SCREW THE STATUS QUO

Can Sharrow Marine's innovative propeller design turn boat performance on its head?

For almost a century the boat propeller hasn't changed much. Since the screw propeller was developed in the early 1830s, the basic design has consisted of a central hub with multiple blades. There have been advances in engineering, but there have not been any new props that were practical for the recreational boating market. That is, until Greg Sharrow released the Sharrow propeller in 2021.

The Sharrow is a breakthrough of sorts. Instead of using the conventional twisted blades that are familiar to all recreational boaters, the Sharrow uses loops. Each loop starts at the forward end of the hub, flows aft and outward as it slowly changes pitch, then takes a 180-degree turn on a parallel path back to the hub, where it reattaches aft of where it started. The goal of the unconventional shape is to increase performance and efficiency. The Sharrow is not an off-the-shelf product. To optimize performance, each propeller is custom designed for a specific hull and engine combination.

Its creator, Greg Sharrow, didn't set out to make a boat propeller. Following an undergraduate program at Boston's Berklee College of Music, and while working in production, he wanted to design an ultra-quiet drone blade that could be used during live music video recordings. He succeeded in developing a quieter drone blade, but also created Sharrow Marine, where Sharrow and his team conceived their new marine propeller.

A QUICK PROP HISTORY

Today's screw propeller evolved from the screw pump, which is over 2,000 years old. The screw pump was once described by the Greek mathematician Archimedes and dates back to at least Egypt before the 3rd century BC. It may even have been used to irrigate the Hanging Gardens of Babylon around 600 BC.

When you merge the screw pump concept with the age-old technique of stern sculling—where a single oar over the transom is used in a figure-eight motion to create lift—the rough concept of a propeller begins to emerge.

The process of creating lift, for an airplane or marine propeller, has fascinated humans for millenia. To wit: The bamboo dragonfly, a toy helicopter consisting of feathers mounted to the end of a stick that flies upward when spun rapidly, dates back to 320 AD. Leonardo da Vinci was making theoretical helicopter sketches in 1480, and in 1683 the Englishman Robert Hooke foresaw that his invention to measure water current, based on the wings of a windmill, could be used for marine propulsion, with the advent of motive power. It was another Englishman, Joseph Bramah—whose greatest claim to fame is associated with the flush toilet—who in 1785 drew the first screw propeller and shaft as we know it, but never trialed it.

In the early 1800s, numerous inventors worked on the screw propeller concept. U.S. Colonel John Stevens III focused on rudimentary windmill-style propellers, a design that consisted of flat iron plates riveted to a shaft. Another early propeller attempt came from Englishman Francis Pettit Smith, who in 1836 filed a patent for a helical screw, similar to a truncated screw pump, which initially had two full turns but later that year, was reduced to one full turn. The helical screws were slow but did provide single-digit boat speeds with low-horsepower steam engines.

By 1842, the windmill-style or screw pro-

Top: Greg Sharrow says he was able to "avoid any preconceived notions" about prop design because he came from outside the marine industry.

peller was used on a French ship, the *Napoleon*, which was built by Augustin Normand in Le Havre and was outfitted with propellers optimized and manufactured by the Englishman John Barnes. To develop the final geometry, Barnes created a series of model tests in which the diameter, pitch, blade area and number of blades were varied. John Ericsson, a Swede who had experimented with contra-rotating earlier in the century, arrived at a similar single-propeller design after the American captain Robert Stockton invited him to the United States to design a propeller steamer.

In the decades that followed, there was a highly focused effort to experiment with multiple variables and to explore the effects of cavitation. Things like pitch, number of blades, adjustable blades, variable pitch and other factors were explored, but the basic shape of the propeller remained the same. Bear in mind that even the first adjustable pitch propellers (those that could adjust the blade pitch underway) were drawn in 1849, even though they were not regularly manufactured for ships until the 1960s.

In 1938, at a model basin in Wageningen, Netherlands, 120 propellers of varying blade count, area, pitch and thickness were tested for open-water characteristics. Known as the Wageningen B-series propellers, the resulting graphs created a starting point for naval architects to further optimize propeller performance.

