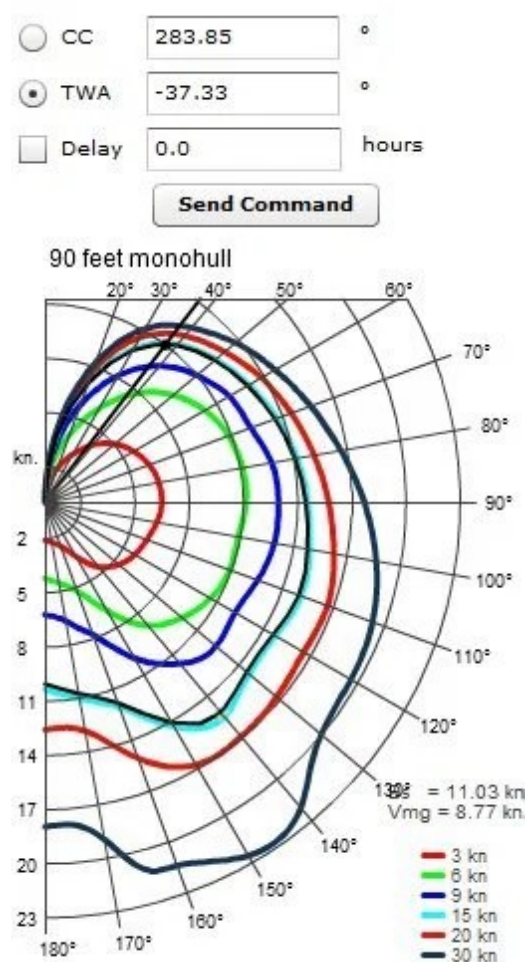


## Polar diagrams – VMG

### Polar diagrams – VMG

17 10 2009

Our sailing “Polar” is a diagram showing boatspeed across a range of wind angles and wind speeds, displayed in polar coordinates. Angles are measured relative to the wind, and shown as “true wind angle” or TWA. Speed is plotted radially outward. Polar diagrams for sailboat performance always show a heart-shaped curve, since we can’t sail directly into the wind.



sailonline.org on-screen polar for a 90 foot monohull

At left is the on-screen polar as displayed by sailonline.org. Straight lines radiate from the origin at 10-degree angles starting from 0° directly into the wind showing the TWA. Boatspeed for different wind strengths are shown by the curved coloured lines, and an additional black line and angle are displayed showing current conditions. The shape of the lines can show how the boat’s performance varies as it changes sail, can carry downwind spinnakers or reaches surfing or planing speed.

