Peters On (Fast) Powerboats

The author's eponymous Florida-based yacht design firm has developed some of the most successful high-performance production and custom powerboats in the world, across a broad range of categories: flats skiffs, sportfishermen, motoryachts, and offshore raceboats. Here, in Part 1, he presents his office's consistent approach to the design process.

by Michael Peters
Artwork courtesy of MPYD

In the 18 years that Professional BoatBuilder *has been producing, or co-producing, the IBEX trade show, we have rarely repeated a seminar topic, even though the seminar program has offered upward of five dozen sessions per show. One notable exception was Michael Peters's IBEX '02 presentation titled "High-Speed Boat Design." Audience response was so enthusiastic, we asked Peters to present it again, which he finally agreed to do…at IBEX '08. But he refused to simply reprise his '02 talk, because technology had evolved, and so had Peters. Having designed several of the fastest powerboats on the planet, he decided to back off from that scary end of the spectrum. What follows is Peters's IBEX presentation in Miami Beach in 2008, adapted for print publication—Ed.*

What exactly is *high speed*?

In 1973, I spent the day wet-sanding the bottom of a sloop, getting the boat ready for a race the next day with a builder I was then working with. I came home and told my dad what I'd been doing, and he just laughed at me. "That's absolutely ridiculous—wet-sanding the bottom of a boat to make it go faster. You know, Michael, in aeronautics we don't even start worrying about rivets until about 250 knots."

My dad, being a mechanical engineer and having worked in the wind tunnel for NACA—the National Advisory Committee for Aeronautics—during World War II, calculated the Reynolds Number for the sailboat to see if it made any sense to wet-sand it [**Figure 1**]. The first thing he found was that the Reynolds Number of a sailboat at racing speed of 8 knots compared favorably with a P-51 Mustang single-seat fighter, one of the war's fastest prop-driven planes. He also discovered that the surface smoothness of the bottom made a difference almost as soon as the sailboat started moving.

The reason I'm showing you this comparison is because I think our idea of high speed is ill-defined. Take, for example, a 34′ [10.4m] Contender outboard-powered center-console that does 50 knots. We'd probably all agree 50 knots is a fast boat; note how the Contender compares to the Reynolds Number of an F-16 fighter jet. Now, take our firm's fastest design—a Tencara raceboat fitted with turbine engines—and it has essentially the same Reynolds Number as the U.S. government's SR-71 high-altitude, high-speed [2,000+ knots], long-range reconnaissance plane.

So my question is: What *is* a high-speed boat? Where do you think the line is when people start talking about *high speed*? Fifty miles per hour [80.5 kmh]? Well, at my office—which I know is different from the way some other design offices work—we compare speed to the length of the boat. We take the waterline length, as you would for a conventional sailboat, and view the waterline in terms of percentages. With that, we can judge all boats, from large to small, in some sort of nondimensional way.

Figure 1. Reynolds Number

$$Re = \frac{\rho \times V \times L}{\mu}$$

This equation non-dimensionalizes vessel speed and length by accounting for fluid properties: density (ρ) and dynamic viscosity (μ)

Figure 2. Speed/Length Ratio

$$S/L = \frac{V\ (knots)}{\sqrt{L\ (ft)}}$$

High speed: **S/L > 5.0**

3

4

Two highly successful, and influential, large yachts—not designed by Peters—that meet the marine industry's generally accepted definition of fast*: the Mulder-designed 120'/36.6m* Moonraker ***(top),*** *and the Blount-designed 220'/67m* Destriero*.* Moonraker's *top speed is 67 knots;* Destriero's*, 60. For a detailed account of the latter's design development, see* Professional BoatBuilder *No. 109, page 100.*

If you accept Renato "Sonny" Levi's definition of high speed, it would be a speed/length ratio of 5 and greater [**2**]. For the purposes of today's talk, I'm using 5—though six years ago, at that IBEX, I said 4. Since then, I ran across someone else's definition of high speed, which loosely agreed with mine, and I decided to change to the higher number.

Okay: Take the waterline length, take the square root of it, and you can calculate the speed/length ratio. For a 100′ [30.5m] waterline, the square root is 10; if you're doing 30 knots, the S/L ratio is 3.

Let's look at a boat most people would consider fast: the Mulder-designed 120′ [36.6m] *Moonraker* [**3**], capable of 67 knots. Her S/L ratio is almost 7. Or consider the Blount-designed 220′ [67m] transatlantic record-holder *Destriero* [**4**]; her S/L ratio is 4. *Destriero* does 60 knots; I think we'd all agree that's pretty fast. But if you put *Destriero* on a graph and actually chart out what S/L ratio you're sitting in, you find that *Destriero* does *not* fit our definition of high speed [**8**].

Also, notice the way *Destriero* is running compared to *Moonraker*. *Moonraker* has much more boat out of the water than *Destriero* has. Remember, there are different speed zones: an S/L ratio of 5 is something of an arbitrary line, and if you lower the ratio to 4, *Destriero* is clearly inside it. My point is, because of her size, because of her length, relative to that length, *Destriero* is planing, even though she's not really up on her bottom the way *Moonraker* is up on hers. This observed phenomenon is purely indicative of relative size.

In theory, speed varies as the cube of horsepower divided by weight. If all factors are equal, eight times the power is needed to double the speed. In reality, things don't stay the same; we can do much better. As we'll see in Part 2, a modern racing catamaran can achieve a speed equal to the square of horsepower divided by weight.

There are several ways to calculate the speed of a planing boat. Crouch's formula is commonly used by many in the industry as a shorthand method for predicting speed [**5**]. Sonny Levi's formula is what I started with, in the 1970s [**6**]. But the formula that we employ in our office today is one taught to me by Eduardo Reyes, a Cuban who escaped the island when Fidel Castro took over [**7**].

