Saving Fuel on Your Recreational or Charter Boat

Fuel prices are going up, and there is no end in sight. By early 2011 the pump price at ports on Alaska’s road system was over $4 per gallon and analysts who study world energy markets predict $6 in the foreseeable future, a figure that people in remote Alaska communities already are paying.

What’s a boater to do? Some leave their boats tied to the dock or sitting on the trailer, but an expensive boat going unused represents wasted money and lost opportunity. Alaska’s boating season is too short to lose even a single day because of the cost of fuel. A better approach is to understand how boats consume fuel and what to do to improve fuel efficiency while still getting full use of the vessel.

This publication:

- Outlines how motorboats use fuel energy and how to calculate fuel consumption and range.
- Describes factors that determine how much fuel motorboats use, and how to minimize inefficiencies.
- Explains how to select, set up, and operate a boat engine for best fuel economy.
- Offers tips on operating a boat for peak efficiency.

The focus is on planing hull boats (which “get up on step” or plane), but the publication also discusses displacement hull motorboats (which plow through the water rather than plane) and sailboats under auxiliary power.

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Calculating Boat Motor Fuel Consumption

Different kinds of engines produce different levels of efficiency (specific fuel consumption, expressed as horsepower generated per unit of fuel consumed, or fuel used for horsepower output). The four most common marine engine types, at their rated output, produce approximately the following horsepower per gallon of fuel consumed per hour:

- Gasoline carbureted two-strokes (most older outboards) = 8-10 hp per gallon per hour.
- Gasoline direct-injection two-strokes (some modern outboards) = 10-12 hp per gallon per hour.
- Gasoline four-strokes (most modern outboards, inboards, I/Os, jets) = 10-12 hp per gallon per hour.
- Four-stroke diesels (modern inboards, I/Os, jets) = 18-19 hp per gallon per hour.

This means that you can estimate full-power fuel consumption by dividing rated horsepower by 10 (gas engine) or by 18 (diesel). At cruising speeds (60-80% of rated power) efficiency improves. For example, a popular four-stroke gas outboard, run at 72% output, uses only 55% of its wide open throttle (WOT) consumption. However, at very low output (slow engine speeds) both gas and diesel engines become slightly less efficient for the power produced, and carbureted two-stroke gasoline engines are much less efficient at low engine speeds because much of the fuel is pumped unburned out the exhaust.

Calculating Boat Fuel Consumption and Range

Engine fuel consumption and boat fuel consumption are not the same thing. A boat’s fuel consumption, expressed in miles per gallon (mpg) or nautical miles per gallon (nmpg), is a function of the engine’s fuel use, the type of hull (displacement or planing), the shape of the hull, vessel speed, sea conditions, and other factors.

Because distances on marine charts are expressed in nautical miles (approx. 1.15 statute miles), we use nautical miles in this publication. For lake or river boating the statute mile is appropriate.

DISPLACEMENT HULL BOATS: TRAWLER YACHTS, SAILBOATS UNDER POWER

A useful concept to remember is speed to length ratio (S/L), which is the speed in knots (nautical miles per hour) divided by the square root of the boat’s waterline length in feet. A 36 foot (waterline length) boat traveling through the water at 6 knots is said to have an S/L of 1:1. “Hull speed” typically is S/L = 1.34:1. For example, a 36 foot displacement boat has a hull speed...
of 8 knots (square root of 36 = 6 x 1.34 = 8.04). Hull speed is the speed at which a boat starts pushing a big bow wave and dragging a huge stern wave, and becomes significantly less efficient in terms of energy consumption because much of the power goes into wave-making.

At S/L = 1:1 a displacement boat typically needs one horsepower per displacement ton (total boat weight), and at 1.34:1 it needs about 4.5 hp per ton. At S/L greater than 1.34 hp demand increases exponentially, and with it, fuel consumption. Hull speed is the upper limit of efficient speed in a conventional displacement hull boat, and many round-bottom, deep-draft vessels are essentially incapable of exceeding hull speed.

Taking it a step further, if a 36 foot boat weighs 12 tons (24,000 lbs), it will require 54 hp to propel it at 8 knots, under favorable sea conditions. Add another 15% (8 hp) “sea margin” to take into account energy lost to wave conditions and it still needs only 62 hp to achieve hull speed. Since diesel engines are most efficient (and experience greatest longevity) at about 80% of rated output, the ideal engine would be 25% more powerful, or about 78 hp.

A boat of the same length and displacement running at S/L = 1:1 (6 knots) could get by with an 18 hp engine (12 tons x 1 S/L = 12 hp x 1.15 = 13.8 x 1.25 = 17.25). Factors 1.15 and 1.25 represent 15% and 25% increase in horsepower.

