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DELTA STEWARDSHIP COUNCIL

Kennedy/Jenks Consultants

SHORE-BASED BALLAST WATER TREATMENT IN CALIFORNIA

TASK 12: MARKET IMPLICATIONS

PREPARED FOR

DELTA STEWARDSHIP COUNCIL
SACRAMENTO, CALIFORNIA

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Revision History

Section	Rev	Description	Date	Approved
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References

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Executive Summary

The cost of building and operating a network of treatment barges will need to be passed on, in some way, to ship operators who use the network. These costs could be reflected in fees charged per treatment service or per ton of ballast water treated or per unit of cargo, or be worked into port charges in some other way. And, these costs and fees could vary widely among California ports resulting in increased inter-port competition among California ports. On the other hand, these fees could be managed on a state-wide basis to even out fees charged at high cost/low volume and low cost/high volume California ports to reduce impact on inter-port competition.

In any case, costs charged to ship operators could be high enough to affect their decisions about using certain California ports or using any California ports. These decisions will be based on two key factors: how treatment costs affect the overall cost per ship call or per unit of cargo picked up at particular California ports and the cost of the “next best” alternative.

The 30-year lifecycle costs of building and operating a network of ballast water treatment barges (treatment barges) capable of treating all ballast water discharged into California waters is estimated in Task 10 at $3.63 billion. While it is not possible to predict how these costs will be passed on to ship operators as fees or how ship operators will respond, the following sections attempt to put these costs and associated fees and possible shipping industry responses into perspective.

1.1 Marine Vessel Operator Perspective

A marine vessel calling into California must already be outfitted with a USCG compliant sanitary system, be prepared to burn low sulfur fuel oil and, in some cases (containerships and cruise ships) be ready to plug into shore power once at the dock. Operators of these vessels are now preparing to install on-board ballast water treatment systems that have an installed cost ranging from $500,000 to $3,500,000. An additional one-time investment of $152,633 to $308,893 to outfit a ballast transfer station in order to be able to discharge ballast water at California ports is not likely to dissuade marine vessel operators that routinely call in California. It will, however, decrease the pool of vessels that are qualified to call in California ports.

1.2 Cargo Shipments

Treatment barge costs passed along to a marine vessel will, in many cases, be equivalent to the cost of several marine vessel transit days. Those additional days in transit could allow the marine vessel to reach an alternative cargo loading port location where these fees are lower or do not exist. For example, a dry bulk carrier taking on grain in Stockton is estimated to need to pay as much as$120,000 to the treatment barge operator to receive offloaded ballast water. However, that bulk carrier only costs $12,000 per day to operate. That allows the ship operator to lower costs by steaming up to 10 additional transit days to pick-up cargo either in an alternative California port where the treatment barge service cost less, or outside of California where there would not be a similar fee.

Of course, there could be many customer-related, cargo-related or logistical reasons why ship operators demand to use a particular California port might be relatively “inelastic” with respect to port costs. For example, it might only be possible to ship an agricultural product out of the nearest port to avoid spoilage. In that case was a low margin good, then an increased shipping cost could make the cargo export unprofitable.

1.3 Panama Canal Costs

The expansion of the Panama Canal raised concerns that California would be bypassed for discretionary mid-west cargos. Reports claim that US west coast ports are losing Asia container market share to US gulf and east coast ports (Journal of Commerce, Rail pricing decider in US coastal port fight, 17 September 2017). One barrier that can keep discretionary cargo moving through west coast ports are Panama Canal tariffs. However, treatment barge costs at California ports could approach 60% of Panama Canal tariff rates for tankers and bulkers, and 10% of the tariff rates for containerships.

1.4 Concentration of Costs and Elasticity

The costs of implementing a shore-based network of treatment barges is likely to be concentrated on a small percentage of marine vessels, have the largest impact on cargo exports, and disproportionately impact remote and low volume ports.

