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DELTA STEWARDSHIP COUNCIL

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SHORE-BASED BALLAST WATER TREATMENT IN CALIFORNIA

TASK 6: OUTFALLS FOR TREATED BW DISCHARGE

PREPARED FOR

DELTA STEWARDSHIP COUNCIL
SACRAMENTO, CALIFORNIA

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Revision History

Section	Rev	Description	Date	Approved
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References

1. *Shore-Based Ballast Water Treatment in California, Task 2: Assessment of Retrofitting Vessels,* Glosten, 4 August 2016.
2. *Shore-Based Ballast Water Treatment in California, Task 3: Assessment of Retrofitting Ports and Wharves,* KPFF Consulting Engineers, 4 August 2016.
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5. National Ballast Information Clearinghouse, Smithsonian Environmental Research Center & United States Coast Guard, http://invasions.si.edu/nbic/, accessed 11 April 2015.
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7. *Shore-Based Ballast Water Treatment in California: Memorandum on Scale-up of Land-based and Barge-based Alternatives*, Glosten, 6 April 2017.
8. Panel Comments on *Memorandum on Scale-Up of Land-based and Barge-based Alternatives*, Delta Science Program Independent Review Panel for the Feasibility Study of Shore-Based Ballast Water Reception and Treatment Facilities in California, 4 May 2017.
9. *Vessels-VGP,* National Pollutant Discharge Elimination System (NPDES) website, United States Environmental Protection Agency, epa.gov/npdes/vessels-vgp, accessed 19 September 2017.
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Executive Summary

Marine vessels currently discharge ballast water into California water while alongside docks during cargo operations, at anchorages, and while underway. The "outfalls" from these marine vessel ballast water discharges are pipes that terminate at the vessel's steel hull where the ballast water is introduced to the receiving waters. Marine vessels discharge an estimated 3 to 4 billion gallons annually into California state water in this manner (~13.5 million metric tons).

As described in Task 13, a treatment barge network is proposed as a practical means to receive these discharges and process them to meet California's Interim Ballast Water Discharge Performance Standards (CA Interim Standards). In this process, marine vessels will continue to discharge ballast water alongside docks and at anchorages, however underway discharges would no longer be practical. What will change is that the ballast water will now flow first into the treatment barges for processing, and then discharged into the receiving waters.

From the perspective of outfalls, there will be no substantial change in volumes, discharge rates, geographic locations, water depths, or velocities from current operations. The discharges will however, be somewhat "cleaner" than current operations given the concept treatment plant envisioned for the treatment barges. Most suspended solids will be removed and the biological organism loading will be all but eliminated. The general water chemistry, however, will essentially remain the same with no significant expected changes to pH, temperature, or conductivity.

One result, however, of this "cleaner" discharge is that solids will be collected in the process that must be disposed to landfills. The solids portion will be the majority of the suspended solids entrained in the ballast water discharges. This includes particulate organic and inorganic material, in other words large and tiny debris from living and non-living sources. The treatment process will collect no significant portion of dissolved materials, in other words salt will not be collected in the process. These solids will be collected through coagulation, flocculation, and then settling. In the coagulation step, additional material is added to the process to increase particulate binding. The settled solids will then be concentrated such that the resulting slurry is 20% solids and the remainder seawater. A ballasting event of 10,000 metric tons, for example, is expected to produce ~2 metric tons of slurry with a disposal cost of ~$710. These solids would be transferred to a tank truck and disposed at a landfill permitted for such operations.

The resulting treatment barge outfalls will be similar to the existing marine vessel outfalls. It is possible that with additional monitoring of these outfalls, the community will become more aware of existing contaminants in these ballast water discharges. While the treatment barge can collect the suspended solids contaminants, it may not be practical to remove existing dissolved pollutants.

The resulting solids are expected to be acceptable for non-specialized landfills. There are no expected pollutants in the solids that will exceed non-specialized landfill requirements. There will be no concentration of salt or other dissolved materials from the treatment process. Most of the material will be a mixture of organic and inorganic debris combined with coagulants. The resultant solids are not expected to be of high caloric value, and as such standard landfill disposal is recommended and not disposal into digesters to produce methane. However, when ships uptake ballast water in contaminated port locations, perhaps in foreign locations, hydrophobic contaminants may be contained in the ballast water and therefore concentrated on the resulting ballast treatment solids. As such, the solids should be monitored for special disposal.

