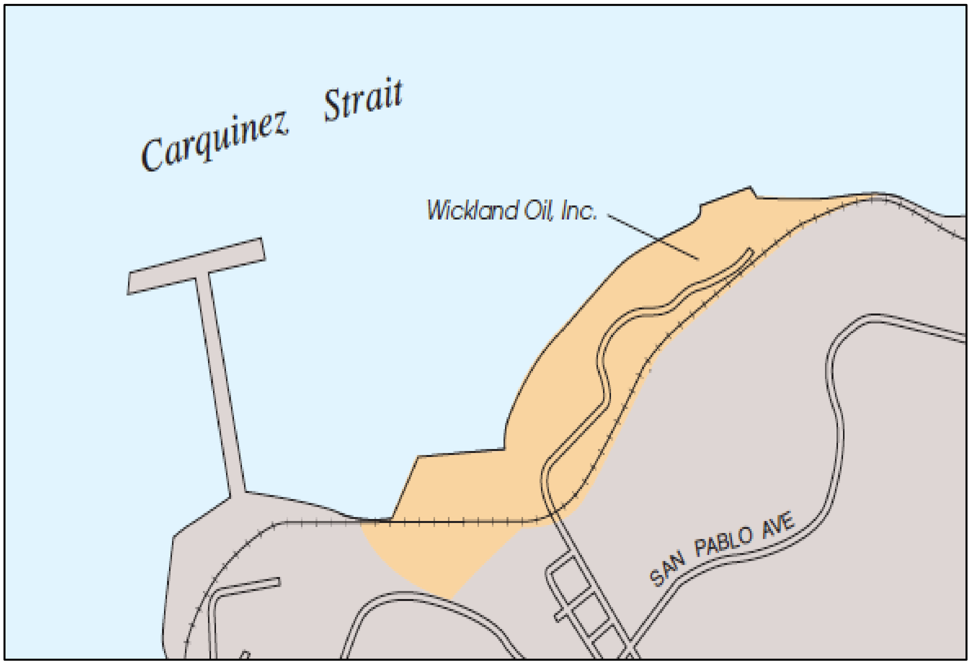
As the analysis of overall seaport acreage requirements shows (Exhibit 208), Bay Area seaports are expected to be at or near capacity by 2050 under Moderate Growth assumptions, and to require space beyond existing active container, Ro-Ro, and dry bulk terminals. Howard Terminal would be one option to supply part of that acreage. Howard Terminal cannot, obviously, serve all three cargo types. If Howard Terminal is used for container cargo, other sites must accommodate the need for Ro-Ro and dry bulk capacity. If Howard Terminal's long-term ability to handle containers is compromised by a truncated berth, Ro-Ro or dry bulk cargo may be a more suitable use.

Appendix: Other Port Priority Land

Selby

The Selby site (Exhibit 220) is included in the current (2012) Seaport Plan as a potential non-petroleum liquid bulk terminal site, although the Seaport Plan notes that it could be developed for other bulk cargo types.

Exhibit 220: Selby Site in the 2012 Seaport Plan



The 60-acre Selby site (Exhibit 221) is the former location of a larger smelting complex (Exhibit 222) that was closed in 1971. There was also a plant at Selby producing sulfuric acid and liquid sulfur dioxide from 1971 to 1976. The toxic slag left behind became a major environmental issue, and the site was added to the Superfund cleanup list in the 1980s. The site was leveled and covered with an asphalt cap in 1992.

Exhibit 221: Selby Site 2018

Exhibit 222: Selby Smelter - 1939

The California State Lands Commission (80%) and C.S. Land, Inc. (a subsidiary of Conoco Phillips, 20%) currently own the site and share responsibility for environmental cleanup. The ownership split is for the site as a whole, and not for sub-parcels.

The State Department of Toxic Substances Control (DTSC) is currently the lead agency for the Selby Slag Remediation Project. Between 1992 and 2006 there were multiple interim remedial measures (IRMs) to mitigate the problems pending a long-term solution. A draft Remediation Action Plan (RAP) and Environmental Impact Report (EIR) were prepared and released for public comment in early 2018. The extensive remediation required is estimated to take 30 months of construction after all permits are obtained, at a cost of $76 million, with $110 million on long-term operational maintenance costs.