- In a given year there are ~9,500 ship visits in California, but only ~1,500 ballast water discharges. In the five year period from 2011 to 2015 all ~7,500 discharges were from only ~2,300 unique vessels. As such, the cost of shore-based treatment will be concentrated on a relatively small number of marine vessels.
- Most ballast water discharges are associated with cargo exports. As export cargo is loaded, ballast water is discharged. As such, the costs to support the shore-based network will be disproportionately driven by cargo exports.
- The per cargo unit cost for the treatment barge is the cost of the service divided by the units of cargo moved. For example, a San Diego $118,321 service call would only be spread over a 1,400 TEU cargo move resulting in $84.52 per TEU. The lower cost barge and higher volume move in Long Beach results in $2.55 per TEU. In other words, remote and low volume ports will see a disproportionate impact.

Market implications are difficult to predict in a quantitative manner. A 2007 study (Reference 9) suggests that elasticity of the ports of LA/LB discretionary cargo is perfectly elastic in proportion to shipping costs, i.e. a 10% increase in shipping costs decreases volume by 10%. It also suggests that local cargoes that are not discretionary have an elasticity of 0.3 meaning that the same increase in cost would only reduce volume by 3%.

The 2007 study combined with the calculated costs to support a network of treatment barges suggests that the market implications are significant, i.e. will have a measurable effect. Further, that effect will be most felt by a small percentage of marine vessels, on exported cargo, and at smaller and remote ports.

Section 2 Introduction

This report is part of an overall coordinated study evaluating the feasibility of using shore-based mobile or permanent ballast water treatment facilities to meet California's Interim Ballast Water Discharge Performance Standards (CA Interim Standards). This report is presented to the Delta Stewardship Council to meet the objectives of Task 12 – Market implications. Description of the overall study can be found in Appendix A, along with definitions for terms used in this study.

This report (Task 12) discusses potential shipping market implications/repercussions in response to statewide implementation of shore-based (i.e. barge-based) ballast water reception and treatment in California.

Section 3 Analysis Methodology

Treatment barge network costs provided in the Task 10 report along with cargo volume estimates presented below are used to develop unitized cost estimates that provide the basis for considering market implications. Task 10 also provides costs for marine vessel outfitting and operations. These costs also have market implications because they raise costs and break-even charter rates for vessels qualified to operate in California.

3.1 NBIC Database

The NBIC database was accessed to identify vessels that actually discharged ballast water in California. These vessels were then categorized by type and discharge location. This was repeated for all vessel types and port locations in order to identify the range of vessel cargo capacities associated with vessels known to discharge ballast water in California.

3.2 Cargo Capacities

These vessels were then examined on shipping company web-sites and other shipping industry websites, such as vesseltracker.com in order to gain cargo metrics. For example, a search for containerships calling on Long Beach that discharge ballast water identified vessels ranging from the *Matsonia* to the *COSCO Fortune*. The Matson website lists the *Matsonia* capacity at 1,712 TEU and 450 Autos, and containership-info.com lists the *COSCO Fortune* capacity at 13,100 containers.

3.3 Vessel Specific Metrics

The initial review considered the cost for a treatment barge service, on average, to the cargo capacity of the largest and smallest vessel in each zone by vessel type. This provided reasonable metrics for passengers and automobiles.

The metric was also applied to containerships, and resulted in a very wide range per TEU as the TEU capacities of the various vessels examined were broad ranging. In the above example, the per TEU cost of treatment for the *Matsonia* would be $21.47 ($36,751 divided by 1,712) which is 7.6 times higher than the per TEU cost of treatment of $2.81 for the COSCO Fortune ($36,751 divided by 13,100). Of course these assume the same cost for the barge and that each ship takes a full load of containers.

To account for those assumptions, a more general container TEU cost model was developed. This compared the total outbound TEU quantities to the total number of ballast water discharges associated with containerships in those ports. Ports of LA and LB see an estimated 3.8 million outgoing TEU each year. When considering 143 ballast water discharges from containerships at $36,751 per discharge event, this reduces to $1.38 per TEU. This is low, however, because not all containerships taking outbound containers had to discharge ballast water.

