"Greening the Fleet – UNOLS should explore how to make the present and future fleet more environmentally sustainable. New and existing technologies and practices should be used in the construction, operation, and recycling of research vessels and UNOLS should take a leadership role in promoting a green U.S. research fleet, as we move forward in developing the academic fleet."

Greening the Research Fleet
January 10-11, 2012
Nicholas School of the Environment
Duke University
GREEN BOATS AND PORTS FOR BLUE WATERS

A Workshop to Promote Environmental Sustainability of Boats and Ports
April 8-9, 2014
Green Boats and Ports for Blue Oceans

Acknowledgements

11th Hour Sailing - Primary Sponsor

Jeremy Pochman, Co-Founder and Director
Rob MacMillan, Co-Founder and Advisor
Kate Neubauer, Program Manager

Additional support from Braemer Energy, Utilidata, UNOLS
UNOLS Activities and Highlights

• **Green Ships and Ports Workshop**, January 2014 – Hosted by GSO with support from UNOLS

• **UNOLS Annual Meeting**: October 21-22, 2014
  – Featured Speaker - Senator Sheldon Whitehouse

• **UNOLS Fleet News**: Three vessels will retire from the UNOLS Fleet at the end of 2014:
  – R/V Knorr
  – R/V Melville
  – R/V Point Sur

• **A new look for UNOLS** – visit our updated website <unols.org>!
Contents

- Ship emissions and regulatory developments
- Energy efficiency, CO2 reduction
- Air emissions and abatement – NOx and SOx
- Operational measures, logistics
- Alternative fuels
Five elements essential for sustainability

- Marine Engineering
  - Basic load optimization
  - Monitoring of hull & propeller conditions
  - Waste heat recovery system
  - Slow steaming and super-slow steaming

- Innovation
  - Voyage planning and execution
  - Auxiliary Engine efficiency
  - QUEST: Low energy chilled containers
  - Modified bulbous bow
  - Ballast water optimization and treatment systems

- Vessel Performance
  - Main Engine efficiency
  - Cylinder oil optimization
  - New propulsion technologies
  - Crew awareness/engagement
  - ISO 14001 certified
  - SOx scrubber studies

- Regulatory
  - Cargo load optimization
  - Optimum trim guidance for all vessel classes

- Business Case
  - Monitoring of new paint technologies
Second IMO GHG Study 2009
Global CO2 emissions

- International shipping: 2.7% of global emissions; domestic/coastal shipping: 0.6%
- CO$_2$: main GHG ships
Eco-efficient ships: consider all relevant technologies. Maximum benefit for business and environment

Example

![Graph showing the cost/benefit of different technologies for reducing fuel consumption and CO2 emissions. The graph illustrates the percentage reduction in fuel consumption and CO2 emissions on the x-axis, and the cost/benefit (PBP, years) on the y-axis. The technologies include:
- Ex: Contrarotating Propeller
- Ex: Waste heat r.
- Ex: Derated ME
- Ex: Hull shape

A 'standard' ship is shown moving to the right to become an A 'green' ship.]

MAERSK LINE, LIMITED
**Regulatory scene**

- **ECA**
  - 2009: Use of low Sulphur fuels in ECA areas.
  - 2011: NOx Tier II
  - 2012: 1.0% S
  - 2013: 0.1% S
  - **2015**:
    - NOx Tier III
    - Invest in NOx reducing initiatives Required for CA port operation.
  - 2016: 0.1% S
  - 2017: 0.1% S
  - 2018: 0.1% S
  - **2020**:
    - 0.5% S
    - Use of low Sulphur fuels globally.

- **Global**
  - 2011: 3.5% S

- **General**
  - **2015**:
    - Ballast water treatment, existing ships.
  - **2020**:
    - Ballast water treatment, newbuildings

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MAERSK LINE, LIMITED
Innovation projects on the Maersk fleet

- Maersk Attender: Crane pendulation
- Thure Maersk: BWTS testing
- Maersk Kendal: Ventilation optimization
- Jeppesen Maersk: Auto-tuning of main engine
- Emma Maersk: Aux. engine waste heat
- Maersk Kalmar: Biofuel
- Olivia Maersk: Air lubrication
- Alexander Maersk: Exhaust gas recirculation
- Gudrun Maersk: Main eng. cooling systems
- Roy Maersk: CLT Propeller
- Laura Maersk: HT Pump optimization
- Maersk Ohio: Propeller boss cap fin
- Maersk Belfast: Water based hydraulics
- Arthur Maersk: Cylinder lube oil reduction

Maersk Maritime Technology
THE HYBRID SOLUTION
Power And Reliability In A Green Package