The implementation of a shore-based network of treatment barges will face a significant permitting process. Risks include: freshwater ports do not receive the required discharge permits, required changes to outfalls and treatment plants result in schedule delays, and cost overruns. That noted, there is a known permitting process and if diligently executed there is a reasonable expectation of success.

Section 1 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 the CA Interim Standards. This report is presented to the Delta Stewardship Council to meet the objectives of Task 6 – Assessment of construction related to outfalls for treated ballast water discharges, and provision for disposal of solids as needed. Description of the overall study can be found in Appendix A, along with definitions for terms used in this study.

This report (Task 6) discusses overboard discharges of treated ballast water from mobile treatment barges, and disposal of residual solids from the filtration and treatment processes. There is significant cross-referencing with Task 13 – Other Analysis, which introduces the treatment barge concept upon which this report is based.

Section 2 Background

This section provides background information helpful in assessing the new material presented in later sections.

2.1 Treatment Barge, Network

Task 13 presents a treatment barge network. This is only one example arrangement of zones. This example aligns zones based on ballast water discharges and physical distances. A different concept would be to align the zones with the California Water Board districts. The below table and figures outline the currently conceived zones.

Table 1 BWTB zone summary

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Medium Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Barges
Zone 1	San Francisco Bay (North Part) and Humboldt Bay	1	1	2	4
Zone 2	San Francisco Bay (South Part) and Monterey Bay	2	-	2	4
Zone 3	Carquinez Strait and Suisan Bay	1	1	2	4
Zone 4	Stockton	-	1	2	3
Zone 5	Los Angeles/Long Beach and Vicinity	3	1	3	7
Zone 6	San Diego	2	-	-	2
TOTALS		**9**	**4**	**11**	**24**

Zone boundaries are shown in Figure 1 and Figure 2.

