

# **BIODIESEL MARINE MARKETING OPPORTUNITIES: SUCCESSES AND CHALLENGES IN THE CHESAPEAKE BAY**

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## **ABSTRACT**

The recreational segment of the marine market appears to offer significant potential for biodiesel sales. An estimated 16,212,000 recreational vessels operate in and around the U.S., consuming almost 100 million gallons of diesel fuel annually. Boaters have an interest in burning biodiesel in their diesel powered vessels because it introduces many benefits to the boating experience. Not only does biodiesel increase biodegradability, improve safety, and decrease emissions, biodiesel also allows for more pleasurable boating without costly engine modifications. Many boaters have indicated that lack of smoke, safety, and the dramatic change in exhaust odor are significant reasons why boaters will consider switching to biodiesel or biodiesel blends.

Marketing efforts have focused on niche markets where environmental benefits or competitive advantage are the basis of buying decisions. Currently sales in the marine market have been concentrated with two buying segments; sailboaters and commercial boat operators. This report highlights aspects of a test market in the Chesapeake Bay which was conducted during the 1997 boating season. The report will also highlight biodiesel attributes and discuss issues faced including regulatory and infrastructure hurdles. Finally, the report will summarize a survey of boaters that used biodiesel and analyze boater responses.

**Keywords:** biodiesel, marine market, biodegradability, safety

## **INTRODUCTION**

The lack of smoke, safety, and dramatic change in exhaust odor are primary reasons for boaters switching to biodiesel or biodiesel blends. Boaters are operating their diesel powered vessels on biodiesel because it introduces many benefits to the boating experience. Not only does biodiesel increase biodegradability, improve safety, and decrease emissions, biodiesel also allows for more pleasurable boating without costly engine modifications.

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Industry marketing efforts have focused on niche markets where environmental benefits or competitive advantage are the basis of buying decisions. Current sales in the marine market are concentrated within two buying segments;

- Sailboat owners - because they are low volume users and the improved exhaust odor and lack of smoke from biodiesel powered vessels increases the quality of their sailing experience. This group represents a very highly motivated market.
- Commercial boat operators - who gain a competitive advantage because riding in their boat appeals to customers who are sensitive to diesel fumes. The higher cost of biodiesel can be offset by consumer preference and a resulting increase in business.

### **WHAT IS BIODIESEL?**

Biodiesel is a cleaner burning alternative fuel for diesel engines produced from renewable sources such as vegetable oils, animal fats, and recycled cooking oils. Chemically, it is defined as the mono alkyl esters of long chain fatty acids derived from renewable lipid sources. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol in the presence of a catalyst to yield glycerin and biodiesel (chemically called methyl esters). Biodiesel is legal for commerce in the United States. Biodiesel has been registered with the US Environmental Protection Agency as a fuel and as a fuel additive. Neat biodiesel has been designated as an alternative fuel by the Department of Energy. Biodiesel can be used in neat form, or blended with petroleum diesel for use in diesel engines. Its physical and chemical properties as it relates to operation of diesel engines are similar to petroleum based diesel fuel.

### **CHESAPEAKE BAY MARINE MARKET BACKGROUND**

The Chesapeake Bay is one of the primary recreational boating areas in the United States and represented a prime opportunity to initiate an outreach and awareness program for biodiesel. Biodiesel was introduced in two phases. In 1996 the Maryland Soybean Board, working with Coastal Properties Management (CPM), NOPEC, and CWW&L, held two fuel trials weekends. The fuel trials weekends, held during the last half of the boating season, were designed to introduce boaters to biodiesel through the media and a free fuel giveaway. The logic was that holding the giveaways prior to Labor Day weekend would be the perfect timing for boaters to entirely consume the amounts given away before contacting them for a follow-up survey. The Fuel Trials Weekends were held at two marinas; Piney Narrows and Mears Yacht Haven. Overall, forty-seven sailboats, sixteen powerboats, two trucks, two Mercedes, three tractors and one boatlift received samples of biodiesel during the fuel trials. Users were encouraged to utilize B20 (20% by vol. biodiesel blended with 80% by vol. petroleum based diesel fuel). Participants were asked to complete a registration form before receiving the free sample of biodiesel. This list of names was utilized to conduct a survey for feedback on customer satisfaction with the product.

