Small Boat Wet Exhaust Water Pollution
Uniform National Discharge Standards (UNDS)

- Federal Register, 25 August 1998
- Vessels affected
  - Navy
  - MSC
  - Marine Corps
  - Army
  - Air Force
  - Coast Guard

Small Boat
Wet Exhaust Water Pollution

Micro-Constituent	
Inboard Engines	**Outboard 2 Stroke Engines**
Acenaphthylene	Benzene
Phenanthrene	Toluene
Chrysene	Ethylbenzene
Benzo(a)pyrene	Naphthelene
Benzo(a)anthracene	
Benzo(b)fluoranthene	**Outboard 4-Stroke Engines**
Benzo(k)fluoranthene	Benzene
Indeno(1,2,3-cd) pyrene	Ethylbenzene
Dibenzo(a,h) anthracene	
Benzo(g,h,i) perylene	
TOTAL PAHs (Inboard Engines)	

Budgets and Operations

Chart 2 - Trendlines FY 1999 - FY 2005

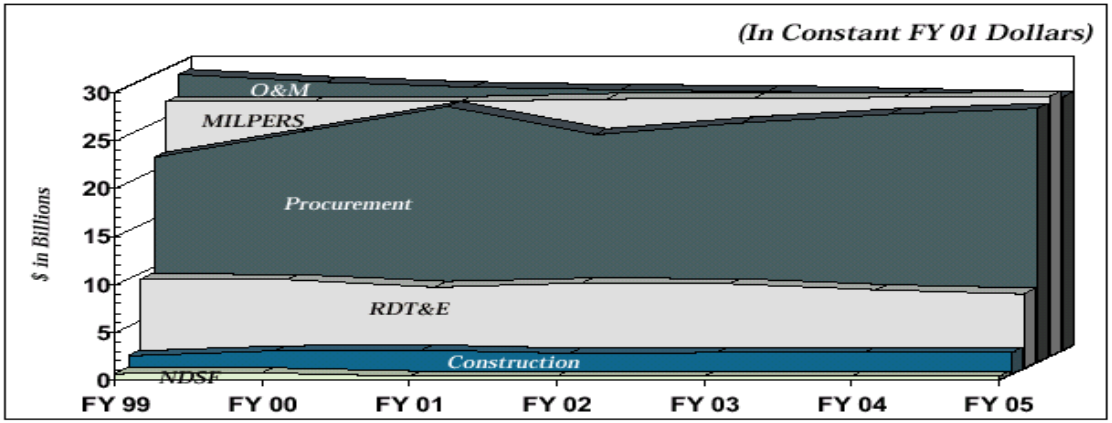


Chart 2 graphically displays Department of the Navy appropriations by title over the Future Years Defense Program.

Chart 4 - Active Force OPTEMPO

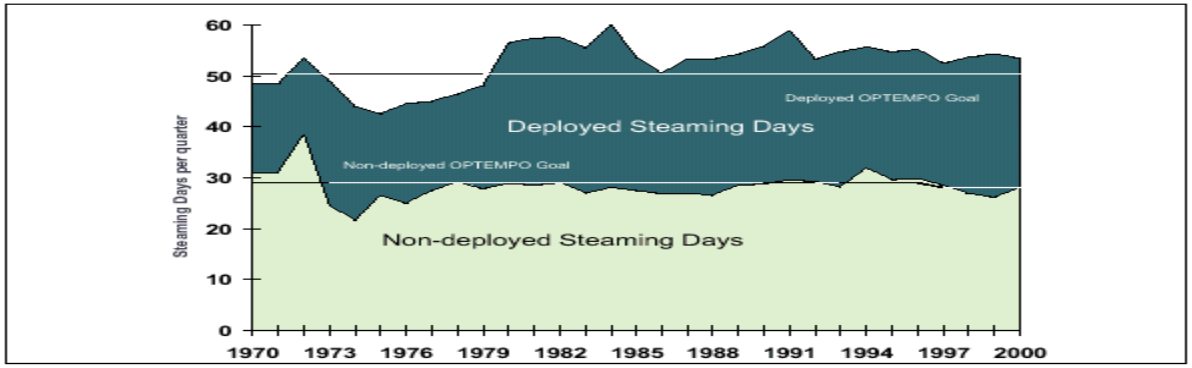


Chart 4 reflects ship OPTEMPO steaming days per quarter deployed and non-deployed. Also, displayed as horizontal lines are the deployed and non-deployed budgeted goals. Fluctuations from the goals reflect real world operations including contingency operations funded through the Overseas Contingency Operations Transfer Fund (OCOTF).