Based on an input of 62 hp at a hull speed of 8 knots, the 36 foot motorboat would consume approximately 3.44 gallons of diesel fuel per hour (62 hp ÷ 18 hp = 3.44 gph). Divide the speed by this and you have nautical miles per gallon (8 knots ÷ 3.44 gph = 2.33 nmpg). The same boat at 6 knots would use less than one gallon per hour, getting more than 7 nautical miles per gallon. (These figures assume a properly sized engine running at nearly peak efficiency. Since most displacement vessels are somewhat overpowered, their engines are not optimally efficient and fuel mileage tends to be a little less.)

Multiply nmpg x fuel tank capacity x 0.9 to get range, which is the one-way distance you can travel on a tank of fuel.

These estimates assume that the approximate displacement (loaded weight) of the vessel is known. The same applies to planing boats, where weight is even more important.

**PLANING HULL BOATS**

A planing hull boat is not constrained by wave-making drag and can go increasingly faster as more power is applied. A general rule of thumb is that it takes about 2.5 hp per 100 lbs total weight to get a planing hull boat on step. For example, a 14 foot aluminum skiff with outboard, a tank of gas, two people, and camping gear might displace 1,000 lbs and would require a 25 hp engine.

On this basis you can calculate power, fuel consumption, fuel efficiency, and range as follows: divide total vessel weight by 100, and multiply that by 2.5 = minimum required horsepower. Greatest horsepower demand comes when getting on step, after which it makes sense to throttle back.

Actual horsepower while cruising is a function of speed and can be approximated by multiplying engine-rated horsepower by percent of rated engine speed. For example, if an engine is rated at 100 hp at 6,000 rpm and is run at 4,000 rpm, it is actually producing roughly 66 hp.
Divide horsepower used by 10 to get gallons per hour (gph) (or 18 if engine is diesel).

Divide boat speed nautical miles per hour (nmph) by gph = nmpg. Multiply miles per gallon (mpg) or nmpg x tank capacity x 0.9 = range.

Remember, range is a one-way distance.

To estimate a safe operating radius, divide range by 3. “A third to get there, a third to get back, and a third as a safety margin.” That safety margin will come in handy if you decide to divert for some sightseeing or assist a fellow boater in trouble, or if weather and sea conditions are less favorable on the return.

These rule-of-thumb calculations provide a rough estimate of fuel demands, but many more factors influence the fuel efficiency of a planing boat than of a displacement boat. Not only engine type and size, but also hull shape, trim, weight, underwater drag, and sea conditions all factor in.

Selecting, Setting Up, and Operating a Boat for Best Fuel Efficiency

People select the boats they do for many reasons, including aesthetics (looks), comfort, “fishability,” and of course, price. Fuel efficiency rarely is the primary factor, but keeping in mind a few principles may help ensure that a boat is as efficient as possible while meeting other criteria.

The shape of the hull determines how the boat will perform, how safe and comfortable it is, and how much fuel will be required to push it. Displacement-hull boats are almost always more efficient than planing boats, but the efficiency comes at the cost of low speed.

The most efficient planing hull is the flat-bottom; this type of boat works well on rivers and small lakes where waves are small, and especially where shallow draft is important. However, flat-bottom boats pound severely and are uncomfortable, even dangerous, in any but mild sea conditions.

The deep-vee hull provides a much more comfortable ride in rougher water, but needs more power (and fuel) to do so.

The shallow- or modified-vee is a popular compromise, offering a somewhat better ride than a flat-bottom and producing better fuel economy than a deep-vee.

Catamarans can produce both a softer ride and better fuel economy than mono-hulls but tend to be more expensive for the same capacity and are more sensitive to variations in weight. Most catamarans require twin engines.

For any given hull several other factors influence efficiency. As outlined above,
one is the type, size, and number of engines. Generally, a single engine of the correct horsepower is more efficient than twins (although twins don’t use twice as much fuel as a single, as some people claim). Correct size (horsepower rating) is a factor; since engines are most efficient at 60-80% of top speed and output, an underpowered planing boat is less efficient than one with the right horsepower engine because it has to run harder to do the necessary work. On the other hand, a bigger engine usually is heavier, which affects overall boat weight as well as trim, so peak efficiency requires selection of the optimum size of engine for the job.

Engine shaft length (outboard motors) has to be correct; the cavitation plate above the propeller should be just slightly below the bottom of the hull immediately in front of it. If the prop is too high it will suck air (aeration) and if too low it imparts extra drag, both of which reduce fuel efficiency. Larger motors have spaced mounting holes in the transom bracket so that the engine can be mounted lower or higher as required. Some boats come equipped, or can be retrofitted, with manual or hydraulic jack plates, which allow precise engine height adjustment; hydraulic units raise and lower the engine even while underway.

The propeller is important. Props are sized by diameter, blade pitch, the number of blades, and the shape of the blades. If the engine cannot achieve rated rpm it is said to be “over-propped” and often the simplest solution is to decrease the propeller pitch. If it over-revs it is “under-propped,” and pitch, diameter, or blade area should be increased. Stainless props, having thinner blades, are more efficient than aluminum. Props must be kept in good condition, since bent, dinged, or eroded blades rob energy and can cause engine damage.

