

Tropical Cyclone Concerns for Marine Interests

I am often asked the question “What do I do with my boat when there is a hurricane approaching?” A simple answer that would be correct for every boat owner is unrealistic. There are many types of boats, boating environments, and almost as many methods and places to store them as well as the characteristics of each the safe havens. Every tropical cyclone landfall is different in the strength, size and duration of the storm, the storm approach to the coast, the tidal situation at landfall and even the amount of freshwater rainfall that accompanies the storm. The best way to be prepared for a hurricane is develop your own detailed plan, and carry out that plan when a tropical cyclone threatens.

I have gathered and consolidated information from numerous sources to help the boat owner in the analysis of his/her particular situation. Then the boat owner can determine the best method to prepare their boat for the eventual tropical cyclone encounter. The suggestions mentioned in this paper are intended to **guide** the mariner in developing an individual preparedness plan to help preserve life and protect their property. If just one of the suggestions I present should reduce property damage, prevent an injury or save a life, then the purpose of this paper will be served. The National Weather Service and other agencies that contributed to this publication can assume no responsibility for actions taken by the boat/marine owner/operator. It’s up to the mariner to take appropriate action to plan, prepare an to take timely and appropriate action. Following these guidelines does not necessarily exempt the owner/operator from responsibility for damage to his/her own vessel, or to another’s property.

This paper was created primarily for distribution at boating, fishing and diving shows and was last updated on Jun 7, 2016. Most landmarks, examples and policies mentioned are for the South Florida because that is the area to which I’m most familiar, and that is where most of my public “outreach” is performed. Additional questions and updates are encouraged.

Martin Nelson, Lead Forecaster & former USCG Licensed Merchant Marine Officer
Tropical Analysis and Forecast Branch (TAFB) of the National Hurricane Center (NHC)
11691 Southwest 17th Street
Miami, Florida 33165-2149
(305) 229-4435 KJ4MCN E-mail Martin.C.Nelson@noaa.gov

The three basic problems that accompany tropical cyclones

The Atlantic and Gulf of Mexico coasts average two land-falling hurricanes each year with the South Florida Atlantic coast being the most hurricane vulnerable area. About 25% of hurricane fatalities result from boaters trying to secure vessels in deteriorating storm conditions. In fact, more than half the deaths attributed to Hurricane Hugo in 1989 were boaters, all drowning while attempting to save their boats.

Tropical cyclones present three basic problems for boaters. The most common problem is the **strong winds**. Although sustained winds of 74 to 130 mph (64-113 kt) are common in hurricanes, winds over 200 mph (174 kt) as observed in Hurricane Andrew in 1992 are possible. These maximum winds can occur as far out as 30 nm (56 km) from the center while tropical storm force winds, 39 mph (34 kt) can extend more than 200 nm (321 km) from the center. Hurricanes are classified by wind strength using the well-known Saffir/Simpson Scale with five categories (see page 5).

Remember that when the wind speed doubles the wind pressure quadruples, or more simply put, when the winds increase the damage increases at a much greater rate. Strong winds can cause vessels to roll and override steering or break anchorage. These winds may capsize the vessel or damage equipment such as sails, masts, antennas and other instrumentation. The greatest hazard to the mariner and his vessel from a hurricane wind is flying debris.

The second problem for mariners encountering a tropical cyclone is the **heavy rains**. Rainfall totals of 6-12" (15-31 cm) in a 24 hour period is common. These rains may cause widespread flooding well inland from the coast where the tropical cyclone made landfall. Heavy tropical rains reduce visibility making safe navigation without radar impossible. Boats can be sunk by torrential rains. Fresh rainwater accumulations combined with breaking waves over the vessel's hull can exceed the drainage capacity of deck scuppers and bilge pumps. Rolling boats can dip drains and pump discharge valves below the waterline resulting in back flow. Locally heavy rains combined with runoff from the land will increase the expected tide level, which may already be enhanced by storm surge and wind driven water. In addition, tropical rains are usually accompanied by dangerous lightning and in rare cases hail.

Additionally, tornadoes accompany land falling tropical cyclones. In general, the more intense the hurricane is before landfall corresponds to a greater the tornado threat. Tornadoes are concentrated in the right front quadrant between radii 30 and 120 degrees with respect to the storm motion, and within 80-220 nm (148-408 km) from the center. This region is outside the general area of hurricane force winds, and sometimes in areas of only 17-23 mph (15-20 kt) surface winds. Tornadoes are often associated with the strongest convective elements of spiral rain bands, with the greatest wind damage tending to occur in regions of the highest rainfall rates. Hilly terrain near landfall may enhance the spawning of tornadoes. Although hurricane spawned tornadoes are shorter lived than the central United States "Plains" tornadoes, they tend to occur in families. Little can be done to protect a boat from a tornado. However, hurricane tornadoes are usually concentrated near the coast, so moving a boat further inland reduces tornado risk. Tornadoes account for a large loss of life in tropical cyclone landfalls, 11 of 46

deaths during Carla in 1961 were tornado related.

