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Treatment Systems, LLC

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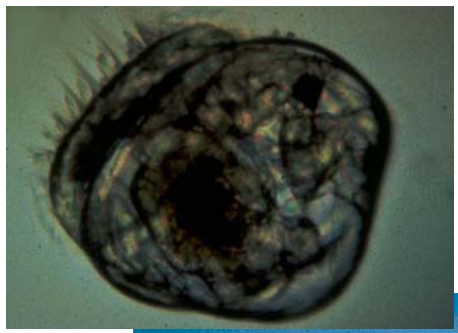
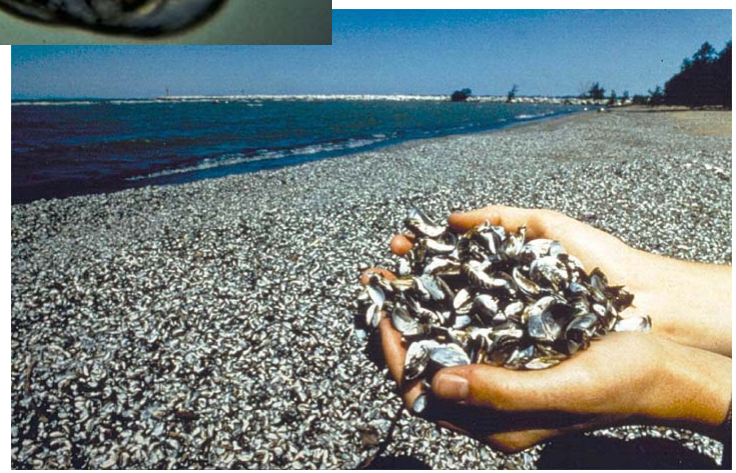
- **Founded 1997 to serve major oil and power companies' environmental compliance issues**
- **Involvement in Oil Spill Response brought the ballast water invasive species issue to our attention**
- **Assessment of existing water treatment technology determined that something new would be required**
- **Began development in 2002 on ballast water treatment system: Venturi Oxygen Stripping™**

Background - Ballast Water Transport of Aquatic Organisms

- **Zebra Mussel: Black Sea to Great Lakes**
- **Comb Jelly: US Atlantic Coast to Black Sea**
- **Thousands of Examples Globally**
- **Damage is Often Irreversible**
- **Cost = Billions of Dollars**
- **International Regulations**





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Current Status of Regulations

- **Brazil, Canada, US, others ballast exchange is mandatory (potentially damaging, new ships – extra steel)**
- **Several US States passed bills (e.g., WA, CA, MI)**
- **US Coast Guard developing treatment standards**
- **IMO Convention in force (2009), all ships exchange or treat**
- **IMO D-2 treatment standards (2009 for "small" new ships):**

Higher Organisms

< 10 viable organisms/m^3 > 50 µm

< 10 viable organisms/ml < 50 µm and > 10 µm

Indicator Microbes

< 1 cfu per 100 ml of toxigenic *Vibrio cholerae*

< 250 cfu per 100 ml of *Escherichia coli*

< 100 cfu per 100 ml of intestinal *Enterococci*

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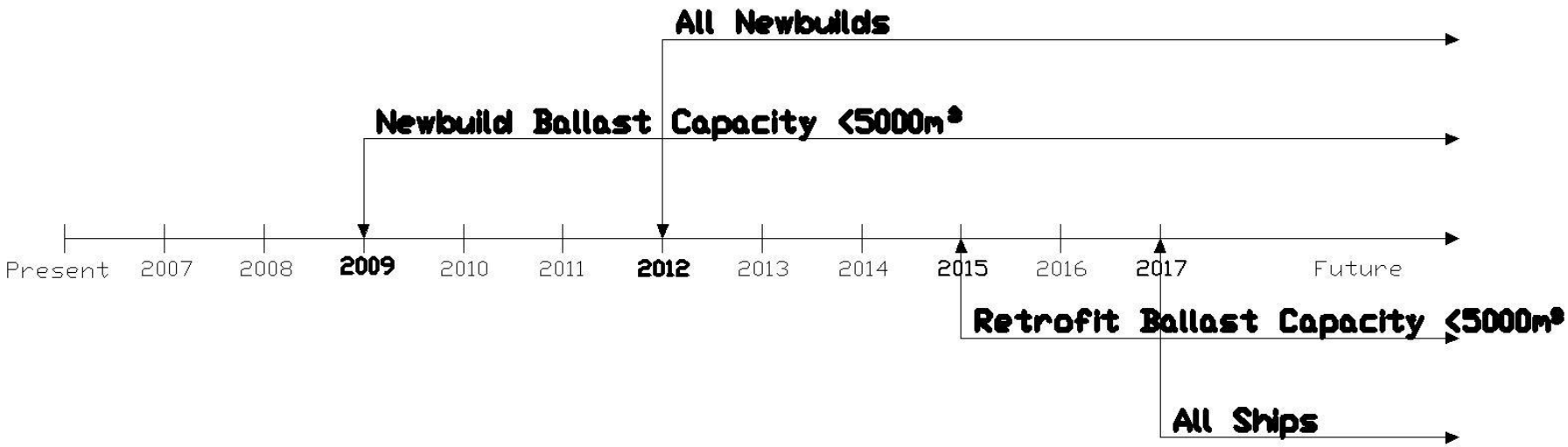
IMO Ballast Water Convention Phase-In