Actually, what we find in our practice is that any one of these formulas will work; it's a matter of becoming fully familiar with the one you're using. They're all fairly simple. But in all three formulas, understanding what

Figure 5. Performance Prediction

Crouch's Formula:

$$mph = \frac{C}{\sqrt{\frac{\Delta}{HP}}}$$

Where:
Δ = Displacement of vessel (lbs)
C = Constant based on boat type **(180–200)**

Figure 6. Performance Prediction

Sonny Levi's Formula:

$$mph = K \times \sqrt{\frac{SHP}{\Delta}}$$

Where:
Δ = Displacement of vessel (LT)
K = 3.9–4 for single shaft
3.5–3.6 for twin shaft
3.2–3.3 for three shafts
3.0–3.1 for four shafts

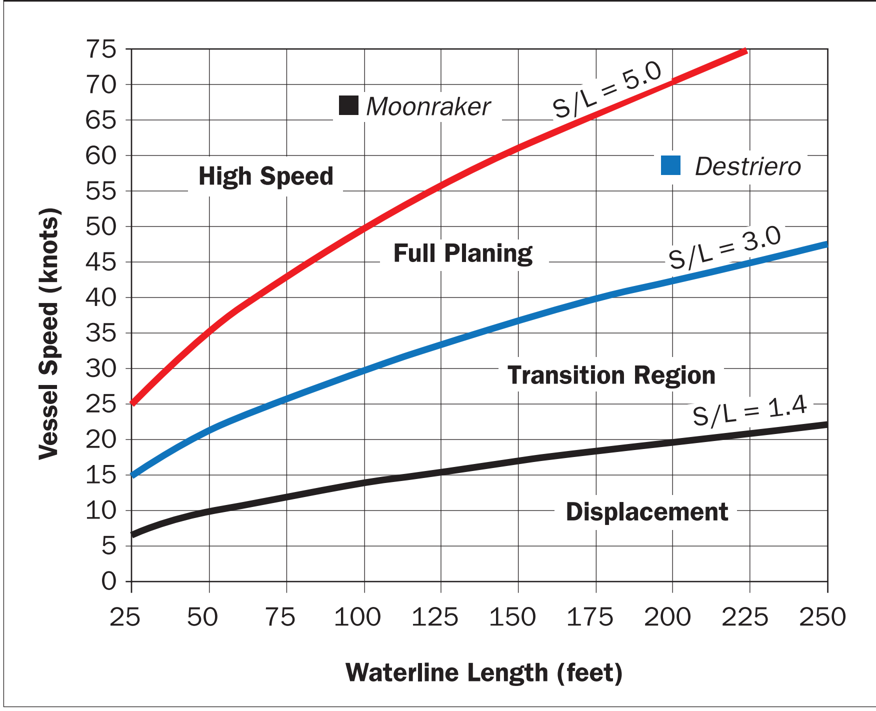
Figure 7. Performance Prediction

Eduardo Reyes's Formula:

$$V\ (knots) = K\sqrt{\frac{HP \times 46.4}{\Delta}}$$

Where:
Δ = Displacement of vessel (LT)
K = Constant based on boat type **(2.0–2.5)**

Figure 8.



A graphic representation of performance designations based on vessel speed-to-length ratio. Note the relative positions of Moonraker *and* Destriero *in this context.*

the K-value (a constant) is—either C or K—is what predicting speed is all about. All three formulas were derived empirically. Meaning, the more boats you have data on and have graphed out, the better your speed calculation will be.

One thing we find is that a lot of designers, especially small-boat designers, start designing the hull *without* knowing the boat that they're designing the hull for. So in our office, we religiously do a *complete* design spiral, perform an initial weight study, establish overall weight and where the center of gravity is. There it is—the first thing is to correct the center of gravity.

All right. You've laid out a boat and all your accommodations are where you want and you've got your engines where you want and all the rest. You end up with a longitudinal center of gravity, and you say, Okay, now I'm gonna design my boat around this. Well, what if that LCG is just plain *wrong* to begin with? Because the center of gravity varies with the speed. You want, generally speaking, to move the center of gravity aft if the speed increases. So, don't design the boat around the center of gravity that you found in the weight study. Correct it. Change your layout. Get everything lining up before you even get started.

We design every hull the same way they did a hundred years ago—that is, regardless of the size and speed of the boat, we establish the hull profile and waterline length, and set up a 10-station waterline, where 0 is the stem's intersection with the water. This allows us to think about the boat *in percentages.* You say, Where does the boat balance? Oh, it balances at 60%. Or, it balances at 56%. Well, regardless of the length of the boat, and regardless of the speed of the boat, this setup puts the new boat into a design construct that you can now compare to all previous boats.

In our office, we'll often ask around, Where do *you* think this boat ought to balance? One guy will say, I think it ought to balance around 6.2. And another one says, I think our drawing puts it at 6.5.

It doesn't matter what length boat we're talking about. What matters is the speed-to-length ratio. The physics of boats are relative to their length; using the percentage of waterline length enables a nondimensional comparison between boats.

Again: It's my observation that because so many small-boat designers tend to skip the steps of weight studies, they skip the critical steps to understanding that it's all relative to the size of the boat.

Balance is everything.

If I had to choose between the weight being right and the balance being right, I'll choose the balance every time. There is a correct LCG for every S/L ratio. Obviously that's within relative numbers; you don't want the horsepower-to-weight ratio to get too far out of whack. But you can actually get a heavier boat to run faster *with correct balance*, than you can the other way around.

We've all experienced—especially in small boats—where you move weight aft and the boat picks up speed, even though you've put some dead weight on or near the stern. So, yes, balance is everything. Re-balance the boat by modifying the layout to the correct LCG if necessary. Do *not* make the hull lines fit the LCG; make the LCG fit the hull.

Improper balance can lead to: dynamic instability, chine walking, porpoising, and broaching. Bad balance can also adversely affect the planing angle, the time the boat takes to plane, the speed at which it will plane, how wet the boat runs, and the overall speed.

The interesting thing is, the boat itself wants to be in balance no matter what. You can screw up the boat by having the weight too far forward, just as easily as you can by having it too far back.

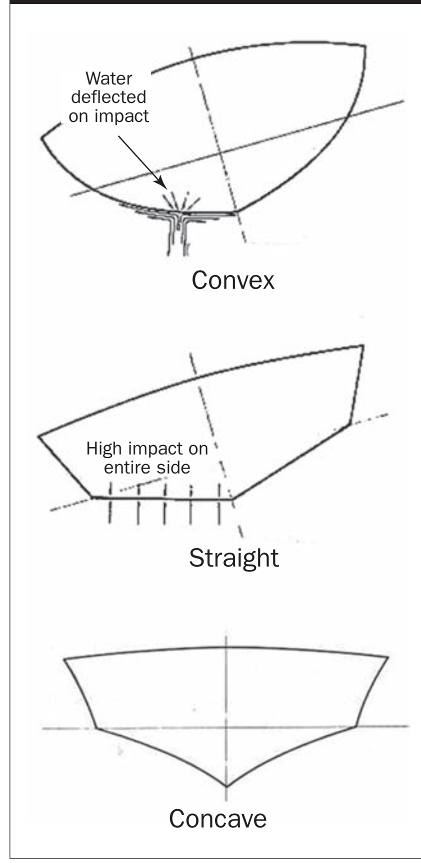
I think the common notion is that if the boat porpoises, the center of gravity must be too far forward. Well, you can get a boat to porpoise by having the CG too far back. The boat is… *talking* to you the whole time you're drawing it. You see that it wants to be certain things. Like when you draw a set of hull lines and you put a reasonable waterline on it; basically, that's how heavy the boat wants to be. When you start having to sink the boat deeper and deeper, you should have a moment that tells you: this boat is getting too heavy for its bottom. You can calculate it. Or you can just look at it visually and say, Something's not right here.

