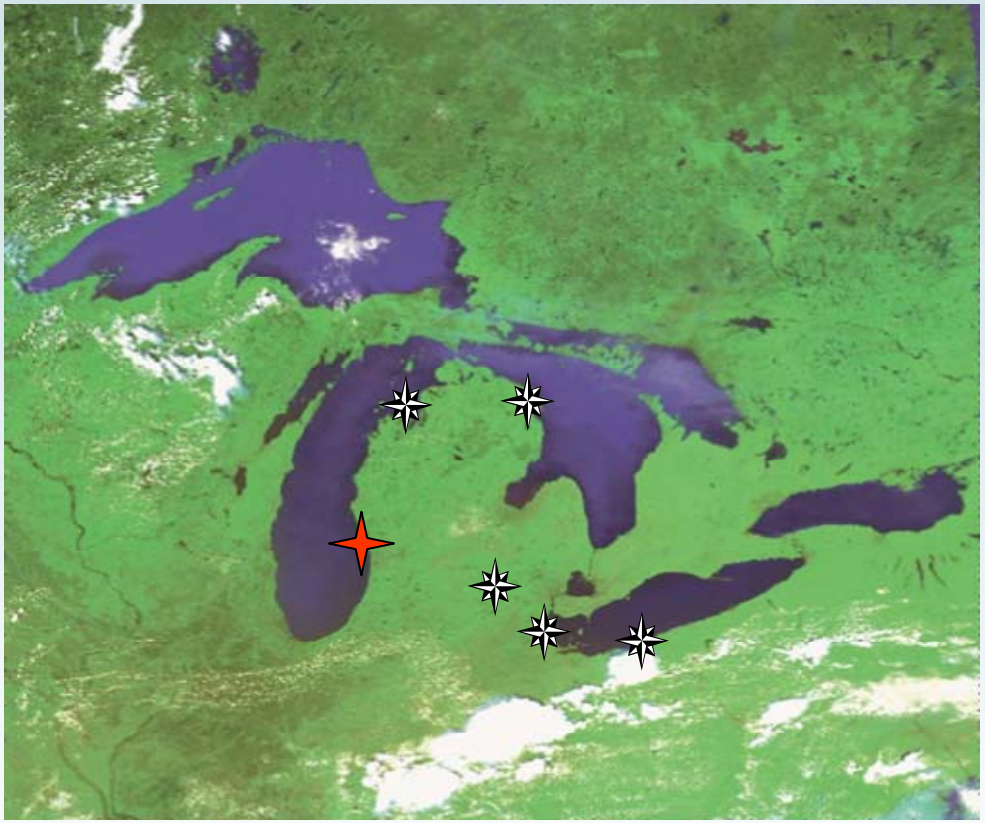
Operational Experience
Bio-Fuels and Lubricants

