Photo: Jack Horner

Sebastian River Marina was among the best prepared marinas in Florida.

Four Hurricanes in One Year: *What We Learned About Hurricane Preparation*

When Doug Hillman came to work the morning after Hurricane Jeanne, he had every reason to be apprehensive; the only thing protecting his Sebastian River Marina from Jeanne's 125-mph winds and eight-foot surge was a two-foot-high seawall. Beyond the seawall there was a daunting three-mile fetch across Sebastian River. Only three weeks before, boats had been sunk, pilings had been pulled out, and docks had been destroyed by Hurricane Frances, a far less powerful storm than Jeanne. But as he pulled into the parking lot, Doug said he was feeling optimistic, even confident.

Optimistic? Confident? Anyone would have to be a little zany not to expect the usual broken docks and battered boats after a monster storm like Jeanne. Hillman, however, said he'd learned a lot from Frances and he had been determined that his marina would do better in Jeanne. As crazy as it seems, Hillman was optimistic.

The reason for Hillman's optimism was rooted in a voluntary "Hurricane Club" he'd started for slip holders at his marina. For $1,000, a Hurricane Club member is entitled to having his or her boat hauled out and blocked ashore twice, whenever a hurricane is approaching. This amounts to $500 per hurricane, and the price includes having the boat strapped down to anchors embedded in the concrete. Fifty-six boats with an average size of 40' had been hauled out and strapped before Jeanne and only four were left in the water.

When he turned the corner into his marina, NONE of the boats that were strapped down had been damaged. Hillman was worried that one or two boats that didn't face the wind might have been blown over, despite the straps, but that didn't happen. Even though the wind had been on the beam for part of the storm, and even though there had been three feet of seawater in the parking lot, the straps had held and the boats were untouched.

The marina facility itself, especially the docks, had been badly damaged and all four boats that were left to weather the storm in the water were washed ashore. But, considering the fury of Jeanne and the devastation to other nearby facilities, Sebastian River Marina and its boats had fared well.

Hillman said the only thing he'll change in the future is that membership in the Hurricane Club will no longer be voluntary. Before Frances, some boat owners hadn't bothered to join the club and only about 60% of the marina's boats had been hauled out of the water. Hillman called it a function of experience; Frances gave them the experience necessary to make them believers. With future slip holders, Doug won't wait for boat owners to experience a hurricane to be convinced; anyone who wants a slip at the marina will have to join the Club.

A similar haul-out/strap-down system was used at the Hinckley Yacht Services in Stuart, Florida. All of the 178 boats at Hinckley were stored ashore and most were held in place by 2" nylon straps that were secured to long concrete runners. A few that were away from the runners couldn't be strapped down. According to Gary Rolfe, Hinckley's yard manager, three were blown over in Hurricane Frances and two in Jeanne. While these were boats that had been strapped down, the ground became so wet that the boat's supports sank into the mud. All but one was repairable.

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If nothing else, the four massive hurricanes that swept through Florida and Alabama this past season gave everyone a unique opportunity to study what works and what doesn't work for boats and marinas preparing for hurricanes. *Seaworthy* talked to veteran members of the BoatU.S. Hurricane Catastrophe (CAT) Team who together spent many months working to identify and recover damaged boats. The science—*the art*—of hurricane preparation could take a giant step forward if marina operators and boat owners are willing to learn from past mistakes. More to the point, the mind-boggling damage throughout Florida demonstrated the clear need for better preparation by both marinas and boat owners.

It should be noted that there will never be any guarantees in a hurricane, and that

includes storage ashore. Certainly Hurricanes Frances and Jeanne proved that straps go a long way toward minimizing damage. But with any boat ashore, there must be a sufficient number of jack stands (at least three per side) and the stands must be chained together. This is the industry standard and it isn't always followed. A lot of boats in the Port Charlotte area, especially sailboats with deep keels, were blown off their jack stands. CAT Team members in the area reported that the stands were often placed on loose gravel, which has a tendency to roll. And some of the stands hadn't been chained together. In the Bahamas, the destruction at marinas was even worse. According to a CAT Team member who visited Marsh Harbor, marinas there sometimes lacked a sufficient number of jack stands and 2 x 4s had to be used for additional support. It didn't work.

