Maximizing A Trawler's Range

Or...What A Difference A Propeller Makes!

by Gary Danielson

Having sailed for years, my wife and I decided it was time to transition from sail to power. Our next planned adventure would be well-suited to a trawler—a cruise from the Great Lakes down to the Amazon River in South America.

Given the primitive wilderness of the Amazon region, we determined that we needed a trawler with plenty of living space, the ability to power long distances without refueling, as well as the ability to be self sufficient without shoreside amenities for long periods of time.

These criteria resulted in the creation of our trawler, *Hemisphere Dancer*, Hull #1 of the Great Harbour 37 series.

She has proven to be exactly what we wanted for such a journey.

Increasing Her Range

Once a boat has been designed and built, the number of things that owners can do to enhance the range of that boat are somewhat limited. Routine activities, such as keeping the engines in good operating condition, and the bottom and running gear clean, will do much to enhance the boat's long range capability.

Beyond that, however, the only other significant options that can impact a vessel's range is to reduce the overall weight as much as possible, and to install a propeller that most efficiently matches the boat.

Since long distance capability was such an important element in our intended use of *Hemisphere Dancer*, we have spent a great deal of time measuring the impact these factors would have on our plans. And it was important to test these factors after the boat was launched and delivered home, so that we could know what she would really do, before we got too deep into planning our South American adventure.

Prior to actually conducting tests and measurements on the boat, I held several assumptions related to the issue of a trawler's range. They were:

• In a full displacement hull, such as *Hemisphere Dancer*, the addition of weight has

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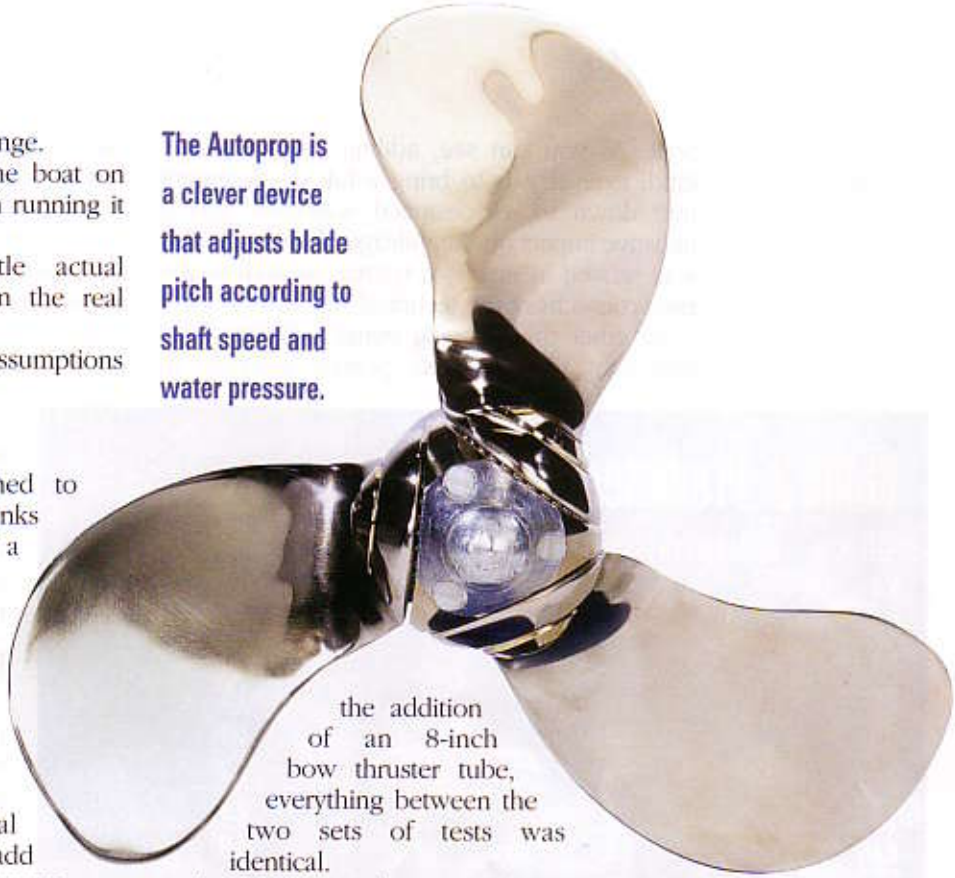
little, if any, effect on the vessel's range.

• On a long passage, running the boat on one engine gives greater range than running it on two engines.

• Changing props makes little actual difference in the vessel's range in the real world.

As it turned out, all three of my assumptions were incorrect.



The Autoprop is a clever device that adjusts blade pitch according to shaft speed and water pressure.

COURTESY OF AUTOPROP

Effects Of Weight On Range

Hemisphere Dancer was designed to weigh 43,000 pounds when her tanks are full and when fully stocked for a long cruise.

When the boat was first launched, she carried no additional ballast, and she initially traveled with just a few personal effects and supplies. With approximately a half-load of fuel and water, *Hemisphere Dancer* weighed in at 31,000 pounds.

After cruising the boat several thousand miles, we decided to add ballast to the boat, for a couple of reasons.

First, the boat had a "snappy" roll that was just too quick to be comfortable. We knew that strategic placement of ballast would slow the roll rate to a much more comfortable level.

We also determined that ballast placed low in the bilges would contribute to the boat's ability to resist and recover from a knockdown. (With the ballast, the boat can now self-right from a calculated heel angle of 110 degrees.)

