Boat and Crew Weight Observations and Recommendations - Bob Smith

The SFBKA Technical Committee asked me for some general observations about the performance effects of different types of added weight after reviewing boat weight data provided by Technical Committee and summarized below. To that end, the following are my thoughts and observations. I hope this will be useful to the fleet as it continues to discuss options to ensure fairness and increase participation in the Knarr class.

BOAT WEIGHT DATA (13 wood and 7 glass boats as of October, 2023)**:**

Class minimum weight per rules (incl. rig):	5017 pounds
Wood boats' range of "overweight-ness":	248 lbs-593 lbs
FRP boats' range of "overweight-ness":	0 lbs-183 lbs
Pounds per inch immersion:	475 lbs/inch

HISTORICAL:

I'm guessing the scantlings of first FRP Knarrs were designed so that they would have equal weight as the original wood boats. Because the FRP hulls would be lighter, and the FRP decks would be slightly heavier, the rule weight of the new keel for the FRP boats was set at 44 pounds heavier, so that the resulting stability of the FRP boats would be the same as the wood boats.

To see if this were true, I did an approximate weight study of both types of construction:

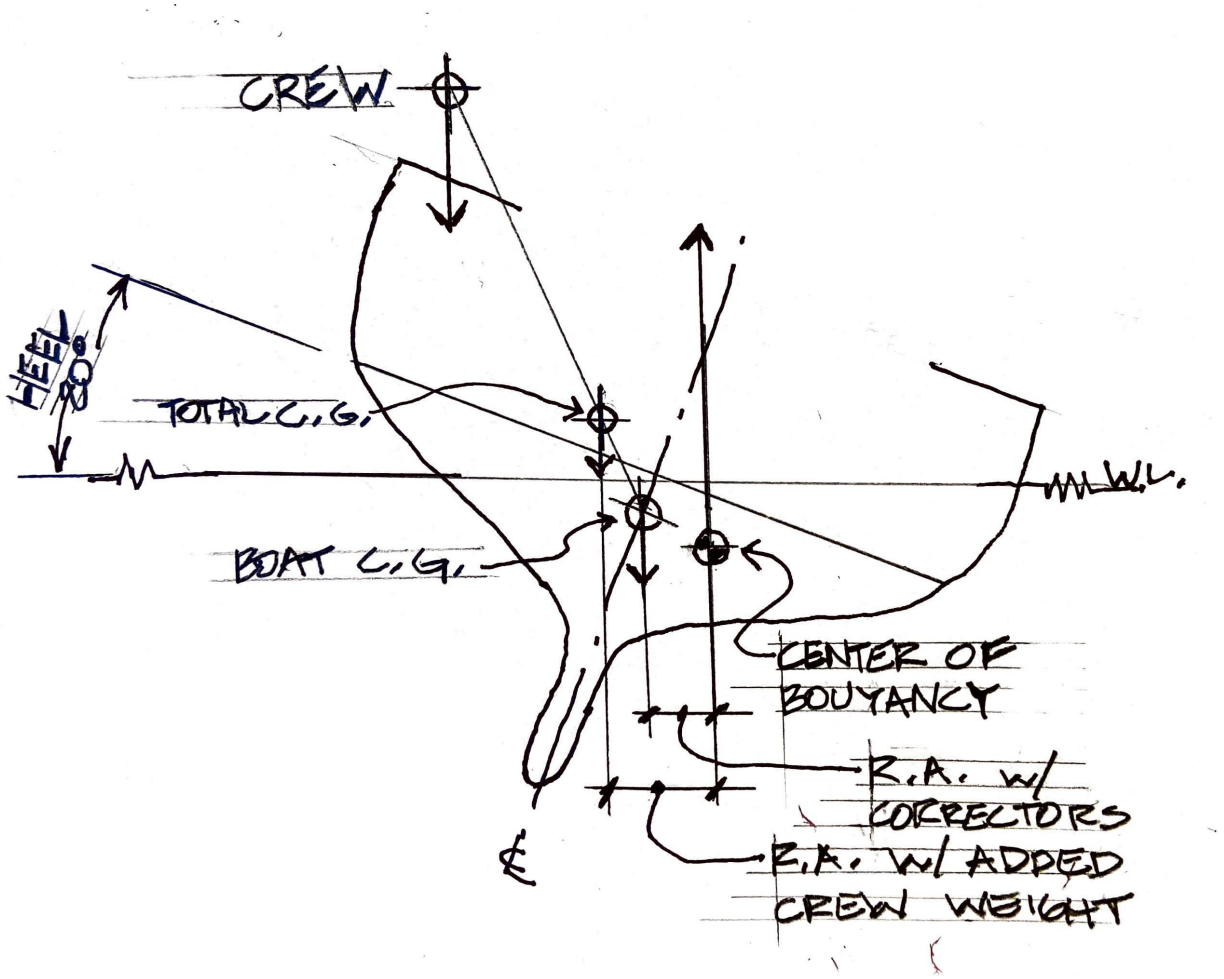
	WOOD BOAT	FRP BOAT
Hull & Structure	940	745
Deck & Structure	370	382
Keel	2821	2865
TOTAL	4131	3992
Difference	+139 pounds	

