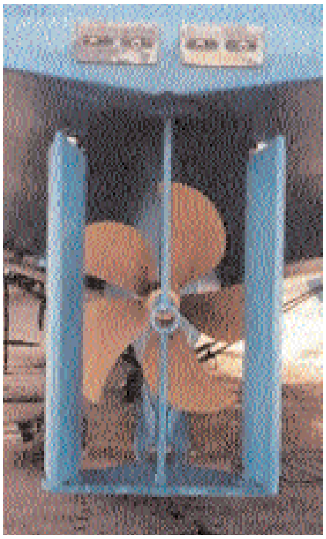
When Two Rudders Are Better

Installing Twin Rudders On This 75-Foot Northern Marine Made A World Of Difference

Story And Photography By Don Stabbert

What do you do when you fall in love with a boat that has everything you want and then discover that she has what could be considered a major problem?

My wife, Sharry, and I purchased *Starr*, a 75-foot Northern Marine long range cruiser, in September 2000, and our goal was to leave the Pacific Northwest on a world cruise just two months later. But during sea trials I learned that the steering response time was slower than I expected. Having spent years running single-screw boats, including tugs, I had a pretty good idea how this boat should respond. And she wasn't even close.



When the boat was at a dead slow and the helm was put hard over to 30 degrees, *Starr*'s response to the rudder was so slow that we needed to give a burst of power to make her turn faster. Putting the helm over 5 degrees at a cruising speed of 8 or 9 knots brought another slow response, but when the helm was back to center the boat's heading would drift past center. It became a guessing game to figure out just where the boat would end up pointing–not a comfortable feeling with a boat this size!

But we had set an aggressive schedule: Leave Seattle for Mexico in November, cruise from Mexico to the Marquesas in March and arrive in New Zealand in October. As our departure date neared, two questions burned in my mind: Can we afford the time to modify the steering? Can we afford *not* to modify the steering?

In an effort to determine what our options were, I met separately with three naval engineers. Each one looked over the boat specifications and design:

- 75-foot boat
- 100 tons displacement
- 6 foot 6 inch draft
- 53-inch-by-32-inch rudder
- Single Hynautic ram
- 30-degree maximum rudder angle

With poor control of the boat running at slow speed, the engineers agreed that we were probably on the light side for control–but they all thought we would be OK. "Marginal" is what it boiled down to. "Is that good enough?" I asked myself.

Than One

The owners of *M/V Starr* recently enjoyed a cruise in picturesque La Rochelle, France, on the Bay of Biscay. These towers, built in the 14th century, were constructed to hold heavy chains that were secured between them to keep English vessels out!

Then I met Ed Hagemann. Ed is considered by many naval engineers in the Pacific Northwest to be the top rudder and hull design engineer in the industry. After looking over the data, his first response was pretty much the same: "Looks light on rudder area … probably will work."

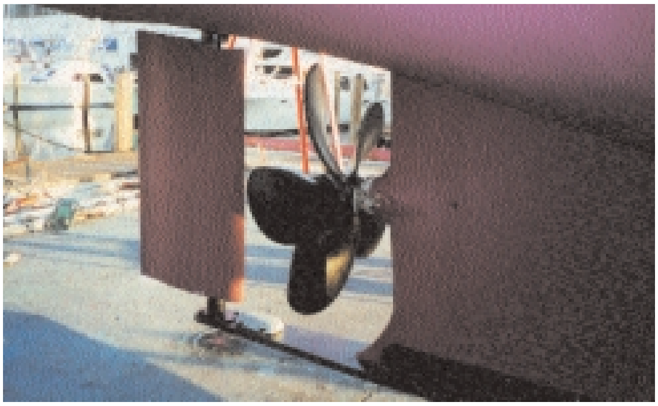
But as Sharry and I described our world cruising plans, Ed began punching numbers into his hand-held calculator. Then he paused, looked up and told us, "If you had *Starr* in an 18-foot following or quartering sea with a 7-second wave interval, you might broach."

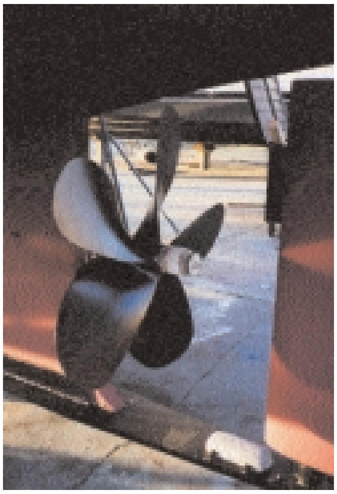
"Let's see," I thought, "broach, broach … we've done that." Sharry and I raced our Cal 40 for over 10 years and before that our 17-foot Thistle. To broach a small sailboat is one thing, but a 100-ton, 75-foot long-range cruiser? I could just imagine Sharry's response after a broach, assuming we survived such an event.

