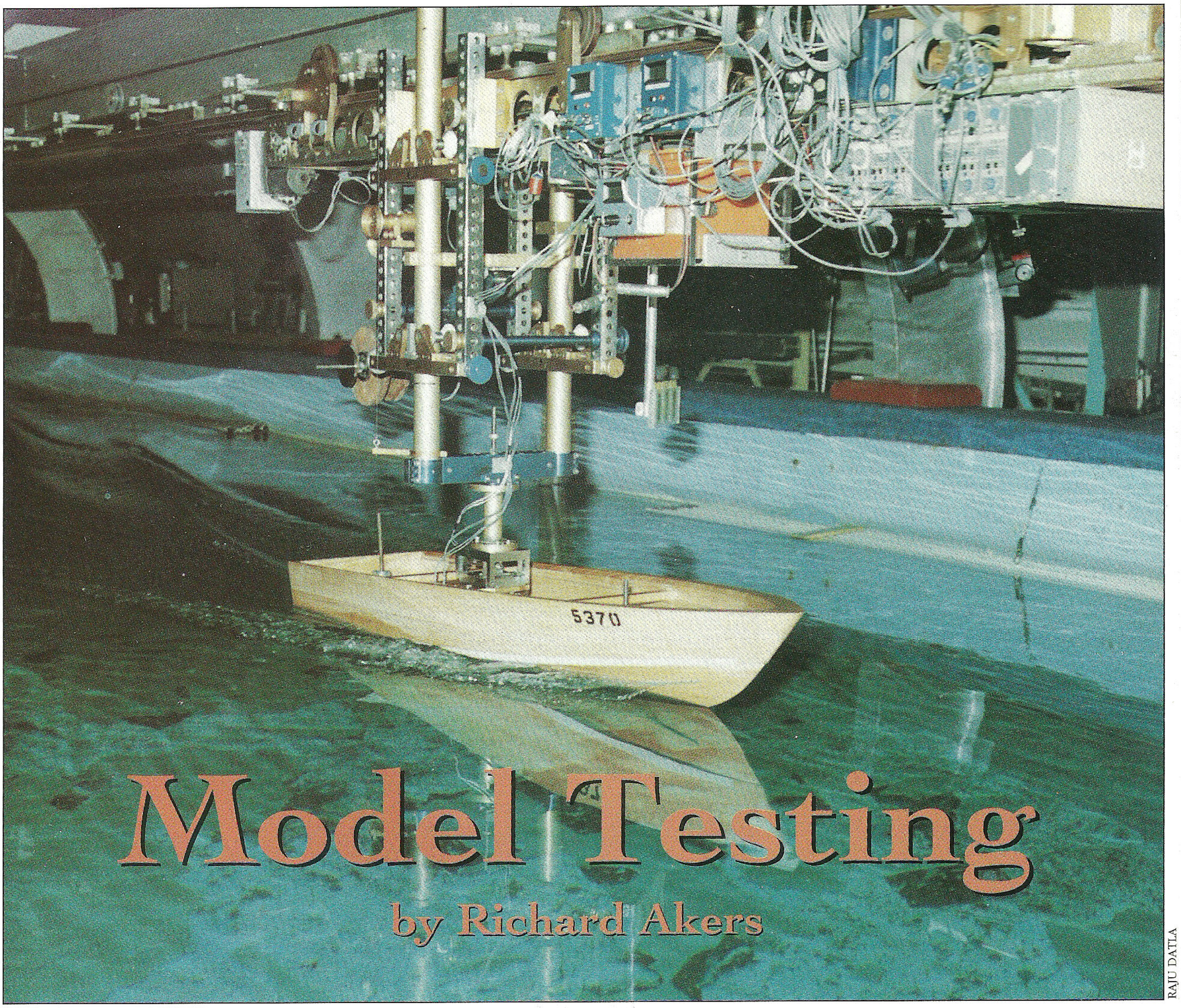

RAJU DATLA

Model Testing

by Richard Akers

A comprehensive testing program at a commercial tank facility can be expensive. Exactly what will the resulting data tell you?

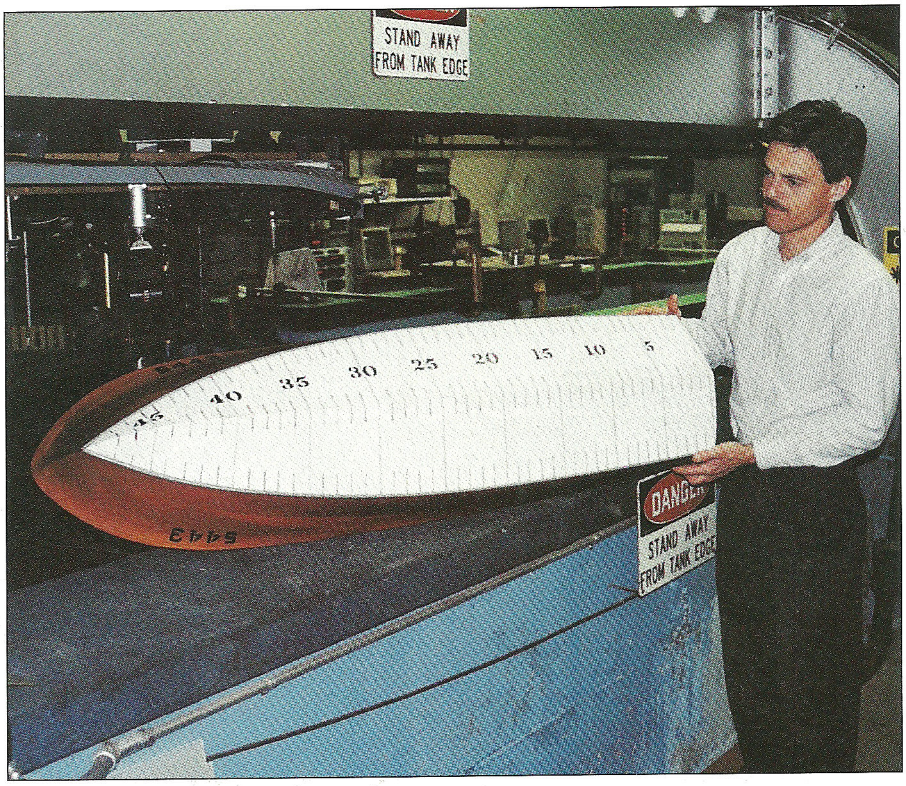
SECOND OF TWO PARTS

Editor's note—In Part I of this series ("Model Testing," PBB No. 55, page 32), the author looked at methods and materials for designing and building scale models for testing in the natural environment, and at the differing results that can be expected from various model types. Here, he continues with a representative sampling of North American test tanks.

The first step in the *tank-testing* process is creating an accurate model. Almost every tank facility has a model shop that can do that for you. You provide the shop with a lines plan—or with a computer data file describing your hull—and depending on the shape of your design, it will build a model from wood, high-density foam, FRP, plastic sheet, or even metal. Traditionally, model-shop craftsmen would glue up rough-cut "planks" conforming to waterlines, and then carve and sand until the model was fair and the station lines matched the lines plan. This was tedious, but the results were works of art.