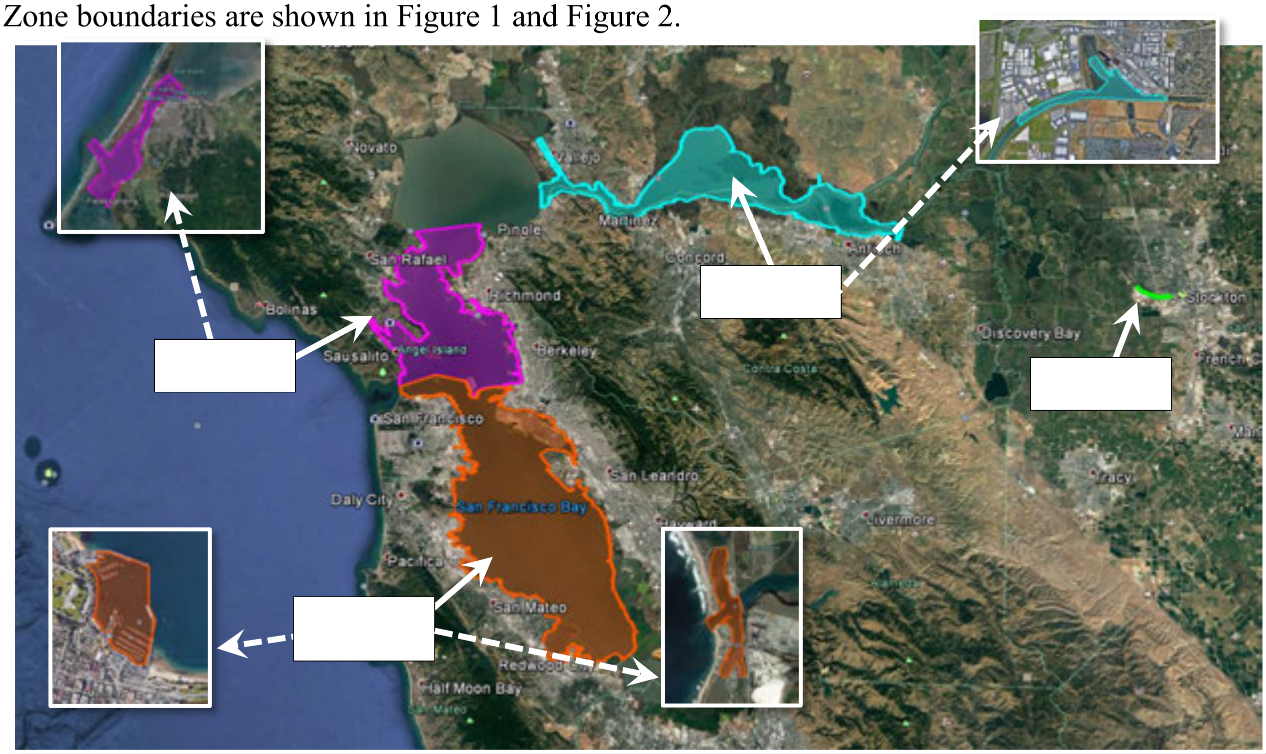

Figure 1 Google Earth capture showing barge network Zones 1-4, with their respective "satellite" areas overlaid

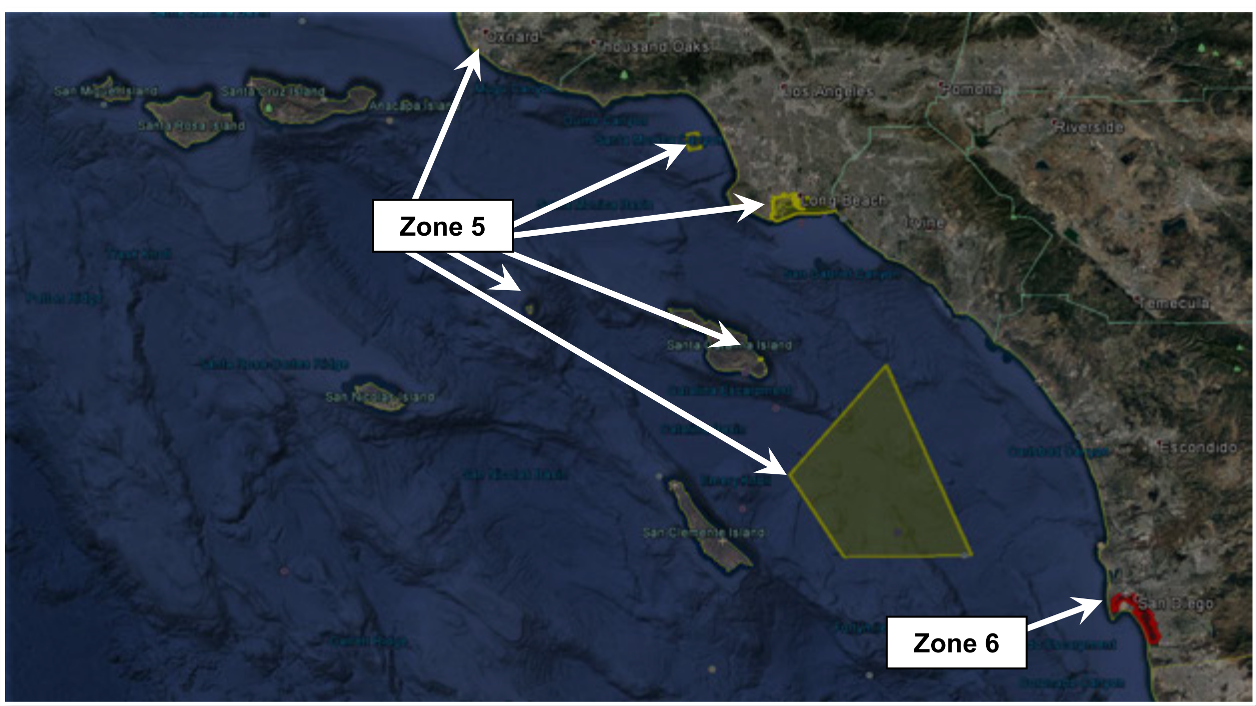

Figure 2 Google Earth capture showing barge network Zones 5 and 6

Section 3 Marine Vessel Discharges

3.1 Geographic Location and Statewide Volumes

Marine vessels currently discharge ballast water into California water while alongside docks during cargo operations, at anchorages, and while underway. Marine vessels discharge an estimated 3 to 4 billion gallons annually into California state water in this manner (~13.5 million metric tons). These discharges are dispersed throughout the port and harbor locations in the state. The table below provides an annual summary discharges by number of events and treatment barge zone locations. Barge sizes and numbers are based on trend analysis performed in Task 13, ensuring 99% availability to services existing ship discharges without delay.

