In this article we will examine the history and evolution of multihulls, showcasing some of their curious features (not all of them successful) and we will delve into the inventive mind of the speed-crazed mariner. We will discuss the origins of the type, through the major evolutions in 19th and 20th century, all the way up to the 34th America’s Cup.

Origins

Considering the current, drag-racing machines built for the 34th America's Cup, it is interesting to pursue their history—the history of sailing multihulls. Their origins lie in the Oceania pirogue: These catamarans, trimarans and proas were already described as "flying objects" by Antonio Pigafetta, who, serving as Magellan's assistant during the World's first circumnavigation, was the first to describe these boats in 1521.

To understand the geographical distribution of these craft and how their design evolved, I have plotted the island-hopping movements of the Pacific peoples on the chart below, from Madagascar to the furthest reaches of the Pacific ocean:

The migrations were carried out in consecutive waves over a period in excess of 50,000 years.
Hello again Masthead readers. As you are reading this ABYC and Westlawn are furiously getting ready for our trek to Louisville, KY and the industry’s IBEX show. We hear pre-registration is up and vendors have increased, so the stage is set for a successful show for both ABYC and Westlawn. There is an unpublished theme surrounding many of the presentations and discussions this year; it’s the changing demographics of the industry we work and play in. It is no surprise that our industry is ageing; with an average age of ABYC members of between 63-65, we are concerned for the future. Beginning with the high school level, ABYC is dedicated to making sure that the marine industry is a viable option for not only a job but a long term career. Engaging the millennial’s/generation Y, while still relating to the baby boomers and generation Xer’s, is a challenging yet necessary task ahead of us.

Not only is it the age, but the nationality challenge that is a recurring theme at industry events. With the Hispanic population on the rise and expecting to dominate by the year 2050, we need to look forward and find a way to shift the general opinion of boating as a “rich white man’s sport.” So what are we doing and what can you do? I encourage you to take a look at some free resources on the state of our industry. The Recreational Boating and Fishing Foundation (www.rbff.org) has published a Special Report on fishing and boating for 2013, and the USCG is conducting a multi-year National Recreational Boating Survey with the 2011 version published on their website (www.uscgboating.org). These have statistics down to the state on the type, size and number of boats and boaters involved in our sport today. Check out your local demographics and see where you stand in the discussion on demographics, you may be surprised at what’s going on out there.

You’re Never Too Young For ABYC Standards
A note from ABYC member and marine surveyor Angel Zeno

As a proud Grandpa I couldn’t help but share this photo and story with you.

My 5-year old Grandson Felix was visiting on the day that my 2013 ABYC standards were delivered by UPS. When Felix saw the box he became very curious about its contents so I told him to go ahead and open the box. I thought that merely opening the box would be enough to satisfy his curiosity. But to my surprise he was intrigued by the book and began asking questions about what the book was and why I needed it. When I explained that the book represented the best practices for building a boat Felix grabbed the standards and a captain’s hat and ran out to the pretend ship’s wheel that I had built for him on our back deck. Much to my chagrin he began questioning if I had followed the practices in the ABYC standards when I built his pretend ship.

So it just goes to show you that even a five year old can understand the importance of the ABYC standards.
The American Boat & Yacht Council (ABYC) won the International Boatbuilders’ Exhibition and Conference (IBEX) Innovation Award for Safety Equipment for the Boating Safety App “Boat Essentials-USCG Safety Gear.” The award was announced on September 17, 2013 while at IBEX in Louisville, Kentucky.

The free app is a simple checklist for boaters to identify the required and recommended safety items to have onboard. It can be downloaded by clicking HERE.

The checklist is also available in paper form and copies can be requested by calling ABYC.

“This is the first time ABYC has won this award and that added to the already high energy at our IBEX booth,” said John Adey, ABYC President. “We are proud to receive this award as a result of our partnership with the USCG and their grant program.”

Funding of the app came as a result of a U.S. Coast Guard Recreational Boating Safety Nonprofit Grant, and the Android version will be developed when funds allow.

ABYC members who also won Innovation Awards at this year’s IBEX include Kenyon International, Clean Marine Systems, Volvo Penta and SeaStar Solutions.

The boating safety app was developed by the Ken Cook Company. It includes suggestions on other items that will make a boat safer and more comfortable. The app can be used on powered and non-powered boats that operate in the waters of the United States. It can:

- store information on up to 3 boats
- file and save float plans
- add boating contacts
- receive maintenance guideline alerts
- access supplies list
- be reminded of important dates
- available in paper form at www.abycinc.org/mobileapps

“This app embodies ‘Boating Safety Built In’ with everything you need listed right there at your fingertips. Gone are the days of getting out on the water only to find your flares are expired,” commented Brian Goodwin, ABYC Technical Director.

“We get so many calls asking, ‘What do I need on my boat?’ Since nearly everyone carries their cell phone with them everywhere they go, including out on the boat, an app is a great tool to get safety information into the hands of the boater,” said Vann Burgess, Senior RBS Specialist with the USCG.
The first wave saw settlers in Indonesia, New Guinea and Australia during the last Ice Age. Indeed, between 50,000 and 35,000 BC, a 150 meter drop of the sea level enabled the Sunda and Sahul peoples to progress towards the East and South (in green on the chart).

In 4,000 BC, other peoples came by way of the Taiwan Sea and intermingled with established populations. From 1,600 BC, this population scattered throughout Micronesia (the Marianas Islands, Mar- will Islands, etc.) and later in Melanesia. In 1,000, they reached western Polynesia including Fiji, Tonga, Samoa (in blue on the chart).

Five centuries would pass before Polynesians would resume their migrations, spreading to Tahiti and the Marquesas Islands. From these archipelagos, a new migratory wave started. Settlers are believed to have reached Hawaii and Easter Island circa 400 AD. Meanwhile, migrations in the Indian ocean reach Madagascar and surrounding lands around the year 600. Finally, settlers make land on New Zealand around the year 700 (in orange on the chart).

As the explorers of the Old World first ventured into the Pacific, they were immediately baffled by the speed of the craft they encountered there. They were even more surprised to realize that the same craft had been used to reach these distant islands at the far reaches of the largest ocean.

If Pifagetta did not elaborate much on describing the proa he saw at the Ladrones islands (modern-day Marianas), his account is an entertaining read. Thomas Cavendish also travelled there and was impressed by the number of these craft. In 1616, Jacob Le Maire gave a picturesque description of the catamarans that he came across in the Tonga Islands. In 1686, William Dampier measured their speed, assessing that these craft, “are the fastest in the World, setting 18 knot averages over hundreds of miles.”

When William Funnell sailed about the Pacific islands in 1705, he sketched a fanciful "flying proa", while Woodes Rogers disassembled one and put it on display six years later in Saint James Park, in London. The first actual plans (featured above), though full of inaccuracies, was drafted by Piercy Brett in 1742 while serving on George Anson's voyage around the world. It appears that it was excep-
tionally difficult for Europeans to understand how these sailing craft operate. François-Edmond Pâris's works were the first to cover the subject in depth when they were published in 1839, followed by those of James Hornell (1936) and Jean Neyret (between 1959 and 1976).

Here we will discuss six types of pirogues that best describe the rich, versatile and inventive minds of these seafaring peoples. (Pirogues are traditional dugout canoes, with or without outriggers.)

The first of the craft to be discovered were the proa of the Islas Ladrones (nowadays Marianas), a thou-
This model is chosen from a drawing by Piercy Brett, twelve meters in length, featuring one double-ended dugout hull with two side boards and with two symmetrical bows on either end. The boat is sewn over with a watertight fabric (a skin) that covered the side boards and the bows. The mast was maintained upright by a strut stepped where the longitudinal stringers meet on the windward outrigger. The mast was also held in position by a shroud fastened in the same place. During tacks (or conversely gybes), the sail was moved from forward to aft by swiveling the mast, and the paddle on the opposite bow would then serve as a rudder. The hull could be made of several parts and overlaid side planks. According to navigational needs, they sometimes featured a platform on the crossbeams. In other cases, a second outrigger was used opposite, with a wider platform. The asymmetry of the hull and outrigger was remarkable in its improvement of the craft's upwind performance. The outrigger was held in position by a vertical peg bound by a lashing to each crossbeam. George Anson pointed out that these pirogues, “are able to sail close the wind better than any other known vessel,” an astounding observation given that the design of these boats was 3,000 years old!

The diversity of the rigs found on sailboats in the Bismarck and the Louisiade Archipelagos, illustrated above and below with two large proas, indicates strong influence from Indonesia.

These sails can also be found on ancient sculptures on Java. Without bringing up any controversy on the original inventor of the rigid wing sail, these particular ones were made of braided leaves, and therefore were rather stiff. The whole sail could swivel around its fastenings at the top of the masts, creating optimal lift depending on strength and incidence of the wind.

These proas typically measured 10 to 15 meters in length, but larger ones between 18 and 25 meters were also built, serving mainly for long passages or for ceremonial use. The masts were also held in position by rounded buttresses and by forestays fastened upwind on the outrigger. A Louisiade “Lia-No,” with a distinctive elliptical sail, also featured flaring and clinker-built topsides that greatly reduced deckwash. The semi-circular sections of the hull were also a perfect example of wetted surface reduction.
The Masthead

A Brief History of Sailing Multihulls  Continued

Following the long string of islands in the eastwards prolongation of New Guinea, settlers finally found Fiji.

