Great Lakes Maritime Research Institute

A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

MICHIGAN

Update and Plans for Ballast-Free Ship Concept Development

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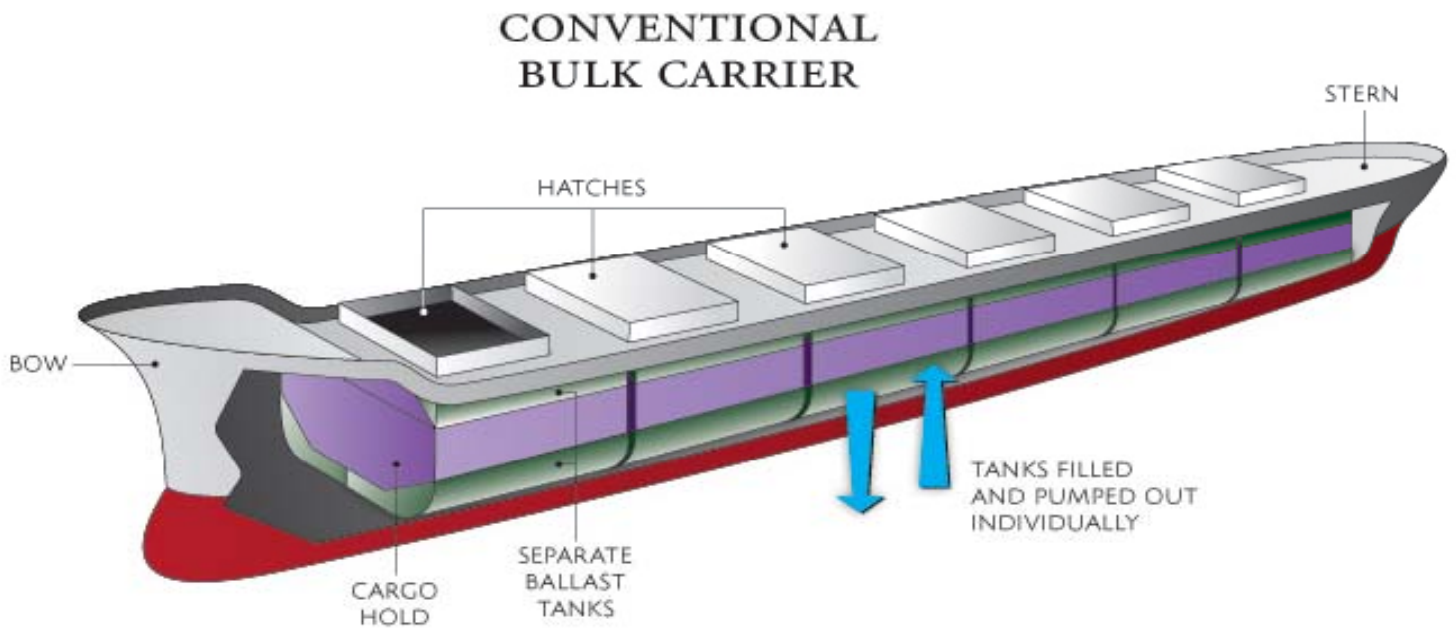
FY 2010 Goal: clarify economic and operational issues related to the use of the Ballast Free Ship concept

