THE REALITY OF 200-MILE DAYS ON A SAILBOAT

We regularly read reviews in the sailing press of 40- and 45-foot offshore cruising boats that are "capable of 200-mile days" and have seen quotes saying things like, "In the right conditions, any well designed modern 48 foot boat should achieve 8.33 knot [200 mile per day] averages." Other articles and books advocate 'larger' boats in order to maneuver with respect to weather systems. Yet low pressure systems can move at 20 knots or more and bring storm- or gale-force winds to areas within a couple hundred miles of the low center. Even good weather routers can usually only give accurate forecasts on the speed and direction of these systems 12 to 24 hours in advance of the storm. Therefore, these authors are assuming that these 'larger' boats can sail 200 miles in a day to get on the right side or to get out of the way of the approaching weather. Yet if we move from theory to reality, we have met only a few crews on cruising boats less than 50 feet who have made good 200 miles toward their destination in twenty-four hours, and only two crews on much larger boats who have averaged 200-mile days for the length of a passage.

Puzzled by this contradiction, we decided to gather some hard data to determine what it really took to sail 200 miles in a day and to average 200-mile days on long passages. Evans and I interviewed a dozen couples on boats ranging in size from 45 to 100 feet and analyzed the data from several Bermuda Races, ARCs (Atlantic Rallies for Cruisers), and the US Sailing's *Performance Characteristics Profile of the North American IMS Fleet.*

In calculating average passage speeds, we defined passage speed as the straight-line distance in nautical miles between two ports divided by the number of hours taken to sail that distance, so it includes time spent hove to or drifting and time spent motoring and does not add mileage for tacking upwind or downwind. A day's run, therefore, means the miles made good toward the destination, not miles sailed over the ground. We defined average as the average passage speed over at least 10,000 offshore miles of both tropical and temperate latitude passages. These are admittedly very tough standards, but they can be calculated in an objective fashion.

After analyzing all of this data, we came to four conclusions.

1. With very few exceptions, cruising boats just don't average 200-mile days. We found that while many cruising boats sail at ten, eleven or twelve knots for hours at a time, very few maintain an average speed of 8.33 knots for an entire day, and almost none do so for the length of even a short passage. Even all out, fully crewed race boats in the ARC and the Bermuda Race rarely make good 200 miles per day for the length of the race. In the 2002 Bermuda race, only two boats out of 123 (Table 1) averaged just over 8.33 knots or 200 miles per day along the relatively short 635-mile course, and they were 60 and 65 feet in length and racing in breezy, beam-reaching conditions. Three boats managed it in the lighter air race this year; all three were hot, new 86-foot Maxis with IMS ratings of less than 400 seconds per mile (9.5 knots). None of the 205 boats in the 2000 ARC, including a Whitbread 60, averaged 200-mile days over the 2,680-nautical mile course. In last year's fast, downwind ARC, only five boats managed it, and they averaged 70 feet in length and were all fully crewed race boats being pushed every minute, not short-handed cruising boats being sailed conservatively to prevent costly gear failures.

Table 1. Summary of ARC and Bermuda Race data

	2000 ARC	2003 ARC		2002 Bermuda Race	2004 Bermuda Race
Sample size	205	191		123	134
% of boats:					

<40 feet	28%	17%		8%	10%
40-49 feet	50%	63%		65%	61%
>50 feet	22%	20%		27%	29%
Average LOA (feet)	46	47		47	48
# averaging 200 MPD	0	5		2	3
Average LOA (feet)	-	70		63	86

When we move from fully crewed boats participating in rallies/races to short-handed cruising boats doing extended offshore passages, almost none averaged 200-mile days. Our interviews with other cruisers showed that experienced crews sailing monohulls with displacement to length ratios (DLR) over 300 average just over two-thirds of their theoretical hull speeds on long passages; while monohulls with lower DLRs average 70-80% (see sidebar for explanation of DLR). That's because average wind speeds even in the tropics are not enough to keep most boats moving at hull speed all the time, and short-handed crews tend to slow their boats down in heavy weather to prevent breakages. To average 200-mile days then, a moderate displacement monohull would need to have a minimum theoretical hull speed of 11 knots – which translates to 68 feet or more of waterline. To achieve regular 200-mile days on shorter waterlines would take a light displacement, high performance boat; good weather routing to avoid too strong or too light winds; and a crew willing to push the boat much harder than most, and to motor whenever boat speed dropped below 7.5 knots or so.