For bulk carriers and tankers, a general rule of thumb was used that 1 ton of ballast water needs to be discharged for each 3 or 4 tons of cargo loaded. In other words, the cost per ton of ballast water treated by treatment barge zone was divided by 3 and 4 to get the high and low range of treatment costs per metric ton of cargo.

Section 4 Costs on Unit of Goods Basis

Cargo metrics are provided in the tables below. Table 1 provides unit costs by zone location. Notice that San Diego is an outlier because there are so few discharge events and such low discharge volumes that the unit cost of providing treatment is extremely high.

Table 1 Zone cargo metrics

		Zone 1 SF North	Zone 2 SF South	Zone 3 Carq. Suisun	Zone 4 Stockton	Zone 5 LA/LB	Zone 6 San Diego
Discharges, Number	*(#/yr)*	236	236	259	88	915	28
Discharges, Volume	*(MT million)*	1.94	1.77	2.54	1.11	5.42	0.034
Volume per Discharge, Average	*(MT/disch)*	8,220	7,500	9,807	12,614	5,923	1,214
Cost per Discharge	*($/disch)*	61,593	60,295	62,282	116,414	36,751	118,321
Cost per Volume	*($/MT)*	7.49	8.04	6.35	9.23	6.20	97.44

Note that these costs reflect the estimated $1.45 billion 30-year lifecycle cost for running the network of treatment barges. The costs do not include the marine vessel modifications and operating costs which are estimated at a $2.17 billion 30-year lifecycle cost. In other words, if all costs were reflected in per unit cargo metrics, these metrics would be (2.17/1.45) 150% higher. These costs also do not include any profit for the treatment barge operators who may face significant investment risks. If they are not able to reduce or share some of these risks, their expected return on investment for these risky investments could add an additional 20% to 30% to the cost per discharge and cost per volume presented here.

4.1 Tankers and Bulkers

Costs to bulkers and tankers can be reliably estimated because there is a fairly narrow ratio of ballast water discharged per ton of cargo loaded, typically between 3:1 and 4:1 cargo to ballast water. In other words, for every 3 to 4 tons of cargo loaded, 1 ton of ballast water needs to be discharged. This establishes the unit cost of ballast water treatment per ton of cargo loaded in each zone which, when applied to typical shipping operations, for example, would be between $127,200 and $169,600 for a tanker loading 80,000 tons of cargo in Zone 3.

Table 2 Zone cargo metrics for bulkers and tankers

		Zone 1 SF North	Zone 2 SF South	Zone 3 Carq. Suisun	Zone 4 Stockton	Zone 5 LA/LB	Zone 6 San Diego
Bulker and Tanker	***($/MT)***						
High Volume	*(Cargo/Ballast)*	4	4	4	4	4	4
Low Volume	*(Cargo/Ballast)*	3	3	3	3	3	3
Low Cost	*($/MT)*	1.87	2.01	1.59	2.31	1.55	24.36
High Cost	*($/MT)*	2.50	2.68	2.12	3.08	2.07	32.48

4.2 Containers

As noted above, it is more difficult to estimate the potential cost of treatment per container being shipped than per ton of bulk cargo being shipped. The below table first presents ship capacity based on discharges and then estimates costs assuming that the cost of using the treatment barge is applied evenly to all containers on board. Given the large range of containership TEU capacity and the relatively fixed cost of the treatment barge servicing marine vessels, this results in significant potential variability in treatment costs per TEU for various size containerships.

For example, ignoring San Diego as an outlier, the range in treatment costs per container varies between $2.55 and $37.08 per TEU. Based on outbound containers, the range narrows a bit, to $1.38 and $7.24 per TEU. Zones where there are typically no discharges from this vessel class were not evaluated.