### **BOATER ATTITUDES TOWARD BIODIESEL: SURVEY RESULTS**

A total of thirty-two participants were available for the follow-up survey. The following information is a portion of the results of the survey:

Question: When and where did you first hear about biodiesel?

Approximately half the participants had heard of biodiesel prior to arrival at the marina, either from a magazine article (31%); friend (6%); Sunrider's visit to the 1995 US Boat Shows (3%); BOAT/US article (3%) or newspaper articles. Fifty-three percent heard about biodiesel for the first time at the marina in 1996.

Question: How did your vessel perform using biodiesel (multiple answers allowed)?

Fifteen respondents said the engine ran the same, while four said they felt the engine ran better. Two respondents said the ride was "smoother" and two said the engine "ran cooler." Four noticed their boat stayed clean. Fourteen said their exhaust "smelled better". Seven said they "could not tell the difference" in engine performance, (although five of them utilized blends lower than B20). One person thought the exhaust smelled worse and one individual didn't answer the question.

Question: What do you see as the primary benefit of using biodiesel (multiple answers allowed)?

<u>Benefit</u>	<u>Number of Responses</u>
Improvement in Odor	18
Environmental Benefit	12
Reduced Foreign Oil Dependency	4
Boat Stayed Clean	2
Fuel System Cleaned	2
Added Lubricity	1
No Answer	1

Question: Would you buy B20 if it added only 30¢ per gallon to the price?

Forty-six percent said "yes", twelve percent said "no", thirty-one percent said "maybe", and three percent didn't answer.

### **BIODIESEL'S ATTRIBUTES SIGNIFICANT TO BOATERS**

Based on the survey results and similar conclusions drawn from an outreach program in the Florida Keys, specific traits of biodiesel are important to boaters. The following information provides a short summary of some of the most significant attributes of biodiesel.

### Emissions Reductions

The use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide, and particulate matter. Emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of the engine and testing methods used.

Particulate emissions from conventional diesel engines are generally divided into three components. Each component is present in varying degrees depending on fuel properties, engine design and operating parameters. The first component, and the one most closely related to the visible smoke often associated with diesel exhaust, is the carbonaceous material. This material is composed of sub-micron sized carbon particles which are formed during the diesel combustion process and is especially prevalent under conditions when the fuel-air ratio is overly rich. The second component is hydrocarbon material which is absorbed on the carbon particles, commonly referred to as the soluble organic fraction. A portion of this material results from incomplete combustion of the fuel, with the remainder derived from engine lube oil that passes by the piston oil rings. The third particulate component is comprised of sulfates and bound water. The amount of this material is directly related to the fuel sulfur content.

The use of biodiesel decreases the solid carbon fraction of particulate matter (since the oxygen in biodiesel enables more complete combustion to CO<sub>2</sub>), eliminates the sulfate fraction (as there is no sulfur in the fuel), while the soluble, or hydrocarbon, fraction stays the same or is increased. Therefore, biodiesel works well with new technologies such as catalysts (which reduces the soluble fraction of diesel particulate but not the solid carbon fraction), particulate traps, and exhaust gas recirculation.

### Health Effects

The impact on human health is a significant criteria when considering the suitability of a fuel for commercial applications. Health effects can be measured in terms of the fuel's toxicity to the human body or health impacts due to exhaust emissions. Evidence does exist which indicates that diesel particulate matter is a potential carcinogen. In 1988, the National Institute for Occupational Safety and Health (NIOSH) recommended that whole diesel exhaust be regarded as "a potential occupational carcinogen," as defined in the Cancer Policy of the Occupational Safety and Health Administration. The use of biodiesel decreases most regulated emissions. Research results indicate that particulate matter (specifically the carbon or insoluble fraction), hydrocarbons, and carbon monoxide are significantly reduced. In addition to reducing the overall levels of pollutants and carbon, the levels of compounds that are prevalent in biodiesel and diesel fuel exhaust are different. Research conducted by Southwest Research Institute on a Cummins N14 engine indicates that biodiesel exhaust has a less harmful impact on human health than petroleum diesel fuel. Biodiesel emissions have decreased levels of all target polycyclic aromatic hydrocarbons (PAH) and nitrated PAH compounds, as compared to petroleum diesel exhaust. PAH and nPAH compounds have been identified as potential cancer causing compounds. All of the PAH compounds were reduced by 75 to 85 percent, with the exception of benzo(a)anthracene, which was reduced by roughly 50 percent. The target

nPAH compounds were also reduced dramatically with biodiesel fuel, with 2-nitrofluorene and 1-nitropyrene reduced by 90 percent, and the rest of the nPAH compounds reduced to only trace levels. All of these reductions are due to the fact the biodiesel fuel contains no aromatic compounds.