The catamaran of the Fiji islands was an assembly of two pirogues. If disassembled, they could each be fitted with an outrigger. Each hull was made of one or more dugout tree trunks, depending on the length of the craft (between 12 and 24 meters), with a freeboard increased by the addition of elements on the topsides, neatly adjusted and sewn up. The two hulls were parallel but in a Quincunx, with one slightly ahead of the other. Like modern multihulls, the bows were vertical. On large catamarans, the space between hulls was covered with decking. The craft was steered by two leeward paddles, one on each hull. The triangular sailing rig was set on the leeward hull, with the windward hull used as an outrigger. To tack, the sail was stowed on the top yard, the rake in the mast was decreased as the rig was carried over to the other hull.

The catamarans from the Tonga islands have been widely illustrated by the first explorers, particularly Willem Schouten, Abel Tasman and James Cook. Daniel Lescallier reproduced their plans in Traité pratique du gréement des vaisseaux, but a few details were omitted.

The Tonga island catamarans were of large size, between 15 and 25 meters in length, able to carry up to 150 passengers. A small dugout was usually kept aboard and used as a tender. They were used to sail to destinations in Melanesia and Micronesia. The platform was placed atop vertical boards and stayed supports. Each hull would be decked and feature a long hatch giving access to the bilges to scoop out shipped water while in rough seas or at high sailing speeds. Typically, the boat featured a semi-circular hut with a cooking stove near the mast foot. The mast was rather short, with a jawed masthead that carried the top yard. The mast was held in position by two lateral deck spreaders, reminiscent of the Open 60s with a wing mast. For short beats to windward, the sail came naturally against the mast, similarly to lateen sails on "the wrong tack," but for long tacks, the mast...
would be swiveled vertically in order to pass the sail over from one side to the other. The two paddles were always positioned to leeward.

Finally, the last example of these antique craft is a trimaran that was prevalent along the African coast, the Comoro islands and Madagascar.

This particular trimaran was drawn in Zanzibar in the early 20th century, and a few of this kind are still afloat to this day. If the loose-footed sail is an Arabian feature, the actual design of the craft is Indonesian. This pirogue has double outriggers with flat bottoms which slope outward, to act like water skis or hydrofoils. The sail was set on a short mast, in the centerline of the craft, and changed tacks on every beating leg. Measuring 7 to 9 meters long, these machines could sail at similar speeds to modern multihulls.

All these "light vessels," as described by our forebears, would ship a lot of water and one crew member would necessarily be assigned to bail the water out, whether it be during fishing or on a open sea passage. But if there was a compromise, it was for speed.

Herreshoff Era Catamarans

If the catamaran, trimaran or proa instances of the pirogue were born several thousand years ago in Oceania, the first modern catamaran of western design was built in England for Sir William Petty in 1662, at a time when the word "yacht" was a very new word. And it would take a yacht builder to make the greatest leap in multihull design after that. The world's first multihull with a racing designation was Nathanael Greene Herreshoff's, and this excerpt from the New York Herald, dated April 16th, 1877, is worthy of notice:

"In the fall of 1875, I was thinking and thinking how to get great speed out of single hulled boats, of the kind in common use. To get great speed, thought I, one must have great power, one must have a great sail, you must have something to hold it up, and that something must be large and wide, and have a large sectional surface, and also a great deal of frictional surface. These properties in a hull to give stability are not compatible with attaining great speed.

Indeed, the more one tries to make a stiff, able hull the less speed will be attained, even if corresponding additions are made to the sail. So then, there are two important principles of speed, which constantly..."
work against each other. If we increase the power to get more speed we must increase the stability of the hull correspondingly. An increased hull has more resistance, both from sectional area and surface friction. So what we would gain one way we must lose in the other.

Well, a boat must have width, and the wider she is, generally speaking, the more stable she will be. But a wide boat cannot have great speed, however much power you will apply to her. So the next thing that is to be done is to decrease the sectional area and, in a measure, retain stability; the boat would have power to lift at a distance each side of the keel, where it would do great work.

I kept on following this principle, getting the keel higher and higher, until by and by the keel came out of the water, when, lo and behold! there was the double boat! Nothing else to be done but take a saw and split her in two, spread it apart a little way, and cover all with a deck, and there you are! That was the rough road which I travelled, and having arrived thus far I abandoned my ill-shaped hulls, and in their place substituted them with two long, narrow, very light boats and connected them at the bow, stern and middle.”

Even as Mr. Herreshoff was reinventing the catamaran, it is surprising that the catamaran was not a firmly established concept. The testimonies of explorers in previous centuries had unanimously described the craft's performance. Yet the western catamaran's development, was instead the result of a reflection on the optimization of performance in monohulls.

Starting with the monohull in (1), Mr. Herreshoff increased the beam to increase stiffness (2); As the beam is further increased the keel is raised and the maximum draught is offset from the centerline to either side (3) until the keel is completely out of the water. It could have been simpler to split the boat along the centerline and spreading them apart (5), but evidently Mr. Herreshoff eventually proposed two narrow hulls (6).

On June 24th, 1876, the day after the Centennial Regatta,
The World printed a column, which said in part:

The catamaran Amaryllis, constructed by Mr. Herreshoff, of Providence [...] fairly flew along the Long Island shore, passing yacht after yacht as if they were anchored. As Amaryllis dashed over the line a winner she was saluted by guns from the yachts that were lying at anchor, and the excursion steamers screeched their loudest in honor of her victory.

The World also printed an editorial about the boat:

A Revolutionary Yacht
Nobody protested against entering her for the race yesterday, for the reason probably that everybody expected to beat her, but everybody seems to have objected to being beaten by her. It behooves the owners of the large schooners, however, to take counsel together lest somebody should build an Amaryllis a hundred feet long and convert their crafts into useless lumber. It is a matter quite as important as keeping the America's Cup.

The previous discussion of Pacific pirogues and the new, small catamarans would have seemed distantly related to the subject of the America's Cup—even if similarities and influences can be found between the different concepts of sails and hulls of the early Pacific multihulls—however, the question regarding the future of America's Cup was raised on the first day that an American catamaran was raced. It was 112 years later that Dennis Conner defended the America's Cup with a catamaran in 1988.

The lines and sailplan of the John Gilpin (1877) were first published in 1870-1887 American and British Yacht Designs (François Chevalier & Jacques Taglang, 1991). The drawings emphasize the elaborate and subtle design of Herreshoff catamarans. Besides the two narrow hulls, the complex assembly with spherical joints and tensioners made the yacht an expensive purchase.

It is interesting to delve into the designer's thinking, and to stop at step (4), where the centerline keel was raised in effect above water: Mr. Herreshoff's "ill-shaped hulls." In 1898, twenty-three years after the launch of the Amaryllis, Canadian designer George Herrick Duggan sought to reduce the wetted surface of his one-tonner to defend the Royal St. Lawrence Yacht Club's tenure of the Seawanhaka Cup. The rating rule only took into account the load waterline length. With their extremely long overhangs, powered up yachts would heel and in effect increase their sailing waterline length. To benefit from this, the deck would look increasingly rectangular from overhead.

In Dominion Duggan created a double-hull by raising the centerline keel. With wetted surface reduced...
by 30%, he easily won the cup! Facing the pressure of angry contenders however, the Seawanhaka rating rule was amended to ban double hulls in subsequent races, by requiring the maximum draft of sections to lie on the centerline of the yacht. This however did not prevent another naval architect known for bold designs, Bowdoin B. Crowninshield, to exploit this loophole. He engineered the trimaran Hades in 1902 for the Quincy Cup, though she would fall in the face of competition given by Starling Burgess’s defense candidate Outlook, one of history’s most extreme scows.

Though catamarans threatened to change the course of yachting history both in 1876 and in 1898, it was to no avail. They failed to convert yacht clubs as rating rules were amended to ban multihulls.

One-tonner Dominion (George Herrick Duggan)
Dominion is a development of the scow, measuring 10.85m overall and only 5.28m on the waterline. By raising the centerline keel above the water so as to increase stiffness and reduce wetted surface, the designer created a catamaran.

Hades (Bowdoin Bradlee Crowninshield)
Hades, measuring 16.75m overall and 6.40m on the waterline, is a pseudo-trimaran, the vaka or centerline keel only present to exploit a loophole in the rating rule which requires maximum draught of the sections to lie on the centerline of the yacht. The plate-thin middle “hull” is so narrow that it needs a supporting tensile structure above deck.

If multihulls did not achieve a popular success in the 19th century, they were never actually abandoned. Every edition of the American Register of Yachts listed in excess of ten cruising or racing catamarans.

The Sailing Machine (Lewis Francis Herreshoff)
In Lewis Francis Herreshoff’s (1890-1972) book The Common Sense of Yacht Design (published 1948), he denounced the controversy en-
A Brief History of Sailing Multihulls  Continued

dured in 1876 by his father Nathanael Herreshoff, which created a void in the development of fast sailing yachts. In his chapter titled The Sailing Machine, which assesses the future of yachting, he proposed several catamarans, including the above, with two hulls borrowed from power yachts, and two swiveling and rotating wing sails set on a quadruped rig.

The Sailing Machine, which L. Francis Herreshoff proposed in 1948, demonstrated that besides the designer’s great drafting talent, capable of turning out plans of utmost precision, he also had a very creative imagination: He would give proof of this with his next catamaran, Sailski.

Sailski (Lewis Francis Herreshoff)
By designing the more prosaic catamaran Sailski, L. Francis Herreshoff proposed many new ideas which became commonplace forty years later. The plans for the Sailski were published in The Rudder magazine, May 1949 through February 1950, and three were built between 1952 and 1966. The Sailski’s asymmetric hulls served to act as keels to reduce leeway and her tripod rig reduced the load of the mast on the crossbeams, all of which were aerodynamically faired. She was the first catamaran to feature a trampoline but the crew was not likely to somersault as on modern-day AC45s!

