How to Evaluate Boats?

So you are in the market for a boat. Hundreds of boats are sold every year and every salesman has his or her own sales pitch trying to perswade you in the brand they are selling. If you have the time on your hand to comparison shop, I have a few of useful computational tools to help making a comparison between boats.

These numbers are nondimensional and can be applied to any size of boat. If using these tools, don't let the spraed between boat sizes get too large otherwise the comparison will be distorted. Try to keep a maximum range of about 2.4 – 3m between the smallest and largest boat you compare.

SPEED –LENGTH RATIO

The speed-length (S/L) ratio is derived from the Froude number.
Froude Number ? William Froude done a number of tests on thin planks in the 1890's. Froude discovered that a boat's speed tops out when the wave it is creating has the same length as the boat's waterline in a displacement mode. I have touched on this a bit in my previous article of Leisure boating explaning the different modes of planing.
The equation for S/L is :

$$\frac{boatspeed(\,knots\,)}{\sqrt{Waterline}}$$

An S/L of less than 1.5 shows that the boat is in displacement mode.
Between 1.5 and 2.5, the boat is operating in a semidisplacement mode.
Above 2.5 and sometimes even higher, the boat is in planing mode.

DISPLACEMENT –LENGTH RATIO

Calculate the boat's displacement-length ratio by dividing the boat's displacement in pounds by 2240 to get long tons. Divide this figure by one-hundredth of the waterline length (ft) cubed. In other words, the ratio is:

$$\frac{displacement\,/\,2240}{(\,Lwl\,/\,100\,)^3}$$

If the weight of the boat is 8500 pounds(3856 kg) and the waterline is 31ft (9.5m), the displacement length ratio equals:

$$\frac{8500\,/\,2240}{(\,31\,/\,100\,)^3} = \frac{3795}{0.03} = 126$$

In general, the higher the number, the heavier the boat for its length and the slower it is. At sea, the heavier the boat, the likely to handle waves better than a similar lighter boat. Planing hulls are in the 130 to 220 range whereas trawler hulls are above 300. Semiplaning boats are typically between 225 and 300.
Don't fall into the trap of lightweight numbers. Many buyers fall for the trap that "heavy" boats are a draw back and so many salespeople use the comparison to sell their product using the words "our boat is so much lighter than our opposition. You as a buyer need to ask yourself the question –

How much boat do I need in terms of displacement?

Simply take the total weight of crew and stores you'll carry and multiply it by 7.5. This is the reciprocal of 8 percent times 60 percent loading – [(1/0.08) x 0.6] = 7.5. The answer is displacement you'll need plus or minus 10 percent.

Let's calculate the displacement required for a Cruiser, Crew of 4 on an ordinary 10 day vacation:

4 x 72kg = 228 Crew
4 crew x 10 days x 6.6kg/day x 1.5 reserve = 396kg food and water
4 crew x 10 days x 2.3kg/day = 92kg personal gear
TOTAL: crew, food, water, personal gear = 776kg

776kg x 7.5 = 5820 kg displacement
Plus or minus 10% = 5240kg – 6040kg displacement boat required.

LENGTH-TO-BEAM RATIO

The length –to-beam ratio gives an indication of how long the boat is relative to its beam and allows you to compare two boats of different size.

$$\frac{Length(LOA)}{Beam(BOA)}$$

For example, comparing a 50ft (15.3m) cruiser with a 12ft (3.7m) Beam to a 40ft (12.21m) cruiser with a 10ft (3m) beam.
We find that the larger boat has a length-to-beam ratio of 4.167 whilst the smaller boat has a ratio of 4.
This just show that for it's length, the smaller boat has more beam. A smaller ratio indicates a boat with greater transverse stability, making it a better for trolling or drifting in beam seas.

POWER-TO-WEIGHT RATIO

When I design a boat, I use the power-to-weight ratio to indicate whether the boat has sufficient horsepower for its weight. The ratio is:

$$\frac{Horsepower}{Displacement}$$

This is merely an indicator of the amount of horsepower a boat needs to push its own weight through the water. When comparing boats, make sure that you use the same horsepower number whether its is brake horsepower (bhp) or shaft horsepower (shp).