The real world bore out this conclusion. The dozen couples we interviewed sailed on boats averaging 60 feet in length. While two couples have averaged 200-mile days for the length of a passage, only one couple plans on doing it all the time. Steve and Dorothy Darden sail *Adagio*, a 52-foot Morrelli and Melvin designed catamaran with 49.7 feet of waterline. They have averaged 200 miles per day on several passages of less than 1,500 miles. They just completed two passages, the first from New Zealand to Tahiti and the second from Tahiti to Hawaii. On these longer passages, they averaged 185-190 miles per day. Claudia and Walter Plenk sail *Whirlwind XII*, a 125-ton, 103-foot cutter. She has a DLR around 120 and 92 feet of waterline, which means a theoretical hull speed of 12.9 knots or over 300 nautical miles per day. The boat's meant to be sailed by a crew of four in addition to the owners, but Walter and Claudia usually only take on a single crewmember to make passages with them. For provisioning purposes they plan on 200 miles per day as their minimum speed; they often sail 220 or more and the boat could probably make good 250 with a full crew. In the real world, then, it would seem to require at least a 75-foot monohull or a 55-foot catamaran to average 200 miles per day for 10,000 or more offshore miles.

2. In perfect conditions, cruising boats with less than 45 feet of waterline will only very rarely sail a 200-mile day, but those with over 50 feet will do so regularly. While most of those we interviewed with 50 feet or more of waterline believed their boats were capable of averaging 200-mile days for the length of a passage if they were fully crewed and had the right conditions, none of them had actually done it. But all of them had hit the magical 200-mile mark on occasion. David and Carolyn Parks on the Able Apogee 58, *Tara*, and Thomas and Pamela Howell on the Farr 58, *Imagine*, both have quite a few 200-mile days to their credit, and both have sailed 220 miles and more in a day. With a DLR of about 200 and 52 feet of waterline, *Tara*'s got a theoretical hull speed of 9.7 knots and a moderate displacement. David says, "She can do nine and ten knots, but we rarely run her that hard. We're comfortable doing sevens and eights, and we plan on 170 miles per day for provisioning purposes and usually do a bit more than that." *Imagine* has a 55-foot waterline and a DLR of less than 100, and when we went out for a day sail on her, she regularly hit 10 knots in moderate winds and flat water with minimal canvas. But the

Howells also plan on 160 to 170 miles per day when provisioning, and have averaged around 180. Crews on a Deerfoot 64, Bougainvillea 60, an Oyster 56, and a Dudley Dix designed 57-foot steel cutter all reported averages between 170 and 180.

Only a few boats with 45 to 50 feet of waterline consistently hit the 200-mile per day mark. The Santa Cruz 52, *Aquila*, cruised for the last six years by Janet and Ken Slagle has a 47-foot waterline and a theoretical hull speed of 9.2 knots. Her best day was broad reaching in 25-35 knots of wind between the Bay of Islands in New Zealand and Minerva Reef when she made good 224 nautical miles in 24 hours. While 200-mile days come fairly regularly aboard this light displacement 'cruising sled,' Ken says, "On the longer (over five days) passages, we probably end up averaging 160-180 miles per day toward our objective." To get this performance, they have to keep *Aquila* light and not load her down with a normal cruising payload.

He feels they could easily average higher speeds, but there are four reasons why they don't, and these were the same reasons cited by the crews of larger boats to explain why they didn't average 200-mile days. First, they're sailing short-handed, and have to keep the forces on a boat this size under control, which means sailing conservatively. "With a full crew, we'd probably add at least a knot to our average speed," which would take them up to around 195 miles per day on average. Second, they jibe downwind at slightly higher angles than are optimal in order to keep the sails full. "We have a huge asymmetrical spinnaker which we can sail down to a 150 degrees apparent wind angle, but in light winds we have to set the autopilot to steer 135-140 degrees to avoid the dreaded 'collapse/fill' scenario." Third, they avoid using the engine because they enjoy sailing and *Aquila* sails well. "If we're going in the right direction and there isn't a weather concern, we sail down to three or four knots of boat speed before we turn on the engine." Finally, they slow the boat down occasionally when the motion gets uncomfortable in big seas. "*Aquila* does pound when sailing upwind, especially if pressing hard. Downwind, the motion is pretty quick, not at all comfortable at times."