Shapes and Appendages

Figure 9 was taken from Sonny Levi's book *Dhows to Deltas*. We always draw convex **bottom sections** forward. Always. Because of the way they dissipate the energy of impact. Note the *concave* sections, at the bottom; they actually *focus* the impact. It's like looking at a lens. You can almost tell what a bottom section like that is going do as it collects, and concentrates, the energy on itself. So for softer running sections, we always draw convex sections forward; that's true in boats we've done from 20 knots up to 180 knots.

Three common bottom sections for a fast monohull. In his designs, Peters avoids a concave shape, which he says concentrates impact loads.

Figure 9. Bottom Sections



I hear from people all the time that they think **trim tabs** [**10**] are the sign of a bad design, or that **wedges** are the sign of a bad design. In fact, a U.S. Navy study concluded that wedges help every boat they've ever seen them on, including large warships. When we saw earlier that boats compare pretty well to medium-speed and high-speed airplanes, why would we ever expect an airplane to go from taxiing on a runway, to taking off, to reaching cruise altitude—without articulating surfaces? A planing boat goes from displacement speed, through the transitional zone, to full planing—and benefits from controlling surfaces just the same as an airplane does. So I think it's strange that we have the mindset that if you put controllable surfaces on the boat, something must be wrong with it.

We recently went through this in Italy, where we had a heavily loaded small boat from a major production builder, and the boat required power trim to get up on plane easily. And they absolutely thought, That's not fair. And I say, Why do you think they invented power trim? And they go, Oh no no—you shouldn't have to control anything.

As I said, the *thing* about trim control is one of the biggest misconceptions we deal with.

I won't name names, but one builder has had a pretty big impact

Unlike some members of the marine design community, Peters does not consider trim tabs to be "cheaters." Rather, he views them as critical, adjustable control-surfaces, just as they are on aircraft.

in powerboat design, especially in Europe. The builder's sailboat concept was wildly popular—with its minimalistic look, its **plumb bow**; altogether a very stark, very graphic presence. Then, when the company did its first powerboat, the designers stuck a plumb bow on it. So now you see, cropping up throughout Europe, a lot of new powerboats with plumb bows.

Our office has absolutely refused, in about a half-dozen cases, to design boats that have plumb bows. A plumb bow and deep forefoot never belong on a high-speed boat. There's a reason why the plumb bow of the 1920s gave way to the cutaway forefoot of the 1960s and '70s, starting with the Levi hulls and with the Cigarettes, and that is: You don't want a rudder at the bow of your boat. A deep forefoot can cause a broach or a spinout, resulting in either pitching the crew overboard, or a barrel roll at high speed.

If you stick the bow of a boat like that in the water, you *will* swap ends—even on a 110-footer [33.5m]. Nevertheless, the trend is now prevalent in Europe, where stylists are influencing the way a hull is designed—to the point that I believe any such high-speed boat is extremely dangerous. You get a very sharp forefoot with that type of design.

An example is a 40′ [12.2m] boat built in Germany with a plumb bow, on a stepped hull, and fitted with conventional shaft drives. When we plugged this design into our formula, it had the worst K-value, the worst efficiency, of any boat we'd encountered. This boat is a mixture of every idea someone's ever seen, all rolled into one. I tell people all the time: If you mix a dozen different colors of paint together, you know what you get? *Brown.* You know how it goes: *this* was a good idea, *that* was a good idea, so let's put 'em all together.

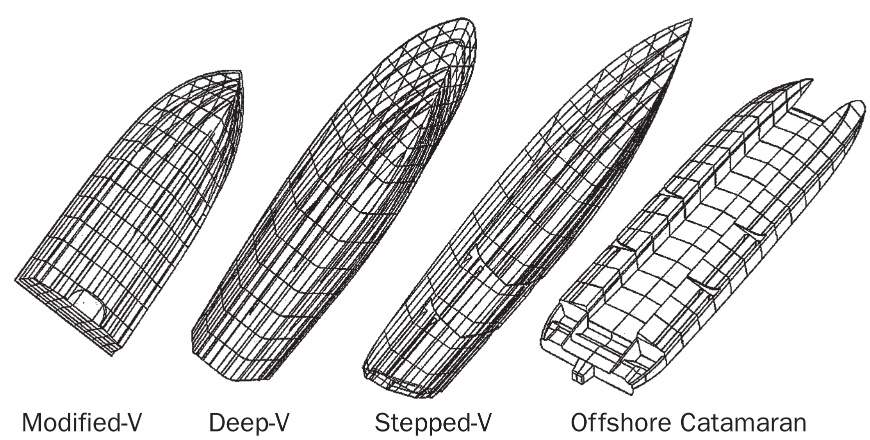
Don't do that.

Hullforms

Time to turn our attention to hullforms. The four basic high-speed hulls that my office works with are: modified-V, deep-V, stepped-V, and the offshore catamaran [**11**]. In effect, those are sorted in order of speed. We'll start with the modified-V.

We approach every single design exactly the same way. The reason

Figure 11. Hullforms

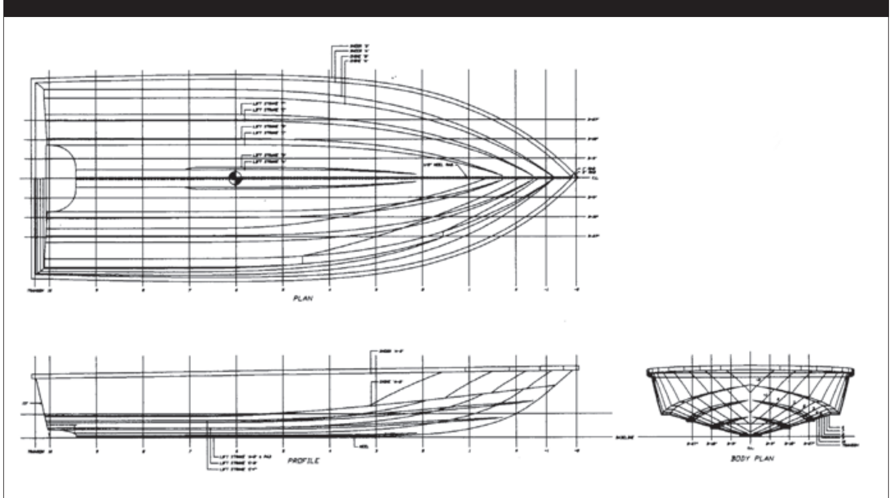


The four types of hullforms discussed in this article. Each of the wire-frame models is a fish-eye view of an actual Peters-designed boat presented here. Part 1 takes in the two types on the left; Part 2, in the next issue of PBB, will focus on the stepped-V and offshore cat.

is, we're trying to get predictable results. We don't just say, Well, that boat ran well, but we don't know why, so we'll do another one and hopefully we'll have good luck on it, too.