Pushing past World War II and then the space race, the computer age led to the field of computational fluid dynamics, which aided the trial and error process of propeller optimization. It helped to further reduce cavitation and improve efficiency, but the screw propeller still had limitations. No major leaps forward for recreational boaters were made until Greg Sharrow recently debuted a completely new and practical design.

PERFORMANCE BENEFITS

When asked why propeller technology didn't change for so long, Sharrow credits his outsider's perspective. "I was fortunate," he says. "I believe coming from outside the marine industry allowed me to avoid any preconceived notions."

While trying to design a quieter drone propeller, Sharrow realized that airflow around the tips of conventional propellers was responsible for most of the noise. As a propeller created lift it would also create masses of whirling air. These vortices would come off the blade tips, generate their own pressure and density variations and create acoustic waves—simply put, sound.

Sharrow asked himself: How do I eliminate the tip? What would a tipless propeller look like and how would it function? The creative process that ensued led to the unique shape of the Sharrow propeller.

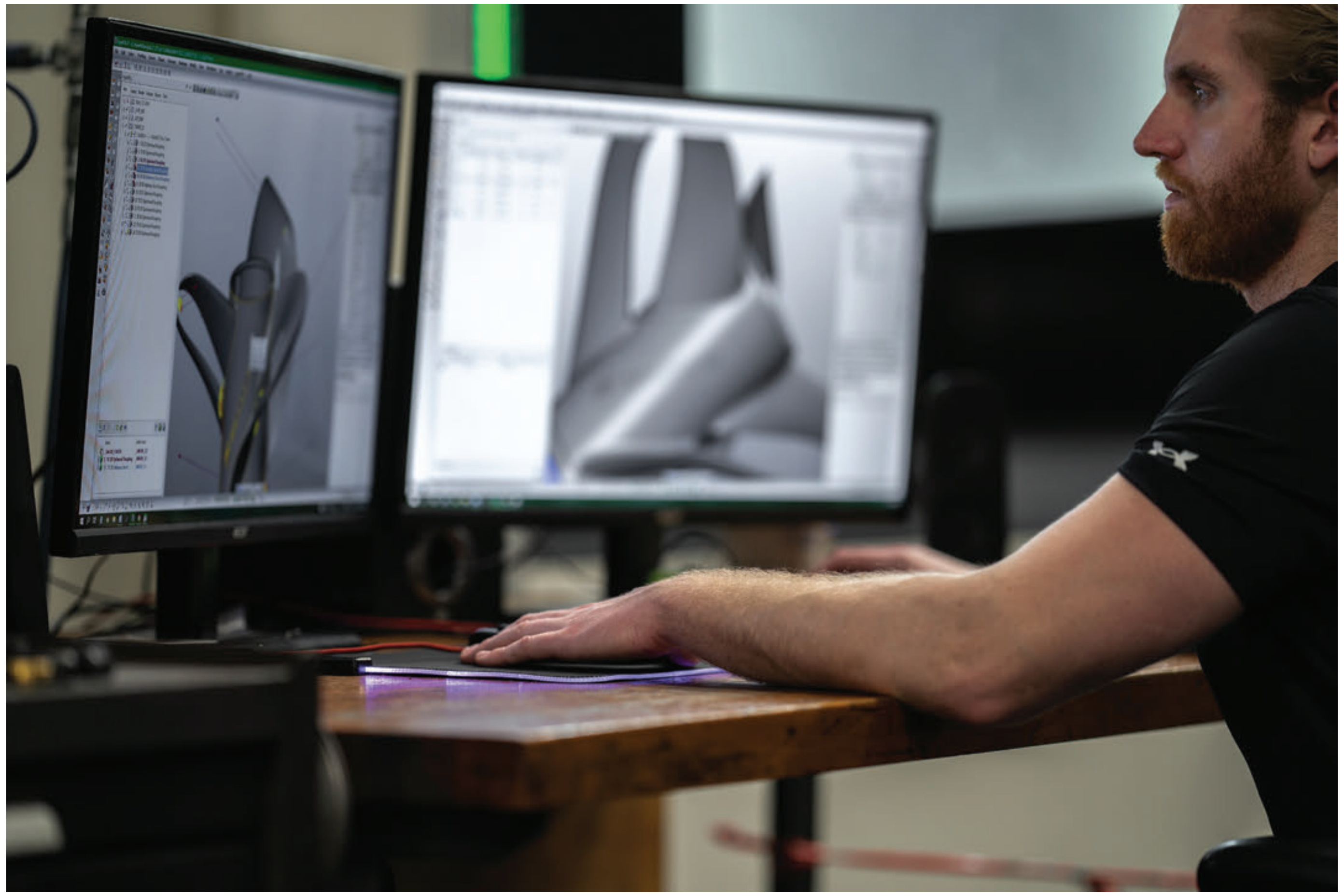
"By dramatically reducing or eliminating tip vortices," Sharrow says, "we can significantly reduce the noise produced by our propellers. We have discovered many other advantages for our propellers across a range of applications and fluid densities, but the original inspiration came from my desire to make a quiet drone to film classical music."

