- HYDROSTATIC DATA -

Jet Tern Marine publishes detailed specifications for all of the Selene Trawlers. Most of the published specifications are pretty obvious, providing key dimensions for the Trawler, such as LOA: Length Over All.

There is also a wealth of information in the hydrostatic data, but the definitions of many of these terms is not as widely understood, let alone their significance to the performance of the vessel.

This technical note will define the key hydrostatic specifications and provide a brief discussion of their significance. We can't possibly cover these specifications in any detail here, so considerably more detailed discussion is available in the references listed at the end of this article.

◊D/L Ratio

D/L Ratio is the ratio of the displacement of the vessel to its length. The formula for D/L ratio is:

$$D/L = \frac{D}{2240(.01L)^3}$$

Where: D = Displacement in pounds
L = Length of the waterline in feet

Displacement is the weight of the water the boat displaces in pounds—which is essentially the same as the weight of the boat. In this formula, the division by 2240 is to convert the weight in pounds to « long tons ». The length (L) in the formula is the waterline length of the boat in feet—the length of the boat measured along the water surface, which is typically considerably shorter than the overall length.

Heavier vessels of the same length have a higher D/L ratio. There is no single « right » D/L ratio, but a heavier vessel will typically be able to carry more fuel and provisions and will have a more comfortable motion at sea. Capt. Robert Beebe, in his classic *Voyaging Under Power* recommends a D/L ratio of at least 270 for a 50-foot ocean-capable vessel. D/L ratio may be somewhat smaller for larger vessels, since relatively small changes in waterline length have a large effect on the D/L ratio.

◊A/B Ratio

A/B ratio measures the ratio of the side-view area of the vessel above the water to the side-view area below the water. For stability and sea-worthiness, this ratio should be as small as possible, since more area above the water means more area on which wind and waves can exert pressure to capsize the vessel.

In practice, it's very difficult to build a yacht with an A/B ratio below 2.0 with reasonably comfortable accommodations. Once again, Beebe recommends an A/B ratio of 2.6 or less for an ocean-going trawler.

◊S/L Ratio

S/L is the ratio of speed to waterline length, and is defined by the formula:

$$S/L = \frac{Speed(knots)}{\sqrt{LWL}}$$

The S/L ratio is tightly tied to the concept of « hull speed ». As a displacement hull moves through the water, it creates a wave. The faster the hull moves, the longer the wave gets until the length of the wave matches the waterline length of the vessel. At that point, the displacement hull has reached « hull speed ». Thus, a longer hull has a higher hull speed, since it can go faster before the wave it creates matches the length of the boat. Hull speed is reached at an S/L ratio of 1.34.

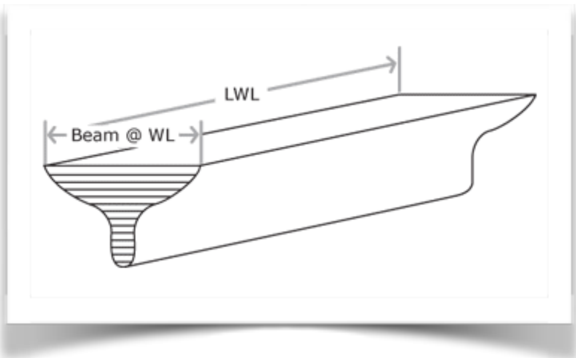
For a boat with a 50-foot waterline length, the hull speed (S/L = 1.34) is about 9.5 knots. At S/L ratios below about 1.2 (about 8.5 knots for a 50 foot waterline length), the amount of power required to move the boat is fairly linear, in other words, doubling the power doubles the speed. However, as the boat approaches hull speed, the amount of power required to move the vessel faster rises dramatically. The key to the long range of a passage-making trawler is operating at low speeds, well below the hull speed, where the engine can push the hull with maximum efficiency.

For most trawlers, maximum range is achieved at S/L ratios under 1.0. For most specifications, even the published « cruising speed » is not the most efficient speed, where maximum range is achieved. However, many voyages don't require the maximum range of the trawler. Careful hull design (including the Selene's disappearing chines discussed in another technical note allows the vessel to operate at considerably higher S/L ratios, with a corresponding decrease in range, but a much higher speed for shorter voyages.

◊Prismatic Coefficient (Cp)

The prismatic coefficient compares the volume of the submerged part of the hull in cubic feet to what the volume would be if the largest cross-section of the hull was extended all the way to the ends of the boat.

In other words, find the spot along the hull where the underwater cross section is largest, and multiply that cross-section area by the length of the hull. Then compare that volume to the actual submerged volume (See the illustration).
In simple terms, the prismatic coefficient defines how fine the ends of the boat are. Vessels with a narrow bow and narrow stern will have a small prismatic coefficient than a boat of the same length, but a broader stern are bow area.



Like D/L ratio, there is no one « right » Cp.