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Serious Engineering Challenge

- **Ships' ballast pumps run near the same flow rate as a municipal drinking water treatment plant. Such plants occupy several acres of land and employ dozens of people 24 hours a day.**

- **Not feasible on a ship. Something new is needed.**

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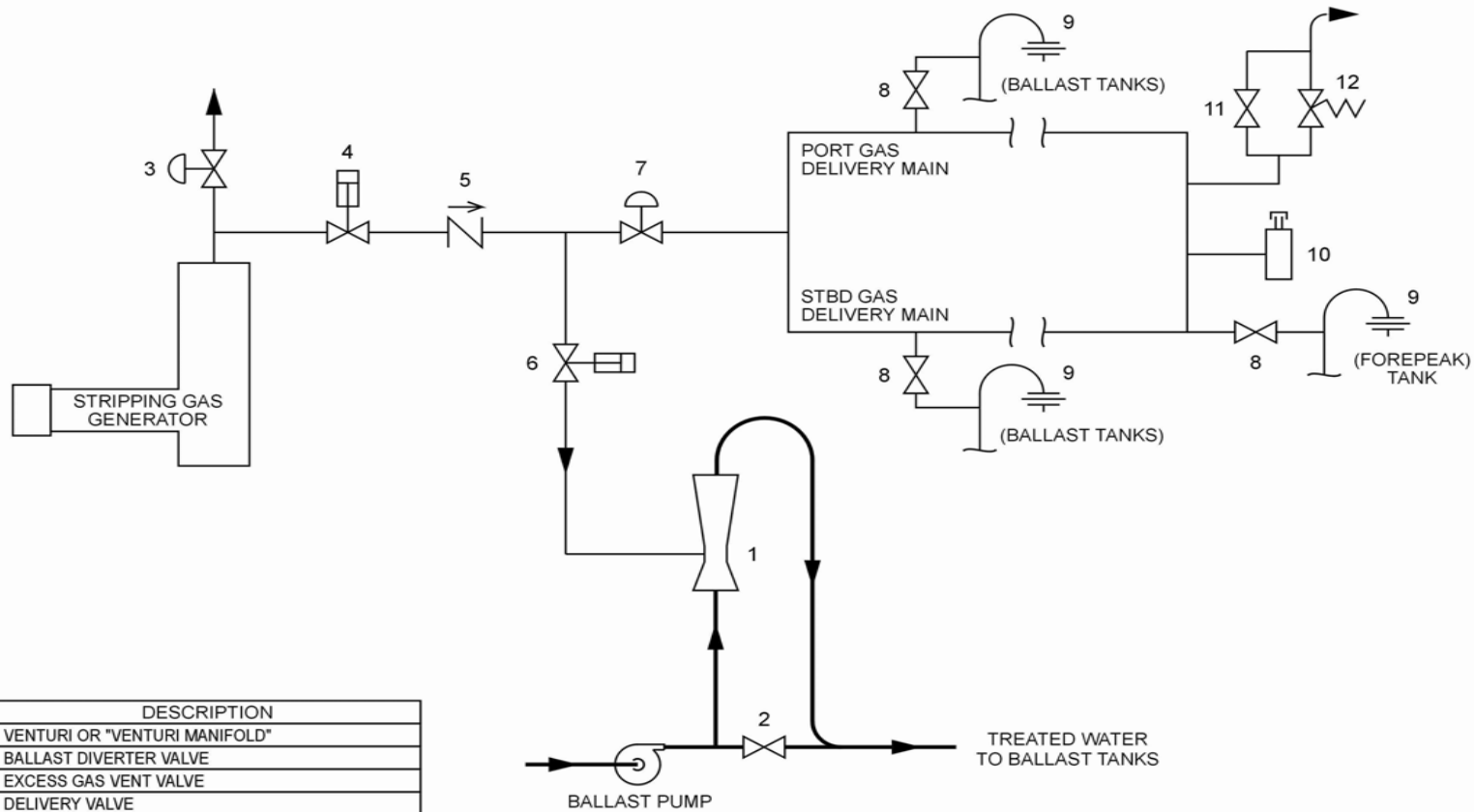
Venturi Oxygen Stripping™



