Operational Measures to Reduce Overall Emissions:
What do we know about the relationship to underwater radiated noise (URN)?

Kevin Bartoy, Chief Sustainability Officer, Washington State Ferries
Workshop on the Relationship between Energy Efficiency and Underwater Radiated Noise from Ships
International Maritime Organization, London
September 19, 2023
The Salish Sea
The largest ferry system in the U.S.

- 21 auto-passenger ferries
- 10 routes serving 20 terminals
- 23.9 million riders in 2019
- 10.5 million vehicles in 2019
- 450 sailings per day
- 1,800 employees
- Largest state-owned shipyard in the U.S.
## WSF Fleet Profile

<table>
<thead>
<tr>
<th>Vessel Class</th>
<th># of Vessels</th>
<th>Size (Length)</th>
<th>Auto Capacity / Passengers</th>
<th>Propulsion</th>
<th>Horsepower</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumbo Mark II</td>
<td>3</td>
<td>460’2”</td>
<td>202 / 2,499</td>
<td>Diesel Electric</td>
<td>16,000</td>
<td>24-26 years</td>
</tr>
<tr>
<td>Jumbo</td>
<td>2</td>
<td>440’2”</td>
<td>188 / 2,000</td>
<td>Diesel Electric</td>
<td>11,500</td>
<td>50-51 years</td>
</tr>
<tr>
<td>Super</td>
<td>2</td>
<td>382’2”</td>
<td>144 / 2,000</td>
<td>Diesel Electric</td>
<td>10,000</td>
<td>56 years</td>
</tr>
<tr>
<td>Olympic</td>
<td>4</td>
<td>362’3”</td>
<td>144 / 1,500</td>
<td>Diesel (CPP)</td>
<td>6,000</td>
<td>5-9 years</td>
</tr>
<tr>
<td>Issaquah</td>
<td>6</td>
<td>328’2”</td>
<td>124 / 1,200</td>
<td>Diesel (CPP)</td>
<td>5,000</td>
<td>41-44 years</td>
</tr>
<tr>
<td>Evergreen State</td>
<td>1</td>
<td>310’2”</td>
<td>87 / 1,061</td>
<td>Diesel Electric</td>
<td>5,100</td>
<td>64 years</td>
</tr>
<tr>
<td>Kwa-di Tabil</td>
<td>3</td>
<td>273’8”</td>
<td>64 / 748</td>
<td>Diesel (CPP / FP)</td>
<td>6,000</td>
<td>11-13 years</td>
</tr>
</tbody>
</table>
## WSF Route Profiles

<table>
<thead>
<tr>
<th>Route</th>
<th>Nautical Miles</th>
<th>Crossing Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anacortes-Friday Harbor</td>
<td>16.3</td>
<td>65</td>
</tr>
<tr>
<td>Anacortes-Sidney, B.C.</td>
<td>35.8</td>
<td>165</td>
</tr>
<tr>
<td>Edmonds-Kingston</td>
<td>4.9</td>
<td>30</td>
</tr>
<tr>
<td>Fauntleroy-Southworth</td>
<td>4.1</td>
<td>40</td>
</tr>
<tr>
<td>Fauntleroy-Vashon</td>
<td>2.8</td>
<td>20</td>
</tr>
<tr>
<td>Coupeville-Port Townsend</td>
<td>5.4</td>
<td>35</td>
</tr>
<tr>
<td>Mukilteo-Clinton</td>
<td>2.7</td>
<td>20</td>
</tr>
<tr>
<td>Point Defiance-Tahlequah</td>
<td>1.6</td>
<td>15</td>
</tr>
<tr>
<td>Seattle-Bainbridge Island</td>
<td>7.5</td>
<td>35</td>
</tr>
<tr>
<td>Seattle-Bremerton</td>
<td>13.5</td>
<td>60</td>
</tr>
<tr>
<td>Southworth-Vashon</td>
<td>1.6</td>
<td>10</td>
</tr>
</tbody>
</table>
Governor Jay Inslee’s Executive Order 20-01:

