Peters On (Fast) Powerboats

Part 2

In Part 1 the author detailed a consistent approach to the design process, concentrating on moderate-V and deep-V hullforms. Here, he concludes with two additional high-performance hull types for which his office, Michael Peters Yacht Design, is justifiably famous: offshore racing catamarans and stepped-Vs.

by Michael Peters
Artwork courtesy of MPYD

In Part 1 (Professional BoatBuilder *No. 126, page 38), Peters emphasized the importance of balance, and the special significance of the K-value, in fast-powerboat design as practiced at MPYD. The K-value is a performance predictor derived via various formulas; Peters favors one developed by Cuban émigré Eduardo Reyes. It's a constant based on boat type. Another valuable indicator is the speed-to-length ratio. For more on both factors, see Part 1—Ed.*

Above—*In 2003, Callan Marine broke the 200-mph barrier with the first offshore raceboat ever to do so. The boat itself was a recycled and repowered Tencara 43 (a MPYD design; see specs on page 58), a world champion in '97.*

The Racing Cat

Racing catamarans of the 1970s, and many well into the 1980s, had a cross-section in which the width of the two sponsons was greater than the width of the tunnel. Those dimensions came about because designers at the time feared their boats would blow over backward at speeds above 125 mph (201 kmh); they didn't want to put too much lift in the tunnel. But, in fact, their tunnels, being relatively narrow, afforded little surface area for wing-in-ground effect.

In 1981 I designed my first racing cat—with the opposite proportions; that is, a very wide wing for the boat's beam [**Figure 1**]. This cat was *fast*: it set a world speed record of 131 mph (211 kmh), with outboards, which stood for seven years. However, the boat failed to finish races. So we made an effort to develop a better all-around boat, not just a sprinter.

Our next generation of cats, from 1983 to '90, featured more moderate proportions: specifically, the two sponsons added up to a little more than the tunnel width. These boats, built in Italy, of aluminum, ran at a reduced speed, but they won races [**2**].

Author Peters's initial entry into the realm of racing cats came in 1981, with a boat that set a world speed record of 131 mph, with outboards*—a record that stood for seven years.*

Figure 3.

CUV 41 Cat

Waterline length	36.2′ (11m)
Speed (knots)	107
S/L ratio	17.8
HP	1,700
Weight (half load)	11,500 lbs (5,216 kg)
LCG (station)	7.4
Weight/HP	6.8 lbs/hp (3.1 kg/hp)
Deadrise @ T	18
K	2.065

The aluminum CUV 41 represented but one design within a broad range of numerous, winning, second-generation raceboats for MPYD.

Figure 4.

***Dirty Laundry* 46′**

Waterline length	40′ (12.2m)
Speed (knots)	142
S/L ratio	22.6
HP	3,600
Weight (half load)	17,650 lbs (8,000 kg)
LCG (station)	7.5
Weight/HP	5.5 lbs/hp (2.5 kg/hp)
Deadrise @ T	18
K	2.01

Dirty Laundry, *launched in 1991, was a next-generation raceboat, at once dependable and successful. Note the progression of wt/hp ratio.*

Figure 7.

Victory 44 Cat

Waterline length	39′ (11.9m)
Speed (knots)	143
S/L ratio	22.9
HP	1,900
Weight (half load)	10,350 lbs (4,695 kg)
LCG (station)	7.6
Weight/HP	5.4 lbs/hp (2.4 kg/hp)
Deadrise @ T	17.5
K	1.985

A Victory-built boat for Victory Team of Dubai. With this particular series, Peters had settled on general proportions, and solved tunnel lift, for MPYD's offshore cats. Wing-in-ground effect enabled these boats to exceed 140 knots. Note the sub-2 K-value.

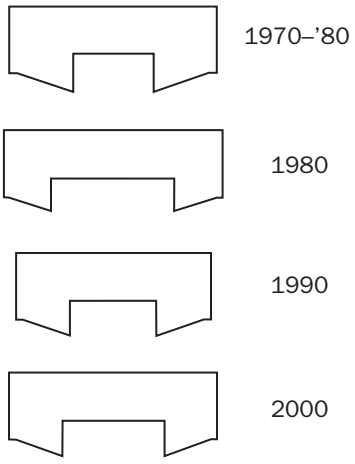
We built about 30, ranging in size from 38′ to 45′ (11.6m to 13.7m), and won a number of major races. Note the K-value: 2.065 [**3**]. Note, too, the speed-to-length ratio: almost 18. But look where the center of gravity is: 74%. So we're three-quarters of the way back for the balance of the boat. And, we're below 7 lbs/hp (3.2 kg/hp). It's a pretty light, highly powered boat.

The 46′ (14m) *Dirty Laundry*, launched in 1991, was a generational shift in racing cats [**4, 5**]. This boat's owner insisted on a *guaranteed* top speed of 130 mph; meaning, our design was obliged to do nothing less. The boat would be competing against a Gentry Eagle that had four 1,200-hp (900-kW) engines, but in order for us to get the dependability—the ability to finish races—we went with less power. We specified four 900-hp (675-kW) engines coupled to two Arneson drives. In trials, we broke the guarantee by 35 mph: *Dirty Laundry* reached 165 mph with a full fuel load of 300 gal (1,136 l), and was never run at wide-open throttle *without* a full fuel load. How to account for this? We were in ground effect for the first time. Above 135 mph, the boat took off, with a flat resistance curve; all our speed curves and calculations had to be adjusted accordingly. By comparison, the 48′/14.6m Gentry could run about 150 mph, tops. The difference between the two boats was all in the wing; the Gentry boat was a "leftover" with a narrow wing. Our wing was 6′6″ (1.9m) wide. *Dirty Laundry*'s K-value is 2.01. Notice that the weight-to-horsepower ratio is now down in the 5.5-lb/hp (2.5-kg/hp) region.

By the time Tencara, based in Italy, began building our catamaran designs, we'd pretty well established the basic proportions for a raceboat, and for tunnel lift [**6–8**]. Lightweight advanced composites were specified to achieve 5.5 lbs/hp. With ground effect, these boats achieved speeds greater than 140 knots. Notice how high they run on the chines: they're out of the water all the way down to the lower strakes, thanks to the amount of lift they're getting. We've now broken a K-value of 2, and the S/L is 23 [**7**]. When you look at S/Ls on our initial graph in Part 1, illustrating what is widely considered to be high speed, an S/L of 5 was fast; here, we're four times that.

