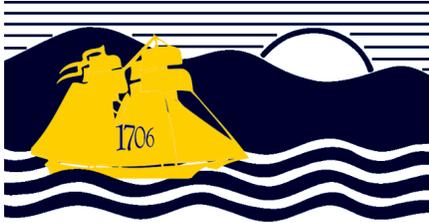


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Maritime Environmental Resource Center

Ref. No. [UMCES]CBL 09-192

MERC Ballast Water Economics  
Discussion Paper No. 1

# Preliminary Cost Analysis of Ballast Water Treatment Systems

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## Overview

This paper presents the results of preliminary analysis of the expected costs of purchasing and installing five types of ballast water treatment (BWT) systems on a “typical” ship within each of eight ship type/size categories. To develop these cost estimates, MERC researchers developed baseline ship operating and cost simulators (Excel spreadsheets), and adjusted them to reflect cost differences with and without various BWT systems. Assumptions about ship characteristics and routes, travel costs, cargo and ballast capacities, fuel and other input prices, and other factors that were used in the cost analyses are presented alongside cost spreadsheets where they were used. These will be updated routinely as new information becomes available to update and refine our cost analysis.

Preliminary cost estimates are presented for a “typical” ship within each ship type/size category and, based on the assumption that this ship is representative of ships in that category, for all ships in each category. Summary cost estimates include annual costs and full life cycle costs over 25 years, as well as estimated cost per ton of ballast water treated.

To estimate these costs, we first developed baseline ship cost simulators. We then contacted each of the technology vendors whose systems had been approved by the International Maritime Organization (IMO) as of May 2009 by email, and conducted follow-up telephone interviews with them. We also consulted with other industry representatives and ship engineers familiar with the details of installing and operating BWT systems on ships. All cost estimates are based on “best available” information that could be collected within the time and budget limits of our study. These cost estimates are considered usable for general planning purposes, but may not be accurate with respect to any particular ship.

## Focus

We estimated preliminary equipment and installation costs and operating costs for:

*Each of the following five types of BWT systems:*

- Filtration and UV
- Filtration and Chemical
- Deoxygenation and Cavitation
- Electrolysis and Electrochlorination
- Filtration, Deoxygenation and Cavitation

*Installed on a “typical” ship in each of the following eight ship type/size categories:*

- Bulker: Cape-sized Vessel
- Bulker: Panamax
- Container: 2500 TEU
- Container: 8000 TEU
- General Cargo: Breakbulk
- General Cargo: Ro-Ro
- Tanker: TAPS Trade
- Tanker: VLCC

*Using each of six potential installation options:*

- New Build (U.S. and Asian Yard)
- Retrofit (U.S. and Asian Yard)
- Retrofit While Ship is in Service (U.S. and Asian Yard)

## **Summary of Results**

Based on information from vendors and other sources, the range of average BWT equipment purchase costs across all ship categories analyzed is \$640,000 to \$947,000; the range of average installation costs for these systems is approximately \$18,000 to \$197,000; and, the range of average annual fixed operating costs (e.g., for system maintenance) across these ship categories is from approximately \$9,000 to \$18,000. For systems that require chemicals and other consumables per ton of BW treated, the amount of BW treated becomes critical: For example, the annual operating costs for systems requiring chemicals/consumables can range from about \$31,000 for smaller vessels to as high as \$296,000 for VLCCs.

The significant range of costs in each category resulted from the fact that in this preliminary cost analysis, we decided not to prejudge which BWT system would be suitable for each ship type/size. This resulted in some cost estimates associated with unlikely combinations, such as chemical treatment being used on VLCCs, Tankers, and Cape Sized Bulkers.

If we exclude combinations of ship type/size and BWT systems that technical experts have identified as highly unlikely, then the typical estimated cost of purchasing and installing a BWT system across all system types and ship categories is about \$1 million. If these purchase and installation costs are averaged over a 25-year system life, the total annual (undiscounted) costs range from \$50,000 or more for smaller vessels to \$100,000 or more for larger vessels such as VLCCs.

## **Caveats**

The eight ship type/size categories used in this analysis are not comprehensive, but are assumed to include most merchant ships that will be complying with IMO regulations by installing BWT systems. Costs were estimated for a single “typical” ship within each of these eight categories, but are not likely to reflect typical costs for some ships or ship groups within these categories. All cost estimates presented here are very preliminary and although the range of error in these cost estimates may be wide, they have no known biases up or down. They are suitable primarily for general planning purposes, rather than for assessing BWT system costs for particular ships, and will be used with global fleet size estimates in subsequent MERC papers to develop a preliminary assessment of the potential economic value and expected pattern of development of global BWT system markets.

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Cape Sized Vessel

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$1,006,833	\$1,078,667	\$783,500	\$745,667	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.04	\$0.23	\$0.19	\$0.05	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,677,615	\$4,087,402	\$3,150,294	\$1,694,260	NA
<b>Average Annual Cost<sup>5</sup></b>	\$67,105	\$163,496	\$126,012	\$67,770	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.15	\$0.36	\$0.28	\$0.15	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 450,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Cape Sized Vessel
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$22,500	\$18,000				
Install - Retrofit			\$62,000	\$73,500	\$85,000	\$74,500
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04
MT Ballast/Year	450,000	450,000	450,000	450,000	450,000	450,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,545,781	\$1,528,781	\$1,678,615	\$1,677,615	\$1,701,615	\$1,678,615
Lifecycle Cost/MT	\$0.14	\$0.14	\$0.15	\$0.15	\$0.15	\$0.15

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$2,000	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$20,000	\$2,000	\$500
Piping Installation	\$6,500	\$5,500	\$22,000	\$19,000	\$27,500	\$24,000
Electrical Installation	\$4,500	\$3,500	\$7,500	\$6,500	\$16,500	\$15,000
Steel Fabrication	\$3,500	\$2,500	\$11,000	\$9,500	\$15,000	\$12,500
QA/QC Costs	\$1,500	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$10,000
Painting Costs	\$0	\$0	\$3,500	\$3,000	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$22,500	\$18,000	\$62,000	\$73,500	\$85,000	\$74,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$36	\$36
Flow Rate	1000	1000
Total Hourly Cost	\$36	\$36
Total Cost/MT Flow	\$0.04	\$0.04

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.
Retrofit prices do not assume that bulk pricing would be procured by the individual shipowner.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulkers
<b>Vessel Size</b>	Cape Sized Vessel
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$60,500	\$52,500				
Install - Retrofit			\$145,000	\$132,000	\$190,300	\$169,000
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23
MT Ballast/Year	450,000	450,000	450,000	450,000	450,000	450,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$3,988,281	\$3,913,236	\$4,167,448	\$4,087,402	\$4,212,748	\$4,124,402
Lifecycle Cost/MT	\$0.35	\$0.35	\$0.37	\$0.36	\$0.37	\$0.37

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	Est
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$5,500	\$3,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$1,500	\$1,000
Piping Installation	\$35,000	\$30,000	\$59,000	\$54,000	\$86,500	\$75,000
Electrical Installation	\$9,500	\$8,500	\$13,000	\$12,000	\$21,800	\$20,000
Steel Fabrication	\$6,500	\$5,500	\$37,000	\$34,500	\$54,500	\$50,000
QA/QC Costs	\$2,000	\$1,500	\$10,000	\$7,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$6,000	\$4,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$60,500	\$52,500	\$145,000	\$132,000	\$190,300	\$169,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	50000
Trip/year	9
Barrel/year	327.3