Those like us with 40 to 45 feet of waterline dream of hitting a 200-mile day, but very few succeed. In close to 80,000 offshore miles, John Neal and Amanda Swan-Neal have sailed a half dozen 200-mile days aboard their Halberg-Rassey 46, *Mahina Tiare III*. They run an offshore sailing school and most of those miles have been sailed with a full crew. John told us, "Our best day was 209 nautical miles… on a fabulous passage two years ago from Panama to Hilo. Our day's runs then were 201, 188, 203, 209, 190, 195, 200, 190, 198, 190 and then a little slower." With a bit over 43 feet of waterline, *Mahina Tiare* has a theoretical hull speed of 8.79 knots, which translates into 211 miles per day. Her performance demonstrates how difficult it is to find conditions that will allow a moderate displacement boat to sail at hull speed for 24 hours straight.

John and Amanda's experiences were typical of those who tried to cross the 200-mile per day threshold with less than 45 feet of waterline. Unless they're sailing ultra-light displacement boats (ULDBs) or catamarans, most cruisers need 50 feet or more of waterline to count on one or two 200-mile days on a long passage.

3. As a general rule of thumb, boat speed increases by a third of a knot for each five-foot increase in waterline length. All of these observations suggest that boat length has less of an impact on average passage speed than most people assume. All else being equal, a five-foot increase in waterline length, say from 40 to 45 feet, will increase the theoretical hull speed of a boat by about half a knot. That translates into a maximum of 12 extra nautical miles per day. In reality, the increase won't be that large because even racers don't sail their boats at hull speed all the time.

To figure out the real impact, we took the ARC and Bermuda Race data and grouped the entrants in each sample by five-foot increments in overall length (LOA), and then looked at their performance as a class. We found that aboard these fully crewed boats an increase of five feet in length overall resulted in an increase of three-tenths of a knot in boat speed – 7 nautical miles per day. These findings were consistent across a slow, light air ARC; a fast, downwind ARC; a fast, beam-reaching Bermuda Race; and a slow, light air Bermuda Race. (We used length overall because waterline length wasn't available, but it tends to average out to 90% of length overall across a large sample of boats. Our findings would theoretically be the same, therefore, if we used waterline length.) That would mean a 20-foot increase in overall length would result in an extra 30 miles per day on average.

4. A "back of the envelope" estimate of average passage speed can be obtained using waterline length and the sail area to displacement ratio. While our three-tenths of a knot for five foot of waterline finding was useful as a general rule, waterline alone didn't come close to predicting average speeds for specific boats. When the data were grouped by speed, we found boats of less than 35 feet averaging 150 miles or more per day and boats over 60 feet averaging 120 miles or less per day. To get a better idea of the factors that determine average speeds for a specific boat, we turned to US Sailing's data in the *Performance Characteristics Profile for the North American IMS Fleet* (see sidebar).

Using a statistical technique called multiple regression to analyze a random sample of 140 monohulls ranging from heavy displacement traditional designs to ULDBs, we examined the effect various boat characteristics had on rated speed as calculated under IMS. We found that waterline length (LWL) and the sail area to displacement (SA/D) ratio explained more than 95% of the differences in speed between different boats, and thus were the key drivers of sailing performance across the fleet. We ended up with the following equation:

IMS rated speed in knots = 2.62 + 0.066*SA/D ratio + 0.051*LWL in feet

This equation says that anything that looks vaguely like a modern sailboat can manage to make good 2.62 knots on average no matter what its other characteristics might be. This is reasonable in light of the fact that 'drift' speed seems to be between 1 and 2 knots: Hugh Vilhen averaged just under a knot crossing the Atlantic in 5'4" *Father's Day*, and Thor Heyerdahl and his crew of scientists floated from Peru to the Tuamotus at an average speed of just under 2 knots on the raft *Kon-Tiki*. Beyond that, IMS rated speed correlates to waterline length and the sail area to displacement ratio. An increase of five points in SA/D ratio, say from 15 to 20, will, on average, result in an increase of a third of a knot of boat speed (5*0.066=0.33) or 8 nautical miles per day; and an increase of five feet in waterline length will, on average, result in an increase of a quarter of a knot (5*.051=0.255) or 6 nautical miles per day, very close to what we found in analyzing the Bermuda Race and ARC data. Because it's based on IMS data, which assumes a certain wind profile, boats will do better than this average on breezy, downwind passages and worse on light air or windward passages.

When we started comparing the speeds predicted from this equation with actual average speeds obtained by the cruisers we interviewed, we were surprised to find a strong correlation. In most cases, this equation came within 5% of what people had actually averaged over the course of 10,000 or more offshore miles. That suggests that on average and over the long run, most cruisers sail their boats at close to their IMS rated speed. This relatively good performance probably reflects the breezy, downwind conditions along most of the trade wind routes.