Navy Environmental Technologies

Department of Defense Research, Development, and Implementation of Environmental Technologies

- **SERDP - Strategic Environmental Research and Development Program for investigating and developing promising new approaches to mitigate the impact of DoD operations on the environment.**
- **ESTCP - Environmental Security Technology Compliance Program for demonstrating/validating (via full-scale field testing) new environmental technologies to mitigate the impact of DoD operations on the environment.**
- **Various investigative bodies within each of the services also support and conduct R&D efforts to mitigate the impact of DoD operations on the environment.**

Emission Control Technology R&D Efforts

Office of Naval Research Fundamental Studies (94-99)

- "Prediction of NOx Emissions from Large Diesels,"
  Professor F.A. Williams, UCSD.

- "NOx Reduction Using Lean Direct Injection in Naval Engines,"
  Professor J.P. Gore, Purdue University.

- "Control of Combustion and Emissions,"
  Professor J.H. Whitelaw, University of London.

- "Investigation of Selective Non-Catalytic Processes for in-situ Reduction of NOx and CO Emissions from Marine Gas Turbines and Diesel Engines,"
  Professor C.T. Bowman, Stanford University.

- "Non-Thermal Plasma Treatment of Diesel Exhaust,"
  Professor M. Gundersen, University of Southern California.

Emission Control Technology R&D Efforts

- **Diesel Engine Energy Conservation Program (secondary objective – emissions reduction) (2000 –annual renewal)**
  - **Near-term technology feasibility demonstrations**
  - **High-pressure common-rail technology insertion**
  - **Auto (digital governor) single SSDG operation**

- **In-House Laboratory Independent Research**
  - **Chaos Control to Achieve Clean, Efficient Combustion in Diesel Engines (20000 – 2002)**
  - **Define control and minimization of pressure/heat release fluctuations to improve combustion efficiency and reduce emissions**

Emission Control Technology R&D Efforts

- **Investigation of Combustion Modifications for Reducing Exhaust Pollutants from Ships' Diesel Engines (1997 – 1999)**
  - **Determined combustion/emission effects of variable air composition and EGR**
- **Diesel Emissions Reduction (1994 – 1997)**
  - **Demonstrated 80 - 90% NO_x reduction (two- and four-stroke) SCR system engines**
- **Reduction of NO_x Emissions from Marine Power Plants**
  - **Evaluated emission control technologies to reduce NO_x emissions from Navy gas turbine and diesel engines (demo on LM-2500 and DDC 12V-71) (1996 – 1998)**

Emission Control Technology R&D Efforts

- **Non-Smoking Injector Development/Demonstration**
  - **Worked with manufacturer to develop non-smoking ECOTIP (small sac volume) Injector (EI) for Detroit Diesel Engines.**
  - **Tested/Evaluated EI on operating Navy small craft.**
  - **New non-smoking EI now being installed on 40 Navy craft.**
  - **EI technology for Detroit Diesel Engines now commercially available.**
- **Pilot Emission Control Program**
  - **Laboratory evaluation of selected PM/NOx reduction technologies (baseline engine and fuel compared to operation with 5 alternative fuels and 6 emission control technologies)**
  - **Shipboard (LCM/LCU, TR/TRB, YSD) testing and application.**