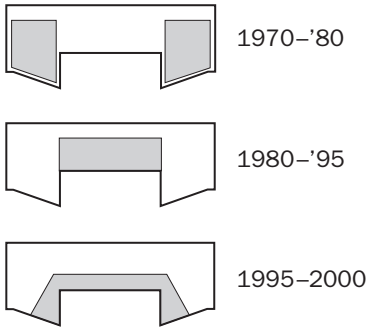
In **Figure 9** you see the ratio of tunnel width and how much width we were utilizing. When I started doing these raceboats I didn't recognize that they were only about a five-year-old animal at the time. I was young and thought they'd been

Figure 9.



Tunnel Beam

Figure 10.



Effect of Fuel Location

Peters spent years on what he calls the "path of discovery," trying to determine the best tunnel beam and fuel location for MPYD's high-speed cats. The diagrams above illustrate evolutionary trends influenced by Peters designs.

around longer than that and I was simply getting my turn at it. So there's been this 25-, 30-year path of discovery as to what's the best configuration.

In 2003 Callan Marine purchased an aging Tencara 43 (13.1m) cat, the 1997 World Champion *Jolly Motor*, and rerigged the boat with a pair of turbine engines [**11**]. The revamped boat became the first offshore raceboat in history to break 200 mph (322 kmh).

Callan Marine managed to have a few successful runs over 200 mph—as high as 209 (336 kmh)—establishing itself as having the first boat to do that. And then, at a race in Key West, the crew wrecked the boat. Wrecked it beyond repair. Which I think was actually the best ending you could possibly have: *because nobody died in it.* It wasn't around anymore to try to go 220 (354 kmh), where someone was definitely going to get killed one day. So the quest for speed with that boat is over. It's like quitting racing at the right time.

Our office is no longer designing these raceboats. The interest I had in them was technical. It wasn't love of the sport. I feel these boats are mature designs now, and that there's not really anything of note left to do with them. The design type has been molded enough in enough different directions so that if you look at the other boats, they all start to look the same. And basically everything begins to head down the funnel of what works. I don't plan to do any more. Besides, I'd prefer not to do my last one…and have a flop.

That said, let's review some of the basics of modern racing-cat design.

• As a lifting surface, deadrise is less effective on a cat than it is on a monohull. A cat also suffers less impact for its deadrise. Whereas a standard deep-V monohull typically has 24° of deadrise at the transom, a racing cat has about 18° aft.

• Fuel location has changed over the years; the mass is now concentrated closer to the center of gravity and away from the transverse ends [**10**]. This arrangement eliminates the "walking" characteristics of the early cats. That concentration of mass near the CG lowers the gyradius—in much the same way that sailboat designers of the 1970s moved weight in from the ends of raceboats in order to eliminate hobbyhorsing [**12**].

• A surface drive runs with only the lower half of the prop in the water; its thrust is basically perpendicular to the blade. Using this thrust to lift the bow robs the boat of potential energy to move it forward. By trimming the bow down, the thrust is then more in line with the direction of the boat, and it supplies maximum power to go forward. Because these boats are generating their lift with the tunnel, we're not trying to generate lift with the propeller. On a perfectly balanced boat, all the forces work together instead of robbing power from each other. The fastest boats run with a 4°–6° negative drive angle. This negative angle helps the boat maintain a level attitude when airborne.

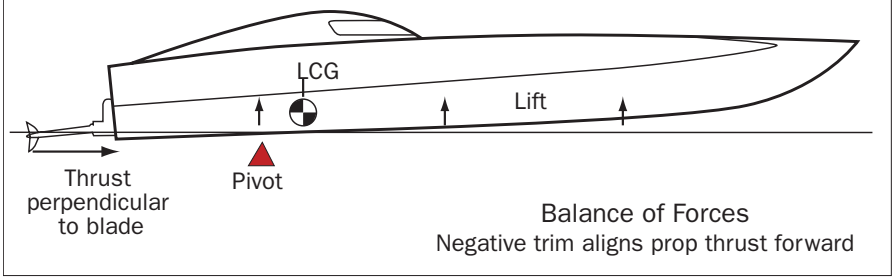
• Fifty percent of a modern racing catamaran's weight is in its structure, and 50% is in its mechanicals. Our office designed the composite structures with finite element analysis modeling. We broke down each laminate by layer to perform exhaustive weight studies.

Figure 11.

Callan Marine's Tencara 43

Waterline length	39′ (11.9m)
Speed (knots)	181
S/L ratio	29.0
HP	3,000
Weight (half load)	12,000 lbs (5,443 kg)
LCG (station)	7.5
Weight/HP	4.0 lbs/hp (1.8 kg/hp)
Deadrise @ T	18
K	1.95

Figure 12. Offshore Catamaran



*Because a surface drive's thrust is basically perpendicular to its blade, the boat is trimmed bow down to better align the thrust with the direction of the boat. By the time his office stopped designing offshore racing cats, Peters had figured out how to best exploit their balance of forces—*balance *being the dominant theme of all MPYD's powerboat design work.*

• The latest cats are the strongest and fastest ever, combined with the best handling, turning, and overall capability in rough water.

The Stepped-V

When we think of stepped hulls, most of us think of seaplanes. The rocker aft of the step was designed to rotate the aircraft and increase the angle of attack and break bottom suction for takeoff. The step of a seaplane hull is very near the center of lift of the wing and the LCG of the aircraft.

More interesting is how the seaplane acts as a high-speed boat. At Catalina Island, off the Southern California coast, where I grew up, seaplanes would taxi miles in open ocean to avoid landing in the harbor in certain sea conditions. When it was too rough for the planes to land in Avalon, they would land up at Long Point, which was about eight miles away, but a wind-protected area. And they would run them in on their hulls. Well, what I observed over time was the lack of pitching, the steady attitude at speed, which surpassed any boats of the day. I later realized the step was developing two pressure centers on the hull: dampening out the pitching; and enjoying the steadying lift from the ground effect of the wings close to the water's surface.

Early Stepped Hulls

Let's briefly review some history here.

• The first boat to plane was in fact a single-step hull, in 1872.

• In the early 1900s, stepped-hull hydroplanes were a common sight. *Maple Leaf IV*, built in 1912, had five steps and could run 57 mph; moreover, it could run straight through a wave.

• My interest in designing a nonpitching stepped hull began with a circa-1970 Uffa Fox design named *Black Maria*, which Fox claimed had superior rough-water characteristics [**13**].

