

Quantifying the Extent of Niche Areas in the Global Fleet of Commercial Ships: The Potential for "Super-Hot Spots" of Biofouling

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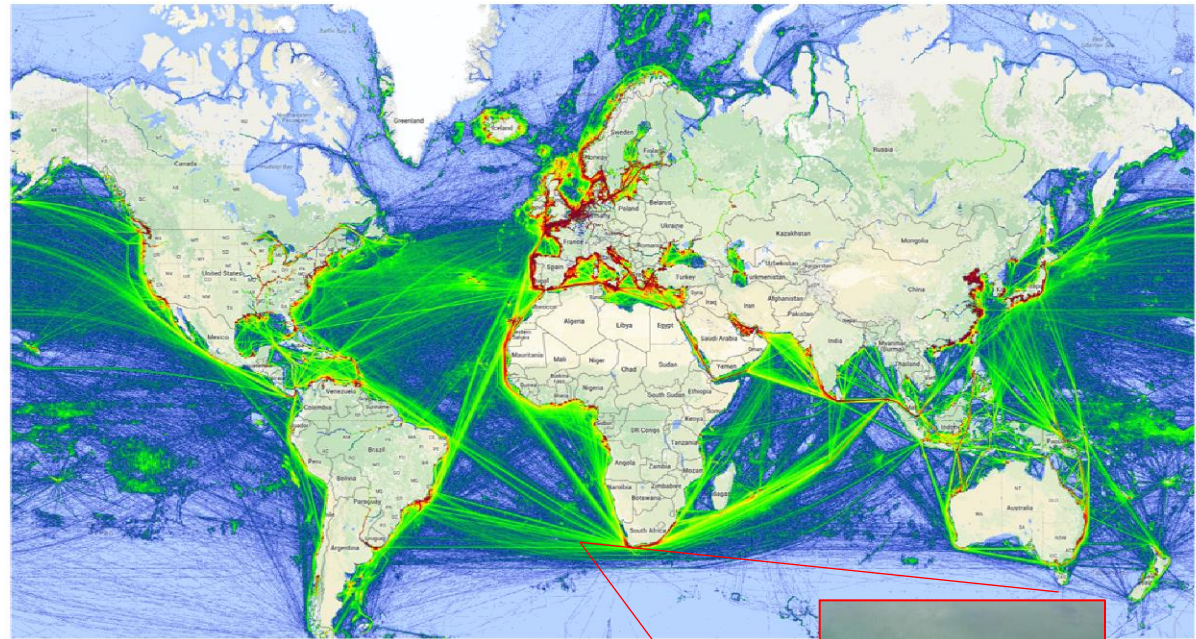
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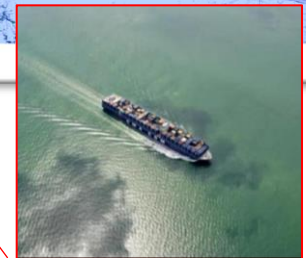
- International Maritime Organization (IMO)
Resolution MEPC.207(62):
 - Guidelines for the Control and Management of
Ships' Biofouling to Minimize the Transfer of
Invasive Aquatic Species
 - Adopted on 15 July, 2011

Ships' Biofouling on a Global Scale

- Policies and management strategies can benefit from an evaluation of biofouling:
 - **Magnitude** on a global scale
 - **Flux** between regions



Global shipping activity;
source: <http://www.marinetraffic.com/en/ais/home/centerx:-28/centery:42/zoom:4>