More recently, computer-based lines have been used to drive three- or five-axis numerically controlled (NC) cutters. In some cases the actual model is cut out of wood or high-density foam; while in others, a mold is cut and a model built of FRP from the mold. If your design consists entirely of "developable surfaces," you may be able to build a model from sheet stock. A developable surface is one that you can make by bending a sheet of flat stock—whether plastic, wood, or metal. For example: a cylinder is developable, but a sphere is not. (Have you ever tried to gift-wrap a basketball smoothly?)

There are more than a half-dozen industrial test tanks in North America that would be glad to test your design. They all have a long, skinny, high-speed towing tank, and many have maneuvering basins, rotary-arm basins, and other specialized test facilities. They all have staff members who are experts in the fine art of "tankery"—coaxing accurate performance and behavior data out of model boats.



RICHARD AKERS

Facing page—*A high-speed planing hull being tested at the Davidson Laboratory. The model is attached to a dynamometer that simultaneously pulls the model down the tank and measures pitch and heave locations and surge forces.* ***Above***—*Former Davidson Lab Assistant Director Ed Lewandowski displays ruled lines painted on the bottom of a high-speed planing hull model. These lines allow technicians to measure the wetted surface of the model while it is being towed down the tank.*

From Seaplane Floats to Planing Boats

The folks at Davidson Laboratory are justifiably proud of their heritage. The laboratory was founded by Kenneth S.M. Davidson of the Stevens Institute of Technology (Hoboken, New Jersey) to satisfy his personal interest in high-performance sailing yachts. Over the years, Davidson and his successors developed and tested a number of remarkably accurate techniques for measuring the forces on sailing yachts. Davidson's laboratory became the leader in this particular field, holding the enviable record of testing models of every victorious *America*'s Cup yacht from the late 1930s until Dennis Conner's *Freedom* in 1980.

Davidson Laboratory has boasted a stellar staff since its inception. Powerboat designers everywhere frequently use the Savitsky Method to predict the hull resistance of their vessels, but few realize that Dan Savitsky of Davidson Laboratory developed the method from data collected in a study of seaplane floats conducted in the 1930s. Savitsky combined empirical tank-test data with some fundamental physics to create his power-prediction algorithm. Dan Savitsky still does consulting work at Davidson Laboratory for commercial and governmental clients.

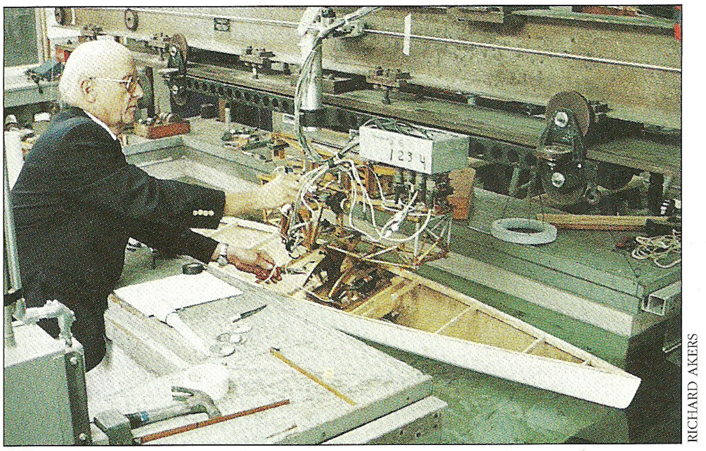
Like predicting the weather, predicting the behavior of a turning vessel is impossible because the water/air flow is so complicated. And measuring the maneuvering characteristics of a powerboat is almost as difficult. The fundamental problem is that most towing tanks go in a straight line, but maneuvering behavior is inherently curved. You can't just drag the model down the tank at a fixed yaw angle, because the quasi-static forces don't correlate well with the dynamic forces experienced by a high-speed craft.

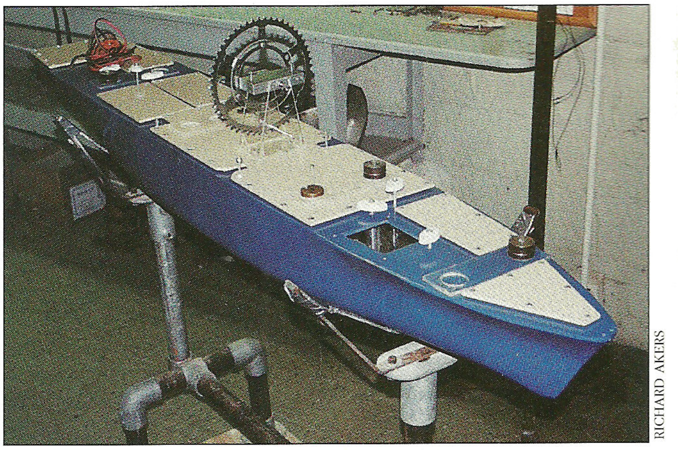
The staff at Davidson Laboratory solved the problem of maneuvering tests by building a rotary-arm basin. They preset the turning radius and the model's yaw angle, swing the model around in the basin, and measure the side forces and moments. Using coefficients calculated from these tests, it is theoretically possible to accurately predict a full-sized vessel's maneuvering characteristics. The theory works well for displacement hulls such as large merchant vessels or combatant craft, but unfortunately there are no good techniques to translate forces and moments into useful maneuvering data for high-speed planing craft. Although great strides have been made in testing, understanding, and predicting planing hull resistance, "high-speed craft maneuvering is still a black hole," according to Ed Lewandowski, assistant director of the laboratory.

That's not to say that high-speed maneuvering tests can't be performed in a test facility. Lewandowski describes a recent maneuvering test in which the U.S. Coast Guard was worried about a "snap roll" on a prototype of its 47′ Motor Life Boat (MLB). At 27 knots, the MLB would roll into a turn as much as 34°, and then abruptly roll back to 18°, sometimes rolling back inboard again. To study this unsettling behavior, the staff tested a ⅑-scale model of the MLB. They were able to reproduce the behavior with a self-propelled model, and concluded that the snap roll occurred because the outboard propeller and rudder ventilated at large heel angles, becoming ineffective as a result.

Davidson Laboratory's High Speed Towing Tank has a length of 313′, a breadth of 12′, and a depth of up to 6′. The carriage on this tank is one of the fastest in the world, capable of speeds from 0 to 100 ft/sec. The tank's wavemaker generates both regular waves and pseudo-random waves, and can be programmed to produce nontraditional wave forms such as wave pulses, complex periodic waves, and dual and triple wave trains. Models for this tank are typically in the 5′–12′ range.

Lewandowski notes that the relatively small size of the lab can be a benefit to the client, because it means that a test program can be extremely flexible and responsive to the needs of the designer. "The designer or client can plane strakes off a hull, and a half hour later be back in the tank looking at a different configuration," he comments. Furthermore, he feels that you "shouldn't be locked into a contractual formal test matrix." The ideal situation is to be able to modify a test program on the fly, based on personal observations and on the recommendations of test personnel.