Ed Hagemann reminded us of the old rule of thumb: *Rudder area = Length at waterline x draft x 0.05.*

At less than 12 square feet, our existing rudder was nowhere near the 20-plus square feet the formula suggests. But what to do?

Because of the hull and keel configuration, the rudder was already as high as it could be. We certainly didn't want to extend the rudder beneath the keel shoe. The primary problem with extending it aft lies in the resulting hydrodynamic imbalance to the rudder stock. The added rudder force might overload the stock and the added effort (moment) to turn the rudder might overload the tiller and ram assembly.





Top: “Impossible!” we were told when we said wanted to cruise this narrow channel in Redon, France. Ordinarily, only boats of about 30 feet or less are able to negotiate the waters, but *Starr*’s twin rudders allowed her to cruise through with ease. Above and left: The original single-rudder configuration limited our cruising options.

We considered adding wedges onto the trailing edge, but while that might help at low speeds it would be of little help in large following seas. We also explored articulating rudders, where the trailing edge operates much like the flap on an airplane wing, only to conclude that a rudder like this would add mechanical complexity and improve low-speed rudder control but would do little to help maintain control running downhill in large following seas.

Ed’s recommendation was to add two spade rudders, one on either side of the original rudder.

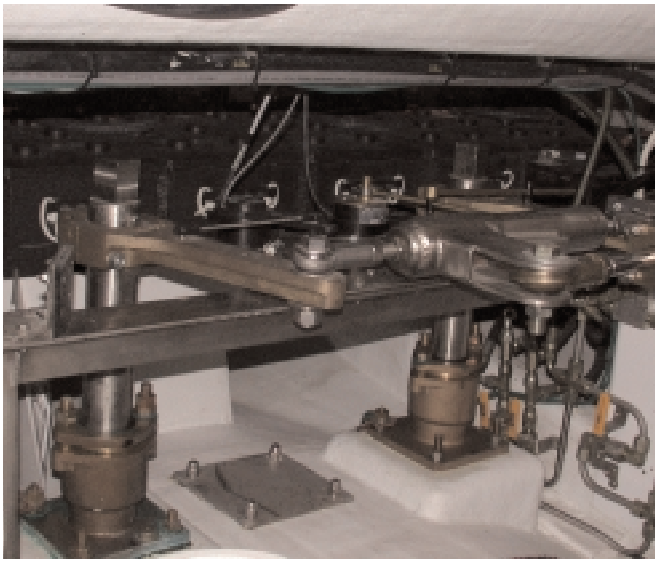
Rather than triple rudders, Sharry and I opted for twin rudders placed on extensions welded onto each side of the 1.5-inch thick keel shoe. One of our considerations was structural: Flanking spade rudders would be more exposed to logs and rocks, while twin rudders would be better protected by the keel. And there was the matter of aesthetics: To our eyes, twin rudders just looked better. Somehow, we just could not picture a big, serious long-range cruiser like this with wing rudders.

Once we made the decision to go with twin rudders, things began to fall into place. We decided to use the original rudder as one of the twins and ordered an identical 12-square-foot rudder from the yacht’s original builder. I selected Delta Marine to do

the refit because I had just used the company to extend *Skookum,* our 55-foot Nordlund, and I had great confidence in Chuck Albertson and his crew. *Starr* was hauled out of the water at Delta in Seattle on Oct. 1, 2000.

I established a two-week refit schedule for *Starr*. Chuck reviewed what had to be done and said it was extremely tight but it could be done. I was to be the project manager, so any foul-ups were my responsibility.

Starr's twin rudders are mounted on a "skate wing" extension, which was welded to the steel shoe for maximum stability and maneuverability. The refit doubled the square footage of the original rudder configuration.



Close-up views of the steering mechanism. Because the two rudders move as one, the controls are stationary in relation to each other. Hydraulic rams are attached to the steering posts.

On The Limitations Of Articulating Rudders…

By Ed Hagemann

The calculation of an 18-foot-by-7-second following sea wave was not intended to be taken as some precise line drawn in the sand. Rather, it was an oversimplified estimate of a following sea whose size and proportion could impose forces large enough to severely test the directional stability of a vessel in the 75-foot-by-100-ton class. Some lesser degree of threat would occur much sooner! It is important to recognize that the degree of threat caused by any one seaway to a boat of a given size is proportional to the inherent amount of directional stability that the boat does or does not have in the first place.