Table 3 Zone cargo metrics for containerships

		Zone 1	Zone 2 SF South	Zone 3	Zone 4	Zone 5 LA/LB	Zone 6 San Diego
Containers (ship capacity)							
High Volume	*(TEU/event)*		8,721			14,414	1,400
Low Volume	*(TEU/event)*		1,626			1,304	1,400
Low Cost	*($/TEU)*		6.91			2.55	84.52
High Cost	*($/TEU)*		37.08			28.18	84.52
Containers (port throughput)							
Annual Container Discharges	*(events/yr)*		72.00			143.00	
Cost of those Discharges	*($/event)*		4,341,254			5,255,346	
Annual Outbound TEUs	*(TEU mill/yr)*		0.60			3.80	
Cost per TEU	*($/TEU)*		7.24			1.38	

4.3 Automobiles

Like containers, it is important to consider the metrics of estimating these per-unit costs. The table below uses the capacity of the marine vessel in car equivalent units (CEUs), and applies this to the cost for a treatment barge in that zone for one event. The variability is due to the range of car carrier capacities, resulting in a range between $6.68 and $30.63 per automobile.

Table 4 Zone cargo metrics for car carriers

		Zone 1 SF North	Zone 2 SF South	Zone 3 Carq. Suisun	Zone 4 Stockton	Zone 5 LA/LB	Zone 6 San Diego
Automobiles							
High Volume	*(CEU/event)*	8,000	8,000			5,500	1,200
Low Volume	*(CEU/event)*	8,000	8,000			1,200	1,200
Low Cost	*($/CEU)*	7.70	7.54			6.68	98.60
High Cost	*($/CEU)*	7.70	7.54			30.63	98.60

4.4 Passengers

The table below states the capacity of passenger carrying marine vessels in terms of numbers of passengers and uses this measure of capacity to estimate cost per capacity for one ballast water discharge event in each zone. The variability in costs shown per passenger is due to the range of cruise ship passenger capacities, which results in a cost range between $17.48 and $123.05 per passenger. The passenger capacity ranges were identified by searching the NBIC database for all passenger ship ballast water discharges over the past five years, aligning those with the relevant zones, and identifying the range of passenger capacities for those vessels.

Table 5 Zone cargo metrics for cruise ships

		Zone 1 SF North	Zone 2 SF South	Zone 3 Carq. Suisun	Zone 4 Stockton	Zone 5 LA/LB	Zone 6 San Diego
Passengers (Cruise)							
High Volume	*(passengers)*		3,450			3,450	3,100
Low Volume	*(passengers)*		490			1,070	2,000
Low Cost	*($/person)*		17.48			10.65	38.17
High Cost	*($/person)*		123.05			34.35	59.16

Section 5 Market Impact Considerations

Any increase or decrease in shipping costs at a particular port could affect the number of ships using that port, the amount of cargo passing through that port, and markets for port services at that port. Vessel costs to install a transfer station to discharge ballast water to a treatment barge puts all California ports at a competitive disadvantage with respect to non-California ports. Ballast water treatment costs at California ports could have similar market impacts and may vary widely enough to result in shipping activity shifting from one California port to another.

For example, if it costs an additional $3.08 per metric ton to ship grain out of Stockton to pay for a ballast water treatment service at that port, there can be a range of possible market impacts, including:

- No impact: demand for grain shipment out of that port is "inelastic" and <u>does not respond to changes</u> in shipping costs. This may be the case, for example, if this cost increase is relatively small with respect to grain cargo value or if regional grain shippers do not have access to other shipping options and will cover shipping companies costs, or if the grain being shipped is part of a charitable or government aid program that covers all shipping costs.
- A reduction in shipment quantities; that is, a reduction in shipment volume that could reflect the relationship between the new fee per unit cargo and the value of the cargo. For example, if $3.08 per metric ton of ballast water treated is 10% or 20% of the cargo value for grain shipments out of Stockton it may be reasonable to assume that it will result in a reduction in grain shipments through Stockton.
- Cargo shipment routes will get diverted to more cost-effective routes considering both port-specific ballast water treatment costs and additional time and costs associated with diverting ships and shipments to other ports. This would primarily impact discretionary cargo movements, i.e. shipments from the mid-west that are currently shipped through California ports, but could also be shipped out of a Gulf coast or East coast port.
- Cargo shipments might not happen at all. This could be the case for time sensitive agricultural products that are being sold at low margins. If an increase in shipping costs made them unprofitable, and alternative routes took longer than acceptable, such goods might not be shipped at all.