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$19	\$19
Flow Rate	1000	1000
Total Hourly Cost	\$19	\$19
Total Cost/MT Flow	\$0.23	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 20MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.
Retrofit prices do not assume that bulk pricing would be procured by the individual shipowner.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Cape Sized Vessel
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$68,500	\$62,000				
Install - Retrofit			\$173,000	\$143,500	\$153,000	\$139,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	450,000	450,000	450,000	450,000	450,000	450,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$3,049,356	\$3,028,794	\$3,193,856	\$3,150,294	\$3,173,856	\$3,145,794
Lifecycle Cost/MT	\$0.27	\$0.27	\$0.28	\$0.28	\$0.28	\$0.28

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$640,000	\$640,000	\$600,000	\$600,000
Average Price	\$640,000	\$640,000	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$31,500	\$115,000	\$98,500	\$95,000	\$87,500
Electrical Installation	\$5,500	\$4,500	\$9,500	\$8,500	\$12,500	\$10,500
Steel Fabrication	\$9,500	\$8,500	\$25,000	\$15,000	\$24,500	\$21,500
QA/QC Costs	\$3,500	\$2,500	\$3,500	\$2,500	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$1,500	\$1,000	\$4,000	\$3,000
Painting Costs	\$3,500	\$3,000	\$5,500	\$4,500	\$4,500	\$3,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$68,500	\$62,000	\$173,000	\$143,500	\$153,000	\$139,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	25kW	25kW
Fuel Costs	\$184	\$184
Flow Rate	1000	1000
Total Hourly Cost	\$192	\$190
Total Cost/MT Flow	\$0.19	\$0.19

Start-up, monitoring of burner unit

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.
Retrofit prices do not assume that bulk pricing would be procured by the individual shipowner.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Cape Sized Vessel
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$40,000	\$33,500				
Install - Retrofit			\$84,500	\$79,000	\$131,500	\$115,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.05	\$0.05	\$0.05	\$0.05	\$0.05	\$0.05
MT Ballast/Year	450,000	450,000	450,000	450,000	450,000	450,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,599,844	\$1,582,094	\$1,711,010	\$1,694,260	\$1,758,010	\$1,730,260
Lifecycle Cost/MT	\$0.14	\$0.14	\$0.15	\$0.15	\$0.16	\$0.15

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$17,500	\$15,000	\$23,500	\$21,500	\$45,500	\$40,000
Electrical Installation	\$7,500	\$6,000	\$12,500	\$11,500	\$21,500	\$20,000
Steel Fabrication	\$5,500	\$4,500	\$22,500	\$21,000	\$35,000	\$31,500
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$8,000	\$7,500	\$6,500	\$1,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$6,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$40,000	\$33,500	\$84,500	\$79,000	\$131,500	\$115,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$40	\$40
Flow Rate	1000	1000
Total Hourly Cost	\$48	\$47
Total Cost/MT Flow	\$0.05	\$0.05

Monitoring

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.
Retrofit prices do not assume that bulk pricing would be procured by the individual shipowner.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Cape Sized Vessel
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	450,000	450,000	450,000	450,000	450,000	450,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
Average Price	\$0	\$0	\$0	\$0

Installation Matrix	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs		
Parts Required		
Est. Breakage		
Industrial Assistance		
Technical Support		
Total Annual Costs	\$0	\$0

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs		
Consumables		
Power Requirements		
Fuel Costs		
Flow Rate		
Total Hourly Cost	\$0	\$0
Total Cost/MT Flow	#DIV/0!	#DIV/0!

**NOTES:**


**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Panamax

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$987,833	\$1,062,167	\$736,000	\$753,667	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.04	\$0.25	\$0.19	\$0.07	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,449,396	\$2,805,775	\$1,960,504	\$1,528,229	NA
<b>Average Annual Cost<sup>5</sup></b>	\$57,976	\$112,231	\$78,420	\$61,129	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.28	\$0.53	\$0.37	\$0.29	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 210,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Panamax
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$22,500	\$18,000				
Install - Retrofit			\$60,500	\$54,500	\$93,500	\$85,000
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04
MT Ballast/Year	210,000	210,000	210,000	210,000	210,000	210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,336,563	\$1,319,563	\$1,467,896	\$1,449,396	\$1,500,896	\$1,479,896
Lifecycle Cost/MT	\$0.25	\$0.25	\$0.28	\$0.28	\$0.29	\$0.28

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	w Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$2,000	\$2,000
Purchasing Support	\$1,500	\$500	\$1,500	\$1,500	\$500	\$500
Piping Installation	\$6,500	\$5,500	\$20,000	\$17,500	\$30,000	\$27,000
Electrical Installation	\$4,500	\$3,500	\$7,500	\$6,500	\$15,000	\$15,000
Steel Fabrication	\$3,500	\$2,500	\$12,000	\$10,500	\$24,000	\$20,000
QA/QC Costs	\$1,500	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$10,000
Painting Costs	\$0	\$0	\$3,500	\$3,000	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$22,500	\$18,000	\$60,500	\$54,500	\$93,500	\$85,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$38	\$38
Flow Rate	1000	1000
Total Hourly Cost	\$38	\$38
Total Cost/MT Flow	\$0.04	\$0.04

**NOTES:**

Fuel cost based on 14MT/day consumption MGO, 1.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Panamax
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$64,500	\$56,500				
Install - Retrofit			\$125,500	\$115,500	\$151,000	\$139,500
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.25	\$0.25	\$0.25	\$0.25	\$0.25	\$0.25
MT Ballast/Year	210,000	210,000	210,000	210,000	210,000	210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$2,698,063	\$2,652,108	\$2,853,729	\$2,805,775	\$2,879,229	\$2,829,775
Lifecycle Cost/MT	\$0.51	\$0.51	\$0.54	\$0.53	\$0.55	\$0.54

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	Est
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,000	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$40,000	\$35,000	\$50,500	\$46,500	\$71,500	\$66,000
Electrical Installation	\$8,500	\$7,500	\$13,000	\$12,500	\$19,500	\$18,000
Steel Fabrication	\$6,500	\$5,500	\$27,000	\$24,500	\$35,500	\$32,500
QA/QC Costs	\$2,000	\$1,500	\$10,000	\$7,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$6,000	\$5,000	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$8,000	\$7,500	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$64,500	\$56,500	\$125,500	\$115,500	\$151,000	\$139,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	15000
Trip/year	14
Barrel/year	152.7

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$38	\$38
Flow Rate	1000	1000
Total Hourly Cost	\$38	\$38
Total Cost/MT Flow	\$0.25	\$0.25

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 14MT/day consumption MGO, 1.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulkers
<b>Vessel Size</b>	Panamax
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$62,500	\$56,500				
Install - Retrofit			\$102,500	\$96,000	\$155,000	\$142,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	210,000	210,000	210,000	210,000	210,000	210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,893,566	\$1,881,004	\$1,973,566	\$1,960,504	\$2,026,066	\$2,006,504
Lifecycle Cost/MT	\$0.36	\$0.36	\$0.38	\$0.37	\$0.39	\$0.38

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$640,000	\$640,000	\$600,000	\$600,000
Average Price	\$640,000	\$640,000	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,500	\$3,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$30,000	\$27,500	\$40,000	\$37,000	\$64,000	\$59,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,500	\$23,500	\$21,500
Steel Fabrication	\$8,500	\$7,000	\$23,000	\$21,000	\$39,500	\$35,000
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$3,500	\$3,000	\$6,000	\$5,500	\$4,500	\$4,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$62,500	\$56,500	\$102,500	\$96,000	\$155,000	\$142,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	25kW	25kW
Fuel Costs	\$184	\$184
Flow Rate	1000	1000
Total Hourly Cost	\$192	\$190
Total Cost/MT Flow	\$0.19	\$0.19

