Safety At Sea Core Topics Handbook

Edited by Sally Lindsay Honey

With contributions by:
Jim Antrim, Kent Benedict, Chris Branning, Bruce Brown, Ken Campbell, Jim Corenman, Dave Endean, Rubin Gabriel, Chuck Hawley, Carol Hasse, Stan Honey, Peter Isler, John Jourdane, Michael Jacobs, Sheila McCurdy, Paul Miller, John Neal, Dawn Riley, Ben Wright

Acknowledgements

This handbook would not exist without the original impetus of US Sailing's Safety-At-Sea Committee Chair, Chuck Hawley, and without the many hours of effort contributed by the experienced offshore sailors who have offered their knowledge in the following chapters. These authors include: Jim Antrim, Kent Benedict, Chris Branning, Bruce Brown, Ken Campbell, Jim Corenman, Dave Endean, Rubin Gabriel, Chuck Hawley, Carol Hasse, Stan Honey, Peter Isler, John Jourdane, Michael Jacobs, Sheila McCurdy, Paul Miller, John Neal, Dawn Riley, and Ben Wright. Each chapter reflects the knowledge and style of its contributor.

I am very appreciative of all the time and thought donated by these mentors in our sport.

The information cited was current at the time of writing in 2014-15 and the principles will remain valid for a long time. It is the responsibility of any sailor to remain current with updated practices and equipment. As with any discipline that relies on modern technology, the specifics are subject to change and eventual obsolescence.

Please use this handbook as a reference and reminder of the many topics that require thoughtful consideration before you push off from the dock for your next offshore adventure. The embedded check lists are only a start for compiling your own specifics relevant to your boat, your crew, and your voyage. Check the information at ussailing.org frequently for updates.

The more you think through your possible situations before you leave, the more likely you are to reach your destination safely, with enthusiasm for your next voyage, and with new knowledge to share with others.

Sally Lindsay Honey

December 2015

Table of Contents

Introduction, Sally Lindsay Honey

The philosophy of “Safety at sea” is intended to enhance the joy of blue water voyages by reducing the risk of serious injury and loss. We go to sea for shared adventure, for the accomplishment of overcoming physical and mental challenge, and for the satisfaction of gaining new skills and experience. The greater our preparation and understanding, the more likely we will overcome challenges.

This handbook presents an overview of best safety practices to minimize the chance of misfortune offshore. Accidents at sea are more threatening than those on shore due to isolation from sources of help. A vessel and its crew must be prepared to handle any eventuality, from a broken finger to a torn sail to sinking. ISAF World Sailing Offshore Safety Requirements (OSRs) and US Sailing Safety-at-Sea training programs follow a prescribed set of training topics that describe practices and equipment known to reduce the chance of offshore emergency incidents. This handbook observes the OSR required curriculum and cites the particular prescriptions addressed in the format OSR x.xx.

The following chapters have been contributed by experienced offshore sailors eager to share their knowledge of passage-making. Each chapter reflects the particular knowledge of the author. But classrooms and books are only a start to proper seamanship. Sailing with experienced sailors is the best way to become competent in the mechanics of sailing and seamanship. Go sailing, respect the sea, enjoy the challenge, and share your knowledge.

US Sailing Safety-At-Sea Seminars and ISAF Offshore Safety Regulations

Responsibilities of Person in Charge (OSR 1.02)

Voyaging across open seas allows complete freedom of the course taken, but not without risk. If done irresponsibly, there is danger involved. As a boat owner, captain, or person in charge, you must remember that the entire crew relies on you for their safety and for the responsible management of the vessel and its gear. These are the words of the ISAF Fundamental definition of the responsibilities involved: *“The safety of a yacht and her crew is the sole and inescapable responsibility of the person in charge who must do his best to ensure that the yacht is fully found, thoroughly seaworthy and manned by an experienced crew who have undergone appropriate training and are physically fit to face bad weather. He must be satisfied as to the soundness of hull, spars, rigging, sails and all gear. He must ensure that all safety equipment is properly maintained and stowed and that the crew know where it is kept and how it is to be used. He shall also nominate a person to take over the responsibilities of the Person in Charge in the event of his incapacitation*.”

Not only must you fit out the vessel properly, you must ensure that all on board will be safe in any emergency. Before you leave the dock, gather the entire crew for a safety briefing. Confirm that they know the location and proper use of all safety gear. Post location charts of stored items and thru-hulls in a place visible to all. Outline your vessel's safe practices for all challenging conditions: how you would go about abandoning ship; how you would recover a crew overboard; when you would make a Mayday call and use EPIRB and flares. Talk through options in case the skipper and/or key crew members are incapacitated; practice them with your crew. Remind each person of his or her responsibilities to follow emergency procedures and to look out for each other.

It is the responsibility of anyone who goes to sea to explore the lessons learned by others and prepare as thoroughly as possible for any voyage. Fortunately, extreme weather and emergency situations are rare. With sufficient preparation and training, challenges can be anticipated and met successfully.

Categories of Voyages/Races (OSR 2.01) ISAF specifies categories of races based on the expected duration and distance offshore, and specifies minimum safety standards for each category. This handbook is aimed at those intending trans-oceanic and/or coastal passage-making.

OSR Categories of Races		
Category 0, 1	Trans-oceanic passage making	Long distance, well offshore, and in waters where large waves, strong currents, or conditions leading to rapid onset of hypothermia are possible, requiring complete self-sufficiency for extended periods of time.
Category 2	Coastal passage-making	Extended duration, not far from shore, requiring a high degree of self-sufficiency.

These categories apply to any voyage – racing, cruising or power. Following the advice presented in this handbook will enable you to take the first steps of responsible action to safeguard your crew. When confronting a difficult situation, handle it before it becomes an overwhelming crisis, after quickly considering your options: STOP. THINK. ACT.

Crew Training (6.01) Safety at sea and medical first aid knowledge is crucial when there is no outside help available in an emergency. Training should include formal classroom sessions; hands-on practical sessions, such as life raft and lifejacket experience in a pool; and continual on-board training with the entire crew. Formal training certification for at least 30% of the crew is required for Category 0, 1, and 2 races, and is highly advisable for any offshore voyage.

Proper seamanship ensures that each yacht's crew culture includes a well-developed safety ethos communicated in periodic crew briefings and that all crew members understand they are responsible for their own safety and that their contribution to the safety of the vessel and the rest of the crew is vital.

Seamanship Check List, John Neal

Ways to prevent poor seamanship from causing the destruction of your vessel and possible loss of life:

Before Departure

1. Be accomplished on all points of sail: reefing, preventer and Lifesling use, and heaving to.
2. Practice single-handling your boat. Have your partner stay below.
3. Establish dedicated safe stowage procedures both above and below decks.
4. Keep your boat free of clutter.
5. Do not overload your boat as it will be then be more vulnerable to damage from large seas.
6. Prepare for a knockdown. Ensure batteries, floorboards, locker doors and drawers are secured.
7. Establish and review emergency systems and procedures for man overboard, fire, sinking, rig and steering failure, first aid, communications and abandon ship. Make sure everyone understands them.
8. Establish a watch schedule and instructions to maintain leadership, responsibility and communication.
9. Have reliable wind speed and direction instruments for determination of proper sail combinations.
10. Post a Sail Reduction Guide so everyone knows the correct sail combination for the given wind speed.
11. Practice hoisting storm sails and deploying storm management devices.
12. Become proficient at navigation, quickly and accurately plotting positions on paper charts.
13. Practice using radar and AIS. If your radar is not AIS compatible, upgrade by adding an AIS transceiver and plotter.
14. Provision with nutritious meals and healthy snacks that are easy to prepare by the entire crew.
15. Consider taking an additional experienced crew person on high-risk passages or in rough conditions.

At Sea

When on watch, stay on deck in a sheltered location in the cockpit, rather than below decks.

1. Keep hourly log entries of position, course, speed, log, wind speed & direction, and barometric pressure.
2. Plot your position on a paper chart at least every six hours.
3. Inspect rigging and sails daily for signs of wear or anything amiss.
4. Consider checking in with a radio/weather net with your daily position report.
5. Keep communication open and ensure responsibility among the entire crew.

Collision Avoidance

The International Regulations for preventing Collisions at Sea (COLREGS) mandates: “Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and the risk of collision.”

This obligation to maintain a continuous visual and audible watch for signs of other vessels includes using equipment such as radar and AIS when the situation requires. AIS is an excellent collision avoidance tool, but is not required for fishing vessels and is not always turned on or working aboard all ships, so you cannot assume others will see you.

1. Modern ships traveling at 25 knots allow only ten minutes from first sighting to potential collision.
2. Never assume that a ship you sight has someone on watch or that they can see you.
3. Never assume that a ship can quickly alter course or stop. They can’t.
4. Never, ever assume right-of-way and never try to cross in front of a commercial vessel.
5. Never cross close astern of a fishing or towing vessel.
6. Be prepared to quickly take evasive action if a ship alters course toward you.
7. Attempt to contact any ship on Channel 16 if you judge your course will come within three miles of the ship in clear daylight weather, or within five miles at night or with reduced visibility.
8. Keep VHF communications short. Speak clearly and slowly, using single digits for positions and courses when advising vessels of your intentions or course change. English is rarely the watchkeeper’s first language. Example: “Motor Vessel Silver Star, Silver Star, this is the sailing vessel Windsong, four point five miles on your starboard bow. I am slowing down so that you will pass ahead of me. Please reply on Channel 16”.
9. Broadcast Securité (see-cure-eh-tay) messages if in fog or reduced visibility. (See format below.)
10. Use radar and AIS whenever within 150 miles of land or in reduced visibility.
11. When mid-ocean at night, turn on radar for one minute every 30 minutes to check for ships, squalls and land.
12. Use a masthead tricolor running light at night for maximum visibility.

SECURITÉ CALL

1. SECURITÉ, SECURITÉ, SECURITÉ.
2. This is the Sailing Yacht __________________________.
3. Our position is __________________________________.
4. Our course is _____degrees magnetic and our speed is _________knots.
5. We are sailing in reduced visibility.
6. Any vessels in the area please respond on Channel 16.

Chapter 1—Care and Maintenance of Safety Equipment, Sheila McCurdy

Key Concepts: On-board safety ethos and training (OSR 6.0); inspection and storage of all safety equipment before departure; continued regular inspection while underway (OSR Section 4).

***Selkie* sailing to Bermuda**

Accidents happen. One dark night off the reefs of Bermuda, I heard someone shout, “Man Overboard!” I was on the helm as we were approaching the finish of the Newport Bermuda Race. We had just set a spinnaker on a shy reach when my brother went over the lifeline on the bow. I quickly steered the boat into the wind to stop within a couple of boat lengths. The noise of the flogging sails was deafening. On that moonless night I could just see to the foredeck on the 38-footer and could tell the mast crew had not responded to my call to drop the spinnaker halyard. Those of us in the cockpit searched the water astern. There was no sign of him, although I knew he was wearing an inflatable life jacket. I shouted his name. Astonishingly, he answered from the bow. The foredeck crew had seen that his tether was clipped to the jackline. He was over the side, but still attached to the boat. They hadn’t dropped the spinnaker halyard because they were busy hauling him on board. We took a few moments to determine that everything was okay and then we were on our way again with only minimal sail damage. Had I not stopped the boat, I might have drowned my brother as he dragged through the water at the end of his tether.

The climax of every riveting sea story hinges on whether some piece of safety gear was used to save the day, or failed to work, sending the situation from bad to worse. Not all gear failure or accidents can be eliminated, but quick response and knowledge of safety procedures can reduce risk. The objective is to promptly and effectively use the right equipment to prevent a developing crisis from escalating. At best, when someone trips and falls overboard, he or she has a whistle, light, or AIS personal locator beacon to aid the rescue effort while being held comfortably afloat by a life jacket. At worst, a crew member without a life jacket is knocked overboard, and the crew on board cannot find the spotlight to keep the person in sight, nor do they know how to use the MOB button on the GPS, how to activate the DSC (Digital

Selective Calling) distress button on the VHF, or how to start the engine. Each of these failings accelerates the crisis; time is lost and the chance to save a life decreases rapidly.

Identify crucial gear: This chapter provides a straightforward method to identify whether crucial gear is on board and easily available to keep the boat and crew safe on the intended passage. By working methodically through the boat, from bow to stern, from rig to deck to cabin, you can quickly determine whether the boat is properly equipped. Since you may be relying on the gear to save a life, your responsibility starts with proper selection, registration, and service. Aboard, there must be a plan for secure and accessible storage for immediate deployment—there may be only moments to grab an EPIRB or launch a life raft. The rest of the safety equipment on board may save the crew from having to make the extreme and risky decision to abandon ship either into a life raft, or possibly onto the 30-foot (9-meter) slab side of a wallowing ship.

Inspect the entire vessel before sailing: Every good sailor develops a method for inspecting a boat, its systems, and safety gear before departing on a passage. Whether sailing on your own boat or crewing on someone else's, you should make a habit of inspecting systems and gear above deck and below. Check that gear is properly positioned or stowed ready to use when needed. Knowing how everything looked before departure will make changes that occur underway more obvious.

A methodical sweep from bow to stern does not take much time. When determining that all crucial safety items are on board, check also that they are in a functional state for ready deployment in an emergency. Over time your eye will become practiced at catching potential trouble.

Starting at the bow, check the integrity of the pulpit and lifeline systems, the jackline terminations, the forestay termination, and the anchor stowage.


Anchor and Rode Storage

- The *anchor and chain* should be secured to prevent shifting in heavy seas. If the anchor is removed from the bow, it should be secured where you can easily access it for immediate use.
- Ensure that the *lifeline* terminals and gates are as reliable as the lifeline material itself. The lifelines should be taut enough to deflect downward less than an inch if a six-pack of soda is hung between the stanchions. Keep an eye out for which *shackles* should be moused or wire tied to prevent opening.
- Check all clevis pins for wear, and tape cotter pins to prevent them from tearing skin or sails.
- Make sure that the *jacklines* are secured at each end to extremely strong points, such as mooring cleats or padeyes with backing plates, and are laid out to allow a crew member using a tether to move the full length of the deck.
- Check *navigation lights* both at the deck level and at the masthead.

At the mast, make sure at least one crew member goes aloft to check the standing *rigging and spreaders*. On deck:

Spreader Inspection, Mahina Tiare

- Determine how the *storm trysail* would be set. Is there a separate, dedicated track so it can be rigged at the ready in threatening weather?
- Assess the *main gooseneck* and vang fittings for signs of wear.
- Tighten the deck fills to keep seawater out of the fuel and water tanks. As you move aft, check that the *clutches* for halyards and other lines are labeled.

In the cockpit, check for safe maneuverability from deck to cockpit to cabin.

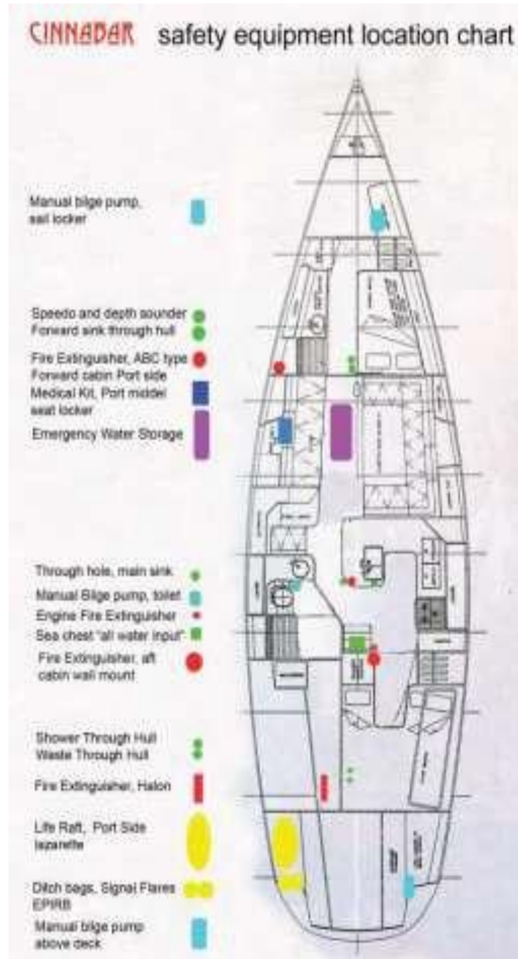
- Figure out how the *companionway* can be secured both from the cockpit and down below. Make certain the *companionway boards* are located near the companionway for immediate use in breaking seas. The companionway boards must be attached to the boat so that they will not be lost if the boat heels over abruptly.
- The *life raft* must be stowed where it will not be damaged, but could be launched within 15 seconds. It must have an up-to-date servicing certificate.
- Verify that the vessel's *EPIRB* is in its bracket and has a current registration sticker.
- Make sure that the proper selection of current SOLAS *flares* (OSR 4.23) is in a watertight container.
- Check the abandon-ship bag for essential items:
  - flashlights
  - first aid kit
  - handheld VHF
  - GPS
  - spare batteries
  - SOLAS flares
  - passports
  - credit cards
  - the ship's papers

Crew Overboard Throwable Devices

- Inspect all deployable *Crew Overboard (COB) equipment* to ensure its service is up-to-date and it's ready to use.
- Be sure the *boat's name* is on all floating equipment; this will help search and rescue efforts should the time come.
- If there is a *drogue or sea anchor* aboard, figure out how to deploy and rig it to a strong bridle. Identify the rode that's intended to be used with the drag device.
- Find the *emergency tiller* and sort out the access to the rudder stock head. Consider what is available for steering if the rudder is lost.
- Ensure that you can rig the *radar reflector* at least 14 feet off the deck. As you go below, notice where you could *clip on a tether* before leaving the companionway.