The following sections address what is likely to be the most important factor that will determine how the California treatment barge network will impact the amount of cargo handled at California ports; that is the ratio of treatment costs to cargo value. This ratio reflects how much ballast treatment will increase the costs of goods shipped out of California ports. The next sections considers the increase in shipping costs relative to shipping day rates and elasticity.

5.1 Percentage of Cost of Goods

Any increase in the cost of shipping through a particular port will shift the demand for shipping through that port. This section presents estimates of new treatment costs at California ports as a percent of the value of goods shipped on marine vessels that discharge ballast water in California ports and will be required to pay for new treatment costs. Market impacts are expressed as none, low, moderate, or high based on the ratio of treatment costs to cargo value which is presented as a percent, and subjective consideration on the elasticity of that cargo. This is intended to show that impacts are likely to be highly variable based on the cargos, and not be a definitive answer on the extent to which various cargos will or will not be impacted.

Table 6 Treatment costs as percentage of cargo value

		Ballast Cost	Cargo Value	Percentage	Market Impact
		($)	($)	(%)	
Automobile	*(CEU)*	11.30	35,000	0.03%	Low
Container	*(TEU)*	18.68	100,000	0.02%	None
Passenger	*(trip)*	46.38	800	5.80%	Moderate
Wheat	*(m.ton)*	2.18	440	0.50%	Low
Crude Oil	*(m.ton)*	2.18	390	0.56%	Low

At this time the predicted market impacts are illustrative only. It seems that 5.8% increase in the cost of a cruise, as shown above, could shift a decision to instead stay at home or pursue an alternative vacation, so this is labelled as having market impacts that are “moderate.”

On the other hand, an increase of 0.5% in the cost of wheat shipped out of a port is likely to be noticed, but perhaps not have a significant impact on decision making, so the market impact is labelled as “low”. An increase in the cost of goods shipped in a container or the cost of an automobile of less than 0.5% is barely noticeable and so is shown here to have no impact.

This is also intended to show that the same percentage could have different impacts for different cargos. A 0.03% cost for automobiles could shift some of those to less expensive Pacific Northwest ports, where a similar cost for non-discretionary containers would have no impact.

5.2 Comparison to Shipping Day Rates

The cost for a ballast water treatment barge to service a marine vessel is high relative to the day rates for many of the marine vessels that will be charged for this services. This is especially true in the bulk petroleum and dry bulk cargo markets where day rates (price they charge per day for crew and use of vessel) are many times less than estimated ballast water treatment costs.

		Ballast Cost	**Day Rate**	**Time**	**Market Impact**	**Alternative Action**
Vessel Type	**Zone**	($/call)	($/day)	(days)		
Car Carrier	2	60,295	35,000	1.7	Low/None	
Car Carrier	6	118,321	35,000	3.4	Moderate	Divert to another CA port
Containership	1	61,593	35,000	1.8	Low	Divert to another CA port
Containership	5	36,751	35,000	1.1	None likely	
Cruiseship	5	36,751	120,000	0.3	None likely	
Bulker	4	116,414	12,000	9.7	High	Divert away from CA, or another CA port
Bulker	5	36,751	12,000	3.1	Moderate	Divert away from CA
Tanker	3	62,282	16,000	3.9	Mixed	If discretionary, divert
Tanker	5	36,751	16,000	2.3	Mixed	If discretionary, divert

The table above presents various shipping day rates and ship steaming time in days from selected treatment zones to alternative ports and compares the cost of steaming to other ports to the costs of the treatment barge in various zones.

