Bio-Diesel Usage in the R/V Blue Heron

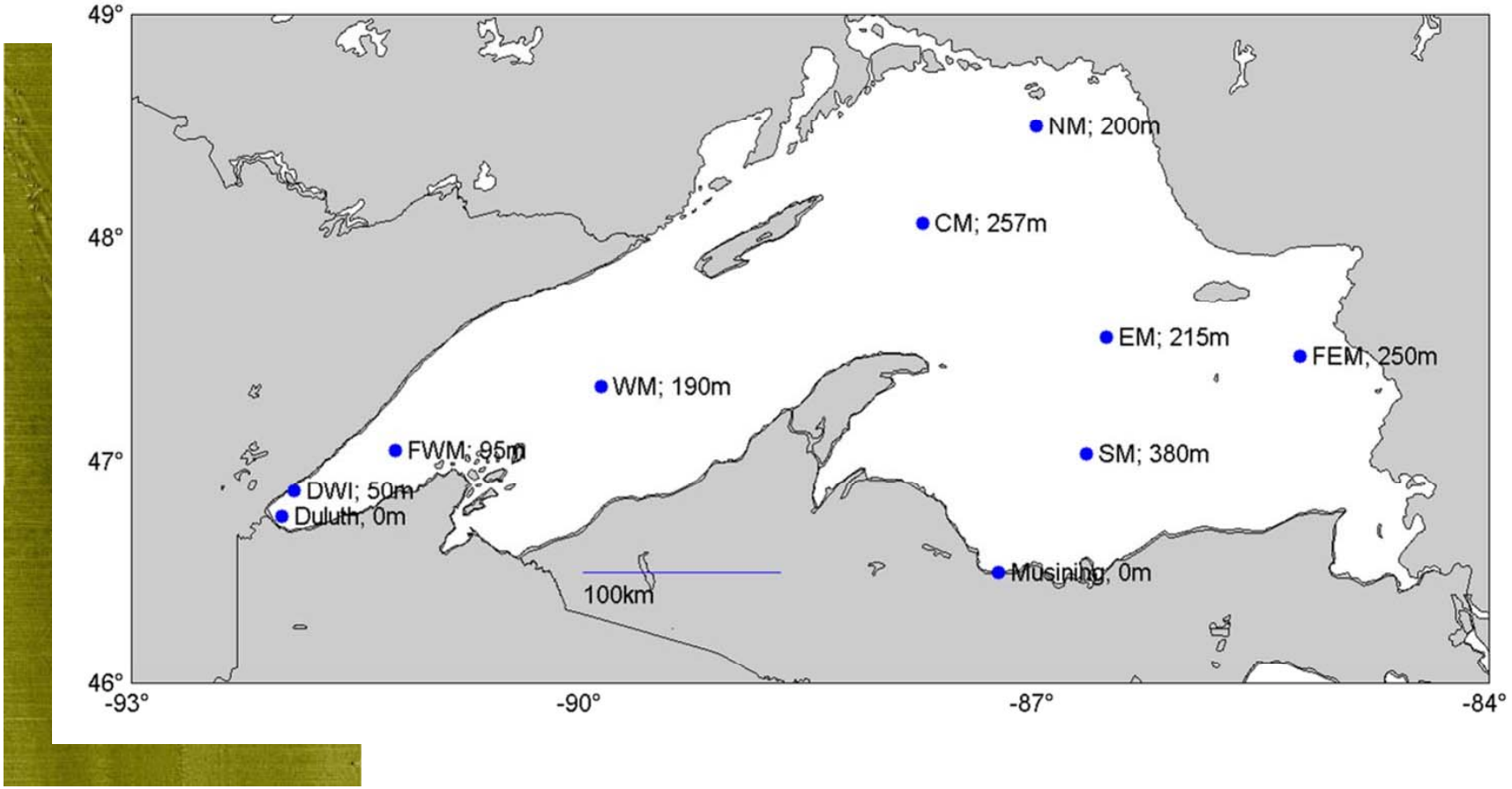
Doug Ricketts
Large Lakes Observatory
University of Minnesota Duluth

Dan Pope
Mechanical and Industrial Engineering
University of Minnesota Duluth

Research Vessel Blue Heron

- **Work with a wide range of scientists and educators**

- **Examples of recent work:**



Data Acquisition

- Measurements
  - Main Engine RPM’s
  - Main Engine Exhaust Temperature
  - Fuel Consumption

  - Emissions
    - Carbon Monoxide (CO)
    - Oxygen (O_2)
    - Oxides of Nitrogen (NO_x)
    - Carbon Dioxide