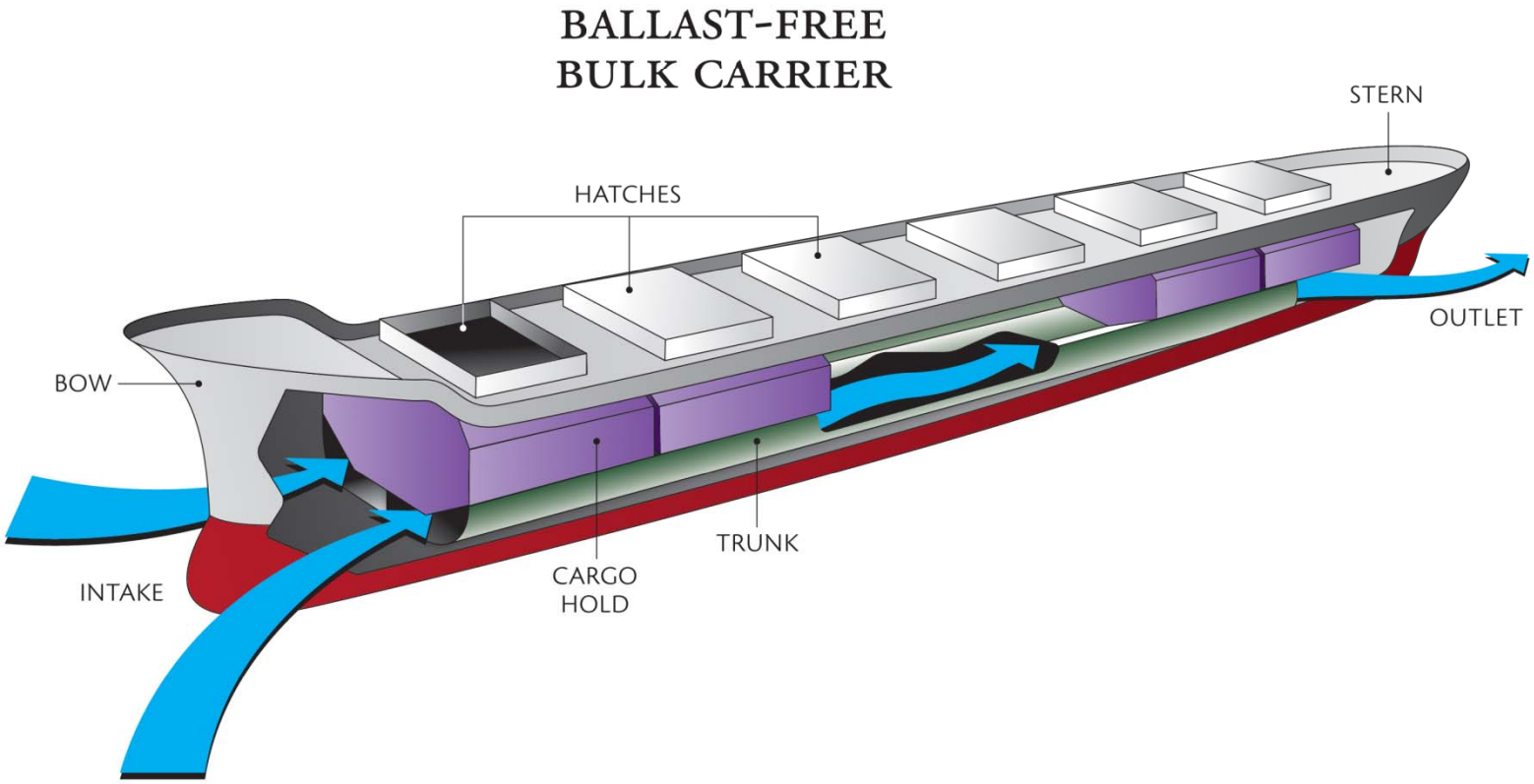
The Ballast-Free Ship Concept

- Traditional approach: Add water ballast to tanks to increase vessel weight in the light cargo condition
- Paradigm shift: instead of thinking add weight, reduce buoyancy
- Ballast-Free Ship concept principles:
  - Replace traditional ballast tanks with longitudinal, structural ballast trunks that extend beneath the cargo region below the ballast waterline.
  - Connect trunks to the sea through a plenum at the bow and another at the stern. Trunks flooded in ballast condition. Pumped when finished.
  - The natural hydrodynamic pressure differential between the bow and the stern region at speed induces a slow flow in the ballast trunks.
  - Trunks are, therefore, always filled with "local seawater."
- US Patent #6694908, 2004