The directional stability of a vessel is like that of an arrow. To fly straight and true, an arrow has to have the equivalent of an appropriately sized set of tail feathers. Notice that the concept of directional stability is in the passive sense. That is to say: course-keeping is obtained by doing nothing. This is separate from having to actively counter external directional upsets. To the extent that instability uses up the rudder's steering authority, less of that total capacity is available to also counter outside forces.

Consider the behavior of a directionally unstable vessel in the absence of any disturbing wind or waves. With the helm centered and left strictly alone, an unstable vessel will spiral off into a turn and eventually settle into a turning circle whose diameter is constant. The size of this circle is a measure of the degree of its instability. Making this measurement in terms of boat lengths will allow this notion to be somewhat independent of the vessel's specific size.

It should be no surprise to encounter water jet boats that exhibit this characteristic where there is a complete absence of rudders, propellers, struts and shafts. Each of these components normally contributes to directional stability in that order of descending influence. This behavior will be particularly noticeable when traveling below planing speeds in a confined waterway. On some boats, the degree of instability is mild enough to escape casual notice, while on others a simple dock approach becomes quite difficult and demanding of piloting skills. In the extreme, this phenomenon will be accompanied by a great deal of sliding.

I've never encountered a jet boat that was truly directionally stable at lower speed. Whatever the degree of instability, the addition of appropriately sized and fixed appendages aft has always transformed the boat into one with quite benign and normal handling.

It can be proven that a vessel poised on a long following sea wave must meet a much higher standard in order to achieve passive directional stability. One can frequently encounter vessels that appear perfectly normal

Onward for the rudder refit!

We removed the original rudder, glassed in its old hole and set two new rudder penetrations at 34 inches apart, evenly centered behind the 50-inch, five-blade propeller. This configuration allowed both rudders to be centered in the main flow line of force from the propeller blades. The rudder bottoms were supported on two gull-like wings welded to the 1.5-inch steel shoe, which took on the look of a manta ray.

We had concerns about how to handle both the upward and downward forces on the extended keel shoe. In the event of the keel shoe being pulled down by being entangled in a net or cable, we needed to keep the rudders from coming out of the lower bearings. We also wanted to make certain that the rudders would not be pounded up through the bottom of the boat if the boat became hard-grounded on a reef or rock. Our solution was to make the rudder system into a strong, interconnected structure. Step one was to strengthen the rudder shoe by adding a 1-inch-by-6-inch vertical steel strut right on the centerline where the old rudder had been.

Next, following a practice common with Pacific Northwest salmon fishing boats, we added a crushable "fuse" in the 1-inch-by-6-inch vertical strut. The idea was to have a part of the structure designed to "give" or fail in a hard grounding, rather than driving the entire structure (including the rudders) into the bottom of the boat. For our fuse, we selected a 5-inch round section of stainless steel pipe, which was welded into the center of the vertical strut. The fuse was calculated to have a 15-ton crush load. The design would also allow the propeller shaft to be removed right through the

when tested in flat-water conditions, but yet turn around and become quite frightening handfuls when exposed to following sea conditions.

Whereas gravity forces are always aimed at a right angle to the earth's surface, buoyancy forces will always be found aimed at right angles to the surface of the water, not to the world! Consider then a boat that is poised on a wave whose length is substantially longer than the boat itself. Its buoyancy will now be tilted, and the interaction between vessel weight and tilted buoyancy leaves a residual horizontal force aimed in a down-wave direction. That force is exactly what propels our favorite surfboard, and its new appearance ultimately demands a new and higher standard of directional stability. Unfortunately, because this force is entirely absented in flat water, no flat-water test will uncover the fact that a demand for a higher standard even exists!

The simple addition of a third, centerline rudder to an existing pair on some twin-screw yachts has often been a cost-effective solution to this problem on boats possessing bad following sea manners!

It should be clear that the substitution of an articulated rudder for a conventional one does *not* cure the inherent problems of a directionally unstable vessel. Refer back to the flat-water test discussed earlier, when we used the common example of an unstable water jet propelled boat. Imagine, if you will, a conventional propeller boat that fails this test. Because dynamic stability is imbedded in the calculus on the rates of change during motion, a truly dynamically stable boat must pass this test with an untended helm. With a helm fixed at a zero angle, articulated and conventional rudders will behave identically. So it is in the more demanding following sea environment.

Do not interpret the above as a position opposing articulated rudders. Unquestionably, such a device has, square foot for square foot, far more authority than a conventional rudder, perhaps by as much as 40 to 50 percent. Its usefulness is unquestioned, and that is not the issue. The point is to be very clear about what one is trying to do, and why it is being done.