ITEM #	DESCRIPTION
1	VENTURI OR "VENTURI MANIFOLD"
2	BALLAST DIVERTER VALVE
3	EXCESS GAS VENT VALVE
4	DELIVERY VALVE
5	SWING CHECK VALVE
6	VENTURI GAS SUPPLY VALVE
7	PRESSURE CONTROL / DECK ISOLATION VALVE
8	TANK ISOLATING VALVE
9	RUPTURE DISK
10	P-V BREAKER
11	VENT VALVE
12	P-V VALVE

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Advantages

- **Proven to meet the IMO Standards**
- **No upper flow rate limit**
- **Works in dirty water (no filters needed)**
- **Minimal crew attention to operate**
- **No negative affect upon discharge**

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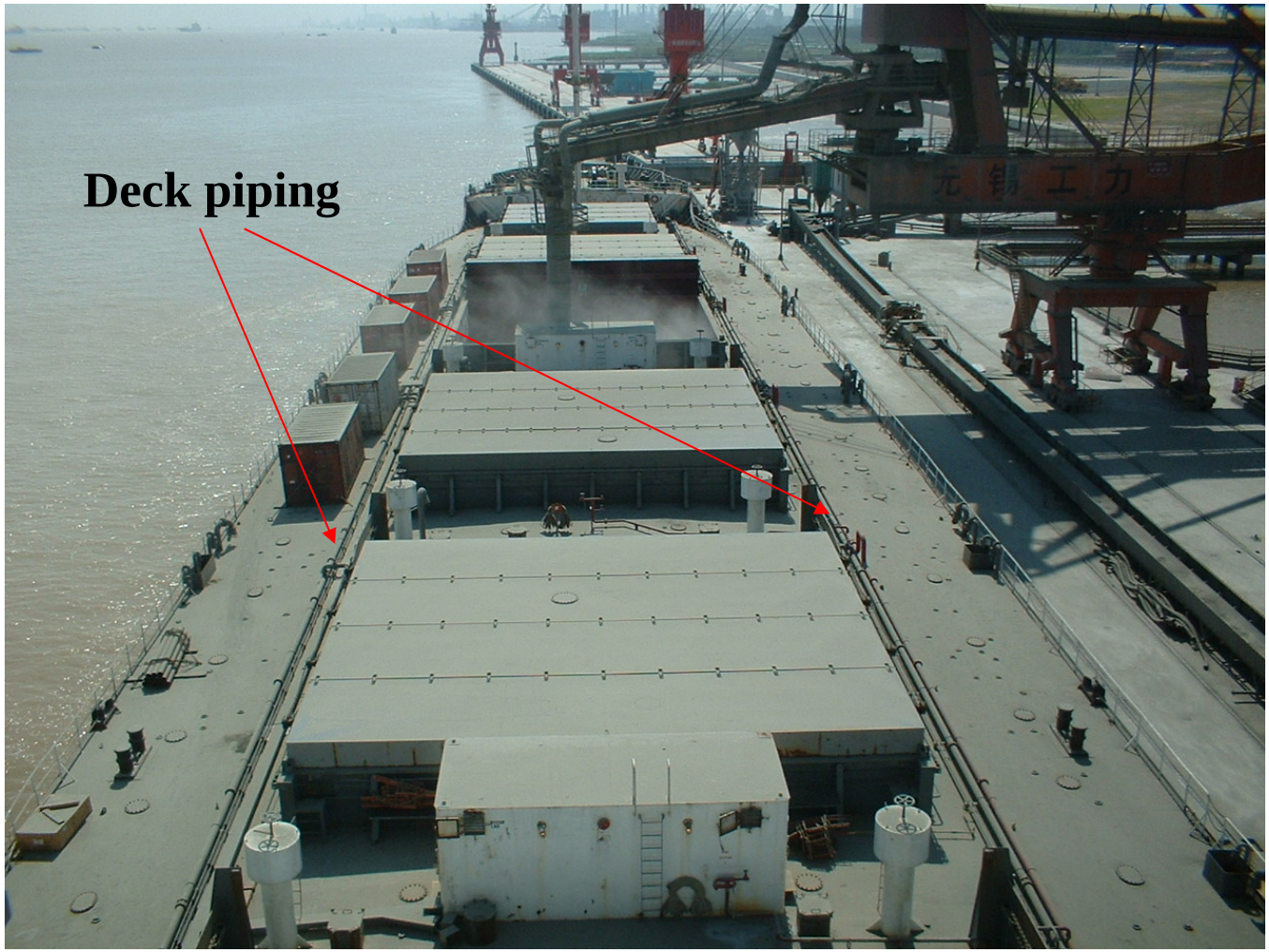
Testing at the Chesapeake Biological Laboratory