January 10, 2012
The Hybrid Tug Rationale

Typical harbour tug duty profile*
The Hybrid Tug Rationale

% of time

hybrid power plant design points

0.0%  10%  20%  30%  40%  50%  60%  70%  80%  90%  100%

percent of full load

Foss
Hybrid Emissions Reductions

- PM: 73%
- NOx: 51%
- CO2: 27%

SOURCE: California Air Resource Board Report
Prepared by: University of California – Riverside
College of Engineering-Center for Environmental Research and Technology
Operational Experience
Bio-Fuels and Lubricants

Dennis Donahue
NOAA-GLERL
Marine Superintendent
B100 Operational Experience

11 years experience
LMFS – 160,000 gallons annually
Cost savings – 20 to 40%
OEM’s – participate, validate
Crew assessment – “Non-issue”, “Prefer B100”
Green Ship Working Group – 1M + gallons (B100) annually
Commercially viable – tug, research, fishing and tour-boat

2010-11 effort to transition expertise

- Federal Green Fleet Working Group (Non-tactical)
- MARAD
- Army Corps of Engineers
Typical Emissions Results

2005 Survey
Port / starboard full load tests – 4 vessels
Cummins 903, Detroit 12V71, Detroit 8-92, Cat 3508
Broad range in engine age, condition and time on B100

Averaged B100 Emissions Reductions as Compared to #2 Petroleum Diesel

<table>
<thead>
<tr>
<th>Emission</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Unburned Hydrocarbons</td>
<td>-77%</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>-48%</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>-59%</td>
</tr>
<tr>
<td>Nox</td>
<td>-7%</td>
</tr>
<tr>
<td>Sulfates</td>
<td>-74%</td>
</tr>
<tr>
<td>PAH</td>
<td>-66%</td>
</tr>
</tbody>
</table>
Environmental Management Plan: Lubricants

Greening the Research Fleet Workshop

January 10-11, 2012
Nicholas School of the Environment
Duke University, Durham NC
Lubricating points on a typical offshore supply vessel.

On Deck:
- Fairleads
- Bearings on cranes, winches
- Open gears on mooring winches
- Open gears on anchor winches
- Tooth racks, rail cranes
- Steel wire ropes
- Stern roller

Below Deck:
- Cranes
- Hydraulic motors on winches
- Open gears on fire monitors
- Main engines
- Pumps
- Compressors
- Generators
- Shaft Bearings

Below the Water Line
- Stern tube
- Controllable Pitch Propellers
- Bow / stern thruster
- Propulsion thruster
- Rudder Bearings
So, what is an “Environmentally Acceptable Lubricant”

*Non-toxic, Non-bio-accumulating, and Biodegradable*

- **Primary biodegradation.** is the alteration in the chemical structure of a substance, brought about by biological action, resulting in the loss of a specific property of that substance.

- **Ultimate biodegradation (aerobic)** is the level of degradation achieved when the test compound is totally utilized by microorganisms resulting in the production of carbon dioxide, water, mineral salts, and new microbial cellular constituents (biomass).

- **Inherently biodegradable** is a classification of chemicals for which there is unequivocal evidence of biodegradation (primary or ultimate) in any test of biodegradability.

- **Readily biodegradable** is an arbitrary classification of chemicals which have passed certain specified screening tests for ultimate biodegradability; these tests are so stringent that it is assumed that such compounds will rapidly and completely biodegrade in aquatic environments under aerobic conditions.
Portfolio of Lubricants Onboard Your Vessel

On Deck:
Environmentally Acceptable Lubricants
- EAL all purpose grease
- EAL highly adhesive grease
- EAL extreme pressure or anti-wear grease
- Biodegradable hydraulic oils

Below Deck:
- Non EAL that achieve performance specifications

Below the Water Line
- Biodegradable shaft/bearing oil
- Biodegradable gear oil
- Biodegradable hydraulic oil
- EAL anti-wear grease
NEW GENERATION
Shipboard Energy
AND
Emissions Management

QUANTIFICATION • LIFE CYCLE ANALYSIS
VESSELS • OFFICES • FACILITIES • TERMINALS
MARITIME ENERGY MANAGEMENT

Method of quantifying and reducing energy consumption and cost and associated environmental footprint
Three Components of Energy Management

- Baseline of Energy Consumption, Cost, and Emissions
- Energy Conservation Measures (ECMs)
- Shipboard Energy Efficiency Plan (SEEMP)
ENERGY CONSERVATION MEASURES (ECMS)

Two Main Types of ECMs

• Operational: Culture and Policy Changes
• Technical: Equipment Upgrades
LESSONS LEARNED FROM GREENING CRUISE VESSELS

Jamie Sweeting
Vice President, Environmental Stewardship
and Global Chief Environmental Officer
Royal Caribbean Cruises Ltd.
Hull cleaning and maintenance

- Biofouling degrades underwater hull conditions
- Results in more power needed for propulsion to maintain service speeds
- Biofouling varies from region, ship speed and type of underwater coat used
Waste Management

- One of the key principles of our environmental program, Save the Waves, is Reduce, Reuse, Recycle

- We contract with suppliers to reduce packaging sources and use more sustainable materials
  - For example, we utilize larger containers with concentrated products to minimize waste, reduce packaging and transportation impacts (environmental & economic)

- We recycle and reuse approximately 40% of all waste landed globally – upwards of 90% in S. Florida homeports.