Start-up, monitoring of burner unit

**NOTES:**

Fuel cost based on 14MT/day consumption MGO, 1.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulker
<b>Vessel Size</b>	Panamax
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$37,500	\$31,500				
Install - Retrofit			\$92,500	\$87,000	\$139,500	\$129,500
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.07	\$0.07	\$0.07	\$0.07	\$0.07	\$0.07
MT Ballast/Year	210,000	210,000	210,000	210,000	210,000	210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,417,313	\$1,406,063	\$1,538,979	\$1,528,229	\$1,585,979	\$1,570,729
Lifecycle Cost/MT	\$0.27	\$0.27	\$0.29	\$0.29	\$0.30	\$0.30

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$3,000	\$2,500	\$3,000	\$3,000
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$15,500	\$13,000	\$31,500	\$29,500	\$51,500	\$47,500
Electrical Installation	\$7,000	\$6,000	\$12,500	\$11,500	\$19,500	\$18,000
Steel Fabrication	\$5,500	\$4,500	\$23,000	\$21,500	\$42,000	\$38,000
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$7,500	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$37,500	\$31,500	\$92,500	\$87,000	\$139,500	\$129,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$60	\$60
Flow Rate	1000	1000
Total Hourly Cost	\$68	\$67
Total Cost/MT Flow	\$0.07	\$0.07

Monitoring

**NOTES:**

Fuel cost based on 14MT/day consumption MGO, 1.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Bulkер					
<b>Vessel Size</b>	Panamax					
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	210,000	210,000	210,000	210,000	210,000	210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	2500 TEU

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$980,333	\$1,052,667	\$734,000	\$747,167	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.03	\$0.23	\$0.19	\$0.03	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,338,688	\$2,320,617	\$1,636,322	\$1,268,841	NA
<b>Average Annual Cost<sup>5</sup></b>	\$53,548	\$92,825	\$65,453	\$50,754	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.37	\$0.65	\$0.46	\$0.35	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 143,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	2500 TEU
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$22,500	\$18,000				
Install - Retrofit			\$51,500	\$47,000	\$74,000	\$67,000
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	143,000	143,000	143,000	143,000	143,000	143,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,233,355	\$1,216,355	\$1,355,688	\$1,338,688	\$1,378,188	\$1,358,688
Lifecycle Cost/MT	\$0.34	\$0.34	\$0.38	\$0.37	\$0.39	\$0.38

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$720,000	\$720,000	\$648,000	\$648,000
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000
System 3	\$840,000	\$840,000	\$756,000	\$756,000
Average Price	\$933,333	\$933,333	\$840,000	\$840,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$2,000	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$6,500	\$5,500	\$15,000	\$13,000	\$22,000	\$20,000
Electrical Installation	\$4,500	\$3,500	\$7,500	\$6,500	\$11,000	\$10,000
Steel Fabrication	\$3,500	\$2,500	\$10,000	\$9,000	\$20,000	\$17,000
QA/QC Costs	\$1,500	\$1,500	\$3,000	\$2,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$2,500	\$2,000	\$7,000	\$5,500
Painting Costs	\$0	\$0	\$3,500	\$3,000	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$22,500	\$18,000	\$51,500	\$47,000	\$74,000	\$67,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$27	\$27
Flow Rate	1000	1000
Total Hourly Cost	\$27	\$27
Total Cost/MT Flow	\$0.03	\$0.03

**NOTES:**

Fuel cost based on 30MT/day consumption MGO, 3.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	2500 TEU
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$51,500	\$45,500				
Install - Retrofit			\$115,500	\$106,000	\$139,500	\$130,000
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23
MT Ballast/Year	143,000	143,000	143,000	143,000	143,000	143,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$2,201,284	\$2,165,451	\$2,359,951	\$2,320,617	\$2,383,951	\$2,344,617
Lifecycle Cost/MT	\$0.62	\$0.61	\$0.66	\$0.65	\$0.67	\$0.66

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard	Retrofit In Service		
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$1,500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$25,000	\$22,000	\$45,000	\$38,000	\$58,000	\$54,000
Electrical Installation	\$7,500	\$6,500	\$12,500	\$11,500	\$19,500	\$18,000
Steel Fabrication	\$6,500	\$5,500	\$27,000	\$24,000	\$35,500	\$33,000
QA/QC Costs	\$5,000	\$4,000	\$8,000	\$6,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$6,500	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$51,500	\$45,500	\$115,500	\$106,000	\$139,500	\$130,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	5500
Trip/year	26
Barrel/year	104

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$20	\$20
Flow Rate	1000	1000
Total Hourly Cost	\$20	\$20
Total Cost/MT Flow	\$0.23	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 30MT/day consumption MGO, 3.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	2500 TEU
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$62,500	\$56,500				
Install - Retrofit			\$101,500	\$94,000	\$140,500	\$131,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	143,000	143,000	143,000	143,000	143,000	143,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,569,291	\$1,558,822	\$1,648,291	\$1,636,322	\$1,687,291	\$1,673,322
Lifecycle Cost/MT	\$0.44	\$0.44	\$0.46	\$0.46	\$0.47	\$0.47

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$640,000	\$640,000	\$600,000	\$600,000
Average Price	\$640,000	\$640,000	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$3,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$30,000	\$27,500	\$39,500	\$36,500	\$58,500	\$54,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,000	\$21,000	\$19,500
Steel Fabrication	\$8,500	\$7,000	\$22,500	\$21,000	\$35,500	\$33,000
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$3,500	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$9,500	\$7,500
Painting Costs	\$3,500	\$3,000	\$6,000	\$5,500	\$4,500	\$4,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$62,500	\$56,500	\$101,500	\$94,000	\$140,500	\$131,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	25kW	25kW
Fuel Costs	\$183	\$183
Flow Rate	1000	1000
Total Hourly Cost	\$191	\$189
Total Cost/MT Flow	\$0.19	\$0.19

Start-up, monitoring of burner unit

**NOTES:**

Fuel cost based on 30MT/day consumption MGO, 3.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	2500 TEU
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$37,500	\$31,500				
Install - Retrofit			\$92,000	\$80,500	\$116,500	\$107,500
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	143,000	143,000	143,000	143,000	143,000	143,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,162,749	\$1,153,174	\$1,283,916	\$1,268,841	\$1,308,416	\$1,295,841
Lifecycle Cost/MT	\$0.33	\$0.32	\$0.36	\$0.35	\$0.37	\$0.36

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$5,500	\$3,000	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$1,500	\$500	\$2,000	\$2,000
Piping Installation	\$15,500	\$13,000	\$55,000	\$49,500	\$43,000	\$39,000
Electrical Installation	\$7,000	\$6,000	\$9,000	\$7,500	\$18,000	\$16,500
Steel Fabrication	\$5,500	\$4,500	\$12,500	\$10,500	\$29,000	\$26,500
QA/QC Costs	\$2,000	\$1,500	\$2,000	\$2,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$500	\$500	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$1,000	\$500	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$37,500	\$31,500	\$92,000	\$80,500	\$116,500	\$107,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$20	\$20
Flow Rate	1000	1000
Total Hourly Cost	\$28	\$27
Total Cost/MT Flow	\$0.03	\$0.03

Monitoring

**NOTES:**

Fuel cost based on 30MT/day consumption MGO, 3.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container					
<b>Vessel Size</b>	2500 TEU					
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	143,000	143,000	143,000	143,000	143,000	143,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	8000 TEU

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$990,833	\$1,075,167	\$748,500	\$742,167	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.02	\$0.23	\$0.19	\$0.02	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,467,833	\$3,520,708	\$2,627,885	\$1,333,633	NA
<b>Average Annual Cost<sup>5</sup></b>	\$58,713	\$140,828	\$105,115	\$53,345	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.17	\$0.40	\$0.30	\$0.15	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 352,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	8000 TEU
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$30,500	\$23,500				
Install - Retrofit			\$65,000	\$57,500	\$103,000	\$91,700
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.02	\$0.02	\$0.02	\$0.02	\$0.02	\$0.02
MT Ballast/Year	352,000	352,000	352,000	352,000	352,000	352,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,360,000	\$1,340,500	\$1,487,833	\$1,467,833	\$1,525,833	\$1,502,033
Lifecycle Cost/MT	\$0.15	\$0.15	\$0.17	\$0.17	\$0.17	\$0.17