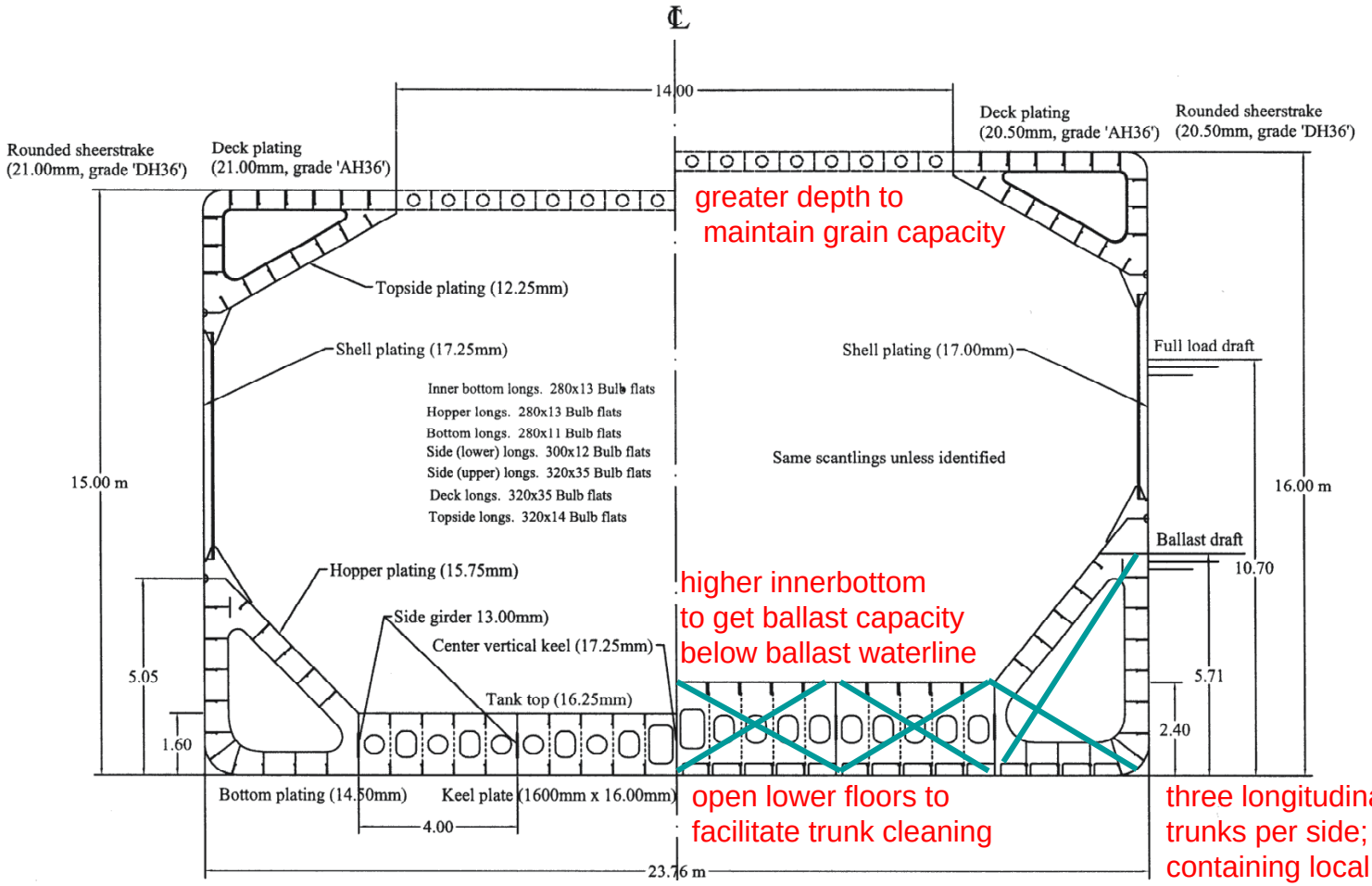
Conventional Bulk Carrier Ballast



Ballast Free Bulk Carrier



Comparison of Midship Sections



Typical Single-hull Salty Bulkcarrier

Ballast-Free Ship Design

Goals of the Past GLMRI Effort

- Design Ballast-Free ship Seaway-sized bulk carrier
- Build a precision scale model for use in subsequent hydrodynamic tests (FY2006),
- Optimize the location and details of the plena openings, particularly aft, in order to,
- Reduce the large propulsion power penalty (+7.4%) found in earlier National Sea Grant study (FY2007)
- Confirm and better explain the suspiciously large power decrease (-7.3%) observed in FY2007 (FY 2008)