Even if a boat stored ashore was blown over, however, the damage was usually significantly less than the damage to boats that were bashed against a dock or seawall for several hours and then sunk. *When asked where they would take their boats if a hurricane warning were to be posted, most members of the CAT Team said they'd have it hauled out ashore!*

Boat Lifts

At the other end of the spectrum—"Where *wouldn't* you want your boat to be in a hurricane?"—just about all of the CAT Team members said emphatically that they wouldn't want their boat to be on a hoist or lift. Damage to boats on lifts was extraordinarily high and included boats being blown off cradles; bunk boards breaking (and spilling the boats); boats grinding against lift motors and pilings; boats being overcome by the storm surge; and boats filling with rainwater and collapsing lifts. Did any boats on lifts survive? In areas that were hard hit, the answer is not many. The few that did were typically subjected to only a slight surge, and the lift had been secured so that the boat and its cradle couldn't be tossed around by the wind.

Sailboats with deep keels are vulnerable on trailers, which are too narrow to provide adequate support when the wind is on the beam. Whenever a deep-draft sailboat is stored on a trailer, jack stands should be used to provide additional support.

Docks

In areas that are exposed to wind and waves, docks proved to be extremely vulnerable. This was true even when there were no boats in the slips; planks were broken and pilings were pushed over and even washed out by breaking waves. Aside from waves, surge was the largest threat to boats. In parts of the Florida panhandle, the surge was over 20 feet. The best way to prepare a boat at a dock is with many extra lines—lines that are longer and larger than the ones normally used to secure the boat. The more lines the better. On some boats, lines were run out 80' or more to distant pilings so that the boat would have a better chance of rising with the surge. Boats were also helped by attaching multiple lines to many different cleats on the boat (the "spider web" arrangement), which spread out loads so that a cleat was less likely to fail. (Note that cleats on docks, which are typically screwed into horizontal planks, were not up to hurricane stresses.)

Concrete pilings proved to be more susceptible to snapping in two (and sometimes landing on boats) than their more pliant wood counterparts. Many of the boats that were wrecked in Charley had been secured to concrete pilings that didn't stand up to the lateral stress and twisting. And at least one marina in Pensacola had almost all its concrete pilings fail.

Because they rise with the surge, floating docks allow boats to be secured more readily than boats at fixed docks. There's no need to run lines to distant pilings; the boats and docks will rise in tandem. The lines can be secured to the docks. There is, however, one potential problem: In almost every major hurricane, there have been instances where the surge has lifted floating docks up and over pilings. When that happens, the docks and boats, still tied together, are usually washed ashore in battered clumps.

When floating docks have been replaced after hurricanes, the new pilings are almost always much taller, *about 18' tall*, and are far less likely to be overcome by surge than the six- to eight-foot pilings that were there.

Bob Forsythe, a member in Punta Gorda, said he used several 12" x 32" fenders and 2" x 10" x 16' fender boards at his dock to keep his 50' Sea Ray from banging against a piling. It worked. When asked about fender

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Boats on lifts proved to be extremely vulnerable, both from wind and surge.

FOUR HURRICANES, *from page 9*

boards, CAT Team members said they were effective at preventing "dock rash" but only if a heavy board was used with several—at least four—large fenders. Using two fenders at either end of a long board wasn't effective. The fenders were either bounced out or the boards broke in the middle.

One problem at docks: Boats that weren't prepared came loose and damaged other boats.

Anchoring Out

At the Diamond 99 Marina in Melbourne, Ed Carter didn't have a travel lift, a forklift or, for that matter, a boatyard where he could store the boats. What he did have was a hurricane hole nearby. Since boats at his docks are vulnerable even in a moderate blow, boat owners at Diamond 99 usually take their boats to a hurricane hole whenever a hurricane warning has been posted. Ed supplied a boat to shuttle people back once their boats were anchored, and in some cases he supplied the anchors. All of the boats used two anchors and a few used three. Of the 65 boats that anchored, 12 were wrecked and six were damaged. All six of the boats that remained at the docks were wrecked; five were sunk and one was washed up onto the highway.