Marine Diesel Engine Navy Pilot Emission Control Program

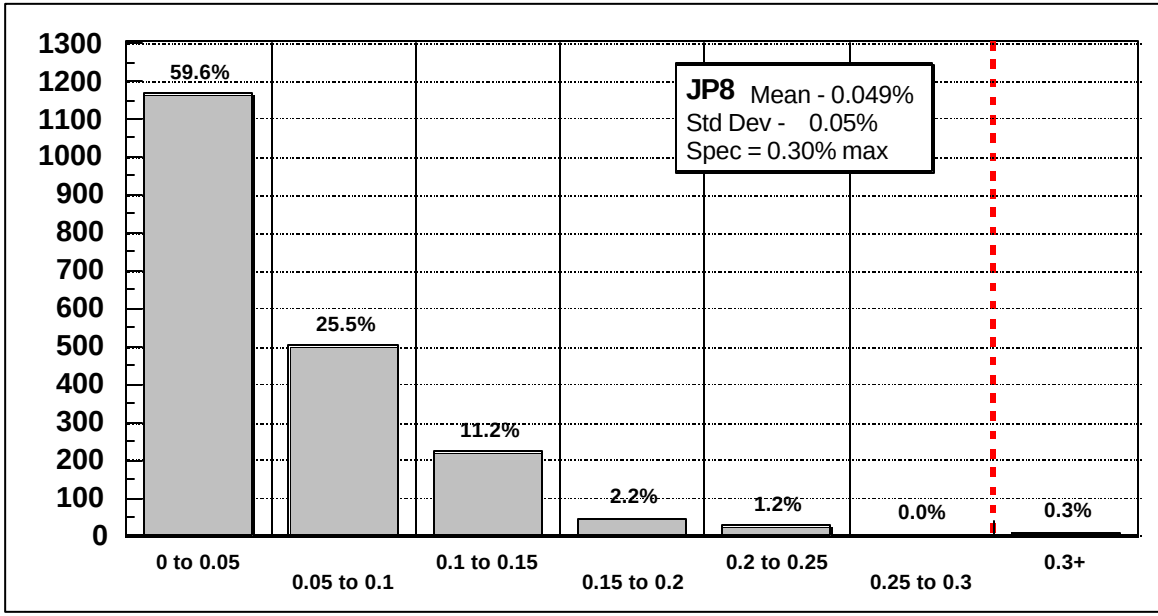
- Laboratory performance testing of PM/NOx reduction technologies (selected for Navy marine application)
  - Single and combined
    - Alternative fuels (naval distillate compared to B100, F-T, JP-5, research low-lubricity fuel, & ULSD)
    - Other control technologies (baseline conf. compared to that w/ DPF, tuning, fuel additive, internal EGR, mini-sac injectors, particle separator, & water humidification)
  - Emissions assessment
    - Gaseous emissions
    - PM gravimetric and limited chem/phys characterization)
- Shipboard reliability and durability evaluation
  - Optimal single or combination of technologies/fuels on three platforms (LCM/LCU, TR/TRB, and YSD)
  - Continuous engine parameter monitoring and periodic emissions measurements
- Sponsors: ONR, NAVSEA, CARB, and MARAD/DOE
  SCAQMD and EPA (anticipated)

Lower PM Emissions Using JP-8 FUEL

[similar marine engine test effort under consideration using JP-5]