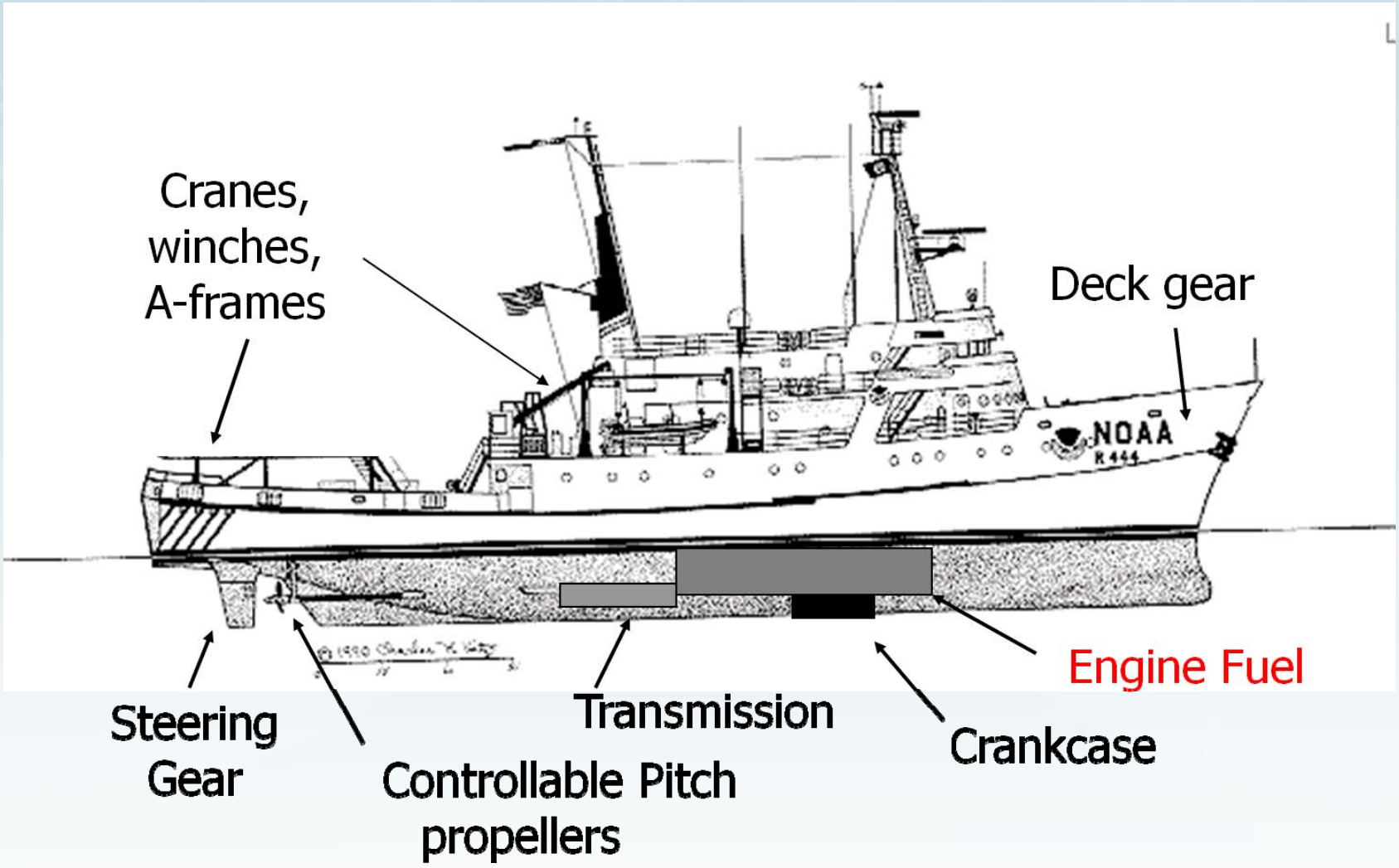


Dennis Donahue
NOAA-GLERL
Marine Superintendent

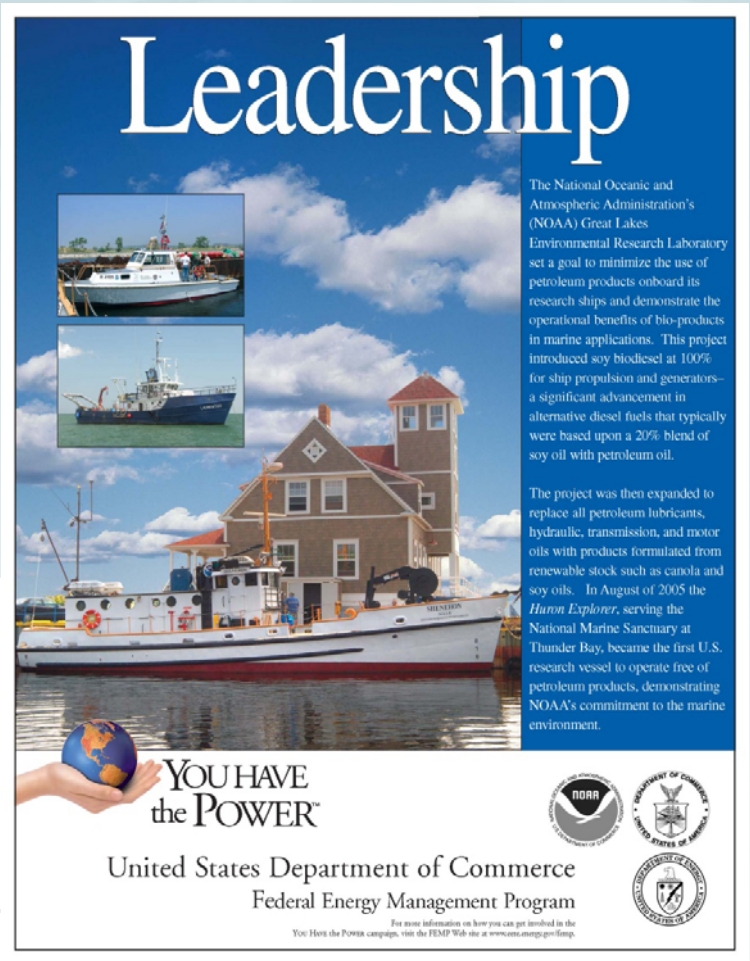
Green Ship Initiative Focus Areas

- Alternative Fuels
- Provide Operational Test Platforms
- Platform Life Cycle
- Emissions
- Renewable Products
- Overboard Discharge
- Energy Efficiency
- Emerging Technologies
- Best Management Practices

Bio-based Fuels, Oils and Lubricants



B100 Biodiesel



Office of the
Federal Environmental Executive
Promoting sustainable environmental stewardship throughout the federal government

B100 Operational Experience

11 years experience

LMFS – 160,000 gallons annually

Cost savings – 20 to 40%

OEM's – participate, validate

Crew assessment – "Non-issue", " Prefer B100"

Green Ship Working Group – 1M + gallons (B100) annually

Commercially viable – tug, research, fishing and tour-boat

2010-11 effort to transition expertise

- Federal Green Fleet Working Group (Non-tactical)