One of those other applications was marine propellers. Sharrow made 641 prototypes before he achieved performance levels that exceeded the Wageningen B-series screw tests, which are still considered an industry standard. That included 72 days of tow-tank testing at the University of Michigan's Marine Hydrodynamic Laboratory. "Every prototype test yielded a result good enough to keep taking another step forward," he says.

The physical testing allowed Sharrow and his team to establish a model for each early propeller design, which allowed for further optimizing through computational fluid dynamics. The end result was the Sharrow propeller, which targets more thrust and is more efficient across the entire speed range.

Sharrow emphasizes that there is not a single design aspect that is responsible for the propeller's performance. "By optimizing thousands of parameter sections each propeller is uniquely designed to fit a specific outboard and hull combination," he says.

Sharrow propellers aim to consume all available torque at the upper rpm limit, but company tests reveal that performance is better than traditional propellers at lower rpms as well. During one test, the company ran a Robalo R302 with Sharrow props and twin Yamaha 300s. Whereas the conventional propeller kept pace with the Sharrow until about 2000 rpm, beyond that there was a considerable deviation



Above: The company runs computer simulations. *Right:* The curved tip, or looped geometry, of the Sharrow creates more thrust by driving more fluid between the intake and exhaust sections of the blade.

in performance. At 3000 rpm, the Sharrow produced 70 percent more boat speed (25.5 knots versus 15). The Sharrow also delivered a higher top-end speed. Fuel efficiency at mid-range cruise speed increased by up to 29 percent on the boat with the Sharrow. This pattern, says the company, has repeated itself with each new installation.

Sharrow says its propellers also provide better control when docking because the design has more thrust near the lower end of the rpm range than conventional propellers, both going ahead and astern. Sharrow says that with up to 50 percent more reverse thrust, its prop can stop a vessel faster in emergency situations and give the operator more directional control in forward and reverse. He says this is true across the entire power range.

Customer reviews also seem to indicate substantial performance gains. Chris Shoupe of Voodoo VI Catamaran Tours is a boatbuilder and charter operator in the U.S. Virgin Islands. He runs his 57-foot custom power catamaran, *Voodoo*, out of St John. Efficiency translates directly to his bottom line, and improved control translates to greater safety, so Sharrow propellers were a business decision for him. *Voodoo* is powered by twin 300-hp OXE diesel outboards, chosen for maintenance simplicity in an area with limited resources. These are high-torque engines which suffer from the same problem as all outboards—a limit on propeller diameter. Shoupe says Sharrow Marine uploaded his boat's hull design and his motor specifications and ran extensive simulations to optimize the propellers.

When his outboards were originally delivered, Shoupe found that the standard 3-blade propellers suffered from high cavitation and caused the boat to handle poorly. So he ordered the Sharrow props and custom five-blade propellers. Shoupe tested both sets. At the target cruising speed of 18 knots, the conventional custom propellers achieved 0.72 mpg, versus 1.05 mpg with the Sharrows—a 46 percent improvement in fuel economy. The Sharrow propellers also hit a top speed of 22 knots, whereas the custom conventional propellers hit 18 knots. Shoupe noticed that vibration disappeared with the Sharrows, even in reverse, and that they gave great performance through the mid and high operating range while remaining quiet. He also noticed that he had more precise control while mooring and docking. "Voodoo would not be the boat that it is without Sharrow," Shoupe says.

HOW DOES IT WORK?