Table 2 Zone annual operating particulars

	Zone 1 SF North	Zone 2 SF South	Zone 3 Carq. Suisun	Zone 4 Stockton	Zone 5 LA/LB	Zone 6 San Diego	Totals
Discharges, Number	236	236	259	88	915	28	1,762
Discharges, million MT	1.94	1.77	2.54	1.11	5.42	0.03	12.81
Barges, Number	4	4	4	3	7	2	24
Port Distance, Nautical miles	15	23	27	3	18	9	95

Stockton, for example, will see 88 discharges in a year, with each discharge averaging 12,600 metric tons (3.3 million gallons). These discharges occur over about 10 hours, and then on average do not occur again for another four days. These discharges can occur at several locations stretching along about three nautical miles of river that compromise the deep water docks in the Port of Stockton. The Port of Long Beach is another example, part of Zone 5. As seen in the figure below, marine vessels discharges occur throughout a port complex, and are not necessarily concentrated in one "outfall" location.

Figure 3 Aerial view of Port of Long Beach, showing geographic spread of discharge locations (photo Bruce Perry, CSU Long Beach)

3.2 Marine Vessel Outfalls, Physical Description

The "outfalls" from these marine vessel ballast water discharges are the ballast water that is discharged through pipes that terminate at the vessel's steel hull where the ballast water is introduced to the receiving waters. These pipes might be in any number of configurations that impact the near-field mixing effects. For example:

- The vertical distance above the water varies significantly, depending on vessel design and draft of the vessel at the time of discharge.
- Overboard pipes above the waterline result in a plunging discharge that is projected out of the vessel's hull and drops into the receiving water.
- Overboard pipes below the waterline, less common, result in a jet mixing effect local to the discharge location.
- Some vessels may discharge through their sea chests, which are steel boxes fit into vessel hull typically at the bilge turn, i.e. bottom of the ship. This is common for bulk carriers.

The below table provides a range of ballast water discharge volumes and rates from typical vessel types. In addition, it estimates the distance above or below the waterline and the estimated pressure of that overboard flow. Figures follow that orient the overboard piping locations in relation to a typical ship, and then show a variety of images of marine vessel outfalls, i.e. overboard discharges.

Table 3 Summary of interfaces by vessel type for shore-based ballast connections

	Ballast Water		Hull Fitting (typical)			
	Capacity	**Rate**	**AWL Deep**	**AWL Light**	**Press Deep**	**Press Light**
Vessel Type	*(m3)*	*(m3/hr)*	*(m)*	*(m)*	*(kPa)*	*(kPa)*
ATB Tanker	20,000	1,700	-1.70	3.80	220	190
Tankers	41,000	3,400	-0.70	8.30	280	410
Bulk Carriers	33,000	2,800	-1.20	7.20	250	350
Containerships	42,000	2,300	-2.90	5.40	360	390
Cruise ships	4,000	300	3.00	3.60	290	250
Car Carriers	13,000	700	3.00	6.10	250	90

<u>Table Notes:</u>

Figures were developed to represent 95% of vessels within a type and class. Vessels outside of this range will require special consideration.

Overboard distances are given above water line (AWL) for the in ballast (Light) and laden with cargo (Deep) conditions. Assumes overboard is at 2/3 depth of hull depth.

Cruiseships and car carriers use watertight deck cut-outs for bunkering stations. In general, these stations are three meters above the water line, but vary based on arrangement.