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$2,000	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$9,500	\$7,500	\$18,000	\$16,000	\$35,500	\$31,000
Electrical Installation	\$6,500	\$4,500	\$8,500	\$7,500	\$16,000	\$15,000
Steel Fabrication	\$5,500	\$4,500	\$15,000	\$12,000	\$25,500	\$21,200
QA/QC Costs	\$2,500	\$2,000	\$6,000	\$4,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$10,000
Painting Costs	\$0	\$0	\$4,500	\$4,000	\$3,500	\$3,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$30,500	\$23,500	\$65,000	\$57,500	\$103,000	\$91,700

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$24	\$24
Flow Rate	1000	1000
Total Hourly Cost	\$24	\$24
Total Cost/MT Flow	\$0.02	\$0.02

**NOTES:**

Fuel cost based on 45MT/day consumption MGO, 5.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	8000 TEU
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$62,000	\$56,000				
Install - Retrofit			\$143,000	\$128,500	\$197,000	\$180,000
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23
MT Ballast/Year	352,000	352,000	352,000	352,000	352,000	352,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$3,414,708	\$3,353,542	\$3,590,375	\$3,520,708	\$3,644,375	\$3,572,208
Lifecycle Cost/MT	\$0.39	\$0.38	\$0.41	\$0.40	\$0.41	\$0.41

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$40,000	\$37,500	\$57,000	\$52,000	\$85,000	\$78,000
Electrical Installation	\$6,500	\$5,500	\$13,500	\$12,500	\$22,500	\$19,500
Steel Fabrication	\$5,500	\$4,500	\$41,000	\$35,000	\$60,000	\$55,000
QA/QC Costs	\$2,500	\$1,500	\$8,000	\$6,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$62,000	\$56,000	\$143,000	\$128,500	\$197,000	\$180,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	32000
Trip/year	11
Barrel/year	256

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$18	\$18
Flow Rate	1000	1000
Total Hourly Cost	\$18	\$18
Total Cost/MT Flow	\$0.23	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 45MT/day consumption MGO, 5.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	8000 TEU
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$67,000	\$62,000				
Install - Retrofit			\$117,500	\$108,500	\$167,500	\$155,500
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	352,000	352,000	352,000	352,000	352,000	352,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$2,557,385	\$2,541,385	\$2,647,885	\$2,627,885	\$2,697,885	\$2,674,885
Lifecycle Cost/MT	\$0.29	\$0.29	\$0.30	\$0.30	\$0.31	\$0.30

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$640,000	\$640,000	\$600,000	\$600,000	Verified
Average Price	\$640,000	\$640,000	\$600,000	\$600,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$3,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$32,500	\$47,500	\$44,000	\$71,500	\$66,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,500	\$23,000	\$21,500
Steel Fabrication	\$8,000	\$7,500	\$30,000	\$27,000	\$44,500	\$41,000
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$3,500	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$3,500	\$3,000	\$6,500	\$6,000	\$5,000	\$5,000
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$67,000	\$62,000	\$117,500	\$108,500	\$167,500	\$155,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship	
Crew Costs per hour	\$8	\$7	Start-up, monitoring of burner unit
Consumables	\$0	\$0	
Power Requirements	25kW	25kW	
Fuel Costs	\$181	\$181	
Flow Rate	1000	1000	
Total Hourly Cost	\$189	\$188	
Total Cost/MT Flow	\$0.19	\$0.19	

**NOTES:**

Fuel cost based on 45MT/day consumption MGO, 5.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container
<b>Vessel Size</b>	8000 TEU
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$40,000	\$33,500				
Install - Retrofit			\$82,000	\$75,500	\$121,500	\$111,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.02	\$0.02	\$0.02	\$0.02	\$0.02	\$0.02
MT Ballast/Year	352,000	352,000	352,000	352,000	352,000	352,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,240,267	\$1,224,967	\$1,348,933	\$1,333,633	\$1,388,433	\$1,369,133
Lifecycle Cost/MT	\$0.14	\$0.14	\$0.15	\$0.15	\$0.16	\$0.16

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$17,500	\$15,000	\$26,000	\$23,500	\$43,000	\$39,000
Electrical Installation	\$7,500	\$6,000	\$11,500	\$10,500	\$18,000	\$16,500
Steel Fabrication	\$5,500	\$4,500	\$19,000	\$17,000	\$34,000	\$30,000
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$7,500	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$40,000	\$33,500	\$82,000	\$75,500	\$121,500	\$111,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$12	\$12
Flow Rate	1000	1000
Total Hourly Cost	\$20	\$19
Total Cost/MT Flow	\$0.02	\$0.02

Monitoring

**NOTES:**

Fuel cost based on 45MT/day consumption MGO, 5.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Container					
<b>Vessel Size</b>	8000 TEU					
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	352,000	352,000	352,000	352,000	352,000	352,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Breakbulk

	Filtration & UV Light	Filtration & Chemical	Deoxygenation & Cavitation	Electrolysis & Electrochlorination	Filtration, Deoxygenation & Cavitation <sup>7</sup>
<b>Total Capital Costs<sup>1</sup></b>	\$966,333	\$1,043,667	\$725,000	\$738,067	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.03	\$0.23	\$0.19	\$0.04	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,288,552	\$1,901,171	\$1,290,751	\$1,237,851	NA
<b>Average Annual Cost<sup>5</sup></b>	\$51,542	\$76,047	\$51,630	\$49,514	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.74	\$1.09	\$0.74	\$0.71	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 70,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Breakbulk
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$27,000	\$18,000				
Install - Retrofit			\$48,500	\$33,000	\$29,000	\$24,500
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	70,000	70,000	70,000	70,000	70,000	70,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,201,719	\$1,180,219	\$1,316,552	\$1,288,552	\$1,297,052	\$1,280,052
Lifecycle Cost/MT	\$0.69	\$0.67	\$0.75	\$0.74	\$0.74	\$0.73

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$4,500	\$2,500	\$4,500	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$1,500	\$500	\$500	\$500
Piping Installation	\$8,500	\$6,500	\$17,500	\$10,500	\$8,500	\$6,500
Electrical Installation	\$5,500	\$2,500	\$9,000	\$5,500	\$5,500	\$5,500
Steel Fabrication	\$4,500	\$2,500	\$7,500	\$4,500	\$4,500	\$2,500
QA/QC Costs	\$2,000	\$1,500	\$2,000	\$2,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$500	\$500	\$0	\$0
Painting Costs	\$0	\$0	\$1,000	\$500	\$500	\$500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$27,000	\$18,000	\$48,500	\$33,000	\$29,000	\$24,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$34	\$34
Flow Rate	1000	1000
Total Hourly Cost	\$34	\$34
Total Cost/MT Flow	\$0.03	\$0.03

**NOTES:**

Fuel cost based on 18MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Breakbulk
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$44,500	\$39,500				
Install - Retrofit			\$114,000	\$97,000	\$140,000	\$131,000
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.24	\$0.23	\$0.24	\$0.23	\$0.24	\$0.23
MT Ballast/Year	70,000	70,000	70,000	70,000	70,000	70,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,774,990	\$1,749,005	\$1,939,156	\$1,901,171	\$1,965,156	\$1,935,171
Lifecycle Cost/MT	\$1.01	\$1.00	\$1.11	\$1.09	\$1.12	\$1.11