• I designed my first stepped hull in 1976, and applied for a patent, issued in 1981. The boat was designed for rough water, not speed; I was crossing Catalina channel in those days and wanted pitch control. The boat ran great: good speed, fantastic turning ability, very dry. That hullform later became the first of the stepped Intrepids (Intrepid Powerboats, Dania, Florida). My early stepped designs did not account for high speed as we know it today, and so they would not have behaved well above 50–55 mph.

Basics of Stepped-Hull Design

• Note the pivot position of the hull and its effect on dampening pitching. The step-as-pivot acts like a large trim tab.

• Balance the deadrise between steps. They can be equal, or within a couple of degrees of each other, but there cannot be an *extreme* difference. Flatter sections of a stepped hull will overpower the deeper forward sections, and force the bow down at speed.

• The decision to go with a single or twin step is determined by length-to-beam ratio, and speed. The low-aspect-ratio lifting surface of a boat with narrow beam requires two steps for lift. Think of an airplane with a short wingspan: to increase lift, you add span and increase aspect ratio. Old biplanes had short spans with multiple wings to increase lift. Leading edge equals lift; but, you can also have too much lift.

• The boat's longitudinal center of gravity should always be kept aft of the single step. For a twin step, the aft step is kept near the LCG.

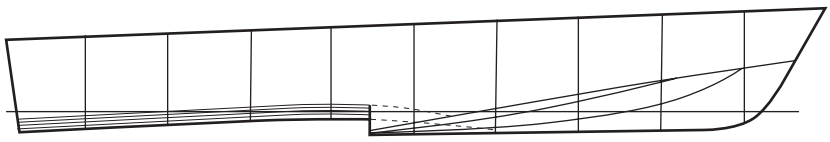
• The height of the step is not an issue, though the angle of attack is. We normally specify steps between 1¼″ and 2½″ (31.8mm and 65.5mm) in height; those dimensions are based on the angle of attack. Height + length of step will dictate the angle of attack relative to the baseline. Length of step is based on the LCG. Our normal range of angle of attack is between 0.5° and 1°. We also measure the angle of attack according to a datum line taken across the surface of the hull. Relative to that datum line, we range from a 0.5° to a 1.75° angle of attack. We always keep the forward angle of attack higher than the aft one.

Let's talk about some of those bullet points in greater detail.

The text of an article on Uffa Fox's *Black Maria* around 1970 in *The Rudder* magazine emphasized the boat's exceptional fore-and-aft stability—it was basically a nonpitching boat. The drawing shown below is of a sistership. I started to read more about early stepped hulls and realized that some of those boats were so stable fore and aft that they would actually run through waves. In other words, you're building so much lift with a multistepped hull you can drive the bow right through a sea.

You can see that the Fox boat had deadrise: 10° at the transom, and 15° at

Figure 13. Uffa Fox design, 1970



Length overall ..... 43′6″ (13.3m)	Beam/length ratio .... 5 to 1
Beam ..... 8′6″ (2.6m)	Length, waterline..... 38′ (11.6m)
Displacement..... 3.8 tons	Draft ..... 2′1″ (0.6m)
Engine: Ford ..... 800 hp	Speed ..... 55 knots
Propeller diameter.... 22″ (0.56m)	Speed ratio..... 9

K = 2.29

Besides being fascinated early on by the stepped hulls of seaplanes operating off the coast of Southern California, Peters was ultimately lured into experimenting with stepped-Vs by a magazine article on Black Maria *from the legendary British designer Uffa Fox.*

the step—a pretty steep angle of attack: 2½° at the step, and 2° at the transom. Those would be very high angles of attack compared to what we would employ today. But considering that Fox's boat had submersed propellers, its K-value of 2.29 wasn't too bad. *Black Maria* could make 55 knots.

Here's a photo of my first stepped hull [**14**]. Fairly radical. My thinking? If you're going to have a step, then why not *really* have a step. One of the reasons for the pronounced height of that step was that I'd decided the air should come from inside. In my research on stepped hulls I would encounter descriptions of how the boats would cross through a wave, shutting off their ventilation at the chines. The boats would literally stop planing—due to the suction they generated.

Note the very high deadrise on my boat. It's the first stepped hull I know of with such high deadrise. All previous stepped hulls had fairly shallow deadrise. Mine was 20° at the transom and 25° at the step. The boat was a *bear* in rough water. People would come by when I was running the thing, off Marina del Rey on the mainland, or off Catalina, and they'd say, "What's with that boat? It doesn't pitch."

It had a pretty strong step and a convoluted shape. But the damn thing worked really well. Here is a hand-drawn perspective view of that hull [**15**]. My patent covered, for the most part, the internal venting. I thought it was important, back in those days, to have a continuous chine. My own boat was built of wood, so a continuous chine was needed. But it generated sort of an S-shape aft. For a while I believed in this varying angle of attack; as the boat got faster, it went from a high angle of attack back to a shallow angle of attack, and worked very well up to a certain speed. But back then, we were happy if a boat was a 40-knot boat. Nowadays I think this boat would be disastrous at higher speeds.

The first production boat we ever designed based on that hullform was an Intrepid. John Michel, the company's owner, approached me around 1990 and our office ended up designing six or eight different models for him [**16, 17**]. There were no internal vents; we discovered that the boat, because of riding on the strakes, really didn't need to have them. But since we were having some trouble in turns, we did ventilate the chine.

Most people, when they think of a stepped hull, think: I'm breaking the wetted surface so the boat goes faster. They believe that's pretty much the genesis of it. But the step introduces a different pivot point to the boat. The area aft of the step works almost like a huge trim tab. Part of the problem with those earlier boats is they had this big trim tab that, once it was down, would drive them right through a wave. What I gradually discovered was: Getting those angles right was what it was all about. That's good, because stepped boats really dampen out the pitching; they tend to run flatter. But if you don't have those ratios correct, you're going