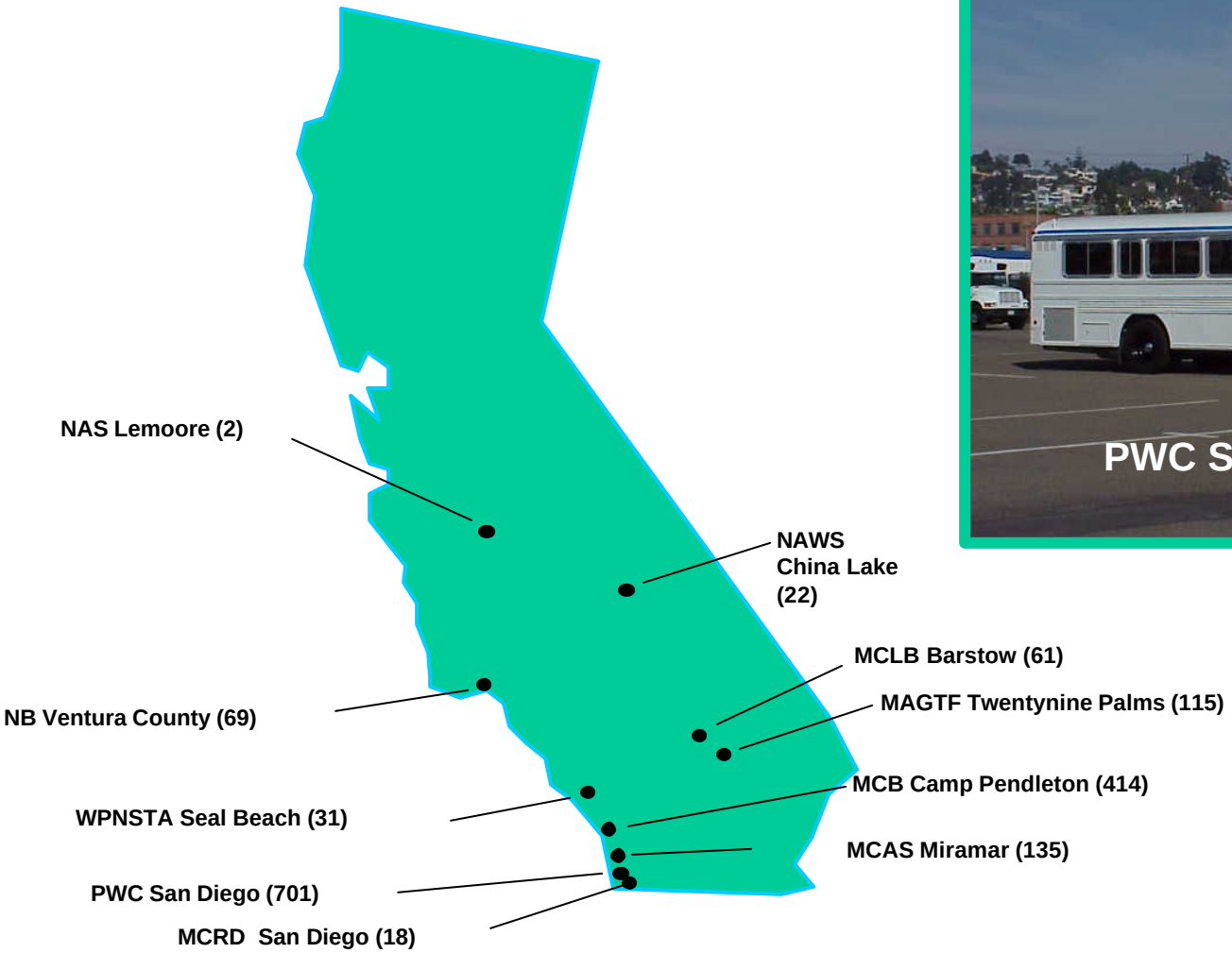
- **Engine specific comparisons of PM emissions using EPA reference fuel (350 ppm sulfur) and JP-8. ***
  - **Detroit Diesel 60 Series Engine PM emissions (JP-8, 2100 ppm sulfur) equivalent to PM emissions of EPA reference fuel.**
  - **GM 6.2 liter engine (HUMVEEs, etc.) PM emissions (JP-8, 3,000 ppm sulfur) less than for EPA reference fuel.**

- **Lower PM emissions of JP-8 fuel relative to EPA reference fuel of same sulfur content is attributed to lower aromatic content and lower distillation end-point.**