- MARAD
- Army Corps of Engineers

Typical Biodiesel Issues

Cost
OEM Warranties
Power Reduction
Cold Flow Properties
Material Compatibility
Microbial Growth
Filter Plugging
Lube oil Dilution
Water Separation
Storage Stability

Terminology
Feedstock Variables
Tangible Benefits
Measurable Results
Logistics
Liability / Risk
Organizational Priorities
Social /Political Issues
Corporate Targets / Support

Initiative Strategy

Conventional Test Methodology

- **Stabilize** the process
- **Maintain** process parameters
- Introduce one variable (Fuel)
- Measure process response

"Measure of Equivalency"

LMFS Test Methodology

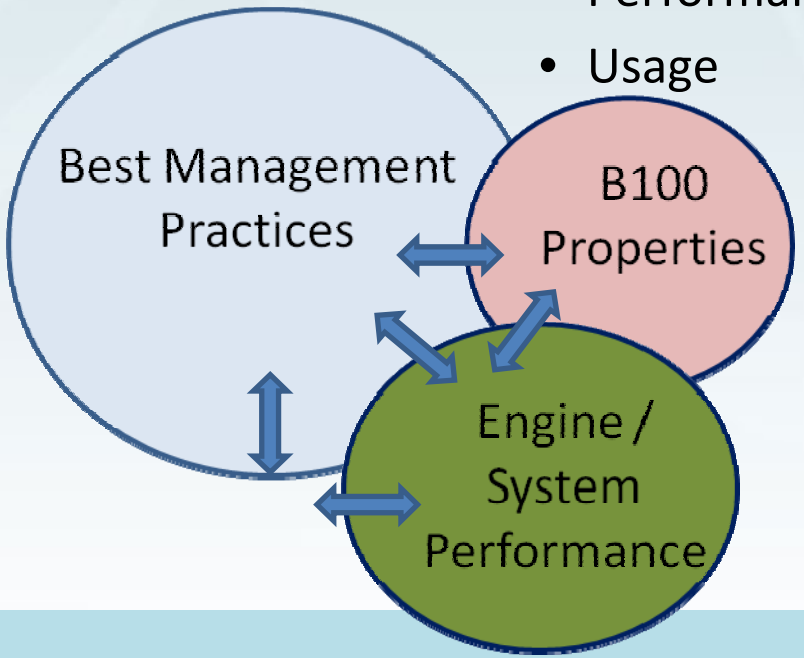
- ***Optimize*** the process
- ***Adjust*** Process variables to reflect what is known about the test material
- ***Monitor*** process controls that could be impacted by unknown attributes
- ***Measure*** changes to output, process and effort
- ***Readjust*** based upon experience