Storm surge is the greatest danger of the hurricane and accounts for much of the loss of life and major damage to boats. Due to low barometric pressure in the hurricane the ocean surface rises upward forming a mound about 1' (31 cm) higher than the surrounding ocean. In the deep ocean, this surface rise is compensated by deeper currents. However, these deeper currents are eliminated by the slope of the continental shelf and shoreline as the hurricane approaches land, and the converging water at the surface rises.

Large storm generated swells arrive at the coast first. As the storm moves across a coastline, the storm surge may cause a rise of 10 ft (3 m) or more above normal high tide. The storm-generated winds also drive water toward the coast resulting in extensive saltwater flooding. The storm surge is accompanied by battering waves that have tremendous energy and can grow to large heights.

Steep breaking waves pound sea walls and sandy spits or barrier beaches that normally provide protection for docks. The rising water may overtop barrier islands with the surge funneled into bays and estuaries.

This dome of salt water can be 50 mi (86 km) wide and 5-15 ft (1.5-4.5 m) higher than the normal tide. The water will rise above many fixed docks with the tethered boats then floating above the docks. During the category 4 1926 Miami hurricane a 10-12 ft (3-4 m) surge covered Miami Beach, Biscayne Bay and Key Biscayne. A sailboat with a 7 ft (2 m) keel crossed the Key Biscayne peninsula during the storm surge. Boats can also end up on a sea wall or in permanent dry dock. During Alicia in 1983, a 10 ft (3 m) surge moved barges across I-10 into a lagoon resulting in a total loss of the vessels. Category 5 Hurricane Camille was accompanied by a storm surge up to 26 ft (8m). Three ocean-going vessels were dry docked and had to be cut up and salvaged. Reefs do not protect land or islands. Although a reef extends all along the Florida Keys, hundreds of people died in the storm surge during the great Labor Day Hurricane of 1935.

Rising storm surge is not the only danger. Storm surge will be negative on the left side of land-falling storms as they cross the coast. Mariners must protect for the extreme low water situation that will occur in this area. Most boats are damaged from cleats pulling out and lines parting because of insufficient slack to allow for the extreme low water in a negative storm surge situation.

If the storm track is certain during the final 6-8 hours before landfall, make final adjustments for either a positive or negative storm surge, otherwise the best you can do is to prepare for a low and a high tide. As you can expect it is difficult to moor a vessel allowing for a 20 ft (6 m) difference between the low and high tide. The extreme low or high tide that your moored vessel actually experiences will be destructive with the opposite allowance that you put in the line length. Remember that in extreme high water conditions your lines will angle downward as water level rises. In extreme low water conditions, your lines will angle upward. Either situation exerts considerable stress on cleats.

Becoming familiar with Watch and Warning terminology

A **Tropical Storm Watch** is an announcement for specific areas that tropical storm or an incipient tropical storm condition, maximum sustained winds of 39-73 mph (34-63 kt), poses a possible threat to coastal areas, generally within 48 hours. A **Hurricane Watch** is issued when hurricane conditions, maximum sustained winds of 74 mph (64 kt) or greater, poses a threat to a specified coastal area, usually within 48 hours.

Mariners are advised that waiting for issuance of a Tropical Storm Watch or a Hurricane Watch may not provide enough time for safely moving a boat from a marina to a better location. You must take measures to protect your vessel while you are able to do so. Foul weather including tropical storm force winds and torrential rains occur in the outer rain bands of a tropical cyclone. These rain bands often precede the referenced storm center by hundreds of miles and are experienced many hours before the winds reach hurricane force.

If you are tracking the storm or hurricane by plotting the location, remember that the location provided by the National Hurricane Center (NHC) in Miami, Florida and broadcast by Inmarsat-C SafetyNet, marine facsimile, NOAA Weather radio, HF Voice, commercial radio and TV, and posted on the Internet, is for the center or eye of the tropical cyclone. Tropical storm and hurricane force winds extend out a considerable distance from the center position. Mariners will experience the adverse weather associated with hurricanes and tropical storms well in advance of the center or eye. The forecast advisory is tailored for marine interests with radii of tropical storm force winds and seas 12 ft (3.7 m) or greater.

Detailed marine information is provided in the Coastal Waters Forecasts issued by local National Weather Service Offices. Mariners are also encouraged to become familiar with the formats and information in the forecast advisory, as well as the Offshore Waters, NAVTEX, and High Seas alphanumeric and graphical forecasts provided by the Ocean Prediction Center (OPC) in Washington, DC and by the Tropical Analysis and Forecast Branch (TAFB) of the NHC. These products are posted to the Internet and disseminated by other methods including VHF radio, NAVTEX, and Marine Facsimile.

A **Tropical Storm Warning** is posted when tropical storm conditions, including possible sustained winds in the 39 to 73 mph (34 to 63 kt) range, are expected in a specific coastal area in 36 hours or less. **Hurricane Warnings** are issued when hurricane conditions are expected in a designated coastal area in 24 hours or less. It would be wise for boat owners to plan for the instance of only a 12-hour warning. Hurricane conditions include sustained winds of at least 74 mph (64 kt), and/or dangerously high tides and waves.