We define a modified-V as 20° deadrise, and lower, at the transom. Here's a flats skiff—a Maverick 21/6.4m [**12–15**]. It gets pretty shallow aft. Now, a 21-footer may be small, but we've got it on a 10-station waterline, so we can think of it in terms of percentages. We do a diligent weight study—for this boat it was probably 10 pages. We go through and figure every single thing on it. The importance of that? Well, we critiqued ourselves in the office 10, 12 years ago. What's our biggest weakness? The answer was: weight studies. Everybody hates to do them. They're tedious, they're boring. But we're committed…we don't care if we get another boat within a foot of this one, we'll do a weight study on it. We take nothing for granted. We do a weight study *every single time.* Over in the right-hand column [**13**], the LCG, we're trying to get the number where we think it should be: appropriate for that hull at that

Figure 12. Modified-V



Lines plan for a production-built flats skiff; in this case, a 21'/6.4m Maverick, whose weight summary and K-value—critical numbers for Peters—appear on the next page, along with a running shot of the finished product.

speed/length ratio. And so in this case we're balancing at a half-load of about 6.4. That's 64% back from the waterline intersection at the bow.

Remember, the lines are for level flotation as a shallow-draft boat; we didn't want it to sink by the stern at rest. It has a wide aft planing surface, shallow chine immersion, and a "notch" at the transom for shallow running and higher drive placement.

Figure 13. Modified-V

Maverick 21′ (6.4m)
Weight Summary

Category Totals	Weight (lbs)	LCG (ft aft st.0)	L_{moment} (ft-lbs)	Lightship	LCG (station)
Hull Rigged	1,618	9.61	15,548	81%	
Engine, Yamaha V-6, 225	380	17,75	6,745	19%	
Lightship Weight	**1,998**	**11.16**	**22,293**	**100%**	**6.56**
Hull Rigged	1,618	9.61	15,548	81%	
Engine, Yamaha V-6, 225	380	17.75	6,745	19%	
Fuel, 50 gal	142	2.75	781	7%	
Person (1)	200	11.25	2,250	10%	
Half-Load Weight	**2,340**	**10.8**	**25,324**	**117%**	**6.36**
Hull Rigged	1,618	9.61	15,548	81%	
Engine, Yamaha V-6, 225	380	17.75	6,745	19%	
Fuel, 50 gal	284	2.75	781	14%	
Livewell, 20 gal	167	15.25	2,545	8%	
People (2)	400	11.25	4,500	20%	
Full-Load Weight	**2,849**	**10.6**	**30,119**	**143%**	**6.22**


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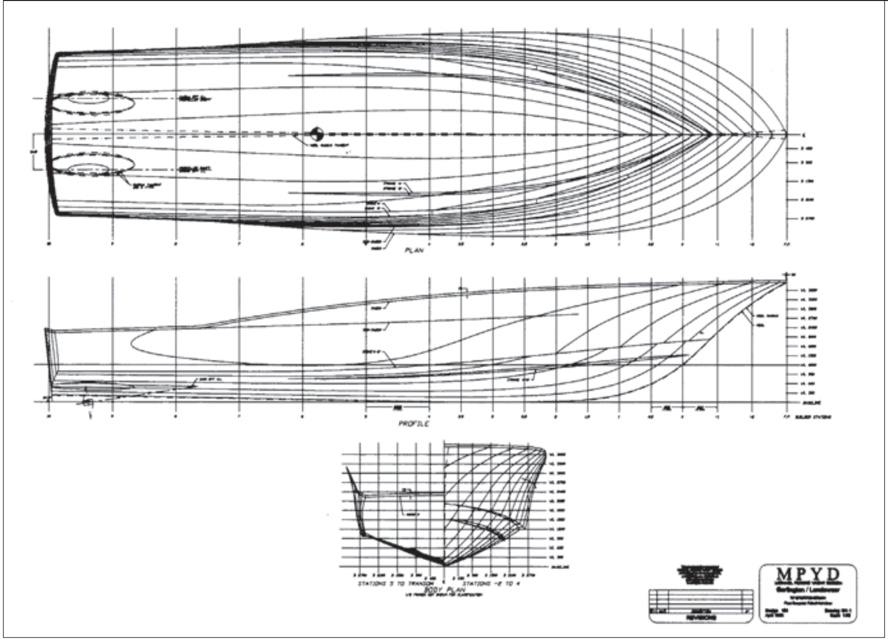
Figure 15. Modified-V

Maverick 21

Waterline Length	18.2′
Speed (knots)	62.5
S/L Ratio	14.7
HP	225
Weight (half load)	2,350 lbs
LCG (station)	6.36
HP/Weight	10.4 lbs/HP
Deadrise @ T	15
K	2.227

A much larger modified-V is this 78′/23.8m sportfisherman designed for Garlington. Again, the weight summary, K-value, and a running shot appear on the following pages.

Figure 16. Modified-V



There's 25° deadrise around station 4, and convex bottom sections. The bow sections are much fuller than previous Maverick hulls; the previous boat proved difficult to drive in a following sea. This design probably could run a little better if we moved the center of gravity back more—closer to 6.8—but then we would defeat the purpose of the shallow draft. What we have is an LCG of 6.36, 15° deadrise at the transom, and a speed/length ratio of 14.7.

Now, as I said earlier, *high speed* is a speed/length ratio of 5. So the S/L of our flats skiff is well above that; for its size, at 62 knots, this little boat is going *really* fast. As for the last line on the chart, watch the bottom-line numbers throughout the rest of the talk: you'll see how the number varies. For an outboard-powered boat, with this horsepower weight and with this type of hull, we're getting a K-value of 2.23.

