Evaluation of Hydrocyclone/UV Ballast Treatment aboard the cruise ship SEA PRINCESS

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WHAT'S NEW

Princess Cruises

BALLAST WATER TREATMENT SYSTEM INSTALLATIONS

Hyde Marine, Inc. of Cleveland, Ohio, is delivering four new full-scale OptiMar Ballast Water Treatment Systems during the second half of 2001. This state of the art technology, manufactured by OptiMarin A/S of Stavanger, Norway, is designed to control the spread of Aquatic Nuisance Species in ship's ballast water.

Hyde Marine delivered the first ever full-scale ballast water treatment system using ultraviolet light with cyclonic separation pretreatment for installation aboard the cruise ship "Regal Princess". This system
OptiMar Ballast Systems - Practical Solutions for Ballast Water Treatment

Problem

Around the world more than 10 billion tons of ballast water are carried in ships each year containing thousands of species of aquatic animals and plants. This creates problems for the marine environment and human health and threatens economies that depend on healthy aquatic ecosystems. The transportation of ballast water cannot be stopped, but the transfer of harmful aquatic organisms and pathogens can be minimized by deep sea exchange or suitable treatment. Ballast water exchange is costly, time consuming and is at best only 90% effective. Pumps may have to run for 3-4 days, which increases fuel consumption, and wear and tear on equipment and stack emissions. Ballast water exchange can result in increased hull stresses and stability problems.

OptiMar Ballast System

The OptiMar Ballast System offers an effective and reliable solution based on solids separation and UV irradiation. The OptiMar system utilizes existing ballast pumps and piping. Standard systems are available for flow rates from 100 m³/h up to 3000 m³/h.
So…

Let’s test the system
Conclusions (at the moment):

• We find no significant effect from the hydrocyclone/UV treatment
• The largest measurable ‘effect’ derives from the ballast tank itself
Flow Diagram
M/S Sea Princess

MicroKill UV Mod: LP350-14- XF

Ovb. disc
Slave
UV Control Panel
Power

BFV 1
BFV 2
Pump C

BFV 5
BFV 9

Tee DN 200
Red 150 x 200

MicroKill Sep Mod. HNN 200

AZ 054
AZ 053
AZ 055
AZ 051
AZ 034
AZ 056
AZ 058

Main bilge line 200 mm CuNi 90/10
Main ballast line 200 mm CuNi 90/10
Measurement parameters:

- Virus-like particles (VLP) – 0.02 um aluminum Anodisc filter, Syber-Gold Stain, Epifluorescence enumeration
- Bacteria – same as VLP,
- Phytoplankton – epifluorescence enumeration, bulk chl a (acetone extraction), HPLC determined chlorophylls and carotenoids
- Zooplankton – taxonomic abundance, survivorship
- Pulse Amplitude Modulated Fluorescence (PAM) – Walz PAM 2000 (diode detection); Walz Water PAM (photomultiplier detection)
- ATP – luciferin/luciferase, Turner 20/20 luminometer

- Others:
  - Carbon/Nitrogen (POC, PON)
  - Electron Transport System (ETS) respiratory activity
  - Bacteria - culture plates, nucleic acid ‘Live/Dead’ stains
  - Grow out experiments – phytoplankton, zooplankton
Diatom (red)

Bacteria (white)

Live Bacteria (SYTO 9)

Dead Bacteria (Dead-Red)

Live/Dead stained

25 um

DAPI stained
Ocean

Hydrocyclone/UV ‘Microkill’ Treatment

Sea-to-Sea

Control Ballast Tank

Treatment Ballast Tank

Ballast/De-Ballast
**Sea-to-Sea Trials**

**Viruses (VLP/mL)**

- **C**:
  - 0.0E+00
  - 2.0E+06
  - 4.0E+06
  - 6.0E+06
  - 8.0E+06
  - 1.0E+07
  - 1.2E+07
  - 1.4E+07
  - 1.6E+07
  - 1.8E+07

- **T**:
  - 1.0E+07

**Bacteria (cells/mL)**

- **C**:
  - 0.0E+00
  - 2.0E+06
  - 4.0E+06
  - 6.0E+06
  - 8.0E+06
  - 1.0E+07
  - 1.2E+07
  - 1.4E+07
  - 1.6E+07
  - 1.8E+07

- **T**:
  - 1.0E+07
Chlorophyll $a$ (ug/L)

ATP (ug/L)

Sea-to-Sea
OptiMar Ballast System Efficacy (M/V Sea Princess Cruises 1 and 2): "Pre-Treatment" vs. "Post-Treatment"

- Pre Treatment
- Post Treatment

N = 10 experiments
n= # specimens counted
n.s. = not significant

Taxa:
- Nauplii
- Calanoids
- Cyclopoids
- Harpacticoids
- Other
- Total
Bacteria (cells/mL)

Ballast/De-Ballast Experiments
Viruses (VLP/mL)

Ballast/De-ballast

Bar chart showing the comparison of viruses (VLP/mL) in Ballast/De-ballast conditions.

- B and D categories are represented in the chart.
- The chart indicates a significantly higher virus count in the D category compared to the B category.
- Other categories (C and T) show lower virus counts.
PAM Fluorescence Yield (Fv/Fm)

Ballast/De-Ballast

C T B D B D B D

T C T

PAM Fluorescence Yield (Fv/Fm)
Elution Time (min)

VIS Absorbance (relative response)

Chl c3, Peridinol, Chl c1,2, Peridinin, Chl a, Fucoxanthin, Diadinoxanthin, Zeaxanthin, 19' butanoyloxyfucoxanthin, beta-carotene
Conclusions (at the moment):

• We find no significant effect from the hydrocyclone/UV treatment
• The largest measurable ‘effect’ derives from the ballast tank itself
• We better do another test!!
Problems…

More work…
Diatom (red)

Bacteria (white)

Live Bacteria (SYTO 9)

Dead Bacteria (Dead-Red)

Live/Dead stained

25 μm

DAPI stained