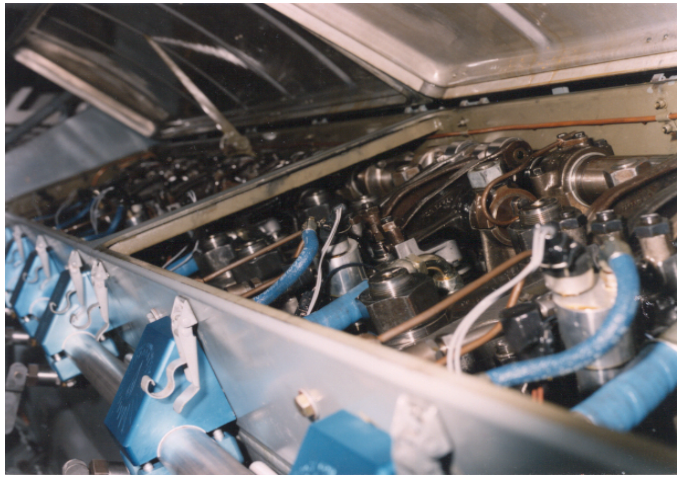


*** report**

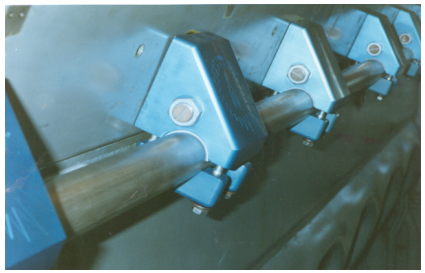
Department of Navy
Natural Gas Vehicle Sites



Conversion of Mobile Utility Support Equipment (MUSE) Diesel Generator (1500 kW, 2-stroke EMD Engine) to Dual Fuel Operation



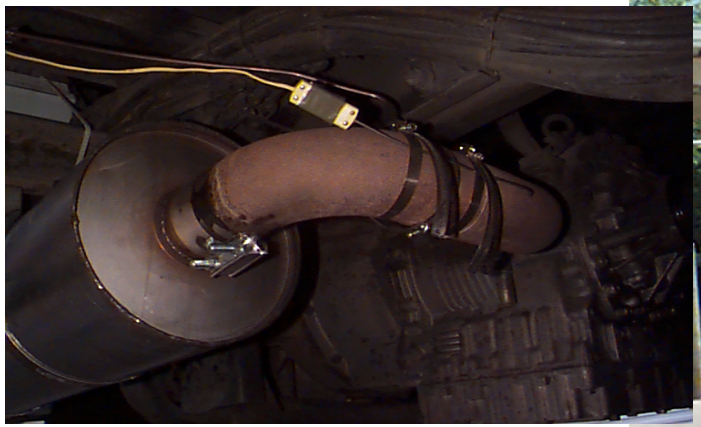
ENGINE			EMISSIONS		
	Fuel	Power (hp)	NOx (grams/hph)	CO (grams/hph)	Particulates (grams/hph)
Before Conversion	Diesel	2,119	10.5	0.25	0.35
After Conversion	Dual Fuel	2,119	2.40	9.2	0.211
	Dual Fuel	2,402	3.42	11.4	---



Military Use of Bio-Diesel Fuel

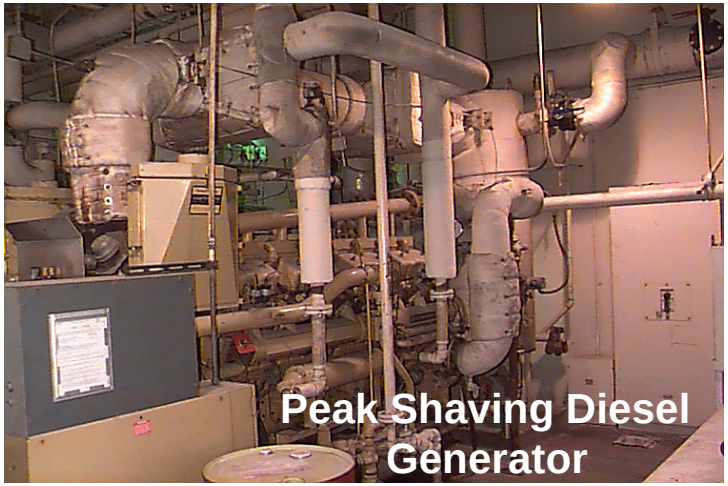
- Bio-Diesel fleet demonstration at Scott AFB using B20 (bio-diesel) fuel starting 1 May 2001 - 1 May 2002.
- Scott AFB plans to convert 270 diesel vehicles to bio-diesel.
- Army installing bio-diesel refueling facility at Pentagon.
- Army conducting tests at Fort Leonard Wood Kansas to determine BD20 operational and maintenance requirements.
- Marines are now soliciting a supplier to purchase 668,000 gallons of bio-diesel fuel for use at Yuma, Barstow, and Miramar Marine Corps Bases.
- CRADA signed between Naval Air Warfare Center Weapons Division (NAWCWD) Point Mugu and Bio-Diesel Industries (BI) to demonstrate the sustainability of a bio-diesel pilot plant.