In addition, the total speciated hydrocarbon mass of biodiesel is nearly 50 percent less than that measured for conventional diesel fuel, and the associated ozone potential is reduced by the same amount. Significant reductions in most aldehyde compounds were also observed with biodiesel, with formaldehyde and acetaldehyde 30 percent lower than the levels observed for conventional diesel fuel.

### Lubricity

In the United States the sulfur level of diesel fuel that is used for on-road purposes is limited to 0.05% by weight. This limit was mandated in October 1993 as a method to decrease particulate matter emitted from diesel powered vehicles. With the introduction of mandated Environmental Protection Agency (EPA) low-sulfur diesel fuel, fleet operators began to encounter premature wear and/or failure of injector pumps in increasing numbers. Pump manufacturers such as Stanadyne and Bosch began recommending a minimum lubricity fuel to alleviate the serious damage that the reduced sulfur content of low sulfur diesel was causing to their injection pumps. Many petroleum distributors are only marketing low-sulfur diesel even though it remains legal to sell high-sulfur diesel in off-road markets. Testing at labs such as Southwest Research Institute, Stanadyne Automotive, and Engineering Testing Services have demonstrated that biodiesel provides significant lubricity improvement over petroleum diesel fuel. Lubricity results of biodiesel and petroleum diesel using industry test methods indicate that there is a marked improvement in lubricity when biodiesel is added to conventional diesel fuel, even at blend levels below 1%.

### Biodegradability

Biodiesel has desirable degradation attributes which make it the fuel of choice by environmentally conscious boaters. Studies at the University of Idaho compared the biodegradation of biodiesel in fresh water to diesel fuel and dextrose (a test sugar). Biodiesel samples degraded more rapidly than dextrose, and were 95 percent degraded at the end of 28 days. The diesel fuel was approximately 40 percent degraded after 28 days. It should also be noted that blending biodiesel with diesel fuel accelerates its biodegradability. For example blends of 20% biodiesel and 80% diesel fuel degrade twice as fast as No. 2 diesel. Thus, biodiesel use has demonstrated biodegradability benefits at levels lower than 100%. Simply stated, neat biodiesel degrades as fast as dextrose (a test sugar) and a B20 blend will degrade twice as fast as petroleum based diesel fuel.

### Flash Point

The flash point of a fuel is defined as the temperature at which the fuel becomes a mixture that will ignite when exposed to a spark or flame. The flash point of biodiesel has been tested and reported by various sources. Specific testing at Southwest Research Institute concluded that the flash point of biodiesel blends increases as the percentage of biodiesel

increases. Therefore pure biodiesel and blends of biodiesel with petroleum diesel are safer to store, handle, and use than conventional diesel fuel. Pure biodiesel has a flash point over 300° Fahrenheit, well above the flash point of petroleum based diesel fuel which is typically around 170° Fahrenheit.

### Toxicity

Tests conducted by Wil Research Laboratories, Inc. investigated the acute oral toxicity of pure biodiesel fuel as well as B20 (20% by vol. biodiesel mixed with 80% by vol. petroleum diesel fuel) in a single-dose study on rats. The median lethal dose (LD<sub>50</sub>) of pure biodiesel, as well as B20, was found to be greater than 5000 mg/kg. The acute dermal toxicity of neat biodiesel was evaluated in a single dose study involving rabbits. The LD<sub>50</sub> of biodiesel was found to be greater than 2000 mg/kg and the 2000 mg/kg dose level was found to be a No Observable Effect Level (NOEL) for systemic toxicity. There were no deaths, remarkable body weight changes or gross necropsy findings for the LD<sub>50</sub> dose levels for each of the studies.

Acute aquatic toxicity tests with Daphnia Magna have also been conducted. Table salt (NaCl), petroleum diesel, and biodiesel were compared to each other. The LC<sub>50</sub> count (the concentration where 50% percent of the Daphnia Magna have died and 50% were still alive) for table salt was 3.7 parts per million (ppm), 1.43 ppm for diesel fuel, and for biodiesel it ranged from 23 ppm to 332 ppm. Therefore, biodiesel is less toxic than petroleum diesel fuel.