• Now let's go to a 78′ [23.8m] sportfish [**16–19**]. Same thing: we're starting out with a hull drawn on a 10-station waterline, again. We go through a weight study and establish an LCG

Figure 17. Modified-V

Garlington 78′ (23.8m)
Weight Summary

Category Totals	**Weight** (lbs)	**LCG** (ft aft st.0)	**$M_{Long.}$** (ft-lbs)	**Lightship**	**LCG** (station)
Hull and Deck Total	17,160	30.0	514,123	16.6%	
Superstructure Total	2,255	41.9	94,567	2.2%	
Mechanical Total	48,075	44.6	2,143,567	46.5%	
Exterior Outfit Total	15,226	34.2	521,430	14.7%	
Interior Outfit Total	15,548	28.5	443,738	15.0%	
Category Totals	98,263	37.8	3,717,426	95.0%	
Lightship Weight Margin	5,172	37.8	195,654	5.0%	
Lightship Weight	**92,453**	**38.5**	**3,913,080**	**100.0%**	**5.77**
Variable-Loads Total	3,800	40.5	153,923		
Tank: Fuel, Cockpit (1,060 gal), ¼″ alum.	7,558	59.0	445,910	1,060	
Tank: Fuel, Pump Room (410 gal) port, ¼″ alum.	2,923	35.0	102,316	410	
Tank: Fuel, Pump Room (410 gal) stbd, ¼″ alum.	2,923	35.0	102,316	410	
Tank: Fuel, Fwd (1,570 gal), ¼″ alum.	0	22.1	0	0	
Tank: Fuel, Amidships (445 gal), ¼″ alum.	0	31.6	0	0	
Tank: Fresh Water (450 gal), ¼″ alum.	3,852	13.9	53,427	450	
Tank: Lube Oil (85 gal), ¼″ alum.	723	53.4	38,589	85	
Tank: Waste Oil (85 gal), ¼″ alum.	0	53.4	0	0	
Tank: Gray/Black Water (250 gal), ¼″ alum.	2,125	8.8	18,700	250	
Half-Load Weight	**116,370**	**38.5**	**4,828,260**	**123%**	**5.77**
Tank: Fuel, Cockpit (1,060 gal), ¼″ alum.	7,558	59.0	445,910	1,060	
Tank: Fuel, Pump Room (410 gal) port, ¼″ alum.	2,923	35.0	102,316	410	
Tank: Fuel, Pump Room (410 gal) stbd, ¼″ alum.	2,923	35.0	102,316	410	
Tank: Fuel, Fwd (1,570 gal), ¼″ alum.	11,194	22.1	246,830	1,570	
Tank: Fuel, Amidships (445 gal), ¼″ alum.	3,173	31.6	100,135	445	
Tank: Fresh Water (450 gal), ¼″ alum.	3,852	13.9	53,427	450	
Tank: Lube Oil (85 gal), ¼″ alum.	723	53.4	38,589	85	
Tank: Waste Oil (85 gal), ¼″ alum.	723	53.4	38,589	85	
Tank: Gray/Black Water (250 gal), ¼″ alum.	2,125	8.8	18,700	250	
Full-Load Weight	**131,446**	**37.0**	**5,213,814**	**138%**	**5.55**

according to a percentage of the design waterline. We end up with an LCG of 5.8, more or less.

Looking at the lines plan, we see a very shallow shaft angle (8.5°), shallow pockets, a wide planing surface aft, convex transverse bottom sections, no warp, and 25° deadrise around station 4.

It's interesting that sportfishing yachts have essentially the same layout they did in the 1950s. With a big cockpit aft, they're hard to balance for high speed; certainly the bigger boats get easier. But a boat in, say, the 32′-to-38′ [9.7m-to-11.6m] range, with a straight shaft, is incredibly difficult to balance. Because right where you want to put the weight, you've got an empty cockpit. And so, trying to slide the center of gravity aft is extremely difficult. You end up putting fuel there, which of course varies as you burn it off.

On this boat, even though we end up with a 5.77 LCG [**19**], we would really like to get it farther back; at 6.1 she'd run faster. Hard to do, though, on a sportfisherman.


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Figure 19. Modified-V

Garlington 78′

Waterline Length	66.7′
Speed (knots)	36.7
S/L Ratio	4.5
HP	3,600
Weight (half load)	115,000 lbs
LCG (station)	5.77
HP/Weight	31.9 lbs/HP
Deadrise @ T	18
K	2.245

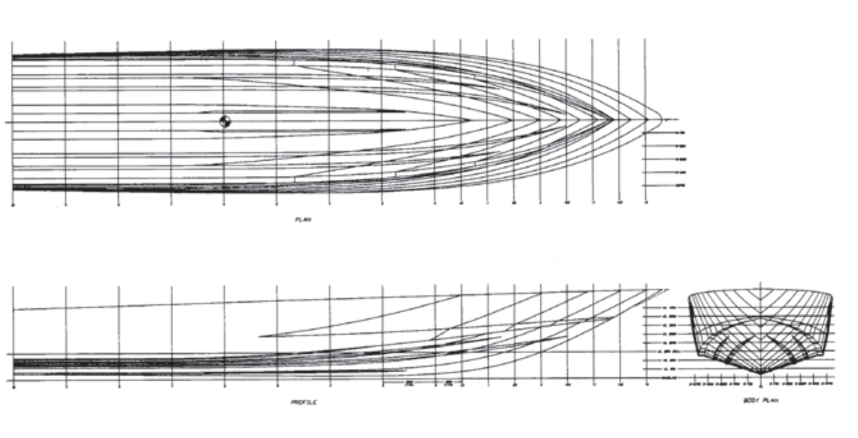
Note the K-value at the bottom. It's at 2.245, whereas the little Maverick was at 2.23. Our efficiency here, the way we're calculating it, is a little bit worse than it was with an outboard on a flats skiff. But we're only at a speed/length ratio of 4.5 on this bigger boat. So we're way down on the speed comparison.

• Here's a proposal for a 128′ [39m] waterjet-powered fast motoryacht, for German builder Abeking & Rasmussen [**20–23**]. Again: the 10-station waterline; we go through a weight study [**22**]; we want the keel level at rest. On this boat we were able to control a lot more about where we wanted the center of gravity: balancing this boat at 6. Everything else in the preliminary design process justified, or verified, where we'd wanted the LCG.

In the body plan, note the convex sections forward, and the absence of warp in the bottom [**20**]. Deadrise is 25° around station 4, and 18° at the transom. The keel is flat for an undisturbed center-jet inlet, and for lift.