Shipboard Installation

Shipboard Installation



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Shipboard Installation

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System Operation

- **Fill Ballast Tanks:**

  1. Push Blue Button to align valves
  2. Push Green Button to start pumps
  3. Push Red Button to stop

- **Drain Ballast Tanks:**

  1. Push White Button to align valves
  2. Push Green Button to start pumps
  3. Push Red Button to stop

- **Chart Recorder Verifies Performance**

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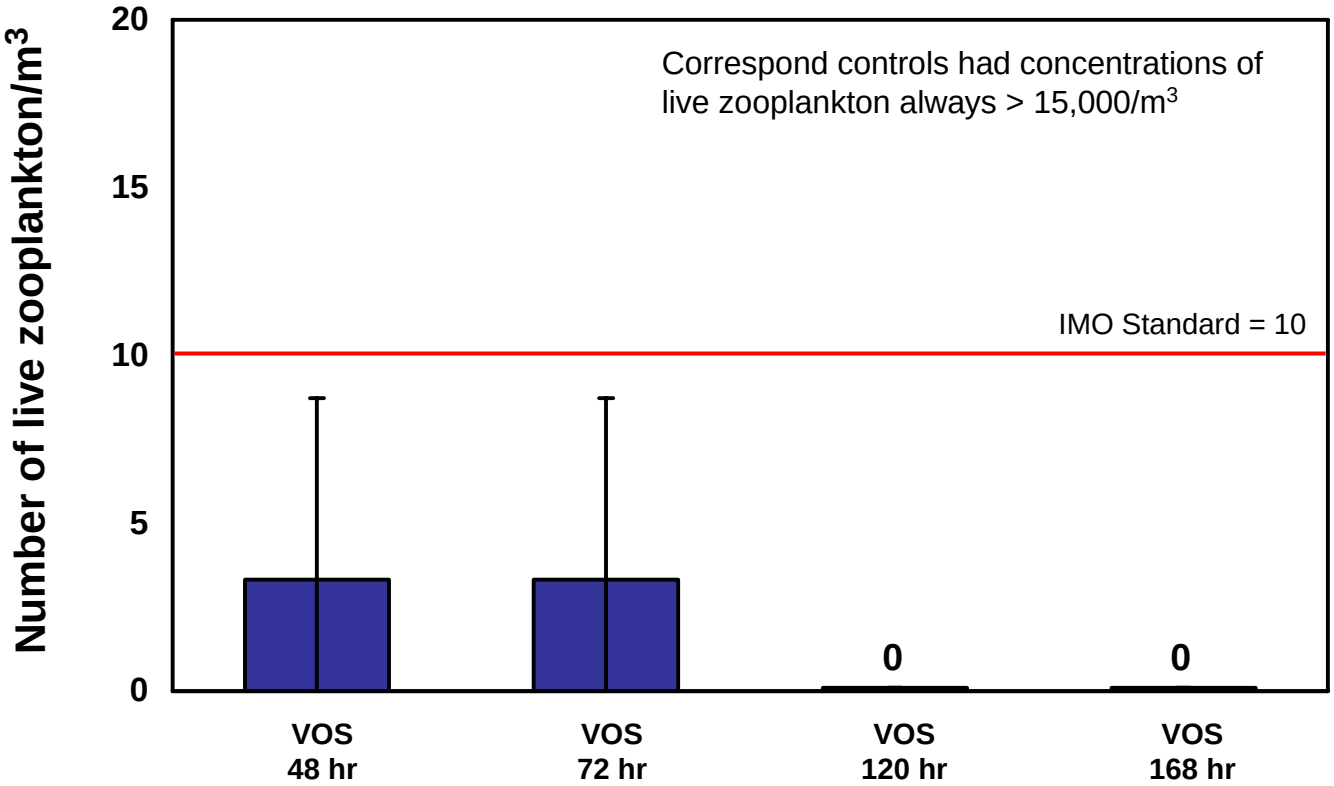
Biological Treatment - Zooplankton