"Measure of Effort for Optimum Results"

Best Management Practices

- Fuel management
  - Inventory turns
  - Incoming QC
  - Storage conditions
  - Temperature control
- Material compatibility
- Filtration
  - Particulate
  - Water
  - Polishing
- Process
  - Pumps
  - Injectors
  - Temperature control

- Measures
  - Repair and maintenance
  - Failure Analysis
  - QA/QC
  - Emissions
  - Performance
  - Usage



B100 Biodiesel Advantages

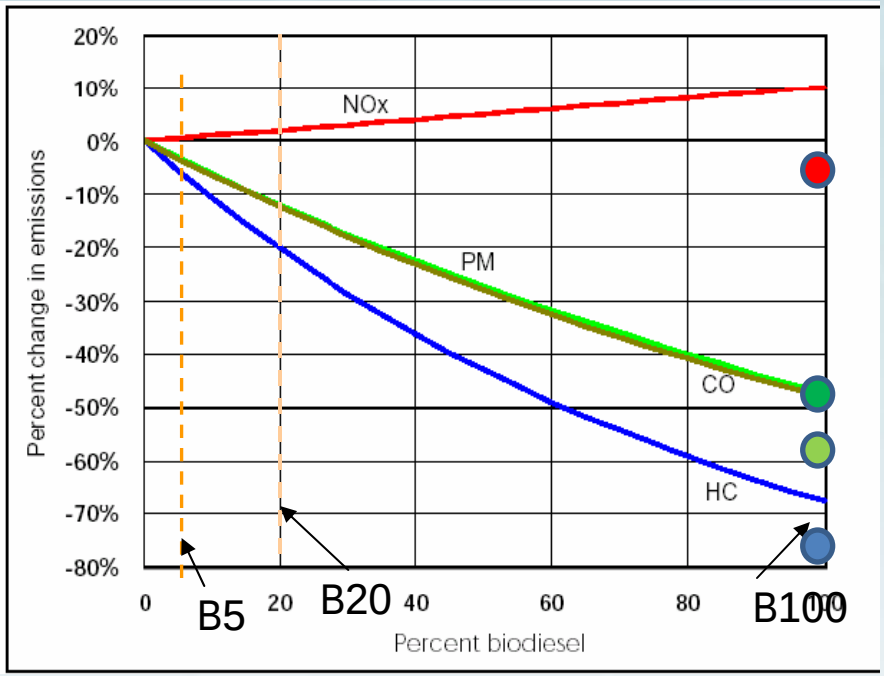
Lower Emissions

Lower Environmental Impact

Renewable Energy Source

Improved Health and Safety

- ✓ Improved Engine Performance
- ✓ Reduced System Maintenance
- ✓ Lower Cost



Typical Emissions Results

2005 Survey

Port /starboard full load tests – 4 vessels

Cummins 903, Detroit 12V71, Detroit 8-92, Cat 3508

Broad range in engine age, condition and time on B100

Averaged B100 Emissions Reductions as Compared to #2 Petroleum Diesel

Total Unburned Hydrocarbons	-77%
Carbon Monoxide	-48%
Particulate Matter	-59%
Nox	-7%
Sulfates	-74%
PAH	-66%

