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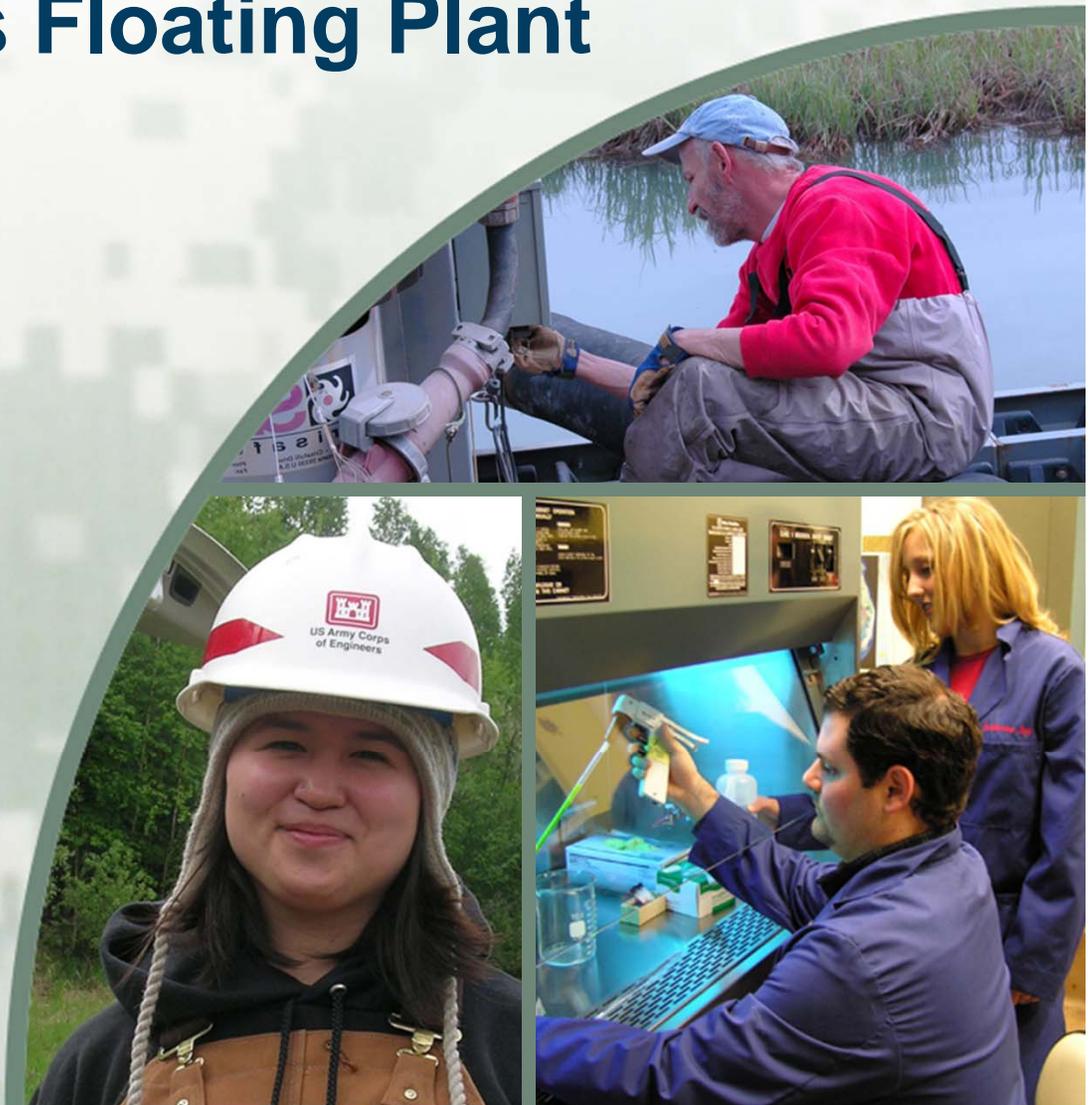
Engineer Research and  
Development Center

# Tests of Alternative Fuels to Reduce Fossil Fuel Use in Corps of Engineers Floating Plant Operations

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# Tests of Alternative Fuels to Reduce Fossil Fuel Use in Corps of Engineers Floating Plant Operations

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# What's this?

## It's the first slide in the presentation and it has a conclusion.

The Strategic Sustainability Performance Plan studies have been ongoing for about three years and have encountered no significant mechanical or operational problems in using biodiesel fuel made from soybeans in Corps vessels. This includes the use of B100 (99.9% biodiesel) and lesser biodiesel content fuels down to B-5 (5% biodiesel and 95% ULSD).