Installing and Measuring PM Emissions from Catalyzed Soot Filters at Camp Pendleton Marine Base (May 2001)



NAVY NOx/PM Reduction

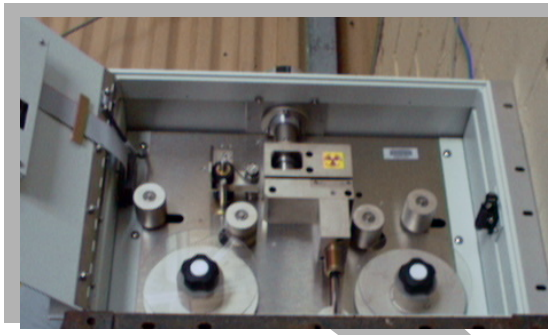
- Stationary diesel engines at work supporting Naval activities.



- Candidate technologies:
  - The Clean-Cam (R) engine modification technology for Detroit Diesel 2-stroke engines
  - Selective catalytic reduction (SCR)
  - Lean NOx catalyst - includes 90% PM reduction
  - NOx trap (lean NOx adsorber using low sulfur fuel)
- Status – now negotiating for field test locations

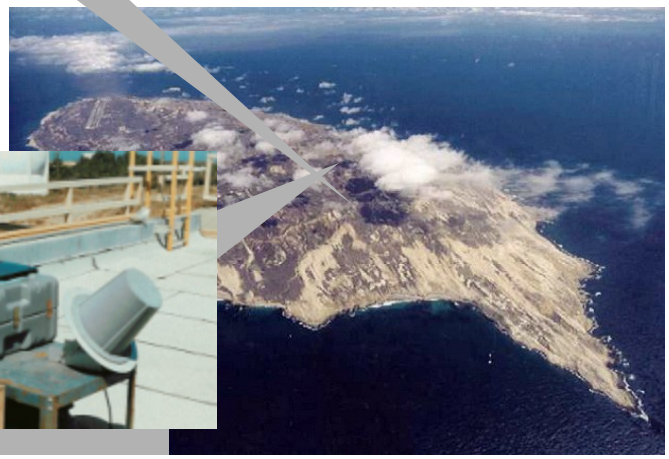
Helping to understand the transport of particulates