When a Hurricane Warning is issued, it is too late in most situations to be concerned about a boat. This is the time to for personal safety preparations. A mariner will likely be occupied securing their personal residence and establishing emergency provisions. These final preparations should be rushed to completion because evacuations may be ordered during this

phase. In Florida, there is a State Statute that requires evacuation of people that live on boats in the event of any hurricane, even a category one hurricane. In addition, all persons that live in low-lying areas or directly adjacent to the water will receive a recommendation to evacuate. Although local laws may vary, these practices should probably be observed in all coastal areas under a hurricane warning!

Saffir/Simpson Hurricane Scale for mariners

Category	Wind Speed	Surge	Marine Damage
1	65-83 kts	4-5 ft	Minor damage to piers and some coastal road flooding.
2	84-95 kts	6-8 ft	Considerable damage to piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of center. Small craft in unprotected anchorages break moorings.
3	96-112 kts	9-12 ft	Coastal flooding destroys smaller structures with larger structures damaged by floating debris. Terrain continuously lower than 5 feet above sea level (ASL) may be flooded eight or more miles inland.
4	113-136 kts	13-18 ft	Major beach erosion with major damage to lower floors of structures near the shore. Terrain continuously lower than 10 ft ASL may be flooded requiring massive evacuation of residential areas inland as far as 6 miles.
5	> 137 kts	18 + ft	Major damage to lower floors of all structures located less than 15 feet ASL within 500 yards of the shoreline. Evacuation of areas on low ground within 5 to 10 miles of the shoreline may be required.

Insuring your vessel

You must maintain the Liability Insurance coverage on your vessel. You can't wait until the last minute to purchase insurance because policies cannot be bound while a watch or warning is in effect. The policy should cover your own vessel, other vessels and property. Even if you purchase a No-Risk policy, you must take action to secure the vessel. Your insurance coverage could be questioned if you abandon your boat at a marina and you were told to leave. Any financial action you take to protect your vessel is usually reimbursable, and some insurance companies encourage evacuation well away from the expected landfall. Always act as if there is no insurance, for example if sinking is a possibility, then add more bilge pumps. A vessel owner is expected to take actions that an uninsured owner would take to save and preserve his property. If damage is incurred to the vessel, immediate action must be taken to save the vessel and equipment to prevent further damage. Document all expenses and even take pictures. Consolidate all documentation to include registration, radio licenses, inventories, lease agreements and contact information in a waterproof box. Make additional copies and store separately.

Protection of Property

Boat and/or marina owners are responsible for taking precautionary measures to protect property when disaster threatens. The key to protecting your property from any weather situation including tropical cyclones is to plan well ahead, make the planned preparations in advance, and then take timely actions when threatened. Prior to the hurricane season, develop your own detailed plan of action. This plan must include a written checklist of procedures that will need to be performed prior to the arrival of a tropical cyclone. This plan should also identify the equipment and supplies that you will require. Be sure other crewmembers know the plan or arrangements. Assemble these items and practice your plan.

If your vessel is stored in a county or privately owned marina, you should be familiar with the terms in the lease contract. Become familiar with your responsibilities and liabilities as well as those of the marina. Also, check the Marina Disaster Plan, the Disaster Standard Operations Plan (SOP), or the Hurricane Plan at your marina. If your boat is berthed in a marina or a harbor, you have three options, securing the boat in its berth, mooring the boat in a previously identified area, or hauling the boat out of the water. Running from a hurricane is not recommended except for large commercial vessels.

If the marina lease has a provision for **keeping** your vessel at the marina, you may be required to take certain actions. Usually the boat owner must provide the marina with an emergency contact phone number or the contact number for a caretaker (i.e. a hired Captain). The owner should have previously filed a "Hurricane Worksheet" with the marina manager. The owner, or owner representative, must make an effort to secure the vessel. Once again, the vessel must have current liability insurance.

When choosing a marina, remember that the marina itself can be destroyed, including those with

vertical stacking (dry-stack storage). This is especially true for marinas located on barrier islands. Look for marinas protected from wind and wave action. The entrance channel to a marina should be at a right angle to the marina. The best marinas are surrounded by dense mangroves. Look for well-built marinas that use concrete docks with wide slips (140% of boat beam). The pilings should be 6 ft (1.8 m) above highest the gunwale allowing the boat to rise and fall about 10 ft (3 m).

There are other factors to consider in marina berthing. If the marina uses water storage, examine the docks. Some docks are not designed for the additional stress that boats will cause during storms. On the other hand, some floating docks are designed to rise as much as 25 ft (7.6 m) above normal levels to compensate for tidal surges. Some marinas provide land storage. Boats that are hauled-out of the water generally suffer less damage than water stored boats. Additionally, hurricane conditions can damage or sink boats causing the release of normally secure fuels, oils and other chemicals into the environment. The boat owner/operator may be held responsible for any damage caused by their vessel during a natural disaster!