The below decks inspection centers around the boat's systems, crew welfare, navigation, and damage control methods, but in addition don't forget to look for things that one assumes are (but may not be) on board, such as a spotlight, binoculars, rigging knife, or foghorn.

Boat systems: Many below decks systems are crucial to preventing flooding and fire. Their locations should be clearly marked on a *diagram of the boat's interior* so the entire crew can locate problem areas and tools in an emergency.



- Check the *bilge* for debris that could foul the bilge pumps. Make sure the *bilge pumps* work, and the pump handles are within reach and secured to the vessel.
- Inspect *seacocks, stern gland, and rudder bearings* for signs of leaks. Be sure a soft wood plug is near each through-hull fitting, including cockpit drains, and that the locations are clearly marked on the posted chart.
- Inspect the *steering system* to ensure that cables are not too loose or tight and there is no sign of metal dust or debris, which could indicate chafe or wear in the pedestal, idler sheaves, or quadrant.
- Locate the *fire extinguishers* and check that the gauges register in the green zone. Inspection tags should show recent servicing. Invert the fire extinguishers several times to loosen compacted extinguishing agent.
- Check that the levels in the *fuel and water tanks* are adequate for the passage. Check the fuel and water filters for contamination and locate spare filters.
- Are *switches and valves* clearly labeled to allow monitoring of the boat's systems while underway, like checking the bilge or fuel filter?
- Check *tanks and other heavy equipment*—like the ship's batteries, the stove, floorboards, ground tackle, and the toolbox—are secured to prevent structural damage or injury in the event of a knockdown or capsize. Think about the boat at a 30° heel or in a worse case, something over 90°: what would happen below?

Crew Welfare: Security of the crew is as important as security of the boat's systems.

- Make sure there are adequate *handholds* for even normal offshore conditions and check for *bunk lee cloths* or other security for sleeping crew.
- Ensure the correct *life jackets* are available for all crew. This will generally mean a high buoyancy inflatable with an active CO2 cartridge and a built-in safety harness. Check each life jacket for the boat's name, reflective tape, lights, and whistles. Make sure that life jackets are stowed and readily available for routine use. Each crew member should have a life jacket adjusted to size and labeled by name. The straps should be snug around the chest and adjustable for varying layers of clothing.
- When racing, *tethers* must comply with the OSR specification (5.02), which also makes good sense

when not racing. Inflatable life jackets need periodic inspection and servicing of the inflation apparatus (covered in a subsequent chapter).

- Check *lights and personal location emergency beacons* (406-PLBs) or AIS-PLBs beacons worn with life jackets for proper operation.
- Inspect the *first aid kit*, which should be appropriate for the level of self-sufficiency of the passage. Its contents should cover injury and illness, especially seasickness and sun exposure, with the objective of stabilizing a patient until you reach land or help arrives.

Navigation: The navigation station is often the protected territory of the navigator, but everyone should have some familiarity with crucial communications.

- Know how to *operate the VHF*, make an emergency call, store a man overboard waypoint on the GPS and take a DSC position from the VHF and enter as a waypoint or calculate range and bearing. Look for a posted Mayday script, which is a good precaution.
- Make sure that an *emergency antenna* is available in case the masthead antenna fails or is over the side, and know the means by which to access the back of the VHF so that it can be attached.
- Verify that the instructions for a *satellite phone* and phone numbers are readily available.
- Ensure there are *manual backups for electronic navigational* methods.
- Make sure there are *charging cords and spare batteries* for handheld electronics.

Damage control: Inventory and check tools and spares against recommended lists. Other chapters will cover damage control and jury-rigging, but during a boat inspection, you should think about what on board you can use as *shoring for hull damage* or *jury-rigging after a dismasting or rudder failure*. Remember that the tools required for damage control are far different from those for an engine tune-up or routine maintenance.

Okay, you have gone through the entire boat to make sure all the required gear is on board. But safety equipment—whether crew overboard gear, an EPIRB, or a life raft—is not a talisman that will protect you from harm. Not only must you have the right gear on board, it must be operational, quickly at hand, and you must know how to use it correctly. Before every passage, check the equipment to make sure it's working properly: charge or replace dead batteries, lubricate moving parts, repair damaged elements, and replace inflation cartridges.

Equally important to having proper and functional gear on board is the ability and readiness of the crew to use the gear, which can only be ensured by practicing safety procedures and drills in the operation of equipment. Inspection is also the first opportunity to start thinking about the "what-ifs" of sailing offshore. There have been several well-publicized offshore accidents in recent years in which lack of caution or poor seamanship has contributed to one or more casualties in a sport we do for fun. Serious accidents usually happen not because one thing goes wrong, but because a string of poor decisions, small oversights, mistakes, or inadequacies conspire towards a calamity. Good preparation and training gives a crew a fighting chance to break a “chain of errors” that can cause a situation to slip from bad to worse and then slide out of control.

Every good skipper makes sure the crew has practiced using the equipment they may need in emergencies. While preparing for a passage and while underway, everyone on board should take responsibility for monitoring, reporting, and correcting anomalies or problems before damage or injury results. By carefully preparing and maintaining the boat, a racing crew can concentrate on speed and tactics, rather than on repairs and jury-rigging. If safety is not enough of an incentive, remember that an accident can demoralize a crew—making it unlikely that the boat will win the race—and risk the lives of fellow mariners who attempt to assist you.

I sailed transatlantic a few years ago on a 60-footer with a crew of midshipmen from the U.S. Naval Academy. We kept busy with the routines of passage making and the many gear problems that arose. The steering system had a hydraulic fluid leak that we couldn’t fix, but we had enough spare fluid to top up the reservoir daily. The mainsail ripped up the luff from the first reef, so the midshipmen set the storm trysail and stuffed the mainsail below for two of us to hand-stitch on ten feet of wide “sticky back” Dacron tape from the sail repair kit. The patch held for 2000 miles. Then, water contaminated the diesel, but the fuel system allowed us to pump from one tank to the other through two Racor filters, which allowed us to separate the water from the fuel. We also had to attend to our crew’s health. One crew member realized his pal wasn’t making sense, and determined that the guy had overmedicated himself with over-the-counter seasickness pills. By sleeping it off, he avoided making any big mistakes. To top off this series of challenges, the head backed up due to a paper clog at the y-valve. I tackled this messy job myself to prevent further endangering crew welfare and morale.

I admit that this would be a much better sea story if each of these incidents built on one another until we were adrift on the Grand Banks, with a low-pressure system bearing down on us. Instead, we rode the weather system toward France with our intact steering, a patched main, a charging engine, a working head, and a crew that looked after each other and the boat. At sea, I am grateful for anti-climaxes.

For Another Approach, Review Safety Equipment according to the following categories:
COB Prevention: Lifelines, jacklines, pad eyes, harnesses, and tethers.
COB Recovery: Life jackets, horse shoe, Lifesling, Dan Buoy, MOM, strobe, and overboard alarms.
Spars and Rigging: Mast, boom, poles, sprits, and standing and running rigging (including preventers).
Attention getting: Navigation lights, radar reflector, flares, and signaling devices.
Heavy items secured: Tanks, batteries, stove, anchor, chain, floorboards, and toolboxes.
Systems: Fuel, electrical, fire suppression, fresh water, bilge, sanitation, propulsion, communications, batteries, and charging systems.
Paperwork: Up-to-date registrations, certificates of inspection, and ship’s documents.
Posted layout diagrams: For through-hulls and emergency response essentials.
Incident response: Medical kit, tools, damage control kits, spares, and jury-rigging material.
Abandon ship: Life raft, grab bag, EPIRB, and extra gear.

Items Requiring Periodic Maintenance, Chuck Hawley

Item:	How to Maintain It:
Inflatable life jackets	Always inspect before use to ensure that the CO_2 cylinder is unused (used cylinders will have a hole in the tip), and verify if you have a manually-activated or water-activated model. 6-month inspections: remove cylinder, inflate orally until chamber is firm, and check for leakage after several hours. Replace water-sensing element if so fitted. Replace life jacket if it has deteriorated or will not hold air. Repack.
Lifesling	Periodic inspection: Remove Lifesling and line from bag. Check for UV damage, especially if line has been exposed to the sun. If equipped with light, verify operation. Make sure lifting tackle is two-blocked and can run free.
Man Overboard Module	Must be inspected every two years by a service center and documented via an external sticker. Ensure that it is mounted so that contents can drop unimpeded into the water.
Dan Buoy	Unpack Dan Buoy and inspect for abrasion or other damage. Verify that CO_2 cylinder and auto-inflate element are unused. Repack according to instructions.
Fire Extinguisher	Inspect general condition: corrosion, hose not damaged. Pressure gauge shows green. No evidence of extinguishing agent in nozzle. Locations marked. Brackets utilized to hold extinguisher securely. Invert dry chemical extinguishers to free up powder inside.
Life Rafts	Periodic maintenance (according to manufacturer's recommendations). Store off the boat in a cool dry location without rodents. Find out if your raft is subject to a recall. Use authorized service stations. Ensure painter is attached to strong point of vessel.
Signals, Pyrotechnics, Flares	Store in a dry, protected location. Replace 42 months after manufacture date. Understand operation of pyros before needing to use them.
EPIRBs	Must be registered, and the information must be accurate. Verify online at beaconregistration.noaa.gov. Verify operation via self-test feature. Battery replacement interval is generally 5 years. Hydrostatic release replacement interval is generally 2 years for Category 1 models.
Dewatering Pumps	Verify operation by flooding bilge and pumping it out. Verify operation of electric pumps and flooding alarms. Inspect pump chamber for corrosion, salt build-up, debris.
Handheld VHF	Verify that the battery is charged using display. If using alkaline batteries: replace annually if not used, more frequently if partially used. Verify transmit and receive operation on ship-to-ship channel like 68, 69, 71, 72. If handheld has DSC capability: register and enter MMSI number for vessel; make sure it can get GPS fix; test DSC using test DSC MMSI numbers.
Fixed mount VHF	If radio has DSC capability: Make sure MMSI number is registered and entered and position data from GPS via NMEA connection is connected correctly, make a test DSC call to local Coast Guard station (verify method). NOTE: Radio should show Lat-Long on its display, and should not "request" an MMSI number. Verify operation of the radio (scan, squelch, volume, PTT, channel modes: CAN, USA, INT, and transmit power). Verify audio quality using WX channel(s). Verify operation of remote station if so equipped. Make test call on ship-to-ship channel (68, 69, 71, 72). Verify that there is a list of common VHF channels and their function near radio. Post MAYDAY script near radio, and a definition of MAYDAY, PAN PAN, and SECURITE calls.
Personal Safety Gear	Replace batteries annually. Verify operation. If water activated, verify operation in water. Operate any zippers and verify that slider is not corroded; replace if "sticky," lubricate if operational. Lubricate and sharpen folding knives.
Anchor and Rode	Verify that anchor and rode cannot break free inside cabin. Mouse shackles with strong line or wire. Do not modify anchors to fit them in lockers or beneath floorboards. Ensure anchor and rode meet manufacturer's recommendations for the size of boat.

Chapter 2 – Communications Equipment, Chuck Hawley & Stan Honey

Key Concepts: VHF installations and hand-helds; Special Regulations requirements for VHF 25W output, masthead antenna, emergency antenna; SSB; Satcoms (OSR 3.29, 4.19). Non-INMARSAT types (e.g. Iridium); terrestrial cellphones and their limitations; GMDSS, DSC, AIS and GEOS.

> Note: The area of Communications Equipment is undergoing the most rapid development of all the topics covered in this handbook, which renders this chapter almost certainly outdated at any given time. Please check www.ussailing.com for the current offshore special regulations.

There are several reasons to use emergency communications when at sea. Examples include:

1. Your vessel has an immediate problem and you need to abandon ship
2. A crew member has a medical problem and you either need to get advice, get help, or evacuate the crew member.
3. You are overdue and want to reassure those on shore that you're OK.
4. You are standing by another vessel and need to relay safety messages on their behalf.
5. You want to report a hazard to navigation or other safety message of interest to other boaters.

It is vital that you use means of communications that are accepted by search and rescue agencies around the world, and that you know the strengths and weaknesses of each method of communication.

Commercial vessels use emergency communications tools that are defined under IMO (International Maritime Organization) by GMDSS (Global Marine Distress and Safety Service). This set of international protocols defines how SOLAS vessels communicate on the high seas and in coastal waters. By having a consistent standard across thousands of vessels, rescue agencies can communicate with these vessels, they can communicate between each other, and therefore come to the aid of each other.

As a result of the standardization in the commercial shipping world, sailors use many of the same devices, frequencies, and protocols. This allows sailors to communicate with the same rescue agencies (Coast Guard(s), RNLI, naval vessels) as well as commercial ships (AMVERS) and each other.

Rescue 21 is a long-awaited system of land-based stations on the coast of the Continental US, Guam, Hawaii, Alaska, PR, USVI, and the Great Lakes. The Coast Guard can communicate with and fix the position of a one-watt VHF transmitter, 6' off the water, up to 20 miles offshore. Stronger transmitters and higher antennas increase the range dramatically. When combined with a DSC (Digital Selective Calling) Mayday Transmission, the Coast Guard can determine the identity and location of a vessel in need. However, sailors must register online for a MMSI (Mobile Marine Safety Identification) number, make sure that it is entered into the radio, and have a GPS connection to the radio for maximum effectiveness.

Marine Communication Options:

Type of Communication	Approximate Range	Voice, Data, Other	GMDSS?	GEOS?	Portable or Fixed Mount	Required Skill Level	Cost with Antenna	Cost of Data per Megabyte
Handheld VHF	3 miles to another handheld, 20 miles to USCG Rescue21	Voice, optionally DSC	Yes		Portable	Low	$100-$300	NA
Fixed Mount VHF with masthead antenna	8 miles to a handheld, 15 miles to another sailboat with a masthead antenna, 30 miles to USCG Rescue21	Voice, optionally DSC	Yes		Fixed	Low	$150 to $500	NA
406-PLB (Personal Locator Beacon)	Worldwide, but position is not immediately available to nearby vessels	Digital, may include GPS position	Yes		Portable	Low	$250-$400	NA
AIS-PLB	3 miles to a vessel with a masthead AIS antenna	AIS position of MOB	no		Portable	Low	$250-400	NA
EPIRB (Emergency Position Indicating Radio Beacon)	Worldwide	Digital, may include position	Yes		Portable	Low	$600-$1200	NA
SART (Search and Rescue Transponder)	5 miles	Radar target	Yes		Portable	Low	$1000	NA
SSB (Single Sideband)	50-4,000 miles	Voice, optionally DSC and data	Yes		Fixed Mount	High	$3000	$250 per year for email via SailMail

Type of Communication	Approximate Range	Voice, Data, Other	GMDSS?	GEOS?	Portable or Fixed Mount	Required Skill Level	Cost with Antenna	Cost of Data per Megabyte
Iridium	Worldwide	Voice and data	Not yet	Yes	Portable or fixed mount	Low	$1500	$60 per megabyte
SPOT	Coastal to 200 nm	Data	No	Yes	Portable	Low	$300	$2,400 per megabyte*
SatCom C	Worldwide	Text	Yes		Fixed Mount	Moderate	$2000	$10,000 per megabyte*
Inmarsat FBB	Almost Worldwide	Voice and data	No		Fixed Mount	Low	$5000	$10 per megabyte
KVH VSAT	Almost Worldwide	Voice and data	No		Fixed Mount	Low	$13,000	$1 per megabyte

* These services are intended for short text messages only.

EMERGENCY COMMUNICATION AND DISTRESS SIGNALS

Emergency Signaling: EPIRB and PLB

EPIRBS (Emergency Position Indicating Radio Beacons): These are transmitters used for "Mayday" type emergencies when the safety of the crew or the loss of the vessel is at risk. They transmit a brief 5W coded transmission every 50 seconds for at least 48 hours. Most new units are equipped with an internal GPS for faster alerts to rescue agencies.