The designers did a good job; the FRP construction is calculated to be only about 139lb lighter. My guess is that the greater weight overage discovered by weighing the wood boats is from soakage, repairs, and equipment add-ons.

DISPLACEMENT:

A heavier Knarr, IF IT'S CENTER OF GRAVITY IS IN THE SAME LOCATION, will be faster upwind and reaching in a breeze, and slower in light air. It will always be slower downwind. Nothing new here. We have all observed this in the Knarrs.

It seems to be in vogue to say that a heavier boat has a longer waterline. This is a mis-conception and we shouldn't keep repeating it. The waterline length increase will be small. It has negligible effect on increasing the distance between the bow and the stern waves. (With boats that have wider stern sections, more weight aft would increase waterline length by pressing these wide aft hull sections into the water. But the fine rear end of a Knarr does not significantly increase the waterplane length when heeled.) What it does do is increase stability.



STABILITY:

Boat weight and *crew weight*, are the big ones. Stability is defined as "the restoring force acting to resist the heeling of a yacht". It can be calculated:

RIGHTING MOMENT = WEIGHT times RIGHTING ARM = DISPLACEMENT times DISTANCE (to leeward between the boat CG and the center of heeled flotation)

So if weight is added as ballast *in the same location of the boat's original CG,* the stability will increase in proportion to the total displacement increase. For example, 250 lbs added weight would increase the DISPLACEMENT of a Knarr by 5%. It would NOT increase the RIGHTING ARM, but the RIGHTING MOMENT would increase by that 5%. (If that weight was added above/below the boat's CG, the RIGHTING ARM would be shorter/longer, and the resulting stability would be less/more.)

LIGHT AIR vs HEAVY AIR:

Heavier boats/crew have an increased wetted surface, which is why heavier boats are slower in light air, in addition to the additional inertia they have to overcome to accelerate more slowly up to speed. But frictional resistance due to wetted surface is only a large component of the total boat

resistance at slow speeds (read: light air). The component that is the major factor at hull speed where Knarrs normally sail in SF Bay is wave making resistance; which is determined by hull length and shape.

CREW WEIGHT:

Has an even bigger effect on stability because it increases both the WEIGHT and the RIGHTING ARM. So if the added weight was in the *crew*, both the WEIGHT and the RIGHTING ARM would increase. For a Knarr, the result of adding 250# to the crew would be about a 10% increase in stability, *twice the effect that of weight in ballast alone*.

As you can see, crew weight and boat weight are irrevocably tied to each other. That's why strict one-design classes have both minimum boat weights and maximum crew weights.

WHAT TO DO?

To make all Knarrs completely equal downwind, you would make all boats weigh the same.

To help make all Knarrs more equal upwind, you would need to impose a maximum crew weight limit similar to other one design classes.

One option would be to consider a crew weight limit of, say, 750-800 lbs based on the weight of crew on the rail (i.e., crew weight in the cockpit or companionway would not be counted) and a 220 lb. increase in the minimum boat weight. While adding 220 lbs doesn't equalize the weight of all boats, it reduces the delta and would reflect the fleet's desire to maintain the relative competitiveness of the wood boats, which is in the long-term interest of owners of glass boats as well as wood boats. This approach also addresses both upwind and downwind speed differences and requires both light and heavy boast to give up something. It also could be adjusted year to year as you learn from the on-the-water experiences.

The fleet could also try to solve both of these issues at the same time with some sort of calculation for *each* individual boat that says their crew weight limit depends upon how much their boat is overweight. A heavier boat would have a lower maximum crew weight, and a lighter boat could have a higher maximum crew weight. That could equalize the stability of the light and heavy boats. But the problem is that the heaviest boats in the fleet now have the heaviest crews, and to make their total weight close to that of the lighter boats, their maximum crew weight would have to be ridiculously low.

In the end, I realize we've not "solved the problem", but more equalizing the boat weights should be done to make the fleet more one-design. Then implementing a maximum crew weight will make the racing more fair.

Best Regards,

Bob