Crew Exposure to Exhaust Plume

Health and Safety

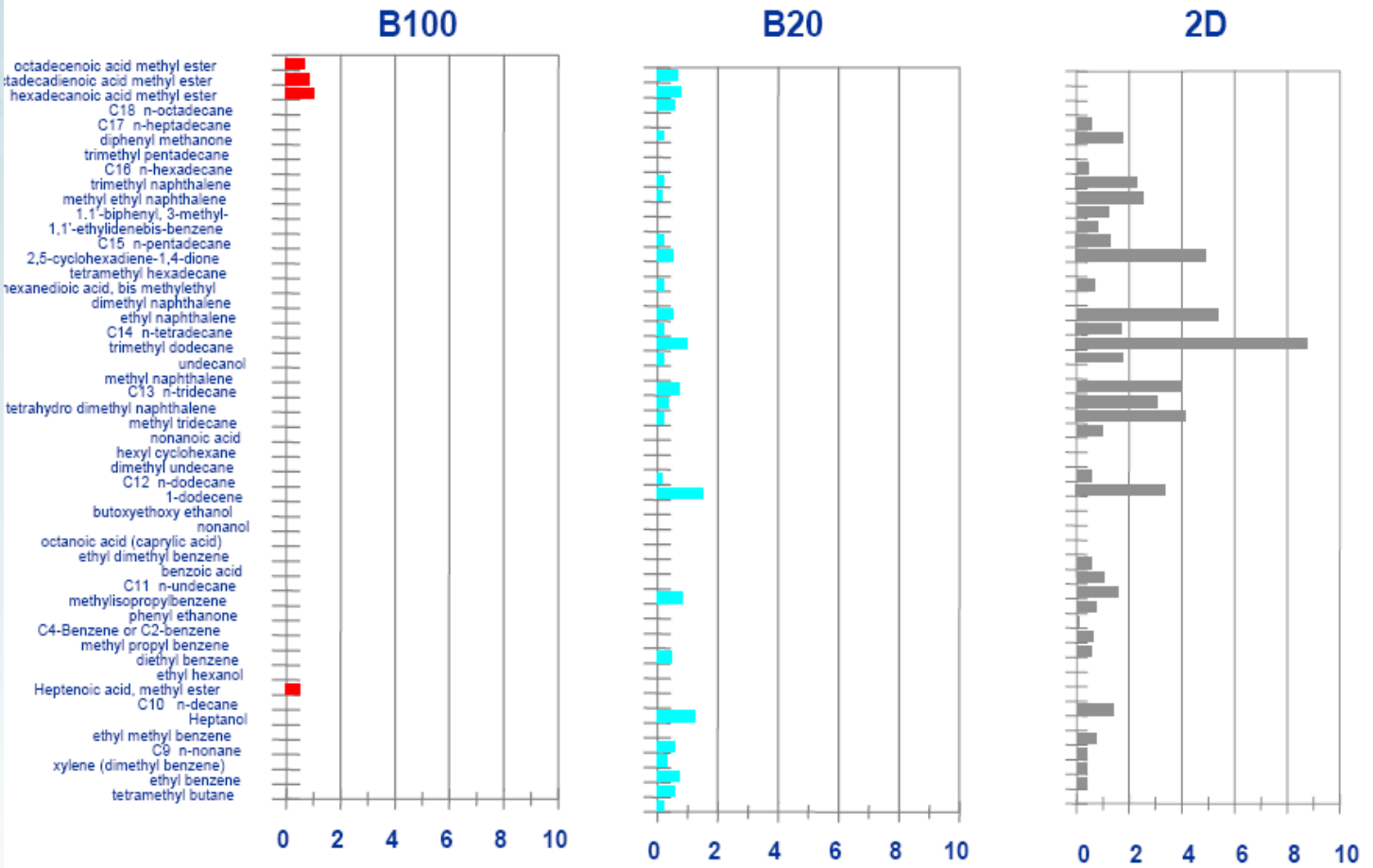
Higher flash point (125F vs. 300F)

