The Efficient Powerboat - Part 2

What Efficiency Means, How It Can Save Money and How it Makes for Better Boats

By Dave Gerr, © Dave Gerr, 2011

In the previous article we looked at the fuel consumption and range of early offshore powerboats, and began our examination of powerboat efficiency, by using transport efficiency and miles per gallon to compare boats. We saw how longer more slender hulls could be moved farther faster for the same amount of fuel. Comparing different hull forms normalized for displacement, we also saw that driving boats at lower speed/length ratios also improved efficiency. We'll conclude our discussion of powerboat efficiency here by looking at the effect of improving propulsion machinery and also at the effect that overall size has on efficiency. We'll also consider how efficient slender hull forms affect seakeeping, comfort, and accommodations.

The Effects of Larger Diameter Propellers

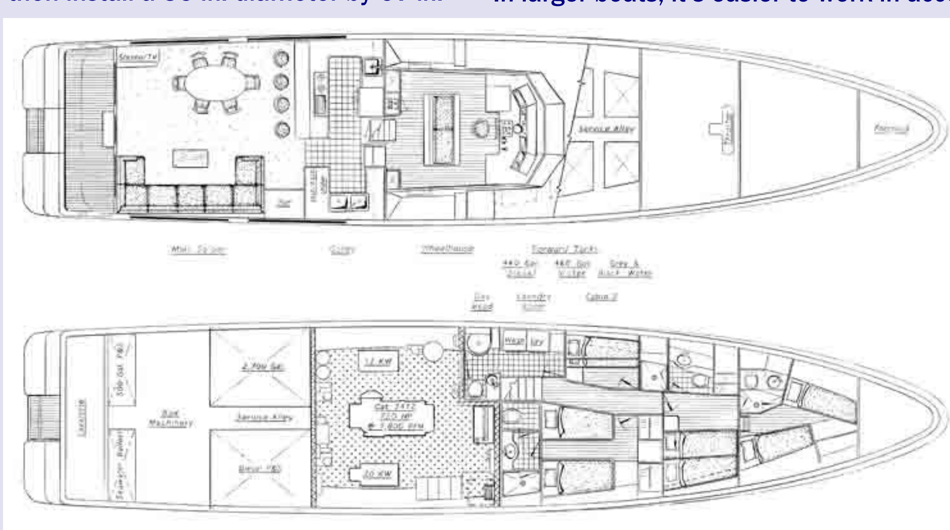
Taking our 67-foot *Ironheart*, we can get an idea what additional performance can be garnered from increasing propeller diameter, which means reducing shaft rpm. If we assume a standard 3:1 gear on *Ironheart*'s 419-hp engine, we'd find a 4-blade propeller of 40-in. diameter by 36-in. pitch, for an approximate propeller efficiency of 65%, If we could install a larger 5:1 reduction gear (and a much larger propeller) we could then install a 56-in. diameter by 67-in. pitch 3 blade, with an approximate efficiency of 73%. The reduction in horsepower from the increase in efficiency can be found from:

Resulting HP = original HP x standard efficiency ÷ new efficiency

In this case, 0.65 ÷ 0.73 = 0.89 or 89%

Accordingly, where we needed 113 hp for 13.3 knots, we would only need 101 hp; and for 16.9 knots we would require 373 hp rather than 419. Obviously, this would increase transport efficiency and thus fuel economy.

Note that this larger-propeller-diameter gain applies for boats in the semi-planing speed range and below. At high-planing speed, smaller diameter and higher pitch (given sufficient blade area to absorb thrust) are more efficient.



Summer Moon II—82-ft. Voyaging Motorcruiser

Better Seaboats

As good as long slender hulls are at being efficient they offer still another advantage—they are better seaboats. Long slender hulls can be driven faster in more elevated sea states than wider shorter craft. Slamming and pounding are much reduced, which in turn makes for greater comfort, better crew performance, and lower loads on the hull, machinery, and gear. This critical consideration is often overlooked in evaluating the advantage of slender hulls. It shouldn't be.

Cabin Layouts in Slender Hulls

One of the drawbacks to slender hulls is working in comfortable accommodations. You can see the arrangement of the very slender *Ironheart* is greatly controlled by the limited beam. Though there are substantial gains to be had in efficiency going this thin—as you can see from the performance tables in the previous article—you can still gain considerable advantages from even moderately slender hulls. *Imagine* and *Peregrine* are two examples. They have quite comfortable and generally what we think of as "normal" arrangement plans.