406-PLB (Personal Locator Beacon: Very similar in function to an EPIRB (described above) but more compact. PLBs can be carried on crew members, but the position of the MOB is not available to nearby vessels other than via communications from a Rescue Coordination Center via satellite phone or SSB. Sometimes used on small craft in lieu of an EPIRB. While they are waterproof, they may or may not float, and they do not float upright to keep the antenna out of the water. Design transmit time is 24 hours. Most have a built-in GPS for faster alerts to rescue agencies. PLBs are registered to the user, not the vessel, although it is possible to add notes indicating the vessel to the online registration form (http://www.beaconregistration.noaa.gov/).

AIS-PLB: This Personal locator beacon uses AIS technology to create a "MOB" target on every vessel's AIS plotter that is within 3 miles. These units provide the first practical solution to allow nearby vessels to quickly locate a MOB. Some AIS-PLBs also transmit DSC alarms.

CELLULAR TELEPHONES

According to the U.S. Coast Guard, sailors use cell phones more often than marine radios to call for assistance simply because more boaters carry cell phones than VHF radios aboard their craft. The cellular phone has many disadvantages when used in search and rescue (SAR). Currently, 16 to 32 km (10 to 20 miles) offshore is the average effective range of cellular phones; range is determined by line of sight to the cell antenna. Therefore, use is restricted to populated areas where there are cellular sites. Gaps in coverage make them unreliable, even for coastal use. Cellular communication is private, in contrast to the more public (party line) broadcast over VHF radio; this excludes potential assistance from boats that might be in the immediate vicinity. In SAR operations, no practical way exists to maintain continuous communication with a number of rescue craft via cellular phone. The Coast Guard is unable to use radio direction finding equipment to locate the vessel in distress if it is calling on a cellular frequency, as it can with the VHF-FM signal. The cell phone has limited battery power and longevity, and most mobile phones are not water resistant. Every boat should have a portable or fixed mounted VHF radio. VHF transmission allows the Coast Guard's new Rescue 21 system to locate a vessel more quickly and efficiently especially when Digital Selective Calling (DSC) is used in conjunction with a GPS unit (see below).

If a cellular phone is the only communications link on board, extra charged phone batteries and a waterproof pouch are needed. A comprehensive list of emergency phone numbers should include local hospitals and physicians, regional Coast Guard stations, harbormasters, and maritime towing services.

IRIDIUM

The Iridium communication system is similar to the cellular phone, but uses a constellation of low earth-orbiting (LEO) satellites. The Iridium Extreme phone is water-resistant, and contains a GPS receiver allowing it to be used via the GEOS system to summon help. The Iridium phones can be used for voice transmissions and for receiving e-mail and digital weather files. Like all satellite telephones, Iridium units require a clear view of the sky to operate (the antenna must be visible to the satellite). Iridium phones may be used with a docking station and remote external antennas for fixed mount installation. Call costs range from $1 to $2 per minute and data transfers at 2400 bps yielding a data cost of about $60 per megabyte. When the mast comes down and the antennas for the SSB and VHF are lost, a satellite phone may be lifesaving, especially when help is out of range of the handheld VHF radio. A satellite phone is a valuable addition to the abandon ship bag. It should be carried in a waterproof bag together with a list of the critical phone numbers of the rescue coordination center and Coast Guard communications centers for the areas in which one will be sailing. Iridium also makes a portable WiFi hotspot, the Iridium Go!. The Go! is battery powered, contains a GPS, can be used to summon help via GEOS, but needs to be used in conjunction with a WiFi connected phone running an Iridium app to make voice calls.

VHF-FM MARINE RADIOS

The VHF-FM radio transceiver is the most popular, user-friendly, inexpensive, and reliable form of marine communication. It is the single most important radio system. It is easy to use, even for crew with minimal experience. The VHF signal range is limited to line of sight and therefore depends on the height of the transmitting and receiving antennas. A transmission range of 25 to 50 km (15 to 30 miles) can be expected between boats having masthead-mounted antennas. The VHF radio is limited to near-shore, ship-to-ship, and ship-to-shore communication. Communication is not private, which is a distinct advantage in maritime emergencies and SAR operations. VHF is the open party line connecting all vessels within the signal range. Any boats in the area monitoring distress channel 16 will possibly receive the distress call. In the new Rescue 21 system (see later), Coast Guard rescue boats and aircraft are equipped with radio direction-finding equipment that can locate the direction from which the VHF-FM signal is being broadcast.

Cruising boats should have both a fixed mounted radio wired to the ship's electrical system and masthead antenna, as well as a portable handheld VHF radio. After a knockdown or capsize, a handheld radio can operate independently of the ship's radio antenna (the mast may have been lost or the antenna damaged). Handheld radios are indispensable in SAR operations and helicopter evacuation, when one is required to be mobile and on the deck. Handheld radios can also be used to communicate with the mother ship from a dinghy, and are essential for communicating with rescue personnel from a life raft.

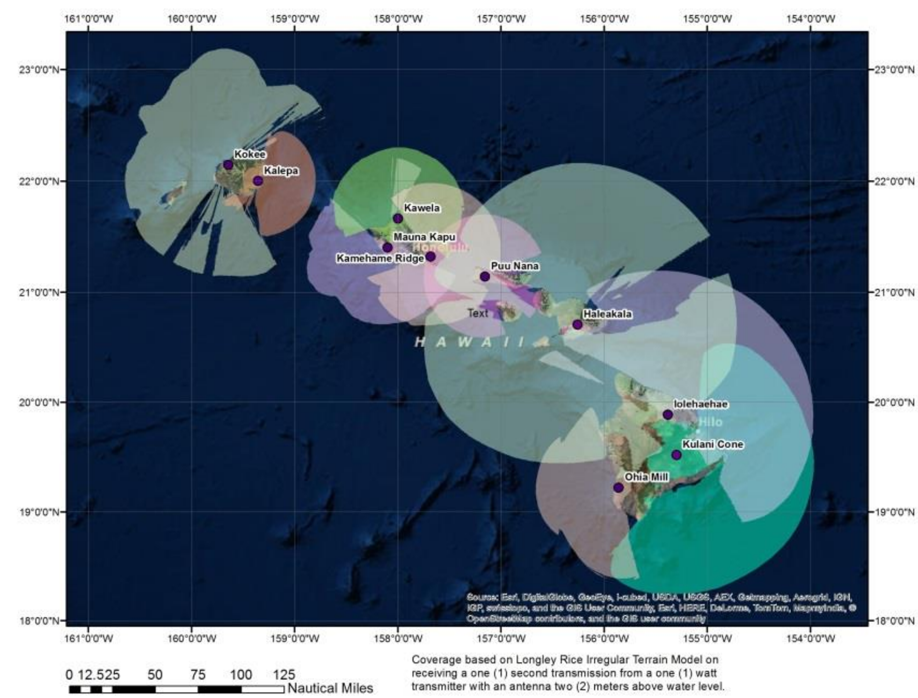
During an emergency, if possible, use the more powerful, permanently installed radio with masthead antenna for the initial distress call. In the spare parts inventory, include an emergency antenna to allow short-range communication should the boat be dismasted (the same problem can befall a powerboat if its antenna is broken).

The range of the portable unit is 3 miles to another handheld, 8 miles to a sailboat with a masthead antenna, and 20 miles to USCG's Rescue21 system. To conserve batteries, the user should transmit only when a ship is in sight and whenever a message is received (even if the calling ship is not in sight). Transmitting uses 15 times more battery power than does receiving; transmitting at full power uses dramatically more power than at low (1 W) output. Although the range of a handheld radio is less than a high-power fixed-installation VHF radio, reliable communication can be established with any visible aircraft or vessel.

The new multichannel VHF survival radios are ideal for life raft or lifeboat use. They are waterproof, submersible to 3 m (10 feet), and float. The operating life with the lithium battery is a minimum of 8 hours. Most normal handheld VHF radios sink, so they should be placed in a foam flotation case for protection. The most important VHF channel is channel 16, the distress and safety frequency (156.8 MHz). This calling frequency is used to initiate contact between any two vessels and is the only frequency constantly monitored by the Coast Guard. When a radio is not active on another channel, it should be left listening for distress calls on channel 16.

RESCUE 21

Rescue 21 is an advanced maritime computing, command, control, and communications system designed to manage communications for the U.S. Coast Guard and significantly improve the rescue of boats in distress. Rescue 21 covers 98% of the 153,000 km (95,000 miles) of coastline, navigable rivers, and waterways in the continental United States, Alaska, Hawaii, Guam, and Puerto Rico. Rescue 21 comprises direction-finding equipment with 2 degree accuracy, enhanced clarity of distress calls, simultaneous multi-channel monitoring, upgraded playback and recording feature for distress calls, reduced coverage gaps, and full support of DSC. The Rescue 21 system relies on digital selective calling as the preferred hailing system for transmitting mayday calls, communicating GPS positions of the calling vessel, and for establishing voice radio communication on the marine VHF band. These radio installations include manned Coast Guard shore stations as well as Coast Guard vessels operating in coastal waters. The new technology enables the Coast Guard to obtain multiple lines of bearing to a mayday call, and determine the location of the



vessel in distress even if the vessel in distress is not using a DSC radio, or has a DSC radio that does not have a GPS interfaced.

SSB-HF RADIOS

For communication offshore beyond the VHF range, a more powerful and elaborate SSB (Single Side Band) radio transmitter can be used. High-frequency marine radio-telephone equipment operates between 4 and 26 MHz using SSB emissions. This equipment can also be used to receive high seas weather broadcasts (see discussion on thunderstorms and weather) and, in combination with a laptop computer and a special HF modem, can provide an easy and relatively inexpensive way to send and receive e-mail. The principal SSB e-mail system providers for the recreational market are SailMail and Winlink. (Winlink requires a Ham Radio license.) E-mail is not just for social exchanges; it offers cruising boats a safety advantage for communicating safety-related data to boats around the world and accessing detailed digital weather forecasts. Depending on the radio frequency band and atmospheric conditions, communication range may be several thousand miles. See http://www.sailmail.com for excellent information about using the SSB for e-mail.

The international distress and calling frequencies are 4125 kHz, 6215.5 kHz, 8291.0 kHz, and 12,290.0 kHz. These frequencies have all been designated for distress and safety calls. The Coast Guard transmits voice and weather information on various marine HF frequencies. The transmitters cover the Atlantic and Pacific Oceans, Caribbean, Gulf of Alaska, and Gulf of Mexico. Up-to-date schedules and frequencies can be found online at http://www.nws.noaa.gov/om/marine/hfvoice.htm and http://www.weather.gov/om/marine/hfvprod.htm. The best way to select an optimum emergency frequency is to listen to the quality of a radio broadcast. A station that your radio receives loud and clear will also provide good reception for your broadcast at that time. SSB is an excellent receiver for voice weather and weatherfax broadcasts, as discussed previously. Optimal use of a marine SSB radio requires instruction and practice. Modern marine SSBs include DSC capability, which require the interface of a GPS. The use of DSC is the most effective way to attract the attention of the USCG via HF radio and initiate voice communications because the USCG automatically monitors all of the distress frequencies for DSC calls.

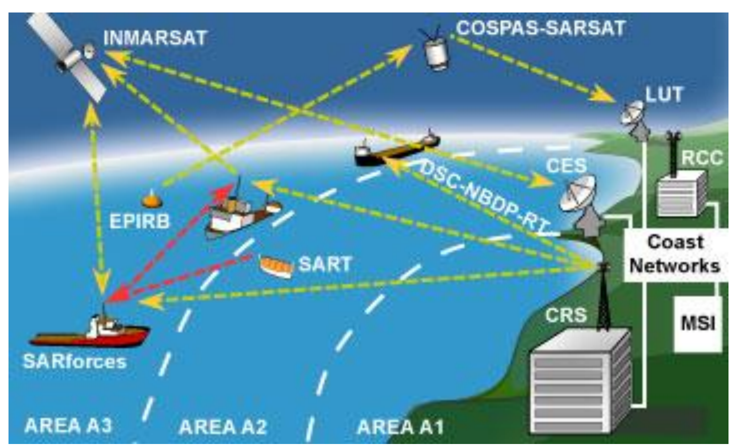
GEOS Alliance

Geos is a non-government, non-GMDSS organization that forwards information from private devices, which include a feature that they can use to summon help. Examples of such devices include the Iridium Extreme phone, the Iridium Go! Hotspot, DeLorme inReach, Globalstar, and various SPOT products. These devices have varying additional abilities to support voice calls, short text messages, and general purpose data transfer. If you are in distress, and are able to use more than one technique to communicate, you will speed up the response because the search and rescue authorities will immediately set aside any concern about a false-alarm if they get duplicate requests for help from two epirbs, or an epirb and a GEOS device, or an EPIRB and a Satcom-C (see below).

GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS)

Since February 1, 1999, ships and coastal stations have not been required to monitor the traditional distress frequencies, such as VHF channel 16 or the HF distress frequencies for voice calls. The GMDSS is a worldwide infrastructure, controlled from a shore-based communications center, to coordinate assistance to vessels in distress. This fully automated system uses satellite and digital communication techniques that require upgraded radio equipment and communication protocols. GMDSS simplifies routine communications at sea and facilitates regular weather forecasts, navigation warnings, and distress relays in the form of maritime safety information (MSI). DSC technology permits a VHF or HF radio (with DSC capability) to call another radio selectively using digital messages, similar to the modem on a computer. As with a direct-dial telephone call on land, only the vessel called receives the initial message. Every vessel has its own unique Maritime Mobile Service Identity (MMSI) number. The radio must therefore be registered in order to be properly identified in an emergency or to be called directly by another boat using a DSC radio. MMSI numbers are assigned by the FCC when one applies for a new ship radio station license. Alternatively a MMSI number can be obtained from the Boat U.S. website at http://www.boatus.com/mmsi, or the Seas Tow website at http://www.seatow.com/boating_safety/mmsi. The vessel's MMSI is registered in the Coast Guard's national distress database together with information about the boat. Distress messages can be sent automatically with DSC radios. The vessel's identity is permanently coded into the unit, and its position can be determined from the data output of a GPS receiver linked to the radio. On a DSC-equipped radio, the receiver sounds an alarm if it receives an "all ships call" (distress or otherwise), group call, or a call specifically to that vessel.

A distress alert (equivalent to mayday) can be also sent to a shore-based rescue coordination center (RCC) covering the area. Once the alert has been sent, the radio will automatically repeat the call at intervals between 3 and 4 minutes until the RCC acknowledges receipt of the message. Subsequent communication should continue on channel 16 or another selected frequency for voice



transmission. A verbal mayday can also be sent immediately on channel 16 after the first alert. Some DSC-equipped transceivers can listen simultaneously for DSC and channel 16 or other channels for voice transmission.

To make a ship-to-ship or ship-to-shore call on DSC, the nine-digit MMSI number of the station to be called must be keyed in on the radio, together with a proposed working radio telephone channel (which is not private) for subsequent voice communication. Four VHF channels are available for special use within the GMDSS: channel 06 is for SAR coordination, channel 13 for intership safety of navigation (bridge to bridge), channel 16 for distress and safety, and channel 70 for DSC alerting.

The GMDSS also uses satellite communication links, such as the International Maritime Satellite Organization (INMARSAT), to provide long-range global communication. Geostationary INMARSAT satellites cover the entire world between 70° north and 70° south latitude. They provide high-quality worldwide speech (voice is full duplex, just like a telephone), data, and facsimile communication as well as reliable distress alerting and follow-up communication within the GMDSS. Products in the INMARSAT Fleet Broadband systems vary in size, price, power consumption, and transmission speed. INMARSAT C is the only two-way marine satellite data message system approved for GMDSS safety at sea. The hardware is small enough to fit in any boat. It can send a distress signal at the touch of a button and includes an integrated GPS receiver. Pressing the distress key sends a message with the ship's identity and location to the nearest RCC. More information about GMDSS can be obtained from the Coast Guard website at http://www.navcen.uscg.gov/marcomms/gmdss/default.htm.

Chapter 3—Lifejackets, Harnesses, and Tethers, Bruce Brown

Key Concepts: Life jacket capabilities and requirements (OSR 5.01), essential accessories; importance of a good fit, compatibility with safety harness, tether (safety line) (OSR 5.02).

> Note: in October, 2014, the US Coast Guard decided to drop the numeric code system (Type I, II, III, IV and V) that was used for years to distinguish the different types of personal flotation. Although the labeling will change, the usage differentiation will remain substantially the same. The types cited in this chapter will continue to apply with different names. Specifically, the type of life jacket recommended for offshore sailing is the Type V inflatable vest that includes an integral harness.

Image courtesy of Absolute Outdoor, Inc

This chapter provides an overview of life jackets and related accessories, such as harnesses and tethers (safety lines), to help you select and maintain appropriate equipment for coastal and offshore sailing. Life jackets are the single most important piece of safety gear a sailor can own. But to be effective, the life jacket must be worn! Wearing a life jacket is a key element to survival in an overboard situation. In recent years, 70% of boating fatalities were due to drowning. The majority of these drownings could have been prevented by the use of a life jacket.