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$25,000	\$22,500	\$40,000	\$37,000	\$58,000	\$54,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,500	\$20,000	\$19,000
Steel Fabrication	\$4,500	\$4,000	\$29,000	\$24,500	\$35,000	\$32,500
QA/QC Costs	\$2,000	\$1,500	\$8,000	\$6,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$9,500	\$7,500
Painting Costs	\$0	\$0	\$8,500	\$1,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$44,500	\$39,500	\$114,000	\$97,000	\$140,000	\$131,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM 150  
Gal/MT 264  
Gal/MT BW @ 150ppm 0.04  
MT per trip 5000  
Trip/year 14  
Barrel/year 50.90909091

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$24	\$24
Flow Rate	1000	1000
Total Hourly Cost	\$24	\$24
Total Cost/MT Flow	\$0.24	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 18MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Breakbulk
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$57,500	\$50,500				
Install - Retrofit			\$92,000	\$85,000	\$136,000	\$124,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.20	\$0.19	\$0.20	\$0.19	\$0.20	\$0.19
MT Ballast/Year	70,000	70,000	70,000	70,000	70,000	70,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,225,439	\$1,216,251	\$1,299,939	\$1,290,751	\$1,343,939	\$1,329,751
Lifecycle Cost/MT	\$0.70	\$0.70	\$0.74	\$0.74	\$0.77	\$0.76

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$640,000	\$640,000	\$600,000	\$600,000
Average Price	\$640,000	\$640,000	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$4,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$25,000	\$21,500	\$33,000	\$30,000	\$50,000	\$45,500
Electrical Installation	\$5,500	\$4,500	\$12,500	\$11,500	\$21,500	\$20,000
Steel Fabrication	\$8,500	\$7,000	\$20,500	\$18,500	\$35,500	\$32,000
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$3,500	\$3,000	\$6,000	\$5,500	\$4,500	\$4,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$57,500	\$50,500	\$92,000	\$85,000	\$136,000	\$124,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	25kW	25kW
Fuel Costs	\$188	\$188
Flow Rate	1000	1000
Total Hourly Cost	\$196	\$195
Total Cost/MT Flow	\$0.20	\$0.19

Start-up, monitoring of burner unit

**NOTES:**

Fuel cost based on 18MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Breakbulk
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$37,500	\$31,500				
Install - Retrofit			\$78,000	\$71,400	\$124,000	\$112,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04
MT Ballast/Year	70,000	70,000	70,000	70,000	70,000	70,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,138,778	\$1,131,284	\$1,245,945	\$1,237,851	\$1,291,945	\$1,278,451
Lifecycle Cost/MT	\$0.65	\$0.65	\$0.71	\$0.71	\$0.74	\$0.73

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$15,500	\$13,000	\$23,500	\$21,000	\$45,500	\$40,000
Electrical Installation	\$7,000	\$6,000	\$10,500	\$9,500	\$18,500	\$17,000
Steel Fabrication	\$5,500	\$4,500	\$18,500	\$16,500	\$31,000	\$27,500
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,400	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$7,500	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$37,500	\$31,500	\$78,000	\$71,400	\$124,000	\$112,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$36	\$36
Flow Rate	1000	1000
Total Hourly Cost	\$44	\$43
Total Cost/MT Flow	\$0.04	\$0.04

Monitoring

**NOTES:**

Fuel cost based on 18MT/day consumption MGO, 1.5MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo					
	Breakbulk					
<b>Vessel Size</b>						
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	70,000	70,000	70,000	70,000	70,000	70,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
 (Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Ro-Ro

	Filtration & UV Light	Filtration & Chemical	Deoxygenation & Cavitation	Electrolysis & Electrochlorination	Filtration, Deoxygenation & Cavitation <sup>7</sup>
<b>Total Capital Costs<sup>1</sup></b>	\$966,333	\$1,067,567	\$748,500	\$749,167	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.03	\$0.23	\$0.19	\$0.04	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,299,927	\$2,114,605	\$1,473,252	\$1,270,745	NA
<b>Average Annual Cost<sup>5</sup></b>	\$51,997	\$84,584	\$58,930	\$50,830	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.50	\$0.81	\$0.56	\$0.48	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 105,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Ro-Ro
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$27,000	\$18,000				
Install - Retrofit			\$48,500	\$33,000	\$29,000	\$24,500
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	105,000	105,000	105,000	105,000	105,000	105,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,213,094	\$1,191,594	\$1,327,927	\$1,299,927	\$1,308,427	\$1,291,427
Lifecycle Cost/MT	\$0.46	\$0.45	\$0.51	\$0.50	\$0.50	\$0.49

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$4,500	\$2,500	\$4,500	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$1,500	\$500	\$500	\$500
Piping Installation	\$8,500	\$6,500	\$17,500	\$10,500	\$8,500	\$6,500
Electrical Installation	\$5,500	\$2,500	\$9,000	\$5,500	\$5,500	\$5,500
Steel Fabrication	\$4,500	\$2,500	\$7,500	\$4,500	\$4,500	\$2,500
QA/QC Costs	\$2,000	\$1,500	\$2,000	\$2,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$500	\$500	\$0	\$0
Painting Costs	\$0	\$0	\$1,000	\$500	\$500	\$500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$27,000	\$18,000	\$48,500	\$33,000	\$29,000	\$24,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$27	\$27
Flow Rate	1000	1000
Total Hourly Cost	\$27	\$27
Total Cost/MT Flow	\$0.03	\$0.03

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Ro-Ro
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$60,500	\$54,000				
Install - Retrofit			\$132,000	\$120,900	\$164,500	\$131,180
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23	\$0.23
MT Ballast/Year	105,000	105,000	105,000	105,000	105,000	105,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,984,766	\$1,953,038	\$2,150,932	\$2,114,605	\$2,183,432	\$2,124,885
Lifecycle Cost/MT	\$0.76	\$0.74	\$0.82	\$0.81	\$0.83	\$0.81

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$31,500	\$58,000	\$55,000	\$68,000	\$54,000
Electrical Installation	\$9,500	\$8,500	\$15,000	\$12,500	\$22,500	\$19,680
Steel Fabrication	\$6,500	\$5,500	\$27,500	\$24,500	\$44,000	\$32,000
QA/QC Costs	\$2,000	\$1,500	\$8,000	\$6,400	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,500	\$7,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$60,500	\$54,000	\$132,000	\$120,900	\$164,500	\$131,180

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	7500
Trip/year	14
Barrel/year	76.36363636

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$19	\$19
Flow Rate	1000	1000
Total Hourly Cost	\$19	\$19
Total Cost/MT Flow	\$0.23	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 20MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Ro-Ro
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$67,500	\$61,500				
Install - Retrofit			\$117,000	\$108,500	\$185,500	\$170,500
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	105,000	105,000	105,000	105,000	105,000	105,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,395,533	\$1,386,252	\$1,485,033	\$1,473,252	\$1,553,533	\$1,535,252
Lifecycle Cost/MT	\$0.53	\$0.53	\$0.57	\$0.56	\$0.59	\$0.58

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$640,000	\$640,000	\$600,000	\$600,000	Verified
Average Price	\$640,000	\$640,000	\$600,000	\$600,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$3,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$32,500	\$46,500	\$43,000	\$82,000	\$75,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,500	\$23,000	\$21,500
Steel Fabrication	\$8,500	\$7,000	\$30,000	\$27,000	\$51,500	\$46,500
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$3,500	\$3,000	\$7,000	\$6,500	\$5,500	\$5,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$67,500	\$61,500	\$117,000	\$108,500	\$185,500	\$170,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship	
Crew Costs per hour	\$8	\$7	Start-up, monitoring of burner unit
Consumables	\$0	\$0	
Power Requirements	25kW	25kW	
Fuel Costs	\$184	\$184	
Flow Rate	1000	1000	
Total Hourly Cost	\$192	\$190	
Total Cost/MT Flow	\$0.19	\$0.19	