Seaway-sized Bulk Carrier Hull Form Design

- Design based upon:

  Polsteam *Isa*

  design from Jiangnan

LWL = 195.5 m
LBP = 192.0 m
B = 23.76 m
D = 16.0 m
T_{FL} = 10.7 m

Block C_B = 0.835
Waterplane C_{WP} = 0.909
Displacement = 42,546 t

Ballasted to 40% fwd; 70% aft
Speed in ballast = 15.5 knots

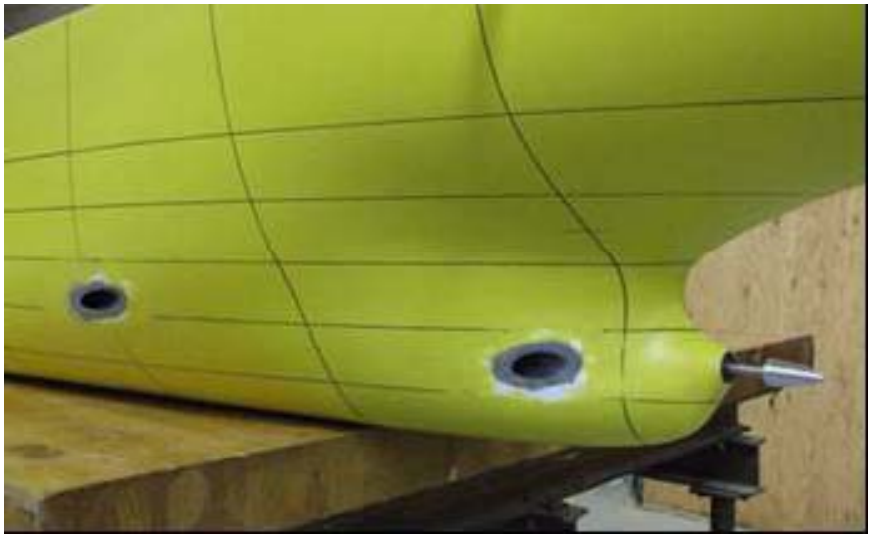
Scale Ratio λ = 37.92 (5 m model)

Five Meter (16.9’ LWL) Scale Model

FY2006 Result

Intake and Discharge Locations – July ‘08

Tip of bulb for maximum input pressure



STA17 – forward engine room bkhd

STA19 – aft engine room bulkhead

FY2007 and FY2008 Testing

Increased Resistance with Trunk Flow

FY2008 Result

Required Power Comparison

- Effective Power (resistance)/η_D = Delivered Power

  up 4.51% ? what really matters $$

- Propulsive efficiency $\eta_D = \eta_O\eta_R\eta_H = \eta_P\eta_H$
- Open water propeller efficiency η_O
- Relative rotative efficiency η_R
- Hull efficiency $\eta_H = (1 - t)/(1 – w)$

	η_O	η_R	η_H	
• Baseline η_D =	0.487 x	1.0126 x	1.0876 =	0.536
• STA 17 η_D =	0.522 x	0.9593 x	1.1380 =	0.570
	up	down	up	+6.27%

Order of Magnitude Economic Comparison

	Typical bulk carrier	Ballast-Free bulk carrier
Installed engine Nominal MCR (kW)	8,580	
Block coefficient	0.835	0.841
Required service MCR in ballast (kW)	7,700	7,575
Hull steel weight (tonnes)	5,553	5,767
CRF (i = 10%, 20 yrs.)	0.1175	
Case: Roundtrip Rotterdam; Seaway draft; discharge at Station 17 compared with filtration and UV treatment when ballast exchange is no longer allowed		
Net capital cost change ($)	- 476,400 lowered	
Net operating cost change per annum ($)	-116,920 fuel savings	
Change in RFR ($/tonne)	**- 1.03**	

almost $1 per tonne grain (1%) cheaper to operate

RFR = Required Freight Rate needed to make a profit
annual cargo capacity 168,000 t grain