Left—*Larry Ward, retired tank director at Webb Institute, prepares a model sailing vessel for a tank test. The model is attached with a fixed yaw angle, representing the sideslip of the sailboat. As the model moves down the tank, technicians measure the roll angle, heave location, and yaw and surge forces.* ***Right***—*This model, designed and built by a Webb student as part of a thesis project, is divided into individually floodable compartments by a series of transverse and longitudinal bulkheads. Combinations of compartments can be free-flooded by a pump and piping system in order to measure the heel and trim of the "damaged" vessel. The model is used in research on both static and dynamic damaged stability, and serves as a demonstration tool in Webb's hydrostatics classes.*

(Ed Lewandowski left Davidson Laboratory in July 1998 for a new position in Washington. His successor is Dr. Raju Datla.)

Science on Long Island Sound

Farsighted William H. Webb, shipbuilder and steamship operator, founded Webb's Academy and Home for Shipbuilders—now called Webb Institute of Naval Architecture (Glen Cove, New York)—in 1889 to fulfill the demand for designers of iron vessels. Webb realized that iron vessels would rapidly replace wooden ships, and recognized the need for formal education instead of the existing apprenticeship system. The Institute has grown to an enrollment of approximately 100 students. Webb students run experiments and some original research in the Institute's Robinson Model Basin.

Webb has recently resolved a problem with staffing in its tank facility, and is attempting to become more attractive for commercial testing, with ambitious plans to upgrade the facility. Even in its current state, the tank at Webb is a cost-effective alternative. Naval architect Bruce King (Newcastle, Maine) has done model testing at Webb and found that it offers inexpensive model construction and testing services for his high-speed powerboat designs.

Webb's test facility includes a single-rail towing tank that is 93′ long, 10′ wide, and 5′ deep. Towing speeds up to 17 ft/sec are possible in the tank, which has a wavemaker capable of producing both regular and irregular waves. Due to the small size and carriage speed of the tank, models are limited to about 3′ in length. Although their tank is quite small, Webb is aggressively seeking commercial business with the goal of keeping faculty and students attuned to the needs of today's marine community. As Laboratory Manager Richard Van Hooff says, "The advantage of a small tank is that it is incredibly quick. You can make changes quickly, and the tank calms down quickly between runs."

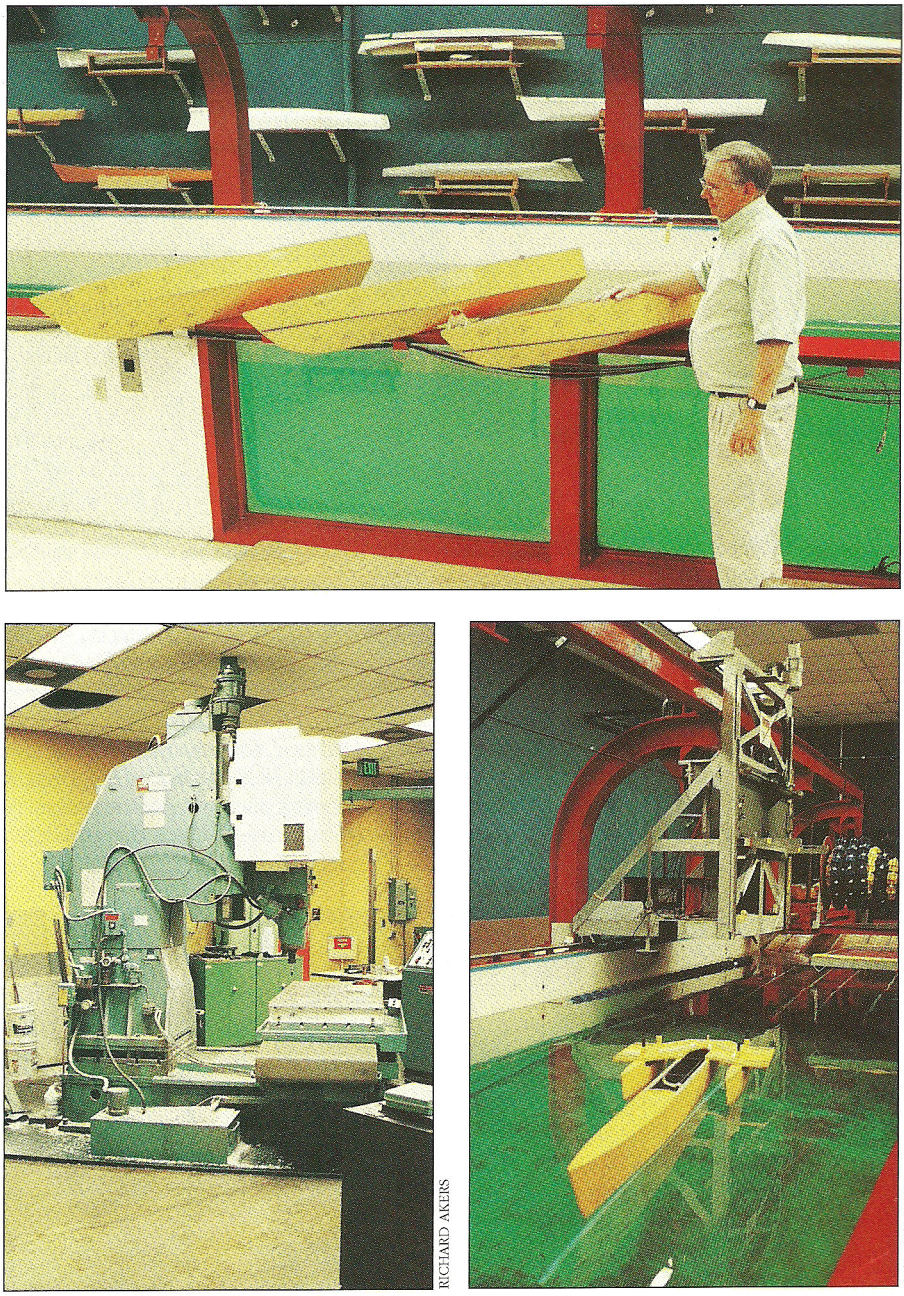
Marine Models for Midshipmen

Graduates of the U.S. Naval Academy (Annapolis, Maryland) are expected to be knowledgeable in boat and ship design. To support this goal, the Academy built a test facility in 1976 that includes several good towing tanks. The top-of-the-line tank in this laboratory is a versatile 380′ tank with two carriages and a sophisticated wavemaker. The 120′ tank is an excellent teaching device. Built into one wall of a classroom, it's great for lecture demonstrations, and its monorail construction makes it easy to load and test models. Naval architect Lou Codega (Alexandria, Virginia) says that for tank-testing, one of the "best-kept secrets is the Naval Academy."

As you would expect, the staff at the Hydromechanics Laboratory includes top-notch hydrodynamicists. John Hill is the Branch Head and has been with the Academy for 22 years. As Hill says, "The success or failure of the organization is strictly due to the people we have." John Zseleczky, a naval architect at the Academy, is well known for his yacht capsizing research, and has also served on the Model Tests of High-Speed Marine Vehicles Committee of the International Towing Tank Committee (ITTC). The ITTC is a well-respected professional association of hydrodynamic marine test facilities.