The draft cleanup approach anticipates that the Selby site would eventually be suitable for selected industrial uses. The site has very good rail and highway access. Vessel access may be limited because the nearby waters are shallow, and dredging may not be feasible due to the presence of contaminated sediments.

- Use for containerized cargo is probably infeasible due to the need for extensive dredging and deep wharf and equipment foundations.
- Use for Ro-Ro or dry bulk cargo may or may not eventually be feasible, depending on final clean-up methods and resulting conditions.
- Use for liquid bulk would depend on vessel access and the ability of the site to support storage tanks or transfer facilities.

There has been significant community concern over both the environmental cleanup process and eventual use of the Selby site. Some community groups have linked the cleanup effort to potential expansion of inbound crude oil shipping at the adjacent Phillips 66 refinery.

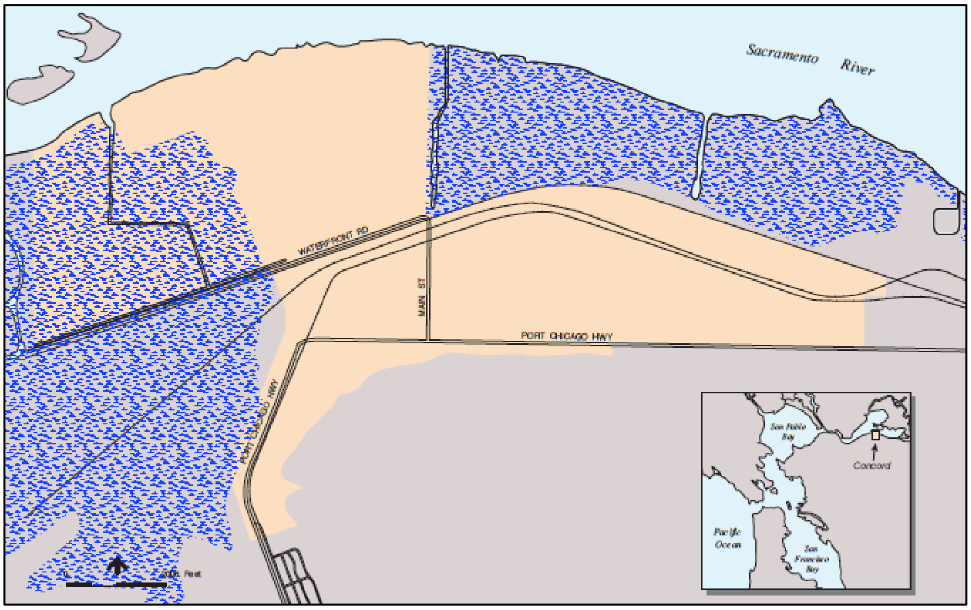
As of mid-2019, DTSC is reviewing public input on the 2018 RAP/EIR. Final or revised draft documents may be released in late 2019 or early 2020. With mixed community reaction and the potential for legal challenges, it is not possible to anticipate starting or completion dates with any confidence.

Given the uncertainties involving the mitigation and cleanup plan and the range of permissible uses, the consultant team did not include the Selby site in the inventory of usable terminal land.

Military Ocean Terminal Concord (formerly Concord Naval Reservation)

A 1,500-acre area of the former Concord Naval Weapons Station is included in the 2012 Seaport Plan (Exhibit 223) as a port priority use area, to be considered for bulk cargo use when and if military use ends.

Exhibit 223: Concord Naval Reservation Site - 2012 Seaport Plan



The area is roughly 1,500 acres, but includes large portions of tidal marsh (Exhibit 224). There is additional tidal marsh outside the port priority area.

Exhibit 224: MOTC Site 2018

The area in question is currently operated by the U.S. Army as Military Ocean Terminal Concord (MOTC). Large inland portions of the former Concord Naval Weapons Station outside the port priority use area are being returned to civilian use under the Base Relocation and Closure (BRAC) process. The water-accessible portion, however, is anticipated to remain in military use indefinitely. Moreover, the U.S. Army Corps of Engineers is providing $89 million in funding for port infrastructure upgrades.

Accordingly, the consultant team did not include the Concord site in the usable port land inventory.