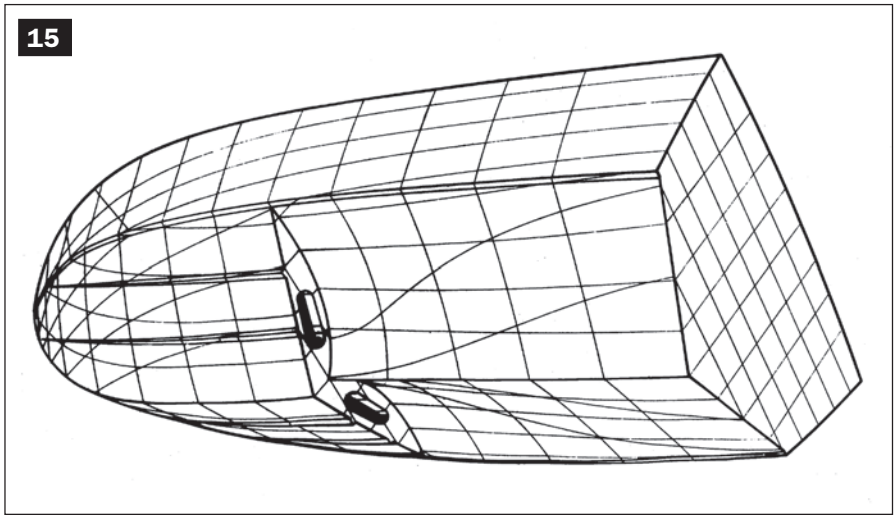
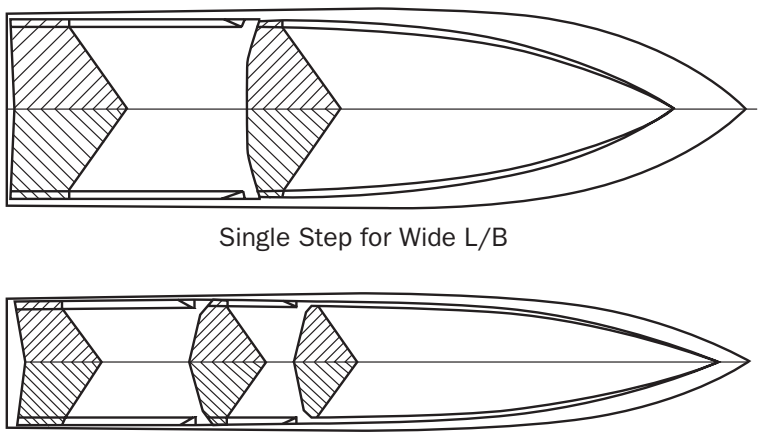


Figure 14—*Peters's initial entry into stepped-Vs came in 1980 with this I/O-powered one-off built of wood. He's on the right in the photo; his hand-drawn perspective view of the complex bottom appears in* ***Fig. 15****. Deadrise was 20° at the transom, 25° at the step. The boat performed well enough in all conditions for Peters to propose a variant of the idea to Intrepid Powerboats, whose first-generation stepped-V is seen in* ***Fig. 16****.* ***Fig. 17*** *shows a later Intrepid model designed by MPYD; note its vented chine.*

For Peters, the number of steps is governed by the general shape of the hull, and thus the aspect ratio of the wetted surface (indicated by the shaded portions). MPYD never specifies more than two steps.

Figure 20.



to have a boat that's too stiff longitudinally and could be a big problem for steering, wetness, broaching…all sorts of things.

Back to my first stepped design for a moment: I kept the deadrises—at the step and at the transom—fairly similar. You definitely want to avoid having too flat a stern with too deep a step. Again, it's a matter of *balance*. You have so much more lift off the shallow deadrise back aft that you'll overpower the stepped portion of the boat. So it's vital to maintain a *balance* between the two.

A lot of people are in a quandary as to how many steps to put on a boat **[18, 19]**. We see some boats now that have five or even six steps. I don't know why they have all those steps, especially since most of them are not properly ventilated. I often wonder if they're causing more harm than good.

At our office, a short, wide boat gets one step, and a long, skinny boat gets two steps [**20**]. There's a reason for this. It's the aspect ratio of the lifting surface. Consider the aspect ratio of the span-and-chord of an aircraft wing. World War I fighter planes were bi-wing and tri-wing craft. That's because aircraft designers couldn't get the wings long enough to use just a single wing; the structures of the time weren't up to the task, so they stacked the wings. Stacked wings are essentially what you're getting with a multistepped boat. Every time you introduce a new leading edge, you're introducing more lift. So the more steps you have, the more lift you're going to get. But in our office we've never felt the need to have more than two steps. It's possible to generate so much lift with a step, depending on the angle of attack, that I don't see the argument for additional steps. Maybe on a really long boat you'd want to consider more than two.

Indeed, you can generate *too much* lift for the boat. I think this is a common mistake: people tend to put too much angle of attack in their steps, and really don't understand what they're trying to achieve. If one step is good, then two must be better, right? And, hell, five must be . . .

Center of gravity is critical on a stepped hull. We always keep the CG aft on a single-step hull. With a twin step we always keep it near the aft step [**21**]. With two-step geometry it's very difficult to get the CG aft of the aft step, though we've done it on a couple of Cigarettes. I'll discuss those in a moment.

Figure 18.

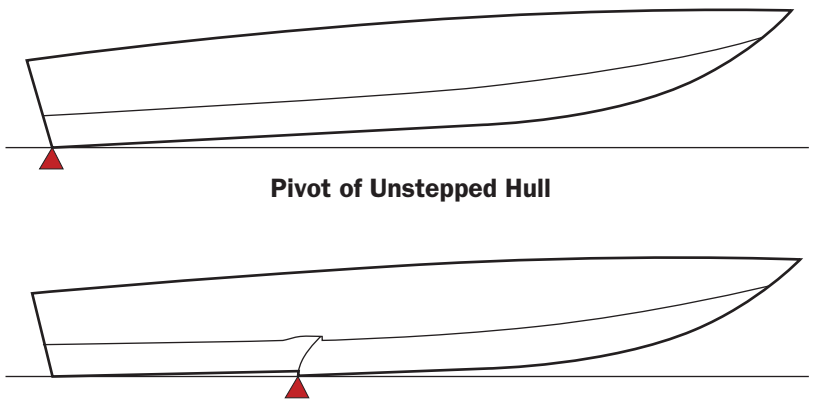


Figure 19.

