Repowering an older boat is a big job, but if done right it can yield some real performance gains, both under power and under sail

The Right way to Repower

According to **Sam Fortescue,** installing a new auxiliary in your boat is about a lot more than just finding another engine

If you dread your boat's antics as you try reversing into your slip or have become used to choking on black smoke, it could be time to start thinking about replacing your engine. Granted, doing so can be more than a little daunting, not to mention expensive. However, bear in mind that a new engine is also an investment, an investment that can substantially increase your boat's resale value further down the road.

Not only that, but in many cases you may even end up with a boat that motors better than when it was brand new. "Modern diesels are not like the old ones. They are generally smoother-running and quieter than engines built in the 1950s to 1980s," says Beta Marine's U.S. distributor Stanley Feigenbaum, describing the improvements made to marine diesels over the years.

As a side note, never forget a reliable auxiliary engine is also not just a convenience but an important safety item in the event you ever find yourself, say, clawing your way off a lee shore with a broken rig—a time you most definitely do not want to find yourself wondering if your auxiliary is up to the job.

GETTING STARTED

To illustrate some of the issues involved in repowering an older boat, we decided to pick a classic mid-'80s performance-cruiser, the C&C 35 Mk III, to serve as a kind of theoretical test bed to more closely examine the repowering process. Note: we will not be discussing the nuts and bolts of actually installing a new engine, just looking at specifying the right kind of equipment—no mean feat, and a task that can easily trip up the unwary.

To begin with, Joe DeMers of Newington, Connecticut, based Sound Marine (sound-marinediesel.com), says our boat's original 27hp Yanmar engine may have actually been too large, given the size of its hull. It all comes down to calculating the power required to move the hull through the water, DeMers says, adding, "The speed of a displacement hull is limited by the length of her waterline. Once top speed [hull speed] is attained, the boat cannot go faster, no matter how much horsepower is installed."

Beyond that, DeMers says, whatever the boat, the engine should get it up to hull speed on a calm day when running at around 85 percent of its maximum rpm, allowing the top end to serve as a kind of reserve for tougher conditions.

With this in mind, the waterline length aboard a C&C 35 Mk III, which displaces 10,500lb (light ship), is 28ft. Given these dimensions, DeMers says the boat should be able to easily reach a hull speed of 7.1 knots with a 20hp engine. "She is a sweet-sailing boat and very easily driven," DeMers explains. "If the customer wants an abundance of power, the Beta 25 will provide it."

That said, Lars Østergaard of Denmark's Gori Propellers, which manufactures a wide range of folding props, maintains he's a little more bullish when it comes to power, explaining his rule of thumb is around 6hp of installed engine power for each metric tonne, or 2,205lb, of displacement. The goal here is not so much more speed, but a healthy margin for things like recharging batteries and dealing with tougher conditions. This in turn suggests a 28.5hp engine, like the Yanmar 3YM30AE. Other possibilities might be the Beta Marine Beta 30, the Vetus M3.29, the Westerbeke Universal M-25XPB, Nanni N3.30 or Volvo Penta D1-30.

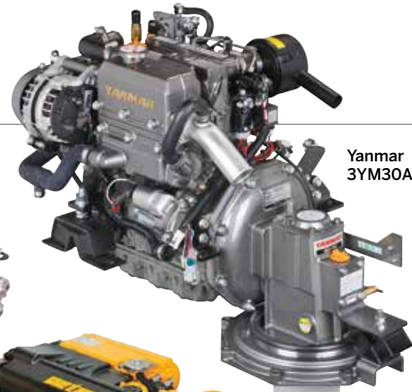
The good news is that any competent engine supplier will be able to give you a detailed recommendation for pretty much any boat, based on long experience with similar installations. Shop around and be sure to ask plenty of questions. The main thing to keep in mind is that choosing a larger engine in the hopes of greater boat speed, may not only fail to provide you with the speed you're looking for, but result in reduced efficiency of the system as a whole.