Sailors can end up in the water when their boat collides with other boats or objects, capsizes, sinks, or a misstep sends them overboard. A harness and tether will keep you connected to your boat if you do go overboard. Staying connected to the boat makes crew overboard recovery much faster and eliminates the search from the rescue. Tethers are the crucial link between the harness and the boat. There must be strong points on the boat, such as jacklines and padeyes, to attach the tether.

Not only are life jackets and harnesses effective, but they are required by offshore racing regulations. US Sailing OSR prescriptions state that, for all offshore racing, "all personnel on deck shall wear properly fitted personal floatation while starting and finishing. . . [and] . . . [a]t other times . . . except when the Captain of the boat directs that it may be set aside." Also, "the safety harness may be integrated with an inflatable personal floatation device" and should "be employed whenever conditions warrant, and always in rough weather, on cold water, or at night, or under conditions of reduced visibility or when sailing shorthanded" (US Sailing OSR 5.01 & .02).

Drowning is the problem and wearing a life jacket and harness is the likely solution. But given the multitude of choices, selecting the appropriate life jacket for your needs can be daunting. As offshore sailors, we face specific and extreme conditions that require the most effective gear available. While the US Coast Guard specifies and approves a wide range of life jackets for a variety of situations, our needs reduce that range to a manageable number. We will briefly review the US Coast Guard types in order to place in context those appropriate for offshore use, and then continue with instructions on proper fit and maintenance of the gear you choose.

Image Courtesy of Absolute Outdoor, Inc.

LIFE JACKETS

Choosing the best life jacket means finding one appropriate for the sailing you do—and one that you will actually wear! Life jackets are designed and manufactured for a variety of sports and activities. Recent upgrades in life jacket design have improved their performance, reliability, and wearability.

In the United States, life jackets are tested to standards and approved by the United States Coast Guard. Inherently buoyant (i.e., foam) life jackets will float a person in the water with no mechanical system necessary to deploy the flotation. Hybrid life jackets include some inherent buoyancy with an inflatable system to provide added buoyancy, but do not meet US Sailing requirements and are not appropriate for offshore sailing. However, some inflatable life jackets, including those integrated with harnesses, are approved by US Sailing OSRs. There are many choices available. The following examples describe the major US Coast Guard life jacket types and highlight the best offshore options.

Type I PFD – Kent Life Jackets

Type I Life Jackets (Offshore): Designed for use in areas where rough weather could be expected or rescue might take an extended period of time. These cumbersome life jackets are generally seen on commercial vessels. US Sailing OSRs require either a Type I PFD, such as this, with a minimum of 22 pounds (or 100 Newtons) of inherent buoyancy, or a Type V inflatable with 33 pounds (150N) of buoyancy be on board for every crew member. Type I PFDs will turn an unconscious person face up most of the time. While Type I life jackets have reasonably good performance in the water, their bulk and inability to integrate with a harness makes them an unlikely choice for offshore sailors.

Type II PFD – Kent Life Jackets

Type II Life Jackets (Inshore): These life jackets meet the USCG minimum for recreational boating. They offer flotation for sailors in calm waters where rescue would be quickly at hand. Type II PFDs *may* turn an unconscious person upright and have 15.5 pounds (70N) of buoyancy. These life jackets are available in sizes and styles that are more comfortable than Type I styles, but are not adequate for offshore use.

Type III PFD- Stohlquist Life Jackets

Type III Flotation Aids: These are designed for use close to shore. They are often the most comfortable to wear of all the inherently buoyant styles, but they are not suitable for coastal or offshore sailing. These life jackets have a minimum of 15.5 pounds (70N) of inherently buoyant material or 22 pounds (100N) if inflatable. This type of life jacket is often seen in kayaking, canoeing, small boat sailing, water skiing/wakeboarding, or stand up paddle boarding. The inflatable belt pack shown at right is included in this category. It requires secondary donning and is not appropriate for offshore sailing.

Type IV Throwable Flotation: These devices are Intended as additional flotation for persons already in the water. At least one of these is required on boats over 16 feet. It must be immediately available on deck to throw to overboard. Approved cushions, ring buoys, horseshoes, and Lifeslings qualify for this requirement. They require a minimum of 18 pounds (82N) of flotation.

Type IV Throwable - Kent

Type IV Life Sling – West Marine

Horseshoe Buoy

Type V Special Use Vests: This broad category includes devices that have life-saving potential but that either do not meet all of the requirements for approval under Type I through Type III or that have features or uses, requiring special user knowledge, not found in Types I through III PFDs. They have various buoyancy requirements intended for many special uses, such as work vests or work suits for the commercial marine industry and law enforcement. Some models are similar to Type III vests but have use restrictions. Performance life jackets varies and labels describe the appropriate limits of use.

Type V Absolute Outdoors, Inc.

Type V West Marine

For the offshore sailor, it is sufficient to know that Type V devices also include the inflatable life jacket/harness integrated systems used in most offshore sailing today. US Sailing OSRs require that inflatable life jackets have a minimum of 33 pounds (150N) of buoyancy and be yoke-type inflatables, as those shown. Belt pack life jackets do not qualify, because they require secondary donning after inflation. Inflatable life jackets may have crotch or thigh straps to help prevent riding up in the water once inflated. Every life jacket must include at a minimum: a light, a whistle, retroreflective tape and labeling with either the boat's or crewmember's name.

Comparison of Inflatable to Inherently Buoyant Life Jackets: The advantages of these inflatable life jackets are integration of the harness, freedom of movement, and excellent in-water performance due to their high buoyancy. By comparison, Type I foam life jackets are bulky to wear, and difficult to integrate with a harness. However, there are a few disadvantages with inflatable life jackets: the inflation system requires more maintenance than inherently buoyant life jackets, they may not inflate when desired, and they do not perform well on high-impact.

Oral inflation tube – Absolute Outdoor, Inc.

Inflation Systems: Inflatable life jackets offer a choice of three types of inflation system: manual by pulling a cord, automatically activated by moisture, or automatically activated by hydrostatic pressure. There are several types of automatic inflation systems and it is important that you understand which you have, how it operates, and what maintenance it requires. All inflatable life jackets also have an oral inflation tube on the upper left side, close to the wearer's mouth, for topping up or in case other systems fail. Know how to use this!

Manual-only inflation systems require you to pull a ripcord on the inflator to activate it. Be sure you can find the pull string when needed: in the water, in the dark, with gloves on.

Automatic inflation systems will activate when exposed to water. Some activate when a bobbin dissolves in the water; others activate through a hydrostatic inflator that requires the device to be under water before it inflates.

1F inflators offer manual or automatic activation, a cylinder seal indication, and a single point status indicator that must be visible both before and after donning. This is an improvement over previous systems that did not clearly indicate when the system was properly armed and ready for use. Be sure to understand how your system operates and carry a spare cylinder and service kit. If a life jacket activates during a passage, you must be able to rearm and repack it to make it functional again.

Inflatable life jackets include various features depending on the manufacturer, including spray hoods, emergency lights, crotch or thigh straps, whistles, and retro-reflective tape (which shines back at a light source and serves as an important element of a night rescue).

Inflatable life jackets may fall into one of several USCG types, and this can be confusing, even to industry professionals. If it has a harness, it is a Type V. If it is a "traditional" automatic (6F inflator), it's a Type V with Type II performance and has to be worn. If it is an automatic with a 1F inflator, it's a Type II and does not have to be worn. Inflatable life jackets are not USCG approved for sailors under the age of 16 or less than 80 pounds, for whom you are required to have an inherently buoyant life jacket on board.

Poor Fit – Photo by Bruce Brown

Fit: A life jacket and harness must be properly fit and maintained to ensure adequate performance when needed. They should be clearly labeled so each crew member can quickly identify the jacket adjusted for his/her proper fit. The fit of a life jacket is critical for its performance. One that is too large or too loose will float high without lifting the victim's mouth and nose far enough out of the water. Test your life jacket in the water to make sure it does not ride up so much that breathing is difficult. See the crotch/thigh strap section for additional means of holding the inflation chamber down, which will provide greater freeboard (height of the mouth out of the water). There have been cases in rough water of the buoyancy chamber shifting over the wearer's head, causing problems due to asymmetrical buoyancy. (See US Sailing's report on the *Uncontrollable Urge* Islands Race fatality.) Be sure to try your life jacket in water to test its fit and functionality before you need it.

Maintenance: Inspect all life jackets when the season begins. Check the straps and webbing for chafe or wear. Ensure that the cover material is intact and will secure the flotation without failure, such as tearing. Be sure that all buckles are fully functional as each strap is an integral part of the design of the life jacket. Replace your life jacket if it shows any sign of wear. This is what the Coast Guard states:

- Check your PFD often for rips, tears, and holes, and to see that seams, fabric straps, and hardware are okay. There should be no signs of waterlogging, mildew odor, or shrinkage of the buoyant materials.
- If your PFD uses bags of kapok (a naturally buoyant material), gently squeeze the bag to check for air leaks. If it leaks, it should be thrown away. When kapok gets wet, it can get stiff or waterlogged and can lose buoyancy.
- Test each PFD at the start of each season. Remember, the law says your PFDs must be in good shape before you use your boat. Ones that are not in good shape should be cut up and thrown away to prevent use by others.

Inflatable life jackets require additional maintenance since they rely on CO_2 for their buoyancy. In addition to the above inspections, before every use insure that the CO_2 cylinder is full by visually checking the indicator on the inflation system. Be sure to review and follow the PFD owner's manual that came with your life jacket. All inflatable devices should be orally inflated, left overnight, marked with the maintenance date and repacked the next day only if they are still hard. Any with leaks should be replaced. Replace the bobbin in the inflation system at the manufacturers recommended intervals. In humid areas and when the vest is exposed to moisture regularly, you should inspect and replace these parts more frequently.

Spinlock DeckVest – courtesy of Sailing Pro Shop

SAFETY HARNESSES

Safety harnesses can function as standalone devices or be integrated with an inflatable life jacket, creating a two-in-one piece of gear. US Sailing OSRs state that all safety harnesses must be compatible with the crew member's life jacket. Compliant harnesses are designed to ISO standards (ISO 12401 or EN 1095). Harnesses must be strong (minimum breaking strength of 4000 pounds). Check with your retailer to ensure your safety harness is compliant before purchase.

Safety Harness – West Marine

To ensure the harness stays on when under the loads created by falling overboard, proper fit is essential. Be careful to adjust your harness so it is easy to put on, yet will secure you if you fall overboard. This balance of fit and comfort is important: do not choose comfort at the risk of secure fit under load. The best location for the harness-to-tether attachment is above the lowest point of the rib cage. Sailors with shorter waists may need to search for a device that has shorter shoulder straps. Michael Jacobs/Chuck Hawley's chapter on *Safety and Survival at Sea* states: "Women should not adjust the chest strap below their breasts. Injury may occur from the upward force that is placed on the harness when it suddenly comes under tension; some harnesses are designed for females to avoid possible injury." US Sailing warns that integrated inflatable life jacket/harnesses are potentially dangerous for people under 5-foot 5-inches tall.

Thigh straps – West Marine

Crotch or thigh straps keep the life jacket/harness in the correct position when loaded, preventing the buoyancy from riding up or the wearer from slipping out when in the water. Leg straps can be added to life jackets and safety harnesses as long as the life jacket is not permanently altered in the process.

TETHERS

The tether is designed to keep the crew attached to the boat. The tether's material and construction must be adequate for the sudden impact loads in the event you go over the side. Tethers must be detachable at both ends.

Tethers - West Marine

Specific hooks for the connection to the boat have been designed and are required for compliant tethers. The hook must be self-closing and require deliberate action to open. It must not be able to open when rotated around a padeye. US Sailing OSR compliant tethers are manufactured with stitching which, when overloaded, will show the potential for failure, indicating that the device should be replaced. Tethers may not be longer than 2 meters (6-feet, 7-inches) (OSR 5.02.1).

Tethers are available with single or double hooks. The double hook version has two legs: one leg is 1 meter (33 inches) long and the second leg is 2 meters long. The shorter leg reduces your chance of going in the water and may reduce your risk of drowning when towed over the side. The OSR requirement for Category 0, 1, and 2 races is that 30% of the crew must have a double tether.

There are several options for connecting the tether to the harness. In cases of possible entrapment, a sailor's ability to quickly release from the tether has been essential to many rescues, so how you attach the tether is important. Some of the common methods are: a cow-hitched loop, which requires an easily accessible knife to cut the webbing; a snap

Glowfast HLR Tether

shackle with an easily-grasped line to a quick-release pin; or a hook similar to the deck connection hook, with a thumb-released safety catch. Make sure you can release your tether under load, with one hand. Recently, Glowfast began producing a releasable cow-hitch tether. Their High Load Release (HLR) system operates with a single-handed pull, without a knife, and is resettable after release.

Jacklines: The jackline is the most common means of attaching the tether to the boat. It may be made of wire, webbing, or line, as long as it has a minimum breaking strength of 4500 pounds. It is stretched between strong, structural attachment points, such as cleats or padeyes, and should allow crew members access to the entire length of the boat without unclipping. Some suggest terminating the jackline 6-feet forward of the transom to ensure a crew overboard will trail no further aft than the transom of the boat, rather than trailing astern.

In conclusion, wear a life jacket appropriate to your use and educate yourself about your specific flotation/harness system. In the US harnesses and lifejackets are required to be worn offshore from sundown to sun up while on deck. Ultimately, the responsibility falls on the skipper to ensure that the crew's equipment is in good working order and that everyone on board has fully operational life jackets that fit properly. But each crew member should be ready to demonstrate how his/her life jacket functions so everyone is familiar with the gear on board. Remember that your tether and safety harness are your direct link to the boat in case you fall overboard. Inspect your safety gear before each race to confirm it is in good condition. By knowing how to properly use and inspect personal safety equipment, like life jackets, harnesses, and tethers, you will increase your chances of survival in an emergency.

Personal Experience: Double-handed near tragedy – Sam Goodchild was changing headsails on the foredeck of the 40-foot Cessna Citation while double-handing in the Global Ocean Race when he was washed overboard into the freezing Tasman Sea. It took his partner 25 minutes to turn the boat around and return to him. Meanwhile Sam cut away his clothing to make it easier to tread water without flotation in the 15-foot seas. Recognizing that he was lucky to survive, he later said, "It was a harsh lesson and one I will never forget. You hear these stories and think, 'Well that's a bit stupid, but that's not going to be me'—which is a bit arrogant. It only takes a second for something to turn into a big disaster. I'll be clipping on in future."

Low Speed Chase use of inadequate flotation, Sally Lindsay Honey

On April 14, 2012, the Sydney 38, *Low Speed Chase*, was capsized by a breaking wave on a shoaling lee shore on the northwest corner of the Farallon Islands, 26 miles outside of San Francisco. Seven of the eight crew members were thrown into the water. Although jacklines were properly deployed, none of the crew was tethered. Five of the seven crew members in the water drowned. Two of those five wore non-compliant life jackets with either less buoyancy than required or with inflation mechanisms that failed to activate. Even those with adequate buoyancy found the lack of crotch/thigh straps and consequent struggle to hold the buoyancy in place took all their strength, which left them with no ability to maneuver to shore. One was found, deceased, on shore with his life jacket up around his head. Without crotch straps, both survivors in the water struggled to keep the buoyancy low enough to keep their airways clear. One of the casualties, whose belt pack never inflated, managed to swim close to shore despite lack of buoyancy, but was swept away by a wave and never recovered.

The primary cause of the tragedy was the selected course, which was too close to a shoaling lee shore in conditions when breaking waves could be expected (see Chapter 4). The boat was capsized on the edge of the break zone. Better safety gear would not have prevented the capsize, but may have prevented some of the deaths.

Bryan Chong, one of the survivors, has made it his mission to share his experience so that others may benefit. Bryan describes his experience of being thrown in the water: "I couldn't tell if I was in the water for a minute or an hour, but according to Nick [the only survivor still on board] it was about 15 minutes. People have asked me if I swam for shore. The best way to describe the water in the break zone is a washing machine filled with boulders. You don't really swim. The water took me where it wanted to take me, and when I was finally able to climb from the surf onto low rocks, I heard Nick shouting from the distance for me to get to higher ground."

The statistics of this particular event: 100% of those who stayed with the boat survived; 5 out of 7 in the water died. When in cold water (51° F) and rough conditions (25-knot winds, 15-foot seas), use of crotch straps and adequate buoyancy would greatly increase survival chance. Two of the casualties wore flotation devices similar to those below. While ideal for inshore applications, they were inadequate for offshore, cold-water conditions. Choose gear appropriate for anticipated conditions.

Belt pack requiring manual inflation and secondary donning.

Zhik harness with insufficient buoyancy for offshore use.

Chapter 4—Weather Forecasting, Stan Honey & Ken Campbell

Key Concepts: Essentials of weather forecasting (OSR 6.02.9), sources, terms and definitions, logging local conditions, preparation for local anomalies.