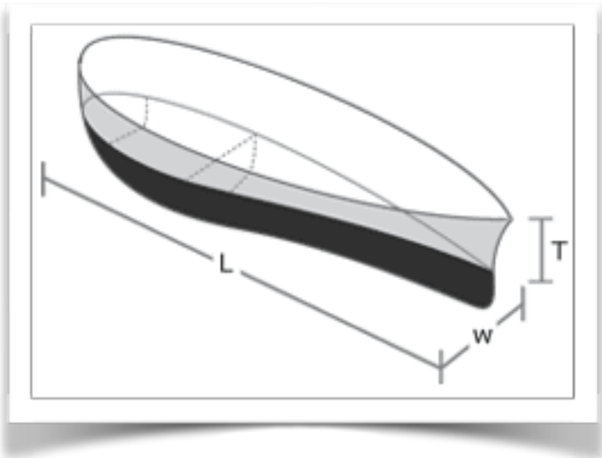
However, tank testing has shown that there is an ideal prismatic coefficient that makes a hull most efficient at a given speed.

The ideal Cp changes with speed (or S/L ratio), so the value of Cp suggests a sort of « sweet spot » for a particular hull where the hull is most efficient. The Selene 53's Cp for instance is 0.67, which corresponds to an ideal S/L ratio of about 1.55, which corresponds to a speed of about 10.8 knots, just over the published « cruising speed. » It is also better to err on the high side of the idea prismatic coefficient, since the performance impact of too low a Cp at high speeds are worse than the impact of too high a Cp at low speeds.

◊Block Coefficient (Cb)

The block coefficient is similar to the prismatic coefficient except that block coefficient measures the volume of a rectangle that encloses the largest dimensions of the submerged hull to the actual hull volume of the submerged hull.

A block coefficient of 1 would suggest that the submerged hull is simply a rectangle with length equal to the waterline length, width equal to the beam at the waterline, and depth equal to the draft of the vessel. See the illustration.

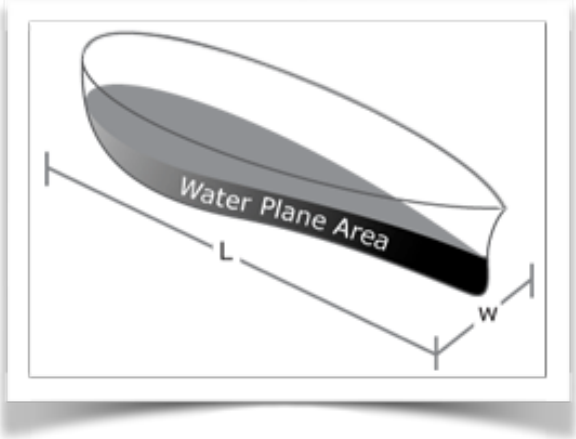


Higher block coefficients suggest indicate a hull with more interior volume, but very full ends and a flat bottom, great for a cargo vessel, but probably not ideally suited for a sea-going yacht.

Smaller block coefficients suggest a hull with more rounded bilges and/or finer bow and stern sections. Hulls with large block coefficients also tend to have poorer directional stability. In other words, they are harder to keep going on a straight course.

◊Waterplane Coefficient (Cwp)

The waterplane coefficient is the ratio of the waterplane of the hull to the rectangle that encloses the waterplane. The waterplane is essentially the shape of the hull where it touches the water, as if you drew the shape of the hull at the waterline on a flat piece of paper. Now enclose that shape in a rectangle that is the same length and width as the waterplane. Calculate the area of the waterplane and the area of the rectangle that encloses the waterplane. The ratio of the waterplane area to the rectangle area is the waterplane coefficient. See the illustration.



A Cwp of 1 is a hull that is a perfect rectangle at the waterline with blunt ends. Lower Cwp suggest a hull with finer sharper ends, which tends to be more easily driven, requiring less horsepower for the same speed. However, all things being equal, a lower Cwp also means lower stability.

◊Metacentric Height (Gm)

Metacentric height is a measure of the vertical distance between a yacht's center of gravity and its « metacenter ».

In simple terms, the center of gravity is the point along a vertical line drawn through the exact center of the hull where the hull would be perfectly vertically balanced. There is an equal amount of weight above and below the center of gravity. The metacenter is the point along this same vertical line around which the boat will heel for small angles of heel (less than about 5°). This point could be thought of as the « hinge » point around which the boat tilts as it heels at small angles (at larger angles the change in shape of the submerged hull has a more significant effect).

The metacenter is always above the center of gravity. Otherwise, the boat will capsize, since it's weight is centered above the « hinge » point. The distance between these two points is called the Metacentric height, and is a measure of stability (resistance to heeling).

A yacht with a large metacentric height will tend to be more « stiff »—it will be more resistant to rolling. However, it will also have a more violent motion and shorter period when it does roll because of the larger force (called « righting moment ») that is exerted to right the boat.

A smaller metacentric height means lower stability—less resistance to rolling, but a gentler rolling motion as well.

Metacentric height is also affected by loading, both the amount of weight and it's location, so both unloaded and fully loaded Gm values are sometimes provided.
References

◊Reference

For a more complete and detailed description of these and other hydrostatic terms and their effects on yacht design, see:

-**Voyaging under power**, by Captain Robert P. Beebe, International Marine, ISBN 0071580190.

-**Naval Architecture for Non-Naval Architects**, by Harry Benford, Society of Naval Architects, ISBN 0939773147.

-**All About Powerboats: Understanding Design and Performance**, by Roger Marshall, International Marine, ISBN 0071362045.

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