(> 50 microns)



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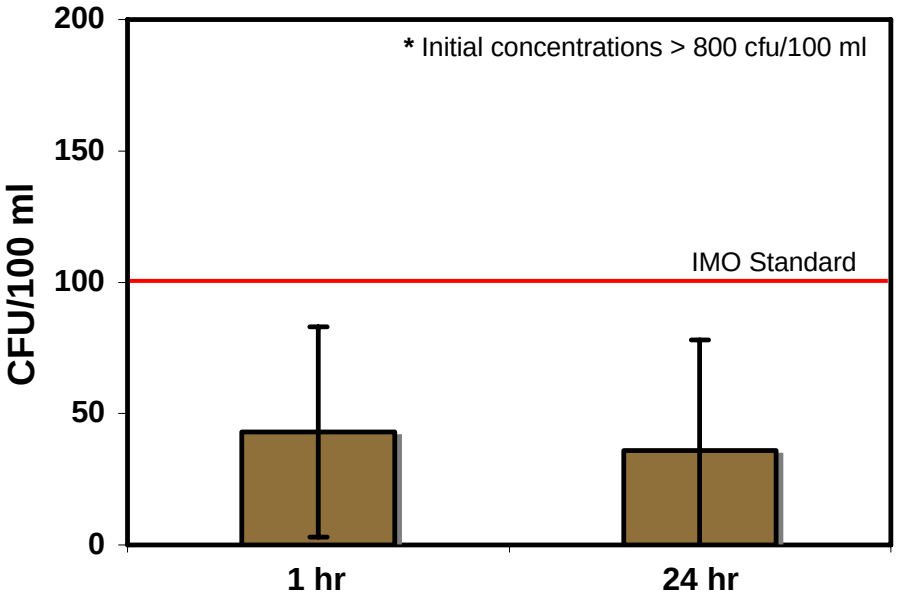
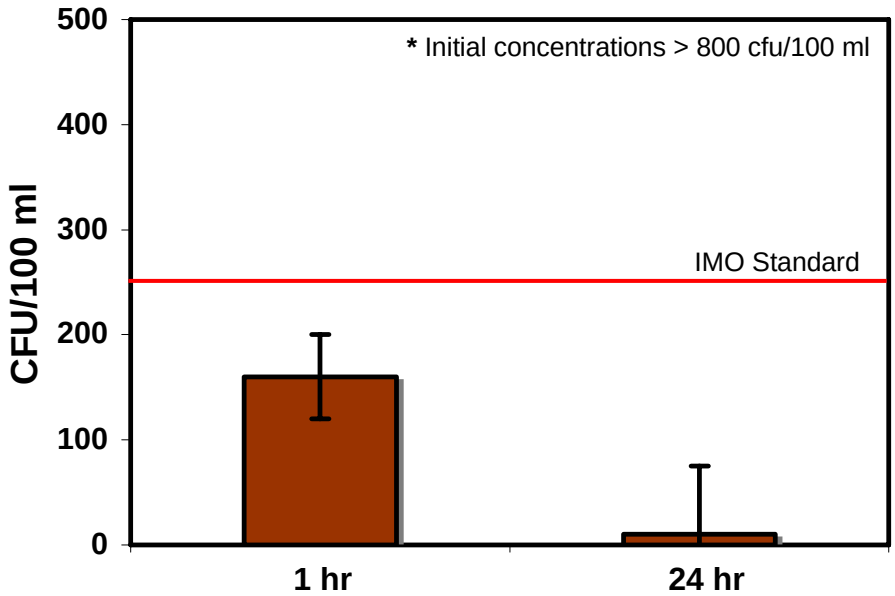
Biological Treatment - Bacteria