Reduced carcinogens

Less offensive odor – seasickness

Crew Health

Tier 1 Health Effect Data



Tier I Health Effects Data supplied by SWRI, 1997-8

Fuel Comparison

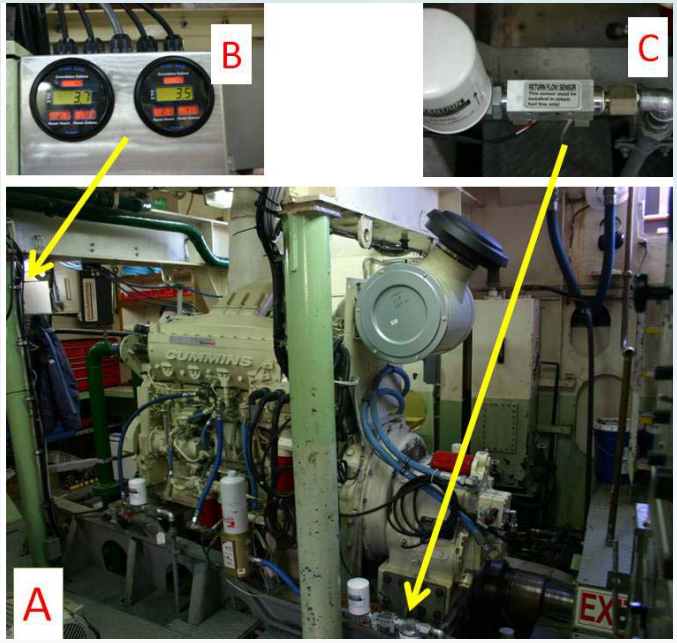
Quality Soy B100 meets or exceeds engine OEM specifications

- Higher Cetane (53 vs. 40)
- Significantly higher lubricity compared to ULSD (7500 vs. 1800)
- Higher viscosity (5.5 vs. 1.8) - better injector pressures
- Cleaner incoming and system fuel

System Requirements (fuel + process)

- Pour point – cold flow
- Water management
- Particle filtration
- Material compatibility

Need for long term engine data

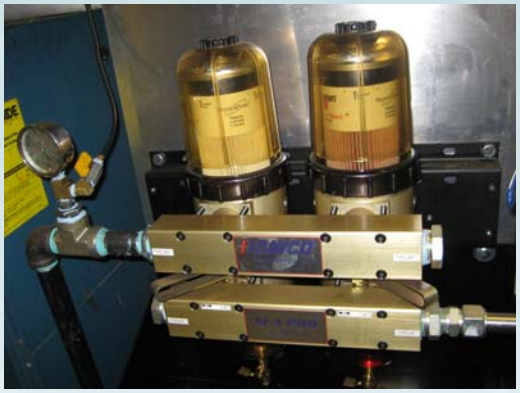


Filtration of Solids

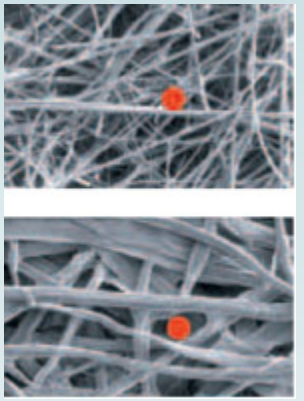
Best Management Practices

- Incoming QC
  - Tanker filtration – 10 micron
  - Water content
  - Free glycerin
- Improve filtration
  - Increase retention time (3x)
  - Vacuum-type units
  - Filter media selection
  - Spent media analysis
- Temperature management
  - Minimize thermal shock
  - Fuel to fuel heat exchangers
- Bacterial growth
  - Maximize tank turns
  - Minimize water
- System cleaning
  - Varnish, wax coatings

Cooperative R &D Projects



Equipment



Media

Measurements - Optics

B100 Detergency

#2 Diesel 4 Years	B100 1 Tank Turn	B100 3 Tank Turns	B100 One year

Tank Bottom Samples

Best Management Practices and B100

Results

- 5 micron primary filters
- No secondary filters
- No manual tank cleaning at 5 years
- No injector replacement
- No fuel pump failures

Monitoring / R &D

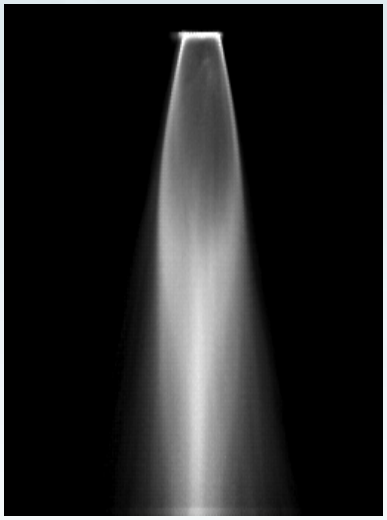
OEM – injector replacement program

Annual injector testing

OEM – fuel pump evaluation program

Component Failure Analysis

Engine OEM's validate performance



Winter Operations - Fuel Heaters

Maintain 70º F prior to filters

Heater R &D

- Electric / fuel
- Water jacket / fuel
- Return fuel / feed

Measurement R&D

Material Compatibility

System Approach

- Fuel system components
  - B100 will accelerate failing materials
- Focus on field repairs and materials
  - OEM failures are rare
- Elevate housekeeping and maintenance standards
- Review adjacent and support systems