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo
<b>Vessel Size</b>	Ro-Ro
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$38,500	\$32,500				
Install - Retrofit			\$89,000	\$82,500	\$136,000	\$124,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04	\$0.04
MT Ballast/Year	105,000	105,000	105,000	105,000	105,000	105,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,162,703	\$1,154,078	\$1,279,870	\$1,270,745	\$1,326,870	\$1,312,245
Lifecycle Cost/MT	\$0.44	\$0.44	\$0.49	\$0.48	\$0.51	\$0.50

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$15,500	\$13,000	\$26,000	\$24,000	\$47,000	\$41,500
Electrical Installation	\$7,000	\$6,000	\$12,500	\$11,500	\$21,500	\$20,000
Steel Fabrication	\$6,500	\$5,500	\$25,000	\$22,500	\$38,500	\$35,000
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$7,500	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$38,500	\$32,500	\$89,000	\$82,500	\$136,000	\$124,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$30	\$30
Flow Rate	1000	1000
Total Hourly Cost	\$38	\$37
Total Cost/MT Flow	\$0.04	\$0.04

Monitoring

**NOTES:**

Fuel cost based on 20MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	General Cargo					
	Ro-Ro					
<b>Vessel Size</b>						
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	105,000	105,000	105,000	105,000	105,000	105,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	TAPS Trade

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$996,333	\$1,066,567	\$737,000	\$763,167	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.03	\$0.23	\$0.19	\$0.04	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$1,834,354	\$5,486,695	\$4,198,488	\$1,940,240	NA
<b>Average Annual Cost<sup>5</sup></b>	\$73,374	\$219,468	\$167,940	\$77,610	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.11	\$0.32	\$0.25	\$0.11	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 680,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	TAPS Trade
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$27,000	\$18,000				
Install - Retrofit			\$72,500	\$63,000	\$106,000	\$92,000
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	680,000	680,000	680,000	680,000	680,000	680,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,717,521	\$1,696,021	\$1,856,354	\$1,834,354	\$1,889,854	\$1,863,354
Lifecycle Cost/MT	\$0.10	\$0.10	\$0.11	\$0.11	\$0.11	\$0.11

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$500
Piping Installation	\$8,500	\$6,500	\$25,000	\$21,000	\$41,500	\$35,000
Electrical Installation	\$5,500	\$2,500	\$12,000	\$10,000	\$19,000	\$17,500
Steel Fabrication	\$4,500	\$2,500	\$12,500	\$11,500	\$22,000	\$19,000
QA/QC Costs	\$2,000	\$1,500	\$5,000	\$3,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$10,000	\$8,000
Painting Costs	\$0	\$0	\$5,000	\$4,000	\$3,500	\$3,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$27,000	\$18,000	\$72,500	\$63,000	\$106,000	\$92,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$34	\$34
Flow Rate	1000	1000
Total Hourly Cost	\$34	\$34
Total Cost/MT Flow	\$0.03	\$0.03

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	TAPS Trade
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$60,500	\$55,000				
Install - Retrofit			\$131,500	\$119,900	\$170,500	\$160,500
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.24	\$0.23	\$0.24	\$0.23	\$0.24	\$0.23
MT Ballast/Year	680,000	680,000	680,000	680,000	680,000	680,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$5,427,552	\$5,327,128	\$5,593,219	\$5,486,695	\$5,632,219	\$5,527,295
Lifecycle Cost/MT	\$0.32	\$0.31	\$0.33	\$0.32	\$0.33	\$0.33

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$2,500	\$3,000	\$2,500	\$3,000
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$32,500	\$50,000	\$45,500	\$75,000	\$69,000
Electrical Installation	\$9,500	\$8,500	\$13,500	\$12,500	\$22,000	\$20,500
Steel Fabrication	\$6,500	\$5,500	\$36,000	\$32,500	\$50,500	\$44,000
QA/QC Costs	\$2,000	\$1,500	\$8,000	\$6,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,400	\$5,000	\$8,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$60,500	\$55,000	\$131,500	\$119,900	\$170,500	\$160,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM 150  
Gal/MT 264  
Gal/MT BW @ 150ppm 0.04  
MT per trip 34000  
Trip/year 20  
Barrel/year 494.5454545

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$25	\$25
Flow Rate	1000	1000
Total Hourly Cost	\$25	\$25
Total Cost/MT Flow	\$0.24	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	TAPS Trade
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$62,000	\$58,000				
Install - Retrofit			\$104,000	\$97,000	\$146,000	\$136,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	680,000	680,000	680,000	680,000	680,000	680,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$4,144,738	\$4,119,488	\$4,226,738	\$4,198,488	\$4,268,738	\$4,237,488
Lifecycle Cost/MT	\$0.24	\$0.24	\$0.25	\$0.25	\$0.25	\$0.25

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$640,000	\$640,000	\$600,000	\$600,000	Verified
Average Price	\$640,000	\$640,000	\$600,000	\$600,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$3,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$30,000	\$28,500	\$40,000	\$37,000	\$61,000	\$56,500
Electrical Installation	\$5,500	\$4,500	\$12,500	\$11,500	\$20,500	\$19,000
Steel Fabrication	\$8,000	\$7,500	\$25,000	\$23,000	\$37,500	\$34,500
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$10,500	\$8,500
Painting Costs	\$3,500	\$3,000	\$6,500	\$6,000	\$5,000	\$5,000
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$62,000	\$58,000	\$104,000	\$97,000	\$146,000	\$136,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship	
Crew Costs per hour	\$8	\$7	Start-up, monitoring of burner unit
Consumables	\$0	\$0	
Power Requirements	25kW	25kW	
Fuel Costs	\$184	\$184	
Flow Rate	1000	1000	
Total Hourly Cost	\$192	\$190	
Total Cost/MT Flow	\$0.19	\$0.19	

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	TAPS Trade
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$45,500	\$40,500				
Install - Retrofit			\$102,900	\$96,500	\$156,000	\$144,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.05	\$0.04	\$0.05	\$0.04	\$0.05	\$0.04
MT Ballast/Year	680,000	680,000	680,000	680,000	680,000	680,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$1,839,573	\$1,817,573	\$1,963,640	\$1,940,240	\$2,016,740	\$1,987,740
Lifecycle Cost/MT	\$0.11	\$0.11	\$0.12	\$0.11	\$0.12	\$0.12

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$3,000	\$2,000	\$4,000	\$3,500	\$4,000	\$3,500
Design Review	\$0	\$0	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$1,500	\$1,500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$19,500	\$16,500	\$35,000	\$32,500	\$57,500	\$52,500
Electrical Installation	\$7,500	\$6,000	\$13,500	\$12,500	\$22,000	\$20,500
Steel Fabrication	\$7,500	\$7,500	\$27,500	\$25,500	\$47,500	\$43,000
QA/QC Costs	\$3,000	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$10,500	\$8,500
Painting Costs	\$0	\$0	\$7,400	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$45,500	\$40,500	\$102,900	\$96,500	\$156,000	\$144,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$37	\$37
Flow Rate	1000	1000
Total Hourly Cost	\$45	\$44
Total Cost/MT Flow	\$0.05	\$0.04

Monitoring

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker					
<b>Vessel Size</b>	TAPS Trade					
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	680,000	680,000	680,000	680,000	680,000	680,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						

**Illustration of BWTS Costs  
(Example for Retrofit Using Asian Yard)**

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	VLCC

	<b>Filtration &amp; UV Light</b>	<b>Filtration &amp; Chemical</b>	<b>Deoxygenation &amp; Cavitation</b>	<b>Electrolysis &amp; Electrochlorination</b>	<b>Filtration, Deoxygenation &amp; Cavitation<sup>7</sup></b>
<b>Total Capital Costs<sup>1</sup></b>	\$1,000,333	\$1,082,667	\$753,000	\$765,667	NA
<b>Annual Fixed Operating Costs<sup>2</sup></b>	\$10,500	\$18,000	\$9,000	\$17,000	NA
<b>Cost per MT BW Treated<sup>3</sup></b>	\$0.03	\$0.23	\$0.19	\$0.04	NA
<b>Lifecycle Costs<sup>4</sup></b>	\$2,286,922	\$8,597,159	\$6,737,045	\$2,528,914	NA
<b>Average Annual Cost<sup>5</sup></b>	\$91,477	\$343,886	\$269,482	\$101,157	NA
<b>Average Cost/MT of BW<sup>6</sup></b>	\$0.08	\$0.28	\$0.22	\$0.08	NA

<sup>1</sup> Includes initial purchase and installation of ballast water treatment system.