One of the rules that applied to boats at the dock also applied to boats that were anchored: CAT Team members routinely said that using working anchors and working anchor lines didn't bode well for a boat's chances of survival. A 43' Hatteras (not insured by BoatU.S.) in Pensacola was anchored with one 25-lb. plow anchor. It dragged, probably very early in the storm, and the boat was destroyed. A 120' commercial tour boat (also not insured by BoatU.S.) was anchored in Stuart Harbor with only its working anchor. That boat also dragged, destroying six other boats, including two fifty-footers.

Many boats, however, were helped by anchors. When Ivan came ashore, boats in Alabama were often taken into bayous and secured with a combination of anchors and lines ashore. These bayous are well protected, according to CAT Team members, and are a good place to ride out a storm. As was the case in Florida, anchors had to be large—not the boat's normal working anchors—and had to be suited for the type of bottom. Again, the key was preparation. A hefty 65-lb. Bruce anchor, to cite one example, was buried so deeply that the owner and CAT Team surveyor couldn't get it out of the bottom. (Note that replacing an anchor is a lot less expensive than replacing a boat.)

Scope is never more critical than in a hurricane. One consistent problem is that boat owners underestimate the impact of storm surge. A boat that is anchored in shallow water with 10:1 scope may only be anchored with 6:1 scope or less at the height of the surge. This loss of scope significantly reduces an anchor's holding power.

Considering that the use of working nylon lines and anchors in a hurricane proved to be inadequate, it shouldn't be a surprise that undersized chain is also likely to fail. A 55' Hatteras that had been anchored securely with only 1/4" chain was found on the beach with three feet of chain dangling off the bow. What may be a surprise is that anchoring a boat with an all-chain rode offers *less* security than anchoring with a combination of rope and chain. A 36' trawler in Sebastian was anchored during Hurricane Frances with 80' of chain and 120' of nylon line. The anchor held and the boat came through the storm without a scratch. For Hurricane Jeanne, the boat's owner decided to not take any chances and used an all-chain rode with the same boat and anchor in the same anchorage. The anchor dragged and the boat wound up on the beach. In moderate weather, chain relies on weight pulling down on the rode to absorb shock. This is called the catenary effect. In a hurricane, chain tends to be as taut as a steel rod with no catenary effect. Without the nylon line to absorb shock, the surging waves and intense gusts are much more likely to yank the anchor out of the bottom.

Finally, all things being equal, using multiple anchors seemed to significantly increase a boat's chances of staying put. One CAT Team member said he was impressed with the number of boats that rode out the storm successfully using two large anchors with lines set 90° apart.

The key to anchoring a boat successfully in a storm is to use large anchors and anchor lines. The larger the better. The anchors must be suited for the type of bottom and the lines must be protected from chafe. On anchored boats, this involves protecting the lines from the extreme buildup of heat in the lines as they are stretched back and forth under extreme loads.

Canals

In theory, canals are great hurricane holes, since there aren't likely to be any large, breaking waves. The boats that fared best were tied securely across the canals with longer lines so that they could rise with the surge. The key was to use larger-diameter lines tied to sturdy trees or pilings. CAT Team members reported that several boat owners used lines to anchors that they had buried in the lawn. The anchors held.

Despite the advantages, however, plenty of boats in canals were damaged. Most were on lifts or at docks where they were still vulnerable to high winds and the surge. All it took in a canal was one or two boats breaking loose to damage a lot of other boats. A

beamy 33' cruiser that had been tied in the middle of a canal in Punta Gorda, for example, with four 5/8" dock lines (probably the boat's working dock lines) broke loose and destroyed four other boats. While the concept of tying the boat in the middle of the canal was excellent, both the number and size of the lines were inadequate for that size of a boat in a hurricane. One CAT Team member suggested that people who live on canals should adopt a "neighborhood concept." Spools of larger line, for instance, could be purchased collectively and then stored for use in preparing *all* of the boats in a canal for storms.

Debunking Several Myths

With every hurricane, the BoatU.S. Damage Avoidance program learns a little more about preparation. Here's more of what was learned from Charley, Frances, Ivan and Jeanne:

The Myth: Since boats are designed to head into wind and waves, they should be facing out from their slips toward open water during a storm.