Industry Partners

- Allied industries
- Material processing plants

Technology Transfer
Green Ship Working Group - 2002

150 + Vessels

1M+ gallons annually

Equipment development

Shared expertise

Logistic support

Broad spectrum of vessels

- Government
- Research
- Passenger
- Fishing
- Tug / Transport
- Utility / dredge

Technology Transfer

Federal Green Fleet Working Group - 2010

Multi- agency

Shared interest in alternative fuels

Consolidate experience / resources

Establish cooperative projects

Establish protocols

Advance renewable technologies

Army Corps of Engineers - 2011

- B100 Feasibility Study
- Package NOAA experience
- Emphasis on engine loading

MARAD – 2011

- 2nd Generation Biodiesel
- T-AGOS platform trials
- Emphasis on protocols

Implementation Process

1.Education

- Benefits of Biodiesel
- Myths and Misinformation
- Similarities and Differences
- Areas of Concern
- Implementation Plan
- Monitoring Plan
- Response Plan
- Measures and conclusions

2.Plant Assessment

- Resources and personnel
- Tank
- Residual fuel condition
- Distribution
- Filtration
- Injection Pumps
- Engine – External condition
- Engine – Performance issues
- Exhaust measures

3. Implementation Plan

- Address mechanical issues / impact
- Consider process improvements /impact
- Biodiesel supplier evaluation
- Training and expectations
- Measures and alternatives

4. Trial

- Feedback Loop
- Measures
- Conclusions
- Next steps

5. Communication

- Feedback
  - Lessons Learned
  - Industry
  - Working Group
  - Partnerships

NOAA Army Corp of Engineers

2011 Technology Transfer Project

PATHFINDER – St. Louis

RACCOON – San Francisco

DB-5 – Washington D.C.