<sup>2</sup> Annual fixed operating costs do not vary with the volume of ballast water treated (ship size), and exclude time costs that vary with volume of ballast water treated. Annual fixed operating costs include crew, consumables, parts, estimated breakage, industrial assistance, and technical support.

<sup>3</sup> Includes costs that typically vary with the volume of ballast water treated such as crew costs, consumables, fuel costs.

<sup>4</sup> Includes capital costs, annual fixed operating costs, and per MT BW treatment costs. Assumes 1,210,000 MT BW treated per year and 25-year life of treatment system.

<sup>5</sup> Lifecycle costs divided by 25 years (not discounted).

<sup>6</sup> Lifecycle costs divided by estimated MT ballast water per year based on an expected 25 year BWTS operating life.

<sup>7</sup> Not enough data found on Filtration, Deoxygenation & Cavitation Systems to include.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	VLCC
<b>Ballast Treatment System:</b>	Filtration and UV Light

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$840,000	\$840,000	\$933,333	\$933,333	\$933,333	\$933,333
Install - New Const	\$32,000	\$23,500				
Install - Retrofit			\$78,500	\$67,000	\$111,000	\$96,500
Fixed Annual Cost	\$11,000	\$10,500	\$11,000	\$10,500	\$11,000	\$10,500
Cost per MT Ballast	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03	\$0.03
MT Ballast/Year	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$2,171,089	\$2,150,089	\$2,310,922	\$2,286,922	\$2,343,422	\$2,316,422
Lifecycle Cost/MT	\$0.07	\$0.07	\$0.08	\$0.08	\$0.08	\$0.08

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$720,000	\$720,000	\$648,000	\$648,000	Est
System 2	\$1,240,000	\$1,240,000	\$1,116,000	\$1,116,000	Est
System 3	\$840,000	\$840,000	\$756,000	\$756,000	
Average Price	\$933,333	\$933,333	\$840,000	\$840,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$1,500	\$0	\$3,000	\$2,500	\$3,000	\$2,500
Design Review	\$0	\$0	\$1,500	\$2,000	\$1,500	\$2,000
Purchasing Support	\$1,500	\$500	\$2,000	\$2,000	\$2,000	\$500
Piping Installation	\$10,500	\$8,500	\$25,000	\$21,000	\$43,500	\$37,500
Electrical Installation	\$6,500	\$4,000	\$14,000	\$12,000	\$19,000	\$17,500
Steel Fabrication	\$6,500	\$4,500	\$15,000	\$12,000	\$25,000	\$21,000
QA/QC Costs	\$2,000	\$1,500	\$6,000	\$4,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$10,000	\$8,000
Painting Costs	\$0	\$0	\$5,500	\$4,000	\$3,500	\$3,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$32,000	\$23,500	\$78,500	\$67,000	\$111,000	\$96,500

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$0	\$0
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$0	\$0
Total Annual Costs	\$11,000	\$10,500

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0	\$0
Consumables	\$0	\$0
Power Requirements	100 kW	100 kW
Fuel Costs	\$34	\$34
Flow Rate	1000	1000
Total Hourly Cost	\$34	\$34
Total Cost/MT Flow	\$0.03	\$0.03

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	VLCC
<b>Ballast Treatment System:</b>	Filtration and Chemical

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$852,000	\$852,000	\$946,667	\$946,667	\$946,667	\$946,667
Install - New Const	\$70,500	\$60,500				
Install - Retrofit			\$147,000	\$136,000	\$210,000	\$197,000
Fixed Annual Cost	\$18,500	\$18,000	\$18,500	\$18,000	\$18,500	\$18,000
Cost per MT Ballast	\$0.24	\$0.23	\$0.24	\$0.23	\$0.24	\$0.23
MT Ballast/Year	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$8,596,159	\$8,426,992	\$8,767,326	\$8,597,159	\$8,830,326	\$8,658,159
Lifecycle Cost/MT	\$0.28	\$0.28	\$0.29	\$0.28	\$0.29	\$0.29

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$1,670,000	\$1,670,000	\$1,503,000	\$1,503,000	Est
System 2	\$400,000	\$400,000	\$360,000	\$360,000	Est
System 3	\$770,000	\$770,000	\$693,000	\$693,000	
Average Price	\$946,667	\$946,667	\$852,000	\$852,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$1,500	\$4,500	\$3,500	\$4,500	\$3,500
Design Review	\$0	\$0	\$2,500	\$3,000	\$2,500	\$3,000
Purchasing Support	\$1,500	\$1,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$45,000	\$38,000	\$59,500	\$55,500	\$95,000	\$90,000
Electrical Installation	\$9,500	\$8,500	\$14,500	\$13,500	\$25,000	\$23,000
Steel Fabrication	\$6,500	\$5,500	\$41,000	\$37,500	\$60,000	\$56,000
QA/QC Costs	\$2,000	\$1,500	\$8,000	\$6,500	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$8,500	\$7,500	\$5,500	\$5,500
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$3,500	\$4,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$70,500	\$60,500	\$147,000	\$136,000	\$210,000	\$197,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$5,000	\$5,000
Industrial Assistance	\$3,500	\$3,500
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$18,500	\$18,000

PPM	150
Gal/MT	264
Gal/MT BW @ 150ppm	0.04
MT per trip	110000
Trip/year	11
Barrel/year	880

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per MT	\$0.03	\$0.03
Consumables	\$0.18	\$0.18
Power Requirements	74kW	74kW
Fuel Costs	\$25	\$25
Flow Rate	1000	1000
Total Hourly Cost	\$25	\$25
Total Cost/MT Flow	\$0.24	\$0.23

**NOTES:**

Units typically to be installed on weather or well ventilated cargo areas
Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Chemical Costs estimated at \$250/drum plus freight and delivery
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	VLCC
<b>Ballast Treatment System:</b>	Deoxygenation and Cavitation

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$640,000	\$640,000	\$640,000	\$640,000
Install - New Const	\$68,500	\$62,500				
Install - Retrofit			\$121,500	\$113,000	\$178,500	\$164,000
Fixed Annual Cost	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000	\$9,000
Cost per MT Ballast	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19	\$0.19
MT Ballast/Year	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$6,690,358	\$6,646,545	\$6,783,358	\$6,737,045	\$6,840,358	\$6,788,045
Lifecycle Cost/MT	\$0.22	\$0.22	\$0.22	\$0.22	\$0.23	\$0.22

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price	
System 1	\$640,000	\$640,000	\$600,000	\$600,000	Verified
Average Price	\$640,000	\$640,000	\$600,000	\$600,000	