Storing a boat on a trailer is usually the best method for small open boats because their low freeboard will usually be overcome by waves, spray and rain if left in the water. Even if the marina provides vertical stacking, still consider removing small boats from the racks and placing them on trailers to be towed well inland. Boats stored ashore should be stored well above the expected storm surge. Even boats on jack stands that are tipped over sustain less severe damage than boats left in the water. If you employ this method use 3 or 4 jack stands on each side for boats under 30 ft (9 m), and five or six jack stands on each side for larger boats. Chain the jack stands together. Dig holes in the ground for the sailboat keel so that the boat profile is lowered further reducing windage. In fact, smaller sailboats can be laid on their sides. Some professional boat yards provide heavy nylon straps that are attached to eyebolts anchored in the ground.

Although it is no longer legal to force boat owners to leave a marina in the event of a storm, your marina lease may have provision for **evacuation** to safe harbor or “hurricane hole.” The marina itself could be very vulnerable and vessels generally fair better at alternate sites in harbors, canals and mangrove channels than those moored directly at the docks. Again, check your Marina Disaster Plan (DPK), Marina Emergency Response Plan or Standard Operations Plan (SOP). If you plan to move your vessel, find a guaranteed storm worthy refuge well in advance for your evacuation plan. Remember that coastal development is constantly reducing the available mangrove swamps, inlets and canals that a boater can use as a “hurricane hole” or refuge. At the same time, the number of boaters seeking refuge constantly increases. Reality is that with the thousands of small boats in each county there may be a shortage of safe harbors for all to seek refuge in inland waters.

Practice your evacuation in advance (before hurricane season if possible) to become familiar with the planned route and bottom conditions at the planned site. The best anchoring is usually in sand followed by clay, hard mud, shells, broken shells, and soft mud. Also consider the possibility of extreme negative storm surge and the situation where your boat is stranded briefly on the bottom (so avoid rocky bottoms).

Remember that drawbridges connecting barrier islands to the mainland open infrequently once the evacuation process begins. Control of Intracoastal Waterway (ICW) bridges is often transferred from the local authority that governs bridge tenders to the United States Coast Guard Captain of the Port (COTP) whenever the local area Emergency Operations Center (EOP) is activated. All draw bridges in the State of Florida are authorized to lock down 8 hours before winds reach tropical storm (gale) force of 39 mph (34 kt), and some may be closed earlier. Boat traffic is sometimes organized into “armadas” with specific upriver travel periods as soon as a Hurricane Watch is announced. These Flotilla Plans are usually directed by the local law enforcement agency, and continue until just after the Coastal Evacuation Order is announced. Bridges are then locked down to facilitate the critical automobile evacuation traffic from the barrier islands to the mainland. If for example, your reaching a safer area requires the raising of the Snake Creek or Jewfish Creek draw bridges on the border of Miami-Dade and Monroe counties in Florida, you must pass under them before an evacuation order is issued for any portion of the Florida Keys.

Boaters should take advantage of the local flotilla plan remembering that the evacuation is a slow, frustrating and time-consuming process and large commercial vessels have the right-of-way. To ensure safe boat passage, all boats should be secured at least 24 to 48 hours in advance of the arrival of tropical storm force winds. In some situations, boat evacuation may need to be done 72 hours in advance, well before a Watch is issued and to avoid deteriorating weather conditions. Monitor the NHC probabilities advisory but remember that the numbers are low 36/48 hours in advance. Unfortunately, acting on these low probability numbers may lead to an unnecessary evacuation.

The expression “Any Port in a Storm” is only correct when life is at risk. Boaters need permission to anchor or tie up in most places. There are Real Estate Laws concerning trespassing. There are also Admiralty Laws (see “Small Boat Law” by H. Markow). Boaters must take precautions not to impose burden of protection of property on another. You have as much right to the navigable waterways as anyone, but you cannot impede the passage of other boats. During the evacuation process, monitor the “Calling, Safety and Distress” VHF channel 16 for USCG “Notice to Mariners” broadcasts. Canal docks that are well inland offer some of the best protection if the pilings are good. The best arrangement is to have a piling at adequate clearance both fore and aft on the water side with the boat between the dock and the pilings.

Securing vessel in water

Ensure your vessel is in running order in case it has to be moved. Make sure the fire fighting and lifesaving equipment are in working order.

Face the bow into expected wind direction or towards open water or the least protected wind direction in order to reduce windage. When choosing this direction you must consider possible eye passage and the subsequent 180-degree wind shift that could occur. Lock the wheel and lash the tiller in the center position.

Check the water seals and the overall watertight integrity of the boat. Make sure all bilge pumps are working correctly and add a secondary bilge system if possible. Plug un-valved through-hull fittings such as sink drains. Seal the engine room side vents. If the vent is small you can use duct tape, but larger vents will require you to screw thin plywood into the vent cowl and then tape over the edges for a better seal. Close the water intake seacocks and tape seal all the fuel and water tank vents. Plug exhaust pipes to prevent water from being driven into the engine room. Although gas engines can usually be plugged with simple wood plugs, cork or Styrofoam, you might need an inflatable ball to plug a diesel exhaust.