CUBIC NUMBER

This is a good way to compare two boats of different size.
Multiply the waterline length by the boat's beam and depth (from bottom of the hull to the deck edge), you get a cubic number (CN).

$$Lwl * Beam * Depth = CN$$

For example:
Boat 1 is 30ft (9.14m) on the waterline and has a maximum beam of 10 ft (3.04m) and a depth of 6 ft (1.83m) and therefore a CN of 1800 ft^3 (50.9 m^3)

Boat 2 is 34ft (10,36m) Lwl, a beam of 11ft (3.35m) and a depth of 7ft (2.13m) and therefore has a CN of 2618 ft^3 ($73.9m^3$).

By dividing the CN of the first boat into the CN of the second boat, you can see that the second boat is 2618 / 1800 = 1.45 (73.9 / 50.9 = 1.45) as large as the first boat. In other words it is 45 percent larger and all other things being equal, should cost more to buy and maintain.

COMFORT RATIO

This is a measure of motion comfort between boats of a similar size and type. It is based on the fact that the quikness of motion or corkiness of a hull in a choppy sea is what cause discomfort and seasickness. The corkiness is determined by two factors:

1. The beam of the hull and 2. the area of the waterline.

The formula is as follow:

$$\frac{Displacement}{65x(0.7Lwl + 0.3LOA)xB^{1.333}}$$

Displacement is measured in pounds and the Lwl and Loa in ft.

Lightweight boats and smaller yachts that have a higher Beam/length ratio will rate poorly on the comfort scale while as we would expect, heavy oceangoing cruisers rate more favorably. The ratio ranges from 10 or less for lightweight day cruiser to thehigher 50-60 such as a old sailing pilot boat. Average ocean cruisers come up somewhere in the mid 30's.

PRISMATIC COEEFICIENT (Cp)

The prismatic coefficient is the ratio of the largest underwater section of the hull multiplied by the hull's waterline length, to the volume of the displacement of the boat.

$$\frac{Displacement}{AmidshipsArea * Lwl}$$

To simplify, if you took a block of wood, the length of the waterline and shaped to the underwater portion of the midships section, then carved it away to model the ends of the boat, the Cp is the remaining percentage of the original midships-shaped block. See fig.1

The optimum Cp ratio varies in direct proportion to the hull resistance and the boat speed. Designers use their experience and knowledge of other designs to select the best Cp for the style and speed of the boat they design.

The Cp of a powerboat hull should become higher as boat speed increase. Obviously, the fastest boats is not a barge which have a Cp of 1.

A typical displacement boat has a Cp of around 0.55 – 0.65.

A high speed deep V hull can have a Cp as high as 0.75, Put in another way, the planing hull needs to be fuller at the ends – especially aft – to develop dynamic lift.

Now you have some tools to evaluate boats of more or less the same lengths. Hope this make your decision easier.

About the author - Kobus Potgieter

Kobus started in the inflatable boat industry 22 years ago. He was the first manufacturer of locally produced inflatable boats in South Africa. Through this company he and a few friends started the Trans Agulhas race, which led to a design revolution in the industry altering designs to have less resistant and smoother ride.

In 2002 he decided to stop manufacturing boats and rather focused his energies on Boat Design, specialising in the design of Ribs, by taking studies in Naval Architecture. This led to him establishing his new company Kobus Naval Designs which creates value through a combination of his practical experience and theoretical knowledge. He was appointed as the Principle Designer for Zodiac International for the design of a range of boats which will be launched in 2007. He has worked at various manufacturing plants within the Zodiac group, primarily focusing on the manufacturing of Military/ Professional Boats. Further, he has designed boats for companies in Dubai, Denmark, Sweden, Germany, India and France, some of which was done in collaboration with Volvo Penta and Rolls Royce.

Relocating back to his homeland with his wife Alyson in January 2006, he started his latest venture, Proxyz Systems, aimed at completing the design cycle through the production of prototypes, plugs and molds for his clients. This is the introduction of the first 5-Axis Robotic CNC machine into South Africa which have the ability to computer controlled cut designed products at a scale of 1 to 1 out of various materials with precision.

Kobus is a member of:	Royal Institute of Naval Architects (UK)
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