Data Acquisition

Testo 350-XL Flue Gas Analyzer
- HC, CO, O2, NOx

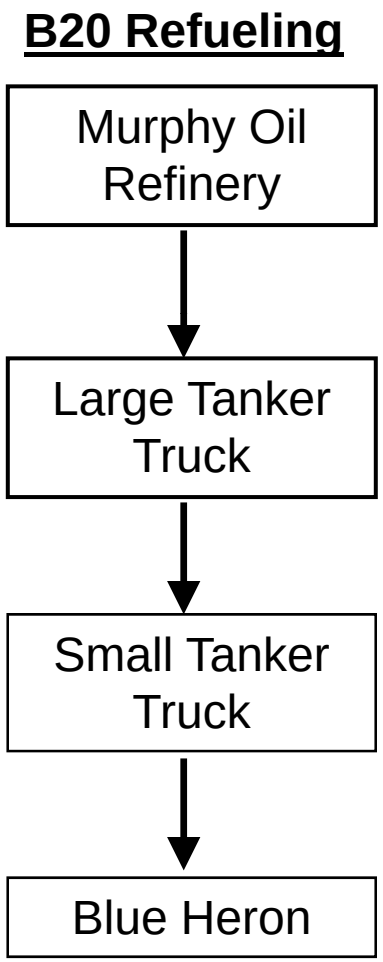
FloScan Fuel Log Systems
- Main Engine – 86TL-6FE-2K
- Generators – 850L-201-2K

Type K Thermocouple
- Omega part # TJ36-CASS-18U-12

Computer

Testing

- Refuel with B20
  - January 26th
  - May 28th
  - June 11th
  - July 29th
  - August 11th
  - August 28th
  - September 16th