To the extent possible, remove sources of pollution that may be affected by the storm conditions. Remove the Marine Sanitation Devices or have holding tanks pumped out to remove raw sewage and chemical disinfecting and deodorizing additives. Remove cans of paint, petrochemicals and cleaners from the boat. A gallon of fuel can contaminate a million gallons of water.

Cover any exposed generators. Close the water intake seacock, plug the exhaust outlet and seal the fuel and water tank vents with duct tape. Ensure all batteries are fully charged. Fill fuel and water tanks, but shut off the fuel valves nearest the fuel tank.

Have enough anchors on hand including chain, shackles and swivels. The anchor rode should always run through a chock. Have plenty of long and strong mooring lines, boat fenders and line chafing gear. Make sure cleats and other deck hardware are structurally sound (marine suppliers always run out of these supplies during warnings). If possible, add more and larger cleats and chocks as part of your hurricane preparedness. This will make securing the boat easier.

Do not use aged cordage. Use new lines as primary and your normal dock lines as backups or doubles. Do not use lines that might have weakened by invisible ultraviolet or fungicidal degradation. The undersides of many bow pulpits have a sharp edge that can slice through a line during the violent motion of a boat in a storm. Use new and slightly larger than normal, about 1/4 in (.01 cm) size lines to resist chafe and excessive stretching. A general rule is to use 2 in (.2cm) lines for boats less than 25 ft (7/6 m), 5/8 in (.25 cm) lines for boats 25 to 34 ft (7.6-10 m), and 3/4 to 1 in (.3 to 2.5 cm) lines for boats larger than 35 ft (10 m).

Use long double crisscrossed spring lines both fore and aft. Spread lines to as many different points as possible reducing the dependency on one particular tie up point. When you are finished

securing the boat it should resemble a spider suspended in the center of a large web. Allow for the extreme rise and fall of water with a positive or negative surge, and the expected bouncing around produced by the storm winds. Usually the longer the lines, the better. Dock lines should be at least as long as the boat itself. Also, allow for line shrinkage when the lines dry.

Nylon stretches five to ten percent of its length, and absorbs shock, but can be weakened where the line rubs against chocks and other contact points. In fact, nylon lines stretched over the edge of a rail can create sufficient heat to melt the line internally. Polyester or Dacron lines have much less stretch but are significantly more chafe-resistant than nylon. So, to get maximum performance of both line types, use a polyester line from the cleat through the chock then join it to a nylon line (using two eyes and five tucks). The nylon line then secures to the piling or mooring. This method takes advantage of both the chafe resistance of the polyester line and the stretch of the nylon.

Install chafe protection on any portion of the line that could be chafed by chocks, pulpits or pilings. Use ready-made chafe protectors or make your own from garden hose. Slide stiff plastic hoses over the end of the line for chafe protection. For the best chafe protection, and provided your chocks are large enough, fit a second larger diameter hose around another hose that fits snugly to the polyester line. Drill holes in the ends of both hoses and tie it to the mooring lines using nylon string running through the laid line to prevent movement. Of course, in an emergency you can use a lot of duct tape to secure several layers of canvas to the line. Remember that rags are usually unsuitable for chafe protection. Prepare these protectors in advance as this process takes considerable time.

Avoid using cleats that are placed on cluttered spots on the hull where other equipment can cut the lines. Never tie to wooden docks as virtually everyone will have damage, and cleats are almost guaranteed to come lose from wooden docks. Wooden pilings have little holding power because they are jetted in with water jets instead of being driven in the bottom.

Inspect cleats on concrete sea walls as well to be sure they have adequate backup plates (aluminum, stainless steel, or fiberglass blanks) on the underside. The plate should be at least 1.5 times longer than the cleat length, and at least as wide as the cleat. Marine plywood can be used if it is free of rot and de-lamination but plywood backup plates tend to crush allowing the cleat to work loose. Properly backed up winches and keel-stepped masts can be used on sailboats to secure lines at a dock. In addition, anchor lines should not be secured to the sailboat mast as it creates more stretch on the line at the chock increasing the chance of chafe failure.

Never tie to cleats on pilings because lines gripped by the knot apply too much pressure on the knot. Cinch knots and hitches should not be used as this pinches the rope. If you have to use hitches make sure the lines leads off the cleat base as far as possible to avoid chafing against the hitches. The best method is to put two raps around the piling making sure they do not overlap. Most of the holding power is due to friction of the line around the piling while the knot only keeps the line from slipping. Use 3 half hitches on the standing end to avoid chafing then wrap the free end back around the piling with hitches to secure it in place. Install a preventer at the top of each piling so the lines cannot slip off when the tide rises.

Cleats can cause the rope to pinch and abrade if not tied correctly. Lines with properly made eye splices attached to cleats are best. The bigger the cleat the better because smaller cleats cause more pinches. Two-hole mounted cleats are more vulnerable than four-hole cleats. Lines led perpendicular from a cleat can wrench the cleat out of the deck, so run lines out parallel to cleat. Do not put numerous lines to a single cleat even if the cleat is backed up. Two lines per cleat is usually the maximum. The bases of palm trees are good mooring posts in winds to 150 mph (130 kt) provided the tree is not too close to the water edge.