Lastly, ballast helped trim the boat, as she sat significantly stern down when first launched.

Ultimately, we added 9,000 pounds of ballast to *Hemisphere Dancer*.

Once we completed our ballast project, and, after some basic cruising gear was brought aboard, the displacement of the boat (still with a half load of fuel and water) increased from 31,000 pounds to 41,000 pounds.

Since the boat is a full displacement hull form, designed for a displacement of 43,000 pounds, I'd assumed that a change in displacement from 31,000 to 41,000 pounds would have little, if any, effect on the fuel efficiency and resulting range of the boat. I was wrong.

It's All In The Numbers

We were fortunate to have taken extensive speed and fuel use measurements, both before and after the addition of the ballast. Other than the increased weight of the boat and the addition of an 8-inch bow thruster tube, everything between the two sets of tests was identical.

Chart 1 outlines the impact that weight had on the actual mileage of *Hemisphere Dancer*.

When I saw the negative impact the additional weight had on the mileage figures for our trawler, I was both surprised and intrigued. My assumption was clearly wrong.

So I reviewed all of the technical literature I could find to see if this effect on mileage was normal, and further, if it could be predicted and/or quantified. I soon learned that all of the technical information agreed that the addition of weight does indeed have an adverse, yet predictable, impact on mileage.

Chart 2 shows the predicted fuel use for my

Chart 1 Actual Fuel Use Measured with Two Engines and Fixed-Pitch Propellers

SPEED (KTS)	GALLONS PER HOUR (31,000 POUNDS)	GALLONS PER HOUR (41,000 POUNDS)
5.4	0.75	0.7
6.0	0.92	1.0
6.3	1.10	1.3
6.6	1.3	1.6
6.9	1.5	2.1
7.2	1.6	2.7
7.5	1.85	3.2 (at 7.4 knots)
8.05	2.4	NA

boat. As you can see, adding weight of any kind, even if it is to bring a full displacement hull down to its designed waterline, has a negative impact on the mileage of a vessel. This was proven in our own testing, as well as the predictions from the technical models.

All other things being equal, a lighter boat generally requires less power, roughly in proportion to its weight. For example, a 36,000-pound boat needs 10 percent less power to reach a given speed than a 40,000-pound boat.

The obvious conclusion here is that you should strive to keep your boat as light as possible if you are really concerned about maximizing the range potential of your boat.

Chart 2 Predicted Fuel Use

SPEED (KTS)	GALLONS PER HOUR (31,000 POUNDS)	GALLONS PER HOUR (41,000 POUNDS)
5.4	0.53	0.73
6.0	0.79	1.1
6.3	0.93	1.3
6.6	1.1	1.5
6.9	1.4	1.9
7.2	1.7	2.3
7.5	2.1	2.9
8.05	2.9	4.0

Effects Of Propeller On Range

Despite their worldwide and universal use, propellers are not particularly efficient at transforming an engine's horsepower into forward motion in water. Much of the energy generated by the engine is lost before it even reaches the propeller, and the propeller's inherent inefficiency consumes much of what's left.

However, it's true that thrust increases directly in proportion with an increase in propeller design efficiency. The higher a propeller's efficiency, the faster a vessel will go using the same amount of horsepower. So it seems natural that another good way to increase range is by increasing the efficiency of the propeller.

Overall, prop efficiency can range from as low as 40 percent (in a very inefficient installation), to as high as 70 percent (in a finely-tuned system using the best equipment available). The standard fixed-pitch, three or four-blade propellers that are commonly installed as original equipment on production trawlers probably have an efficiency of about 50 percent.

A self-pitching propeller, one that is properly matched to the boat and engine, will probably have an efficiency of around 60 percent.

The ultimate set-up, of course, is to have a controllable pitch propeller (CPP), along with full measurement instrumentation, so that the propeller can constantly be adjusted to remain at its maximum efficiency, despite changing speeds, sea states, and loads. A CPP installation can yield propeller efficiency as high as 70 percent.

Put in absolute terms, if you need 50 effective horsepower to propel the boat, a system with an efficiency of 40 percent will require a 125-shaft horsepower engine, while a more-efficient system (approaching 70 percent) will only require an engine rated at 72 shaft horsepower.

Fixed Propellers

The majority of propellers on trawlers are fixed-pitch, with either three or four blades. Fixed-pitch means that the shape, angle and pitch of the propeller can not be changed on demand. The reason they are so common is their relative low cost, while still providing an acceptable level of performance.

Unless your builder has spent a great deal of time optimizing a propeller to your boat, it is likely that some amount of improved efficiency can be achieved by working with your current fixed-pitch propeller, optimizing the angle of the blade to find the sweet spot for your boat in normal running conditions.

Remember, however, the actual modification of your prop is a job best left to a professional. Any out-of-balance condition will lead to reduced performance, increased vibration and a whole new set of headaches.

Other Propeller Options

If you are really serious about getting maximum range out of your boat, the next step up in propeller efficiency comes through the use of a self-governing, self-pitching propeller.

With this type of propeller there is no pitch control mechanism. Instead, the geometry of the blades and their pivoting attachment to the hub are designed so the blades automatically adjust pitch, in response to changes in torque, shaft speed and water pressure.

Unfortunately, these are production propellers, and are therefore meant to be mounted on a variety of boats. The self-governing mechanism is engineered to fit different boats and applications, so such a propeller may not always pitch the blade "perfectly" for your boat at any given time.

But from the available data, I believe this type