When you think of the Navy, you automatically think of big vessels; but research at the Academy is not limited to large warships. Ensign Tullio Celano has done some important work on planing-hull porpoising, and presented his findings at the Society of Naval Architects and Marine Engineers' annual meeting in November 1998. Recently the Academy tested a scale model of the U.S.S. *Constitution*. The Navy was considering towing her out of Boston Harbor up to Portsmouth, New Hampshire, for a Tall Ships event and was concerned that the elderly sailing vessel might not tow properly. Tests at the Naval Academy showed that Old Ironsides would experience significant pitch motions under tow, as sea state conditions worsened. The Navy's Chief of Naval Operations, Admiral Johnson, subsequently remarked in a press release that "I simply cannot justify the risk of unexpected weather harming this national treasure."

One of the problems with hiring a test facility associated with an academic institution is that there can be scheduling conflicts between commercial tests and student tests. Hill states the priorities of his institution in no uncertain terms: The classroom needs absolutely come first, followed by midshipmen's research projects. The remaining time—about 20%—is available for staff work, which includes sponsored, industrial research. Hill concedes that "it's tough to do long projects at the Naval Academy because of scheduling difficulties. Right now we have more work than we can do.” On the other hand, Hill notes that it’s important to keep staff and students current, so the Academy is motivated to take on outside research. Codega summarizes the situation: “Depending on the political winds, they may or may not be able to do testing.”


RICHARD AKERS

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Top—*John Hill, Branch Head of the Hydromechanics Laboratory at the U.S. Naval Academy, displays three models in a standard series used to study planing craft motion as a function of deadrise. The models are resting on the edge of the Academy’s 120′ teaching tank, whose underwater viewing windows are clearly visible.* ***Left***—*A three-axis numerically controlled (NC) milling machine is a prominent feature of the Academy’s model shop. In the 1970s, Professor Dave Rogers of the Academy’s Aerospace Department did some of the earliest research work on producing test models with NC milling equipment.* ***Right***—*Wave interaction between the individual tri-hulls on this trimaran model can be employed to study the effect on the hull resistance of the entire vessel. John Hill holds the model steady.*

A Turning Point in Tank-Testing

In 1974, the Society of Naval Architects and Marine Engineers published a technical paper co-authored by Karl Kirkman and David Pedrick entitled “Scale Effects in Sailing Yacht Hydrodynamics Testing.” Their paper analyzed the errors from testing small-scale sailboat models, and the authors concluded that the bigger the model, the better the results. In the extremely competitive world of yacht racing, where a fraction of a knot may be the difference between a win and a loss, this paper was a bombshell, effectively eliminating smaller facilities such as Webb Institute and Davidson Laboratory from the high-performance sailing-yacht market. The Hydronautics facility—a larger, private test lab located in Fulton, Maryland, where Kirkman worked at the time—picked up much of the racing-yacht work, and today almost all of the high-performance sailing-yacht tests in North America are taking place in the big tanks at the U.S. Navy’s Carderock facility or at Canada’s Institute for Marine Dynamics. (More on these two shortly.)

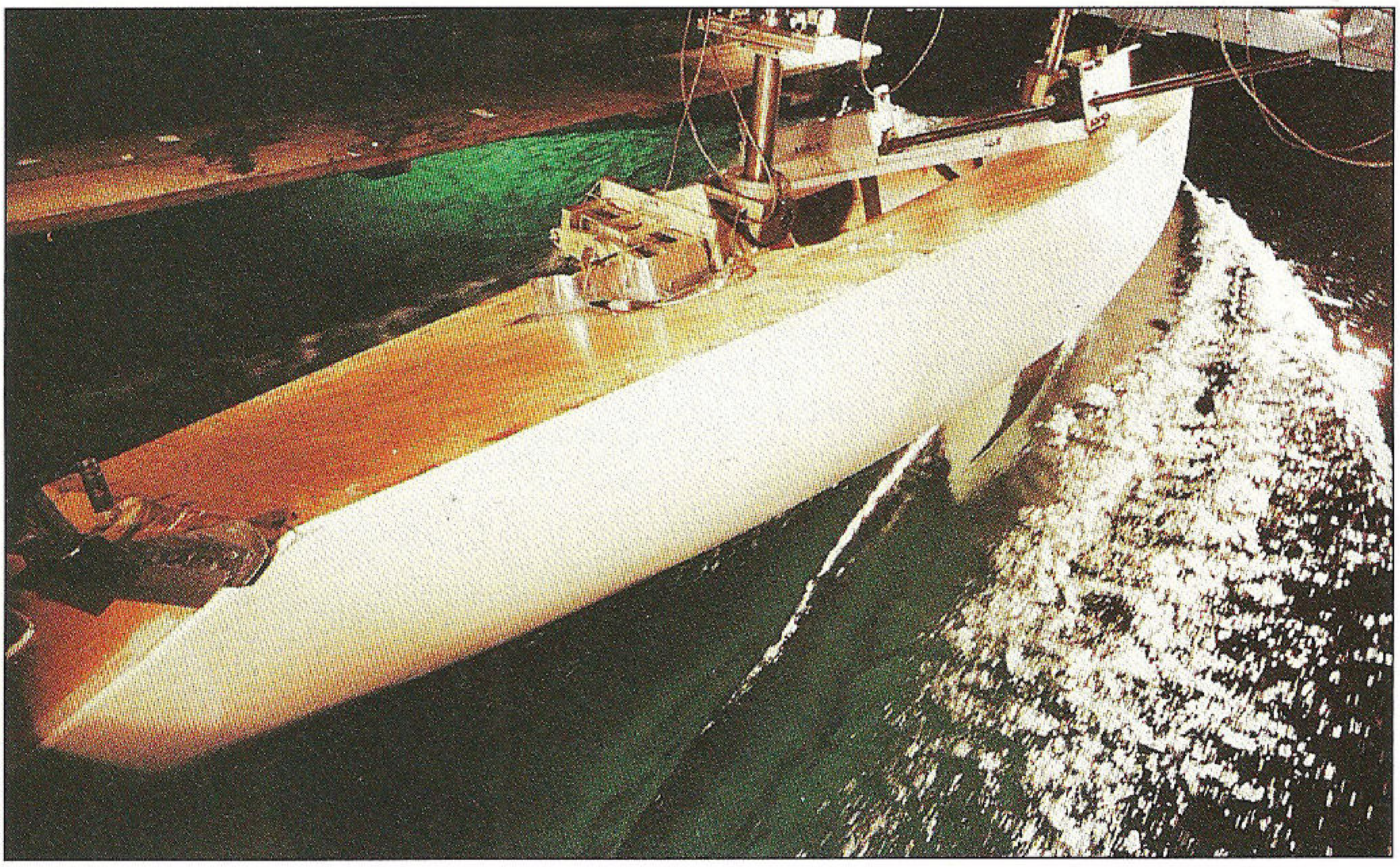
Walk Softly but Carry a Big Stick

Hydronautics, officially called Hydronautics Research Incorporated, has a complicated history. Many prominent individuals at other hydrodynamics facilities—including John Hill of the Naval Academy—got their start at Hydronautics. Military contractor Tracor purchased Hydronautics to support its work for the Navy. Tracor proceeded to shut it down, but Rob Barr, Virgil Johnson, and Alex Goodman restarted the firm in April 1991.