L. Francis Herreshoff met the demands of The Rudder readership, who wanted a version of the Sailing Machine catamaran that would be cheap, lightweight, fast and easy to build. The Sailski measured 27 feet in length and announced the development of beach catamarans.

In the next issue, we will continue to examine the development of beach cats.

François Chevalier is a naval architect, author, journalist, illustrator, and university lecturer based in Paris, France. With Jacques Taglang, he has worked on the history of the America’s Cup and also on American and English yachts in the nineteenth century. He is an alumnus of the Westlawn Institute of Marine Technology and of the École Nationale Supérieure des Beaux-Arts (ENSBA) Paris.

Visit François Chevalier’s blog with Jacques Taglang at: chevaliertaglang.blogspot.fr
1. BACKGROUND
During the late 18th century, small boats specifically designed for saving life from shipwreck started to appear at dangerous harbor and river entrances around the UK. These early lifeboats were manned by large crews, the majority of whom were oarsmen providing motive power. The boats rarely operated far from shore, often within the surf line, so featured a self-draining cockpit plus permanent buoyancy to ensure they remained afloat if swamped (originally termed “the unimergible boat”).

Despite the strong likelihood of capsize, very few boats were actually designed to self-right, crews preferring high initial stability and a buoyant hull-form that would ride the seas. In reality, lack of righting ability was no great disadvantage; crew members were not attached to the boat and capsize invariably resulted in them being thrown into the sea. Re-boarding any boat in breaking seas is difficult enough, but for a lifeboat crew, already tired by having to row against wind and waves and wearing heavy waterlogged clothing, the relatively high freeboard of an upright self-righter would have presented an almost insurmountable obstacle. An upright vessel also experiences greater hull windage, which could result in the boat being blown away from the crew. By contrast, an inverted vessel tends to float lower, making it less influenced by wind and sea and easier to climb onto.

Most lifeboat-men at this time were seafarers, often fishermen, who recognized the risks associated with their profession and accepted that accidents frequently resulted in loss of life.

1824 saw formation of the National Institution for the Preservation of Life From Shipwreck, now the Royal National Lifeboat Institution (RNLI), which led the way in lifeboat development throughout much of the 19th century. By 1880 self-righting and un-sinkability had been successfully merged, but with the need to accommodate a large crew plus survivors, any mechanism to facilitate self-righting was pushed to the extreme ends of the hull. This limited its effectiveness and meant that late 19th and early 20th century self-righting lifeboats were generally narrower and had less upright stability than their non-self-righting counterparts. Lifeboat crews nick-named these boats “Roly-Polys,” often refusing to accept them on the grounds that they were unsafe. Analysis of RNLI statistics for the late 19th century indicates these concerns to be understandable, showing crew losses from self-righting boats to be slightly higher than those from non-self-righters.

The introduction of mechanical propulsion in 1904 saw little change. The then RNLI Consulting Naval Architect, J R Barnett, of G L Watson & Co, did not believe self-righting to be suitable for large offshore lifeboats, so very few new designs were produced. All changed in 1958 when the RNLI introduced the Oakley 37, the first self-righting lifeboat to combine high initial stability with a reliable self-righting system. Although still essentially an open boat, the Oakley 37 became an instant hit and served the Institution well for over thirty years.

The next significant development, surprisingly, did not come from the RNLI or even Europe. In 1966 the United States Coast Guard (USCG) exhibited a 44ft surf lifeboat at the International Lifeboat Federation Conference in Edinburgh. With a speed of fourteen knots, the USCG 44 was almost twice as fast as most lifeboats then in service, but more importantly, was self-righting by virtue of a buoyant super-structure. The design was subsequently adopted by other rescue organizations, including the RNLI, and paved the way for the highly sophisticated vessels we see today.
2. NAVAL ARCHITECTURAL REQUIREMENTS
All craft of conventional design possess a heel angle at which the curve of righting levers has degraded to zero (Point of Vanishing Stability). Often the vessel founders well before this point is reached, but for those with sufficient buoyancy to stay afloat, any heel angle beyond the Point of Vanishing Stability results in the craft continuing to rotate until equilibrium is reached. This often does not occur until the vessel is fully inverted and in this attitude it can be more stable than when upright.

To achieve self-righting, a vessel must therefore meet three fundamental requirements:
- Possess a curve of righting levers for which there is no Point of Vanishing Stability (i.e. the curve remains positive throughout the full 360° rotation).
- Be unstable when inverted to initiate the righting process.
- Remain buoyant and watertight.

2.1 SELF-RIGHTING METHODS
To meet the above criteria, self-righting craft generally possess a non-flooding hull and sufficient buoyancy suitably placed to ensure that the vessel is unstable when inverted. For larger vessels the superstructure usually provides the required buoyancy with all hull and topside openings being non-flooding or self-closing to maintain watertight integrity. Such craft are deemed to be inherently self-righting as the capability is inherent in the design. Smaller boats with insufficient space for a large deckhouse use an inflatable bag to provide the necessary buoyancy that is activated, either manually or automatically, after the vessel has capsized. A third method uses moveable weight, commonly water ballast, to create an out-of-balance force and hence a positive righting moment.

Neither the inflatable bag nor moveable weight method will actually prevent capsize. Both are activated after capsize to make the vessel unstable when inverted, enabling it to right until past the point of vanishing stability after which normal hull form stability criteria come into play.

It should be noted that although most self-righting vessels are inherently buoyant, the converse is not always true - many buoyant, unsinkable craft will not necessarily self-right.

One fundamental of any self-righting vessel design is the relationship between weight and buoyancy necessary to achieve the required stability curve. It is vital that nothing affects this relationship during a roll, so crew, passengers and equipment must be secured in place to ensure they cannot move and change the vessel’s centre of gravity (and hence the righting curve) to the extent that that recovery is impaired.

The following paragraphs describe the three methods in more detail.

2.1(a) Inherent Self-Righting
Craft utilizing this method have their self-righting capability inherent in the design, where it is always available and will return upright from any angle of heel without action from the crew.

The design will feature a watertight hull with at least part of the superstructure also watertight. This provides strategically located buoyancy above the deck-line to counteract any tendency for the vessel to capsize. Buoyancy location is vitally important and even small changes in volume or position can have a significant effect on self-righting ability. This is particularly noticeable when the main machinery lies under the after deck. Such craft can demonstrate large changes in trim during capsizing and require extra lift aft to prevent the stability curve becoming negative as the after deck is immersed.

Benefits of inherent self-righting include:
- No working parts to go wrong.
- Self-righting capability is always available and at any angle of heel, so can prevent full capsize.
- Can, within reason, be applied to any size vessel, although weight limitations on very small craft can limit effectiveness.

Disadvantages include:
- Superstructure volume must be adequate to provide the necessary inverted buoyancy, which often results in the seemingly oversize deckhouses fitted to modern rescue boats.
- All hull and superstructure openings must self close or remain above the waterline during the full 360° roll.
- Structure of hull & superstructure, including any deck recesses, must be designed to withstand hydrodynamic forces resulting from capsizing.
- Windows & doors must be capable of withstanding the same pressures as hull and superstructure.
- A good effective mechanical ventilation system will be necessary as the vessel will effectively be operating closed down with all doors and windows shut.

Figures 1 and 2 show a modern inherently self-righting lifeboat and associated stability curves for the same craft.

![Figure 1: Modern inherently self-righting lifeboat – RNLI Tamar class — Photo © RNLI](image-url)
Self-Righting Craft (continued)

2.1(b) Inflatable Bag
This method is generally employed on smaller craft, particularly rigid inflatable rescue boats (RIBs). It takes the form of an inflatable bag, carried on and securely attached to, a substantial gantry frame located across the stern, straddling the engines or propulsion units. The bags are commonly made from neoprene or hypalon coated fabric, similar to that used in the manufacture of inflatable boats and are inflated using compressed gas injected under pressure. The gas canister is usually fired manually by the crew after they have escaped from the inverted vessel and have attached themselves to a tether line running from the stern. This keeps the crew in contact with the boat before, during and after righting. To fire the bag automatically with personnel still underneath could result in injury and, in strong winds, the upright vessel being blown away from the crew before they can re-board. Automatically activated inflatable bags are occasionally fitted on vessels where the wheelhouse volume provides insufficient buoyancy to effect satisfactory and reliable self-righting.

Benefits of the inflatable bag method include:

a. Simple and light weight.
b. Volume can be adjusted by changing the size of airbag.
c. Easy maintenance as bag can be removed and replaced with a substitute.

Disadvantages include:

a. Bag must be fitted and folded correctly to achieve 100% reliability.
b. Roll bar structure and bag attachment must be substantial to resist the forces present during the righting process, particularly at 90° heel.
c. Provides a once only righting ability. Some boats are fitted with duplicate gas cylinders for 100% system redundancy and to provide a second inflation, should this be necessary, but the bag is not repacked between firings.
d. Bag liable to damage if inflated in shallow water or close to a casualty.
e. Gas pipework and bag injection point must be correctly designed to avoid freezing.

Figures 3 & 4 show a typical RIB inflatable bag installation with the bag stowed and inflated following a self-righting.

Figure 2: Typical Tamar-class stability curve

2.1(c) Moveable Ballast
Self-righting using moveable ballast is now rarely used, having been largely superseded by inherent buoyancy, but could still be relevant to small craft where the provision of large quantities of buoyancy high up might not prove feasible. The method utilizes a quantity of ballast, usually seawater, located low down in the hull while the vessel is upright. This moves following capsize to provide an offset weight moment sufficient to return the vessel past its point of vanishing stability. With the required quantity of ballast up to 10% of light displacement, the method is most appropriate for slow speed displacement craft where the additional weight will not be detrimental to performance.