While very much "back of the envelope," this equation gives some indication of how fast or slow a boat will be over the course of several thousand miles of offshore passage making. For example, it predicts an average speed of 143 miles per day for *Hawk* versus the 148 miles per day we have actually averaged over 35,000 nautical miles. For the Shannon 37, *Silk*, on which we completed a circumnavigation and sailed about the same number of miles, it predicts 126 miles per day versus the 118 we actually averaged. All but one of the dozen or so boats (including catamarans) we've been able to get reliable data for have ended up within 7% of the speed predicted by this equation.

These results demonstrate the difficulty of averaging 200 miles per day on a monohull. The equation predicts that with a SA/D ratio of 30, you would need 70 feet of waterline to average 200-mile days, and with a SA/D ratio of 20, it would take 87 feet of waterline, consistent with the figures we arrived at through interviewing other cruisers and examining the ARC and Bermuda race data.

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In the real world, then, to count on crossing that magical 200-mile day mark once or twice on most passages, you'll need a minimum of 45 feet of waterline if you get a light displacement (less than 100 DLR) catamaran or monohull and keep the weight off it. For a moderate to heavy displacement boat, you'll need at least 50 feet of waterline. To average 200-mile days over long passages, you'll need a minimum of 75 feet of waterline on a monohull and 55 feet on a multihull – well beyond the means of most of us.

SAIL AREA TO DISPLACEMENT AND DISPLACEMENT TO LENGTH RATIOS EXPLAINED

Over the years, naval architects have created various ratios designed to quantify different aspects of yacht performance, two of which are referred to in the article: the displacement to length ratio (DLR) and the sail area to displacement (SA/D) ratio. Table 2 summarizes the formulas to calculate these and provides typical ranges.

Table 2. Calculation and range of performance ratios

Ratio	Formula	Range
Displacement to Length (DLR)	$(D/2,240)\div(0.01xLWL)^3$	From about 50 (very light) to above 450 (very heavy) for the boat's length
Sail Area to Displacement (SA/D)	$SA\div(D/64)^{2/3}$	From about 12 (little sail area) to about 35 (lots of sail area) for the boat's displacement

D = Displacement in pounds
LWL = Length at the waterline in feet
SA = Working sail area, defined as total area of main and mizzen (including roach) plus area of foretriangle (ignoring any jib overlap), in square feet

The displacement to length ratio (DLR) is a non-dimensional number that measures wave-making drag by quantifying how many long tons of water the boat displaces for each foot of waterline length. A high value means that the boat must move a great deal of water out of its way for its length, and its speed will be constrained by that length. Low DLRs means low wave-making drag, which means that in the right conditions the boat can surf. High DLRs correspond to comfort and load-carrying ability and low DLRs to speed.

The SA/D ratio is a non-dimensional number that roughly corresponds to the power-to-weight ratio for a car. It quantifies how much sail area the boat has for each cubic foot of water the boat displaces. A high ratio means the boat will perform well, particularly in moderate to heavy wind conditions where friction is less important than wave-making drag in determining speed. High SA/D ratios correspond to agile, responsive boats under sail, and low SA/D ratios, particularly below 15, mean sluggish, under-canvassed boats.

Unfortunately, comparing different boats using these ratios can be problematic due to a lack of consistency in reported numbers. Boat builders tend to overstate sail area and understate displacement in order to make the ratios look better. To ensure consistency, the equation in the article is based solely on data from US Sailing's *Performance Characteristics Profile of the North American IMS Fleet*. This booklet gives actual measurements for every boat that has been rated under the IMS racing rules in the United States. It tabulates these measurements, computes DLR, SA/D, and a variety of other ratios for each boat, and provides useful stability data. IMS follows the definitions shown under Table 2 for waterline length and working sail area, and these are pretty easy to calculate for any boat. IMS displacement is the actual displacement of the boat in IMS measurement trim, which means set up as it will be raced with at least two batteries, 275 pounds of ground tackle, and basic safety equipment, but with empty tanks and no stores. Boats of the same design can vary in displacement by several thousand pounds depending on whether or not they have roller furling, radar arches, generators, and so on.

To calculate the equation shown in the article, use IMS data if the boat you're interested in or a similar sistership has ever been measured. Otherwise, use the manufacturer's published numbers, but assume the answer you get will be less accurate, perhaps within 10 or 15% instead of less than 7%.