## **CONSIDERATIONS FOR THE USE OF BIODIESEL**

Boaters also expressed the need to fully understand any special considerations for the use of biodiesel. The following information discusses some of the properties of biodiesel which are different from petroleum based diesel fuel or relevant to operation.

### Infrastructure

In general, the standard storage and handling procedures used for petroleum diesel can be used for biodiesel. The fuel should be stored in a clean, dry, dark environment. Temperature extremes should be avoided. Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene and teflon. Copper, brass, lead, tin, and zinc should be avoided. Biodiesel has a solvent effect which may release deposits accumulated on tank walls and pipes from previous fuel storage. The release of deposits may clog filters initially and precautions should be taken.

### Materials Compatibility

Biodiesel over time will soften and degrade certain types of elastomers (rubber replacements) and natural rubber compounds. Precautions are needed when using high percent blends to ensure that the existing fueling system components (primarily fuel hoses

and fuel pump seals), do not contain elastomer compounds incompatible with biodiesel. Manufacturers recommend that natural or butyl rubbers not be allowed to come in contact with pure biodiesel. Biodiesel will lead to degradation of these materials. If a vessel's fuel system does contain these materials and user's wish to fuel their vessel with pure biodiesel, replacement with compatible elastomers such as Viton® B is recommended. The recent switch to low sulfur diesel fuel has caused many original equipment manufacturers (OEMs) to switch to components suitable for use with biodiesel, but users should contact their OEM for specific information. Rubber is not the only material affected by biodiesel's solvent properties. If left on a painted surface too long, biodiesel can dissolve certain types of paints. Therefore, it is recommended to wipe any biodiesel or biodiesel blend spills from painted surfaces and wash with warm soapy water so that the boat's paint or teak are not affected. Contact the National Biodiesel Board to check about specific materials compatibility issues.

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### Spontaneous Combustion Risk

Biodiesel soaked rags should not be stored together due to the risk that the rags will oxidize, give off heat, and potentially create an environment favorable to spontaneous combustion.

### Cold Flow Properties

As with diesel fuel, cold flow properties are important. Users of a 20% blend of biodiesel will experience an increase of the cold flow properties (cold filter plugging point, cloud point, pour point) of approximately 1 to 3° Celsius. Thus far, no precautions beyond those already employed for petroleum diesel have been needed for fueling with 20% blends. However neat (100%) biodiesel will result in faster gelling than petrodiesel in cold weather operations. Solutions for winter operability are much the same as that with low-sulfur No. 2 diesel (i.e., blending with No. 1 diesel, utilization of fuel heaters and storage of the vehicle in or near a building). Biodiesel appears to be largely unaffected by conventional pour point depressants.

### Operating Performance

One of the major advantages of biodiesel is the fact that it can be used in existing engines and fuel injection equipment without negative impacts to operating performance. Biodiesel has a higher cetane number than conventional diesel fuel and its use in previous in-field demonstrations showed similar fuel consumption, horsepower, torque, and haulage rates as conventional diesel fuel. Boaters in the Chesapeake Bay report increases of power and performance when their boats are fueled with biodiesel blends.

### Engine Warranties

Manufacturer's warranties generally cover defects in material and workmanship of the engine and its components. Those warranties do not cover engine problems related to any type of fuel issues, including petroleum based diesel fuel. Manufacturers usually list the types of fuels that are recommended or approved for use in their engines. For biodiesel, the fuel is defined by the biodiesel specification. Care must be taken to ensure that only

fuel meeting these specifications is used and that the proper precautions are observed (materials compatibility, cold flow, etc.) to ensure trouble free use of biodiesel.

### **1997 CHESAPEAKE BAY MARKETING AND OUTREACH PROGRAM -- SUCSESSES**

In 1997, the outreach program was continued with the same partners in addition to the National Biodiesel Board. Neat biodiesel was sold at all nine marinas owned or operated by Coastal Properties Management (CPM) throughout the Chesapeake Bay region. Media coverage and advertising from the activities in 1996 had been successful at raising the awareness of boaters. This prior work was leveraged into a successful marketing program.

#### Sales

During the 1997 boating season biodiesel was available for sale at CPM marinas in two forms; bulk and five-gallon containers. At marinas without pumps but with stores, the biodiesel sold in containers was displayed and sold like any other product in the store. At marinas with normal fuel dispensers, pump attendants were encouraged to introduce biodiesel to each diesel customer. If they expressed interest, the education and sales process continued. In marinas without stores or pumps, the literature was in the office/reception area and the fuel was brought around and placed in customer's cars.