The best examples of a moveable ballast self-righting sys-
Self-Righting Craft (continued)

A system can be seen in the RNLI Oakley 37ft and 48ft 6in lifeboats developed during the 1950s and 1960s. Both lifeboats were traditional in appearance and construction (i.e. built in wood with a double-ended hull form having a low superstructure and an iron ballast keel) and incorporated a double-bottom ballast tank that flooded automatically as the boat went afloat. Following capsizing the ballast transferred, via gravity operated valves and connecting trunks, to a righting tank high in the hull under one side deck to create an offset weight moment to initiate self-righting. The righting tank emptied overboard, again through gravity operated valves, as the boat came upright and at the same time the double bottom ballast tank was re-filled.

The smaller Oakley 37 was effectively an open boat with just a small watertight engine casing plus fore & aft watertight end boxes. Even with the offset ballast weight, these provided insufficient moment to initiate self-righting, so superstructure buoyancy was made asymmetric by creating an external watertight recess in the engine casing on the same side as the righting tank.

Although simple and totally reliable in service, the self-righting system used in both Oakley lifeboats did present one disadvantage. Transfer of ballast started once the boat had rolled beyond 110°, either to port or starboard, but with the righting tank on one side, the vessel would always right in the same direction (for the Oakley 37, it was roll to starboard). Roll to port therefore resulted in the capsizing before 180°, with the boat returning upright rolling to starboard. Roll to starboard almost always resulted in a full 360° rotation. Figures 5 & 6 show the righting process and activation of the various components during port and starboard roll. (Reference 1)

It should be noted that these illustrations are diagrammatic only and do not convey the exact timing sequence for opening and closing the valves at the appropriate angles of heel, which is vital to the design.

Benefits of the ballast transfer method include:
   a. Can be fitted to small open boats where buoyant superstructure is not a feasible option.
   b. Ballast is plentiful and readily available (usually seawater).
   c. Can be designed to be self-operating.
   d. Ballast can be used to enhance upright stability.

Disadvantages include:
   a. High number of mechanical components (i.e. self-operating valves) requiring maintenance to ensure 100% reliability.
   b. Quantity of ballast might restrict application and size of vessel.
   c. Not viable for planing craft where the additional weight would limit performance. Planing craft also have the difficulty of keeping water ballast in the tank whilst under way.
d. Vessel structure must be designed to withstand continuous immersion in seawater. The RNLI Oakley 37 was always kept ashore as incompatible materials (copper, steel & aluminum alloy) used in the ballast tank construction quickly corroded if left afloat.

e. System can result in vessel being recovered in one direction irrespective of the direction of capsize.

2.2 VESSEL DESIGN & COMPUTER MODELING

A critical question with any self-righting vessel is where to place the buoyancy. When using the air bag or weight transfer systems there may not be much choice, but with an inherently self-righting vessel, hull form, deck and superstructure geometry and weight distribution all play a significant part in the righting process, so the most obvious location may not always be best.

Prior to reliable computer modeling, a set of cross curves, derived using Planimeter and Integrator, could take eight weeks or more to complete. To avoid unnecessary repetition, preparation of stability data was often left until the design was well advanced with the hull form and superstructure geometry finalized. Correct location of the buoyancy depended on the naval architect’s skill and experience with an understandable strong reluctance to depart from a proven format.

The advent of powerful hull modeling and analysis software has transformed the naval architect’s task, enabling designs to be checked for self-righting capability much earlier in the development process. Alternative superstructure configurations can easily be evaluated, allowing designers more freedom to investigate unusual hull and deckhouse shapes.

It is not within the scope of this paper to recommend any particular computer software, but the system chosen must obviously be capable of handling full 360° rotation (180° roll to port and starboard) together with high angles of trim, particularly when inverted. It must be capable of accurately modeling the true shape, volume and weight distribution of finished craft. This particularly applies to rescue vessels that often have very angular deckhouses containing appendages and/or recesses. The software must also be capable of including pieces of buoyancy not directly attached to the main superstructure (e.g. mast volume) as even the smallest component can have a significant effect on self-righting.

Computation of hull weight and centers is standard practice for any new vessel, but self-righting craft design requires this data much earlier than normal for predicting righting ability. All weights and centers information needs to be as accurate as possible and updated regularly, with corresponding re-calculation of the stability data, as the design progresses. Vertical centre of gravity (VCG) is particularly important as any significant rise during the vessel construction can result in curve of righting levers becoming negative. It is not unknown for full weight monitoring to be carried out on vessels where weight and/or centre of gravity height are...
known to be critical. All items added or removed during construction, together with their location, are recorded so that the weights and centers calculation may be continuously updated. It is not unknown for craft to be weighed at specific stages to confirm the accuracy of the data.

Finally, the prudent Naval Architect will always verify the weight estimate by carrying out an inclining experiment on the completed vessel. This provides accurate data for computation of the stability curves for the operating envelope. Only when these are shown to be 100% positive can the craft be confirmed as self-righting.

### 2.3 MODEL TESTING
#### 2.3(a) Static Self-Righting Tests
Model tests most commonly associated with self-righting will be those carried out using small static models to investigate specific loading or flooding conditions or to verify the results of computer analysis.

The model should be watertight and represent the completed vessel as closely as possible with all external hull and superstructure features, such as recesses, appendages and separate pieces of buoyancy, (i.e. masts, radar, inflatable dinghy, etc.), included. The model is ballasted to a weight and centre of gravity representative of the full scale condition under investigation then rolled over to simulate capsize using a procedure very similar to that employed when testing full size craft (see paragraph 2.4 - Full Scale Trials). Once inverted it is allowed to right naturally. A load cell can be inserted between the strop and lifting device to measure the capsizing force, useful when specifying the crane for a full scale self-righting trial. Recording the test on video enables the righting process to be examined in detail using stop-motion playback.

Designers of rescue craft face scenarios rarely encountered in other vessel types, one typical example being additional personnel (i.e. survivors) taken onboard part way through a mission while at reduced fuel load. These changes obviously influence self-righting ability, particularly if the survivors are accommodated within the vessel. Although such conditions should always be verified by computer analysis, this does not always provide a clear indication of how the vessel will react. Model testing provides a visual reference, particularly when evaluating small changes to a specified loading condition as the model can be quickly re-ballasted to represent the new survivor weight, position and fuel load.

Some rescue craft have compartments designed to partially flood during capsize with the quantity of water taken on board being dependent on how long the inlet remains immersed. Even the best computer analysis software can struggle when faced with such scenarios and model testing often provides the best way of examining the true effect such flooding will have on self-righting capability.

### 2.3(c) Dynamic Model Testing
For vessels operating in extreme conditions, preventing capsizing is as important as safe recovery. With rescue vessel development costs often well in excess of £2 million it is important to confirm how a design will handle in extreme sea conditions before committing to a prototype. Standard computer analysis software rarely predicts how craft respond to their operating environment and dynamic model testing is often used to provide the necessary visual indicator.

Most Naval Architects will be familiar with dynamic model testing in its most basic form; a non-powered hull being towed into waves in a tank. This provides a good indication of bow wetness and any tendency to slam, but nothing on vessel response to seas from other headings. Such information is best provided by running self-propelled, instrumented, models in either a large enclosed wave tank or the open sea. Being radio-controlled, the model can be directed to encounter waves from all headings, the aim being to replicate situations likely to result in an uncontrolled maneuver, broach, knock-down or capsize.

The model hull form must be accurate and, ideally, propelled by a drive type equivalent to that proposed for the full size vessel (i.e. waterjets or propellers). The propulsion system must allow good duration while achieving a scale speed at least equivalent to the maximum operating speed of the vessel. To avoid the need for frequent battery recharging, small internal combustion engines are a viable option for larger models, especially when running at sea. A watertight superstructure must be fitted to prevent damage to internal systems should the model take water on deck or be rolled over. As self-righting evaluation is not a function of these trials, superstructure shape need not be 100% accurate but should be representative enough to provide an accurate weight distribution. When running trials in open water it is recommended that the hull contains sufficient buoyancy to keep the model afloat.

Model runs are generally videoed, allowing them to be replayed at a reduced speed representative of the full-scale response rate. It is not uncommon for larger models to be fitted with telemetry to record roll, pitch, heave, rudder angle and heading, thereby providing a detailed record of the response to any particular sea state. Running the model in following sea runs can be particularly revealing, this being a small vessel’s most vulnerable heading, but one most difficult to evaluate with other forms of analysis. (Reference 2)

### 2.4 FULL SCALE SELF-RIGHTING TRIALS
A full scale self-righting trial provides the ultimate physical proof that a vessel is capable of righting herself following capsize. In the past such trials were considered essential as the design and analysis methods available were not considered accurate enough to provide categorical proof of self-righting capability. Although modern computer analysis is now capable of providing all the evidence needed, making a
Self-Righting Craft (continued)

full scale trial theoretically un-necessary, the results of any analysis is only as good as the input. Mistakes in modeling and/or weight information are not unknown and with the safety of the crew heavily reliant on the expertise of the naval architect, it is wise to adopt all available checks to ensure the vessel performs as intended.

As a consequence, the RNLI, in common with many other rescue organizations, still carries out full scale self-righting trials on selected new, inherently self-righting, all-weather lifeboats. Not only do these trials confirm computer analysis data but, more importantly, prove to the customer (in this case the crew) that their new boat will look after them should the worst happen.