The Reality: That may or may not be true. Swim platforms at a boat's stern are vulnerable to being bashed against dock pilings. Since they are just a few inches above the waterline, a platform that is shoved through the hull in a hurricane will almost always sink the boat. With boats at docks, protecting the swim platform should be a major consideration. Depending on the docking arrangement, the boat may fare better if it is facing the dock.

The Myth: When boats are anchored or moored in hurricanes, chafe guards are essential on nylon anchor lines.

The Reality: It is becoming evident that chafe on nylon rope at a dock and chafe on nylon rope at an anchorage or mooring must be considered separately when preparing a boat for a storm. The same chafe protection that is used successfully at a dock likely won't be as effective on rope at a mooring. At a dock, rope is usually in a direct line between the boat and piling and chafe occurs wherever the rope could come in contact with another piling, dock or a chock. The rope fails *externally*, starting from the outside, as it is abraded. When a boat is anchored, however, that same nylon rope would be stretched to almost half its normal diameter while at the same time working back and forth over a chock at a steep angle down to the anchor. This produces a tremendous amount of heat inside the rope. (The further the cleat is from the chock, the more the line stretches and the more heat that's generated.) At anchor or at a mooring, the rope typically fails *internally*. The fibers melt.

Photo: John Myran

Canals are wonderful hurricane holes if boats are properly prepared. This sailboat was stripped and tied off in a canal in Gulf Breeze, Florida using three large anchors and 13 lines to shore. Despite considerable damage to other nearby boats and homes, the sailboat survived Hurricane Ivan without so much as a scratch.

There have been many examples of this type of failure, most recently during Hurricane Jeanne in Florida. Ed Carter, who owns Diamond 99 Marina, had always been careful to use chafe protection on lines when his boat was at a dock. In Hurricane Frances, he anchored the boat, a 38' Downeaster, using a long section of fire hose for chafe protection. His son anchored his own 37' sailboat nearby using only denim wrapped around the line for chafe protection. The line on Ed's boat failed—it had melted in big plastic clumps under the fire hose—because, he speculated, water wasn't able to cool the nylon fibers. He felt that his son's anchor line, with only denim for chafe protection, came through the storm intact because water was able to cool the fibers.

Ed Carter is on to something. Tests at MIT in Massachusetts after Hurricane Bob show that under heavy cycling loads, wet nylon yarn is more abrasion-resistant than dry nylon. (Under light cycling loads, the reverse is true—dry nylon yarn outlasts wet nylon.) Heat builds up because of friction between the fibers and also because of internal molecular friction. Wet nylon holds up in a hurricane because the storm's heavy rains provide additional lubricity. (Good marine nylon line, when it's new, has a finish that helps to reduce yarn-on-yarn friction.) The water also carries off heat, which cools the stressed fibers.

Aside from using chafe protection that wicks water, the people at MIT reasoned that a simple way to provide durability to an anchor line in a storm would be to use polyester line from the cleat through the chock. Polyester line stretches far less and is more abrasion-resistant than nylon line under heavy cycling loads. When the polyester and nylon lines are wet, the MIT study found that the difference in abrasion resistance is even greater.

Instead of joining the nylon and polyester lines with a knot, which would create a weak spot in the rode, the two should be joined using an eye splice in the polyester line and one in the nylon line (use six tucks). The polyester line can be passed through the existing nylon line in an eye-to-eye fashion. This gives the anchor line or mooring line the best features of both types of rope—polyester's abrasion resistance and nylon's stretch to absorb shock.

The Myth: Roller furling sails can be tied to the forestay so that it won't come unfurled in high winds.

The Reality: No matter how well it's tied, a roller furling jib will come unfurled and the sail will be shredded. Even worse, furled sails present a tremendous amount of windage, both when they're furled and after they come unfurled. The same is true of outriggers, which create windage and are easily broken in a hurricane. Take roller furling jibs and outriggers down and store them out of harm's way.

The Myth: Concrete pilings are sturdier than wood pilings.

The Reality: They're not. Concrete pilings are often more likely to be sheared off during a hurricane.