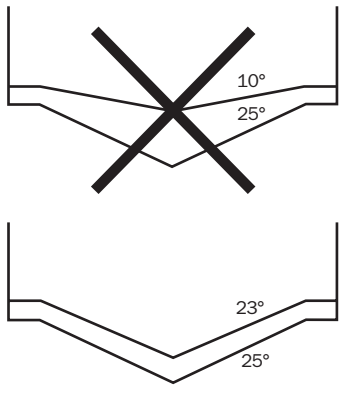
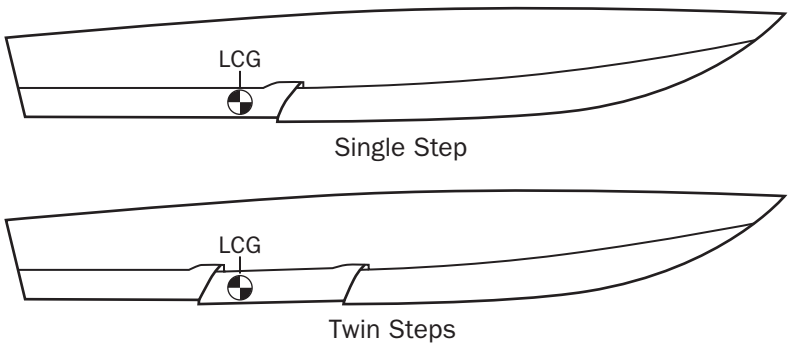


Figure 18—*A step acts to reduce pitching in a deep-V by changing the hull's pivot point.* ***Fig. 19***—*According to Peters, the deadrise of the step should closely correspond with the deadrise of the transom. Too great a difference in those deadrise angles leads to performance problems at high speeds. Here again, it's a matter of* balance.

Figure 21.



"Center of gravity is critical on a single-step hull," says Peters. "With a twin step we always keep it near the aft step."

We're always looking at angle of attack. Compared to the baseline of the boat, we set the boat on that line and then measure the angle of attack two different ways [**22**]. We measure it relative to the baseline, and then relative to the datum line connecting the step, or steps, and the transom. We're generally working in angles of less than 1.5°. We tend to be pretty close to 1°. Very shallow.

We always keep the angle of attack of the forward section of the boat higher than what it is aft, to keep the boat from driving its bow through waves. For twin steps we do it a similar way. But we always have less angle of attack after the aft step, to produce a little bit of rocker, which gets the boat to settle back and not drive through waves.

The Cigarette Series—Before and After

I'd wondered for years about stepping the traditional deep-V Cigarette-type boat. Can you really use steps to increase the speed of a boat that spends much of its time running almost all the way out of the water?

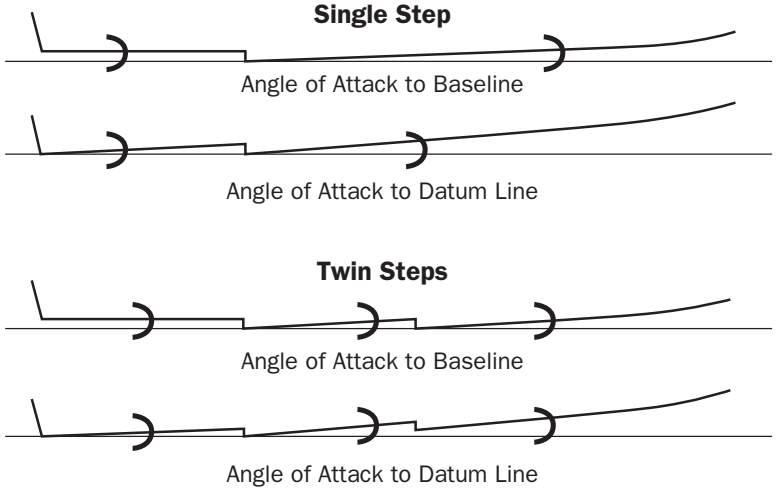
Around 1994 we were asked to help get a 42′ (12.8m) Aronow deep-V to run faster. The boat was built with no rocker and ran too flat, falling well below predicted speed. The client suggested we cut apart the existing boat and add rocker. Instead, we flipped the boat over in the shop and added a single transverse step about 1¼″ deep. That change, while keeping everything else—engines, drives, props—the same as before, added *22 mph* (35 kmh) to top-end speed. This magnitude of difference would not have been possible had the hull been correct to begin with. But what a difference that step made.

Six years later we were asked by Cigarette Racing Team (Opa Locka, Florida) to step the bottoms of four different models ranging in size from 30′ to 42′ (9.1m to 12.8m). Each of those required us to work with the existing molds. We developed step inserts, and each of the four models picked up 7–8 mph (11.2–12.8 kmh). To my mind, those boats offer perfect before-and-after examples of what a well-designed step can achieve.

Here's a stepped Cigarette [**23, 24**]. Now we're at about 80 mph (129 kmh), we're balancing at 73%, and the K-value is down to 2.178 with Mercury engines.

The initial reports we received from Cigarette were about how much speed the boats had increased with the same power. The trials crew was obviously very impressed, but they neglected to mention that in executing a high-speed turn on the

Figure 22.



The Peters office measures the angle of attack two different ways: relative to the baseline; and then relative to the datum line connecting the step, or steps, and the transom. The angles are shallow: "pretty close to 1°," he says.

23

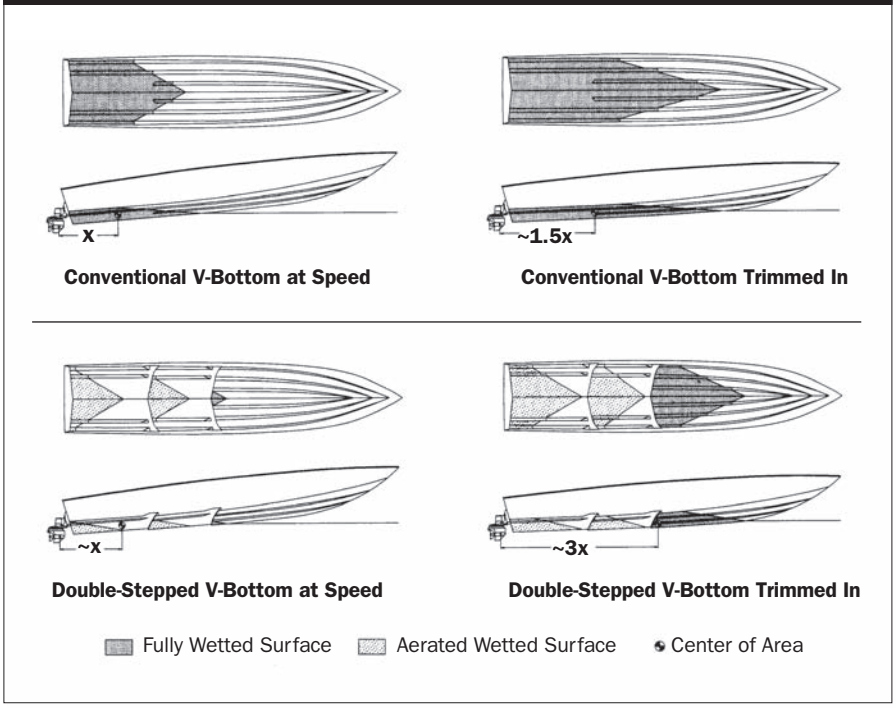
Figure 24.

