Sail Area/Displacement Ratio. A Useful Way to Compare Cruising Dinghies, by Martin Corrick

When I bought my Topper Cruz, *Foxy*, I was initially surprised by her relative lack of stability compared with my previous cruising dinghy, a Cornish Cormorant. I had sailed a Cruz before and had not found it particularly 'twitchy' – but that was two-up, whereas I sail my own boat single-handed. Not being a particularly brave or agile sailor, I began thinking about small boat stability and the related questions of displacement and sail area.

There are obvious differences between the two boats. The Cruz is about 1.5m longer and 15kg lighter than a Cormorant, and its sail area is nearly three square metres greater. The Cruz has strongly flared topsides, producing a maximum beam even greater than that of the tubby Cormorant, but its waterline beam is much narrower. These are substantial differences, and it's easy to guess that the Cruz will be more 'tippy'.

But that's just a guess. If one is choosing a small cruising dinghy, it would be useful if its characteristics were assessed scientifically rather than by guesswork.

A number of factors are relevant to the calculation. The most significant are the all-up sailing weight of the boat (its 'displacement'), its overall beam, its length (increases in beam and length both make a boat more stable), and its sail area. These four factors have long been considered in comparisons of heavy displacement sailing boats, sometimes by means of the 'sail area/displacement ratio', or SA/D.

Of course a degree of caution is needed in applying a formula designed for boats displacing several tons to small boats which, even when fully loaded, displace much less than a quarter of a ton. The 'payload' that a displacement yacht carries (crew, stores, fuel, etc.) may not have a very significant effect on its displacement, but the displacement of a dinghy can easily be doubled by the weight of its crew and their gear. This means that SA/D ratios should only be used to compare boats of a similar size and type.

We also need to use a constant value for the normal weight of crew and stores. For instance, we could assume that the mass of a single crew with weekend stores was 100kg, or 180kg for a two-person crew. It doesn't matter whether these values are exactly right; what matters is that we use the same value in all the boats we are comparing.

Several SA/D calculators can be found online. I used one provided by the Canadian Nepean Sailing Club, which can be found at **http://nsc.ca/nsc_library/tools/boat_metrics.htm**. The site allows calculation in metric or Imperial units.

The table shown on the next page contains the basic data for eight cruising dinghies of the type often sailed by DCA members, including the Cruz and the Cormorant. The NSC online calculator has produced the values in the last three columns, maximum hull speed, SA/D and for what is called 'motion comfort'. Values in the table are metric except for the SA/D ratio itself, which is a 'dimensionless' number.

Note that I have chosen to increase the displacement by a standard 100kg for crew and stores in all cases. I have entered a value of zero for 'ballast', because I suspect that this calculator, intended for keel boats, will assume that the ballast is well below the waterline – not the case with a dinghy, of course. To produce comparable figures for your own dinghy, you should follow the same principles.

The Cruz: perhaps not as stable as Topper claimed? *© Topper International*

Type	LOA	LWL	B	EWt	SWt	SA	V	SA/D	MC
Mirror	3.3	3.1	1.39	63	163	6.5	4.3	22.2	6.6
Corm-orant	3.7	3.6	1.7	160	260	8.17	4.6	20.4	7
Enter-prise	4.04	3.8	1.6	94	194	10.5	4.7	31.9	5.3
Roamer	4.26	4	1.8	272	372	9	4.9	17.7	8.3
Wand-erer	4.3	4	1.8	130	230	10.7	4.9	29	5.1
Cruz	4.58	4.5	1.82	145	245	11	5.1	28.6	4.9
Way-farer	4.82	4.5	1.86	168	268	13.1	5.1	32.1	5.1
Dras-combe Lugger	5.72	4.6	1.9	340	440	12.26	5.2	21.6	7.5

Notes on the table: The boats are listed in this table in order of **LOA**. Units are metres, square metres and kilograms, with speed in knots. **LWL** is the estimated waterline length. **EWt** is the boat's empty weight as given in its specification. **SWt** is a notional 'sailing weight' – the empty weight plus 100kg, representing an average weight male crew member (80kg) plus 20kg of stores. The Roamer's 70kg of fixed ballast is included in its displacement, but no other boat has provision for ballast as standard. **SA** is the sail area as given by the manufacturer. **V** is the maximum displacement speed as given by the NSC calculator. **SA/D** is the calculated sail area/displacement ratio for the boat at the given sailing weight.

The formula for SA/D is the sail area divided by the displacement (strictly, the displaced volume) and raised to the power of 2/3 to give a dimensionless number which can be used to compare boats of different sizes. It originally employed Imperial units, but the NSC version can accommodate metric values. **The lower the figure, the greater the boat's stability.**

MC is a measure of 'motion comfort'. **The higher the value, the less violent is the motion experienced by the crew.**

The table shows that the SA/D values for the Cruz (28.6) and the Cormorant (20.4) are radically different – indeed, they are almost at opposite ends of the range shown here. Yes, the Cruz is much tippier than the Cormorant! In that respect, at least, the SA/D value supports my own impressions.

