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

Washington State Ferries

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The Salish Sea

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WSF Overview

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.

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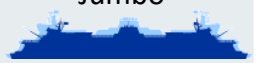
WSF Fleet Profile

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

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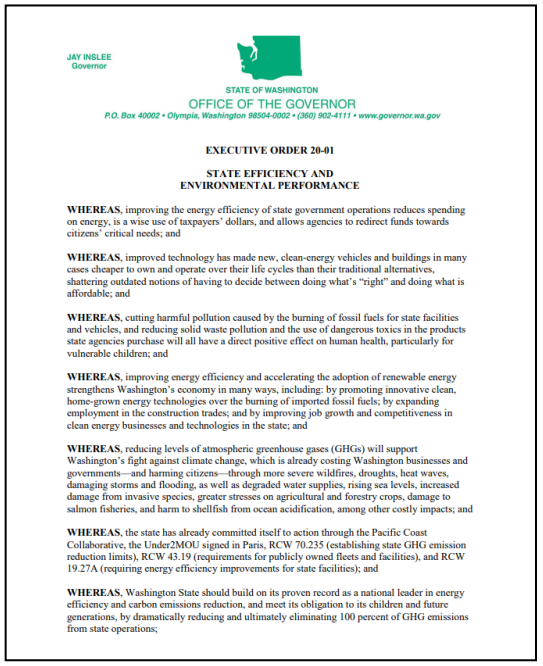
WSF Route Profiles

Route	Nautical Miles	Crossing Time (Minutes)
Anacortes-Friday Harbor	16.3	65
Anacortes-Sidney, B.C.	35.8	165
Edmonds-Kingston	4.9	30
Fauntleroy-Southworth	4.1	40
Fauntleroy-Vashon	2.8	20
Coupeville-Port Townsend	5.4	35
Mukilteo-Clinton	2.7	20
Point Defiance-Tahlequah	1.6	15
Seattle-Bainbridge Island	7.5	35
Seattle-Bremerton	13.5	60
Southworth-Vashon	1.6	10

Leadership



JAY INSLEE
Governor

STATE OF WASHINGTON
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EXECUTIVE ORDER 20-01

STATE EFFICIENCY AND ENVIRONMENTAL PERFORMANCE

WHEREAS, improving the energy efficiency of state government operations reduces spending on energy, is a wise use of taxpayers' dollars, and allows agencies to redirect funds towards citizens' critical needs; and

WHEREAS, improved technology has made new, clean-energy vehicles and buildings in many cases cheaper to own and operate over their life cycles than their traditional alternatives, shattering outdated notions of having to decide between doing what's "right" and doing what is affordable; and

WHEREAS, cutting harmful pollution caused by the burning of fossil fuels for state facilities and vehicles, and reducing solid waste pollution and the use of dangerous toxics in the products state agencies purchase will all have a direct positive effect on human health, particularly for vulnerable children; and

WHEREAS, improving energy efficiency and accelerating the adoption of renewable energy strengthens Washington's economy in many ways, including: by promoting innovative clean, home-grown energy technologies over the burning of imported fossil fuels; by expanding employment in the construction trades; and by improving job growth and competitiveness in clean energy businesses and technologies in the state; and

WHEREAS, reducing levels of atmospheric greenhouse gases (GHGs) will support Washington's fight against climate change, which is already costing Washington businesses and governments—and harming citizens—through more severe wildfires, droughts, heat waves, damaging storms and flooding, as well as degraded water supplies, rising sea levels, increased damage from invasive species, greater stresses on agricultural and forestry crops, damage to salmon fisheries, and harm to shellfish from ocean acidification, among other costly impacts; and

WHEREAS, the state has already committed itself to action through the Pacific Coast Collaborative, the Under2MOU signed in Paris, RCW 70.235 (establishing state GHG emission reduction limits), RCW 43.19 (requirements for publicly owned fleets and facilities), and RCW 19.27A (requiring energy efficiency improvements for state facilities); and

WHEREAS, Washington State should build on its proven record as a national leader in energy efficiency and carbon emissions reduction, and meet its obligation to its children and future generations, by dramatically reducing and ultimately eliminating 100 percent of GHG emissions from state operations;

<u>Governor Jay Inslee's Executive Order 20-01</u>:

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.