Navy PM Efforts on San Nicolas Island



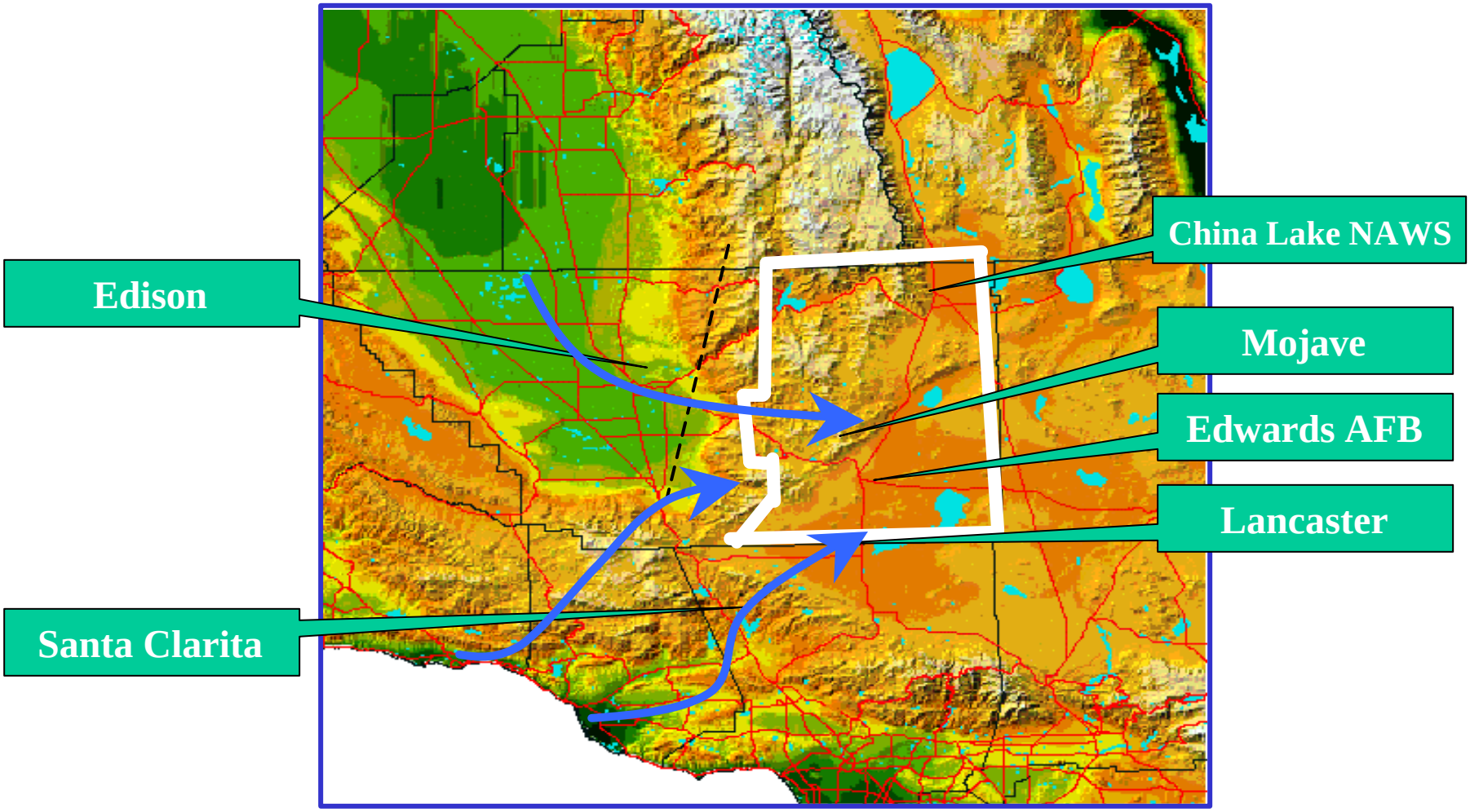
- CARB Beta Attenuation Mass (BAM) Monitor
  - SNI is a background site along with Figueroa Station/San Rafael mountains and Point Reyes Nat'l Park
  - In support of PM2000 Monitoring Net, IMPROVE and Regional Haze programs
  - Ion analysis on samples for comparison to Point Reyes $BAM_{2.5}$ data

- Scripps SIO Sunphotometer
  - SNI is a data collection site in support of the NASA/GSFC Aerosol Robotic Network (AERONET) program
  - Data provides globally distributed observations of spectral aerosol optical depths, inversion products, and precipitable water in geographically diverse aerosol regimes
  - Goal is to assess aerosol optical properties and validate satellite retrievals of aerosol optical properties



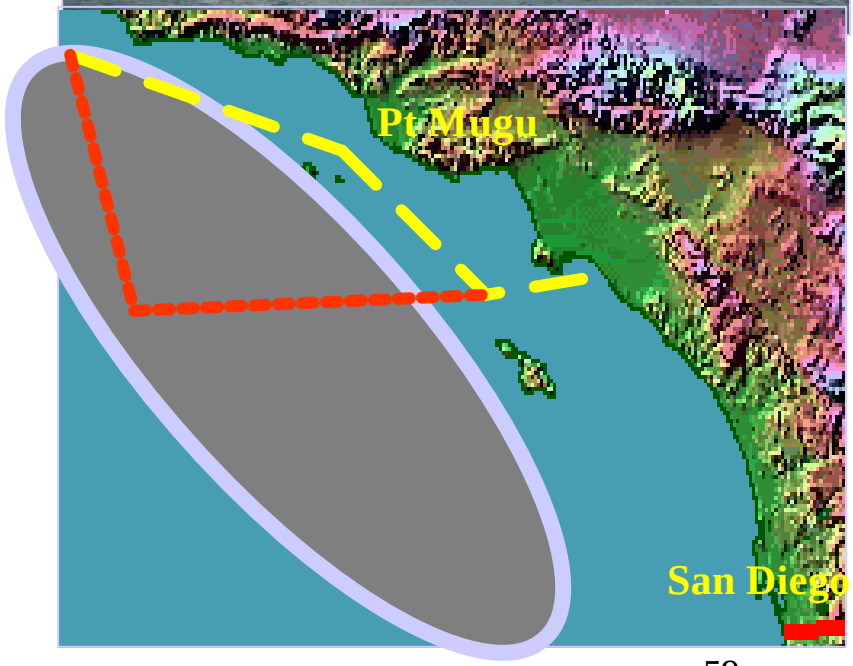
Navy Helps Explain Complex Transport from South Coast to East Kern County