The table then compares that cost to the day rate of the representative ship. A day rate is the fee that ships charge per day for their services, excluding fuel oil. For example, a bulker discharging ballast water in Stockton would be charged $116,414 for the ballast water service. The current day rate for bulkers is estimate at $12,000 per day (Bloomberg.com, BDI Index on 20 September 2017 at 1,149). This means that the bulker could spend an additional ($116,414 / $12,000) 9.7 days in transit if it was able to avoid that additional fee. Where there are viable alternatives, i.e. 10 days for a bulker to sail to an alternate port, then an impact is noted and possible alternative action suggested.

5.3 Shipping Elasticity

A 2007 study (Reference 9) of the ports of LA/LB linked cargo movement elasticity to the percentage of shipping costs. While the findings were focused on that port system, and specifically the container trade, the illustration is reasonable to consider statewide. The study suggests:

- Discretionary cargo (cargo that can be moved through alternative corridors) is elastic. This means that a 10% increase in cost results in a 10% decrease in volume.
- Nondiscretionary cargo (cargo that must move through its current corridor) is less elastic at 0.3, meaning that a 10% increase in cost results in a 3% decrease in volume.

Figure 1, below, shows shipping costs in 2007 for containers. Today's container shipping rates are much lower, suggesting that smaller changes in shipping costs can have bigger impacts on volumes. When considering that a treatment barge service could add an average of $18.68 per TEU ($37.36 per marine container) the 2007 study would suggests that volumes could be reduced by ($37.36 / $3,750) 1% for discretionary containers and ($37.36 / $3,200 * 0.3) 0.3% for non-discretionary container movements.

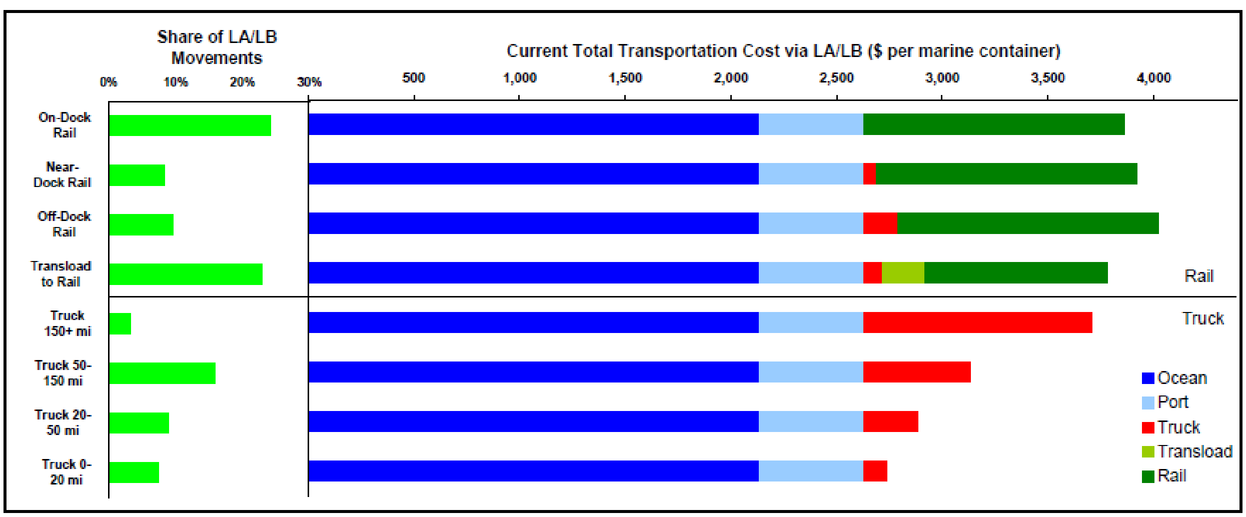

Figure 1 Summary of container transportation costs for ports of LA/LB (Moffatt & Nichol 2007, Reference 9)

Appendix A Study Overview and Definitions

Study Overview

Marine vessels routinely uptake ambient sea or harbor water as ballast, transit to another port, and then discharge that ballast water. Unfortunately, the resulting ballast water discharges have been linked to the introduction of aquatic invasive species and harmful pathogens. In an effort to reduce or possibly eliminate further introductions, marine vessels are being required to manage ballast water discharges by a myriad of international, federal, and regional guidelines and rules. Vessels discharging in California will be required to meet an interim standard that is more stringent than international and US federal standards.