While on the topic of engines, be aware that if your boat is from the 1990s or earlier, expect to replace the exhaust system as well. Best practices have evolved over the years, and a new system will be both safer and more robust. Among other things, the rubber in your ducting will have likely hardened over time and could crack when attached to the new engine. You'll also want a modern stainless steel high-rise exhaust elbow, a fiberglass or plastic muffler and a siphon break for optimum protection against back-flooding.

While you're at it, get your fuel tank pressure tested for peace of mind and make sure a fuel

PHOTO AT TOP LEFT BY **GRAHAM SNOOK**

Volvo Penta D1-30



Yanmar 3YM30AE

RESOURCES/ENGINES

Beta Marine - betamarinenc.com
Nanni - nannienergy.com
Vetus - vetus.com
Volvo Penta - volvopenta.com
Westerbeke - westerbeke.com
Yanmar - yanmarmarine.com

Vetus M3.29

Universal M-25XPB

Beta Marine 25

FEATHERING AND FOLDING PROPELLERS

There are a number of different low-drag propellers on the market, and the engineering involved in their design, manufacturer and operation is nothing less than exquisite. The two major categories are folding propellers, which flap open and shut a little like clam shells; and feathering propellers, where the individual blades rotate about an axis to create the necessary driving force in both forward and reverse. Two-, three- and even four-blade models are available in each type.

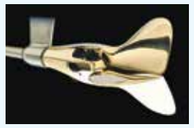
Beyond that, the various low-drag props out there are available in a number of different materials and at a range of price points. Some models also offer clever overdrive-type functions for increased efficiency and better fuel burn. Be warned, this type of gear doesn't come cheap, so do your homework and make sure you talk to the experts before ordering anything. Fortunately, it would be hard to imagine a more dedicated bunch than the folding and feathering propeller manufacturers of the world. (They can, on occasion, even make sailmakers seem mellow by comparison!) Better still, they never seem tire of talking about this stuff with an eye toward getting all you can out of your boat. What follows is a list of some of the leading brands currently on the market.

EWOL

Italian-made EWOL adjustable-pitch feathering propellers are manufactured out of stainless steel and offer an exceptionally low-resistance profile when in sailing mode. Multiple models are available with either three or four blades. For those in search of the ultimate, EWOL's four-blade Pegasus feathering propeller can also be ordered in titanium. **ewoltech.com**

GORI

The GORI folding prop is engineered in Denmark from nickel-aluminum bronze. Blades are fully shaped and geared so that they cannot open or close independently, but only do so in a coordinated manner. In operation, the blades don't just open and shut, but pivot through a full 180 degrees in order to provide optimum pitch in both forward and reverse. GORI's also have an "overdrive" function, which provides a second pitch, thereby creating the same amount of power at a lower rpm. "This can be compared to the fifth gear on a car," says GORI's Østergaard. **gori-propeller.com**



Varifold

Manufactured by Bruntons in the UK of nickel-aluminum bronze, Varifold propellers are equipped with precisely pitched blades featuring a reduced pitch toward the tip to reduce noise and vibration. Varifolds are available with anywhere from two to four blades depending on a boat's power needs and to further reduce noisy pressure pulses against the hull. **bruntonspropellers.com**

Autoprop

Also manufactured by Bruntons, Autoprop feathering propellers feature a set of uniquely offset blades that rotate through a full 180 degrees depending on whether you are sailing or motoring in forward or reverse. Under power, the Autoprop also adjusts its pitch to match the speed of the boat and the speed of the engine to maximize efficiency whether motorsailing or under power alone. **bruntonspropellers.com**

Max-Prop

Engineered in Italy since the mid-1970s, and distributed in the United States by PYI Inc., Max-Prop blades feather automatically as soon as the propeller stops spinning, thereby providing a minimum of water resistance when not engaged. A number of different models are available offering from two to five blades. Pitch can be adjusted independently in forward and reverse at the turn of a screw. With the company's Easy and Whisper models, you can even do so with the boat still in the water. **pyiinc.com**