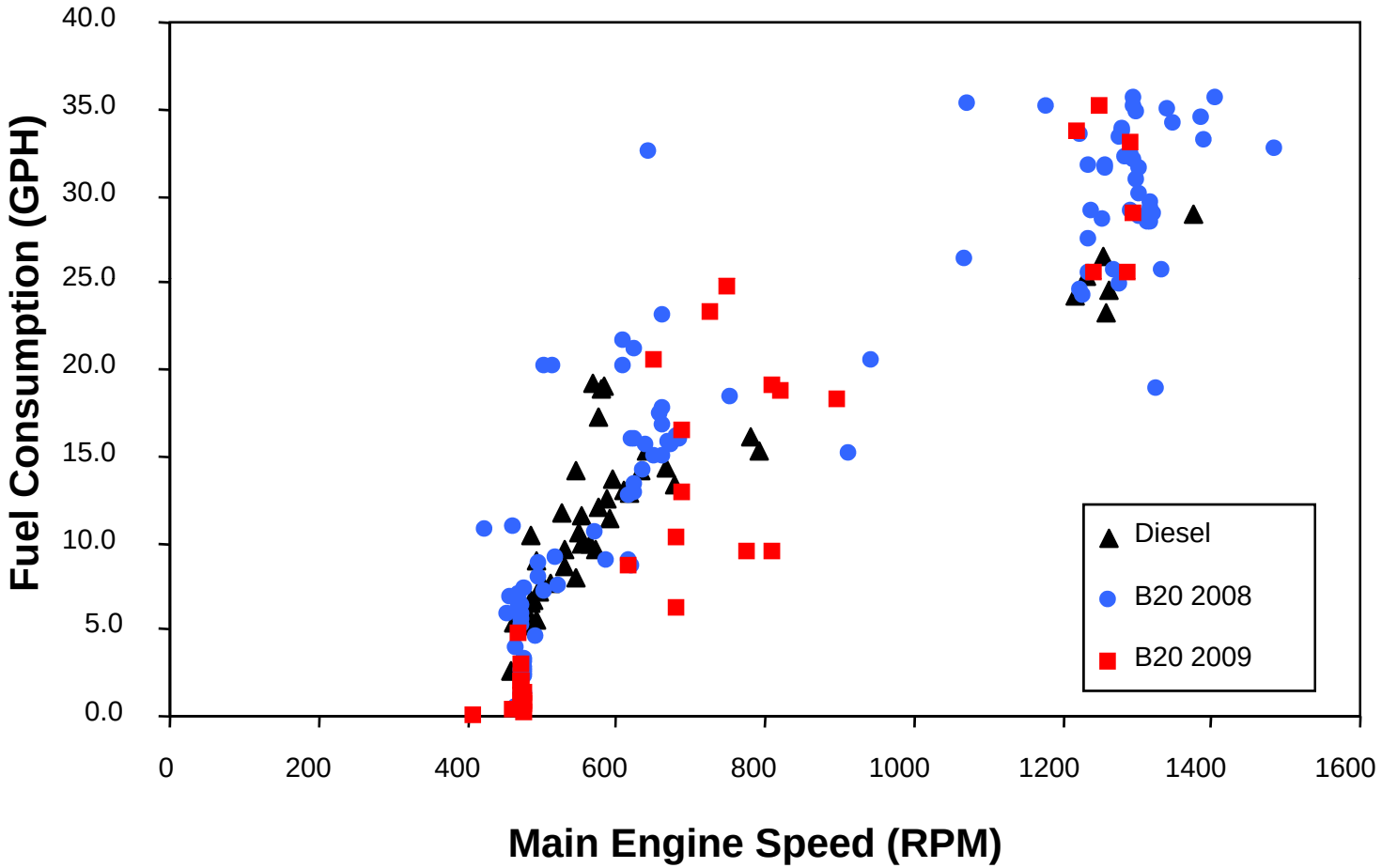
“Expected” Results

Biodiesel Content	B100	B20
Energy Content/Gal	-8%	<-2%
Emission		
Regulated		
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2%