In response, there has been significant development work and commercial installations of ballast water management systems (BWMS) onboard marine vessels themselves. However, there is a lack of data to determine if shipboard BWMS are capable of meeting the CA Interim Standards. Therefore, shore-based ballast water reception and treatment is under consideration as an approach to meet the CA Interim Standards.

This study evaluates the feasibility of shore-based ballast water reception and treatment in 13 separate tasks, beginning with a review of shore-based treatment research, followed by a series of detailed analyses, including: permitting and legal requirements, detailed cost estimates, timeline to implementation, and market implications.

Tasks Overview

Tasks 6 through 13 are submitted together to discuss the practical implementation of shore-based ballast water reception and treatment throughout California state waters, accomplished by a "network" of six (6) independently operating fleets of mobile treatment barges (see Table A-1).

During the course of this study, following completion of Tasks 2-5 and the comparative scale-up exercise described in Reference 7, this approach was deemed most technically, operationally, and financially feasible of the five approaches that were evaluated (i.e. new onsite treatment facility, new offsite treatment facility, existing wastewater treatment facility, shore-side mobile treatment, mobile marine vessel-based treatment).

Table A-1 Tasks 6 through 13

Task	Description
6	Assessment of construction related to outfalls for treated ballast water discharges, and provision for disposal of solids as needed.
7	Summarize pertinent permitting and legal requirements.
8	Comparative review of shipboard vs. barge-based ballast water management operations.
9	Assessment of current practices related to ballast water discharges in California.
10	Cost analysis.
11	Implementation timeline.
12	Market implications.
13	Other analysis and findings. Introduces the concept of a statewide network of mobile treatment barges for the provision of ballast water reception and treatment services across the state, and forms the basis for assessments and analyses in Tasks 6-12.

Definitions

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
ASTM	An international standards organization.
ATB	Articulated Tug Barge
AWL	Height Above Waterline
AWWA	American Water Works Association
Ballast Water	Water taken on by a ship to maintain stability in transit.
Ballast Water Exchange	The process of exchanging a vessel's coastal ballast water with mid-ocean water to reduce concentration of non-native species in accordance with regulatory guidelines.
Ballast Water Management	The entire process of treatment and handling of a ship's ballast water to meet regulatory requirements and prevent spread of non-native species.
BMPF	Ballast Manifold Presentation Flange
Booster Pump	Pump, typically centrifugal, that adds additional pumping force to a line that is already being pumped.
BWDS	Ballast Water Discharge Standards
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWMS	Ballast Water Management System
BWTP	Ballast Water Treatment Plant
BWTB, BWT Barge	Ballast Water Treatment Barge
BWTS	Ballast Water Treatment System
Capture	Capture is the method by which ballast water is transferred onto or off a marine vessel.
CD	Chart Datum
CFU	Colony Forming Units
CMSA	California Marine Sanitation Agency
DAF	Dissolved Air Floatation
DIN	Deutches Institut für Normung (German Institute for Standardization)
Discharge	Discharge of ballast water is the method by which post-treatment ballast water is disposed of in compliance with applicable standards and regulations.
DOC	Dissolved Organic Carbon
DWT	Deadweight Tonnage
EPA	Environmental Protection Agency (US, unless otherwise noted)
Filtrate	Water that has been separated from any particulate matter (used to clean ballast water treatment filters).