- All garbage is hand sorted and segregated onboard allowing the recycling of:
  - glass, paper, cardboard, aluminum and steel cans, scrap metal, incinerator ash, plastics, toner cartridges, wooden pallets, batteries, fluorescent lamps, electronics, plastic wrap and kitchen oil
SNAME

Marine Vessel environmental Performance Assessment (MVeP)

Presentation to: UNOLS 2012, Greening the Research Fleet
10 January 2012

Presented by: Timothy S. Leach, PE
MVeP is developing guidance for marine vessels to reduce and to measure their environmental impact.

Mission Statement: “Provide a common technical basis for assessing environmental performance, so that marine vessel designers, builders, and operators can understand relative environmental impacts of design decisions and operational practices.”
Objective: **Minimize** Marine Vessel Environmental Impact

**Approach:**
- Provide a **standard assessment methodology**
  - Best Practices, **guidance** to achieve excellence
- **Team** Industry, Academia, Environmental Groups, and Regulatory Agencies for Practical Solutions
- **Performance driven** metric
  - Use readily available data by monitoring or calculation
  - SNAME Technical & Research Bulletin
- Encourage **voluntary** assessment
  - Recognize leaders and exemplary performance
  - Minimal administrative burden on applicants
Phase 3 Implementation
UNOLS

UNOLS Gains
- Method to compare performance of different vessels...
- or to compare same vessel over different time periods
- Identify better performers to emulate
- Means to demonstrate improvements made to others

Shared Goals
- Objective performance evaluation
- Reduce ocean research's environmental impact (ie. CO₂, NOx, PM)
- Reduce operation costs (ie. ↑ fuel efficiency, ↓ port & regulatory fees)

SNAME MVeP Gains
- Contained peer group to establish methods and baselines
- Funding partners
Smarter Greener Better Ships

Gregory Marshall
I design great big yachts for VERY wealthy people
People who want to own “Everything”
Solar Reflective Paints:
Reduces the HVAC loads by 30% in average use

- Available in every color except Flag Blue
- No power to run it
- Cost similar to conventional paint
- Application can be done in any existing paint facility
- Can easily be retrofitted into existing vessel
- Cooler to the touch on decks etc
- Same warranty as conventional paint
- ........And it is “Greener”
**Electrochromic Glass:**

**Reduces the HVAC loads by 30% or more in average use**

- Solid state system requires 1 watt of power to run
- Completely controls tint from 5% transmission to 95% transmission
- Can eliminate the needs for blinds or in a yacht costly and complicated motorized blinds
- Reduces hot spots in the accommodation
- Costs about 30% more than conventional glazing
- Can easily be retrofitted into existing vessel
- ...And it is “Greener”
The use of Electrochromic glass reduces the heat load by 30%
**LED Lighting**

A typical 200 foot yacht has more than 4000 light fixtures on board for interior exterior and underwater lighting

Switching from Halogen to LED saves approximately 75kw of power but also reduces the heat load in the vessel by another 15 percent
In a 73 meter (240 foot) yacht project we are integrating 2 x 10kw Wind Turbines that fold into the mast when not in use to make the structure more aesthetically pleasing.
The same 73 Meter (240 foot) vessel has a solar array on the hardtop producing an additional 10kw of power.
And a helipad that generates 16kw of power
Harvesting Noise energy
12 Kilowatts of power from the noise bouncing around in the Engine room.
Piezo tiles in the high vibration hull panels
And led to a self powered dancefloor on a 240 foot yacht
We attribute our survival and success almost entirely to a business strategy that integrates making a Better yacht first with being Greener as a pleasant by-product.

At this point I do not think it would be commercially viable for us to go back to the way we used to build yachts prior to 2008. The clients simply do not want them.
Moving toward resilience: A research agenda for sustainable seaports

Austin Becker, PhD
Assistant Professor of Coastal Planning, Policy, and Design
Departments of Marine Affairs and Landscape Architecture
University of Rhode Island

Green Boats and Ports for Blue Waters
4-9-14
Fundamental shift...

- 1 year
- 5-10 yrs
- My career (~35 years)
- The rest of my life (~55 years)
- My child’s life (~100 years)
- My grandchild’s life (~105 years)

- Engineering & Design – 5 years
- Permitting & Regulatory Process – 10 years
- Construction – 10 years

- Project Design Life – 50 years
- Actual working life – >75 years

Time:

Today 2023 2050 2100 2150