TYPICAL SURFACE WIND FLOW PATTERNS AFTERNOON HOURS (1300 - 1700)



M-13 SIP ISSUE
(Pt Mugu Ship Channel)

- **Feb 1998 Navy proposal to establish working group to study speed reduction as alternative to moving channel.**
  - **CARB establishes working group (June 1998)**
  - **Participation by Navy, Shipping Industry, Ports, USEPA**
- **Dec 2000 Final Report**
  - **Relocated commercial channel <u>increases</u> estimated 2010 SIP NOx pollution by 1.3 tons per day (greater steaming distance of relocated channel)**
  - **Estimated 2010 SIP NOx reductions ranging from 3.9-10.7 tons per day from speed reduction in existing channel**
  - **All exceed M-13 target and are feasible for shipping industry**
- **Marine vessel emission reduction/Navy operations can co-exist**



Emerging Issues

Uncertainties in Reduction of Diesel Engine Emissions

- **Still Developing Emission Reduction Technologies**
  - **Engine development**
  - **Exhaust gas treatment (requires low-sulfur fuel)**
  - **Alternative fuels and tailored, compatible lube oils**

- **Availability of ultra low-sulfur (15ppm) fuel (being implemented on uncertain schedule).**

- **Military requirement to use fuel of variable quality (from different sources). Fuel sulfur variability of 0-10,000 ppm can be anticipated.**

CARBON DIOXIDE REDUCTION: VERY SIGNIFICANT CHALLENGE FOR THIS CENTURY

Options:

- **Reduction in carbon based fuel consumption**
  - **Increase fuel efficiency**
  - **Use alternate fuels**
- **Sequestration**

Future Plans

Proposed Course

- Commercially based technologies and innovations which accommodate Navy unique requirements
- Characteristics of these technologies should include:
  - Sulfur tolerant emission control technologies
  - Low load factor (low exhaust temperature) effectiveness
  - High turn down ratio solutions
  - Low maintenance and high reliability approaches to reduction
  - Innovative strategies for mitigating CO_2 burden
  - Solutions common to both gas and distillate fuels
  - Space and weight compatible
  - OEM partnering, DOE complement
  - Readily measurable
  - Retrofittable

Potential Thrust Areas

(edited excerpts from SERDP Report: "Research Needs Related to Improving Air Emissions From Diesels Engines, Gas Turbines and Ordance")

Research and Development Unique to DoD

- Develop and implement an emission technology research database
- Develop new sampling and analysis tools for ultrafine particles and associated organic compounds
- Develop remote imaging and characterization techniques for air emissions from DoD facilities and operations
- Characterize volatile organic emissions from diesel engines and gas turbines for DoD-specific fuels, duty cycles, and engine types
- Develop engine control algorithms to control undesirable combat-related emissions such as black smoke, etc.
- Develop improved materials for thermal management
- Investigate innovative low-emissions high-performance combustor concepts for new or upgrades of gas turbine and diesel engines for ships
- Demonstrate technologies to enable the development of advanced engine, modified, or combined cycles and cost-effectively improve the performance of engines with reduced emissions of NOx, PM, CO, VHC
- Characterize mobile source emissions at military installations with concentration of mobile sources

Keeping America's Navy #1 in the World

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