GA	General Arrangement
GM	Metacentric height (a measure of a ship's stability).
gpm	Gallons per minute. Any measurements quoted in gallons of ballast water per minute will also be shown in MT of ballast water per hour, or MT/h.
HDPE	High-density Polyethylene
IMO	International Maritime Organization
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards (organization)
L	Liter
Lift Station	Means of receiving a liquid, typically from a drain or low-pressure piping, and 'lifting' it with pump(s) to a different location such as a remote tank.
Lightering	Cargo transfer between vessels, commonly practiced to reduce a vessel's draft before entering port.
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MARPOL	International Convention for the Prevention of Pollution from Ships
MF	Microfiltration
mg	Milligram
MG	Millions of gallons. Any measurements quoted in MG of ballast water will also be shown in MT of ballast water.
MGD	Millions of Gallons/Day
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MPA	Megapascal (unit of pressure)
MSL	Mean Sea Level
MT	Metric tons. One cubic meter of seawater is roughly equivalent to 1.025 MT, but this value varies depending on temperature and salinity of the water. In this report, conversions between volume and weight of seawater are merely approximate and assume 1 m3 of seawater has a mass of roughly 1 MT, for convenience.
Navy Mole	A man-made peninsula in the Port of Long Beach that flanks entrance to the middle and inner harbor
NBIC	National Ballast Information Clearinghouse
NOM	Natural Organic Matter
Non-native Species	Species that are not indigenous to a particular region. Non-native species can be introduced to marine ecosystems through a ship's ballast water. "Invasive" species are non-native species with the potential to cause harm to the environment or human health.
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit

NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance (cost)
OCIMF	Oil Companies International Marine Forum
POTW	Publicly Owned [Wastewater] Treatment Works
PSU	Practical salinity units.
Residuals	Particulate matter collected from cleaning ballast water treatment filters.
ROM	Rough Order of Magnitude (cost)
Ro-ro	Roll-on/roll-off (vessels designed to carry wheeled cargo such as car, trucks, trailers, and equipment)
RWCF	Regional Wastewater Control Facility (e.g. City of Stockton, CA)
Shipboard Ballast Water Treatment	Ballast water management approaches that do not require support from shore-based infrastructure and are conducted entirely by a vessel's crew.
Shore-Based Ballast Water Management	Ballast water management approaches that require support from shore-based infrastructure in order to meet ballast water management requirements. Such infrastructure may include: means of transferring ballast water to a land-based or another marine vessel facility for storage and/or processing, deployment of shore-based equipment and personnel for onboard treatment approaches, etc.
Slurry	Mixture of filtrate and filter residuals resulting from cleaning ballast water treatment filters.
Slurry Handling	Slurry handling includes activities related to the storage, treatment, and discharge of filtrate and residuals collected from cleaning ballast water treatment filters.
SOLAS	International Convention for Safety of Life at Sea
Storage	Storage of ballast water includes provision of space and containment for ballast water, either pre-or post-treatment.
STS	Ship-to-Ship. Transfer from one marine vessel to another.
TDS	Total Dissolved Solids
TEU	Twenty-foot Equivalent Unit
TOC	Total Organic Carbon
Transfer	Ballast water transfer considers the logistics and equipment required to capture the ballast water from the marine vessel and transport to a reception and treatment facility.
Transport	Transport is the method by which ballast water is moved post-capture from marine vessels to remote, non-mobile reception and treatment facilities – either land-based or otherwise.
Treatment	Treatment includes the various methods to process ballast water such that it is suitable for discharge in compliance with applicable standards and regulations.

Treatment Approach	A general method for implementing ballast water treatment. Treatment approaches may include mobile systems, land-based facilities, shipboard systems, etc.
Treatment Technology	Specific techniques for removal or inactivation of organisms in ballast water (e.g., UV disinfection, filtration, ozonation, etc.)
TRO	Total Residual Oxidant
TSS	Total Suspended Solids
UF	Ultrafiltration
UKC	Underkeel Clearance
UL	A global independent safety consulting and certification company (formerly Underwriters Laboratories).
USCG	United States Coast Guard
UV	Ultraviolet Light
UVT	UV Transmittance
VLCC	Very Large Crude Carrier
WWTF	Waste Water Treatment Facility
WWTP	Waste Water Treatment Plant