Recall that *any* rudder force that is used to correct a following sea instability introduces a roll moment that is adverse to the situation; that is, that moment is in the direction towards the wave trough. This is to emphasize the importance of a fundamental safety issue. Removing a rudder force made necessary by instability also reduces adverse rolling. Being adversely heeled over-aggravates the vessel's tendency to round up, and this scenario begins to snowball towards the classic broach.

Starr's rudder overhaul may have started a trend in the Seattle area. After witnessing the improved maneuverability evident in *Starr,* another area boat owner, Bill Buchan, had his *Saginaw Bay,* a sistership of *Starr,* fitted with a similar rudder system (above). A gold medalist Olympic yachter, Buchan is accustomed to having a boat that responds predictably and accurately to even the smallest adjustments.

pipe. To handle the load transfer through the hull bottom, we built an H-beam of fiberglass that was designed to handle an upward thrusting load of 40 tons.

Next we turned our attention to the hydraulic steering system. To handle the additional turning torque of two rudders, we added a second Hynautic K4 steering ram with the stops set for a maximum rudder angle of 45 degrees, fully 50 percent more than the previous 30 degrees. Other steering changes included Roberts FU-35 jog controls at all four steering stations and an Accu-Steer HPU200 hydraulic pump, both considered hydraulic workhorses by Pacific Northwest commercial fishermen.

After just over two weeks on the hard, *Starr* splashed and we left the Delta yard to sea-trial the new rudders. Creeping down the Duwamish River, dodging back and forth trying to avoid tangling in Muckleshoot Indian gill nets, the steering was squishy and we couldn't be certain there was a big change in the steering because there was still air in the hydraulic system–a result of having the system apart.

Under way in Elliot Bay, we purged the air from the system and ran the boat up to 9 knots. Wow! What a difference! We were able to execute a 180-degree turn in just over a boat length. By using the propeller, rudders and bow thruster simultaneously, at low speeds we could walk the boat sideways was ease. It was like handling a fin-keeled sailboat!

Coming back up the river with the air purged from the steering system, it became obvious that low-speed handling was vastly improved. We put the boat in neutral, traveling at 1.5 knots and could now make a full 90-degree turn, and then another 90-degree turn back to our original course–all while we were still in neutral.

Another benefit of twin rudders is the ease of control steering with an emergency tiller. When using a 6-foot tiller attached to the top of the rudder shaft, we found we could easily steer the boat by hand without using any other mechanical device. The force of the water from each side of the propeller has an equalizing effect on the rudders, so they are perfectly balanced. This ability to steer by hand is obtained by the proper hydrodynamic balance mentioned earlier. Ed Hagemann says that the rudderstock should be located 23 to 25 percent of the way aft from the leading edge.

Entering the basin at St. Martin de Re, France, on the northern end of Bay of Biscay. Here again, these waters are generally restricted to smaller boats.

Starr left Seattle in November, ran down to Mexico, then 2,600 nautical miles across to the Marquesas. From there, we ran down through the Tuamotus, Society Islands, Cooks and Tonga to New Zealand, in time to miss the cyclone season. Once settled in New Zealand, we realized that we had not spent enough time in the Marquesas and Tuamotus, so we returned 3,400 nautical miles from New Zealand the following April and did the islands all over again. That made the 2001 season a run of 7,800 nautical miles just to get a second look–and it was worth it.

We had Starr *shipped from New Zealand to Ft. Lauderdale, where my friend Milt Baker helped me move her from Port Everglades to a nearby marina. I put Milt on the helm while I used the cell phone to find a slip. "I expected* Starr *to handle just like a similar yacht I have experience with–slow, ponderous and just a bit unpredictable," Milt said. "But I was truly amazed how quickly and completely this big 75-footer answered her helm. I felt totally in control."*

A few days later, Sharry and I took Starr *out for a Ft. Lauderdale Sunday waterfront tour with Milt and his wife, Judy. In front of Bahia Mar, with Milt at the wheel, I asked him to slip the boat out of gear, drop down to 2 knots and put the helm hard over. He was amazed all over again. "This 100-ton, single-screw yacht did a 360-degree turn in little more than a boat length," Milt said. "If I hadn't just done it, I would not believe it!"*

In 2003, Sharry and I ran *Starr* across the North Atlantic to La Rochelle, France, via Bermuda and the Azores. The twin rudders are proving very useful, especially running up some of the rivers and canals where the harbors are both shallow and narrow. In our 25,000 miles of cruising aboard *Starr*, we have never had those 18-foot following or quartering seas and 7-second wave interval Ed Hagemann talked about. But I am confident that *Starr*'s new steering system will take them in stride when the time comes.

Update: *After seeing* M/V Starr *and her twin-rudder configuration, two other owners in the Seattle area made the same modifications to their long-range cruisers. One builder also is considering making the twin rudders its standard.*