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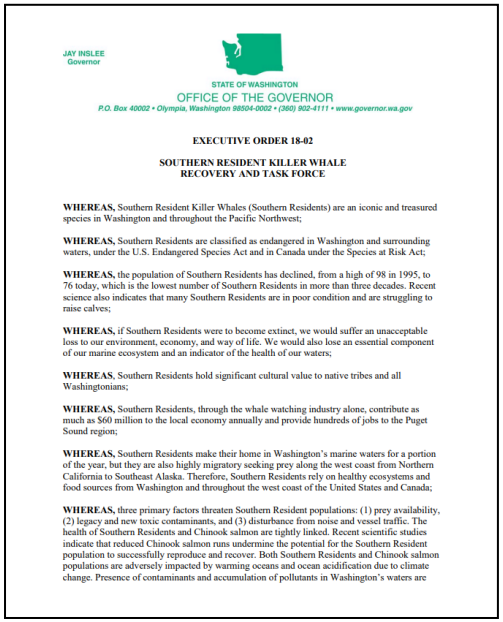
Leadership



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EXECUTIVE ORDER 18-02

SOUTHERN RESIDENT KILLER WHALE RECOVERY AND TASK FORCE

WHEREAS, Southern Resident Killer Whales (Southern Residents) are an iconic and treasured species in Washington and throughout the Pacific Northwest;

WHEREAS, Southern Residents are classified as endangered in Washington and surrounding waters, under the U.S. Endangered Species Act and in Canada under the Species at Risk Act;

WHEREAS, the population of Southern Residents has declined, from a high of 98 in 1995, to 76 today, which is the lowest number of Southern Residents in more than three decades. Recent science also indicates that many Southern Residents are in poor condition and are struggling to raise calves;

WHEREAS, if Southern Residents were to become extinct, we would suffer an unacceptable loss to our environment, economy, and way of life. We would also lose an essential component of our marine ecosystem and an indicator of the health of our waters;

WHEREAS, Southern Residents hold significant cultural value to native tribes and all Washingtonians;

WHEREAS, Southern Residents, through the whale watching industry alone, contribute as much as $60 million to the local economy annually and provide hundreds of jobs to the Puget Sound region;

WHEREAS, Southern Residents make their home in Washington's marine waters for a portion of the year, but they are also highly migratory seeking prey along the west coast from Northern California to Southeast Alaska. Therefore, Southern Residents rely on healthy ecosystems and food sources from Washington and throughout the west coast of the United States and Canada;

WHEREAS, three primary factors threaten Southern Resident populations: (1) prey availability, (2) legacy and new toxic contaminants, and (3) disturbance from noise and vessel traffic. The health of Southern Residents and Chinook salmon are tightly linked. Recent scientific studies indicate that reduced Chinook salmon runs undermine the potential for the Southern Resident population to successfully reproduce and recover. Both Southern Residents and Chinook salmon populations are adversely impacted by warming oceans and ocean acidification due to climate change. Presence of contaminants and accumulation of pollutants in Washington's waters are

<u>Governor Jay Inslee's Executive Order 18-02</u>:
Washington State Department of Transportation (WSDOT)—By May 31, 2018, develop strategies for quieting state ferries in areas most important to Southern Residents.