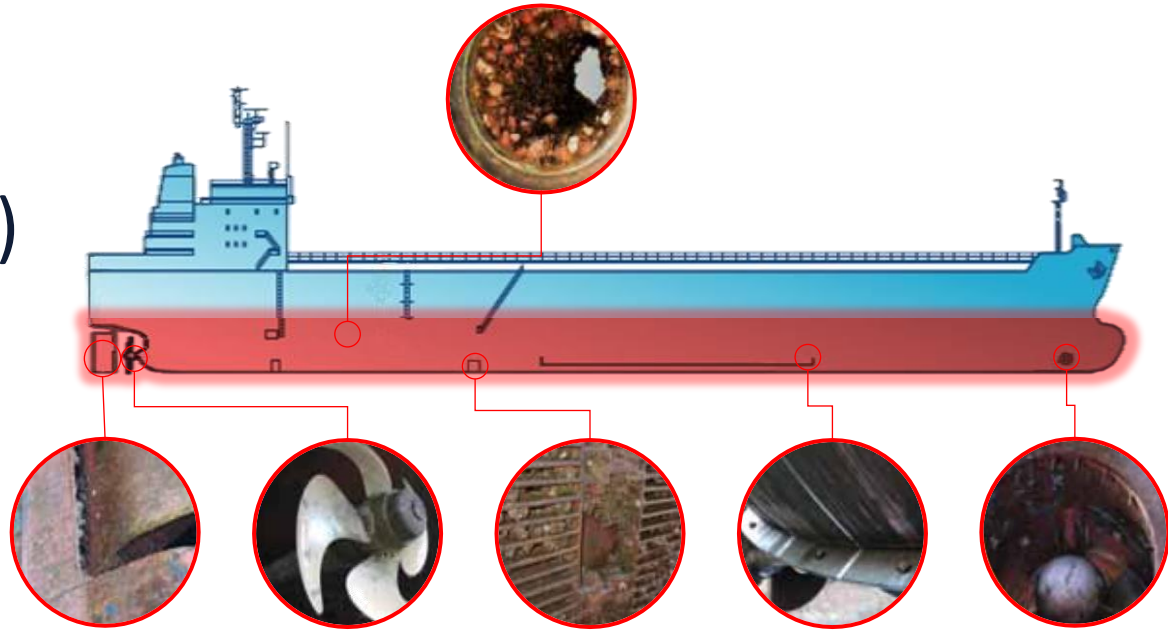


Goals of this Work

- Develop a method to quantify the scope or extent of biofouling for a given set of data on a fleet of ships
 - Apply the method to the **global fleet** of commercial ships
- Methods can be used to inform risk assessment models for invasion

Quantifying Biofouling on a Ship

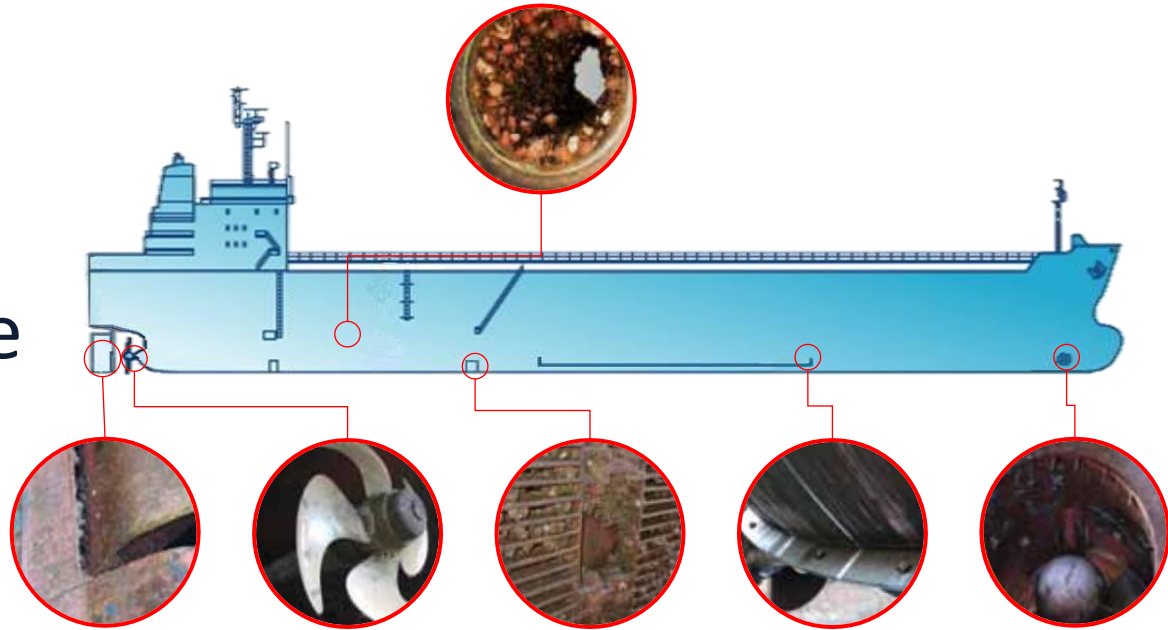
- Total wetted surface area (WSA)
 - Represents *potential* for biofouling
- Niche areas
 - “Hotspots” for biofouling