Cigarette 36 F2

Waterline length	31.8′ (9.7m)
Speed (knots)	79
S/L ratio	14.0
HP	940
Weight (half load)	7,260 lbs (3,293 kg)
LCG (station)	7.3
Weight/HP	7.7 lbs/hp (3.3 kg/hp)
Deadrise @ T	24
K	2.178

After Peters successfully retrofitted steps to four existing Cigarette Racing Team models, the company commissioned his firm to scratch-design several new stepped boats, one being the 36 F2 shown here.

Figure 25.



The drawings above illustrate the difference in wetted surface—at speed, and at speed trimmed in—between a conventional deep-V and a stepped-V. Note the aerated wetted surface; it's full of bubbles that can behave like ball bearings.

Intracoastal Waterway, they trimmed the drives in and were thrown out of the boat. The lesson? *Never trim the drives in on a stepped hull for a high-speed turn.* At speed, a conventional deep-V runs with its lateral area aft; and when trimmed in tight for a turn, the boat *adds* lateral area and carves a nice, controllable turn [**25**]. A stepped hull, however, behaves differently. At speed, the wetted surface and lateral area have gaps caused by the steps. The water under the bottom, aft of the steps, is actually an air-and-water mix—there are bubbles—making for very little resistance and a very fast bottom. So when you turn the boat, if you trim in (as with a conventional deep-V), you plant the bow and move all the lateral area forward, with nothing but bubbles—a wetted surface that behaves more like ball bearings—to serve as lateral area aft [**26**]. As if this were not bad enough, a standard I/O is poorly equipped to cope with all those bubbles; indeed, the lower unit doesn't even have a section that will maintain attached flow. As far as the boat's concerned,

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there *is* no drive aft—and therefore no resistance to spinning out and rolling.

We've since learned that virtually every manufacturer of stepped hulls has had the same thing happen. *Repeatedly.* It is the best-kept secret out there. In its worst manifestations it has killed people and generated major lawsuits. What we, collectively, never realized with stepped boats is that they can be lethal in a fast turn. Everything that makes the boat go fast doesn't add up very well when it goes into a turn.

Victory Patrol, Invincible, and More

During the past four decades there've been a number of attempts to marry a deep-V monohull with an offshore catamaran, the goal being to combine speed with lateral stability. These were often radical solutions, but they seldom, if ever, resulted in practical hullforms. In 1988 I began toying with the problem: I drew a catamaran stern on a deep-V and in 1993 incorporated a tunnel into a stepped hull in Intrepid's 23′ (7m) flats boat.

Figure 26.

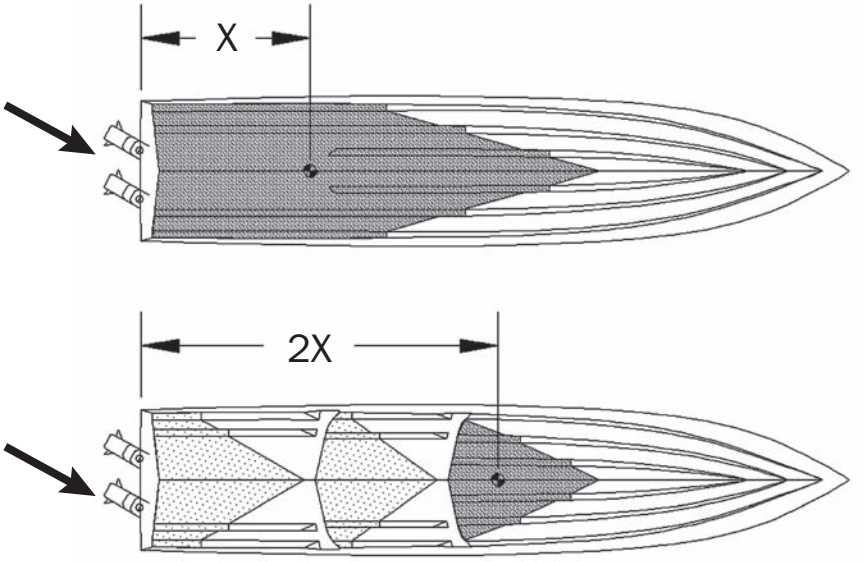

Figure 26 *illustrates the difference in turning dynamics between a conventional deep-V and a stepped-V. Note the relative locations of the wetted surface and effective lateral area. Note too, however, the abundance of aerated water on the stepped bottom.*

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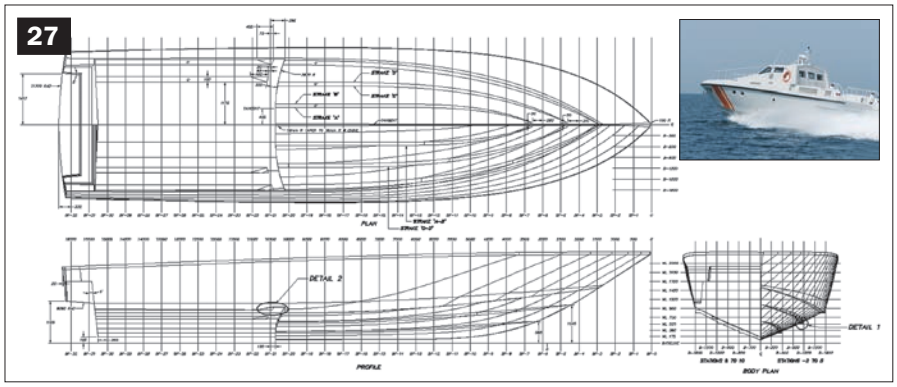
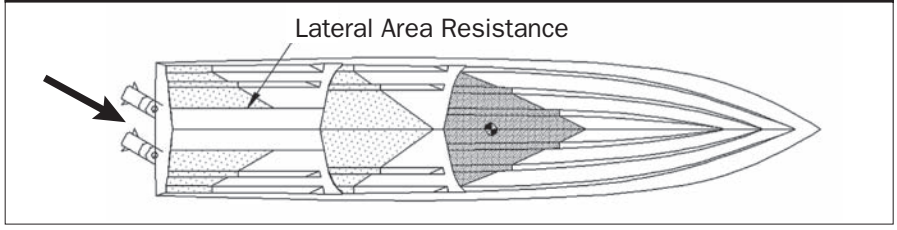


Figure 28.