J Prop

The J Prop feathering propeller is available with two, three or four blades and can be used with saildrives as well as conventional shafts. Pitch can be easily adjusted in both forward and reverse, and the helical gears controlling the feathering blades include a large contact area in the interest of creating added strength and wear resistance. **betamarinenc.com/j-prop**

Kiwi Prop

With blades made of a nylon-glass composite called Zytel, the feathering Kiwiprop is not only lighter than bronze, but cheaper and corrosion-free as well. When a boat is under sail, the propellers are engineered so that the individual blades are free to "weathervane," aligning themselves with the water flow over the hull to further minimize drag. **kiwiprops.com**

PHOTO AT FAR RIGHT BY **GRAHAM SNOOK**

Flexofold

Manufactured in Denmark from nickel-aluminum bronze, Flexofold folding propellers are available with anywhere from two to four blades and offer an incredibly small profile when in sailing mode. The Flexofold product line includes models configured expressly for installation on either a conventional shaft or saildrive. The Flexofold two-blade saildrive "Composite" employs a composite hub for maximum corrosion resistance. **flexofold.com**

Variprop

Germany's SPW makes this robust feathering prop to order in "ice-class" nickel aluminum bronze for extreme long life. The blades are precisely machined with camber using a five-axis robot, and the amount of pitch can be adjusted independently in forward and reverse, even with the props in the water. Equipped with a proprietary "SoftStop" anti-clunk shock-absorber, the prop's short hub makes it especially suitable for use aboard full-keeled boats with small apertures. **variprop-usa.com**

Variprofile

Similar to its Variprop, Variprofile is SPW's lighter, small-boat feathering prop. It is mass-produced for modern serial yachts with engines up to 140hp, but otherwise has many of the same features as its custom-built sister, including micro adjustment for the forward and aft pitch. **variprop-usa.com**

filter is fitted between the tank and the engine. Dirty fuel is the bane of any diesel engine, no matter how reliable or high-tech.

PART OF A SYSTEM

Once you've determined your horsepower needs, the next step is configuring your drivetrain. Never forget, an engine is just one (very important) part of a much larger, fully integrated system, one in which it operates in concert with both the propeller and a gearbox to optimize thrust.

With this in mind, it's important to understand that the various marine diesels on the market, in addition to offering varying amounts of power, are also designed to operate at different maximum rpms. (Many modern engines have faster shaft rotations than their predecessors, in particular.) This in turn will mean possibly making changes to the rest of your boat's drivetrain to ensure you take full advantage of whatever power it's generating. Whatever you do, don't assume your current transmission and prop will automatically make the most of a new engine's horsepower.

"Many times, when customers complain about poor boat performance, it's because the propeller's diameter or pitch, or the transmission reduction ratio do not compliment the engine's power," Sound Marine's DeMers warns.

To illustrate, Østergaard cites what he describes as the classic example of a sailor with a 1980s sailboat running a Volvo Penta engine on a 110S saildrive with a gear ratio of 1.66:1, in which the engine is spinning 1.66 times faster than the propeller. "You take out a 2,500rpm engine, but exchange it with a bigger, higher-revving engine, without changing the ratio. This will not work," Østergard says. "The shaft is spinning too fast, so you end up with a small-diameter propeller that cannot put the horsepower to the water."

"The reduction ratio gear is of paramount importance," agrees David Sheppard, whose Bruntons Propellers Ltd. manufactures the Autoprop and Varifold lines of feathering and folding propellers, "especially when selecting a new engine installation and also the optimum diameter propeller." According to Sheppard, in this case a ratio of 2:1 or below would equate to one of his 15in three-blade wheels. However, he adds, "I would prefer a ratio above 2.5:1 for a 3,600rpm engine. That would mean we could use a 17in diameter propeller."