According to these calculations, the ballasted Roamer is far and away the most stable of these boats, with an SA/D of 17.7, and that is what one would expect. The rank order of stability, starting with the stiffest boat, is: Roamer, Cormorant, Drascombe Lugger, Mirror, Cruz, Wanderer, Enterprise and finally the Wayfarer.

Now it's obvious that one must use this kind of data with care. Some of my figures are estimates – LWL, for example, is rarely specified for dinghies. A major factor is crew weight. I have used a constant figure of 100kg, but it would be relatively unusual for a large cruising dinghy – a Wayfarer, for example – to be crewed by a single person. If we add another 60kg for an additional average weight female crew member, the Wayfarer's SA/D changes to 28.0, which is close to the SA/D of a single-handed Cruz. If we add the same 60kg crew to the little Mirror, its SA/D falls to 15.3, making it more stable than a Roamer ... !

I own a Cruz, have taught sailing in Wayfarers and Seaflys, and have owned an Enterprise, two Cormorants and a Drascome Lugger; my father had a Wanderer and close friends had a Mirror – so I have sailed the majority of these boats. I think that the 'ranking order' given by SA/D is much as I would expect. The only curious figure generated by the calculator is the maximum speed predicted for the Lugger; its very short waterline, heavy displacement and inefficient rig made it the slowest small boat that I have ever sailed, certainly much slower than the Cruz.

So experience suggests that SA/D might well be used as a fairly reliable indicator of the cruising performance of small sailing dinghies. Of course its reliability isn't proven – that would require a more careful study than this quick survey. But it does look as though the SA/D value should be considered when choosing a small cruising dinghy, and in judging the effects of adding ballast and/or changing the sail area.

Stability experiments with a Topper Cruz

In its normal state – i.e. without additional ballast or heavy equipment aboard – it is not possible for me to stand on the gunwale of my Cruz without submerging it (I weigh about 80kg). Experimenting with bags of sand, I found that 100kg distributed around the centreboard case reduced the roll to about 18 degrees. Half that amount still made a useful improvement, reducing the roll to around 25 degrees, with the gunwale still clear of the water. Recently I have been experimenting with water rather than sand ballast, and have found that a mere 30kg (i.e. two 15 litre water bags) makes a very useful improvement in stability, both in the lateral direction and fore-and-aft. Fore-and-aft stability is important for a knockabout cruising dinghy, since one often has to clamber to the extreme ends of the boat, or get aboard over the bows.

Of course the additional stability is also useful when sailing in breezy conditions. Not only does the ballast improve the lateral and fore-and-aft stiffness of the boat, it also increases its overall inertia, so its motion is less lively. Since the single-handed dinghy sailor often gets near the limit of multi-tasking – simultaneously fumbling for a chart, keeping watch on an approaching ship and sailing the boat in a tricky sea – extra stability is very useful.

How much ballast is required to bring the Cruz to the same SA/D as (say) the Cormorant? According to the NSC calculator, adding another 40kg gives an SA/D of 25.8, and adding 100kg gives 22.8 – this is getting down towards Mirror levels of stability, but still doesn't reach the Cormorant's stability. Indeed, the Cormorant, with its thick, heavy GRP hull, puts one in mind of the previous generation of small wooden working boats that once were so common in our harbours and rivers. In those days a sixteen-foot dinghy could easily displace several hundred pounds, and hence they made excellent working platforms for all sorts of marine activities.

However, using ballast is not the only way to increase sailing stability: we could also reduce the sail area. That is what I have done when re-rigging my Cruz with lugsails; the new sails are about 12% smaller and are also rigged on much shorter masts, so their centres of effort are lower. With water ballast and smaller sails, *Foxy* is a much more stable boat.

It seems to me that a lot work remains to be done on the factors that make for a good cruising dinghy, and it is about time we started using a more scientific approach. One of the interesting numbers produced by the SA/D calculator is that the maximum displacement speed of all the boats is rather similar: the laws of physics determine that all small boats of between 3.5 and 5.5 metres in length will have a maximum displacement speed between 4.3 and 5.2 knots. This suggests that, when designing a cruising dinghy that is not intended to plane, it's not worth worrying about achieving high speeds, as most small boats travel at about the same speed. However, the stability, handling and sheer practicability of such boats are much more variable, and the differences are well worth investigating. **MC**

The well-built, well-appointed CRUZ. A boat worth improving, especially now that it is no longer made and secondhand prices seem to have fallen as a result. Plenty of room for the secure fixing of ballast under the thwart. *© Topper International*