# What are the questions addressed in this paper?

Cost → Fuel usage

- No significant mechanical problems that could increase maintenance costs were encountered.
- The cleaner engines observed are a hopeful sign that engine maintenance might decrease.
- The primary issue is the difference in fuel costs, which depends on price and fuel usage.

## Emissions

- CO<sub>2</sub>, NO<sub>x</sub>, CO and Particulate Matter (PM<sub>2.5</sub>)
- Real emissions versus EPA emissions factors



# Corps vessels used in the study



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# Two Corps vessels were chosen for monitoring of fuel usage and emissions.



The *Raccoon*, a drift collection vessel based in Sausalito, California.



The *BD-5*, a drift collection vessel based in Washington, D.C.



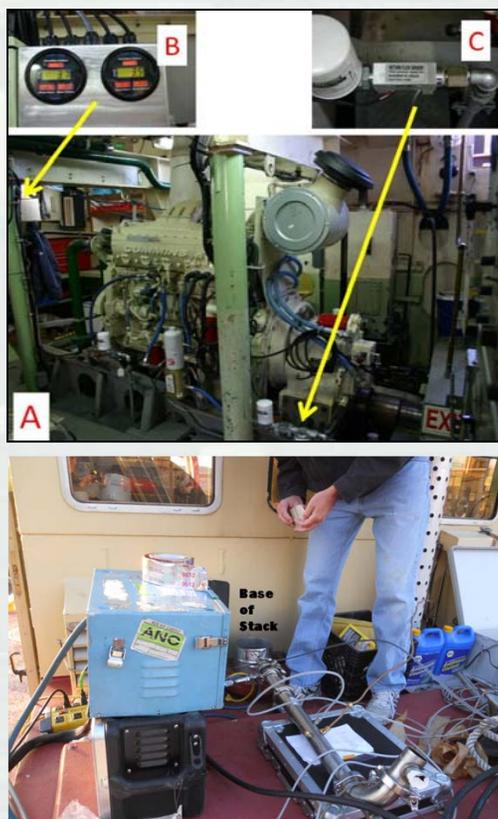
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# Fuel Usage and Emissions Testing

Conducted by the University of California, Riverside's Center for Environmental Research and Technology (CERT).



*Raccoon* starboard engine (A) with FlowScan fuel-flow interface meter components:  
(B) fuel consumption LCD readout and  
(C) fuel-line flow meter.

Emissions testing instrumentation connected directly into the exhaust stack on the *BD-5*.



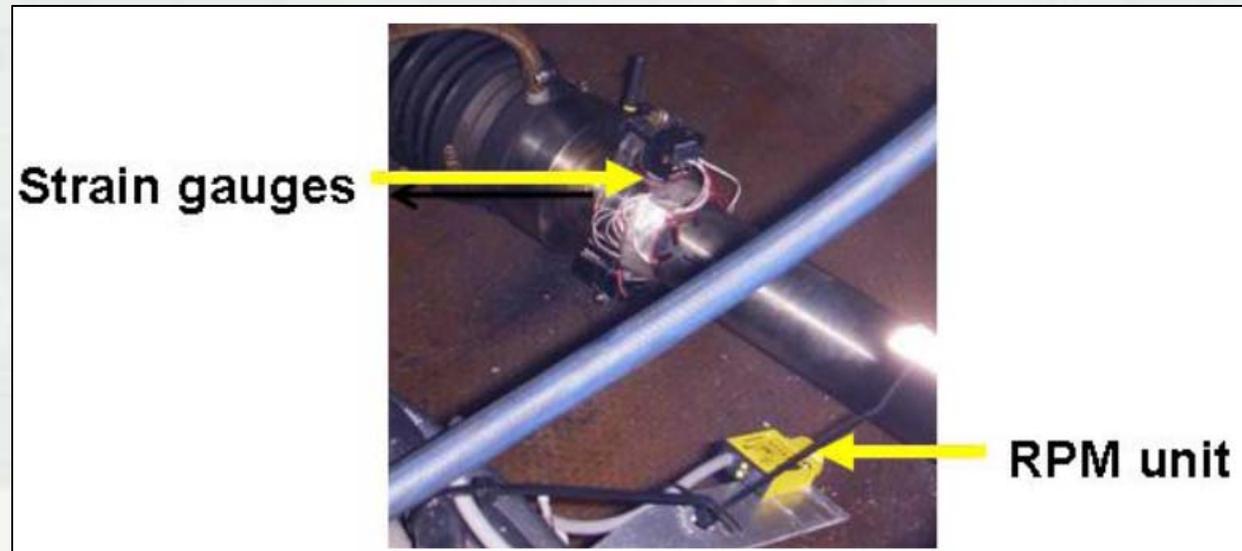
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# Engine Power

Measurements made by Bristol Harbor Group



Engine power is proportional to torque x RPM

Torque was measured by bonding strain gauges to the propeller drive shaft. RPM was measured by sensing magnets which were also bonded to the propeller drive shaft. There were problems with the torque measurements.