Cross tie lines in channels. Canals, rivers or waterways can serve as hurricane holes as an alternative to crowded and exposed harbors and marinas. A properly moored boat will swing to face into the wind reducing windage and will not slam into docks. In narrow channels, boats should be secured in the center with several sturdy lines ashore to both sides of the canal. Remember you cannot block navigation early in the warning process! Face the boat to canal entrance and as far back as possible in the canal to help maintain a navigable waterway. Do not crosstie lines more than 12 hours in advance. Remember to install fenders to protect the boat from striking the pier, pilings, and other boats.

Consider the angle of storm approach. An east-west channel usually experiences more of the wind and storm surge, and boats at the head of the channel have the best chance of breaking lose and being driven downwind into other boats. Use a combination of anchors and lines ashore in the wider channels. Instead of deploying two anchors, use three anchors set 120 degrees apart and joined through a swivel to limit the arc of boat swing. Embedment type anchors, with helical and expanding flukes, are less likely to be dragged than mushroom or deadweight block anchors. In addition, embedment anchors do not rely on increased line scope to increase their holding power, but the scope must be adequate for the storm surge. The scope should be least 10:1 and the chain to line ration should be 50/50 using oversize chain. Again, the more lines and anchors the better because additional anchors decrease the boat swing and the chance of anchor dragging. Adding riding weight, or sentinel, placed on the anchor rode at the chain to line juncture will lower the pull angle reducing the jerking motion and boat strain. An all chain rode should have a nylon line snubber to avoid shock about 10% of the rode length.

Remove expensive equipment and loose gear in case of theft or sinking. This includes the electronics mounted in covered boxes. The cost of reinstalling equipment including splicing wires and cables is cheaper than replacement of costly electronics. Use tape and plastic sheeting to tightly seal any electronics that cannot be removed. Consider that the wind force can bend plastic and separate seals creating gaps exposing sensitive equipment to elements. Use tape to seal all switches and cable connector ends. Tape around the doors of electronic panels. Use tape in an overlay shingle pattern to protect instrument faces including compasses, and tape close any instrument dash holes. Remove tape as soon as possible after the storm, preferably, before the sun has time to heat up the tape adhesive.

Disconnect shore utility services. Commercial electric power will be lost so store the shore power cables. Turn off all DC breakers except for main and bilge pumps. Seal the vessel as watertight as possible because bilge pumps may not be able to keep up the combination of heavy

tropical rains and waves. Do not plug deck or cockpit scuppers; instead make sure they will remain clear.

Reduce profile. Remove all top hamper including outriggers, antennas, radar reflectors, canvas covers, Bimini tops, T-tops, dinghies, portable davits, swim ladders, fender racks, life rafts and rings, anchors, enclosures and furling sails. It is best to remove sails from the vessel because cabins stuffed full of canvas and sails hamper a salvage operation and may soak up water. Unstepping masts on sailboats is advised. Remove all halyards from sailboats as they also increase wind resistance, or run halyards to masthead and secure with a single line to the rail. Remove the boom from a sailboat or at least lash it down securely.

Remove all furniture. Tape up cabinets, drawers, cowl ventilators, hatch covers and entrance jambs, companionway hatch joints and seal the openings. Secure the interior by removing heavy contents of galleys because the tape might not be able to hold the doors shut during heavy rolling. Remove everything from interior that is possible so that the passageway is clear. Remember that anything left in vessel can become soggy and heavy, and possible clog the drainage. Protect all breakables and consider the possibility of water damage. Curtains and linens will get wet so seal them up in garbage bags. Carpets will also get wet so remove from the floor, roll them up and seal in plastic. Berthing and cushions should also be rolled up and sealed in plastic. Do not forget to protect your paper navigation charts. Raise or remove the window blinds. The windows may break so remove anything that can cause more damage if the wind gets inside the cabin.

Empty the refrigerator of perishables and breakables. Turn off the power to the refrigerator so the batteries are not drained, bilge pumps are more important. Close the seacocks for the head. Close or plug all sink drains. If the cockpit drains into the bilge, consider closing the seacocks.

Remove Plexiglas windscreens. Even though marine glass usually holds up better than Plexiglas you must still lock and duct tape the outside of all sliding and fixed windows along the joints and seams. Wind pressure can bow window glass and hatches opening up gaps and allowing exposure to elements. Wind driven rain often penetrates the window frame seals creating gaps and allowing the window to vibrate, and in some cases actually rattle the window open.

Coordinate your mooring plans with the boat owners around you to be sure their boats are also prepared correctly. Plan and cooperate with slip neighbors and marina management. You may have to use other boat owners pilings, and they may have to use your pilings as well. Consider the possible domino effect that could occur if one boat breaks loose and crashes into another resulting in a chain reaction. Do not raft vessels together, especially if there are large and small vessels.

Consolidate boat records and remove them from the vessel. These records include insurance policies, registration, radio license, logbooks and owner's manuals. Recent and dated photos or videos should accompany an equipment inventory, which includes serial numbers and receipts.