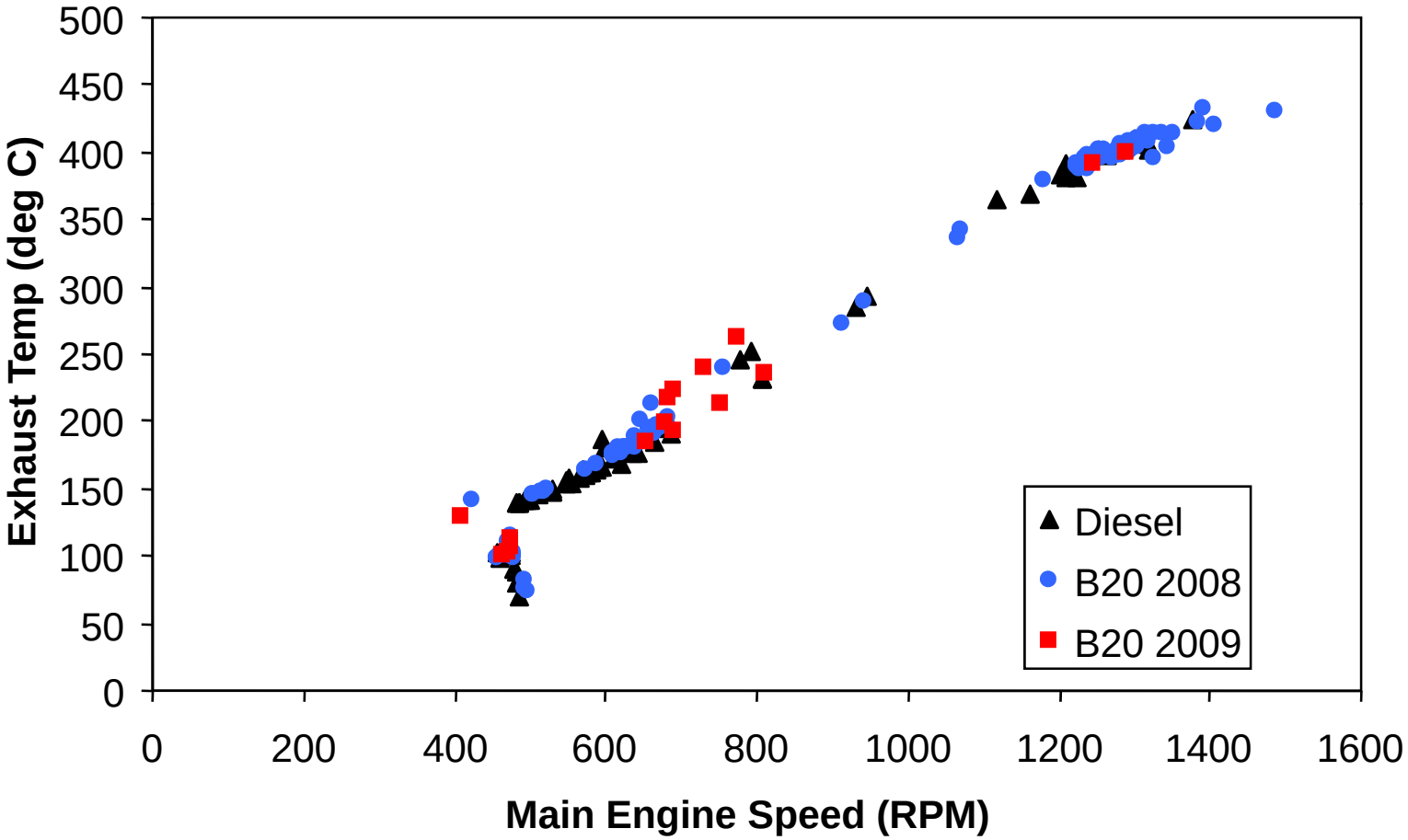
For Heavy-Duty Highway Engines

Source: National Biodiesel Board; Based on EPA Report

Fuel Consumption

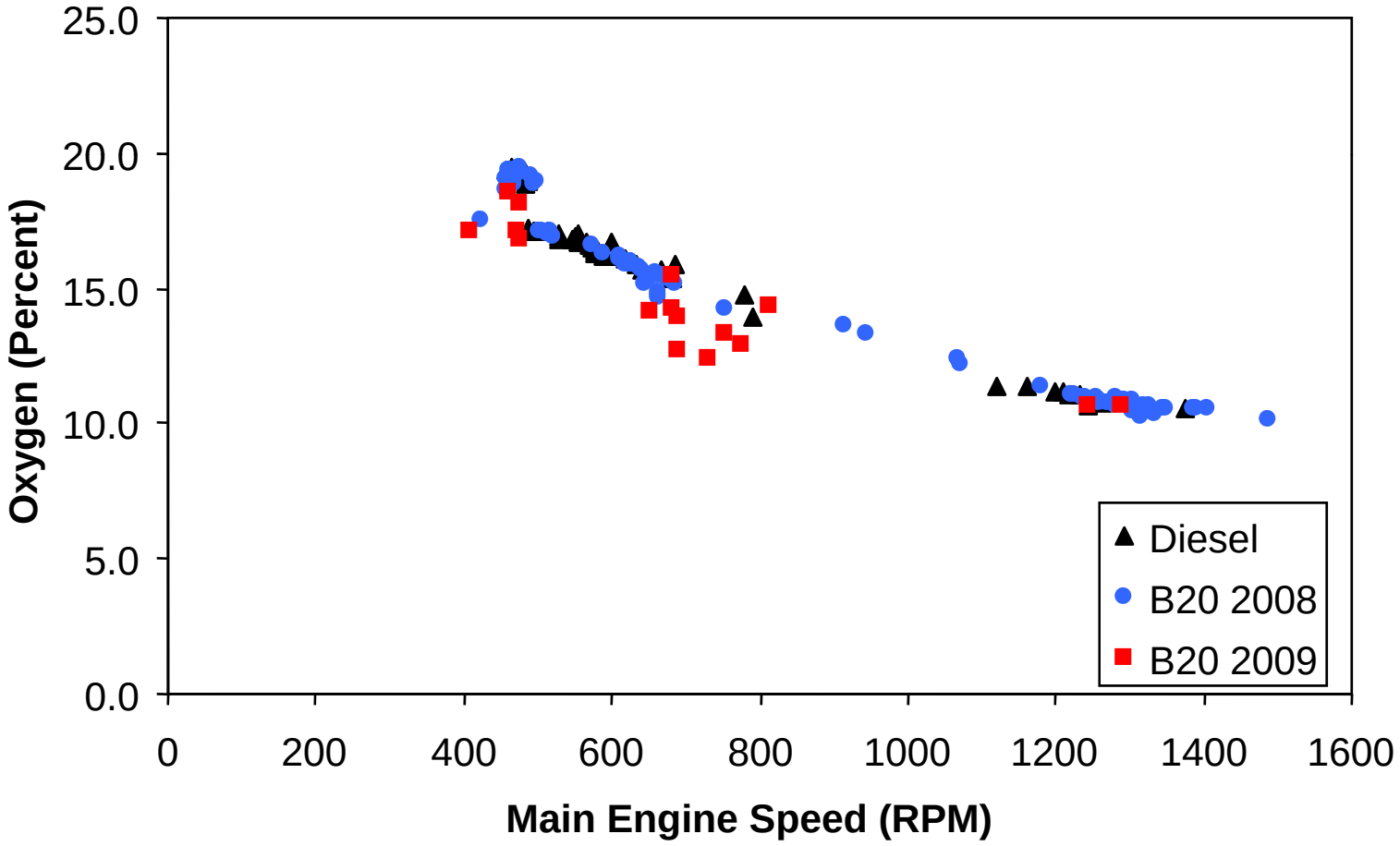


Main Engine Exhaust Temperature