The boat's model was tank-tested in Austria—before we got there. When I arrived, they said, Mike, the

Figure 20. Modified-V



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The towing-tank model, ***above,*** *and lines plan, at* ***left,*** *for an even larger modified-V: a design proposal for a 128'/39m fast motoryacht for the German yard Abeking & Rasmussen. Weight summary and K-value on facing page.*

boat's not running so good. We're going to move the center of gravity forward because the model's running bow high [**21**]. I said, Actually, you've got the center of gravity about where we want it; we'd move it aft. And they said, Okay, but y'know it costs x-amount every time we take it down the tank.

Well, we moved the center of gravity *back*. And the bow dropped. We've had this happen in a number of boats. It's completely counterintuitive that you would move the center of gravity aft and get the bow to drop. But it brings us back to the concept of proper balance. *When the boat is properly balanced, everything works well.*

You can screw up the boat by improper balance, in ways that are not intuitive. We have our own theory about why that happens, though I'm not at all sure that we're correct. It has, however, been consistent.

Look at this boat's K-value. We're now down to 2.07 [**23**]. It's approaching what we get on a raceboat. That's because waterjets are so efficient when the boat goes really fast; the faster it goes the more efficient the jets get. Jets are not very efficient in the lower speed ranges. Also, here we're at an S/L of 5.1, so we're right on the line of our

Figure 22. Modified-V

Abeking & Rasmussen 39m (128')
Weight Summary

Category Totals	Weight (kg)	LCG (m aft st.5)	$M_{Long.}$ (kg/m)	Lightship	LCG (station)
Hull Structure Total	33,437	1.2	39,346	26%	
Superstructure Total	9,394	0.9	8,713	7.4%	
Final Finish Total	2,640	2.2	5,823	2.1%	
Machinery Systems Total	57,502	–9.0	–515,474	45%	
Ship's Service Systems Total	5,782	0.5	3,164	4.5%	
Accommodations Total	15,435	2.4	36,581	12%	
Variable-Load Total	3,125	–1.4	–4,270	2.5%	
Liquid-Stores Total	0	–0.7	0	0%	
Lightship Weight	**127,315**	**–3.3**	**–426,117**	**100%**	**6.10**
Half-Load Weight	**151,581**	**–2.9**	**–442,281**	**119%**	**5.99**
Full-Load Weight	**175,846**	**–2.6**	**–458,445**	**138%**	**5.87**

Figure 22. Modified-V

A&R 39m

Waterline Length	100.2′
Speed (knots)	51
S/L Ratio	5.1
HP	10,950
Weight (half load)	334,000 lbs
LCG (station)	6.0
HP/Weight	30.5 lbs/HP
Deadrise @ T	18
K	2.070

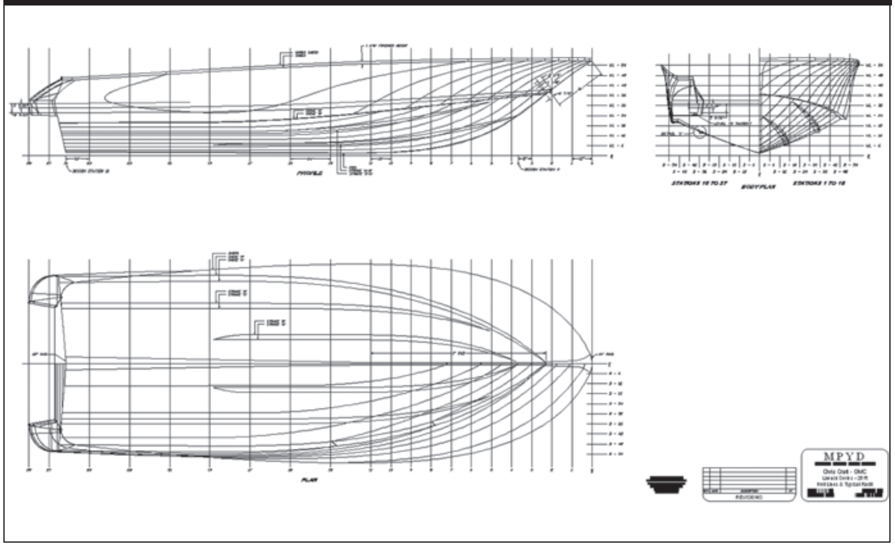
definition of a high-speed boat. And it's a pretty big boat, too. With a 100′ [30.5m] waterline, it's not operating that fast compared to its length.

What's a "deep-V"? In our office we define a deep-V as 20° and greater. Most deep-Vs in the marketplace are 20° to 24°, although it's noteworthy that much of the deep-V research was done at *25°*. Not 24°. But everybody's sold on 24°; apparently they think that one degree makes the boat a little bit faster.

• Here's a 28′ [8.5m] Chris-Craft launch [**24–27**]. It's got 20° deadrise at the transom. This boat's lines-plan format differs slightly from the others' I've presented, but, as before, we establish a center of gravity according to a percentage of the design waterline and we end up with an LCG of 6.03 [**26**]. With a speed-to-length ratio of 11 the boat would run faster with an LCG at 6.5, but it would be more difficult to plane. It's a family boat; we designed it with a level keel to plane easily, so it probably does better with the LCG farther forward.

Once more, note the convex sections forward, the absence of warp in the underbody, and the 25° deadrise at station 4.

Figure 24. Deep-V



Here we have a K-value of 2.265. This number is actually the worst of the designs discussed so far. Those numbers are a way of gauging efficiency across different boats. Of course, we have different charts for different drives, different horsepower to weight, and different hull types. You get to where these numbers are pretty accurate. On the previous boat, the 128′ A&R, the builders did their own calculations prior to going to the tank, and told us they thought we were wrong…by about 3 knots.

A deep-V launch designed for Chris-Craft. K-value and weights on facing page.

The Germans are, shall we say, fastidious. So, we're thinking, Oh man, those guys don't agree with our numbers. But we ended up *getting* those 3 knots. Our prediction was based on empirical information, with a very simple calculation, and ended up agreeing almost dead-on with the tank test.