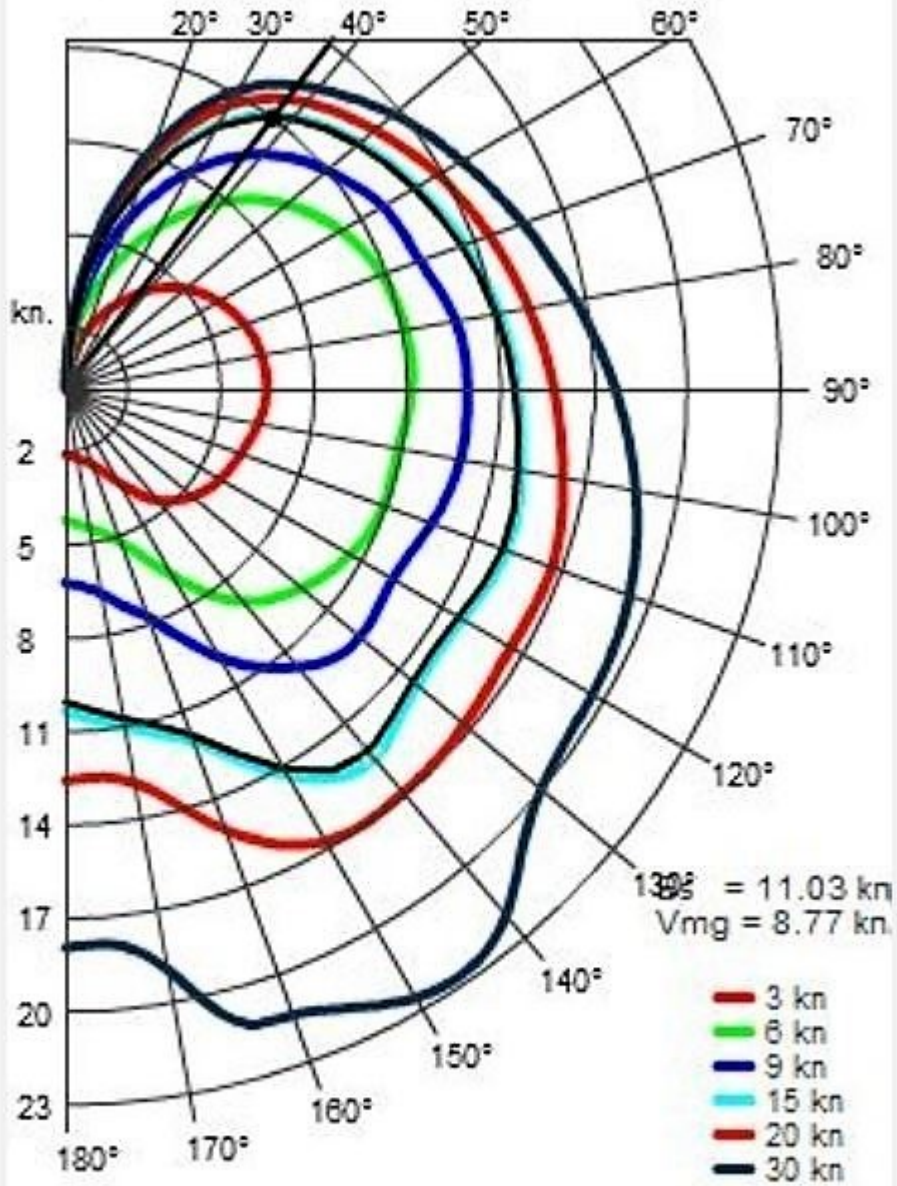
We can use the polar diagram to determine the best angles to sail. One of the first

things that most sailors are taught is that sailboats need to tack upwind, and almost invariably the angle used to demonstrate is  $45^\circ$  – a pretty safe starting point. We quickly learn that pointing too high or sailing too far off the wind is a slow way to get to windward, and before too long figure out how to read the luffing of headsails or the behaviour of tickler or telltales to make sure that we are sailing the best angle. In reality, we aren't sailing  $45^\circ$  anymore, but constantly adjusting our angle to the wind as conditions change.

We can't use sailtrim as a way to pick angle in virtual sailing, but the polar diagram shows us the effect of pinching or footing, and we can use it to pick upwind angles across the whole range of windspeeds. If we are trying to get to windward on a beat, it stands to reason that the best angle is the one that gets us there first. On a polar, the vertical axis shows the speed that the boat is making into or away from the wind, "Velocity Made Good" or VMG. This is the upwind component of speed that you average toward the windward mark after all the tacking has been taken into account. To find the maximum VMG, you just pick the point furthest forward on the polar – in the example diagram, this is shown by the black dot at TWA 37.33 and speed 11 knots. Best VMG for the 90 foot monohull in close to 15 knots of wind (the cyan curve) is 8.77 knots. If we point any high than this, we'll be pinching, and sailing slower. If you foot a bit (sail a little further off the wind), boatspeed will be higher, but distance sailed will be longer and the angle will work out slower in the end.

We use VMG the same way on downwind legs. The point on the curve furthest to the bottom of the graph is the fastest way to get downwind for the current conditions. Most boats that can fly extra sail off the wind gybe back and forth to maximise speed downwind. For our 15 knots of wind – the best VMG downwind will be around  $145^\circ$ .

### 90 feet monohull



sailonline.org on-screen polar for a 90 foot monohull