After securing the vessel, you **should** leave it. There is little that can be done to save a boat in

hurricane force winds, surging tides, breaking waves and blinding rain that can drag moorings and break boats free. Never try to ride out a hurricane in your boat. This is probably the most dangerous place to be because of the combination of wind, rain and storm surge. You cannot count on rescue until well after storm moves on. The exposure to the weather itself can also be deadly. About twenty-five percent of hurricane fatalities result from boaters trying to secure vessels in deteriorating storm conditions. More than half the deaths in Hurricane Hugo in 1989 were boaters, drowned while attempting to save their boats. During Hurricane Andrew in 1992, two mariners died trying to protect their vessel. It is interesting to note that a half-billion dollars in boat damage occurred in Hurricane Andrew alone. During Hurricane Iris landfall on 9 October 2001 in southern Belize an estimated 20 dive tourists drowned when the 120' M/V Wave Dancer capsized while in a shallow protected harbor. Another boat, the Vendura also capsized killing an unknown number of people aboard. Boats can be replaced, you cannot.

Securing vessel in davits

Boats on backyard davits or lifts should be stored on the ground. If the boat must be left on its lift, expect that the storm surge will likely be higher than boat can be raised. Remove the drain plug so the accumulated rainwater weight will not collapse the lift. Although the boat will be vulnerable to storm surge with the plugs removed, the damage from water will likely be less than the structural damage if the lift collapses. Strip the boat of all loose gear and canvas. Plug the exhaust outlets. Secure the boat to the lifting machinery to prevent the boat from swinging or drifting away.

Trailer able boats

Securing boat on a trailer. Your Hurricane Plan should identify a suitable tow vehicle and the trailer to be used. Your pre-hurricane season hurricane preparation should include trailer maintenance. Too often, a flat tire or frozen wheel bearing will prevent the owner from moving the boat. The idea is to tow your boat well inland away from the expected flood areas. Consider local laws concerning trailering during an evacuation. For example, if you live in the Florida Keys and plan to trailer your boat to the Florida mainland, you must do so before the mandatory evacuation order is issued. Dangerous winds often precede a hurricane by many hours. All persons evacuating and planning to trailer a boat are required to leave early. Emergency management officials suggest that all boat trailering be carried out when the order is issued for mandatory non-resident evacuation and voluntary evacuation. This is the preliminary stage when the recreational vehicles (RV's) must also be evacuated. Later in the mandatory evacuation phase these high profile vehicles, including large boats will be removed from traffic.

Protect the boat from wind as much as possible. A car is heavier and can withstand greater wind stress than a boat so consider leaving the boat in a garage rather than a car. If the boat and trailer must be left outdoors put them where they will have the best protection from wind and falling branches.

Boats sit high up on a trailer offering too much wind resistance and will likely be blown over.

Sailboats stand very little chance of remaining upright. The best option is to remove the boat from the trailer and place it on the ground with the bow into the expected wind. If this is not possible and the boat must remain on the trailer then lash the boat to the trailer. Secure the trailer to trees or to the ground with anchors or augers. Hurricane winds rotate and change direction, so try to pick a location that allows you to secure the trailer from four directions. You may consider letting some air out of the boat tires and blocking the wheels.

Whether the boat is on the trailer or on the ground you should still reduce windage by stripping all loose gear especially the Bimini tops and canvas covers. Depending on boat design, the drain plug may be left in (outboard engines). On inboard stern drive boats, the drain plug might have to be removed to avoid engine flooding.

Plugging the drain holes and filling the boat with water will help stabilize the boat. However, you must consider the additional weight of the trapped water and the capacity of the boat trailer. You should consult with the manufacturer because there may also be increased stress on the hull from the weight of the water. If you decide that this is the best method for protecting your boat, do not forget to plan for the additional weight of gallons of rainwater. Place wooden blocks between the trailer frame and the trailer springs to support the increased weight. Also, consider that high levels of trapped water may damage the batteries and electronic equipment. Water may enter the fuel tank and other fluid reservoirs. However, fresh water damage is usually less than the damage that would occur if the vessel is blown around. There is also the added advantage of having a several gallons of emergency non-drinking water after the storm passes.

Checklist for Pre-Season Preparation Marina Berthed Vessels

Review your vessel insurance coverage.
Review the Marina Disaster Plan (or SOP Hurricane Plan).
Review and update your Hurricane Worksheet filed with the marina manager.
Review and update your emergency contact phone numbers provided to the marina.
Review your boat inventory. Ensure your inventory photographs and videos are current.
Inspect the lifesaving and firefighting equipment. Check the expiration dates on the inspection tags.
Insure that your boat ownership documentation and licenses are consolidated and protected from water damage.
Review and update your individualized detailed plan of action.
Provide copies of your individualized detailed plan of action to other crewmembers.
Inspect cleats and their backup plates.
Inspect pumps and batteries
Assemble the extra equipment (anchors, shackles, swivels, lines, fenders and line chafing gear).
Practice and time your individualized and detailed preparation plan as much as possible.