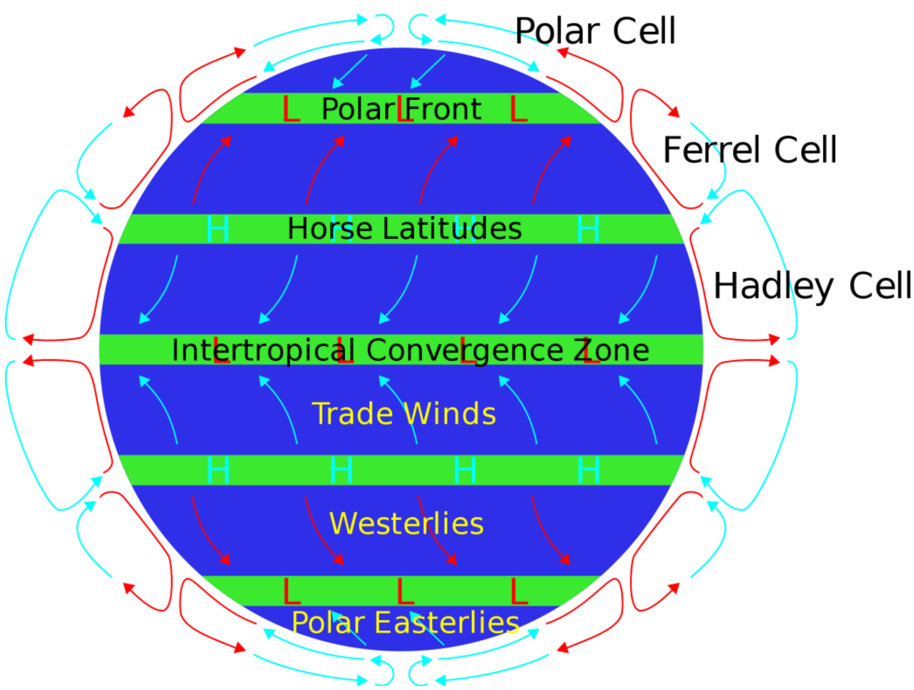
Weather forecast models:

There are several different computer-generated models used around the world to forecast the weather. The GFS is the most commonly used model and is the U.S. global forecast model. It is free and so is often used by racers who are precluded by Racing Rule of Sailing 41 from purchasing weather data during a race. It is also one of the best models. The NAM is the US high resolution model for North America. The European weather model, ECMWF, is the EU's global forecast model and is also one of the best. The UKmet is the British global forecast model. The GEM is the Canadian global forecast model; it is not very reliable. It is well known for over-forecasting tropical lows.

Forecasts are frequently different from model to model, so it is important to match the reality of your current conditions to each weather model. It is very important to watch the weather patterns several days in advance before starting a race or cruise to get a "feeling" about the overall weather pattern and the forecast reliability.

Global Weather zones:

Understanding weather forecasting begins with understanding the overall structure of global weather. Global patterns interact with local conditions to produce the weather that affects your



Credit: Burschik, Wikipedia Commons

present situation. Global weather is an often-invisible 'sea' moving above the earth's surface in three dimensions similar to the ocean currents moving below the surface of the sea. The upper levels of the atmosphere, such as the jet stream, play an important role in what happens on the surface to affect your boat. It is crucial to understand these interactions in order to prepare for developing conditions.

This simplified diagram shows the major cells of air currents, rising up into the atmosphere at the equator and at 60° latitude and sinking back to earth at 30° and at the poles. In between, the major air currents respond to the Coriolis Effect, the jet stream and local conditions.

Working from the Equator and moving towards the poles, the major weather patterns can be divided into five major zones: the Inter-Tropical Convergence Zone (ITCZ), tradewinds, horse latitudes, variable westerlies, and the polar front.

- The ITCZ is also called the Doldrums or "Le Pot-au-Noir" (Pot of black). The ITCZ will shift north during the northern hemisphere summer and south during the winter. It can be squally and unpredictable or exceedingly light, so a key tactical decision when racing is where to cross it.
- The *Tradewinds* are generally delightful and enable consistent sailing. This is home to the seasonal Tropical Lows, one of the three critical types of lows, which we will discuss in detail later in this chapter.
- *T*he *Horse Latitudes* are home to semi-permanent summertime highs, such as the Pacific High and Azores High, which have a critical impact on Transpacific and Transatlantic passages. There is generally pleasant weather here, unless you are stuck in a stationary high with no wind.
- The *Variable Westerlies* are called "the variables" because they are home to another type of low, the transiting mid-latitude lows, with their associated fronts generating wind shifts from the southwest to the northwest. Of the three critical types of lows, mid-latitude lows are probably the best understood by sailors due to TV weather reports providing widespread recognition of their associated cold fronts and warm fronts.
- Most sailors can ignore the *polar front* and polar Easterlies. Volvo and Vendee sailors make certain to stay on the equator side of the polar front and stay in the Westerlies.

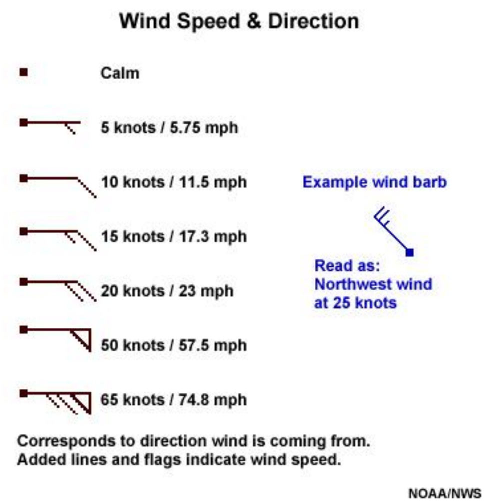
Weather maps:

The best way to predict the weather is to understand weather maps. When viewing a weather map be sure to note the "valid time" for the features shown. While a surface analysis shows current conditions, forecasts may have a valid time of 24-hours, 48-hours, or 96-hours in the future, so the features appearing on the chart may not be evident locally until later.

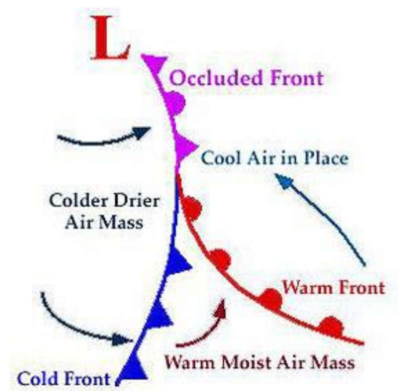
The following movements occur in the Northern Hemisphere:

- Wind flows clockwise around highs. Wind descends in highs, which causes clear skies. The locations of highs are shown with a bold **H** on weather maps. The locations of highs 24 hours before/after the chart valid time are sometimes shown by a circled **X** with an arrow to/from the valid time location. (See Surface Analysis chart at end of this section.)

- Wind flows counter-clockwise around lows. Wind ascends in lows, forming clouds. The location of a low is shown with a bold **L**. The location of the low 24 hours before/after the chart valid time is sometimes shown by an X.
- Wind arrows on weather maps fly with the wind. The feathers always point towards the low pressure. It is very helpful to remember this. The arrow feathers have the following designations: short feather = 5 knots, long feather = 10 knots each (cumulative), triangular feather = 50 knots.



Fronts are drawn by humans. This is a major advantage of weather maps; they reflect human intelligence. Cold fronts are shown with triangles. Warm fronts are shown with half-circles. The movement of the front determines which is used. For example, an occluded front, which occurs when a cold front overtakes a warm front, is shown by alternating triangles and half-circles on the same side of the frontal line. Stationary fronts, which are not moving, are shown by triangles on one side of the frontal line and half-circles on the other side.



From University of Illinois-Champaign, Dept of Atmospheric Science, WW2010

Isobars are lines of constant barometric pressure, typically depicted in millibar or hPa (hectopascal) units. Isobar spacing is conventionally in 4 mb increments. Wind speed can be inferred from isobar spacing, the curvature of the isobars, and the latitude.

Know your Lows:

There are three major types of lows: tropical lows, mid-latitude lows, and cut-off lows. It is important to understand the differences between them.

Tropical lows live in the belt of tradewinds, and are also known as tropical depressions, tropical cyclones, hurricanes, and typhoons. They are seasonal and travel east to west in the trades. The GFS weather model dramatically underestimates the strength of tropical lows, but predicts their location and movement reasonably well. It is critical to receive hurricane advisory forecasts for accurate prediction of their strength and movement.

Tropical lows derive energy from the warmth of the oceans and the release of latent heat energy from the formation of the clouds. Cold, dry air can weaken a tropical low. A concentration of thunderstorms over water temperatures of 27° C or warmer is the first sign of a tropical low forming. It is mandatory that there is no jet stream or strong winds aloft for tropical low pressure formation because thunderstorms need to develop vertically and not be torn apart by jet stream winds or wind shear.

Since the jet stream is frequently not present near a tropical low, the low's movement can be erratic and less predictable than a mid-latitude low. A tropical low is much smaller in size than a mid-latitude low, frequently only 400-500 miles across. A big tropical low might be 800-900 miles across. The strongest winds will be found within 25-50 miles of the center. Barometric pressure gradient is also much less than with a mid-latitude low.

The most dangerous side of a tropical low is the "right side" in the northern hemisphere. If the tropical low is moving east to west, this would be the north side; if it is moving from south to north, this would be the east side. Winds are strongest over a much larger area on the "right side" and the seas are also largest on the "right side." Even though sailors know that the right side of a tropical low is the dangerous side, never try to cross in front of a tropical low.

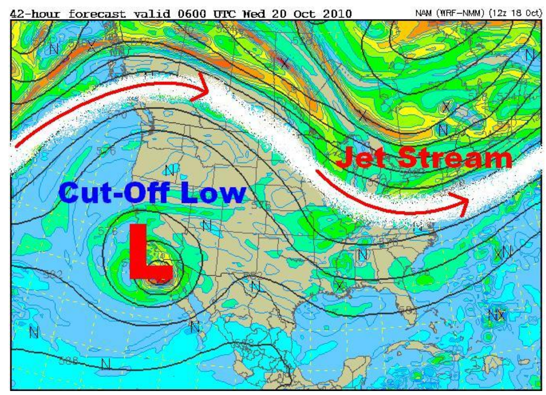
North Atlantic and northeast Pacific hurricane season is generally May to November. It peaks from late August through early October. The low is designated a tropical depression when a defined low pressure circulation exists - rather than just a cluster of thunderstorms - and when sustained wind speeds are under 35 knots. The low becomes a tropical storm, and is named, when sustained winds are 35 knots or higher over any part of the low. The low becomes a hurricane when sustained winds are 64 knots or higher over any part of the low. Tropical storms are called tropical cyclones in the western North Pacific and are given names.

Mid-latitude Lows are very different from tropical lows. Mid-latitude lows are the low pressure areas we most frequently experience in mid-latitudes, from 30° to 60° north and south. They are the traditional low pressure areas with attached fronts that move west to east in the mid-latitudes with the variable westerlies. Newly formed lows have small and intense centers. Old lows can have broad centers with light wind. Lows travel in a direction that is parallel to the isobars in the cold sector, the area between the cold and warm fronts on the equator side of the low. They move at about half the speed of the 500mb upper level wind in their vicinity. They are reasonably well forecasted by the GFS weather model.

Energy for the mid-latitude low comes from a mixing of cold and warm air, such as when east coast storms move from land to over the ocean. The greater the temperature contrast, the stronger the low can become. This is why the strongest lows in the northern hemisphere occur during late October through December, and again February through April. Warm currents like the Gulf Stream, Kurishio, East Australian (EAC), and the Agulhas can increase the temperature contrast, which makes these areas breeding grounds for strong lows. These storms can be very large - 3000-5000 miles across - which makes them very difficult to avoid completely. In the northern hemisphere, they will have a warm front to the east of the low, where east winds shift to south as the front passes. They will have a following cold front where south winds shift to west and northwest as the front passes.

As the cold and warm air mix within the low and the air mass becomes more homogeneous, the low will weaken and the winds will diminish. This is the occlusion phase of the storm's life cycle. However, even though winds diminish, the leftover seas can still be large, leaving rough conditions in spite of the diminished winds. This is the "washing machine" phase with little wind, but agitated seas.

Cut-off lows are critical for a sailor to understand. This will be on the final exam, so memorize it. Cut-off lows occur when a mid-latitude low is removed from the jet stream. They have unpredictable movement as they are "cut off" from both the easterly tradewinds and the westerlies. Many times, but not always, the low is weak and the wind field near the low is also weak. Their movement can be erratic. They sometimes move quickly, but can stay stationary for days.



From Mark Fisher, unofficialalpine.com

Cut-off lows can be extremely dangerous and should be avoided. They have their origins in the lower latitudes - south of 30N and north of 30S - and can have some tropical low pressure characteristics. They can transition into a tropical low if they remain over warm water and the jet stream is non-existent. Examples of deadly cut-offs include the Halloween Storm of 1991 (famous as "The Perfect Storm" in book and movie) with 8 mariner fatalities, the Fastnet race in 1979 with 18 fatalities, the Sydney-Hobart race in 1998 with 6 sailor fatalities, and Hurricane Sandy. These were all strong cut-off lows that mixed tropical characteristics with a mid-latitude weather system. When two extreme weather systems merge, they can result in extraordinary weather. (For an excellent review of the 1979 Fastnet Race, see John Rousmaniere's *Fastnet, Force 10: The Deadliest Storm in the History of Modern Sailing.* For an excellent book on the 1998 Sidney-Hobart race, see G. Bruce Knecht's *The Proving Ground.)*

These are some danger signs to watch: tight core at the center of the low, rapid pressure drop, significant temperature gradient on the polar side of the low, a comma shape, and fast-moving jet stream over the top which can be seen in the 500mb charts.

Squalls and thunderstorms:

There are three types of squalls/thunderstorms: those associated with a cold front or low pressure area, the "air mass" thunderstorm, and tradewind squalls.

Cold front thunderstorms develop along the leading edge of a cold front. Remember, the cold front brings a wind shift from the south or southwest into the west and northwest. The cold front also brings a change in temperature and increased dryness of the air. Thunderstorms develop vertically into the atmosphere, reaching heights of 40,000-50,000 feet. The rule of thumb is the taller the thunderstorm, the more violent the weather will be. Taller, more violent thunderstorms will be preceded by an area of high clouds that spread out from the top of the thunderstorm, moving with the jet stream. Since these higher clouds appear overhead before the thunderstorms arrive in your area, they will give you an early warning signal of an approaching squall line.

When thunderstorms develop up into the jet stream level - which moves faster than the cold front - they will move out in front of the cold front. Thunderstorms can precede the cold front by several hours. If this happens, there will be a weather lull between the squall line and actual cold front. But if the lull lasts for more than three to four hours, there could be a second squall line closer to the actual cold front.

Air mass thunderstorms form inland during the afternoon and move very little. During late afternoon and evening, when the afternoon sea breeze weakens and ends, thunderstorms will move towards the shoreline. If the thunderstorms persist long enough, they can bring squally weather to the coast around and after sunset. The Florida coast, parts of the Central American coast, Africa, and Brazil are notorious for the late afternoon and evening squally thunderstorms, especially during the summer seasons.

Tradewind squalls are typically smaller, less developed, and less violent than thunderstorms. A simple rule of thumb is: the taller the cloud, the stronger the squall will be. They generally move from east to west in both hemispheres. They are strongest two to three hours before sunrise. They are weakest from late morning thru mid-afternoon. Mid-morning showers can cause very large areas with very little wind. Squalls that form around or just after sunset can also be gusty.

Sea breezes and land breezes:

A *sea breeze* is an afternoon wind that blows onshore and can cause a significant increase in wind speed. Typically a sea breeze is preceded by a calm period during the morning. As the land warms, the sea breeze increases. Since the warming air is less dense, it rises and creates a low pressure area, which pulls cooler/denser air in from the ocean. Sea breezes can extend 30-40 miles offshore during the late afternoon. Sea breezes can be predicted by the rapid improvement in visibility when looking at the horizon out to sea, coupled with the appearance of cumulous clouds over land. A sea breeze will end quickly during the evening as the land cools and can leave a large, very light wind area within 5-10 miles of the coastline.

A *land breeze* is a late night wind that forms at the shoreline as the land cools more than the sea. Since the land must be colder than the ocean, clear nights are most vulnerable to a land breeze. Land breezes can be predicted by the rapid drying of dew on deck. Typically, a land breeze is a soft wind coming off the shoreline. But when the shoreline is elevated or mountainous, such as with the Adriatic coastline of the Balkans, the land breeze can be briefly quite strong around sunrise; 20-plus knot northeasterly and easterly winds are common late at night along the Balkan Adriatic shoreline.