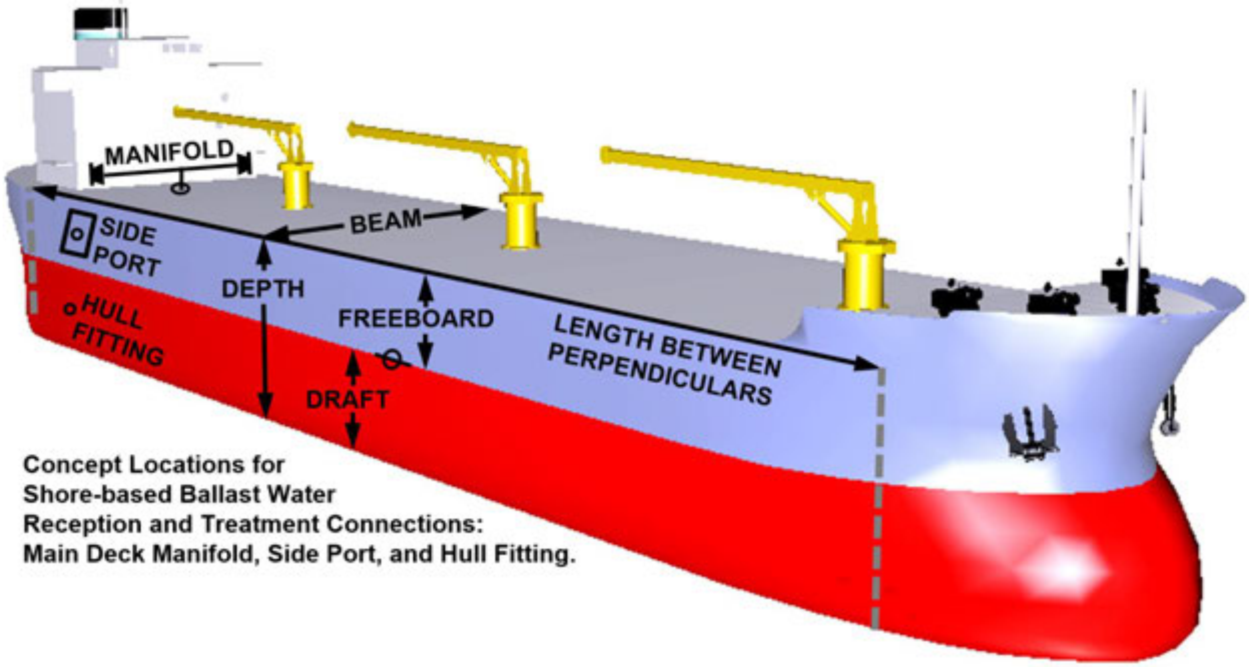

Figure 4 Marine vessel diagram showing a typical hull fitting where ballast water would be discharged; side port and manifold locations are proposed for transfer to treatment barges

Figure 5 Overboard discharge from tankship located at deep water line; vessel is light and in ballast, so overboard is above water line; fully laden with cargo, and overboard would be at the water line

Figure 6 Bulk carrier discharging ballast through sea chest, well below water line

Figure 7 Very large crude oil carrier discharging ballast from multiple overboard pipes (image, wikimedia commons accessed 19 September 2017)

Section 4 Outfalls, Proposed Treatment Barges

As described in Task 13, a treatment barge network is proposed as a practical means to receive these discharges and process them to meet the CA Interim Standards. In this process, marine vessels will continue to discharge ballast water alongside docks and at anchorages, however underway discharges would no longer be practical. What will change is that the ballast water will now flow first into the treatment barges for processing, and then discharged into the receiving waters.

4.1 Treatment Barge Outfalls, Ballast Volumes and Flow Rates

The treatment barges will receive ballast water from the marine vessels, process that ballast water, and then discharge directly into the receiving waters. While the treatment barges have some surge capacity, it is not practical for them to collect all of the ballast water from most of the ballast water discharges. For this reason, the treated ballast water is discharged in the same location, rates, and volumes as where the marine vessel would have been discharging had there been no treatment barge. The table below provides a summary of the volumes and rates that each of the treatment barges can process the ballast water, including a surge capacity for some reception capacity.