<http://www.asa.com.au/>

Biological Niche Areas

- **Niche areas** on a ship are those areas that may be **more susceptible** to biofouling due to different



<http://www.asa.com.au/>

hydrodynamic forces, susceptibility to coating system wear or damage, or inadequate coating

WSA Approximation Formulas

- Denny Mumford: $WSA = 1.7 \times L_{BP} \times T + \frac{\nabla}{T}$
- Froude formula: $WSA = \nabla^{\frac{2}{3}} \times \left(3.4 + \frac{L_{BP}}{2.06 \times \nabla^{\frac{1}{3}}} \right)$
- Schneekluss and Bertram (S&B): $WSA = \nabla^{\frac{1}{3}} \times \left(3.4 \times \nabla^{\frac{1}{3}} + 0.5 \times L_{WL} \right)$
- Where:
 - L_{BP} = Length between perpendiculars (m)
 - L_{WL} = Length at waterline (m)
 - T = Draft (m)
 - ∇ = Displacement (m^3)

Data Collection

- Sources include:
 - Smithsonian Environmental Research Center (National Ballast Information Clearinghouse; NBIC)
 - American Bureau of Ships
 - Bureau Veritas
 - Russian Register of Shipping
 - Det Norske Veritas
 - GrossTonnage.org
- 191,440 ship records
- 120,252 confirmed active ships from 1999-2013 (NBIC)
- All ships include IMO numbers and ship type

Data Collection - Interpolation

IMO_No	Beam	Depth	Design	Draft	DWT	Hull_Type	LBP	LOA	Nrt	Status	Sull
9621259	45	24.4		16.029	174707		279	289.98	59000	Delivered	Bulk
9621247					250000		?				ORE
9621235	57	25.1	Namura Wozm	18	250950		321	330	45971	Delivered	Ore
9621223	20	10.2		7.8	12692	Double Hull (M	133.2	141.7	3911	Delivered	Proc
9621211					5448		?				LIVE
9621209					5448		?				LIVE
9621194					5488		?				LIVE
9621182	30	14.7		9.81	33694	Double Hull	172	180	11160	Delivered	Bulk
9621170	30	14.7		8.816	33752	Double Hull	172.93	180	11160	Delivered	Bulk
9621168					180000		?				BUL
9621156					179965		?				BUL
9621144					179959		?				BUL
9621132					56734		?				BUL
9621120	32.3	18	DOLPHIN 57	12.8	56724		185	189.99	19231	Delivered	Bulk
9621118	11.59	5.24		3.7	0		28	28.05	107	Delivered	Tug
9621106	8.6	4.3		3.312	194		25.77	28.05	77	Delivered	Tug
9621091	8.6	4.3		3.312	193		25.77	28.05	77	Delivered	Tug
9621089	11.23	5.85		4.75	2367		70	74.7	816	Delivered	Gen
9621077					71290		?				LNG
9621065	17	9.1		7.15	7014		97.3	105.86		Delivered	Gen
9621053					4410		?				GEN
9621041					35501		?				BUL
9621039	30	14.7		10.1	35000		172	179.99	12109	Delivered	Bulk
9621027	46	23.9		6.84	151962		258	262.4	46799	Delivered	Floa
9621015	32.3	18	DOLPHIN 57	12.8	56928		185	189.99	19142	Delivered	Bulk
9621003					37200		?				BUL
9620994					37227		?				BUL
9620982	20	8.6	VS 485	7.16	4900		77.7	85	1800	Delivered	Sup
9620970					26000						RO-