At 415′, the Hydronautics ship model basin is larger than most research tanks. Its 24′ beam and 12½′ depth permit testing of 20′ models at speeds ranging from 0.8 ft/sec to 18 ft/sec (10.7 knots). The programmable wedge-type wavemaker generates regular waves with heights up to 1.3′, and irregular wave spectra with significant wave heights up to 0.9′. Hydronautics has access to the model shop, which Tracor sold to Advanced Marine Enterprises.

Hydronautics can address maneuvering problems with its large-amplitude planar motion mechanism (PMM). The PMM allows a model to be tested in a pure sway motion. Test engineers combine data from PMM tests with data from straight-line tests to predict maneuvering forces. This may seem somewhat arcane, but the PMM is a useful tool for predicting the maneuvering and controllability characteristics of large displacement vessels.

Hydronautics is now a lean and mean firm with five staff members, and Director Bob Kowalyshyn says business is good. He mentioned that they are doing some *America*’s Cup work and that they are involved in a


ROD BARR

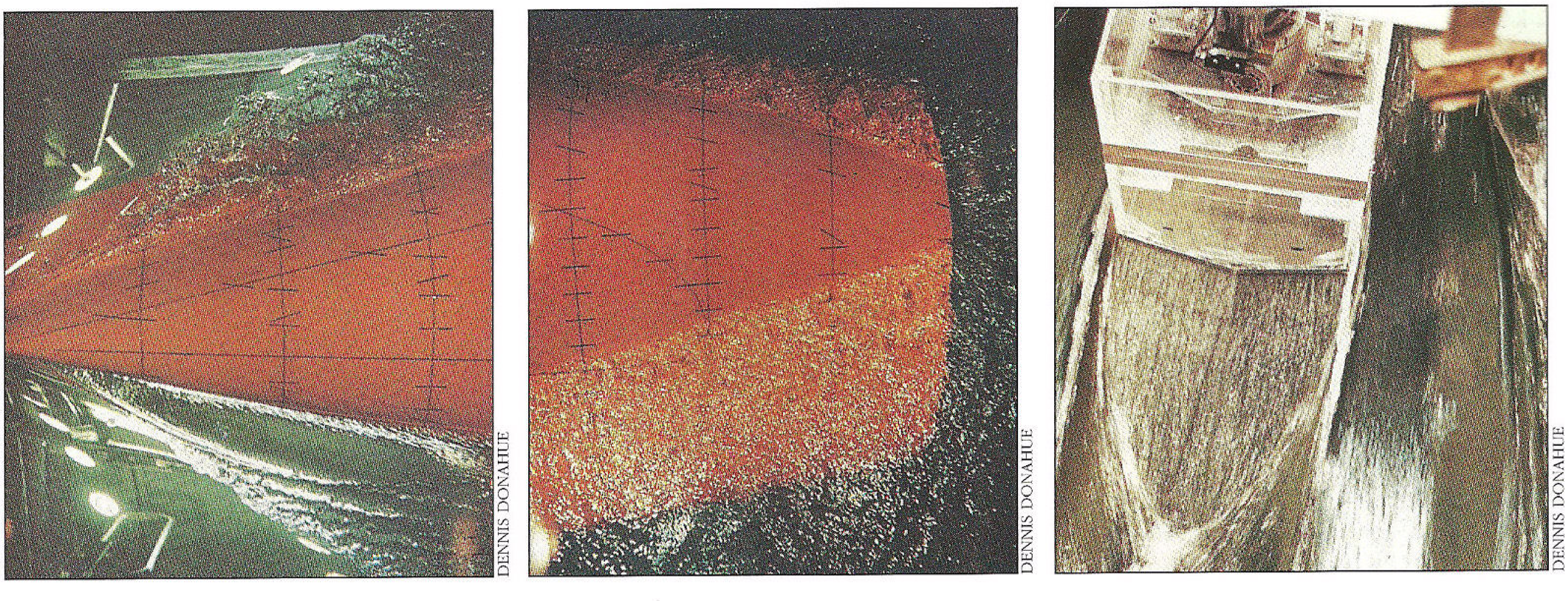
Hydronautics Research Inc. has a reputation for performing highly accurate tests on sailing-yacht models. The maxi-boat model above is attached to a special sailboat dynamometer capable of measuring surge, sway forces, and yawing and rolling moments, as well as pitch and heave locations. Note the bow wave this model creates.

variety of research programs, some marine-related and some not. Completed projects include testing models of an LNG tanker, a fireboat, an oil-spill recovery vessel, and a variety of other commercial vessels. Hydronautics marketing activities have traditionally been rather limited, but this is changing in response to the changing marine marketplace. As Kowalyshyn says, "Over the years, we have done no marketing—except to let people know we exist. People who want the services of a tank know it and will approach us." He is optimistic about the future, saying that today's clients and designers are pushing performance: "It's becoming more important to nail down the power requirements to the last few percent instead of the last 10 percent." A towing tank remains the only way to ensure performance with this level of accuracy.

Go Blue!

Another time-honored towing tank is located at the University of Michigan (Ann Arbor, Michigan). Built in 1905—but remodeled many times since then—the tank is 360′ long, 22′ wide, and 10′ deep. The manned-bridge carriage is capable of 20 ft/sec, and is large enough to accommodate computers, instrumentation, and a number of technicians. The computer-controlled wavemaker can generate regular and irregular waves.

The staff at Michigan pride themselves on innovative tankery, having tested everything from moored oil platforms to *America*'s Cup models for the 1996 series. They even tested a Ford truck for cooling problems by dragging it down the tank and observing the water flow through the radiator. Stuart Cohen, the laboratory director, describes some recent work with personal watercraft (PWC). In an effort to predict stopping distance and maneuverability, they put together a program that combined tank-testing with field work. They towed several PWCs in the tank to measure the quasi-static maneuvering forces, and then they rigged the PWCs to run under radio control and tested them in a nearby lake. The results could be ground-breaking data on the characteristics of these hybrid vessels. Cohen adds that they are talking with a boatbuilder about doing the same kind of tests on a bass boat. Just imagine—a remote-controlled bass boat!