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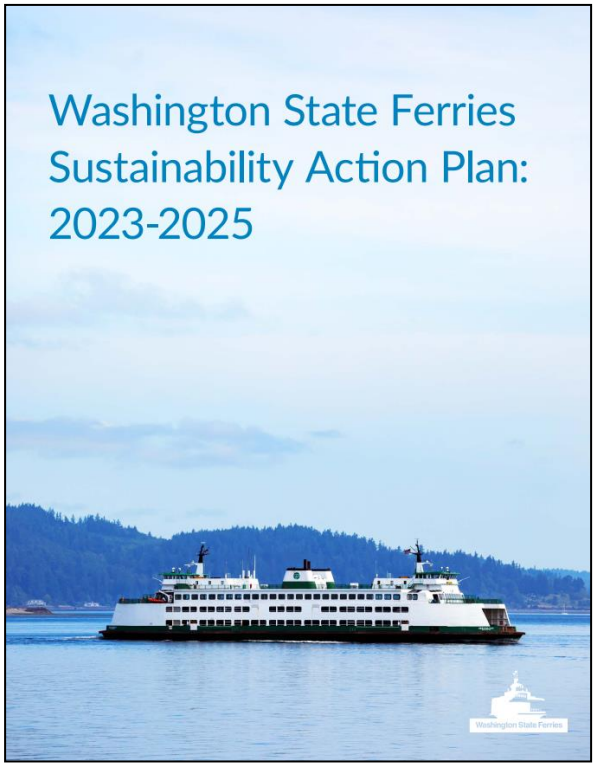
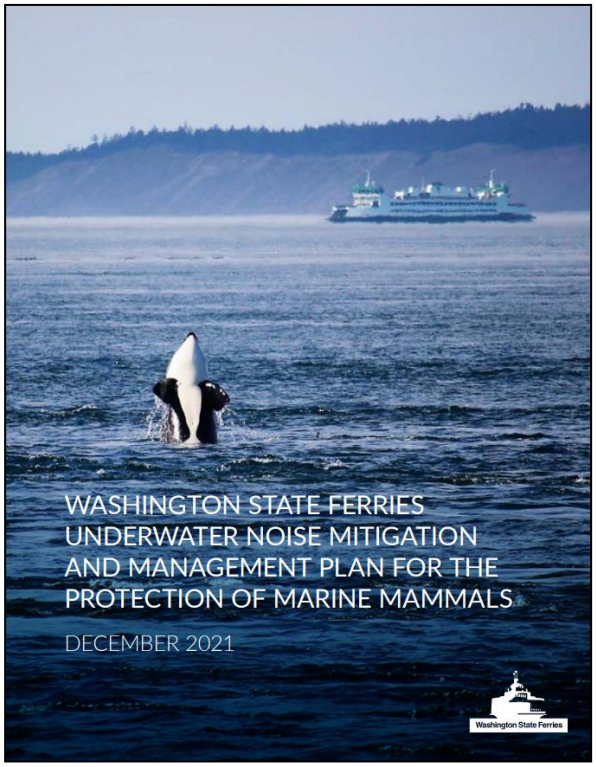
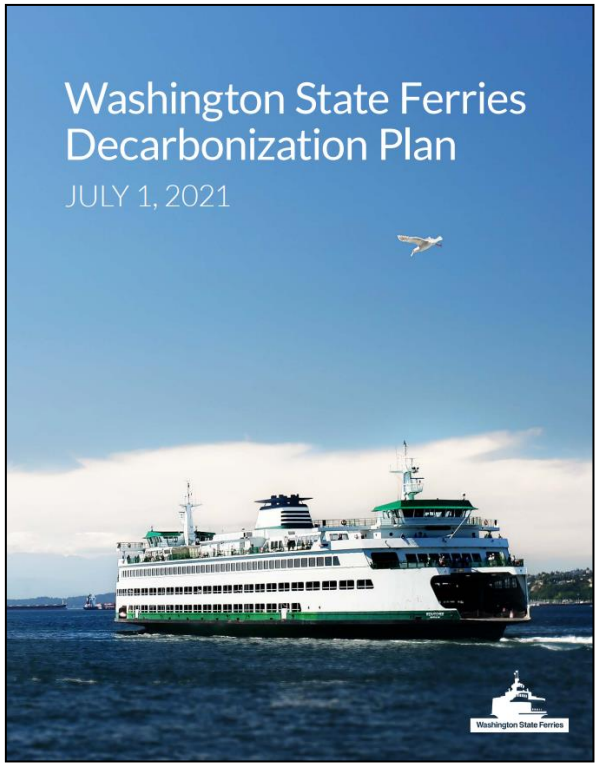
Planning







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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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Speed and Schedule Optimization

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.

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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.

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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.

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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.

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Questions

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