The engine is just one of a number of parts that must work together as part of an effective drivetrain

Similarly, Keld Willberg, general manager of Danish folding-propeller maker Flexofold, says that with a 25hp Beta and a reduction gear of 2.60:1, he would recommend a three-blade 15x12 Flexofold. ("15" refers to the propeller's diameter; "12" refers to blade pitch.) With a 29hp Yanmar, on the other hand, Willberg says, "I would go for the 2.62:1 gear reduction and recommend a three-blade 16x13 Flexofold. This gearbox has 3.06:1 in reverse, so with the 2.62:1 in forward, you minimize the difference. If the propeller were sized for 2.21:1 (forward) it

When repowering, it makes sense to upgrade the rest of your drivertrain as well: (above) a Vetus shaft coupling and muffler; (below) a SigmaDrive coupling from Bruntons

would demand relatively more rpm to get good stopping power in reverse."

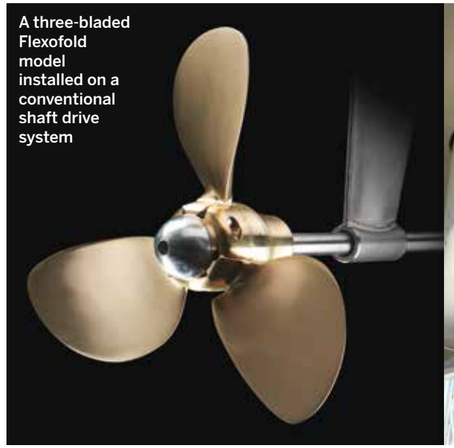
As for Fred Hutchison of feathering Max-Prop propeller distributor PYI Inc., he also says that in a retrofit his aim is to match the new drivetrain to optimize the diameter of propeller fit on the boat. With the Beta 25, for example, he therefore recommends a reduction ratio of 2.6:1 and a 16in Max-Prop with 10in of pitch. With a more powerful Yanmar 3YM30, which has a top speed of 3,200 rpm, he recommends an even lower gear ratio of 2.21:1 and a three-blade 16x11 prop. "With the correct paring of engine and transmission, you can get the same performance out of either engine," he says.

To understand what's going on here, it's important to realize that when it comes to propellers, the most efficient system in terms of fuel economy and noise is one equipped with a large propeller turning slowly. The biggest cargo ships, for example, have props with diameters of 34ft or more rotating at just 90 rpm. By comparison, a typical sailboat, with its restricted propeller clearance, might have a 17in-diameter prop rotating at a max shaft rpm of up to 1,500 and a cruising rpm of a little over 900. (These numbers will vary somewhat depending engine rpm and the gear ratio; also, note these are shaft rpms, not the rpms of the engines themselves).

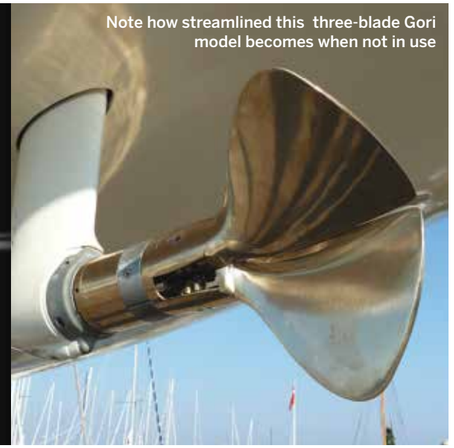
Of course, the faster a propeller turns, the more work it can do—one of the reasons the propellers on fast powerboats spin so fast. However, as rpm increases, the surface area of the blades also needs to increase in order to grip the water; something that can be done by increasing the number of blades, the area of the individual blades, or both. "You can compare it to a performance car," Østergard says. "If you have a high-powered engine, you need wide tires to put the horsepower to the asphalt—same thing with a propeller."

As for pitch, or the angle of attack of the propeller's blades, the key here is the ease with which the hull is driven through the water. Increased pitch, like increased rpm, generates greater thrust. Outboard props, for example, have dramatically pitched props in order to get dinghies and powerboats up on a plane and keep them there. Aboard a heavier displacement hull, however, especially as it nears hull speed, too much pitch will result in undue cavitation, which will quickly degrade performance and can even damage the propeller itself.

Pitch is typically measured in inches, with reference to the distance forward the prop would travel in one revolution if it gripped the water to perfection. (Think a wood screw going into a 2-by-4.) A propeller with a 12in pitch, for example, would move the propeller forward 12in over the course of a single revolution.