Table 4 Standardized barge designs for service in California

BWTB Design	Small Barge	Medium Barge	Large Barge
Service Capacity			
Ballast Volume	10,000 m^3	20,000 m^3	35,000 m^3
Particulars			
Length	200 ft	240 ft	280 ft
Breadth	62 ft	74 ft	84 ft
Summary Totals			
Treatment Plant, Rate	721 m^3/hr	1,450 m^3/hr	2,570 m^3/hr
Surge Capacity, Volume	2,789 m^3	5,502 m^3	9,297 m^3

4.2 Treatment Barge Outfalls, Treatment Process

The discharges from the treatment barges will be somewhat “cleaner” than current discharges from marine vessel operations given the concept treatment plant envisioned for the treatment barges. Most suspended solids will be removed and the biological organism loading will be all but eliminated. The general water chemistry, however, will essentially remain the same with no significant expected changes to pH, temperature, or conductivity.

The figure below provides a notional arrangement of the typical treatment barge. The treatment process includes flocculation tanks (Step 3 in notional design above) where solids are combined with a flocculent material for ease of separation. Plate settlers (Step 4) collect these solids in a wet slurry. The wet slurry is concentrated by centrifuges with the watery effluent returned to the flocculent tanks and the concentrated slurry, estimated at 20% solids, stored for later disposal. The separated water stream is then passed through membrane filtration (Step 5) and UV disinfection (Step 6), before being discharged overboard (Step 7).

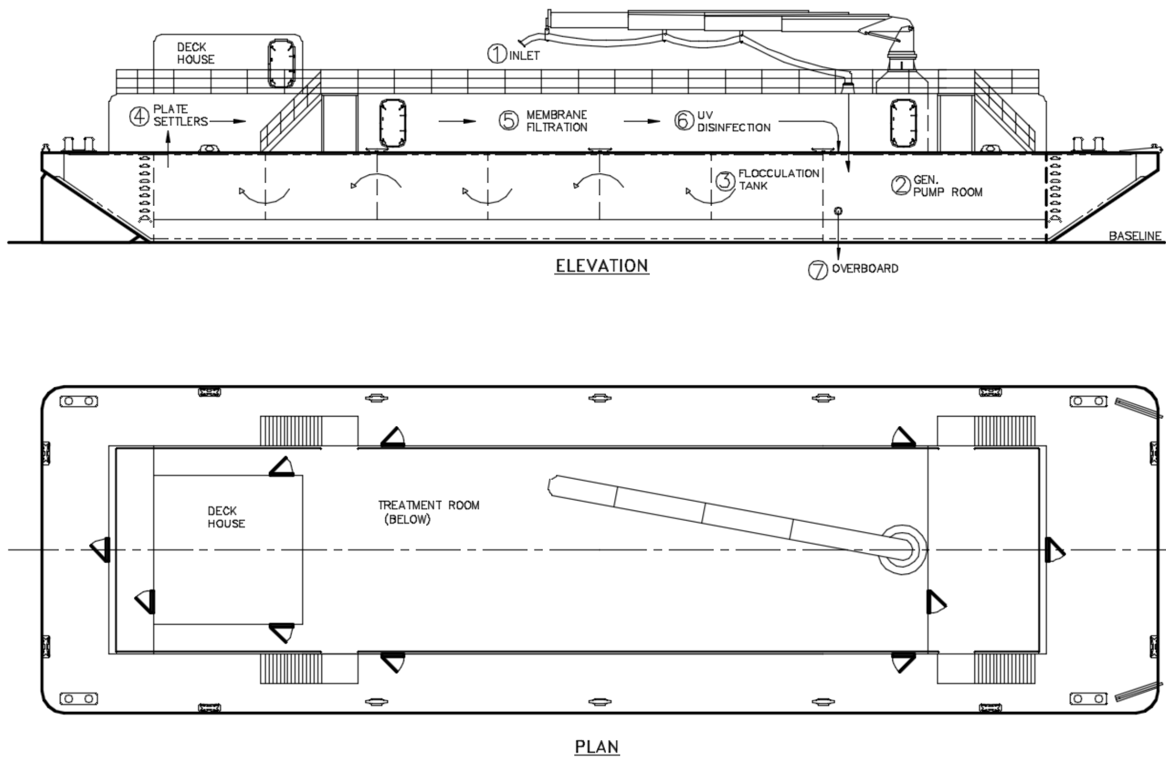

Figure 8 Notional treatment barge design

4.3 Treatment Barge Outfalls, Overboard Pipe Design

The treatment barge can be designed with the overboard pipe, (i.e. the outfall), to be at, above, or below the waterline. It is also possible to affect the velocity of the effluent discharge and the number of discharges. For example, it might be least impactful for the barge to have two discharges at high velocity discharged below the waterline. The image below is from a study of a jetted discharge at the surface level. The discharge resulted in rapid mixing and dilution in the near-field close to the overboard. Near-field mixing will be considered in the design of the barge overboard discharge (i.e. outfall) incorporating an optimized ballast water overboard to encourage increased mixing.