• Next up: a Contender 34/10.4m [**28–31**]. Again, a weight study, lines drawn according to a 10-station waterline, thinking about balance in terms of percentages. The keel is down by the stern at rest, so the LCG is quite far aft on this boat. In fact, it's a little

Figure 26. Deep-V

Chris-Craft Launch

Waterline Length	22.9′
Speed (knots)	53
S/L Ratio	11.1
HP	560
Weight (half load)	7,300 lbs
LCG (station)	6.03
HP/Weight	13.0 lbs/HP
Deadrise @ T	20
K	2.265

farther aft than we would want, partly because the new V-8 outboards are so heavy…making that factor difficult to control. But the boat runs really well. Even though it's at 6.8—68% of the waterline [**30**]. Still, we're getting good numbers: 51 knots, S/L ratio of 9.7, a K of 2.25.

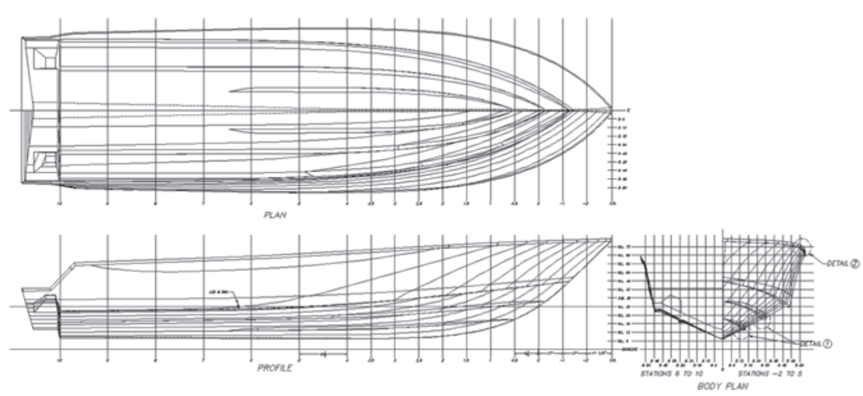
Those numbers are fairly consistent for a deep-V with outboards, no steps, or anything tricky like that. We'll discuss a dramatically different boat later on, in Part 2. The 2.25 K is where you are with outboards, when they're at a moderate height. Unless

Figure 27. Deep-V

Chris-Craft 28′/8.5m (7.4L Single-Engine Installation) Weight Summary

(%)	Category Totals	Weight (lbs)	LCG (in + Trn)	$M_{Long.}$ (in-lbs)	TCG (in + Port)	$M_{Trans.}$ (in-lbs)	Amount (##)	Units
	Lightship Weight	**6,795**	**107**	**727,389**	**–0.1**	**–559**	**100%**	**STA = 6.11**
	Loading Conditions Summary							
	Driver and Passenger	350	150	52,500	0	0		2 each
	Additional Passengers, Aft	0	65	0	0	0		0 each
	Additional Passengers, Fwd	0	250	0	0	0		0 each
	Additional Stores	50	100	5,000	32	1,600		50 NA
25%	Fuel Tank	308	105	32,134	0	0		200 gal
0%	Porta-Head	0	198	0	–32	0		5 gal
0%	Water Tank	0	129	0	–29	0		9 gal
	Light-Load Weight	**7,502**	**109**	**817,023**	**–0.1**	**1,041**		**STA = 6.04**
	Lightship Weight	6.795	107	727,389	–0.1	–559	100%	
	Driver and Passenger	350	150	52,500	0	0		2 each
	Additional Passengers, Aft	0	65	0	0	0		0 each
	Additional Passengers, Fwd	0	250	0	0	0		0 each
	Additional Stores	50	100	5,000	32	1,600		50 NA
50%	Fuel Tank	615	105	64,268	0	0		200 gal
50%	Porta-Head	21	198	4,128	–32	–667		5 gal
50%	Water Tank	38	129	4,841	–29	–1,088		9 gal
	Half-Load Weight	**7,868**	**109**	**858,126**	**–0.1**	**–714**		**STA = 6.03**
	Lightship Weight	6.795	107	727,389	–0.1	–559		
	Driver and Passenger	350	150	52,500	0	0		2 each
	Additional Passengers, Aft	350	65	22,750	0	0		2 each
	Additional Passengers, Fwd	350	250	87,500	0	0		2 each
	Additional Stores	50	100	5,000	32	1,600		50 NA
100%	Fuel Tank	1,230	105	128,535	0	0		200 gal
50%	Porta-Head	21	198	4,128	–32	–667		5 gal
100%	Water Tank	75	129	9,683	–29	–2,177		9 gal
	Full-Load Weight	**9,221**	**113**	**1,037,485**	**–0.2**	**–1,803**		**STA = 5.91**

Figure 28. Deep-V



The lines of a 34'/10.4m Contender outboard-powered canyon-runner. K-value and weights on facing page.

you get into surface drives, you usually don't see a better K-value—calculating it this way.

Note the convex sections forward, the absence of warp in the bottom, the wide aft planing surface.

Interestingly, Contender asked us to redesign the entire product line. They wanted the boats to be faster, drier, and softer riding. And I said, Well, you can have any two; you can't have all three. The very idea of one cancels out the other. Usually, if the boat is softer riding, it's wetter, because it just doesn't shed water as well.

I'll confess this relatively simple line of boats made me nervous. The company's owner already had boats that could take some really rough water; I didn't know whether we were going to get them to ride better and go faster. It turned out the owner felt this particular 34 model accomplished all three things. I think the approach we took was: Don't do anything radical. We carry a lot of deadrise in these boats: 24° at the transom, and greater than 25° at station 4. They're just well-blended, well-balanced boats. And today I think we've done six or seven designs for the company.

• Which brings us to the Magnum 80/24.4m [**32–35**]. Again, the same lines-plan approach: divided into 10 stations [**32**]. There's a summary of the weight study [**35**]; we're balanced at 6.2, for 62% on this one [**34**]. Sixty-two percent will give you a basically level keel on a deep-V. It might be down by the stern just a tiny bit, but level at rest.