Storm avoidance:

Crucial to storm avoidance is early planning and understanding the seasonal changes in storm patterns. Large mid-latitude lows will be impossible to avoid all together, but try to be as far away from the center of the low as possible. It is also helpful to be on the downwind side, but that is not always possible. If going upwind, try to limit the time on the tack heading into the low. There is an excellent discussion on hurricane avoidance from the National Hurricane Center. (See http://www.nhc.noaa.gov/prepare/marine.php)

Be sure to plan early, realize the potential for errors in predicted storm tracks, and remember hurricanes are relatively small compared to mid-latitude Lows. The GFS model dramatically underestimates the strength of hurricanes, but does a satisfactory job of predicting their movement. However, skilled and trained experts pay close attention to the forecasts for hurricane movement and strength, so it is essential to receive and consider NHC, Marine Prediction Center, and Tropical Prediction Center advisories in addition to grib (gridded binary data) file forecasts.

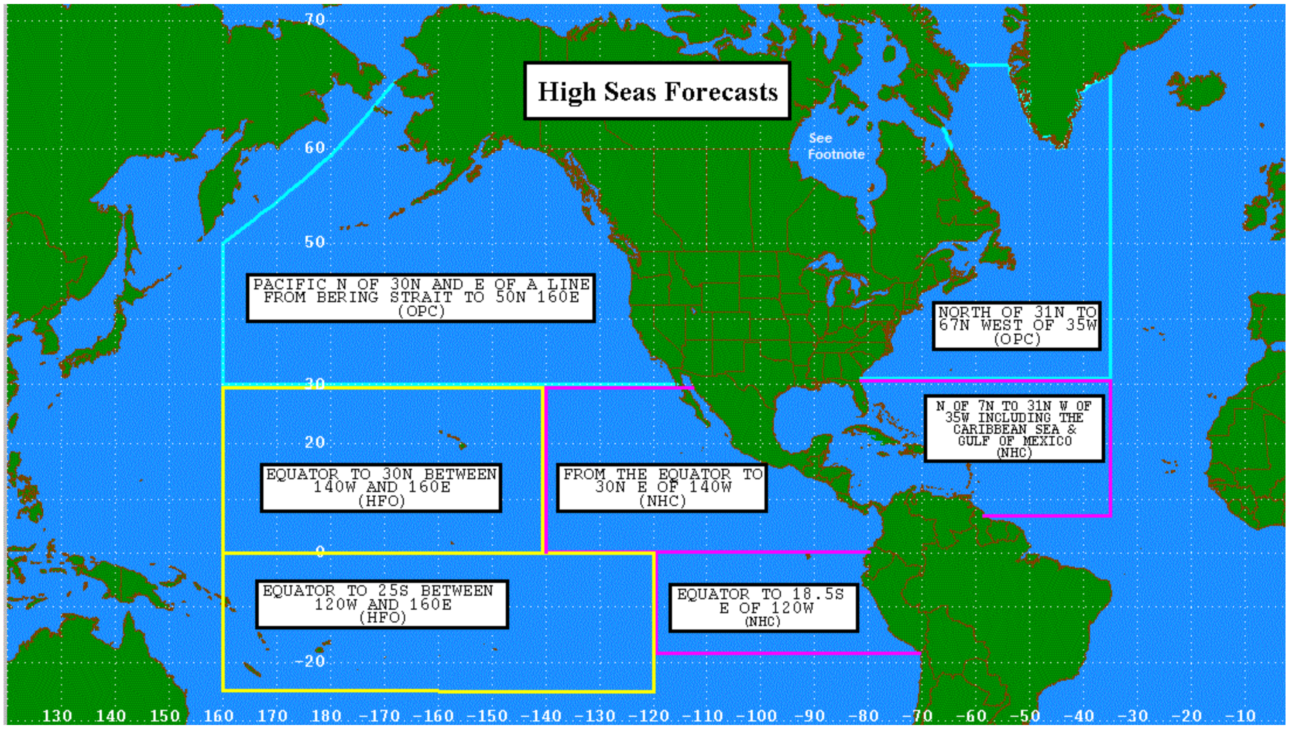
Sources of Weather Forecasts:

There are multiple weather forecast sources, including NOAA text/voice forecasts, NOAA graphic forecasts, NOAA and U.S. Navy forecasts in grib format, private forecasts, forecasts from non-U.S. sources, and sea-state forecasts.

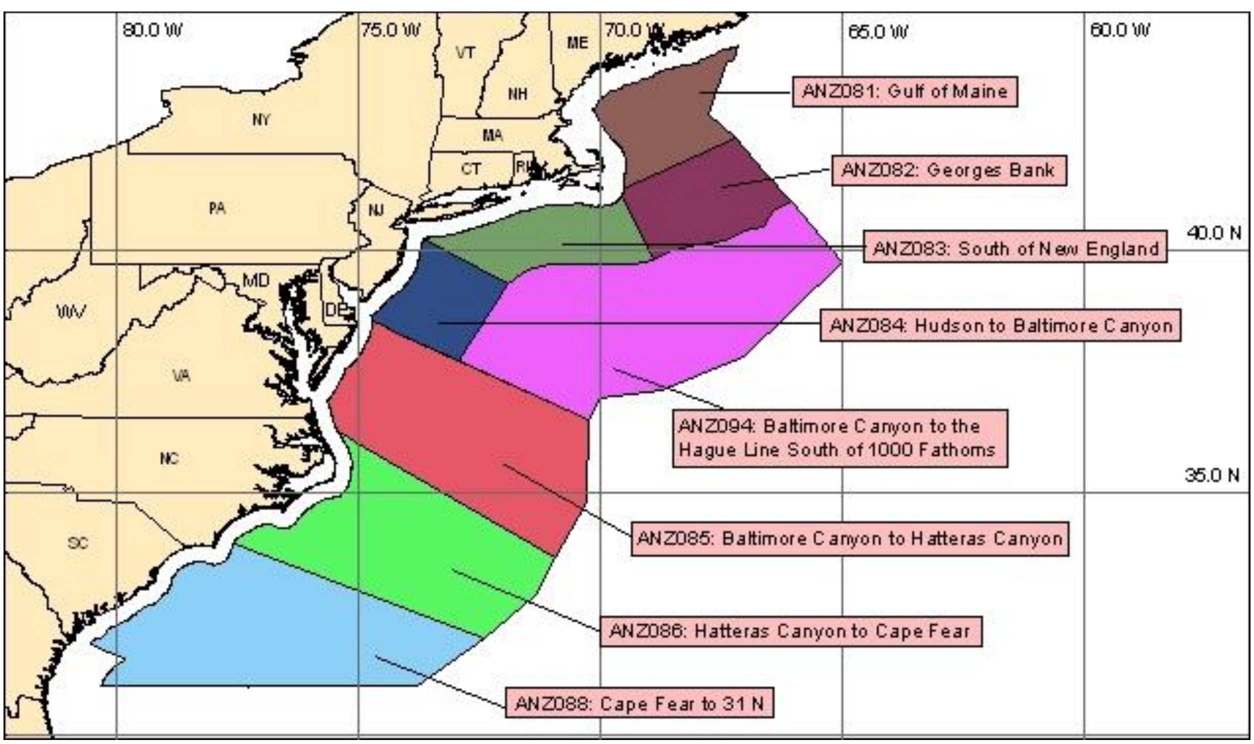
NOAA text/voice forecasts are the best source of formal weather warnings, such as small craft, gale, storm, hurricane, etc. Memorize exactly what these terms mean. This will be on the final.

- *Hurricane*: 74 knots or more. Note that the wind does not have to result from a tropical storm or classic “hurricane” to cause Hurricane warnings.
- *Storm*: 48 knots or more
- *Gale*: 34 to 47 knots
- *Small Craft Advisories*: varies by location but often 25 to 33 knots

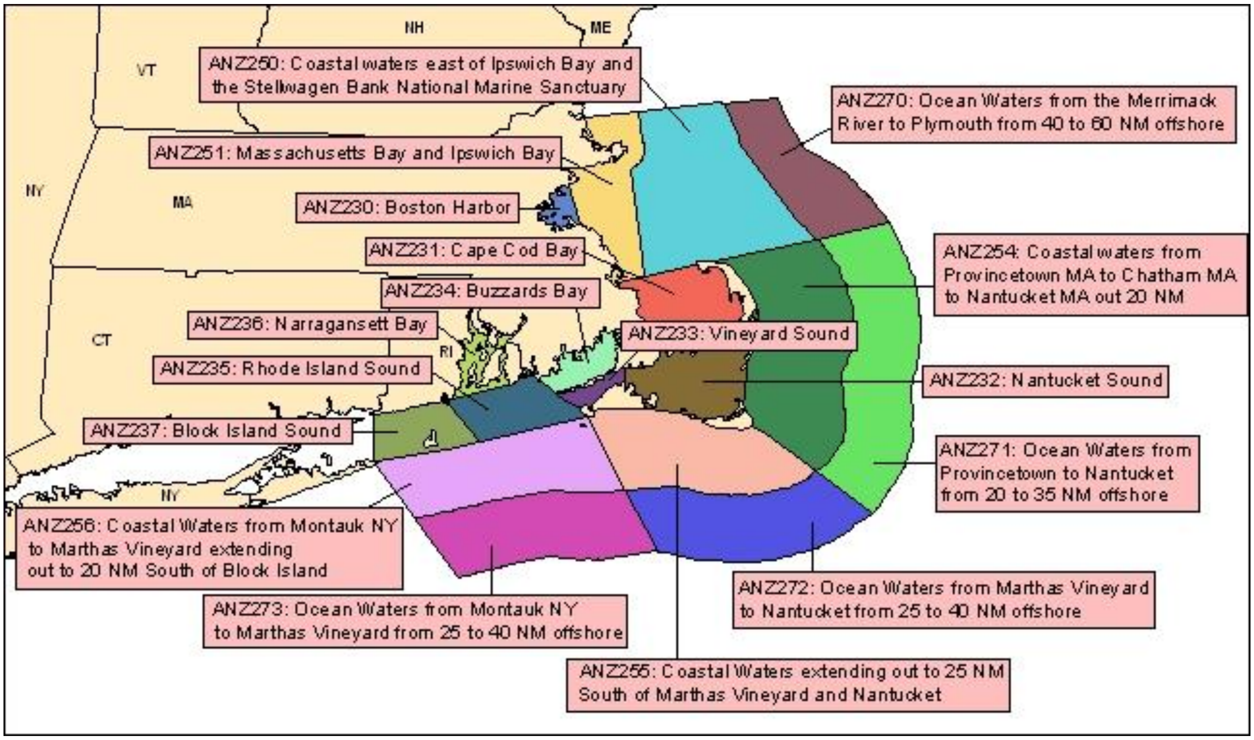
Coverage Areas: NOAA text/voice coverage areas are specified on the NOAA website. These areas vary and are much easier to understand from the coverage graphic plots than from the text descriptions of the areas. Here are some samples of coverage graphic plots.



NOAA High Seas Forecast Areas



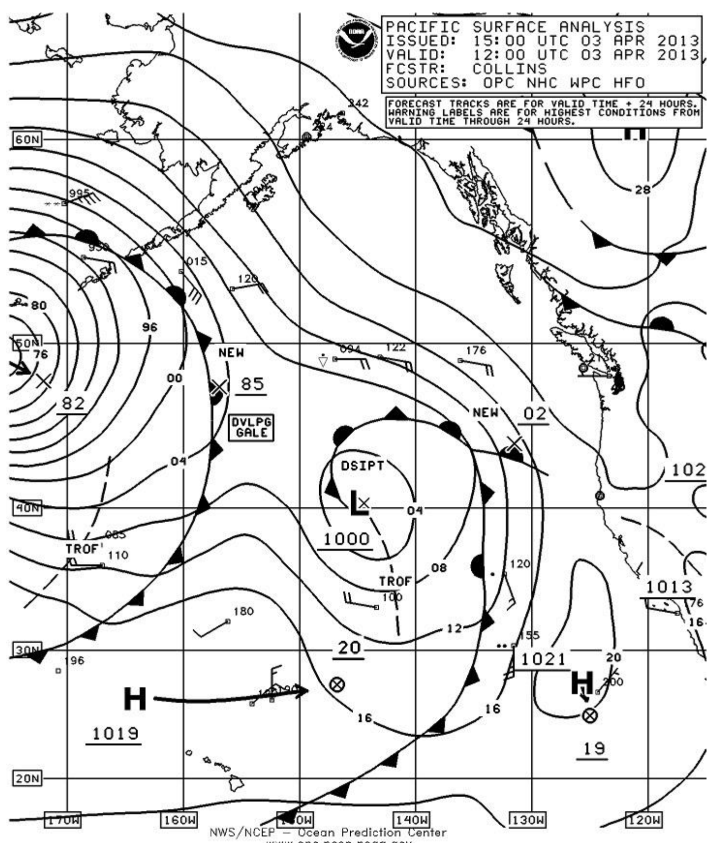
NOAA Offshore Forecast Areas



NOAA Coastal Waters Forecast Areas

NOAA forecasts are very good and are written by humans (as opposed to computer-generated) who do it daily so they develop valuable local knowledge. NOAA text forecasts draw clear attention to wind and sea warnings, and they are free. NOAA High Seas, Offshore, and Coastal forecasts are available via the web, FTP, email, and voice radio transmission (HF and VHF), as well as a variety of private weather services that forward them in various formats.

NOAA graphic forecasts are traditional weather maps. They include wind/wave, surface, upper air, tropical cyclone, ice, and satellite image charts. Since they are drawn by individuals, they incorporate "genuine" intelligence. Warnings are shown, such as "dvlpg gale," front locations, and frontal types. The forecasts are available from the web, via FTP, and via traditional HF weatherfax, which can be received over SSB radio using a PC and an inexpensive interface.



In addition to these sources, NOAA has been very aggressively introducing new graphic interfaces to access their forecast data, marine and otherwise. Be resourceful and look around on the NOAA website for their latest products.

NOAA and US Navy forecasts are available in *grib format.* NOAA GFS data is available directly from NOAA if you are resourceful, but grib files are more easily retrieved from Saildocs, Great Circle, UGrib, Mailasail, Zygrib, Theyr, or Predictwind, all of whom provide free NOAA GFS grib data via email and/or FTP. There are other free vendors as well. During a race, unless the organizing authority changes RRS 41, it is only legal to use a free source of weather data. Grib data is terrific for routing and has worldwide coverage - which is very helpful as certain parts of the world are no longer covered with weatherfax maps - but do note that GFS grib files underestimate the strength of tropical lows and do not show the location of fronts.

Private forecasts are available through highly trained expert meteorologists who can provide specific forecasts prior to a race, as well as before and during any offshore passage. These forecasts are legal prior to the start of most races but not legal during a race, unless the organizing authority has changed RRS 41. Custom forecasts can be extremely useful to pick a departure time for a non-race offshore passage or boat delivery, and are very affordable.

Forecasts from non-US sources will likely give wind speeds based on the Beaufort scale. (See Beaufort descriptions in the following section.)

Be aware that for forecasts from any source wind gusts can exceed the forecast wind speed by 40%. Also, forecasts overlook small, but potentially severe features like thunderstorms and waterspouts.

Seastate forecasts: As noted elsewhere in this publication, the forecast “significant wave height” is the average height of the highest third of all waves. Individual waves may be more than twice the stated significant wave height. A seamanlike practice is to stay in water that is at least three times the depth of the significant wave height, or 2.5 times the sum of the forecast swell and wind-wave height.

Additional sources of weather background information include college courses, commercial maritime courses such as the USCG license course “Advanced Meteorology for Masters and Mates”, and the following books:

- *Meteorology Today* by C. Donald Ahrens, a good introductory text on meteorology
- *Bernot on Breezes* by Jean-Yves Bernot, particularly useful for inshore racers
- *Weather at Sea* by David Houghton. All of Houghton’s books are worth reading
- *Heavy Weather Avoidance and Route Design, Concepts and Applications of 500MB Charts* by Ma-Li Chen and Lee Chesneau, for the committed navigator

Recommended Practices:

It is best to start monitoring the weather a few weeks in advance of a race or offshore passage. See what is available online and closely follow the sources of weather information that you will have available on the passage. These sources must be free (when racing) and retrievable using the technology you will have available onboard. Review prior races and/or passages and their weather patterns if they are available.

During the passage, review the weather and your course selection four times per day when the forecasts become available. Brief the crew four times per day on the big picture, as well as the expected conditions and objectives for the next 6-12 hours. Keep a log of the sky appearance, seastate, barometric pressure, wind direction and speed. Include notes in the log of every crew briefing. Finally, always watch the sky and become a student of it.

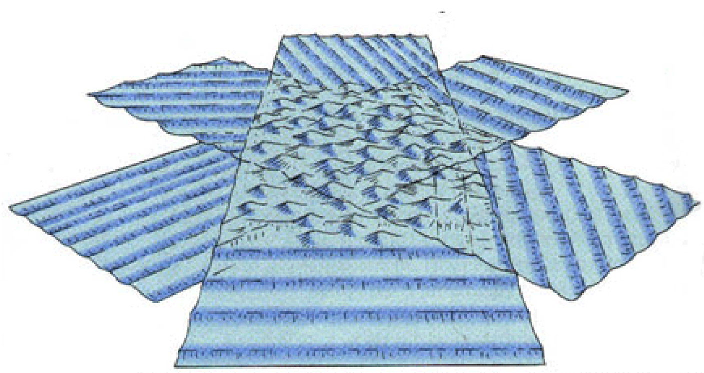
Beaufort Scale: The Beaufort Scale was invented in 1805 as a way to standardize descriptions of weather conditions. For each number over Force 5, consider a reduction in sail area. Photos courtesy: John Jourdane.