DWT More
Common



Data Collection

- 78% of ship records contain DWT
- Regression analysis can be conducted for each ship type*, plotting DWT vs. WSA and then using the resulting equations in place of Denny-Mumford, Froude, or S&B

*Bulk carriers, tankers, containerships, general cargo ships, tugs and supply vessels, liquefied natural/petroleum gas carriers, fishing vessels, and passenger ships

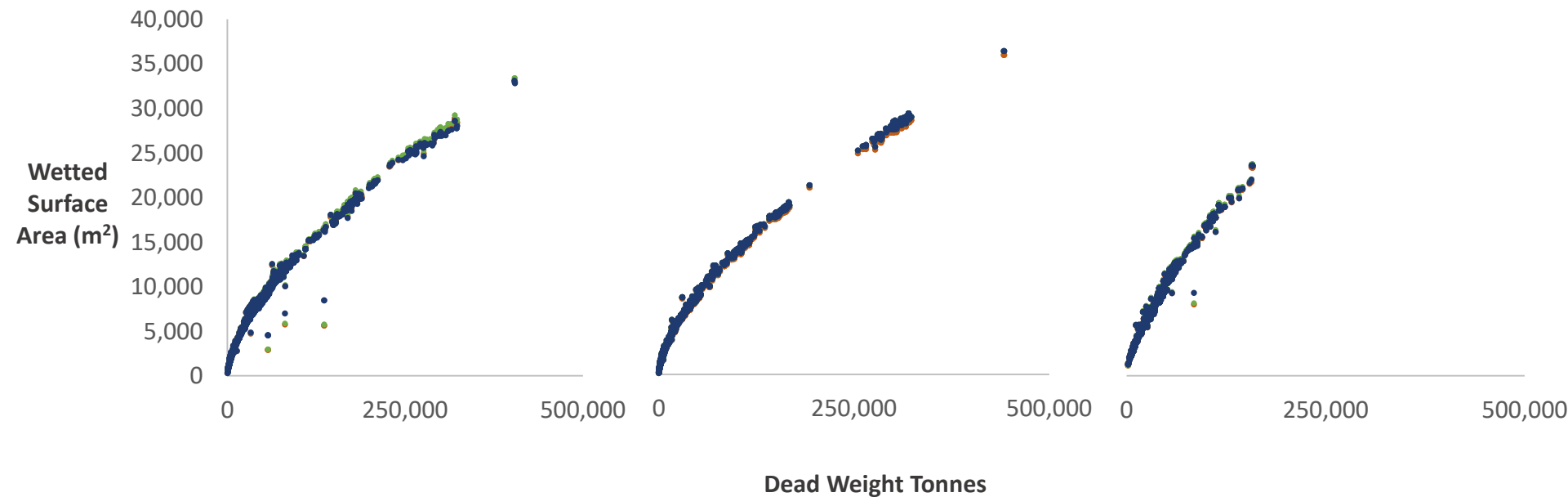
- **Deadweight tonnage** (DWT) = measure of how much weight a ship is carrying or can safely carry
 - \sum weights of: cargo, fuel, fresh water, ballast water, provisions, passengers, and crew