The Secretary of the Department of Transportation (WSDOT) shall ensure that Washington State Ferry system begins the transition to a zero-carbon-emission ferry fleet, including the accelerated adoption of both ferry electrification and operational improvements that will conserve energy and cut fuel use.
Governor Jay Inslee’s Executive Order 18-02:
Washington State Department of Transportation (WSDOT)—By May 31, 2018, develop strategies for quieting state ferries in areas most important to Southern Residents.
Planning

Washington State Ferries Sustainability Action Plan: 2023-2025

Washington State Ferries Underwater Noise Mitigation and Management Plan for the Protection of Marine Mammals
December 2021

Washington State Ferries Decarbonization Plan
July 1, 2021
Operational Efficiency Work Group

- Formed in 2017 in advance of Governor’s executive order
- Includes decision-making representation from all affected departments
- Encourages suggestions from the fleet
- Commits to quickly truthing measures
- Commits to quickly implementing measures that are deemed to have potential
- Commits to “failing fast” and continuous improvement
- Increases communications and understanding across organization
- Saves millions of gallons of fuel and helps foster a culture of continuous improvement
Operational Efficiency Actions

- Fleet Speed Optimization
- Reducing Number of Engines in Operation
- Revised Loading Procedures to Minimize Trim
- Optimizing Vessel Assignments
- Optimizing Sailing Schedules
- Fuel Consumption Instrumentation
- Weather Deck Doors / Boilers
- Shore Power
- Carrying Less Fuel
- Issaquah Class Propellers
- Data Dashboard
- Ship Energy Efficiency Management Plan
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Setting optimal speeds based on hull design led to significant fuel savings with almost 1M gallons saved in the first two years.

Needed to optimize sailing schedules and vessel assignments to avoid need for higher speeds to keep on-time performance.

Since vessel URN is primarily from cavitation, the reduction in speed led to reduction in noise.

~5 dB reduction at each one-third octave band above 100 Hz for diesel electrics and ~10-20 dB reduction at each one-third octave band above 100 Hz for diesel geared vessels.

Reductions seen across the fleet even in vessels with controllable pitch propellers due to use of variable shaft RPM in a combinator mode.

However, two classes of vessels (Olympic and Issaquah) produced significant shaft squeal noise at lower speeds.
Engine Optimization

Jumbo Mark II Class equipped with four engines and standard practice was to operate three at all times, leading to low loading and inefficient operations.

Jumbo Class equipped with four engines and standard practice was to operate four engines also leading to low loading and inefficient operations.

Research and sea trials proved a reduction in engines would still allow for all power necessary for normal operations of vessels.

Jumbo Mark II Class currently using two engines, and Jumbo Class currently using three engines.

Two Jumbo Mark II vessels showed 3% and 11% lower fuel consumption, saving 350,000 gallons of fuel. One Jumbo vessel showed 2% reduction, saving 250,000 gallons of fuel.

Assumed although not tested as part of our fleet noise characterization that reduction in number of engines would result in a reduction of URN.
Other Efficiency Measures

**Minimizing trim**
Allows for greater efficiency and better operation of propellers, and may have some effect to noise that would be neutral or beneficial, but not likely detrimental.

**Carrying less fuel**
In testing noise levels of the fleet, there was variability shown in noise as it related to vehicle load. Although inconclusive, there appeared to be a correlation between load and noise. Less weight of fuel has a potential to benefit and likely is not detrimental.

**New propellers**
Designed to reduce cavitation and result in a 6-8% improvement in efficiency. Will likely have a beneficial noise effect as well.
Challenges

- Diesel Electric vessels operate with the forward propeller operating in reverse at 10% lower than aft causing additional cavitation.
- Maintaining regular schedules with an aging fleet often results in need to use higher speeds.
- Need for new vessels produced from previous designs rather than new designs.
- Funding for new designs.
Future

01 Continue to optimize efficiency through existing measures and new ones.

02 Continue to use slowing as an effective means for noise reduction when cetaceans are in vicinity.

03 Begin to require underwater noise reduction as a design criteria for new vessels.
Questions

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