DENNIS DONAHUE

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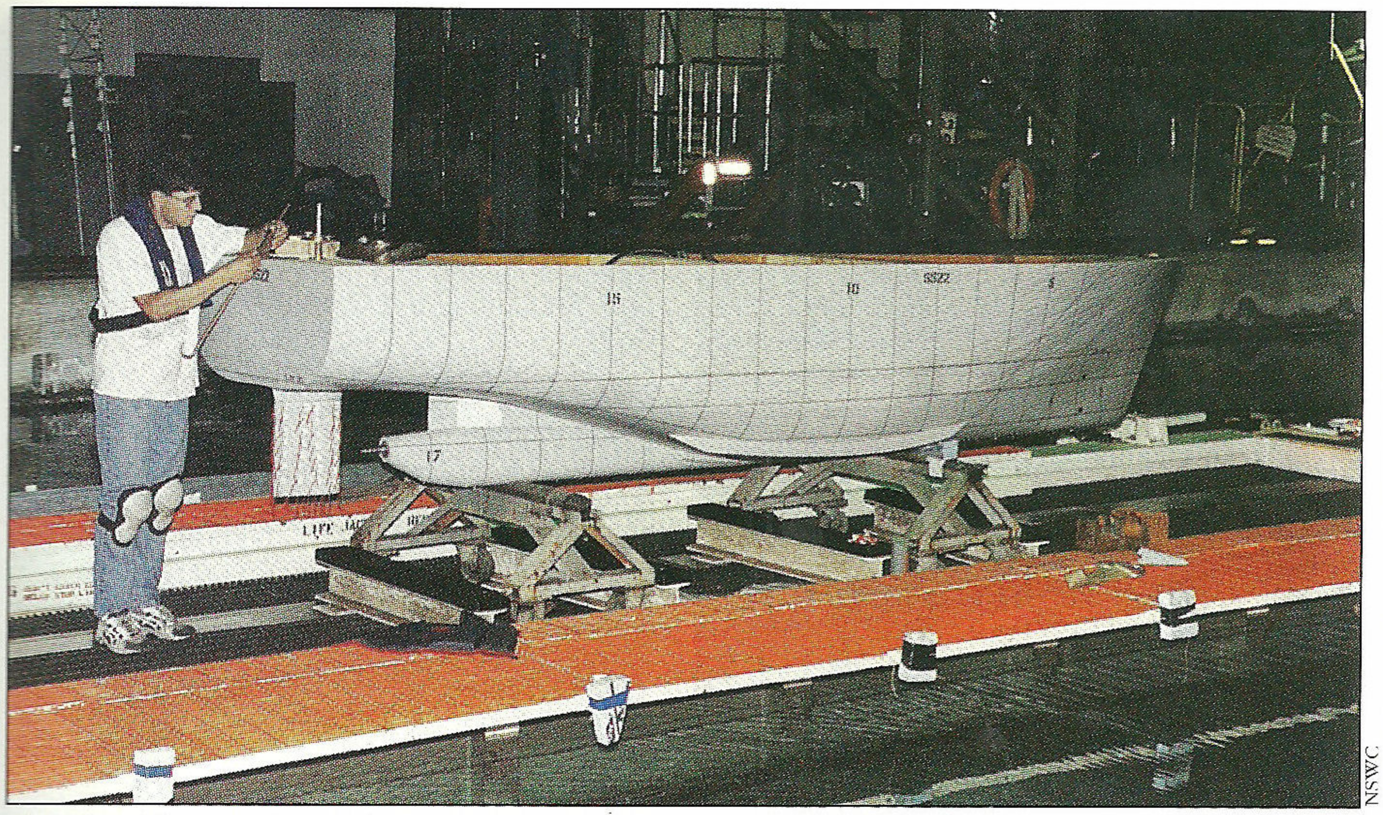
DENNIS DONAHUE

Left, middle—*At the University of Michigan's Marine Hydrodynamics Laboratory test tank, underwater cameras document a model's flow patterns and wetted surface at various yaw and heel angles.* ***Right***—*Intended for high-speed prismatic planing-boat tests, this model is constructed of clear Lexan to facilitate measurement of chine and keel wetted length. The test series includes variations in deadrise.*

"We are a full-service lab. What we want to do is to provide model build-



NSWC

Carderock naval architect Ian Mutnick prepares a model of a NOAA-funded fisheries research vessel for a test run in the David Taylor Model Basin. The finished vessel must be extremely quiet underway, and will have a centerboard arrangement for mounting sonar and other research equipment. The model, constructed of 2″-thick planks of sugar pine, was CNC-machined and hand finished to a tolerance of $\frac{1}{100}$*″.*

ing, testing, education, invention—whatever the customer requires," says Cohen. He adds that the lab's first priority is to the UM undergraduate program, but that commercial customers aren't affected, because the student work is planned a year in advance, and because Michigan has seven staff members who can juggle the schedule. The lab is large enough that undergraduate work is a fairly small percentage of the overall workload. Furthermore, adds Cohen, Michigan "wants commercial work so that we can have students doing real-life stuff."

Big Kid on the Block

No question about it—Carderock is the big kid on the block. Even the official name is big: "Hydromechanics Directorate, Carderock Division, Naval Surface Warfare Center, Naval Sea Systems Command" (Carderock, Maryland). But, mixing metaphors a bit, Carderock is also the Old Man of the Sea. In 1896, Congress authorized construction of a model tank at the Washington Navy Yard for U.S. naval vessels and for private ship builders. That one-hundred-year-old charter remains relatively unchanged today. Of course, Carderock's mission is still to provide research and technical support for the Navy, but it is also chartered to provide support to the Maritime Administration and to the maritime industry. In other words, Carderock is eager to work with recreational and commercial boat designers, and always has been. (For more on Carderock, see PBB No. 42, page 39.)

The turn-of-the-century Experimental Model Basin at the Washington Navy Yard was replaced by the present facility in Maryland in 1940. The large Deep-Water Basin is enormous: 1,886′ long, 51′ wide, and 22′ deep. The extreme length of this basin results in an unexpected advantage to the designer: you can get multiple speeds in a single run. If you've got a large test program with many load configurations and speeds, then the ability to combine multiple speeds into a single run is a significant time advantage. The carriage in this basin can move at up to 20 knots.

Carderock's High-Speed Basin is of particular interest to powerboat designers. This 2,968′-long tank is 21′ wide and 10′ to 16′ deep. There are two carriages in the basin, and the fastest goes up to 60 knots. If you are testing a $\frac{1}{10}$-scale model, that corresponds to a blistering 190 knots for the full-sized craft! For small vessels such as PWCs, the high-speed tank is large and fast enough that you could simply test the full-sized craft without even building a model.

Carderock offers more than straight-line basins, however. Its Maneuvering and Seakeeping Basin is a rectangular pool 360′ by 240′ by up to 35′ deep. Two banks of pneumatic wavemakers can generate complicated regular and irregular waves, and a large fan (built from a surplus modern windmill) generates 20-knot winds. You can test a radio-controlled, self-propelled model to the equivalent of a sea state nine, and you've also got enough room to check the maneuvering characteristics of your model in calm water and waves under a wide range of conditions. Some sophisticated position-tracking electronics in this facility *make it easy to get precise data back* from your model when it's under test.

Carderock is also the facility of choice for high-performance sailing-yacht testing, because not only does its sheer size allow you to test large models, the institution also knows how to keep a secret. As Bill Day, head of the Facilities Engineering and Operations Department, says, "One thing Carderock offers folks is a proprietary program. Carderock respects that and will protect it the way we would handle a Navy program." There are at least two *America*'s Cup syndicates currently testing at Carderock—the New York Yacht Club's *Young America* and the St. Francis Yacht Club's *America One.*

Carderock as a test facility is a powerful tool, but like all good tools, it is expensive. When asked about commercial testing at Carderock, Martin Dipper, a Carderock hydrodynamicist, comments, "If you're going to come here, you should have a big test program. Big facilities can be expensive, but if you've got big plans, you can get more data points per dollar." The results from model tests at Carderock may not be gospel, but they are pretty close. "No tool is absolute; there are always scale effects," observes Carderock's Bill Day. But, he thinks the high accuracy that you get from a Carderock test is worth the expense, saying, "The so-called 'affordable' test isn't worth doing, because you don't get enough data from it."