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# Fuel Properties

Fuel Type	Density (kg/m <sup>3</sup> )	Carbon Content (% by weight)	Cetane Number
Federal ULSD	835.9	86.51	46
CARB ULSD	835.9	86.51	51
Neste	806.5	85.47	75
B100	890.0	77	50

- Federal ULSD

Meets EPA standards and was the fuel used by the *BD-5* prior to its conversion to B100.

- CARB ULSD

The Raccoon used B100 for a couple months and normally uses diesel fuel with properties specified by the California Air Resources Board (CARB).

- Neste

A second generation biodiesel fuel of hydrotreated vegetable oil in a 50/50 blend with ULSD. The Neste was donated by the Navy for these tests.

- B100



A soybean derived biodiesel meeting ASTM D6751 specifications.



# Results

## Fuel Consumption

Results are percent greater fuel consumption than ULSD by volume.  
 Black is volume difference and red is volume difference per kw-hr.

	B100		Neste		
<b>Raccoon</b>	25% load	-1.4	0.5	1.9	6.0
	50% load	-0.4	3.5	1.4	5.6
	75% load	1.7	3.3	2.0	3.8
	100%load	1.3	1.2	1.8	4.2

	B100		Neste		
	port	stbd	port	stbd	
<b>BD-5</b>	25% load	-0.4	-2.3	3.1	17.1
	50% load	10.9	-3.2	1.9	0.3
	75% load	2.6	0.5	7.9	3.8
	100% load	-2.0	0.7	-3.7	-2.4



# Results

## Emissions

- B100 and Neste **CO<sub>2</sub>** emissions for the *Raccoon* were within 2% of those for ULSD. For the *BD-5* they were within 3.5%, with the exception of 12% for B100 at 50% load (the same exception noted for the fuel usage), and 6.4% for Neste at 25% load.
- B100 **CO** emissions were significantly less than for ULSD or Neste, with the exception of the *BD-5* at 25% load where they were slightly higher. Neste had higher **CO** emissions than ULSD at the 50% and 100% loads, and about the same emissions at at the 25% and 50% loads for the *Raccoon*, and lower **CO** emissions for *BD-5* at the 25% and 50% loads.
- B100 **NO<sub>x</sub>** emissions for the *Raccoon* were about the same as ULSD for all loads except 100% load where the B100 emissions were higher. For the *BD-5*, **NO<sub>x</sub>** emissions were higher for B100 than ULSD at all loads. Neste had lower **NO<sub>x</sub>** emissions than ULSD or B100 at all loads.
- B100 **PM<sub>2.5</sub>** emissions were much lower than for ULSD or Neste in all cases except for the *BD-5* at 25% load where they were higher.



# Emissions are not the same as weighted emissions factors

- Emissions factors are emissions weighted by operating load percentages.
- The EPA assumes 15% vessel operations at 25% and 50% loads, 50% vessel operations at 75% load, and 20% vessel operations at 100% load.
- If you use those weighting factors, based on the measurements we made, for the *Raccoon*, B100 has the same NO<sub>x</sub> emissions as ULSD and less CO<sub>2</sub> emissions than ULSD.
- Corps vessels have a wide range of operating conditions. In many cases the EPA weighting factors are not realized. The dustpan dredge *Potter* estimates their operational loads to be 20% of the time at 25% load, 75% of the time at 50% load, 5% of the time at 75% load, and 0% at 100%.
- With the EPA weighting factors, B100 meets EPA Tier 2 emissions standards for CO, NO<sub>x</sub> and PM<sub>2.5</sub> (CO<sub>2</sub> emissions are not included in the Tier 2 standards).



# Conclusions

- No significant mechanical or operational problems in using biodiesel fuel made from soybeans.
- Crews and mechanics like biodiesel because it's cleaner.
- CO<sub>2</sub> emissions are about the same for B100.
- NOx emissions are generally higher for B100, but, depending on operational loads, they can be the same, and potentially lower.
- CO and particulate matter emissions are lower for B100.
- Our tests found no significant increase in fuel consumption when using B100.
- The price of B100 in comparison to ULSD can be higher in certain geographies and under certain purchase conditions, but it can also be less in other parts of the country, based on availability and favorable contractual conditions.