Preparation Checklist

Remove any sources or pollution including sanitation devices that could be released into the environment.
Assemble and inspect safety and firefighting equipment.
Protect all documentation and navigation charts that must remain on vessel from water damage.
Insure the watertight integrity of boat (inspect seals; plug the through-hull fittings and intake seacocks).
Seal engine and generator intake and exhaust vents, and the intakes for their cooling system.
Clear deck and cockpit scuppers.
Ensure batteries are fully charged.
Disconnect all utility services, and turn off the DC breakers except for the main and bilge pumps.
Check the primary and secondary bilge pumps.
Fill fuel tanks, but shut off the fuel valves that are nearest the fuel tank.
Fill water tanks.
Remove all top hamper.
Remove all loose or expensive equipment including electronics.
Seal electronics that cannot be removed and seal switches and cable connectors.
Seal doors to electric panels.
Remove perishables from refrigerator.
Remove breakables.
Tape seal cabinets, drawers, hatch covers, and entrance jambs.
Tape the outside of all sliding and fixed windows along joints and seams.
Install chaff protection on mooring lines.
Double cross spring lines fore and aft.
Install fenders.
Lash steering in center position.
Coordinate mooring plans with slip neighbors and marina management.
LEAVE VESSEL

Post Storm Checklist

If damages have incurred take immediate actions to reduce further damage.
Document all expenses.
Remove tape and seals before the sun heats up adhesives.
Contact insurance company if necessary.

Checklist for Pre-Season Preparation Home Berthed Vessels

Review your vessel insurance coverage.
Review your boat inventory and insure inventory photographs and videos are current.
Inspect the lifesaving and firefighting equipment. Check the expiration dates on the inspection tags.
Insure that your boat ownership documentation and licenses are consolidated and protected from water damage.
Review your individualized detailed plan of action.
Inspect cleats and their backup plates. Inspect pumps and batteries.
Assemble the extra equipment (anchors, shackles, swivels, lines, fenders and line chafing gear).
Practice and time your individualized and detailed preparation plan as much as possible.

Preparation Checklist

Remove any sources or pollution including sanitation devices that could be released into the environment.
Assemble and inspect safety and firefighting equipment.
Protect all documentation and navigation charts that must remain on vessel from water damage.
Insure the watertight integrity of boat (inspect seals, plug through-hull fittings and intake seacocks).
Seal engine and generator intake and exhaust vents, and intake for engine cooling system.
Clear deck and cockpit scuppers.
Ensure batteries are fully charged.
Disconnect utility services, and turn off the DC breakers except for the main and bilge pumps.
Check primary and secondary bilge pumps.
Fill fuel tanks, but shut off the fuel valves that are nearest the fuel tank.
Fill water tanks.
Remove all top hamper.
Remove all loose or expensive equipment including electronics.
Seal electronics that cannot be removed, and seal switches and cable connectors.
Seal doors to electric panels.
Remove perishables from refrigerator.
Remove breakables.
Tape seal cabinets, drawers, hatch covers, and entrance jambs.
Tape the outside of all sliding and fixed windows along joints and seams.
Install chaff protection on mooring lines.
Double cross spring lines fore and aft.
Install fenders.
Lash steering in center position.
LEAVE VESSEL

Post Storm Checklist

If damages have incurred take immediate actions to reduce further damage.
Document all expenses.
Remove tape and seals before the sun heats up adhesives.
Contact insurance company if necessary.

Checklist for Pre-Season Preparation for Trailered vessels

Identify a suitable tow vehicle and inspect towing equipment including wiring.
Inspect trailer and perform necessary maintenance or repairs.
Identify a place well inland away from storm surge flooding.
Become familiar with local laws concerning trailering during an evacuation.
Review your vessel and trailer insurance coverage.
Review your boat inventory and insure inventory photographs and videos are current.
Ensure that your boat ownership documentation and licenses are consolidated and protected.
Review your individualized detailed plan of action.
Inspect cleats and tie downs.
Inspect bilge pumps and batteries.
Assemble equipment (tarpaulins, anchors, augers, shackles, lines, line-chafing gear)
Practice and time your individualized and detailed preparation plan as much as possible

Preparation Checklist

Remove all vessel documentation.
Lash boat to trailer.
Lash trailer to ground with anchors or augers.
Place wooden blocks between trailer frame and springs.
Let air out of boat tires.
Depending on your individual plan, clear all drainage scuppers or plug scuppers and fill vessel with fresh water.
Ensure batteries are fully charged.
Disconnect utility services.
Disconnect battery power except for bilge pumps.
Check primary and secondary bilge pumps.
Remove all top hamper.
Remove all loose or expensive equipment including electronics.
Seal electronics that cannot be removed. Seal switches and cable connectors.
Seal doors to electric panels.
Tape cabinets, drawers, hatch covers, and entrance jambs.
Tape the outside of all sliding and fixed windows along joints and seams.

Post Storm Checklist

If damages have incurred take immediate actions to reduce further damage.
Document all expenses.
Remove tape and seals before the sun heats up adhesives.
Contact insurance company if necessary.