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$2,500	\$2,000	\$3,500	\$3,000	\$4,500	\$3,000
Design Review	\$1,000	\$1,500	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$35,000	\$32,500	\$48,000	\$44,500	\$71,000	\$66,000
Electrical Installation	\$5,500	\$4,500	\$13,500	\$12,500	\$23,000	\$21,500
Steel Fabrication	\$9,500	\$8,000	\$33,000	\$30,000	\$54,500	\$49,000
QA/QC Costs	\$3,500	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$1,500	\$1,000	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$3,500	\$3,000	\$7,000	\$6,500	\$5,500	\$5,500
Regulatory Fees	\$4,500	\$5,500	\$4,500	\$5,500	\$4,000	\$5,000
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$68,500	\$62,500	\$121,500	\$113,000	\$178,500	\$164,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$2,500	\$2,000
Parts Required	\$1,500	\$1,500
Est. Breakage	\$2,500	\$2,500
Industrial Assistance	\$2,500	\$3,000
Technical Support	\$0	\$0
Total Annual Costs	\$9,000	\$9,000

Cost per MT Ballast	US Ship	Foreign Ship	
Crew Costs per hour	\$8	\$7	Start-up, monitoring of burner unit
Consumables	\$0	\$0	
Power Requirements	25kW	25kW	
Fuel Costs	\$184	\$184	
Flow Rate	1000	1000	
Total Hourly Cost	\$192	\$190	
Total Cost/MT Flow	\$0.19	\$0.19	

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Fuel rates for NEI burner \$178.09/hr as per published report dated 24 Apr 2007
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker
<b>Vessel Size</b>	VLCC
<b>Ballast Treatment System:</b>	Electrolysis and Electrochlorination

	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Initial Purchase	\$600,000	\$600,000	\$666,667	\$666,667	\$666,667	\$666,667
Install - New Const	\$50,000	\$44,000				
Install - Retrofit			\$105,000	\$99,000	\$167,500	\$154,000
Fixed Annual Cost	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000	\$17,000
Cost per MT Ballast	\$0.05	\$0.04	\$0.05	\$0.04	\$0.05	\$0.04
MT Ballast/Year	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	\$2,443,497	\$2,407,247	\$2,565,164	\$2,528,914	\$2,627,664	\$2,583,914
Lifecycle Cost/MT	\$0.08	\$0.08	\$0.08	\$0.08	\$0.09	\$0.09

Initial Purchase Cost	US Yard	Foreign Yard	US Bulk Price	Foreign Bulk Price
System 1	\$700,000	\$700,000	\$630,000	\$630,000
System 2	\$750,000	\$750,000	\$675,000	\$675,000
System 3	\$550,000	\$550,000	\$495,000	\$495,000
Average Price	\$666,667	\$666,667	\$600,000	\$600,000

Installation Matrix Expense	New Construction		Retrofit Yard		Retrofit In Service	
	US Yard	Foreign Yard	US Yard	Foreign Yard	US Vessel	Foreign Vessel
Design Engineering	\$3,500	\$2,500	\$4,000	\$3,500	\$4,000	\$3,500
Design Review	\$0	\$0	\$2,000	\$2,500	\$2,000	\$2,500
Purchasing Support	\$1,500	\$1,500	\$2,000	\$2,000	\$2,000	\$2,000
Piping Installation	\$19,500	\$16,500	\$35,000	\$33,000	\$60,500	\$55,000
Electrical Installation	\$8,500	\$7,000	\$14,500	\$13,500	\$24,500	\$23,000
Steel Fabrication	\$10,500	\$9,500	\$28,500	\$26,500	\$52,000	\$47,000
QA/QC Costs	\$3,000	\$2,500	\$5,000	\$4,000	\$0	\$0
Supervisor Costs	\$0	\$0	\$3,000	\$2,500	\$12,000	\$9,500
Painting Costs	\$0	\$0	\$7,500	\$7,000	\$6,000	\$6,000
Regulatory Fees	\$3,500	\$4,500	\$3,500	\$4,500	\$4,500	\$5,500
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$50,000	\$44,000	\$105,000	\$99,000	\$167,500	\$154,000

Fixed Annual Costs	US Ship	Foreign Ship
Crew Costs	\$3,500	\$3,000
Parts Required	\$5,000	\$5,000
Est. Breakage	\$3,500	\$3,500
Industrial Assistance	\$3,500	\$4,000
Technical Support	\$1,500	\$1,500
Total Annual Costs	\$17,000	\$17,000

Cost per MT Ballast	US Ship	Foreign Ship
Crew Costs per hour	\$8	\$7
Consumables	\$0	\$0
Power Requirements	110kW	110kW
Fuel Costs	\$37	\$37
Flow Rate	1000	1000
Total Hourly Cost	\$45	\$44
Total Cost/MT Flow	\$0.05	\$0.04

Monitoring

**NOTES:**

Fuel cost based on 25MT/day consumption MGO, 2.0MW normal bus load
Fixed annual costs are only for maintenance of BWT system
Retrofit in Service based upon use of riding crew
Assumes vessel operates in salt water environment
New construction purchase cost assumes bulk price procured directly by shipyard.

Preliminary Analysis of Cost of Ballast Water Treatment Systems  
December 22, 2009

<b>Vessel Type</b>	Tanker					
<b>Vessel Size</b>	VLCC					
<b>Ballast Treatment System:</b>	Filtration, Deoxygenation & Cavitation					
	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Initial Purchase	\$0	\$0	\$0	\$0	\$0	\$0
Install - New Const	\$0	\$0				
Install - Retrofit			\$0	\$0	\$0	\$0
Fixed Annual Cost	\$0	\$0	\$0	\$0	\$0	\$0
Cost per MT Ballast	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
MT Ballast/Year	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000
Expected Life	25	25	25	25	25	25
Total Cost of System	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Lifecycle Cost/MT	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
<b>Initial Purchase Cost</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Bulk Price</b>	<b>Foreign Bulk Price</b>		
Average Price	\$0	\$0	\$0	\$0		
<b>Installation Matrix</b>	<b>New Construction</b>		<b>Retrofit Yard</b>		<b>Retrofit In Service</b>	
<b>Expense</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Yard</b>	<b>Foreign Yard</b>	<b>US Vessel</b>	<b>Foreign Vessel</b>
Design Engineering	\$0	\$0	\$0	\$0	\$0	\$0
Design Review	\$0	\$0	\$0	\$0	\$0	\$0
Purchasing Support	\$0	\$0	\$0	\$0	\$0	\$0
Piping Installation	\$0	\$0	\$0	\$0	\$0	\$0
Electrical Installation	\$0	\$0	\$0	\$0	\$0	\$0
Steel Fabrication	\$0	\$0	\$0	\$0	\$0	\$0
QA/QC Costs	\$0	\$0	\$0	\$0	\$0	\$0
Supervisor Costs	\$0	\$0	\$0	\$0	\$0	\$0
Painting Costs	\$0	\$0	\$0	\$0	\$0	\$0
Regulatory Fees	\$0	\$0	\$0	\$0	\$0	\$0
Drydock Costs	\$0	\$0	\$0	\$0	\$0	\$0
Divers Costs	\$0	\$0	\$0	\$0	\$0	\$0
Vessel Downtime	\$0	\$0	\$0	\$0	\$0	\$0
Total Costs	\$0	\$0	\$0	\$0	\$0	\$0
<b>Fixed Annual Costs</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Parts Required						
Est. Breakage						
Industrial Assistance						
Technical Support						
Total Annual Costs	\$0	\$0				
<b>Cost per MT Ballast</b>	<b>US Ship</b>	<b>Foreign Ship</b>				
Crew Costs						
Consumables						
Power Requirements						
Fuel Costs						
Flow Rate						
Total Hourly Cost	\$0	\$0				
Total Cost/MT Flow	#DIV/0!	#DIV/0!				
<b>NOTES:</b>						