Data Collection - Regressions

Bulk Carriers

Tankers

Containerships



● Froude

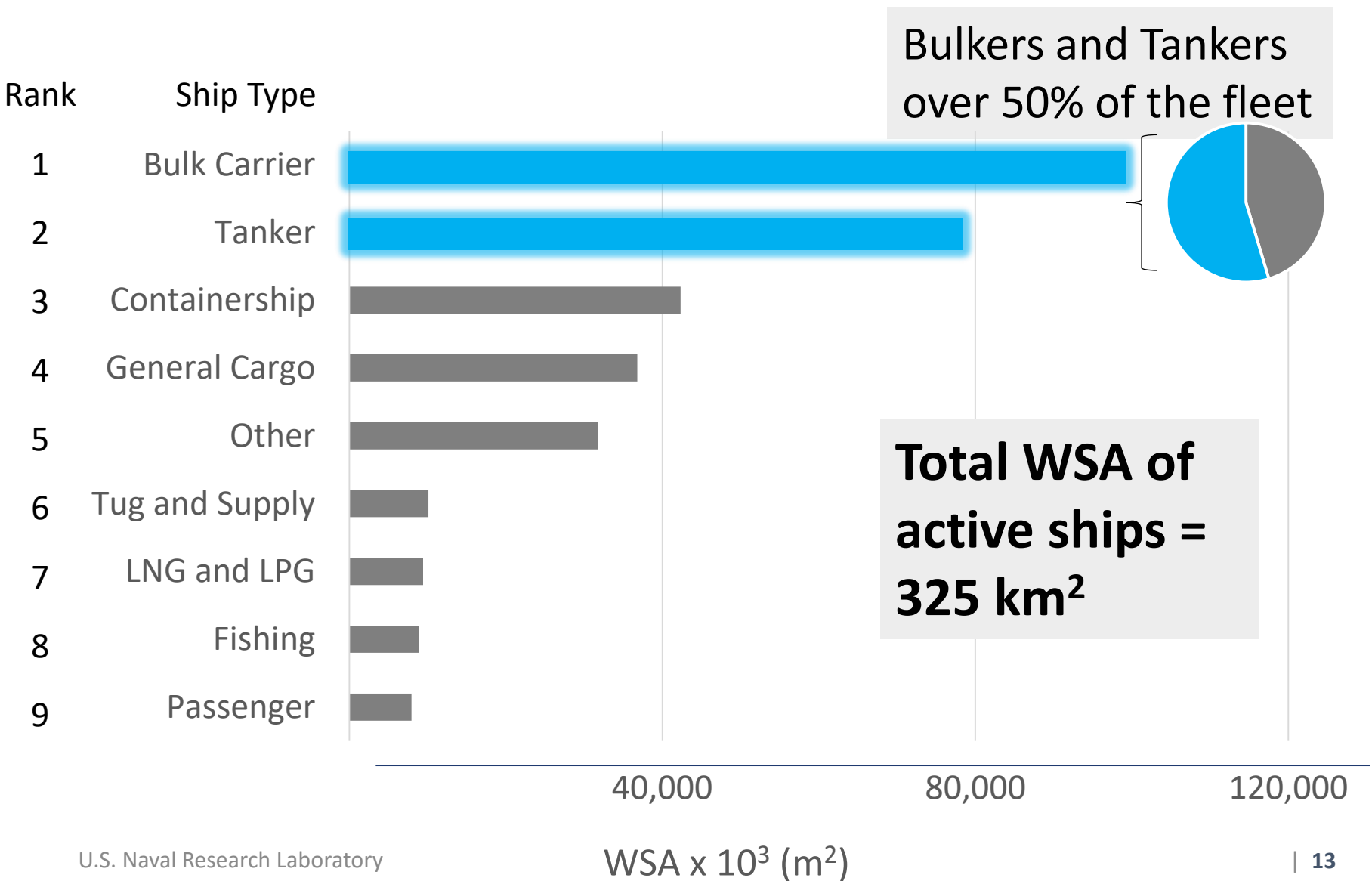
● Scheenkluth & Bertram

● Denny-Mumford

Extent of Niche Areas

- Niche areas examined in this study:
 - Rudders
 - Bilge keels
 - Dry dock strips
 - Sea chests and sea chest gratings
 - Propellers
 - Thrusters, thruster tunnels, and gratings
- Same methodology used to estimate WSA applied to each niche area

Results - Total Hull WSA



Extent of Niche Areas

Area	Surface Area (m ²)
Football Field	5,400
Manhattan Island	87,460,000
Washington DC	176,900,000
Malta	316,000,000
WSA of Global Commercial Shipping Fleet	324,846,268
Grenada	344,000,000
Guam	541,000,000
Los Angeles	1,302,000,000
Everglades	1,900,000,000
Rhode Island	3,140,000,000