Force 0 – Calm: Sea surface smooth and mirror-like 	Force 2 – Light Breeze 4-6 knots: Small wavelets, crests glassy, no breaking 	Force 4 – Moderate Breeze 11-16 kts: Small waves 1-4 ft. becoming longer, numerous whitecaps 
Force 5 – Fresh Breeze 17-21 kts: Moderate waves 4-8 ft taking longer form, many whitecaps, some spray 	Force 6 – Strong Breeze 22-17 kts: Larger waves 8-13 ft, whitecaps common, more spray 	Force 7 – Near Gale 28-33 kts: Sea heaps up, waves 13-19 ft, white foam streaks off breakers 
Force 8 – Gale 34-40 kts: Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks 	Force 9 – Strong Gale 41-47 kts: High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility 	Force 10 – Storm 46-55 kts: Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility 
Force 11 – Violent Storm 56-63 kts: Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced		Force 12 – Hurricane 64+: Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced (two square flags)

Wave Development, Jim Corenman, Jim Antrim & Sally Lindsay Honey

Key Concepts: How waves develop, forecast sources, definition of SWH; what changes wave shape, height, direction; unusual waves, seamounts; effects of shoaling and lee shores, how to determine safe depth.

Waves develop as a result of wind blowing for a certain amount of time (duration) over a certain distance (fetch). The stronger the wind and the longer the fetch, the higher the waves become over time. Ocean waves that move beyond the place from which they were generated become deep-water swell and underlie the surface waves that are kicked up by local wind effects. Ocean swells travel great distances and inevitably encounter swells of different lengths and heights generated in other areas. In this way, a typical sea-state is made up of a mixture of deep-water swells and waves from many different sources, which all combine to form the apparent chaotic ocean surface known as the wave spectrum. Periodically the wave peaks will coincide to produce especially large waves, and at other times they will virtually cancel each other to form relatively small waves, so there is no single "wave height" that will describe all waves at a given place and time.



The ocean waves that we observe are a complex of many different sets of waves of different wave lengths, periods and heights.

From geology.uprm.edu/Morelock

Wind is always changing in strength and direction. New waves are forming all the time; ripples, chop, bigger waves, and swell. They all pile on top of each other, usually from a variety of directions. This action forms lulls, wave sets, "rogue waves" and "sneaker waves."
from Jim Antrim

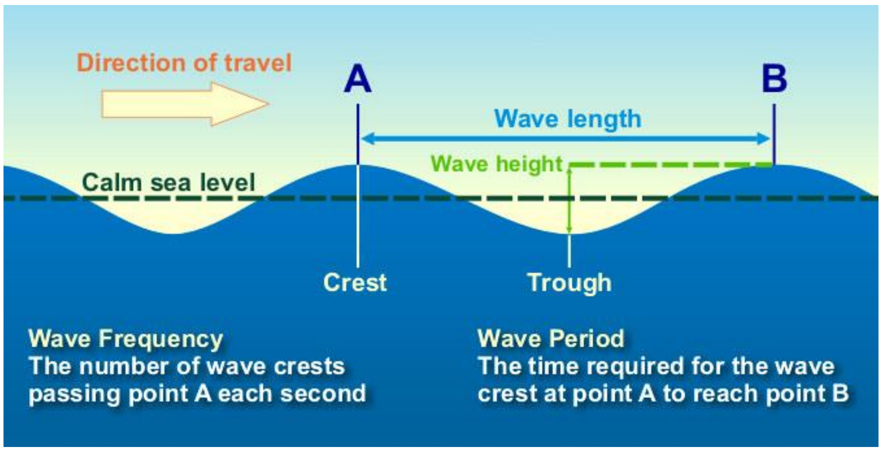
Because there is never one specific wave height, oceanographers use a statistical analysis to forecast "Significant Wave Height (SWH)," which is defined as the average of the largest one-third of all waves. This is the wave height that an experienced observer will typically report. The actual wave height at a given time and place can be much higher, as much as twice the forecast SWH. The following table shows the likelihood of actual wave heights given a forecast Significant Wave Height of 10':

Forecast "Significant Wave Height" (SWH) of **10'**
Mean Wave Height = **6.4'**
Highest 10% of waves = **12.7'**
Highest 1% of waves **16.7'**
Max wave height to be expected = **20'**

(For a fuller explanation of waves, see "Significant Wave Height, A closer look at wave forecasts" by Tom Ainsworth, NWS Juneau, Alaska http://www.mxak.org/weather/pdfs/waves.pdf).

Wind waves are independent of the swell and add to the wave height. The resulting "Combined Seas (CS)" is the square root of the sum of the squares of the swell and wind waves. The National Weather Service considers CS equal to significant wave height.

Waves are defined by four components: height (trough to crest), length (distance between crests), period (time elapsed from the passage of one crest to the next), and steepness. Steepness is the ratio between height and length, which can be approximated from period. Equal wave height and period indicate steep waves, which are a particular danger to small boats. When wave steepness exceeds 1/7, the wave will begin to break. This generally happens in 12-15 knots of wind.



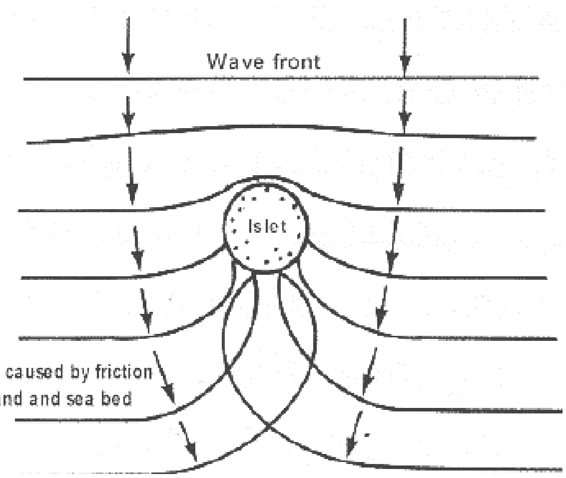
NOAA image

There are a number of influences that that can change the shape, height and direction of the deep-water swell, including reflection, refraction and current.


Wave Interactions and Interference

Reflected waves occur when waves bounce back from an obstruction and combine with the waves still approaching the obstruction. The phenomenon can sometimes be seen many miles off a steep shore. For example, reflected waves have been seen as far as 15 miles off the California coast where the shore falls steeply into the ocean.

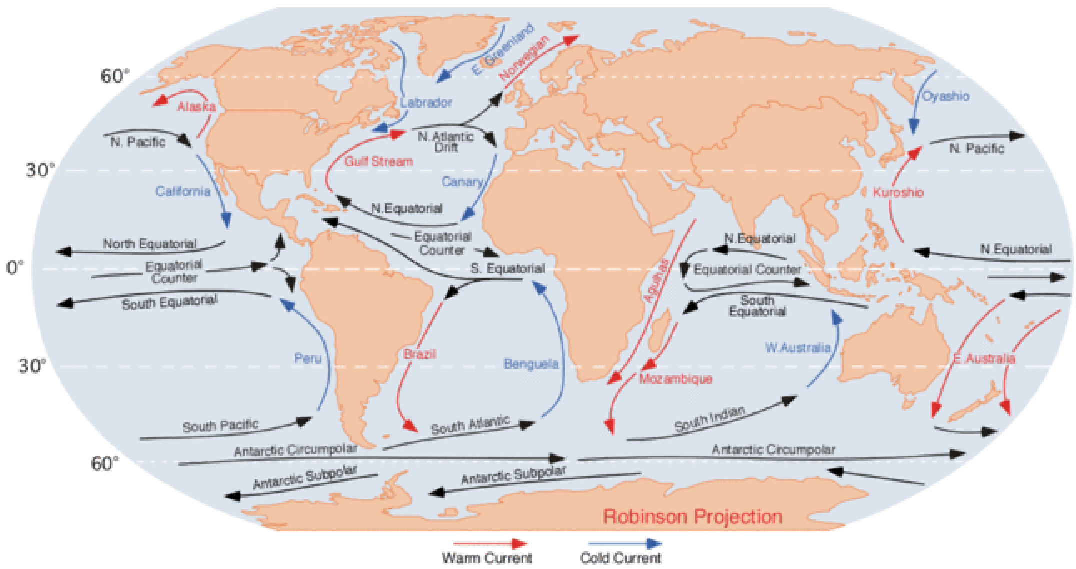
Refracted waves occur as the waves are bent around projecting land. The shallower water, which is closer to land, slows the land-side of the wave, causing the wave to bend (refract). Around a headland, wave energy focuses on the tip of the point. The waves will wrap



From geographyfieldwork.com

around the tip and erode the land just behind the point to form a tombolo, a very thin strip of land leading out to what would otherwise be an island. When waves rejoin on the down current side of an island, they can augment each other to form larger, sometimes breaking, waves.

Current: When current opposes the wind, waves can build quickly to steep and dangerous proportions. Common examples include the Gulf Stream, the Agulhas current, and cases where wind opposes tide, e.g., San Francisco Bay during a strong ebb.



Major currents of the World, Wikipedia

Unusual Waves, sometimes called 'rogue' waves, result from the infrequent amassing of smaller waves to form a larger than normal wave. These occur much less frequently than the 2.0 x SWH described above and often appear from a different direction than the main wave pattern. They can appear as sudden breaking seas and cause unexpected damage in an otherwise manageable sea state. Factors which contribute to exceptional seas include wind opposing current, multiple wave patterns occasionally combining to form a single breaking sea or a set much larger than the average, length of fetch, and shelving, shoaling or promontories. Exceptional waves are known to occur along the Alaska, British Columbia, Washington, Oregon, and California coastlines; in areas affected by the Gulf Stream and Agulhas currents; and in the Tasman Sea, Cape Horn, Bay of Biscay, North Sea, and southern tip of Norway and Ireland. (From John Neal)

Cortes Bank, Photo credit Keith from SurferMag.com

Underwater bathymetry: Seamounts such as the Cortes Bank, which is 100 miles off the coast of San Diego, can create 14' breakers in the middle of an otherwise calm sea. Seamounts affect surface conditions throughout the

Pacific, Atlantic, and Indian oceans.

The Effects of Shoaling/Lee Shores: In shoal waters, waves change character, not just height & length. In deep water, the apparent "movement" of a wave is actually a moving pulse of pressure with individual water particles rotating within the wave crest as the pulse passes. As waves encounter shallow water and "feel the bottom," they slow down. However, the period is unchanged so the longer, open water wave becomes a slower, taller wave. The wave height increases as the depth decreases until the wave becomes unstable and breaks. As the wave breaks, the water particles no longer rotate within the wave crest, but instead rush down the face. If the breaker forms gradually (e.g., on a gently-sloping beach), then the waves will form "spilling" breakers, with the water tumbling down the sloping face of the wave. If the breaker forms quickly (e.g., a faster-moving wave and a more steeply-sloping shoreline), then a "plunging" breaker forms with the face becoming vertical, curling, and then collapsing into the trough like classic surfing waves. The plunging breaker generally incorporates more energy and can therefore be more dangerous. ("Shallow Water Waves", COMET MedEd Program, http://www.meted.ucar.edu/marine/SWW/print.htm)

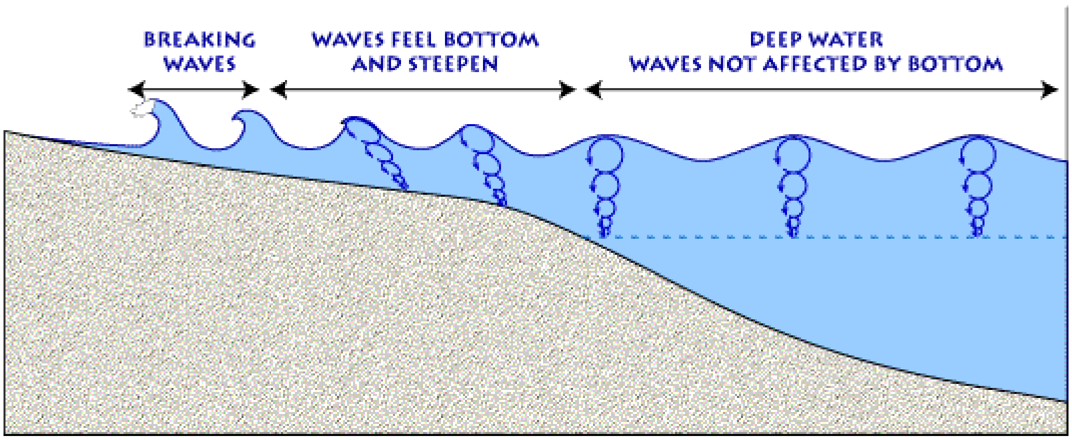


Figure From: USGS "Park Shorelines"

Breaking waves are much more dangerous than significantly larger ocean swells. The surface force of a breaking wave has the tendency to turn a boat broadside - the "log effect" - which renders the boat extremely vulnerable. A breaking wave equal in height to the beam of the boat is likely to capsize the boat.

The critical question for sailors is at what depth breakers will form when approaching a lee shore. There is a series of calculations beyond the scope of this chapter that answers that question. Factors that affect whether a wave will break in shallow water are the size and steepness of the wave, the depth of the water, and the shape of the bottom contour. Wavelength and wave period are related. For instance, the wavelength (L) of a wave with a 14-second period is 1000 ft. Depths over half of that (L/2 or 500') are considered "deep water" and depths of less than L/20 (50') are considered "shallow water" for wave dynamics. The height of a breaking wave depends on the deep-water wave steepness as well as its height, and also on the bottom slope. This is described as a "shoaling factor," which is the ratio between the deep-water wave height and the height of the breaking wave. Its value is found from an empirical nomogram from the deep-water wave steepness and the bottom slope. To find the breaking depth - the water depth where waves will break - one more term is needed, the "breaker steepness," which is a measure of the breaker height relative to the original (unchanged) period. Specifically, it is the breaker height divided by (g x period squared) where "g" (gravity) is 32 ft/sec^2. The "breaking depth coefficient" can then be found on another empirical nomogram, which again is a function of the steepness of the bottom slope. This coefficient is then multiplied by the shoaling breaker height to find the depth at which the wave will break.

Fortunately, for the sailor approaching a lee shore, there are several simple rules of thumb to calculate safe water depth from a given weather forecast. Those specified below are for a forecast of 7' wind waves on top of a 15' swell, which were the conditions for the following case study from the Low Speed Chase tragedy.

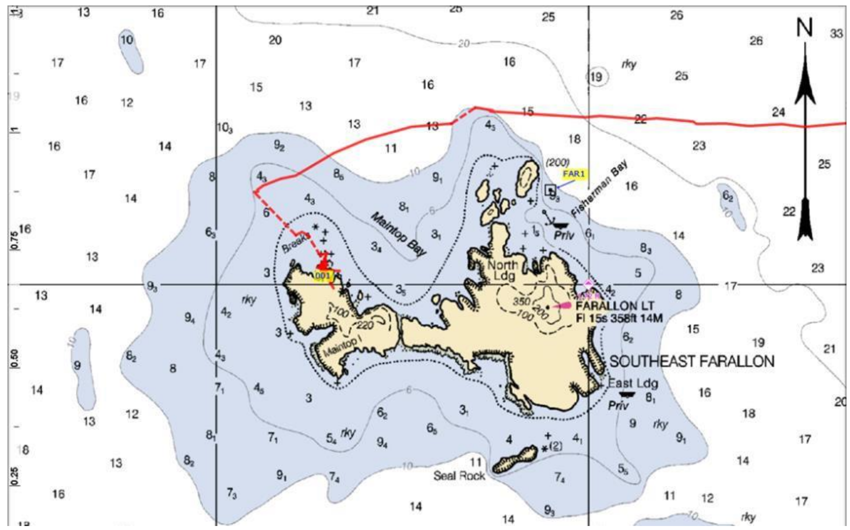
What Depth is Safe for forecast 15' swell + 7' wind-wave?
3 ways to calculate Safe Depth from Wave Height Predictions:
1. Cosmic: Depth = Sqrt (Swell^2+ Wind-Wave^2) x 2 x 1.3 > 43'
2. Stan Honey: Depth = 2.5 x (Swell + Wind-Wave) > 55'
3. Max Ebb: Depth = 3 x Swell (or 4 x Swell) > 45-60'

Bottom line: be aware of the many factors affecting wave formation and the variety of wave heights and characteristics in any given sea-state. Know how your particular boat will handle waves from the bow, the quarter, and abeam, and be ready to orient your boat to best advantage in any given sea-state. Avoid shallow water and lee shores. Remember you will not be able to see breaking waves as you approach from the deep water side.