DONLON - Cleveland

NOAA – Army Corp of Engineers

2011 Technology Transfer Project – B100

Focus

Applied GLERL methodology

27,000 gallons

4 Locations

6 Month duration

Emissions testing

Engine load testing

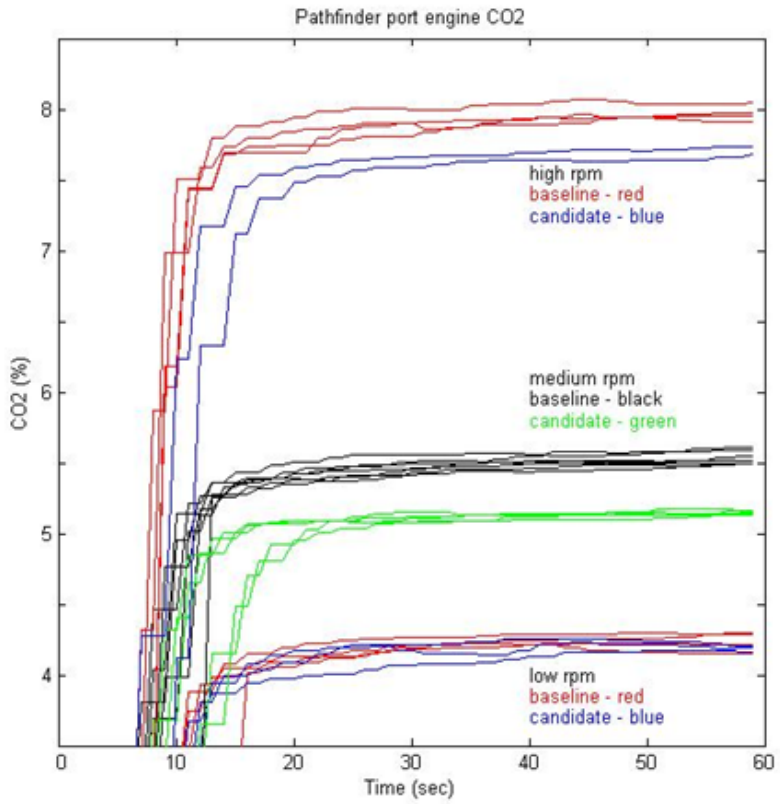
Fuel usage monitoring

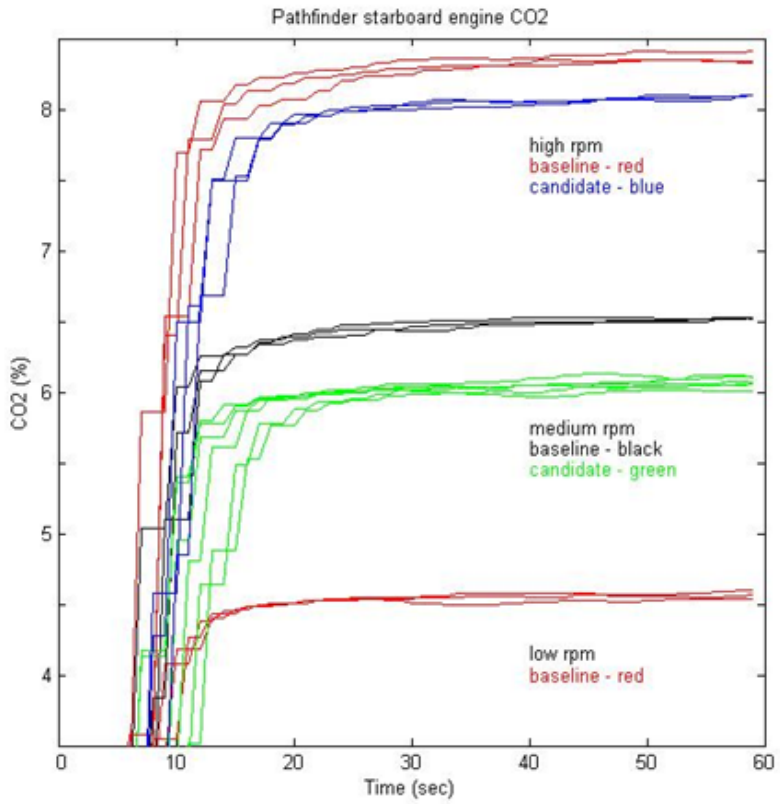
Results

- Operators and crew prefer B100
- No adverse impacts
- Availability and quality of fuel confirmed
- No cold flow issues to date
- Material compatibility issue on 1 vessel (hoses)
- No observed microbial growth, lube oil dilution, water separation, and storage stability
- No filter plugging
- No issue with switch fueling

NOAA – Army Corp of Engineers -
CO_2 Preliminary Results

- Higher or equal for biodiesel at low RPM
- Lower for biodiesel at mid RPM
- Lower for biodiesel at high RPM





MARAD – 2nd Generation Biodiesel

Large scale trial of HR-D (50% petroleum / 50% algae)

Navy test protocols

Trial translates to large Research Vessel platforms

- 4 Caterpillar D398 engines
- 450 Hours
- 10,000 gallons

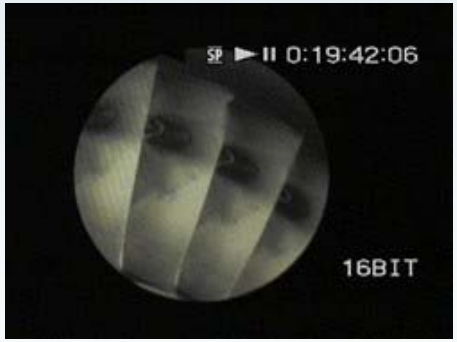
Potential test of higher bio content

MARAD – 2nd Generation Biodiesel

Emissions Results – Preliminary

- NOx 9-10% reduction
- CO 16-18% reduction
- CO2 4-5 % reduction
- PM 25% reduction

Engine Diagnostics



Turbo charger blades

Cylinder heads

Pistons

Questions ?

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