The Impact Of Globalisation On International Maritime Transport Activity:
Past Trends And Future Perspectives

Sustainable Intermodal Freight Transportation Research (SIFTR)
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Transport and Environment in a Globalising World
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Overview of Paper and Presentation

- Maritime shipping and multimodal goods movement
- Global economic growth coupled with shipping, trade
- Maritime technology responds to globalization signals
- Maritime energy use and environmental impacts
  - Energy and power trends
  - Characterizing fleets using activity-based data vs. statistics
  - Taxonomy of maritime shipping environmental impacts
- Sustainable intermodal freight transport and shipping
Maritime Shipping and Goods Movement
A tradition of stewardship and service to society

They that go down to the sea in ships, that do business in great waters; these see the works of the Lord, and his wonders in the deep.

(Nature)

Psalm 107, KJV

As by means of water-carriage a more extensive market is opened to every sort of industry ... , so it is upon the sea-coast, and along ... navigable rivers, that industry of every kind naturally begins to subdivide and improve ..., and ... not till a long time after that those improvements extend themselves to the inland parts of the country.

Adam Smith: [http://www.adamsmith.org/smith/won-index.htm](http://www.adamsmith.org/smith/won-index.htm)
Ocean shipping among intermodal transport

- Global freight transportation system: ocean and coastal routes, inland waterways, railways, roads, and air freight

- Ocean shipping serves both as a substitute and as a complement for other freight modes
Mode share comparisons: Cargo demand and CO$_2$ emissions

- Trucking is 40-45% of total work (ton-kilometers)

Source: Bureau of Transportation Statistics (2007); Energy Information Administration (2007). Note that units are on log scale.
Unitized cargoes grow faster than bulk cargoes

- Globalization has encouraged transactions of goods and services in smaller packets delivered “just-in-time”

- Labor advantages and inexpensive transport allow materials on one continent to be shipped to another for intermediate processing, moved to a third continent for assembly, and then delivered to market
Economy, Transport, Energy are Coupled

- For every percentage increase in GDP for OECD, there has been ~4% rise in trade over this period
Relationship between OECD economic growth and growth in exports and imports

- For every one percentage increase in GDP for OECD, there has been ~4% rise in trade over 1992-2006
Economic coupling with goods movement can be directly measured

- Relationship between cargo shipments and container traffic (TEUs) and GDP as measured in ton-miles for the U.S.
Technology shift during last century

Transition by number of ships slower than by tonnage

Number of ships in fleet by vessel technology

Gross maritime shipping tonnage by vessel technology

Trends in global fleet cargo capacity

- Fleet capacity (gross tonnage) increased significantly with globalization
- Vessel flags have largely transitioned from OECD nations to others

This is associated with a shift to more international seafaring labor …
Seafaring professions use international labor

- Qualified seafarers hired according to economic (not residency) criteria

- Professionally skilled seafarers across ranks and nationalities remains an issue of international importance to safety and environment

Nations selling most fuel to ships are typically nations with strong interests in cargoes or services those ships provide.

<table>
<thead>
<tr>
<th>Million tonnes fuel</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>150,568</td>
<td>100%</td>
<td>167,734</td>
</tr>
<tr>
<td>OECD</td>
<td>81,425</td>
<td>54%</td>
<td>91,326</td>
</tr>
<tr>
<td>OECD North America</td>
<td>20,873</td>
<td>14%</td>
<td>26,213</td>
</tr>
<tr>
<td>United States</td>
<td>19,559</td>
<td>13%</td>
<td>24,828</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>47,860</td>
<td>32%</td>
<td>51,442</td>
</tr>
<tr>
<td>OECD Pacific</td>
<td>12,692</td>
<td>8%</td>
<td>13,671</td>
</tr>
<tr>
<td>Non OECD</td>
<td>69,143</td>
<td>46%</td>
<td>76,408</td>
</tr>
<tr>
<td>Singapore</td>
<td>20,809</td>
<td>14%</td>
<td>19,567</td>
</tr>
</tbody>
</table>

(OECD) nations account for roughly half of these fuel sales.

Source: International Energy Agency and OECD (2007a) and (2007b)
Switch to more fuel-efficient engines was more than offset by increased engine power requirements to meet rapidly expanding demand for more and faster global trade.
Activity-based methodology
Data confidence higher than fuel sales data only

Fleet statistics
(Lloyds)

Fleet activity
(AIS, industry data, other)

Fuel and combustion characteristics
(BLG 12/6/INF.10, IPCC, etc.)