Boat speed is another factor. A planing hull is reasonably efficient at very low speed, then becomes extremely inefficient as speed increases until it gets up on step where efficiency improves. Efficiency continues to improve gradually as more of the hull lifts from the water, reducing hull drag, until it reaches an optimum speed that commonly is where the engine is turning around 70% of its rated rpms. Above that point, additional speed comes at increasingly greater cost in fuel consumption. Every boat has its “sweet spot” where the efficiency is greatest (least fuel consumption per mile traveled) and the engine is relatively smooth and quiet, and that is never at wide open throttle.

Overall vessel weight is critical in planing vessels. Since it takes 2.5 extra horsepower to plane each additional 100 lbs, an extra gallon per hour of gasoline is burned for each additional 400 lbs in passengers, fuel, and gear.

Vessel trim controls how much hull surface area is in contact with the water and how much water it pushes out of the way, both of which impart drag. Most planing hulls are designed to run just slightly (approx. 2-5 degrees) bow-up. A boat trimmed at too much bow-up is plowing too much at the stern, and a bow-down boat is both plowing and hard to steer. Correct trim is achieved with the engine’s power trim setting and with trim tabs, where fitted.

Sea condition has a big effect on planing boat fuel efficiency. When waves build and a planing-hull boat starts pounding or plunging, fuel efficiency decreases, and if conditions force a boat to slow to the point where it comes off step, efficiency plummets. Remember that wave height and steepness are influenced by wind velocity, fetch (the distance waves travel unimpeded by land), and tide or current. Waves will be bigger in open areas lacking shelter, and when the wind is against the current, so boaters should use weather conditions that are calm to decrease fuel consumption.
forecasts, the chart, and the tide book for planning routes and voyage timing that minimize exposure to unfavorable sea conditions.

**Other Tips for Reducing Fuel Consumption**

- Keep propulsion unit tuned. Keep valves adjusted, fuel and air filters changed (where fitted), prop correct and well-maintained, engine height correct, and steering adjusted to minimize play.

- Keep the boat’s bottom clean. Algae, barnacles, and other marine growth create drag that rob fuel energy. Even rough and flaking bottom paint imposes a fuel penalty.

- Minimize weight by leaving behind anything you don’t need. Reduce wind resistance if possible. Don’t carry around more fuel (while remembering the one-third rule) and water than you need for the trip.

- Experiment with the motor’s trim system, and with trim tabs if you have them, to get the optimal running attitude.

- Get a fuel flow meter and use it to adjust speed and trim for the most miles per gallon. A fuel flow meter will also tell you how much fuel you have remaining, to avoid running out, and it will indicate if anything is wrong with the engine or drive system if speed decreases when throttle setting remains the same. If you have installed a GPS with NMEA 2000 (National Marine Electronics Association) features you can incorporate fuel flow and engine monitoring sensors to produce more accurate fuel usage data calculations than most stand-alone fuel flow meters.

This pleasure boat is in need of a bottom scrubbing and a coat of antifoulant paint. The growth on the bottom diminishes fuel efficiency.

Trim tabs (lower left) keep the boat in the best attitude of attack for efficient operation.
Use an autopilot and navigation electronics to travel the shortest distances and to go as straight as possible. Meandering and zigzag courses waste fuel.

Get on step quickly and then throttle back to your boat’s most efficient cruising speed.

Fish closer to home, or stay out overnight so you use less fuel running back and forth to fish.

Share the trip with friends, who also share the cost.

Keep detailed records. Maintain a logbook in which you record engine speeds, boat speeds, weather and sea conditions, and fuel consumption. Good records help you recognize trends as they occur, such as diminished performance due to inadequate maintenance, and to identify which changes you make that increase efficiency. Periodically do the math to determine what you could save by replacing equipment such as your engine or by changing operating habits.

Consider trailering expenses too, if yours is a trailerable boat. Maintain correct tire pressure, put a tight-fitting cover on the boat when going long distances, drain water from live well and bilges, and drive less aggressively and at slower highway speeds than normal.

Keep It in Perspective
Don’t obsess about fuel costs. Even a small sportfishing boat with minimal overnight accommodations can easily cost $50-100 per hour at cruising speed for gasoline alone, and another $10-20 per hour in depreciation/replacement costs, maintenance, financing, insurance, moorage/storage, and other expenses. But most of those are fixed costs that continue whether you run the boat or not, so the hourly cost decreases the more you use it. Thinking about all that money can take the fun out of boating, so budget during the winter for your summer time on the water and then make the most of it. If cost is a big consideration, plan to fish closer to town, or anchor up and enjoy the weekend on the hook in a wild and beautiful place.

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For information on undergraduate and graduate opportunities in marine biology, fisheries, oceanography, and other marine-related fields at the University of Alaska Fairbanks School of Fisheries and Ocean Sciences, visit http://www.sfos.uaf.edu/.


For more resources on Alaska boating fuel efficiency, see http://seagrant.uaf.edu/map/recreation/fuel-efficiency/.