In larger boats, it's easier to work in accommodations in quite sender hulls. The drawings of *Summer Moon II*, show just how comfortable the arrangement can be in an 82-footer, with a length-to-beam ratio of 4.5:1.

Larger Boats are More Efficient

In order to keep the boat comparison tables from growing too large and complex, I did not include a normalized *Summer Moon II*. This, however gives us an opportunity to look at another aspect of transport efficiency: Simply being larger makes for greater transport efficiency.

Summer Moon II is 82 ft. – 3 in. LOA, 72 ft. – 11 in. DWL, 17 ft. – 0 in. beam, 16 ft. – 3 in. BWL, and 137,400 lb. displacement. This gives a DL ratio of 158 and a length-to-beam ratio of 4.5 on the waterline. Maximum hull speed is 14.6 knots (SL 1.71), driven by a single 720-hp diesel. At 12-

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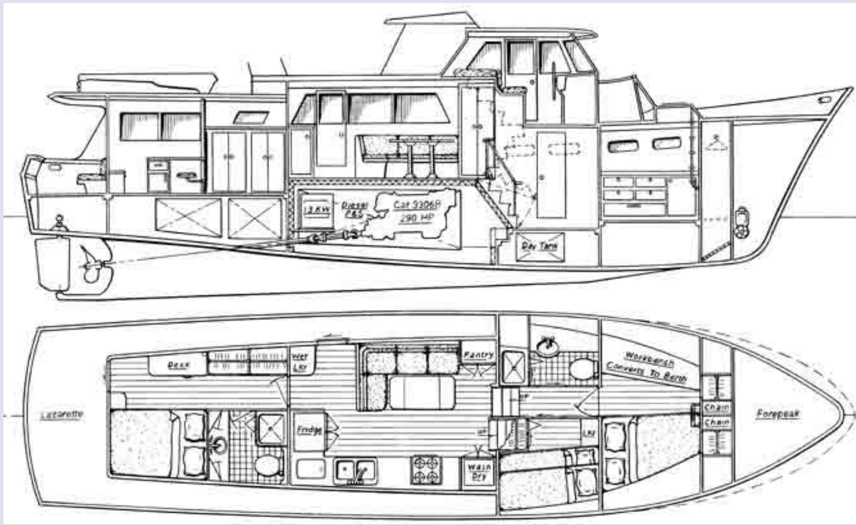
knot cruise transport efficiency is 15.5—higher than any of the other normalized boats at any speed. Even if modified to run semi-planing at 16.9 knots, transport efficiency would still be 6.5—again higher than any of the other normalized boats (see table from the previous article).

This is the reason that larger and larger cargo ships and tankers are economically attractive. The bigger the vessel the higher the transport efficiency. If we scaled *Summer Moon II* up to 900 feet LOA supertanker size, she would displace 80,500 tons on an 800-foot waterline. Because the waterline is so long, we would only need to drive this supertanker *Summer Moon II* at an SL ratio of 1 because—with such a long waterline—this still gives 28 knots. (Slower is more efficient, and 28 knots is faster than normal for cargo transport.) Power would be around 55,000 hp. The resulting transport efficiency: 289! Yes, simply by scaling *Summer Moon II* up to super giant size. (Naturally, *Summer Moon II* isn't the right proportions for a supertanker, but it's the principle that counts here.) Of course, compare any vessels of the same size (displacement) and we're right back to the three underlying efficiency drivers: going slower, longer more sender hulls, efficient propulsion package.

Summer Moon II is both a relatively large boat and is long slender, and light, and is fitted with a deep reduction gear for a large-diameter, slow-turning prop. With 5,840 gallons of diesel, she has a range at 14 knots of 2,000 miles. At 9 knots, *Summer Moon II* is non-stop transpacific capable, with a range of 5,500 nautical miles, plus a 10% reserve.