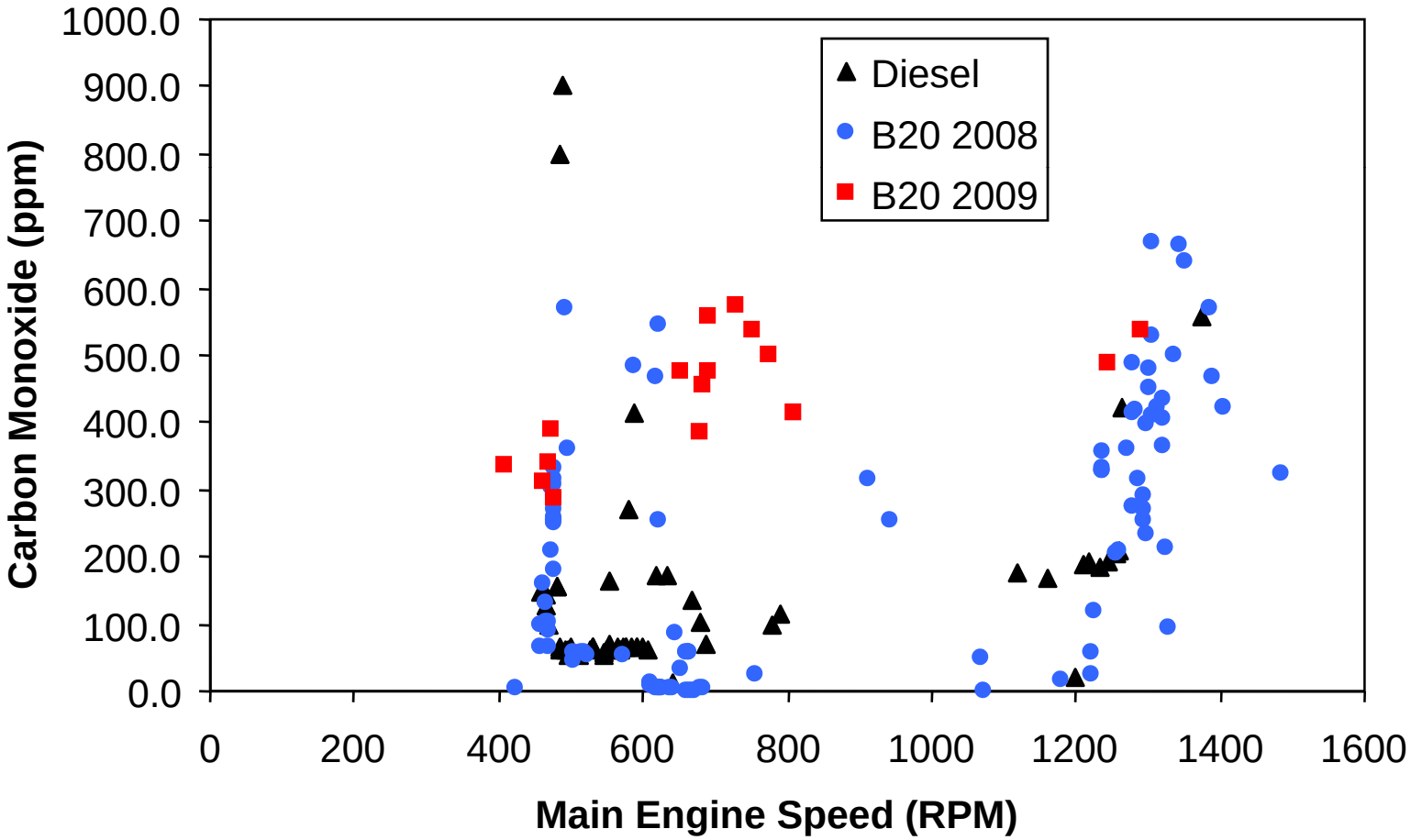
Emissions

- Percent O_2



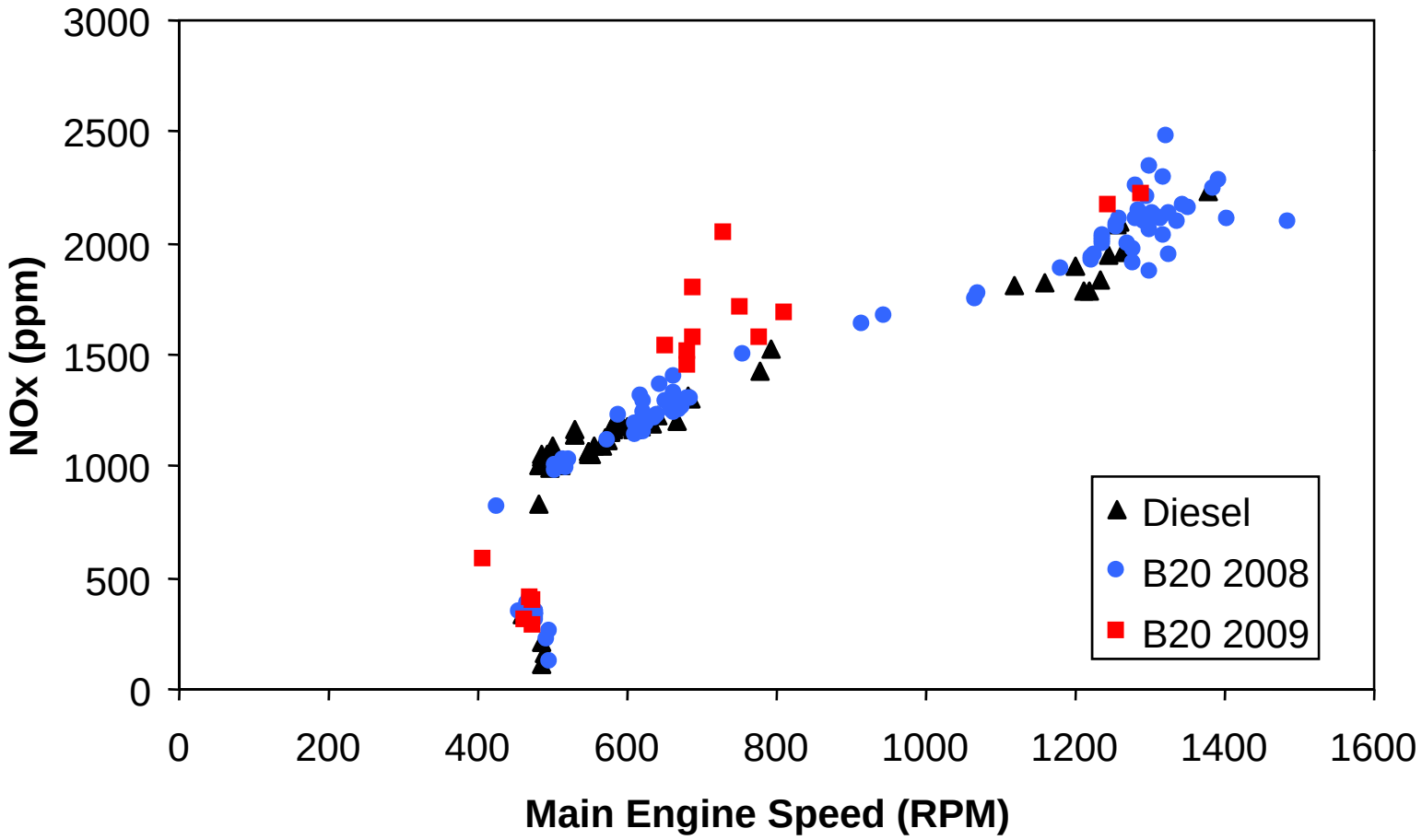
Emissions

- ppm CO



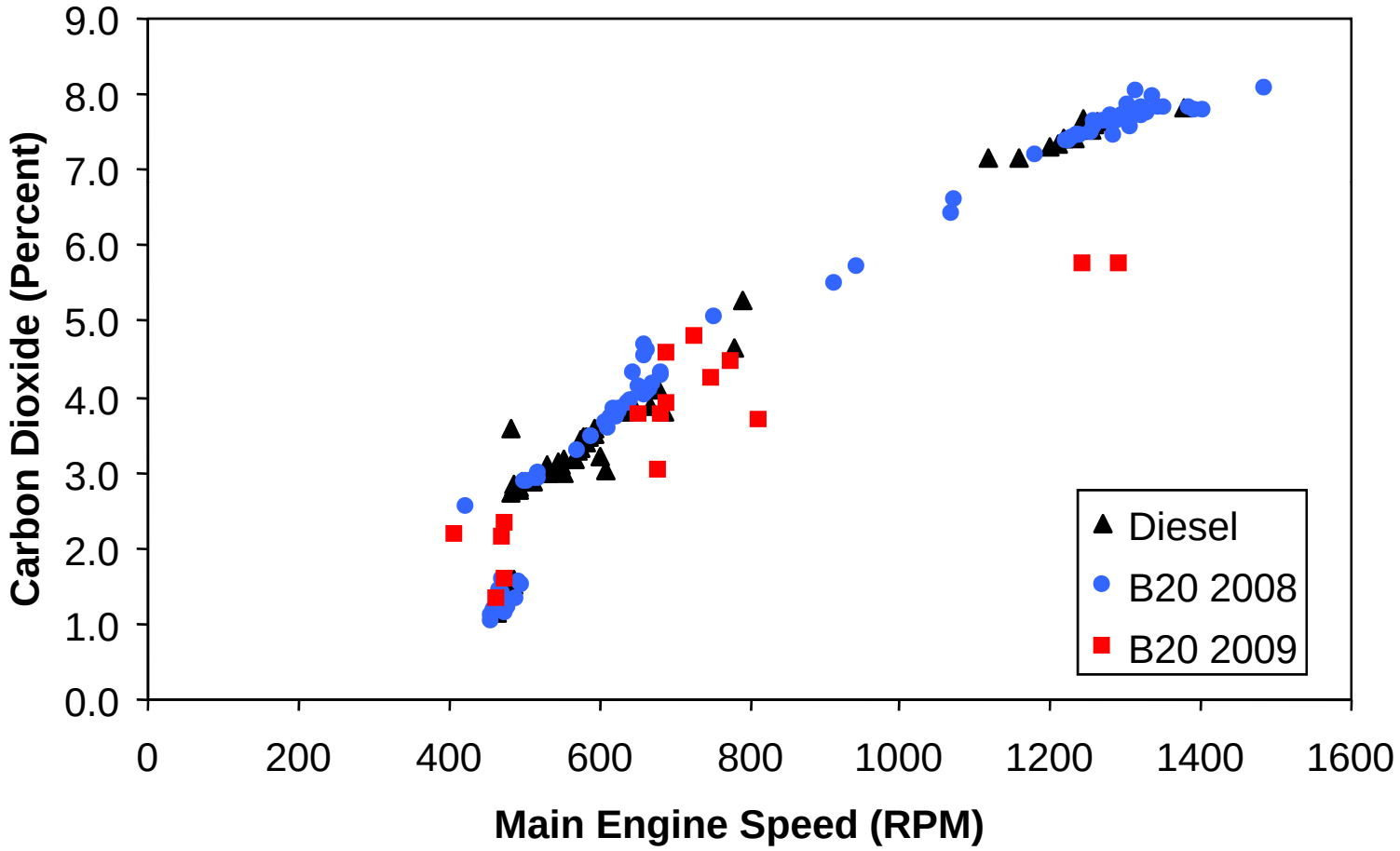
Emissions

- ppm NO_x



Emissions

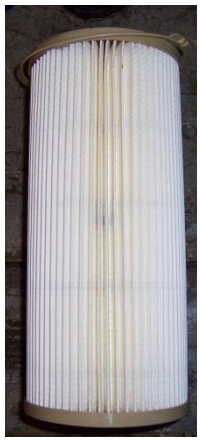
- Percent CO_2



Operational Issues

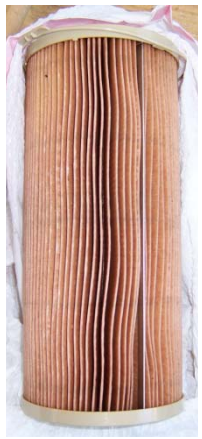
- After two years - still NO material compatibility issues observed
  - e.g. “weeping” at connections, failure of hoses, etc.
- Primary Fuel Filter
  - Racor 2-micron
  - Replace when fuel pressure < 50 psi at full throttle
  - After refueling with B20
    - Short initial operational lifetime (hours)
    - Lifetime slowly increases for subsequent filters