Logistical delays in distribution resulted in container and bulk sales beginning between April 20th and May 1st at all facilities instead of the first week of April. Strong sales kicked in quickly in May, and clear trends and consumer preferences began to emerge as the season progressed. The top three selling marinas began to run out of their initial fuel shipment in late August to early September.

June and July successively showed the largest sales growth. Sailboaters may fill up or top off only once or twice a season if they are light users - June and July are the months when they would do so. For powerboaters or heavy use sailors, the weather is the nicest in these months, so fuel use should be high. The month of August drops off dramatically. This is the heaviest vacation month. Boaters will take off from their home port for a one to four week trip. Unless a marina receives a high volume of transients because of a strategic location, their fuel sales will drop dramatically. Far and away, bulk pump sales were the preferred method of purchase.

Less than 2,000 gallons of biodiesel were marketed during the 1997 boating season by CPM marinas. It is estimated that up to 3,000 gallons of sales could be anticipated for the 1998 boating season and up to 24,000 gallons of sales in the Chesapeake Bay region if 20% of the 400 marinas on the Bay decided to market biodiesel. Although the total volume of biodiesel sold into this market will be limited, marina operations such as CPM are committed to handling the product during the upcoming boating seasons due to consumer interest and the environmental aspects of the product.

## **1997 CHESAPEAKE BAY MARKETING AND OUTREACH PROGRAM -- CHALLENGES**

Although the marketing and outreach program conducted in 1997 was considered a success, several issues surfaced which must be addressed in order to sustain sales in the Chesapeake Bay.

### Regulatory Constraints

The primary roadblock was that Maryland law only allows licensed fuel distributors to blend fuel. No marina could consider substituting their conventional diesel with a blended biodiesel product in their existing tanks. Most every marina has only one diesel tank and would not eliminate the choice of conventional diesel. Exclusive contracts with fuel suppliers prohibit stocking competing products, pointing out again that the distributors must be a part of the ultimate solution. This law led to distribution issues for the program.

Also, biodiesel can not currently relieve boaters from their liability of cleaning up spills. Although biodiesel is nontoxic and biodegradable, it is currently treated by the Coast Guard and EPA like a petroleum based product. An industry coalition is working to remedy this situation. The Edible Oil Regulatory Reform Act, signed into law on November 20, 1995, requires federal agencies to differentiate between fats and vegetable oils and other oils, including petroleum, in issuing or enforcing any regulation or establishing any interpretation or guidelines relating to the transportation, discharge, release emission, or disposal of oil under federal law. The law was intended to avoid the application of costly and inappropriate regulatory requirements intended for petroleum and other oils on nontoxic animal fats and vegetable oils. To date no agency has fully implemented the Edible Oil Regulatory Reform Act.

### Distribution and Packaging

An efficient distribution system is very important to the success of biodiesel. Consumer demand is pointless if it cannot be properly satisfied. The logistics of shipping, pumping, packaging, and blending biodiesel provided to be the greatest challenge of the Chesapeake Bay outreach program. Long-term solutions to these issues are critical to expanding distribution sites on the Chesapeake Bay in the future. Although there is a definite market for biodiesel marketed in containers, consumer feedback indicated problems with the five gallon containers which were marketed in 1997.

## **CONCLUSIONS**

Biodiesel marketers are concentrating efforts to expand the number of retail outlets that offer biodiesel and decrease the consumer price through an effective distribution system or other means such as limiting the liability of fueling with biodiesel compared to petroleum diesel. Biodiesel is currently available in major boating areas such as the Florida Keys, the Chesapeake Bay, the Chicago Harbors, and the West Coast; however the number of sites in each of these geographic areas is currently limited. As demand for biodiesel increases,

it will become more readily available and marinas and harbors will be able to offer bulk facilities and pre-blended product to customers.

Biodiesel can be packaged in small volume containers or sold in bulk form. Sailboat operators that consume low volumes of fuel during the boating season primarily purchase biodiesel packaged in 2.5 gallon containers and blend the product themselves. Survey results from the West Coast suggest that sailboat operators prefer to purchase biodiesel 'over the counter' rather than wait in a fueling line with large capacity power boaters. Commercial charter boaters, on the other hand, have expressed interest in biodiesel blends sold at bulk facilities.