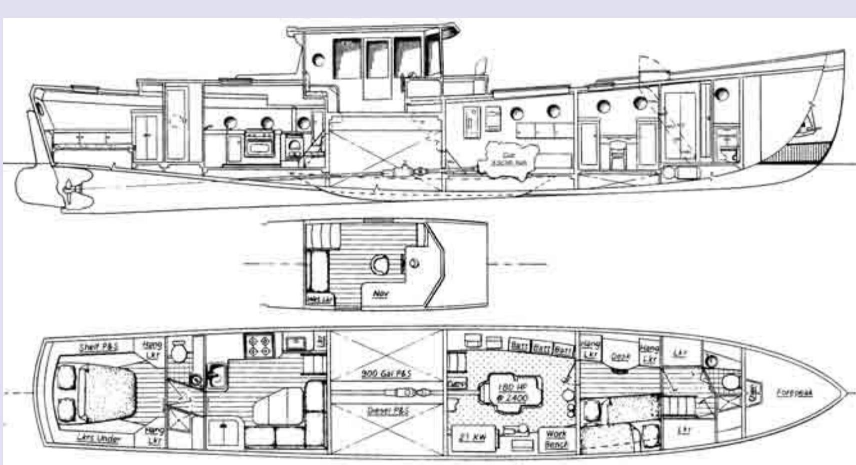


Imagine—57-ft. Voyaging Motorcruiser

The Motorsailing Option

It wouldn't do to talk about efficiency and fuel economy without considering the motorsailing option. *Ironheart*'s two masts (see drawing, previous article) are intended for dinghy launching, steadying sails, flopper stoppers and paravanes, and for real motorsailing. The short rig that can be set will allow *Ironheart* to sail moderately well from a close reach on down. With some sail up, the engine can be throttled well back to achieve the same speed as without the wind-power boost. Fuel savings and increased range can be immense.

Another advantage to being able to motorsail is that—should the engine shut down completely offshore—you can still make progress and maneuver under sail alone. You'll be able to take care of yourself rather than having to call for help.



Ironheart—66-ft. Voyaging Motorcruiser

The Problem with Dockage and Storage Fees

One of the unfortunate problems with long slender hulls is that almost the entire boating industry charges for boats based on length not on their real size, which is their displacement. If only dockage and storage was calculated based on displacement in tons not length in feet. Using tons, all of our normalized example boats from 45 to 67 feet LOA, would pay the same storage fees. Instead—as things are—the much more economical longer slender boats are penalized by paying higher storage due to their greater length. This is a real shame and something that the boating industry ought to address to encourage more efficient boats.

Tons may be too abstract a number to be practical. After all, how is a yard to check on the tonnage figure you supply them with? I've long proposed that dockage and storage be based on simply 3.5 times beam. For our three example boats (normalized) this would give billable dockage lengths as:

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BOAT NAME	LOA, ft.	Beam, ft.	3.5-Beam Dockage Length
Iron Kyle (n)	43.42	13.00	45.5
Imagine (n)	51.17	13.17	46.1
Peregrine (n)	51.72	14.88	52.1
Ironheart	67.00	11.00	38.5

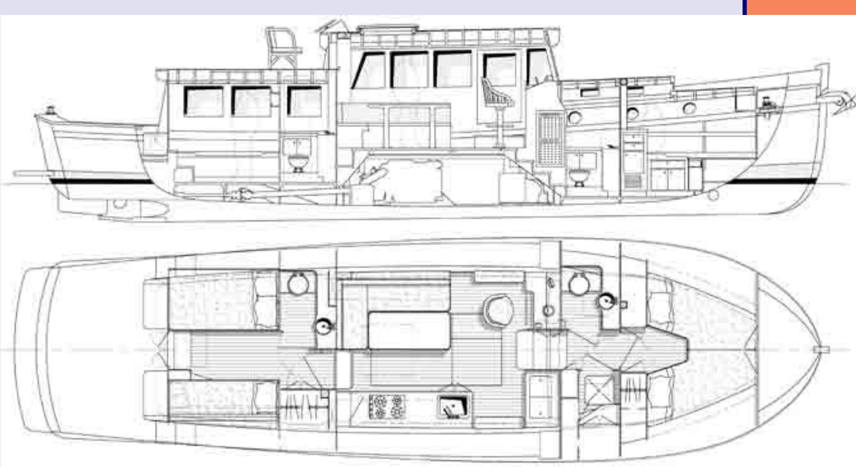
I can't think of any single change in the boating industry that would effectively result in more efficient hulls than this one. If enough people realize that increasing fuel economy is critical to the future of boating, perhaps it will happen. In fact, it could happen if the larger industry associations (NMMA, ABYC, ABBRA, NAMS, Boat/US, SAMS, etc.) all agreed together it was in the best interest of the future of boating and collectively worked for this change.