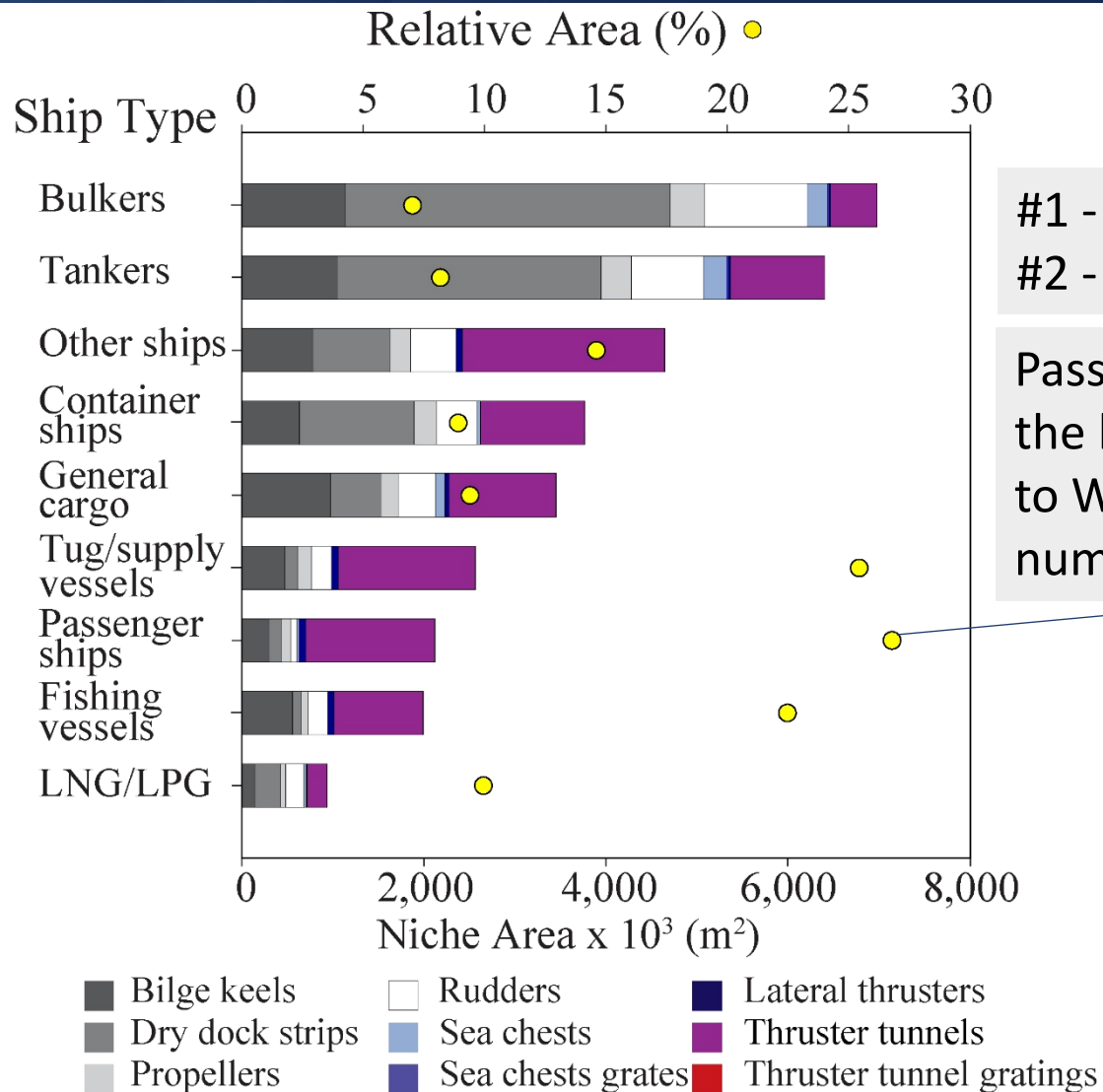
Surface Area Comparisons

WSA of Global Commercial Shipping
Fleet
324,846,268 m²

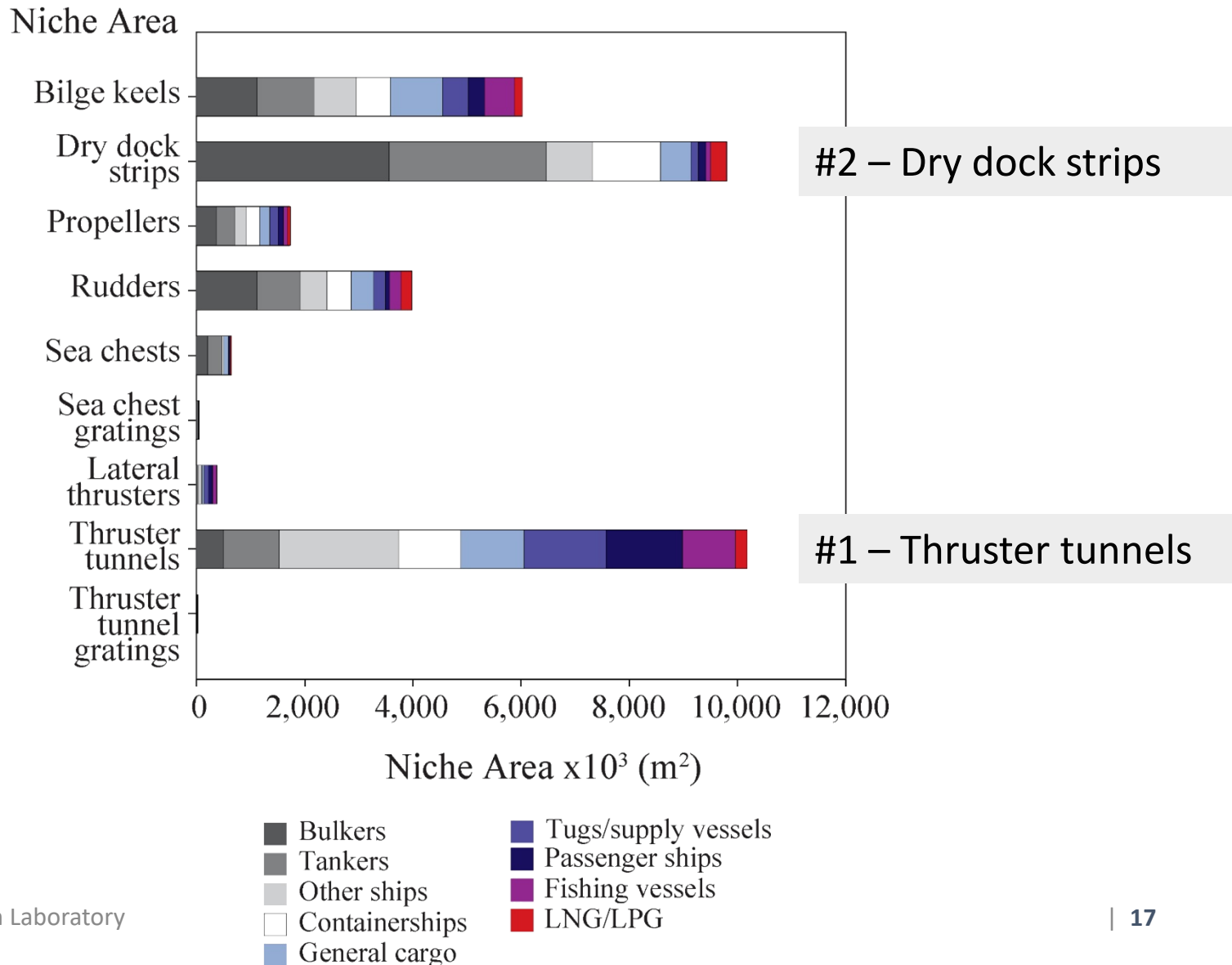
Washington DC
176,900,000 m²



Results – Extent of Niche Areas



Results – Extent of Niche Areas



Conclusions

- **Bulk carriers** and **tankers** comprise a majority of the hull WSA of the global fleet of commercial ships
- **Thruster tunnels** and dry **dock strips** make up a majority of the extent of niche areas
 - Thrusters could be considered “**super hot-spots**” as they could actively expel organisms when activated, usually when maneuvering close to port

- Methods developed to estimate the hull WSA and extent of niche areas for a given data set on a fleet of ships can be used to help determine flux of biofouling into ports and local regions and ultimately inform risk assessment models for invasion

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