Knowing that steps often adversely and dangerously affected the turning dynamics of a high-speed deep-V, Peters set about trying to solve this problem. ***Figure 27—***Victory Patrol *was based on the lines of a successful aluminum model designed for Hy-Lite Powerboats in the late '90s—with the addition of a central tunnel aft of the step.* ***Fig. 28—****As illustrated in the drawing of a generic bottom, such a tunnel creates lateral area resistance to reduce a stepped hull's tendency to spin out in a fast turn.*

Figure 29.

***Victory Patrol* 56**

Waterline length	43.5′ (13.3m)
Speed (knots)	64
S/L ratio	9.70
HP	2,300
Weight (half load)	40,000 lbs (18,148 kg)
LCG (station)	6.45
Weight/HP	17.4 lbs/hp (7.9 kg/hp)
Deadrise @ T	21
K	2.091

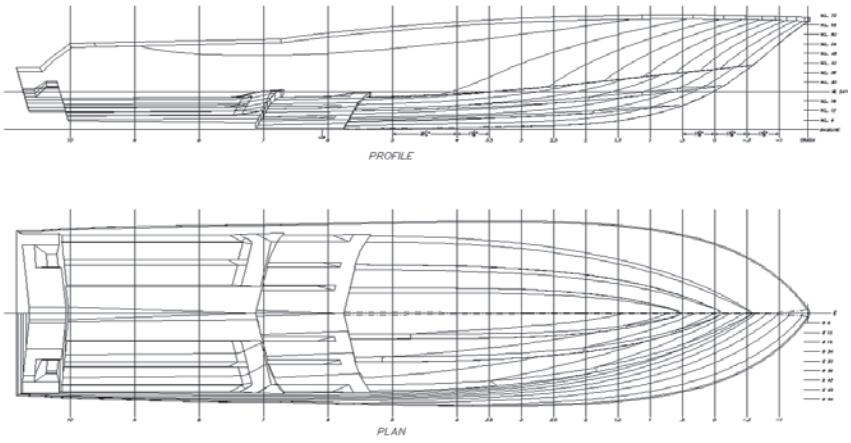
Victory Patrol, a 56-footer (17m) designed in 2002, is based on the same hull lines as a model we designed in the late 1990s for Hy-Lite Powerboats (Leamington, Ontario), except we incorporated a central tunnel aft of the step [**27, 28**]. With that tunnel we were trying out the concept of creating lateral area to reduce a stepped hull's tendency to spin out in a high-speed turn. The tunnel is internally ventilated with

Figure 30.

Invincible 36

Waterline length	31.5′ (9.6m)
Speed (knots)	64.3
S/L ratio	11.45
HP	900
Weight (half load)	10,000 lbs (4,536 kg)
LCG (station)	6.62
Weight/HP	11.1 lbs/hp (5 kg/hp)
Deadrise @ T	22
K	2.196

31



The Invincible 36—a high-performance, outboard-powered, offshore tournament sportfisherman—demonstrates a further development of the central-tunnel concept.

air tubes. Shut the air off, and planing time doubles; also, top speed drops by 5 mph (8 kmh). *Victory Patrol* achieved a K-value of 2.091 with Arneson drives [**29**]. According to Rolla Propellers, it's the most efficient surface-drive boat they've ever seen. Two 1,150-hp (863-kW) diesels deliver a speed of 64 knots.

Invincible Boat Company's (Miami, Florida) 36-footer (10.9m) is a twin-stepped outboard-powered tournament sportfisherman with a central tunnel in the hull and chine ventilation [**30, 31**]. It has demonstrated superior rough-water capability, and is fast and stable in all conditions. The tunnel airs out at 40+ mph (84 kmh). The K-value, 2.196, is the best we've ever seen for an outboard-powered boat. It's approaching what we get with surface drives now. If you consider a K-value of 2.12 or 2.13 for a surface-drive boat, then we're close. Besides great speed, the boat is dry running, and soft riding.

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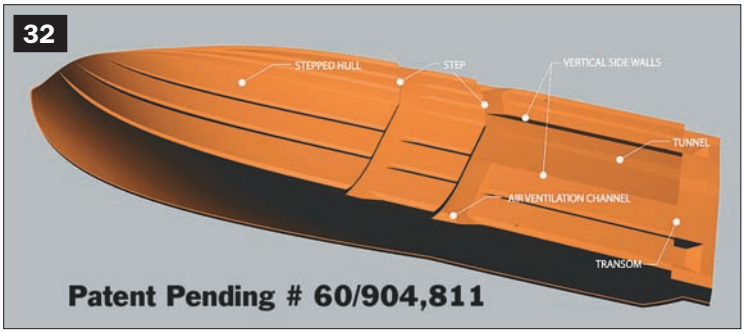
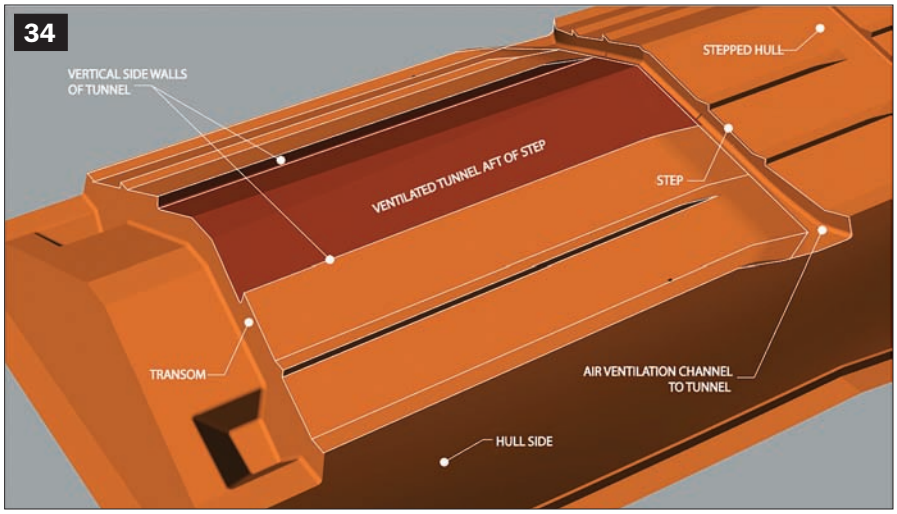


Convinced by now that he'd solved the spinout problem associated with stepped hulls, Peters refined his quintessential design and patented it—the only hullform he's applied for patent since protecting his first stepped-V design 30 years earlier. The solid-model views shown were submitted to support the patent application. Zodiac, among others, commissioned a version of the new hullform for its military RIBs.