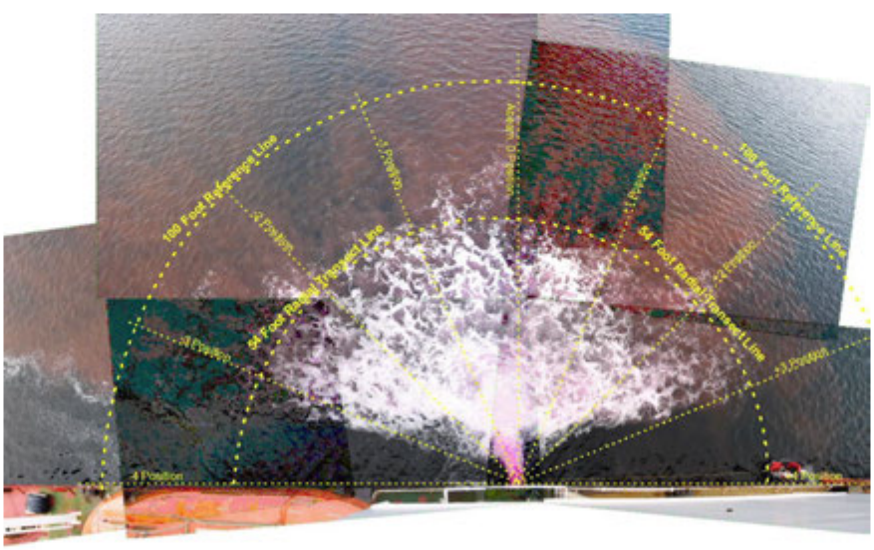

Figure 9 **Study of ballast water discharge (Reference 10)**

Section 5 Solids Disposal

One result, however, of this "cleaner" discharge is that solids will be collected in the process that must be disposed to landfills. These solids will be from the suspended solids entrained in the ballast water discharges and the coagulant added to assist in their removal. These materials will include particulate organic and inorganic material, in other words large and tiny debris from living and non-living sources. The treatment process will collect no significant portion of dissolved materials, in other words salt will not be collected in the process.

These solids will be collected through flocculation, where additional material is added to the process, settling and then concentrating such that the resulting slurry is 20% solids and the remainder seawater. A ballasting event of 10,000 metric tons, for example, is expected to produce ~2 metric tons of slurry with a disposal cost of ~$710. These solids would be transferred to a tank truck and disposed at a landfill permitted for such operations.

The table below shows various solids production volumes for different barge sizes and for the treatment barge zones. These are based on estimated average total suspended solids (TSS) of 20 milligrams per liter, although solids concentrations in ballast water can range much higher or lower. The calculations also assume that the coagulant added is of the same concentration as the TSS, and that the resulting slurry is 20% dry materials by weight in order to stay pumpable. Trucks are assumed to have 20 tons of capacity and on average be 75% full.

Table 5 Predicted solids production

	Treated Ballast Volume	Typical Slurry		
		Volume	Total Cost	Truck Loads
	(m.tons)	(m.tons)	($)	(#)
Small Barge	10,000	2	$710	0.1
Medium Barge	20,000	4	$1,420	0.3
Large Barge	35,000	7	$2,485	0.5
Zone 1 (annual production)	1,940,000	388	$137,740	25.9
Zone 2 (annual production)	1,770,000	354	$125,670	23.6
Zone 3 (annual production)	2,540,000	508	$180,340	33.9
Zone 4 (annual production)	1,110,000	222	$78,810	14.8
Zone 5 (annual production)	5,420,000	1,084	$384,820	72.3
Zone 6 (annual production)	30,000	6	$2,130	0.4
Statewide (annual production)	12,810,000	2,562	$909,510	170.8

It is expected that the resulting solids will be similar to those resulting from the purification of potable water. This material is suitable for most landfills, and does not have high enough organic content to consider processing in biogas digesters. The solids are expected to have a biological component, and will require special handling to ensure that these elements are not exposed to marine, estuary, or fresh water systems where potentially invasive species or pathogens in the solids could be released.