The following paragraphs describe the process and equipment used by the RNLI. Equipment used by other organizations may differ in detail, but the concept remains the same. Small craft fitted with air bags use a similar capsize method but righting does not commence until the bag has been activated by the crew. As correct procedure is essential for safe recovery of both boat and crew, righting trials for this type of RNLI craft are carried out with the crew on board and form an essential part of Inshore Lifeboat crew training.

During an RNLI self-righting trial the vessel is rolled over until upside down using a heavy webbing or rope strop attached to a crane. Once fully inverted, the strop is released from the crane hook and the vessel allowed to return upright. Trials are usually carried out on a dead ship, i.e. all systems and machinery turned off, although the main fuel tanks are often full.

The strop, or parbuckle, is connected to the outboard side deck (i.e. furthest from the quay) using self-releasing attachments that fall away once the strop is no longer under tension, ensuring they do not become snagged as the vessel rights. The strop then passes under the hull to emerge on the inboard side and continues upward to a roller shackle fitted into the jaws of a slip hook attached to the crane. The craft is thus rolled away from the quay, limiting any possibility of damage, and rights with the superstructure facing towards the quay, allowing the righting sequence to be observed from the shore. A 360° angle board with gravity activated pointer is fitted to one end of the vessel at a position where it will remain clear of the water throughout the capsize. (e.g., vessels that trim by the stern when inverted will have the angle board located on the bow). The angle board needs to be large enough to be seen by the person releasing the slip hook as it essential that this takes place as soon as the board shows 180° to avoid any tendency for the crane to over-pull and initiate the righting process.

The following basic safety procedures ensure that the trial goes to plan and the new vessel self-rights satisfactorily.

- The crane should have adequate lifting capacity at the outreach necessary for the vessel to self-right without striking the quay or other fixed objects. Prediction of crane loads required to capsize the vessel at any angle of heel are derived using the righting moment from the dynamical stability curve divided by the separation between the contact point of the parbuckle on the hull and the vessel vertical centre of gravity (VCG) in righting condition.

- The capsize site should have adequate depth of water to accommodate the inverted draught of the vessel in the trial condition. Slender topmasts, whip aerials and other delicate electronic equipment on the wheelhouse are generally removed to reduce inverted draught and prevent damage caused by water resistance during righting.

- All doors and windows should be securely fastened and remain closed and watertight throughout the trial. Door seal leaks can be detected using air leak detection instrumentation.

- All large ventilation openings, particularly those designed to self-close during capsize, should be blanked off. Although openings on self-righting vessels should be designed to minimize ingress of water, it is unlikely that large closing flaps will be 100% effective. A capsize in service happens very quickly, a full 360° roll often taking less than ten seconds, during which time the quantity of water entering is likely to be small and have minimal effect on the self-righting capability of the vessel. During a self-righting trial the crane will rotate the vessel much more slowly, with time to full inversion being measured in minutes rather than seconds. Hull and superstructure openings are therefore immersed for much longer, allowing more water to enter. With the vessel inverted, this naturally gravitates to the underside of the decks or superstructure where it reduces the available righting moment and causes unnecessary damage to equipment.

- Small self-closing ventilation openings can be left open during the trial, but it is advisable to disconnect and blank off associated trunking at the vessel side, particularly that serving electrical equipment, such as battery boxes. The RNLI often fits substantial watertight bags over the inboard ends of these openings so that any water passing through can be caught and measured.

- The vessel should be inspected immediately after self-righting to determine the extent of any water ingress.

- A substantial trip line should be provided for the crane slip hook. Experience has shown that the actual curve of righting levers is rarely zero at 180°, so even when the vessel is fully inverted there will be some load on the parbuckle. A thin trip line is not only more difficult to pull, but has been known to break before the hook released. A vessel self-righting with the parbuckle still attached to the crane runs a risk of superstructure damage from the “over-roll” beyond upright as a result of the righting momentum.
Self-Righting Craft (continued)

- A safety line should be attached between the roller shackle and the crane hook to prevent the shackle hitting the vessel superstructure as it falls after release. The line length should be set to hold the shackle clear of the superstructure after righting.

- Most self-righting craft are fitted with a self-operating mechanism to stop or return the main engines to idle during capsize. Indicators (usually lights) are fitted to the angle board at the system activation angle to confirm that the mechanism has operated successfully.

A typical RNLI self-righting trial is shown in the photographic sequence below.

2.5 LIVE SELF RIGHTING TRIAL
Less common than dead-ship trials, the RNLI carries out a live self-righting trial (i.e. with all systems and engines running) on at least one boat in each class. The procedure is essentially the same as for dead-ship trials, but a live trial provides the opportunity to confirm satisfactory system operation in a controlled environment.

3. DESIGN & OUTFIT
In general, design and outfit requirements for self-righting vessels differ little from those of conventional craft of similar size and function. There are, however, a few areas requiring special consideration, particularly for rescue vessels, as discussed below.

3.1 STRUCTURAL STRENGTH
Not all self-righting craft are employed in a rescue role, but those that are must, by definition, be capable of safe operation in extreme sea state and high wind, well outside the envelope for normal hull load prediction methods. Hull loadings for rescue boats are therefore difficult to predict with any degree of accuracy, particularly for vessels using planing hull forms. It is outside the scope of this paper to provide detailed information on design standards, but some organizations (typically the RNLI) develop their own criteria based on standard design data modified by experience. Although rarely available to the wider naval architectural public, specific data is sometimes included in published information on specific craft. (Reference 3).

Whatever the prediction method used, it is essential that the hull structure is designed with sufficient reserve of strength.
to survive the unexpected. The introduction of faster rescue boats has seen more vessels becoming airborne from large seas, sometimes falling for two or three seconds before impacting the water surface. The resultant shock loadings can far exceed normal design criteria on hull structure, internal structure and equipment.

Operation in large breaking seas also increases the risk of pitch-pole (i.e. capsize end over end), following which the vessel lands inverted on the superstructure. With the superstructure contributing most of the self-righting capability it is essential that this remains intact and watertight, so it is now common for lifeboats to be capable of withstanding the full weight of the vessel impacting on the wheelhouse top.

3.2 DOORS, HATCHES AND WINDOWS

With watertight integrity essential for vessel safety, all doors, hatches and windows fitted to self-righting craft must be capable of resisting the hydrostatic forces associated with capsize. In addition, most will be fitted in compartments or spaces used as part of the vessel's watertight subdivision, so could be required to keep water in as well as out. All doors, hatches and windows fitted to self-righting craft must therefore be as strong as the adjacent structure and capable of accepting hydrostatic pressure from either side.

No door, hatch or window can be expected to do its job of keeping water out if not securely closed, so to minimize the risk to vessel safety, all should be kept shut at sea unless actually being used. Those that do need to be opened regularly for crew access to other parts of the vessel, such as wheelhouse doors onto the deck, should remain open for the shortest possible time and must consequently be quick and easy to operate with a positive and secure locking mechanism. Wheelhouse doors on rescue vessel are often located facing aft to protect them from direct wave impact.

Even modern lightweight composite doors can inflict serious injury when driven by a heavy roll, so it is important to provide grab rails adjacent all doors to discourage crew members from using the door frame as a handhold when moving around the vessel.

To prevent any likelihood of them being left open during capsize, wheelhouse windows fitted to inherently self-righting craft are generally fixed. Glazing can be laminated glass, but the need to withstand substantial hydrostatic pressure results in a thick and heavy panel, even on small windows. For many designers and operators the preferred glazing material is optical quality polycarbonate. Not only is polycarbonate significantly lighter than glass, but its greater flexibility permits much larger deformation before failure. Windows can therefore be designed using thinner material, reducing structural weight in the superstructure where it offers most benefit.

Unfortunately, polycarbonate suffers two disadvantages when used for marine windows.

The material has a high coefficient of thermal expansion, resulting in stress cracking around fastener holes unless suitable allowance is made. It is therefore preferable to clamp the material and one secure, well tried method is to use a two-part ‘C’ section aluminum alloy frame bolted into the vessel structure. The polycarbonate panel is bonded into the ‘C’ using a non-setting synthetic sealant that allows the glazing to move under pressure but prevents it being displaced from the frame. Although well proven over many years, this has been superseded in the latest RNLI vessels by windows bonded directly onto the superstructure.

As manufactured, the surface of polycarbonate sheet is very soft, making it liable to scratching when used with windscreen wiper blades often carrying a layer of abrasive salt crystals. This problem is well recognized and not exclusive to the marine industry, so since the early 1980s polycarbonate glazing has been available with hard surface coating applied by the manufacturer during final finishing. This coating resists all but the worst wiper abrasion and most small craft using polycarbonate glazing now fit hard coated material.

Rescue craft are not the most comfortable vessels at sea with all doors and windows closed, so it is not unknown, in calm weather, for crews to lock the wheelhouse door open to improve ventilation. Such action can become normal practice, even in bad weather, despite the obvious risk to vessel safety. Such an incident occurred in 2006 when Anna Margeretha, an Arie Visser class lifeboat operated by KNRM, the Netherlands lifeboat society, capsized whilst on service with the main wheelhouse access door open. Luckily the lifeboat self-righted satisfactorily and was able to make port unaided, but the large quantity of water entering the wheelhouse caused significant system and control failure resulting in temporary loss of engine power (Reference 4).

3.3 STOWAGE AND SECURING OF EQUIPMENT

A vessel under way in big seas can easily see accelerations in excess of 10g in its forward compartments, while capsize is likely to produce at least -1g. All equipment carried aboard a self-righting vessel, portable or fixed, must therefore be held securely and prevented from falling should the vessel invert.