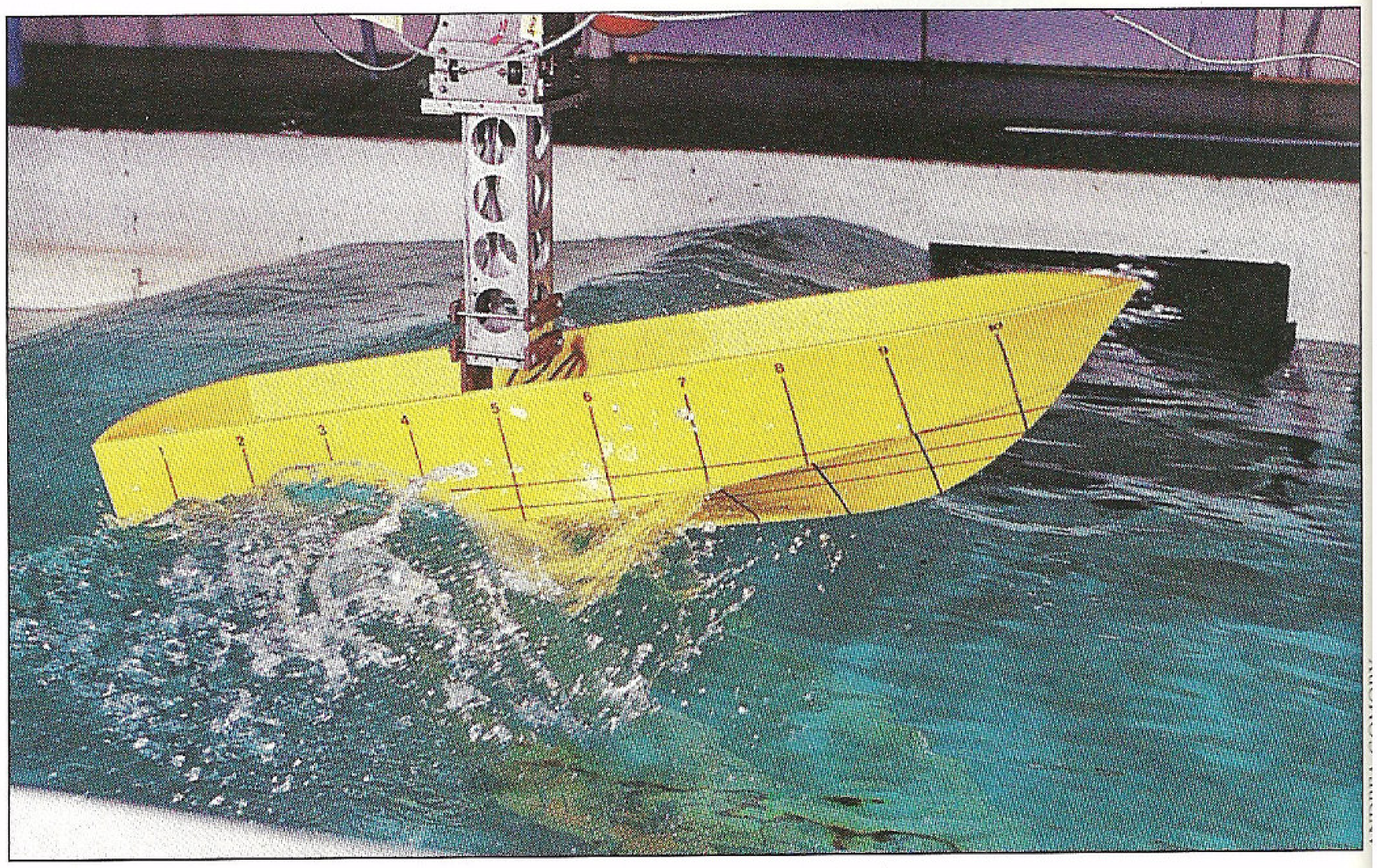
Best Test in the West

A number of naval architects and builders have availed themselves of the services of the Ocean Engineering Centre of British Columbia Research Inc. (Vancouver, British Columbia). BCRI is a private R&D contractor that is loosely affiliated with the University of British Columbia. Its linear tank is 220′ long, 12′ wide, and 8′ deep, and is equipped with underwater viewing windows. The carriage is cable-driven so it can accelerate quickly, which means you get a longer stable testing period per run. The facility's shallow-water tank, equal in length to the deep-water tank, is useful for shoal-draft performance tests.

The Ocean Engineering Centre has a large rectangular wave basin that is used to study harbor and breakwater engineering, and also the maneuvering and seakeeping of vessels. The wave basin has even been employed by the movie industry—remember the flooding scene in *Jumanji*? At 20 years of age, this modern facility is a relative youngster.

BCRI has done a lot of testing for commercial vessels such as fast ferries, sup-

Model of a 42′ sportfisherman hull coming off a wave during seakeeping tests at the British Columbia Research Inc.'s Ocean Engineering Centre towing tank. Studies such as this help the designer predict the wetness and roughness of a ride before finalizing a new design.



ply boats, drilling mud boats, and large fishing boats. According to Ben Thompson, Project Naval Architect at BCRI, the majority of the staff's work today is with large power yachts (80′–150′). Naval architect Tom Fexas (Stuart, Florida) recently did some testing at BCRI. He was designing a high-speed jet boat and wanted to minimize hull resistance without compromising the boat's ride quality. Fexas tested two models, one of which he describes as a "typical hard-chine planing hull," and the second with a rounded bilge. The tests confirmed what Fexas had suspected for some time: that the design with the rounded bilge had a lower resistance at the design speed.