Fleet fuel consumption

Fleet emissions

Average installed power
- Confidence High

Average operating time
- Confidence moderate
- Known variability high
- Dominates output range

Average engine load
- Confidence moderate
- Known variability moderate
- Second most influential to output range

Average SFOC
- Confidence high

Average Carbon content
- Confidence high
- Some variability due to fuel characteristics

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Fuel consumption growing with global trade

- 2002 World fleet (including cargo, noncargo, and military vessels) consumed ~280 million tonnes fuel, ~200 million tonnes for cargo ships
  - IMO Informal Cross Government/Industry Scientific Group of Experts estimated 2007 global ship fuel consumption at ~369 million tonnes, increasing to ~486 million tonnes by 2020

![Graph showing fuel consumption trends](image_url)
## Taxonomy of Environmental Impacts

<table>
<thead>
<tr>
<th>Episodic environmental events</th>
<th>Routine environmental events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vessel-based</strong></td>
<td></td>
</tr>
<tr>
<td>Oil spills</td>
<td>Engine air emissions</td>
</tr>
<tr>
<td>Ocean dumping</td>
<td>Invasive species introductions (ballast water/hull fouling)</td>
</tr>
<tr>
<td>Sewage discharges</td>
<td>Hull coating toxics releases</td>
</tr>
<tr>
<td>Oily wastewater</td>
<td>Underwater noise</td>
</tr>
<tr>
<td>Vessel collisions</td>
<td></td>
</tr>
<tr>
<td>Ship-strikes with marine life</td>
<td></td>
</tr>
<tr>
<td><strong>Port-based</strong></td>
<td></td>
</tr>
<tr>
<td>Dredging</td>
<td>Storm water runoff</td>
</tr>
<tr>
<td>Port expansion</td>
<td>Vessel wake erosion</td>
</tr>
<tr>
<td>Ship construction, breaking</td>
<td>Cargo-handling air emissions</td>
</tr>
</tbody>
</table>
Efforts are now underway to evaluate and reduce air pollution from ships

- Emissions → Pollution fate/transport → Exposure → Impact

- Summary of global emissions from maritime shipping, 2002
List of example air pollution control technologies for maritime shipping

- Emissions → Pollution fate/transport → Exposure → Impact → Mitigation
- Example technologies (not complete list)
  - Likely to include operations, logistics to fully address GHGs

<table>
<thead>
<tr>
<th>Stage</th>
<th>Control technology</th>
<th>Target Pollutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-combustion</td>
<td>Fuel water emulsification</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Humid air motor</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Combustion air saturation system</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td>In-engine</td>
<td>Aftercooler upgrades</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Engine derating</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Injection timing delay</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Engine efficiency improvements</td>
<td>NO\textsubscript{x}, SO\textsubscript{x}, PM, CO\textsubscript{2}</td>
</tr>
<tr>
<td>Post-engine</td>
<td>Selective catalytic reduction</td>
<td>NO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Seawater scrubbing</td>
<td>SO\textsubscript{x}</td>
</tr>
<tr>
<td></td>
<td>Diesel particulate filters</td>
<td>PM</td>
</tr>
<tr>
<td></td>
<td>Diesel oxidation catalysts</td>
<td>PM</td>
</tr>
<tr>
<td>Vessel designs</td>
<td>Hull form</td>
<td>CO\textsubscript{2}, energy ratio pollutants</td>
</tr>
<tr>
<td></td>
<td>Propeller</td>
<td>CO\textsubscript{2}, energy ratio pollutants</td>
</tr>
</tbody>
</table>
Mitigation focus not only emissions, GHGs
Globalization addresses entire ship impact taxonomy

- Globalization trends increase other impacts, global focus on environment motivate mitigating action for these too
  - Example: Right whale strikes and global average ship momentum

\[ y = 11.343x + 1.3014 \]
\[ R^2 = 0.6166 \]
Creating a Sustainable Intermodal Freight System

Summary

• Intrinsic connection between maritime transport, trade, globalization continue to be coupled (e.g., IPCC SRES)

• Industry responds to regulatory, market-driven, & advocacy pressure to improve environmental performance

• Environmental and security policy shifting to international agreements and global frameworks for regional policy

• A sustainable intermodal freight system is preferred to a mode-by-mode approach for at least two reasons:
  - It can show where shipping modes offer least-cost mitigation
  - It can identify where shipping offers the least polluting transport service
Discussion Welcome

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