Narrow Boats Do Not Mean Tender Boats

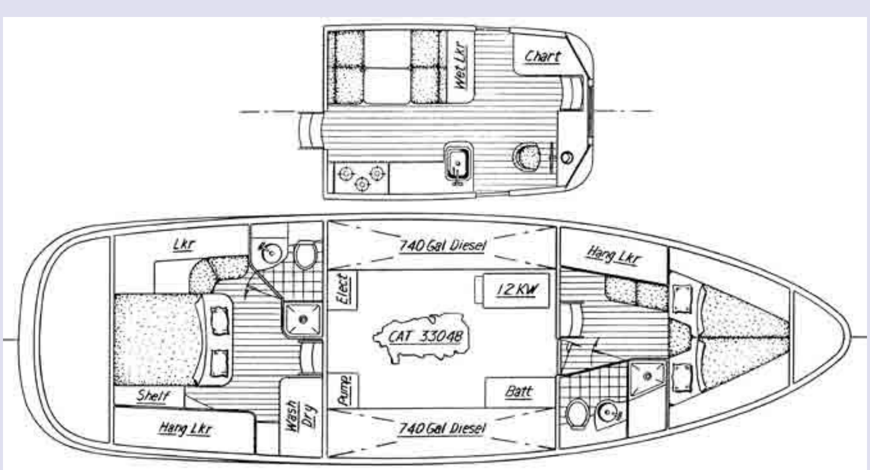
One of the common misconceptions about slender hulls is that they are necessarily tender and deep rollers. In fact, this was a difficulty experienced aboard the early, slender offshore powerboats of the 1907-era Bermuda race we discussed last article. It absolutely does not have to be that way and shouldn't be if the designer knows his or her business.

The belief that narrow boats are rollers is so pervasive that the builder of one of the boats we've used for an example here simply couldn't imagine that that vessel would be workable. He was astonished when the boat not only floated exactly on its lines but was moderately stiff as well.

The key is that the stability characteristics have to be worked out from the early stages in design so that roll time in seconds is equal to between 1 and 1.1 times the beam in meters, or a bit less. Roll time is governed by metacentric height (GM), which in turn in controlled by the moment of inertia of the waterplane and the relationship of the vertical center of gravity (VCG) to the waterplane. These are standard naval-architecture calculations. (See the articles: *Stabilitky is the Key, Parts 1 and 2*, and *Basic Criteria For Powerboat Stability,* for details on these calculations.) There's no reason not to get roll characteristics right on every design, slender or beamy.



Peregrine—45-ft. Ultra-Shoal Motorcruiser



Iron Kyle—45-ft. Tug Yacht

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Jet Drives and Efficiency

Clients often ask me about the efficiency of jet drives. The short answer is that jets are usually (not always) less efficient than propellers. Remember that the larger the propeller diameter and the slower the RPMs the more efficient the propulsion on displacement to semi-planing boats. Jets by their very nature have limited impeller diameter and limited (smallish) intake and outlet diameters. The fundamental laws of physics mean that—at low to moderate speeds—jets will always be at least somewhat less efficient than a properly sized propeller.

As boat speeds increase, the appendage drag of the propeller, shaft, strut, and rudder—the running gear—increases geometrically. Albert Hickman (the inventor of the Hickman Sea Sled and of the surface drive) said, "The resistance of water at 60 knots is the same as the resistance of hard cheese at 3 knots." He was right. This is why he came up with the surface drive—to reduce the drag from running gear at high speed.

Jets accomplish this same thing. As speeds approach 25 to 30 knots—even though the actual thrust delivered from the jet is less than a comparable prop—the reduced appendage drag compensates. From 25 to 30 knots you will loose some efficiency with properly proportioned jets but not too much. As speed increase over 35 knots, the reduction in appendage drag can make jets net out more efficient than props. This holds up to around 60 knots, where the surface drive is generally more efficient than jets or standard propellers.

Jets offer other advantages: shallow draft and extreme maneuverability. It can make good sense where these to features are primary mission goals to go with jets even in the 22- to 28-knot range. The modest loss in efficiency may be worthwhile. At higher speed there should be little loss, and at high speed an actual gain.

Roseate — 44-ft. bechable, tunnel-drive motorcruiser, of the *Summer Kyle* Class, designed by Dave Gerr