How does the Sharrow blade achieve better efficiency and quieter performance? Although each blade can be divided into an intake section, tip and exhaust section, each component is acting in concert with the others. However, the curved tip of the Sharrow blade (if it can even be called a tip), creates more thrust by driving more fluid between the intake and exhaust sections of the blade. The loop creates a barrier that decreases tip vortices, which results in a noticeable reduction in cavitation, something that has been shown to be true in testing. This translates to performance gains, but the reduction in cavitation also means quieter operation. Sharrow Marine's testing shows that its propellers can be up to 80 percent quieter at cruising speeds. Sharrow runs computer simulations of its designs and conventional propellers but also runs full scale tests. "Our efficiency graphs speak for themselves," he says.

While photos of Sharrow props frequently show three blades, the company says it will optimize the blade count based on the needs of the boat and motor combination, with performance always being a driver.

Most conventional propellers have a significant amount of slippage. Slippage is the difference between the ideal path through the water, known as pitch, and the actual path it takes, known as the advance rate. When a propeller is advertised as a 15x20, that second figure is the pitch and the distance the propeller should move through the water in a single turn. Propellers do not perform at an optimal rate throughout their full range. They are built to function best at a certain design point, but as they move away from that, the design is compromised. Cavitation, among other factors, prevents propellers from hitting their pitch. They especially suffer through their middle range of operation. Based on test results, Sharrow props achieve less slippage through a broader range and the lack of cavitation in their images and videos speaks to that.

Small disturbances, like marine growth, can interfere with optimal performance but Sharrow's testing has shown that disturbances affect their propellers at a similar rate as traditional propellers because they have similar blade area.

Because each propeller is unique, the Sharrow manufacturing process would not be possible without today's modern manufacturing technologies. Once a new design has been optimized for a client's boat and propulsion, a 3D printed wax positive is made to order. The wax is then used in an investment casting process (Yamaha is one such supplier) to create an oversized casting of the propeller. The casting then enters Sharrow Marine's machine shop in Detroit, where a 5-axis CNC milling machine cuts 100 percent of the propeller surface. Each propeller is then mechanically polished and shipped directly to the customer. Standard industry propellers are finished to an accuracy of 70 thousandths of an inch, but Sharrow finishes its propellers to within 1 to 2 thousandths of an inch of their CAD drawings. "We make the Sharrow Propeller in my home state of Michigan and I'm very proud of the fact that it is made in the U.S.," Sharrow says.

It is the 3D printing that allows thousands of unique designs to be put into production. Relying on conventional molds for each design would be expensive and would drastically slow down the design cycle. Currently, Sharrow Marine can go through 10 unique design cycles per day, whereas the typical propeller manufacturer might go through 3 to 6 per year. In their early days of research and development, Sharrow Marine would use aluminum to manufacture their prototypes: each propeller was CNC machined from a solid block in less than 12 hours.

Today, they use hardened stainless to create their propellers. Because the ends of the loops, or tips, are thicker than a standard propeller and since there are two connection points on the hub that provide stiffness and strength, the Sharrow blades are highly resistant to damage from strikes.

Every design—whether it is a boat, a propeller or any other component—is a compromise between functionality, performance, style and cost. In the case of the Sharrow prop, the area of compromise is cost. The dedicated level of engineering and complex manufacturing process mean that it's expensive to produce. In 2023, for most recreational vessels, one Sharrow propeller costs roughly $5,000. It is a large up-front investment. For some early adopters, performance may be enough of an argument to convert to this new technology. For others, the long-term fuel savings may offer a sensible rationale. Efficiency gains vary by boat and motor combination, but a 30 percent increase in cruising speeds seems common. A Sharrow propeller typically requires a longer lead time than a conventional propeller, but despite that, the Sharrow propeller appears to be gaining traction.

Today, the Sharrow team is focused on creating propellers for outboards that exceed the 300-hp mark. Sharrow says it's tough to equip 500-hp engines with a standard blade prop because of the diameter limitation and the available torque. "This is where our prop can really excel," Sharrow says.

Sharrow Marine has taken a unique approach. Greg Sharrow came up with a unique geometry and then leveraged modern technology to make rapid design and manufacturing possible. "No one has been dialed in to specific boat and motor combinations before," he says. We are at the dawn of a new era in prop technology, and it will be exciting to see what comes next.