Note the shallow chine immersion, the wide aft planing surface, the convex sections forward, the absence of

Figure 30. Deep-V

CONTENDER 34

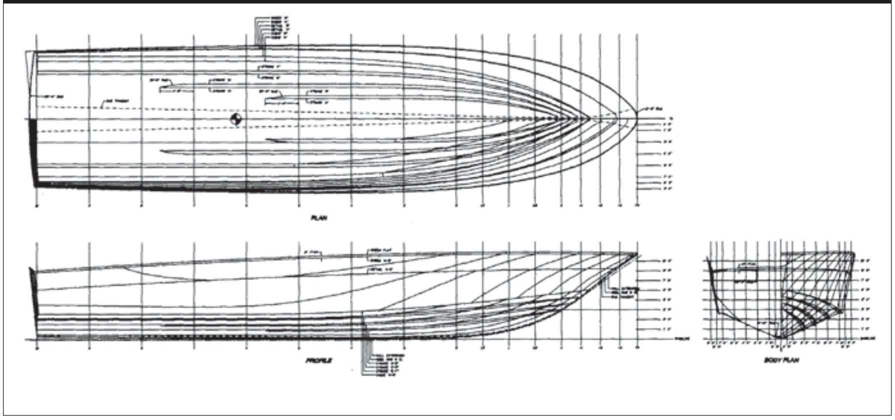
Waterline Length	27.9′
Speed (knots)	51.4
S/L Ratio	9.7
HP	700
Weight (half load)	10,200 lbs
LCG (station)	6.8
HP/Weight	14.5 lbs/HP
Deadrise @ T	24.5
K	2.251

Figure 31. Deep-V

Contender 34′ (10.4m)
Preliminary Weight Summary

(%)	Category Totals	Weight (lbs)	LCG (ft)	$M_{Long.}$ (ft-lbs)	Lightship	LCG (station)
	Hull, Deck, and Structure Total	5,020	19.3	96,863	51%	
	Mechanical Total	3,441	30.5	105,073	35%	
	Exterior Outfit Total	830	18.7	15,499	8%	
	Interior Outfit Total	114	18.0	2,059	1%	
	Category Totals	9,405	23.3	219,495	95%	
5%	Lightship Weight Margin	495	23.3	11,552	5%	
	Lightship Weight	**9,900**	**23.34**	**231,047**	**100%**	**6.93**
	2 Driver and Passenger	350	21.5	7,525	2 each	
	0 Additional Passengers, Aft	0	29.3	0	0 each	
	0 Additional Passengers, Fwd	0	16.0	0	0 each	
	Additional Stores	50	9.3	465	50 NA	
50%	Fuel Tank, Centerline (200 gal)	615	23.4	14,391	200 gal	
50%	Fuel Tanks, Wing Tanks (2 x 110 gal)	677	21.0	14,207	220 gal	
50%	Water Tank	94	27.3	2,561	22.5 gal	
	Half-Load Weight	**11,685**	**23.12**	**270,196**		**6.85**
	2 Driver and Passenger	350	21.5	7,525	2 each	
	2 Additional Passengers, Aft	350	29.3	10,255	2 each	
	2 Additional Passengers, Fwd	350	16.0	5,600	2 each	
	Additional Stores	150	9.3	1,395	150 NA	
100%	Fuel Tank: Centerline (200 gal)	1,230	23.4	28,782	200 gal	
100%	Fuel Tanks: Wing Tanks (2 x 110 gal)	1,353	21.0	28,413	220 gal	
100%	Water Tank	188	27.3	5,123	22.5 gal	
	Full-Load Weight	**13,871**	**22.94**	**318,140**		**6.78**

Figure 32. Deep-V



Lines plan for a big high-performance deep-V, the Magnum 80 (24.4m), along with weights and K-value. All of the Peters designs shown here go fast, and ride well, because they share a consistent approach to a design process whose underlying principle can be summarized in a single word: balance.

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Figure 34. Deep-V

Magnum 80

Waterline Length	67.3′
Speed (knots)	46
S/L Ratio	5.6
HP	3,600
Weight (half load)	107,000 lbs
LCG (station)	6.2
HP/Weight	29.7 lbs/HP
Deadrise @ T	24
K	2.135

warp. Deadrise is 25° around station 4, and 24° at the transom. A large keel radius enhances lift and serves as rocker to lift the bow. For a higher-speed version of this boat we would move the LCG aft. Over time, Magnum had developed most of its bigger boats by simply stretching the original 53-footer [16.1m]. We approached this project the same as usual, and achieved results exactly as predicted. Forty-six knots. S/L ratio of 5.6. Look where we are with surface drives: 2.13. And this is the contribution of a surface drive; typically, when we're calculating surface drives, we're going to be in the 2.12 to 2.13 range, following the Eduardo Reyes formula.

Figure 35. Deep-V

Magnum 80 (24m) Sportboat
Weight Summary

Category Totals	Weight (lbs)	LCG (ft aft st 0)	$M_{Long.}$ (ft-lbs)	Lightship	LCG (station)
Hull and Deck Total	32,769	34.0	1,113,134	34.1%	
Superstructure Total	2,394	56.2	134,568	2.5%	
Mechanical Total	37,177	53.6	1,994,500	38.7%	
Exterior Outfit Total	5,085	38.1	193,747	5.3%	
Interior Outfit Total	13,750	30.6	420,827	14.3%	
Category Totals	91,176	42.3	3,856,776	95.0%	
Lightship Weight Margin	4,799	42.3	202,988	5.0%	
Lightship Weight	**95,975**	**42.30**	**4,059,764**	**100.0%**	**6.29**
Variable Loads Total	2,300	27.5	63,248		
Tank: Fuel, ER Bulkhead (1,125 gal)	4,011	47.8	191,708	563	
Tank: Fuel, Keel (515 gal)	1,836	40.0	73,439	258	
Tank: Fresh Water, Fwd (410 gal)	1,755	29.3	51,416	205	
Tank: Black Water (260 gal)	1,105	21.3	23,537	130	
Half-Load Weight	**106,981**	**41.72**	**4,463,111**	**111%**	**6.20**
Tank: Fuel, ER Bulkhead (1,125 gal)	8,021	47.8	383,416	1,125	
Tank: Fuel, Keel (515 gal)	1,836	40.0	73,439	515	
Tank: Fresh Water, Fwd (410 gal)	3,510	29.3	102,831	410	
Tank: Black Water (260 gal)	2,210	21.3	47,073	260	
Full-Load Weight	**113,852**	**41.54**	**4,729,771**	**119%**	**6.17**

Notice that all of the boats discussed here—from the slowest to the fastest, from the smallest to the biggest—were all calculated using the same method. The weight studies were all done the same way. The drawings were all done based on percentage of waterline. And we find that we get *very* consistent results. All through it. By *not* changing the method. PBB

About the Author: *Michael Peters is the principal of Michael Peters Yacht Design (Sarasota, Florida), founded in 1980 and specializing in power craft. A profile of MPYD was the cover story of PBB No. 66. More recently, Peters was author of a feature article in PBB No. 117 titled "The Large Green Yacht, Part 2"—based on his presentation at the latest Yacht Vision symposium in Auckland, New Zealand, in March 2008. Part 2 of "Peters On (Fast) Powerboats" will appear in the next issue of PBB, and focus on offshore cats and stepped-V hullforms.*