Section 6 Permits

A permit will need to be developed for either each individual treatment barge, or possibly one general permit that can cover the entire network. This section discusses the pre-permit study and then permit monitoring and reporting.

6.1 NPDES Pre-Permit Study Design

A monitoring and reporting program study design is proposed with the following objectives:

- Assess any impacts on the different ports receiving waters (marine/enclosed bays/estuaries/freshwaters).
- Assess reasonable potential to exceed applicable water quality standards for priority pollutants per the Ocean Plan, the California Toxics Rule, and applicable Basin Plan's objectives.
- Characterize pollutant loads in the effluent leaving the treatment system and measure the effectiveness of the treatment process.

The mechanics of the study will need to be developed, and may include:

- Upfront evaluation using computer models of treated effluent discharges into receiving waters.
- Confirmation field trials to confirm computer model mixing studies, and to collect samples for possible contaminants. This would calibrate computer models during set-up of the permit, and annually afterwards.
- Desktop reviews of established allowable pollutant loads in comparison to computer and field trial data.

6.2 Permit Monitoring and Reporting

A permit monitoring and reporting program will be required. The issued permit will detail its requirements, which may include many components, most importantly effluent limitations, compliance effluent limits monitoring, compliance receiving water limits monitoring, special provisions such mixing zone studies, effects of salinity into freshwater, or confirmation of mixing zone models, and reporting. The following is an example of a monitoring program:

- Intake of treatment system monitoring (chemical, bacteriological).
- Effluent of treatment system monitoring (chemical, bacteriological, toxicity).
- Internal process control monitoring (chemical).
- Receiving water monitoring (multiple stations chemical, toxicity).

6.3 Permitting Logistics

Each of the twenty-four treatment barges will require a permit for each Regional Water Board district where it will operate. This will ensure that the vessel has the appropriate level of monitoring and reporting needed to meet that specific regions requirements. It is likely that the most efficient operating regions for a given treatment barge will overlap with more than one region, meaning that some barges will require either a combined permit or multiple permits.

The evaluation and permitting process is expected to take two to three years to complete. A coordinated approach is planned that will attempt to result in a single outfall design and monitoring program that meets all regional requirements. That will allow generalized studies, such a near-field mixing, to apply to all regions. Some specific studies, such as far-field mixing, will be needed for specific locations. For example, seawater discharges at Sacramento and Stockton may require additional study.

The permitting process is expected to cost the treatment barge network an estimated $1 million to $3 million depending on whether a single evaluation process will work for most regions, or if each region will require special analysis and considerations.

Section 7 Pollutants Discussion

Although the resulting treatment barge outfalls will be similar to the existing marine vessel outfalls, it is possible that with additional monitoring of these treatment barge outfalls the community will become more aware of existing contaminants in these ballast water steams. For example, a marine vessel may have unknowingly taken up fire retardant chemicals in a distant port and discharge them in California. There is no current requirement to monitor marine vessel ballast water discharges for such chemicals. If the barge NPDES permit did require such monitoring, the presence of this pollutant would now be known. However, it might not be practical to remove such pollutants.

Some examples of potential pollution from ballast water include:

- Metals from the marine vessel including rust and scale from ballast tanks, protective anodes (zincs and aluminum) inside those tanks, and piping systems.
- Contaminants taken up from source ports that might include flame retardants, dioxin, pesticides, and heavy metals.

Recognizing that these discharges are currently ongoing in California waters, it is likely that the instantaneous concentrations are low due to the high volumes of ballast water, and that the frequency of such contaminants are also low. However, there is no known survey of these concentrations and frequency. The treatment barge may be able to reduce some of these pollutants, but dissolved pollutants will not be practically removed. Some practical considerations:

- The permitting process will need to consider monitoring requirements based on potential pollutants, and actions when these are detected.
- Solids may require testing for pollutants that might be removed and concentrated in this process.
- The treatment facility will need to monitor for potentially oily discharges and explosive gases, including appropriate safeties and shutdowns.

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