Stowage for portable items should be quick and easy to operate, even for gloved hands, but still hold the item securely against gravity.

Mountings for built-in equipment must be secure and robust and are often included as part of the vessel structural design. The risk of system failure is significantly higher in vessels operating at extremes of weather, so critical items need to be accessible to allow repair or replacement without dismantling large parts of the boat. If access is difficult or replacement at sea is impractical, consider duplication to provide 100% redundancy.

Custom seating will be designed for purpose, but the same...
cannot always be said for those included as part of bought-in assemblies, one typical example being the resilient mountings supplied with machinery. Designed to accept compression loads when upright, few are capable of accepting significant load in tension, as would occur during capsize. The RNLI fits mechanical restraints, often in the form of fabricated saddles attached over the mounting feet, which allow the necessary movement when upright but carry the weight should the vessel roll beyond 90°.

3.4 SEATING
Correct seating is an essential part of crew safety for any small craft, but is particularly important for one designed to survive capsize. Not only must the seat hold each crew member comfortably and securely while they operate the vessel, but it must also keep them in place whatever attitude it adopts. For many years, seats on self-righting craft have therefore been fitted with belts to hold the occupant in place. Initially, these were simple lap belts, but the latest designs now feature a fully adjustable harness (i.e. twin shoulder straps plus a lap belt).

Having ensured that the occupant remains in place, it is also important that the seat remains in place when the vessel is rolled over. Seat structure, attachment to the deck and any supporting structure must therefore be capable of accepting the full weight of seat and occupant when inverted.

It is now generally accepted that fast-vessel seating should include some kind of suspension. With craft now travelling faster in worse conditions the suspension system must react quickly enough to damp out excessive motion. If not, seat and vessel motion could become unsynchronized, resulting in the seat and occupant continuing downward as the boat rises. This can result in the seat bottoming-out and imparting load into the base of the occupant’s spine. The latest rescue vessels therefore feature custom bucket type seats designed to accept extreme boat motion without bottoming.

With up to 300 mm of movement in each direction, access to essential controls could prove difficult, so items such as engine and helm controls are located on the seat, often on the arm rest. The latest RNLI lifeboat seats also contain a control for the boat’s integrated management system, allowing each crew member to access vessel systems without leaving their seat.

Although crew seating obviously has priority, survivor/passenger accommodation must not be forgotten, particularly on rescue vessels. Unsecured personnel could be injured during a knock-down or capsize and can also affect vessel safety – people on the deckhead of an inverted boat make excellent ballast, tending to reduce self-righting capability. Survivor/passenger seats should therefore be designed to the same standard as crew seats, including, if possible, full harness belts, although generally without suspension.

3.5 VENTILATION
With all doors and windows closed at sea, a good, efficient ventilation system is essential for both crew and boat. Not only must this provide adequate airflow, but air supplied to crew spaces must be heated and, where appropriate, cooled to provide a good working environment.

All ventilation openings in the hull and superstructure must be self-closing or designed to prevent the free flow of water when immersed, both when the vessel is upright or when rolled over. There are numerous ways of achieving this protection, from crossed ventilation ducts (arranged so that both ends never become immersed at the same time), to simple valves operated by floats and/or weights. Whatever the methods used, it is essential that they are well proven before the vessel becomes operational. As previously discussed, self-righting trials rarely offer the possibility to test the principal ventilation systems as the longer roll-over period requires closure of larger openings. Computer analysis can be used to investigate water flow in larger systems (e.g. main-engine ventilation), but in many cases the simplest solution is to build a test rig to verify the efficiency of the closing device.

4. REFERENCES
2. High Speed Craft – Control In Following Seas; MCA Information Film produced by BMT SeaTech Ltd; Maritime & Coastguard Agency, 2005.

This pleasure craft is designed for production in series and was ordered by a local shipyard in New Caledonia. The design is ideal for weekend sailing in comfort for a family and friends. She has good autonomy, excellent maneuverability and low draft. These make her the perfect coastal cruiser. The seaworthiness of her catamaran hulls, makes her also suitable for high-seas. Thanks to her lightweight and optimized hydrodynamics, fuel consumption is estimated to 2 liters per nautical miles for a cruise speed of 13 knots.

Design:
The hull shape is drawn from a recently built 78-foot, wave-piercing catamaran with inverted bows. The aft end of the hull forms are wide to reduce squat. Particular attention has been paid to centering the weights (tanks, batteries etc.), which is crucial to reduce the pitch to handle rough seas.

The interior is designed to fully integrate the outside into the interior thanks to large hull opening ports and a saloon with 360-degree view. The flybridge allows excellent visibility, which is rare on this type of craft.
conviviality and to share good times in comfort, she is equipped with two luxurious staterooms including separate showers in each head. The galley is fitted with plenty of working space, a fridge and many storage compartments. The saloon allows flexibility of use for day or night. The exterior deck offers deep storage areas, a large platform for fishing, great access for bathing.

Construction:
The design was fully executed in 3D on Rhino from the hull design, to the cleats to the water piping system, to the
structural calculation of the bulkheads. The modeling allows extremely precise assembly of the parts and provides a solid integration of any systems required onboard. The 3D process also offers excellent detail in the materials purchasing stage of the project since all the material lists are automatically created, which represents a gain on the planning for the shipyard.

The hull material selected is the M foam sandwich reinforced with glass and epoxy resin. All bulkheads, frames, and storage areas onboard are made with this material. The joining of all these parts contributes to the overall strength of the structure. This assembly gives excellent rigidity to the hull with low weight.

The flat-panel technology reduces the usage of special tools by the shipyard, reducing the construction time for a semi-custom project without using moulds. The vessel is thus quick to build which can offer a higher profit margin for the builder.

12 Meter Outboard Power Cat - Particulars
Length: 11.98 m (39.3 ft.)
Molded breadth: 5.25 m (17.2 ft.)
Engine power: 2 x 225 HP Outboard Yamaha
Displacement: 7.4 Tonnes (7.3 tons)
Max. Speed: 25 Kts
Material: Gurit Panels M Foam/Glass/Epoxy

Corentin Bigot Yacht Design
44 rue de la riviera,
Noumea, New Caledonia,
corentin@cbyd.fr
www.cbyd.fr
In addition to the traditional ability to dock toolbars around the edge of the drawing area, Rhino 5 introduced toolbar tabs along the top of the drawing area. If you would like to create an Orca3D tab that contains the Orca3D toolbars, follow these steps:

1. If the Orca3D toolbar that you wish to put in the tab is docked, undock it by dragging it into the drawing area. You must click on the double lines at the top of the toolbar to drag it.

2. Stretch the width of the toolbar by dragging on the right side of the toolbar, so that you can see the title of the toolbar. This step is required.

3. Click on the title to drag the toolbar up to the tabs at the top of the drawing area. You can place it anywhere in the row of tabs that you like.
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- Orca3D Level 1 & Rhino/Flamingo/Penguin/Bongo $558 (commercial price $3,085)
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Cheesy puns aside, the last few weeks have shown that standards based questions are contagious making Thermal Appliance and more specifically liquid petroleum gas (LPG) Systems, one Hot Topic. I have on more than one occasion answered the same question multiple times in one day. That made choosing a “back to school” topic for this issue easy.

With LPG being the dominant cooking and heating fuel for boats in the US, it’s easy to see wild fluctuations in how the fuel systems and appliances are installed from boat to boat. Many installations are thoroughly thought out, with every safety precaution being made and every detail of the standards being observed. Unfortunately there is no shortage of improperly installed systems as well. The results of improper installations can be catastrophic.

Since LPG is heavier than air, when released into a boat it settles in the lowest spot it can find and will invisibly overflow from one compartment into another through shared airspaces. The slightest spark in that pool of invisible gas will ignite the fuel and the resulting flame travels at 2,800 feet per second and can burn at nearly 3,500°F. So there is good reason to be cautious with this fuel. Much like natural gas in our homes, an odor is added to help notify the user when a leak may be present. For that to be valuable however, there must be a user on-board the vessel that can recognize something is wrong and shut off the fuel.

The most common cooking appliance installation is the portable rail mounted grill with a 16.4-oz. bottle screwed into the side. With the simplicity of this installation, any leakage that may occur merely leaks overboard. But did you know that the canisters are subject to the same requirements as the larger permanent cylinders? The capacity of the portable tank exceeds the maximum allowable for interior storage as required in A-30 Cooking Appliances with Integral LPG Cylinders.

Looking towards the larger permanent installations, storage cylinders need a dedicated locker that does not share air space with the hull interior and vented at the bottom of the locker draining only outboard (above the waterline). We often see LPG lockers used to store additional items like cleaning supplies, fenders, and mooring lines because of the locker’s convenience to the cockpit. A-1, Marine Liquefied Petroleum Gas Systems strictly prohibits this in order to limit the possibility of the drains being plugged. A-1 goes on to require that all appliance fuel lines must originate inside the locker and be dedicated for each appliance with no connections along the path. A manifold is acceptable to distribute the fuel to multiple appliances, but it must remain in the locker along with the fuel pressure regulator. Finally, when the fuel line arrives at the appliance, a flexible connector is allowed to accommodate gimbaled stoves, but only perma-
Memoriam
Richard C. “Dick” Newick – May 9, 1926—August 28, 2013

One of the most influential multi-hull designer of the twentieth century departed for his final sail on August 28, 2013. Richard Cooper Newick left a legacy that altered the entire world of multihulls.