Enterococci



E. coli



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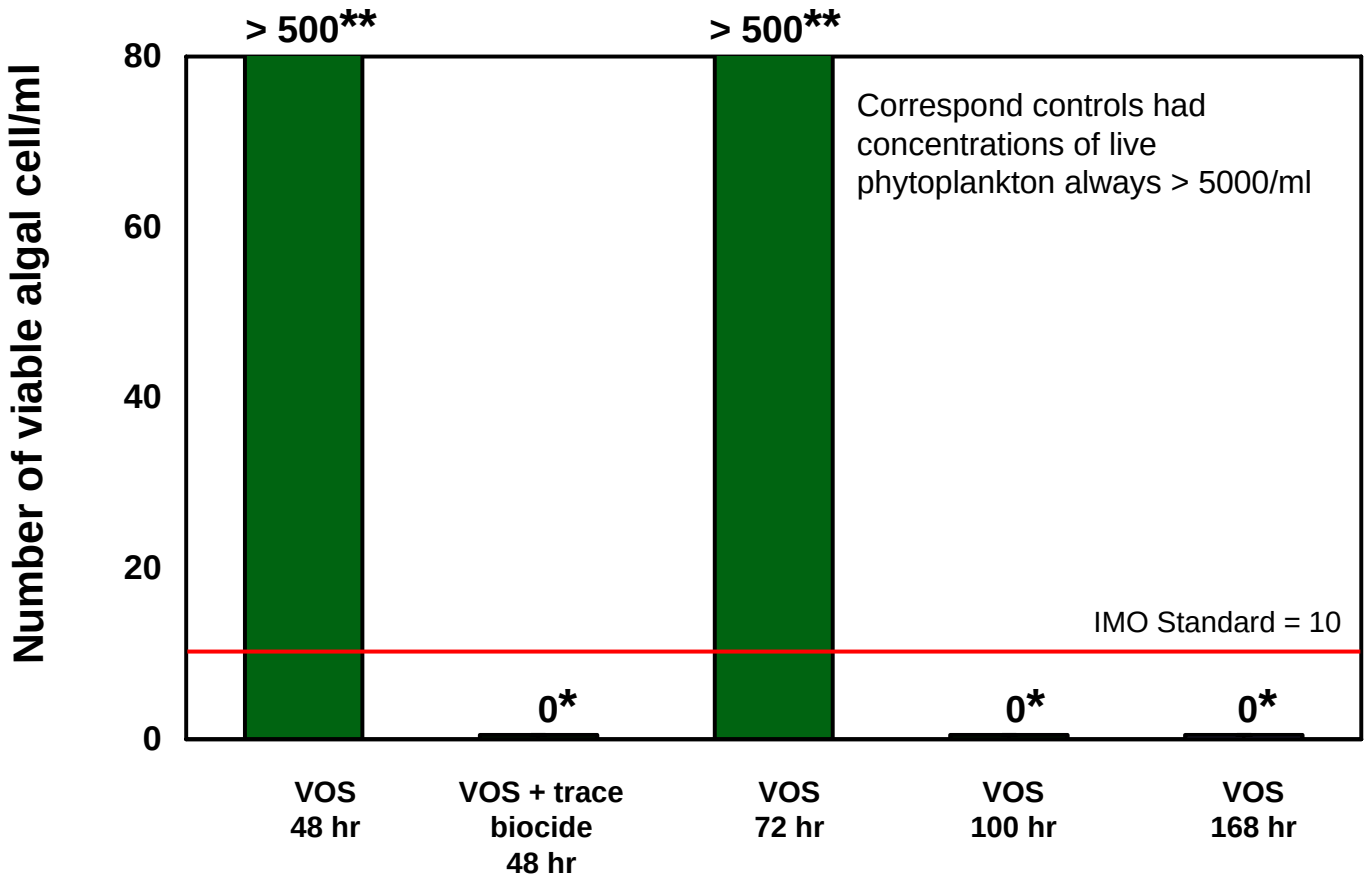
Biological Treatment - Phytoplankton

(10 - 50 microns)



* Below method detection limit, not significantly different form nanopure water blank.

** Significantly greater than standard.

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Impacts of Discharge

- **Reoxygenation upon release is rapid**

	Ambient	<1 meter	3 meters
DO (mg/l)	10.5	8.7	10.5
pH	7.8	7.0	7.8

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Current Status / Future Plans

- **Testing ongoing to verify biological and mechanical function**
- **Preparing STEP application for** *Mary Ann Hudson*
- **Expecting next shipboard system installation early 2007**
- **For more information :www.nei-marine.com**
  213-383-5855

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