A three-bladed Flexofold model installed on a conventional shaft drive system



Note how streamlined this three-blade Gori model becomes when not in use

In practice, a light boat with a slippery hull could use a higher pitch to, say, compensate for a smaller diameter because it is more easily accelerated, thereby reducing the amount of cavitation. However, aboard a heavy-displacement boat, you want to go with a larger-diameter propeller with a more gentle pitch turning as slowly as reasonably possible. "Our experience is that the best ratio for pitch is between 60 and 85 percent of the diameter," Østergard says.

Finally, since your engine compartment is going to be taken to pieces anyway, why not take advantage of this opportunity to replace things like your cutless bearing (if your boat has one), your seals and maybe even the prop shaft, if necessary? (Note: with respect to prop shafts, in particular, if you go up in torque—a function of rpm, power and the gearbox ration—you may well need a larger-diameter shaft whether you want one or not.) Similarly, if you're already going to the expense and trouble of installing a new engine, why not upgrade to a high-efficiency, low-profile feathering or folding propeller as well?

Granted, a feathering or folding prop will cost you a fair bit more than a fixed one. But in doing so you will add at least a half knot of boat-speed—likely more—under sail thanks to the reduction in drag. In light-air conditions, you will also likely find your boat easier to jibe and tack, and in all conditions your boat will point higher thanks to cleaner water flow over the rudder. Tests have repeatedly shown a feathering or folding propeller generates as little as 15 percent the drag of a fixed unit, with the latter often likened to the effect of towing a bucket behind the boat. By going with the appropriate feathering or folding model your repowering efforts will result in a boat that not only performs well when the engine is on, but also when it's not.

"When it really makes a difference is in light or medium air," PYI's Hutchinson says. "Suddenly you can carry speed through a tack. I tell customers it makes it fun to sail in light air again, because you can."

"When a sailor with a fixed propeller is forced to turn on the engine due to light wind, the one with a folding propeller is still able to enjoy his sailboat," Flexofold's Willberg says, summing up the performance difference.

THE REAL WORLD

Of course, thus far we have assumed you have all the space in the world under your hull to fit the optimum propeller. Reality, however, is often not so accommodating. Full-keeled and more traditional yachts, in particular, may not have enough clearance between the hull and shaft to fit the ideal diameter given the horsepower you have in mind. Similarly, the proximity of a skeg may rule out a longer folding prop in favor of a shorter feathering one.

For this reason, Beta Marine's Feigenbaum says it is often better to work back from the propeller as this is actually what drives the boat. "If you are restricted in diameter, you are also going to be restricted in how much horsepower you can deliver," he says. "If the propeller calculation recommends a 16in-diameter, 11in pitch propeller, and you only have space for a 12in propeller, you cannot make the combination work."

In other words, it may be better to settle for a slightly less powerful engine that can efficiently drive a smaller propeller at optimum speeds rather than try and force the issue by piling on the horsepower.

Note, this is an area in which some "armchair engineers" will recommend trying a high-pitch "square" propeller (so called because the pitch and diameter are nearly the same), the idea being that it will allow a boat to hit hull speed at a lower rpm. The problem with this approach, though, is that it means the engine never reaches its optimum point on the power curve (a graphical representation of the amount power generated across an engine's rpm range), usually 85-95 percent of maximum rpm. This in turn will result in incomplete fuel burn, the dumping of diesel into the exhaust, and excessive wear and tear on the transmission.

Bottom line: anyone looking to repower their boat needs to 1) do their homework and 2) recognize the limitations of whatever kind of hull, shaft, rudder/skeg arrangement they might have, if they want to ensure they're satisfied with the result. Horsepower, propeller diameter and pitch, and gear-box reduction ratio all need to come together to if you are to have the right system for your boat.

Again, ask around. Talk to as many drivetrain experts and engine and propeller manufacturers as you can to find out your options and ensure you end up with the drivetrain that's right for you. Doing so will result in the best possible combination of reliability and performance—both under power and under sail—for years to come.