New Filter



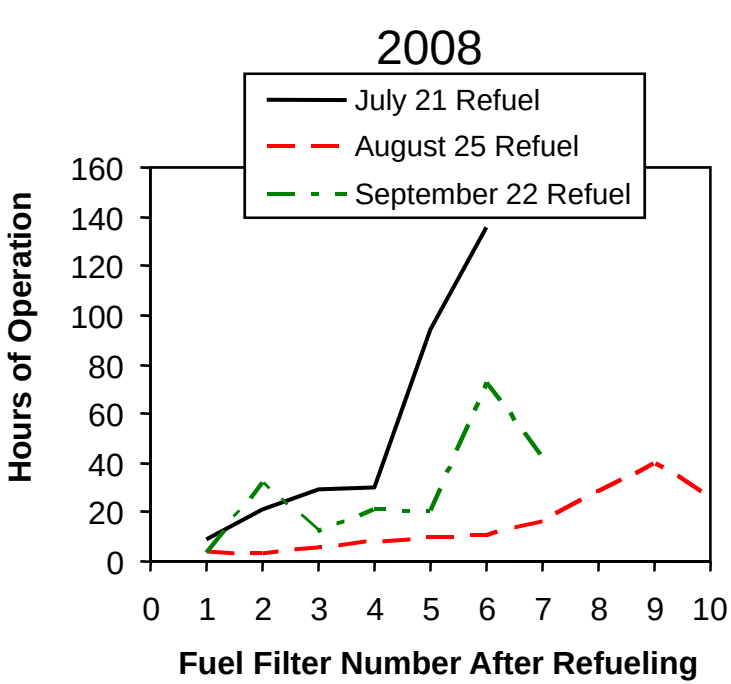
Typical Used Filter (> 100 hrs operation)

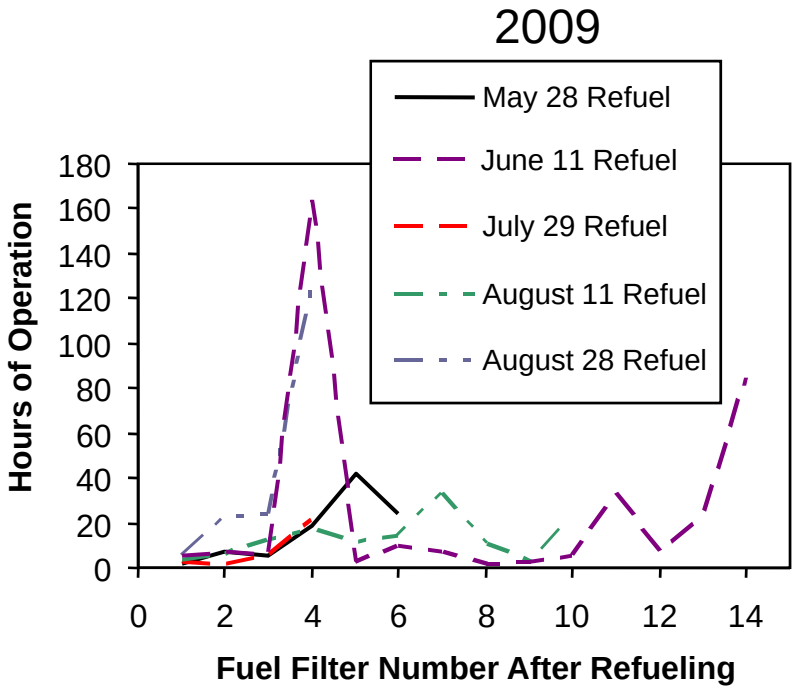
Used Filter After B20 Refueling (9 hrs operation)



Operational Issues

- Operational Lifetime of Primary Fuel Filter
  - Diesel
    - First fuel filter after refueling sometimes exhibits a shortened lifetime
    - Typical lifetime of filters from 100 to 200 hrs
  - B20
    - Short initial lifetime with increasing lifetime for subsequent filters





Conclusions

- Results NOT corrected for external factors
  - Wind, current, sea state
- Engine Load and RPM not directly correlated
  - Difficult to compare results at same RPM
- Exhaust Temperature correlates well with RPM
- 2008 and 2009 Data for B20 were Consistent (consumption and emissions)
- Fuel Consumption
  - Data **ambiguous** about increased fuel demand when using B20 at higher RPM's
  - Additional data still being collected and analyzed

Conclusions

- Emissions
  - Emissions monitoring was problematic during 2009
  - Unburned Hydrocarbon concentration too small to measure
  - O_2, NO_x, and CO_2 correlate well with RPM
  - NO_x and CO_2 emissions were similar for the two fuels, but the 2009 NO_x data may show an increase.
  - CO measurements appear questionable

- Operational Issues
  - Primary Fuel Filter had to be replaced more frequently – problem may be solved with prefiltering or by using a larger pore size
  - Filter problem may go away if producer, fuel transport and ship only using B20
  - No warrenty issues for B20 and Caterpillar engines (maybe with others?)
  - Price- little difference between B2 and B20