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The Peters Principles

- Believe in the basic tenets of naval architecture. Never skip any steps in the design process. No matter how tedious and boring weight studies might be, they are unquestionably the most crucial part of design.
- Always copy someone. The only way to improve is to understand what has been done before. Be a student of history. Always analyze what others have done, both good and bad, in order to create a baseline of design.
- Breakthroughs come slowly. Have faith that there will always be another project, enabling you to try your ideas in controlled increments. Resist the temptation to try all your ideas at once.
- Always get someone else to pay to try your ideas. A true design breakthrough can be made only with willing partners who understand the risk. Nothing new can be done without risk. Finding people who appreciate this maxim—and give you the freedom to fail—is critical to exploring new ideas.

—Michael Peters

The design work on the Invincible series led to my second patent—the first time in 30 years I decided to patent a hull design—and, as with the first, in the realm of stepped hulls [**32**]. The 11m (36′) RIB made by Zodiac (headquartered in Paris, France) employs a version of this hullform [**33**]. Several U.S. and foreign government agencies have rigorously tested the hullform and experienced no spinout. Zodiac has taken its Mach II RIB to 62 knots with triple outboards. The boat is getting the same K-value as the Invincible.

The big innovation was the very shallow tunnel in the stern, which has effectively eliminated spinout. You can see it's pretty much a conventional stepped hull…except for the tunnel [**34**]. One thing that was surprising: the Invincible, being a fishing boat, had to be able to do normal things, like pick up water for its fish tanks. So we said, Okay, just put your water pickup *right there*; you ought to be able to get plenty of water. Wrong. At 40 knots and above, it's *dry*. We discovered the boat is actually running on the two sponsons, and is drying that area out. We never thought that would happen. We thought the water would reattach by then. But it's actually running with the aft loading characteristics of a catamaran, which creates a dry area down the middle, and helps account for the boat's speed.

Getting a boat to have this much lift and run this fast *and still be controllable* was the hard part. That

Figure 35.

Example Vessel	Hull Type	Drive Type	LWL (ft)	Top Speed (knots)	S/L Ratio	Installed HP (bhp)	Displacement (lbs)	LCG (station)	Weight/HP (lbs/hp)	K-Factor
Garlington 78	Modified-V	Inclined shafts	66.7	36.7	4.5	3,600	115,000	5.8	31.9	2.245
A&R 39m M/Y	Modified-V	Water jets	100.2	51	5.1	10,950	334,000	6.0	30.5	2.070
Magnum 80	Deep-V	Surface drives	67.3	46	5.6	3,600	107,000	6.2	29.7	2.135
***Victory Patrol* 56**	Stepped-V	Surface drives	43.5	64	9.7	2,300	40,000	6.5	17.4	2.091
Contender 34	Deep-V	Outboards	27.9	51.4	9.7	700	10,200	6.8	14.5	2.251
Zodiac MACH II	Stepped-V	Outboards	32.3	59	10.4	900	12,185	7.0	13.5	2.196
Chris-Craft 28	Deep-V	Stern drives	22.9	53	11.1	560	7,300	6.0	13.0	2.265
Invincible 36	Stepped-V	Outboards	31.5	64.3	11.4	900	10,000	6.6	11.1	2.196
Cigarette 36 F2	Stepped-V	Stern drives	31.8	79	14.0	940	7,260	7.3	7.7	2.178
Maverick 21	Modified-V	Outboards	18.2	62.5	14.7	225	2,350	6.4	10.4	2.227
CUV 41	Catamaran	Surface drives	36.2	107	17.8	1,700	11,500	7.4	6.8	2.065
Dirty Laundry	Catamaran	Surface drives	40.0	142	22.6	3,600	17,650	7.5	5.5	2.010
Victory 44	Catamaran	Surface drives	39.0	143	22.9	1,900	10,350	7.6	5.4	1.985
Tencara 43	Catamaran	Surface drives	39.0	181	29.0	3,000	12,000	7.5	4.0	1.950

A chart summarizing key elements of the MPYD-designed boats covered in this two-part article facilitates comparisons and underscores the conceptual consistency the boats share—despite obvious differences in size, and four fundamentally different types of hullform.

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goes back to our racing-cat days, when achieving speed wasn't the issue; *finishing* a race was. So this design detail represents *our* solution to solving the problem of spin-out in stepped hulls, a problem that appeared only as speeds increased.

The vertical sidewall is key. We did a boat in France, a single step with this configuration. The clients weren't so sure they liked it. So they filled in the tunnel. First time they took it out, they spun around. Well, that, for us, was absolute proof that we'd successfully figured out what's happening.

Finally, we arrive at a chart that summarizes the boats our office has designed that appear in Parts 1 and 2 of this article [**35**]. They're arranged according to speed/length ratio. You can see the CG moves aft in all cases. And you can see that the K-value, except for one, gets increasingly better as speeds increase.

What I stressed in Part 1 bears repeating. Our office approaches all projects the same way, namely: a design spiral; weight studies; a 10-station lines plan; longitudinal center of gravity according to a percentage of the designed waterline; convex sections; 25° of deadrise around station 4; and then we determine our K factor. Over the course of numerous projects, we can fill in the curves for each type of vessel and come away with a pattern of data allowing consistent, predictable results. Even though each project is vastly different, we find the same principles of naval architecture apply to them all.

In preparing for this presentation *[an IBEX seminar; see below—Ed.]* I came to further appreciate four books that have probably meant the most to me in my professional career. In alphabetical order, they are: *Dhows to Deltas*, by Renato "Sonny" Levi (published in 1971); *Elements of Yacht Design,* by Norman Skene (Skene's own 1938 revision was recently reissued by WoodenBoat Publications); *High-Speed Small Craft*, by Commander Peter Du Cane (first published in 1951); and *Naval Architecture of Planing Hulls*, by Lindsay Lord (first published in 1946). Now, I'm what I call a *pretengineer*. I'm not an engineer. I'm not a naval architect. So everything I do relies on somebody to set me straight and interpret it. In revisiting these books I realized the person I really learned everything from was Sonny Levi. Anyway, I would encourage people to read those four references. Updated editions exist in all cases except Levi's. 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. This pair of PBB articles on designing fast powerboats is an adaptation of a seminar presentation Peters made at IBEX '08, in Miami Beach, Florida.*