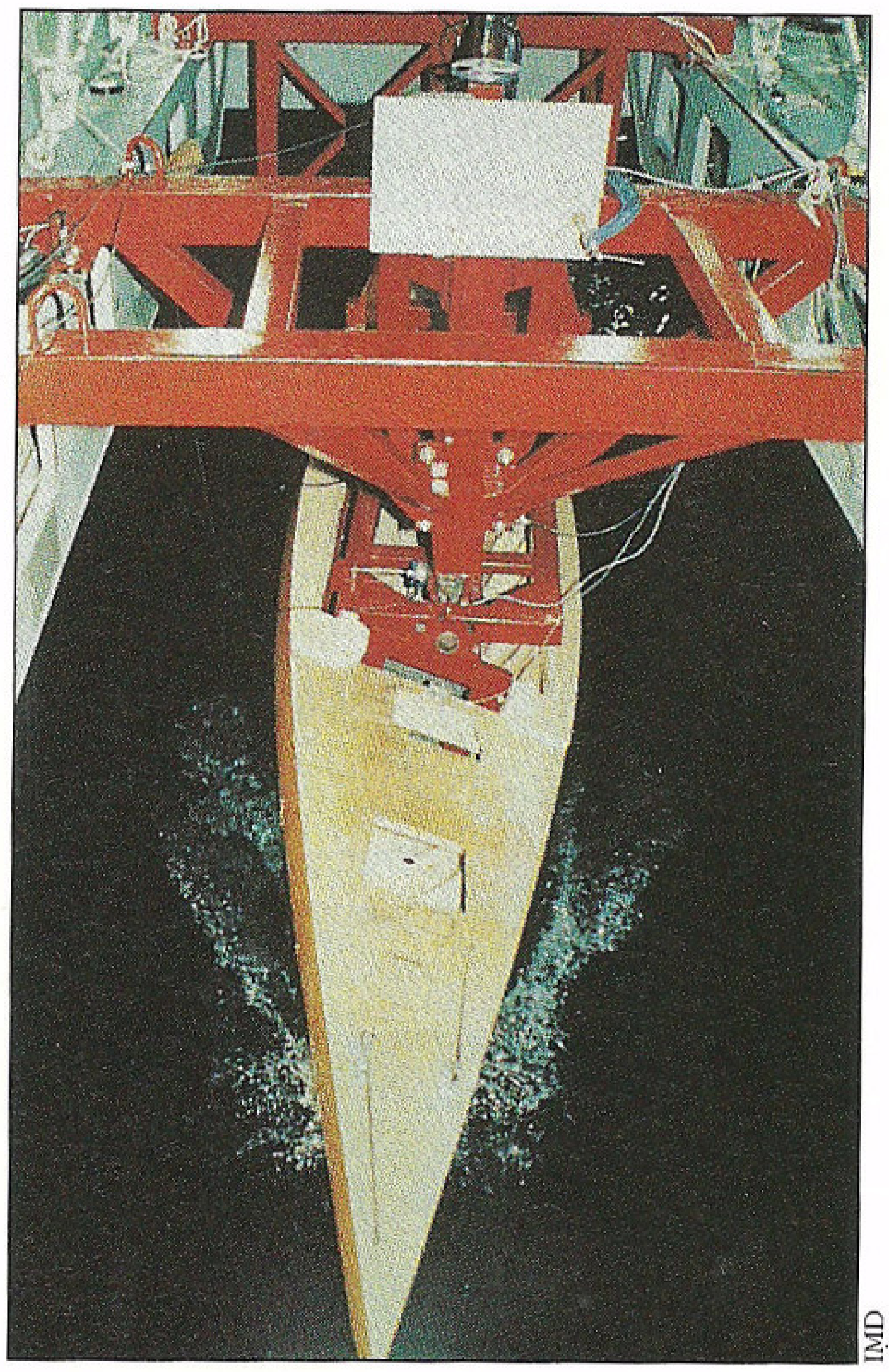
Thompson comments that business is good at BCRI. Theirs is an up-to-date facility—the only modern tank on the West Coast—and a now-favorable exchange rate makes BCRI's work extremely cost-competitive.

Tank Titan to the North

The United States may have Carderock, but Canada has the Institute for Marine Dynamics (IMD). In 1985, the Canadian government combined a number of labs to form the Institute. IMD's facilities include a 220m (722′) towing tank with a sophisticated towing carriage and a hydraulically driven wavemaker capable of generating waves up to 1m (3.28′) high. The Offshore Engineering Basin is for self-propelled maneuvering tests and moored-structure tests. And to top it off, IMD has a pretty "cool" facility unlike any others mentioned here: an Ice Tank—a towing tank covered with an "adjustable" ice sheet up to 15cm (6″) thick.

According to Noel Murphy, Industry Liaison Officer, IMD tends to get involved at the "high end," both in sailing and power yachts. "It seems, for the most part, it's only the designers of very expensive and high-performance vessels who come to us," says Murphy. He adds that IMD tends to refer smaller jobs to smaller tanks such as BCRI. Although IMD does test motoryachts from time to time, these boats tend to be large (in excess of 100′). IMD often gets involved due to special design requirements such as very high speed or extreme shallow draft.

IMD certainly has some leading-edge sailing-yacht technology. "When we test sailing yachts, we try to get the extra 1/20 of a knot. Arguably, we have the most accurate yacht dynamometer in the world," says Murphy. The dynamometer was designed and built by IMD personnel specifically for *America*'s Cup research. The lab's technology is so good, in fact, that the New York Yacht Club's *Young America* syndicate wanted to use the facility to test design variations for the year 2000 *America*'s Cup challenge. But, when the powers-that-be ruled that the syndicate had to test in the United States, the group leased the dynamometer and is using it to do their testing at Carderock.



IMD

At Canada's Institute for Marine Dynamics (IMD), a sailing vessel's hull undergoes performance evaluation. IMD is a consortium of test labs, one of which operates an Ice Tank—a towing tank with an ice sheet up to 6″ thick.

The Bottom Line

Realistically, models cost about $1,000 to $1,300 per foot, so a 6′ model costs between $6,000 to $7,800. You can build the model yourself (and possibly hide the real costs), or you can pay a modelmaker or tank to build it. If you can build your model from sheet stock, you may be able to reduce the cost of the model by a factor of two or more (depending on the number of panels).

The University of Michigan estimates that tank-testing will cost you about $2,500 per shift, including the cost of one technician. A typical tank run takes about 15 minutes without waves and 30 minutes with waves, because you have to let the tank settle down between runs. Assuming it takes a couple of hours to set up your model, you can get 12 runs in an 8-hour shift. Bob Kowalyshyn of Hydronautics explains that the typical setup time is more like half a shift, so the number of runs per shift may be even fewer.

If all of this seems a bit intimidating, there are firms that will assist you in setting up a test program and in arranging for testing time. Marineering Inc. (Mount Pearl, Newfoundland, Canada), for example, is a consulting firm specializing in performance evaluation. It is closely connected with IMD and Memorial University of Newfoundland, and has run a lot of testing programs. A major advantage to hiring such an intermediate consulting service is that it can advise you on the least expensive way to meet your testing needs. Dan Walker, General Manager of Marineering, notes that Canadian government testing facilities have labor fees fixed at three times a staff member's salary. You can save some money by having the government lab employees only run the tests and asking Marineering do the rest of the project management and analysis work.

Tank testing is not for everyone and every occasion. A complete resistance and seakeeping series can be quite expensive, and is often not necessary. Kowalyshyn estimates that it will cost as much as $25,000 to do complete resistance tests on a megayacht, including the cost of the model. "I'd like to say that it's not as expensive as the designer thinks, but unfortunately it is," he comments ruefully. As Noel Murphy of IMD says, "If you are churning out a displacement hull that is similar to boats you have built before—and you have a large database—then it's not appropriate."

On the other hand, Tom Fexas sums it up this way: "Model testing is fun. It goes back to kids playing with model boats in bathtubs. The clients enjoy it and we enjoy it. Basically, it's a worthwhile effort. Plus it results in a great model for the client's den!" PBB

About the Author: *A graduate naval architect and marine engineer, Richard Akers is the principal of Ship Motion Associates, specializing in marine software for hydrodynamic analysis. He is based in Portland, Maine.*

HYDRODYNAMICS TESTING FACILITIES

Below are the addresses and contact information for the testing facilities listed in this article. This is not intended as a comprehensive list of North American tank-testing facilities. Also, please note that Marineering Ltd. is a consulting firm, not a testing facility. See text above on this page for an explanation. —*Ed.*

BC Research Inc.
Ship Dynamics Group
Ocean Engineering Centre
3650 Wesbrook Mall
Vancouver, BC, V6S 2L2, Canada
Contact: Gerry Stensgaard
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