Early in Newick’s career he got a job as a boatbuilder and ended up managing the company before the Korean War shut down the shop due to scarcity of materials. Dick went on to sail and explore much of the U.S., Europe, and the Caribbean. In fact, he arrived in the Caribbean delivering a 34-foot ketch to St. Croix. He liked it there and decided to stay. Not only did Dick meet his wife in St. Croix but he designed and built a 40-foot day-charter catamaran—the boat that got him started in multihulls.

Dick’s designs were visionary in the 1970s and 1980s and beyond. They were unique and almost instantly recognizable for clean lines, organic shapes, light weight, and simplicity of construction and outfit. Challenged by the OSTAR transatlantic race (today the TransAt), Dick designed one of the most radical offshore sailing racers in sailing history—the 40-foot, schooner-rigged proa Cheers, which became the first U.S. boat ever to complete the OSTAR. Such boats had never entered an offshore sailing race and they had hardly been seen by western sailors. Cheers was later followed by the 60-foot Rogue Wave and the 50-foot Moxie trimarans, both skippered by Boston-based newspaper publisher Phil Weld, who was the first U.S. winner in 1980. Over the years, these and other Newick multihulls placed, 1, 2, 3, 4, 5, 7 and 10!

Phil Weld, in winning the 1980 OSTAR at the age of 65, defeated twenty five younger competitors, and after his OSTAR win France, in particular, went multihull crazy.

In trying to identify the root cause of French enthusiasm, nautical historian Richard Boehmer drew attention back to Dick Newick and his Three Cheers. In Boehmer’s words:

“I think it was not just the speed but also the beauty of Newick’s boats that so strongly stimu-
Who Will Be The September 2013 Know It All Winner?

Email your answer to: nnudelman@westlawn.edu

Want to see how much you know? Want to show everyone else how much you know? The first three people to submit the correct answer to the following question will win a Westlawn tee shirt and cap, and will also receive a Know It All certificate. The answer and winners to be published in the next issue of The Masthead.

There are nine standard or common methods of planking wooden boat hulls. Can you name and describe all nine planking methods?
Know It All Contest Solution to the June 2013 Question
On what is causing bottom-paint discoloration and loss?
(This issue’s new Know it All question is on page 29)

The Know It All questions and correct answers are important design tips for students as well as other marine professionals. We suggest that you file them away for future reference.

The Question Was:

Prancing Petunia is a 1981, Chinese-built, fiberglass trawler. The fiberglass hull is sound and the bronze hull fittings are of good quality and in good shape. The zincs on the prop shafts are nearly gone, with a great deal of marine growth on them. Both the through-hull fittings and the rudder and strut are painted with anti-fouling paint—the same paint as on the hull.

Looking at the photos, you can see that there is a clear ring discoloration and loss of paint around the through—hull fittings and the strut. What phenomena is causing this, and is it likely to be structurally harmful?

The Solution is:

Though we received several answers to this question, none of the answers were quite on the mark.

The phenomena is hallowing from overprotection. Some bottom paints have a high copper content, over 15%. There was too much zinc and this overprotection is causing the reaction in the high-copper paint.

If you examine the boat—most likely—you’ll also find that the bonding system is faulty as well. The reason for this is that—if the bonding system were solid—then the hallowing would be found to some degree on all the metal underwater fittings. This problem is visible only on the fittings shown. It would make sense to check if the bonding system is faulty or if there’s no bonding system.

The solution is to clean to new metal and surface with and epoxy barrier coat and then to reapply the anti-fouling paint. It is also recommended to back down on the anode protection level to 650- 700 mV.

Hallowing has no direct effect on the boat’s structure.

Thanks to Kevin Ritz, Ed Sherman and Lachlan Mackenzie for insight into this phenomenon.
**Recreational Boating is $121 Billion Economic Driver for U.S.**

New data show 88 million Americans expected to take to U.S. waterways this summer

CHICAGO, June 11, 2013: The National Marine Manufacturers Association (NMMA) today announced that recreational boating in the U.S. has an annual economic value of $121 billion. The industry’s rising tide supports 964,000 American jobs and 34,833 businesses, generates $40 billion in annual labor income and drives $83 billion in annual spending.

The NMMA, on behalf of the U.S. boating industry, released these findings today as part of its annual U.S. Recreational Boating Statistical Abstract, a collection of data and analysis on the state of the U.S. recreational boating industry. Additional data highlights include:

**New Boat Sales**
Retail sales of new power and sailboats increased 10.7 percent in 2012 to 163,245, demonstrating a post-recession recovery for the industry. *(Note that this number includes inboard, outboard, sterndrive, jet and sail boats).*

New powerboat (inboard, outboard, sterndrive and jet boat) sales increased 10 percent to 157,300 in 2012. New sailboat sales increased 29.2 percent to 5,945 in 2012.

**Trends**
Small fiberglass and aluminum outboard boats 26 feet or less in size, continued their upward climb with an 11.3 percent increase in the number of new boats sold. Outboard boats are the most popular type of new powerboat sold, making up approximately 82 percent of the market.

Ski and wakeboard boats are seeing healthy growth with an increase of 13.4 percent new boats sold in 2012.

Jet boats, which are small fiberglass boats less than 26 feet in length, are a growing category. Of the 157,300 new powerboats sold in 2012, 4,500 were jet boats. New jet boat sales increased 36.4% in 2012.

**What’s Ahead**
Sales of new powerboats have remained steady during the first half of 2013 and continued growth is expected with the summer boating season. NMMA anticipates sales of new powerboats to grow five percent in 2013.

“Summer is a peak selling season for recreational boats, accessories and services throughout the U.S. as people look for ways to disconnect from the daily grind and enjoy fun times on the water,” said Thom Dammrich, NMMA president.

“One boat sales have historically been a barometer for the U.S. economy and the steady sales increases we’re seeing is being reinforced by the slow uptick in consumer confidence, housing and spending. As economic growth continues, we anticipate sustained steady growth through the remainder of 2013.”

Source: NMMA, Contact Ellen Hopkins ehopkins@nmma.org

**Recreational Boating Industry Conducting New Department of Energy Funded Research on Alternative Biofuels**

Tri-fuel testing, including isobutanol, ethanol and gasoline kicks off in Washington, DC

On June 5, 2013, the National Marine Manufacturers Association (NMMA) kicked off a third summer season of alternative biofuel testing in an effort to further advance marine engine technology and find an alternative to fuel containing more than 10 percent ethanol as a result of its damaging effects on marine engines.

The tests are funded by the Department of Energy, which released a 2011 report on engines using E15 revealing...
performance issues like stalling, corrosion leading to oil or fuel leaks, increased emissions and damaged valves, rubber fuel lines and gaskets. These results reinforced the recreational boating industry's concern that E15 is not a suitable fuel for boat engines.

Although the Environmental Protection Agency has approved the use of E15 for model year 2001 and newer cars and trucks, the boating industry has found that fuel containing more than 10 percent ethanol causes severe damage to boat engines. While marine engines are not currently approved by the EPA for use with E15, misfueling at the pump is a danger for boaters unaware that E15 is not compliant with boat engines.

The tests, in conjunction with the American Boat and Yacht Council (ABYC) and Evinrude, are part of ongoing research conducted by the recreational boating industry, to explore the alternative bio-fuel isobutanol in response to the U.S. introduction of gasoline containing fifteen percent ethanol, commonly referred to as E15.

Source: National Marine Manufacturers Association, Chicago IL

Coast Guard Rescues 2 Men After Sailboat Capsizes in Lake Superior

CLEVELAND August 13, 2013: A Coast Guard crew rescued two people from the waters of Lake Superior on Monday afternoon after the sailboat they were on capsized.

Just before 2:30 p.m. CDT, local 911 dispatch contacted a communications watchstander at Coast Guard Station Bayfield, Wis., stating that they received a report of a capsized 17-foot sailboat with two men in the water near Madeline Island. Coast Guard Sector Sault Ste. Marie, Mich., issued a urgent marine information broadcast, which informs mariners of a situation, asks them to keep a sharp lookout and report any sightings to the nearest Coast Guard unit, and to assist if possible. A boat crew from Station Bayfield launched aboard a 45 foot Response Boat-Medium, arrived on the scene, and rescued the men from the water. The crew took the sailboat in tow and transported the men to Madeline Island Marina. There are no reports of any injuries.

“Both men did the right thing wearing their life jackets,” said Petty Officer 3rd Class Daniel Harris, the officer-of-the-day at Station Bayfield. “The men were also wearing wetsuits, which have greatly helped their chances of survival if we had not found them right away”

Source: U.S. Coast Guard

Thermal Appliances Continued from page 27

nently attached fittings (such as swaged sleeves) can be used. The goal is to minimize the number of connections between the fuel tank and the appliance and reduce the possibility of connections being loosened.

The single most common misinterpretation among LPG requirements is the location of a fuel shut off valve. A-1 requires that the shut off valve be installed in a readily accessible location. Commonly we see a fuel shut off valve at the appliance in an attempt to meet this requirement... however, this is against the requirement that a line be dedicated and continuous. For the shut off valve to be permissible at the appliance, it must be a remote (solenoid) shut-off valve. So that brings up the term “readily accessible.” In order for a valve to be readily accessible, it must be “capable of being reached quickly and safely under emergency conditions without the use of tools.” Most LPG cylinder lockers today meet this intent so long as the boat owner is not storing fenders, a crusty mop and a boat hook on top of the fuel cylinders. A remote shut off is not required, yet it is recommended in installations where the LPG locker is a challenge to get to and it would certainly fall within a prudent mariner’s best interest to install one.