Conclusions from Testing in FY2008

- Jan. 2007 STA17 improvement of -7.3% was incorrect
- Detailed analysis of changes in components showed inconsistent behavior compared to STA19 test and July 2008 test
- There is an increase in resistance (+4.5%) at STA17
- There can be a decrease in required power (-1.6%)
- Ballast-Free Ship concept can result in a significant savings compared to filtration and UV treatment etc. when ballast exchange is no longer allowed
- Still an issue of the effects of using stock propellers

Publications from GLMRI Effort

Short Invited Articles

Maritime Reporter
Great Lakes/Seaway Review
2008 Yearbook of Maritime Technology (Scandinavia)

Papers

Kotinis, M. and Parsons, M. G., "Hydrodynamic Investigation of the Ballast-Free Ship Concept" SNAME Annual Meeting, Ft. Lauderdale, Nov. 2007; in *Transactions* SNAME, **115**, 2007.

SNAME ABS/Captain Joseph H. Linnard Prize for the Best 2007 Paper

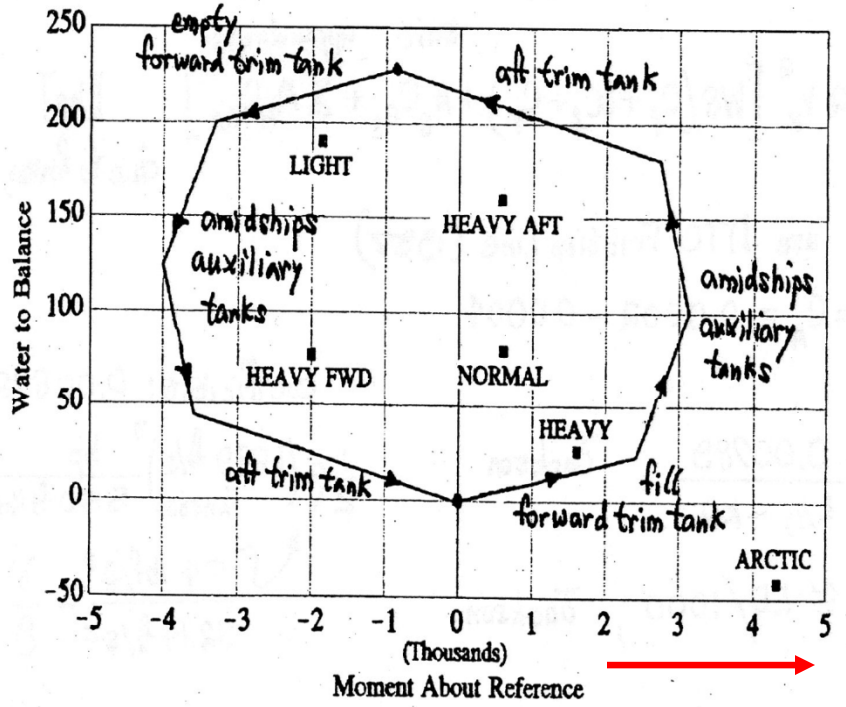
Kotinis, M. and Parsons, M. G., "Hydrodynamics of the Ballast-Free Ship Revisited," Great Lakes and Great Rivers Section Meeting of SNAME, Ann Arbor, MI, Nov. 13, 2008; submitted to *Marine Technology*

Goals for Coming Year FY2010

- Propulsion Investigation using Custom Propeller Design
  - resolve issue of stock versus optimum propeller
  - further clarify expected power/fuel savings (- $$)
  - Computational Fluid Dynamics (CFD) analyses
  - propeller design, rapid prototyping, MHL testing
- Details and Flow Resistance of Trunk Isolation Valves
  - early work used sluice valves – industry criticism
  - new design with motor operated butterfly valves
- Operations Capabilities of Trim/Draft Control
  - control is discrete (trunk segments full or empty)
  - versus continuous (various levels in ballast tanks)

Capability to be Displayed with an Adaptation of Submarine Equilibrium Diagrams

Weight or draft change



Trim moment

- Draft change versus trim moment envelope

Cases:

- Discrete segments from ends only (full or empty)
- Added piping ($$) to allow any discrete segment
- Use piping to fill segments to any level

Thank You

Questions?