Liquid Propane Gas is an efficient and practical fuel for cooking and heating onboard your boat. However the slightest oversight in its use can be devastating. Following the Thermal Appliance Committees guidelines contained in A1, A-3 and A-30 is not just a requirement, but it’s a smart decision. If you aren’t systems certified, consider taking ABYC’s Marine Systems class. Everything from this article and more is covered in the class.
Essential Continuing Education
For Marine Surveyors, Boatbuilders, Managers and Small-Craft Designers

Fiberglass Boatbuilding Materials & Methods (Course No. BC 401)

This comprehensive distance-learning course provides instruction in the fundamental concepts of sound fiberglass boat construction practices and structural calculations.

This course focuses on current information on fiberglass/composite and related boatbuilding materials, and the best techniques for using them. Topics include: reinforcement fibers, resin systems, core materials, mold construction, production-facility requirements, boatbuilding methods, elements of strength of materials, laminate design and specification, assembly of components, and design examples.

NOTE: This course consists of lessons excerpted from Westlawn’s larger Elements of Technical Boat Design course and also in the full Yacht & Boat Design Program. On completion of BC 401, students may transfer into either program and receive full credit.

CLICK HERE for a detailed syllabus
CLICK HERE for more details and enrollment information on this and other Westlawn essential continuing education courses

Elements of Technical Boat Design (Course No: ETD)

Elements is a comprehensive introduction to the fundamental concepts in yacht and boat design for marine professionals. Students will gain a firm understanding of resistance, hydrostatics and stability as well as fiberglass design. Topics include: Hydrostatics, Stability and Trim, Principles of Resistance, Drawing of Hull Lines, Ergonomics and Interior Design, Fiberglass Boat Design and Construction. Note: Graduates of Elements may transfer to continue on and complete the full professional Westlawn Yacht & Boat Design Program, receiving credit for all the subjects covered in the Elements course.

“Since I have added Elements to my resume I have had several job offers from different companies and even a promotion with the company I am employed with now. If anyone is wondering if it would be beneficial to complete the program, I would say YES.”
Charles Bursk
Tiara Yachts

CLICK HERE for a detailed syllabus
CLICK HERE for more details and enrollment information on this and other Westlawn essential continuing education courses

ABYC Courses and Schedule for 2013

The ABYC education department has been providing industry certifications, training, high school and college curriculum, and industry seminars for over twenty years. They are providing the marine industry with the skilled workers required to build and maintain modern small craft of all types.

ABYC is currently scheduling on-site and factory training for 2013. Please call ABYC for custom tailored, flat rate, instruction by top industry trainers at your facility (410-990-4460, Ext. 104).

The Marine Technician Certification Program developed by ABYC with “NOCTI Certification”* has proven to be the industry standard. ABYC continues to provide the highest quality marine education and training throughout the country and throughout the year.

For course dates and descriptions Click Here

*NOCTI (National Occupational Competency Testing Institute) is a regular provider of the assessments on which many certifying bodies depend for measures of applicants’ standards-based knowledge and skills. Certificates benefit employers by showing that applicants have acquired specific skills. The status of having a certified staff can lead to higher sales and customer satisfaction.
Advance Your Career, Train Your Employees

ABYC is the acknowledged leader and certifying body in education for the marine industry. We offer technical classes that progress from entry level to advanced courses, meeting the needs of every experienced marine professional seeking improved skills. ABYC educational programs support the career path of individual technicians and provide a training curriculum for marine businesses. Our goal is to provide continuing, convenient education to improve the quality and professionalism of our industry.

Learn About the ABYC Certification Program & Courses

Read about the ABYC Certification program, who should become certified, how to certify and the eight different areas you can get certified in.

Need to Re-Certify?

The two most important reasons to recertify are your career and yourself. If your certification is about to expire your certification is about to expire

ABYC Class Schedule Through DEC. 8, 2013

ABYC Standards Certification (Annapolis, MD)
9/10/2013 » 9/12/2013
ABYC Systems Certification - College of The Albemarle
9/10/2013 » 9/13/2013 Manteo, North Carolina
Marine Diesel Engines Certification (Key West, FL)
9/10/2013 » 9/13/2013
Marine Electrical Certification (Port Hadlock, WA)
9/12/2013 » 9/15/2013
Technical Board Meeting on September 20, 2013
9/20/2013, Louisville Kentucky
Marine Corrosion Certification (North Vancouver, BC)
9/24/2013 » 9/27/2013
Systems Certification (Medford, Massachusetts)
10/1/2013 » 10/4/2013
ABYC Marine Corrosion Certification (San Diego, CA)
10/7/2013 » 10/10/2013
Marine Electrical Certification (Actuant - Menomonee Falls, WI)
11/4/2013 » 11/7/2013
Marine Electrical Certification (Honolulu, Hawaii)
Marine Electrical Certification (Lulenburg, Nova Scotia)
12/8/2013 » 12/12/2013

For more information and to register for ABYC courses go to: http://www.abycinc.org/educationprograms/descriptions.cfm

With integrity, pride in our product, and commitment to building long term relationships with our customers, Armstrong Marine, Inc. was launched with the goal to build the best boat on the water. It is that goal that drives us today.

With that in mind, Armstrong Marine set aside $80,000 for training in 2012, and the majority of the systems training will be through ABYC. Training with ABYC insures increased profitability through better trained and more efficient employees while also ensuring better safety and service.

Cory Armstrong, Owner, Armstrong Marine, Inc

Our goal at Diversified Marine Services, Inc. is to have all of our long term technicians certified to the “Master ABYC” status and to help pass this valuable information onto our client base. I feel like we are in partnership with the ABYC organization!

Thomas F. Kicklighter, Diversified Marine Services, Inc.
ABYC Webinars

ABYC is now offering webinars as a new and exciting learning tool to train marine professionals. Webinars are good for you and your company because they:

- Are relatively inexpensive
- Are monthly
- Are current and topical
- Can be viewed in real time or on your own time
- Can be archived for members
- Help you train your staff
- Give you a taste of an ABYC certification class

A typical webinar might feature an ABYC instructor or other industry expert doing a 60-90 minute talk with a PowerPoint presentation on a relevant topic. You might hear Ed Sherman talking about new battery technology or Captain Dave Rifkin discussing corrosion or John Adey explaining the details of a new ABYC standard. We have learned how to stream these presentations to your computer in your office with top quality sound, graphics and deliverability.

Order a pizza and gather your technicians in for a shop lunch. Have them all listen and view the presentation. Each one of them will learn something to take to the boat with them. This will make expertise and knowledge synonymous with your company and your technicians.

Go to the class calendar on the ABYC Website and sign up for one

2013 Events Program

RINA organizes a programme of international conferences, workshops and training courses covering a broad range of experience and opinion on research, development and operation on all aspects of naval architecture and maritime technology. For more information about any event, click on a title.

Pacific 2013: International Maritime Conference
7-9 October 2013, Sydney, Australia Register Now

World NAOE Forum 2013 & International Symposium on Marine and Offshore Renewable Energy
28-30 October 2013, Minato-Ku, Tokyo

Design and Operation of Passenger Ships
20 - 21 November 2013, London, UK Register Now

2013 President’s Invitation Lecture & Dinner
27 November 2013, London, UK

ICSOT India: Technological Innovations in Shipbuilding
12-13 December, Kharagpur, India Call for Papers Open

Design & Operation of Offshore Wind Farm Support Vessels
29—30 January 2014, London, UK Call for Papers

For a complete listing of upcoming RINA events, go to:
www.rina.org.uk/events_programme
The Masthead Archive

All back issues of *The Masthead* are available online. CLICK HERE to read the back issues of *The Masthead* CLICK HERE to access the complete combined index of all issues of *The Masthead*

See and Hear Dave Gerr’s Interview with Mad Mariner Magazine

*Mad Mariner*, the online daily boating magazine, interviewed Westlawn director Dave Gerr on July 20, 2010. In this wide-ranging, half-hour radio show, Gerr discusses almost all aspects of Westlawn, including history, operation, student and alumni successes, costs, and more. Click on the links below to listen to the full interview and watch the accompanying slide show of over a hundred boats designed by Westlawn alumni.

Click Here to watch on Windows PC
Click Here to watch on Macintosh

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There are over 9,000 subscribers to *The Masthead*, Westlawn Institute's quarterly E-journal. Our readers are yacht and boat designers, boatbuilders, marine techs, surveyors, boat design students, and members of the boating public.

The Masthead

The Journal of the Westlawn Institute of Marine Technology

Westlawn Institute of Marine Technology
16 Deep Cove Road
Eastport, ME 04631 USA

Phone: 207 853 6600
Fax: 207 853 6605
E-mail:
Student Services: pschulte@westlawn.edu
Information: info@westlawn.edu
The Masthead:
Norm Nudelman, Editor
nnudelman@westlawn.edu

We're on the Web at
www.westlawn.edu

Who We Are

Westlawn is a not-for-profit educational affiliate of the American Boat and Yacht Council (ABYC). Our school is nationally accredited by the Distance Education and Training Council (DETC), and is listed as an accredited school by the U.S. Department of Education and by the Council for Higher Education Accreditation. The Westlawn Yacht & Boat Design Program is also accredited by the Royal Institution of Naval Architects (RINA).

Our Mission

Founded in 1930, the mission of the Westlawn Institute of Marine Technology is threefold:

■ To provide our students with the skills and knowledge required to build a rewarding career in the profession of yacht and small-craft naval architecture via distance learning.

■ To support continued growth of the recreational and small-craft marine community through the development of well-trained, safety-oriented, boat designers developing better products for the benefit of the boating public.

■ To provide continuing education to marine-industry professionals.

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