Case Study: Low Speed Chase

Synopsis of events: On April 12, 2012, a normal spring sailing day in San Francisco turned tragic. The Full Crew Farallones race has one turning mark, the SE Farallon Island, 26 miles west of San Francisco near the edge of the continental shelf. The northwest corner of the island features a rock-strewn shoal with depths of less than 6 fathoms, extending 1000' offshore. In typical winds, this is a treacherous lee shore with continual breakers over exposed and partially submerged rocks. This day was no exception. The coastal waters forecast on the morning of the race was for northwest winds 15 to 25 knots, wind waves 3 to 7 feet, northwest swell 12 to 15 feet at 13 seconds.

As the Sydney 38, *Low Speed Chase*, rounded the northwest corner of the island, they bore off to a course that took them over the 4-fathom shoal in 28' of water. They encountered breaking waves when less than 0.2 nm (400 yards) off the northwest point. A set of larger than normal waves capsized the boat, throwing seven of the eight crew members into the water. The one crew who stayed on board survived. Of the seven in the water, five drowned.



LSC course over the 4-fathom shoal. They capsized at the 90-degree turn in their course

The charted depth where *Low Speed Chase* capsized was 27 feet. Had they heeded the calculations below and sailed in marginally deeper water, they likely would have prevented the tragedy.

Foam line shows breakers forming where *Low Speed Chase* capsized.

S.E. Farallon Island viewed from Maintop

Actual conditions at the time of the capsize were calculated from data recorded by a Waverider buoy located 25 miles northwest, directly upwind, of the Farallones, with adjustment made for travel time over those 25 miles. It showed a significant wave height of 14.4 feet at 14.3 seconds, indicating the largest 10% of the waves could be expected to average 18 feet and the largest 1% would average 24 feet. Those on board could have predicted that 2-3 times an hour there would be a wave of up to twice the significant wave height of 14, which would be 28 feet. The shoaling effect of this point on the Farallones would increase the height of the largest wave to 31 feet and create “plunging” breakers, which become vertical, curl and collapse. This is consistent with observations reported by the survivors of *Low Speed Chase*. A common rule of thumb is that a wave will generally break in depths less than 1.3 times the height of the wave, which means it could be predicted that a few waves on this day would break in depths less than 38-40 feet of water.

There are several ways to calculate safe minimum depth from a given weather forecast. Forecasts typically include a swell forecast (i.e. waves from outside the immediate area) and wind-waves generated by the forecast winds. These are usually given as a range, and the maximum forecast for each should be used.

The mathematically-inclined could combine swell and wind-wave significant wave heights as the square-root of the sum of the squares, multiply that by 2.0 to get the largest expected wave, and then multiply that number by the 1.3x rule-of-thumb to get minimum water depth, adding some margin in case the waves are larger than forecast. Doing this for a forecasted 15 foot swell and 7 foot wind-wave would yield a minimum depth of 43 feet, to which some margin needs be added.

Stan Honey uses a simpler rule for minimum depth: 2.5x the sum of the maximum forecast swell and wind-wave heights. This sum will be larger than the square-root of the squares, which adds some safety margin. For our forecasted 15 foot swell and 7 foot wind-wave, this calculation would yield a minimum depth of 55 feet.

Another rule for minimum depth is to simply multiply the deep-water significant wave height by 3 (or 4, for some additional margin)[1], which would indicate a minimum depth of 45-60 feet for our 15 foot swell forecast.

It is unclear whether LSC could have avoided capsize at the first signs of breaking waves; there was a prior wave that broke very close to the boat. Of the 14 GPS tracks submitted by the boats racing that day, one other crossed the shoal at the same 28 foot depth and four others crossed inside the 6-fathom line. They were lucky. *Low Speed Chase* was not.

---

[1] “Max Ebb’s Breaking Point”, Latitude 38 June 2012 pg. 06-108, http://www.latitude38.com/eBooks/2012/L38201206.pdf
Credit to The COMET Program, Shallow Water Waves, 2012 Update http://meted.ucar.edu/marine/SWW

Bascom, Willard, Waves and Beaches: The Dynamics of the Ocean Surface, Revised and Updated, Garden City, 1980
Ainsworth, Tom “‘Significant Wave Height’: A closer look at wave forecasts”, NWS Juneau, Alaska, http://www.mxak.org/weather/pdfs/waves.pdf
“Shallow Water Waves: 2012 Update”, Copyright 2012, University Corporation for Atmospheric Research (http://www.ucar.edu).
“Shallow Water Waves”, COMET MedEd Program, http://www.meted.ucar.edu/marine/SWW/

Chapter 5—Heavy Weather Sailing, Dawn Riley

Key Concepts: Prepare in advance; know how to shorten sail; learn to use storm sails in moderate air before needing them in heavy air (OSR 4.26).

Heavy air and storm conditions are not something we sailors seek out, but we absolutely need to be prepared for them. When we go to sea, we try to plan a safe and fast voyage. Sailing expert Stan Honey points out that, for the uber-powerful multihulls he sails, the fastest route is often in moderate and consistent weather conditions. It does not make sense to go all *Rambo* and try to find the heaviest winds, but sometimes we cannot avoid them. Here are some tricks for making sure you are prepared to face heavy weather.

I recommend a three-pronged attack: *education, preparation, and practice*. In my opinion, the last is the most important and often the most overlooked. Learn how to anticipate heavy weather and prepare your boat with the proper tools for it. Plan the best means of surviving on *your* boat, knowing that techniques that work on another boat may not be best for yours. Visualize what you will do, try it out. Establish routines suitable to *your* crew and their specific skills. Set policies for when to wear life jackets and when to tether into jacklines. Make sure you have strong, small sails and a reliable means of setting them and that the crew knows procedures for when and how to shorten sail. Set your storm sails in moderate air before you need them in heavy air. Understand how challenging winds and

seas can affect your particular boat and train the crew in appropriate techniques to manage them. Most important: *practice*. Practice with the entire crew. Practice reefing, shortening sail, using tethers, and responding to damage and emergencies.

You can't always avoid heavy weather, so it is essential that you and your crew know how to keep the boat—and yourselves—safe, whatever your offshore passage brings. This chapter offers some possible solutions for the challenges you may face.

ESTABLISH SAFETY PROCEDURES BEFORE SAILING AND ENFORCE THEM DURING THE PASSAGE

The best way to survive an offshore passage is to stay attached to the boat. Theoretically, if you do this successfully you will never need a life jacket. I believe safety harnesses are the most important piece of personal safety equipment on board. Run your jacklines and ensure that all crew members have appropriate personal safety gear: life jackets, harnesses, and proper tethers (OSR 5.01, 5.02). Make sure your harness fits you properly and adjust it to suit your wardrobe as the weather changes. There is a big adjustment required in a harness when you go from wearing a bikini to wearing eight sets of long underwear and foul weather gear.

Establish safety rules and stick to them. Proposed US Sailing guidelines say "Life jackets and harnesses shall be worn when the vessel is reefed, in conditions when overboard recovery would be difficult, or when the captain or race committee requires it." In addition, I recommend the following:

- Use harnesses offshore whenever it is blowing harder than 15 knots, when reefed, and in all conditions when it is dark.
- When wearing a harness, clip in. Announce you are going to do it—then do it.
- Have a life jacket policy for the entire crew. In my opinion, you should wear a life jacket
    - Whenever you are likely to fall over, e.g., slippery deck, rough seas, unfamiliar boat;
    - Inshore and offshore when the winds are above 15 knots;
    - At night, always.
- Make sure everyone on board helps police as well as follow these rules.

- Make safety your priority and trust your team to accommodate unusual circumstances. It is better to come on deck two seconds late while the other watch stands by than to arrive on time, but become incapacitated due to insufficient preparation.

Remember no one should be above following safety protocols, no matter how many times they've sailed. Too often it is the most experienced person on board who dies because they think that they do not need to take as many precautions.

TRY TO AVOID HEAVY WEATHER THROUGH BOTH MODERN AND ANCIENT METHODS

Before you leave the dock, research expected weather conditions for your planned departure date. If possible, avoid departing into threatening conditions. Do not time your departure based on business or vacation schedules. If you are already at sea and you encounter heavy weather, decide if you can make it to a safe harbor even if that was not your initial intended destination.

How do you determine if heavy weather is imminent and how long it will last? How do you deal with the conditions when they arrive? How do you know when changes in depth or a lee shore will dangerously affect the sea state? How do you determine if you can safely enter a harbor of refuge? In addition to the weather prediction tools listed in the previous chapter, here are some tricks for predicting changing conditions through observations from your boat.

Living in an age of ever-changing technology and constant connectivity, we sometimes forget to use our own natural senses. However, humans have sailed for thousands of years without the aid of modern navigation tools like chart plotters and weather faxes. Instead, ancient navigators observed the weather and waves to guide them across oceans. Smart sailors nowadays will make themselves aware of their surroundings and watch for changing patterns. By monitoring and understanding your surroundings, you can better predict the weather and navigate more effectively than by relying on technology alone.

Cortez Bank Breaking Wave

A feeling of moisture, increased humidity, or a ring around the moon, often signals a coming warm front. Increased wave height, shortened wavelength, or a change in swell direction likely mean more wind is coming. However, if the waves are smooth and spread apart, the storm is likely farther away. Wave patterns are also affected by changes in depth and current. We all know that waves break on a shore, but the same phenomenon will occur when the depth of the sea changes dramatically, for example, from 2000 feet to 100 feet over the Cortes Bank off San Diego. You may also notice a change when you reach the edge of a major current (such as the Gulf Stream), or when you reach the mouth of a river (such as the Mar del Plata in South America). Knowledge of wave patterns can also be helpful when your crew is battling heavy weather. If you are in the middle of the storm and starting to get worn down, pay attention to the waves. Once the waves start to round out and settle down, you and your crew can breathe a sigh of relief—see, it is going to get better.

Humidity is increasing, ring around the moon means:	Warm front approaching
Wave height is increasing, wavelength is decreasing means:	Wind speed is likely to increase

Modern sailors may also find old mariners' axioms useful for predicting weather. Although sayings like "red skies at night, sailors delight; red skies in the morning, sailors take warning" and "mackerel scales and mares' tails make tall ships lower sails" may not be 100% accurate, they can offer valid warnings. Like changing wave patterns, clouds can indicate changing weather. The key is to be aware and curious; note changes and record them in your logbook. Track the trends to help predict approaching weather. In addition, use all the modern methods described in Chapter 4.

If, despite your efforts to track and avoid heavy weather, you are caught out in a storm and seeking shelter, choose your port of refuge carefully. As shown in the previous chapter, a lee shore can be lethal. Also, do not attempt to cross a bar at the entrance to a channel in extreme conditions. Remember that, no matter how badly you want dry land, a hot shower, and a cheeseburger, it is not worth it to make risky decisions. If possible, wait for conditions to improve: a couple of hours for the tide to change and the ebb current against sea breeze conditions to abate and the seastate to diminish.

Fishing boat attempting to navigate the Grey River bar in New Zealand during extreme conditions. From a video by Geoff Mackley and Bradley Ambrose

However, there are times when strong currents cannot be avoided and you must cope with the effects, which can be especially difficult in heavy cross winds.

On Board "Heineken" during the Whitbread: One time I wish we had avoided current against wind was in the Le Maire Strait just after rounding Cape Horn. The winds were in the high 50- and low 60-knot range just forward of our beam as we were sailing north. The prevailing current was accentuated by the tidal current and we had a solid 5 knots pushing us. The resulting wind against current created huge breaking waves that crashed down on our deck from great heights. Our only option was to hunker down. We wore two safety harness strops each to wedge ourselves against the force of the water and avoid being *flung around the deck and impacting hard objects. The good news is the winds always die down eventually and the tides do change.*

SECURE GEAR TO KEEP CREW AND BOAT SAFE

Okay, so you have tried to avoid the heavy weather, but it is upon you. Time to prepare!

First, clear the decks. Remove all extraneous gear, such as fuel jugs, dinghies, cushions, and unused sails and store them below. Run jacklines if not already in place; add tethers near the companionway for use when coming on deck or going below. Consider running additional jacklines in the cockpit.

Secure all gear below. Not only can flying objects hurt your crew members, but they can also break through a porthole and render your vessel unseaworthy. Whether you are racing or cruising, it is critically important to have a place for everything and everything in its place, especially in rough weather. Secure books, canned goods, tools, and engine spares. Lockers, if not specifically designed to resist a knockdown, tend to fly open in a rough seaway. Fit them with strong, reliable latches and thru-bolts. Don't count on gravity for stowage under berths or floorboards.

Double check that you have adequately secured heavy items that can be lethal projectiles, such as the stove, anchors, batteries, and lead ballast, to ensure that they stay in place if the boat rolls completely. It is unlikely that your boat is going to roll, but take the couple of hours before heavy weather arrives to make sure your pre-departure preparations are sufficient for the worst.

In addition to securing gear, do the following:

- Make sure the handheld VHF is charged for cockpit use.
- Review damage control procedures with the entire crew: abandon ship; flooding, including review of thru-hull locations; tools and jury rig equipment; crew overboard; and standing rules for life jacket, harness use, etc.
- Monitor all available weather sources.
- Charge the batteries to ensure the engine will run when needed.
- Pump the bilges and check for debris.
- Find and deploy the proper heavy weather tools, including storm sails and drag devices.

MAINTAIN CREW HEALTH: STAY HYDRATED, EAT, AND REST

Even the most hearty, salty sailor doesn't feel good 100% of the time. In heavy weather, you may be tempted to just hunker down, curl up into a ball, and wait for conditions to improve. But this is counterproductive. It is critical to stay hydrated and eat whatever your stomach can hold down. Make it easy to consume plenty of liquids by having palatable drinks available, preferably with extra electrolytes. Preparation is the key to keeping food in your stomach and seasickness at bay. Keep a thermos of hot water safely secured in the galley so you can quickly prepare cups of soup and noodle bowls. You may want to carry some freeze-dried meals specifically for heavy weather. In addition to a long storage life, they can be easy (and safe) to prepare when normal meals would require too much work. Race boat crews have simplified meal preparation down to dumping the ingredients into an insulated bowl, adding boiling water, and waiting 20 minutes. This is much safer than trying to keep a hot pot of food on a gyrating stove.

Use a galley belt in rough weather, Mike Litzow credit

Easy alternatives to just-add-water meals are pre-made sandwiches, fresh fruit, and energy bars. You may want to have something ready to reheat in the oven. I have friends who, during an around-the-world missionary journey, kept their oven on low and constantly restocked it with potatoes. Remember to use a galley belt to avoid being thrown around the cabin while preparing meals, although it is not advisable to be tethered to the stove while it is in use.

For an iffy stomach, try ginger snaps, electrolyte drinks, or saltines. Sometimes a carbonated drink will help settle a queasy stomach. (See Chapter 11 for more on seasick treatment.)

To avoid breaking dishes or spilling your food, try this old sailing trick: stainless steel dog bowls or deep plastic bowls with non-skid rings instead of plates. These durable, deep bowls can be found with insulation, making them perfect for meals during heavy weather.

Lee cloths improve safety & comfort

In addition to keeping your crew well fed, make sure your team is as well rested as possible to ensure you have smart thinkers and strong drivers during the storm. Lee cloths greatly increase the likelihood of sleep in rough weather and can also provide side pockets for you to store essential personal gear, like your glasses, knife, and headlamp, which you can then grab quickly when you are called on deck.

REDUCE SAILS TO ACCOMMODATE INCREASING WINDS

As the wind increases, have the entire crew review the sail crossover chart (example below) that you have posted on your bulkhead, which shows sail combinations that work for your boat in specific wind strengths.

Cal 40 Illusion Sail Cross-over Chart

TWS -->	4	6	8	10	12	14	16	20	25	30	40	
AWA												AWA
28				G1	G1	G1	G1	J3	J3-1R			
32			G1	G1	G1	G1	G1	J3	J3-1R	J3-1R		
36	Dr	G1	G1	G1	G1	G1	G1	J3	J3-1R	J3-1R	SS-2R	36
40	Dr	G1	G1	G1	G1	G1	G1	BR	J3-1R	J3-1R	SS-2R	40
45	JT	G1	G1	G1	G1	G1	G1	BR	BRR	BRR-1R	SS-2R	45
50	JT	G1	G1	G1	G1	G1	G1	BR	BRR	BRR-1R	SS-2R	50
55	JT	JT	JT	JT	JT	JT	JT	BR-SS	BRR	BRR-1R	SS-2R	55
60	JT	JT	JT	JT	JT-SS	JT-SS	JT-SS	BR-SS	BRR	BRR-1R	SS-2R	60
70	JT	JT	JT	JT-SS	JT-SS	JT-SS	JT-SS	JT-SS	BR	BR-1R	BRR-2R	70
80	JT	JT	JT	JT-SS	JT-SS	JT-SS	JT-SS	JT-SS	JT-SS	BR-1R	BRR-2R	80
90	0.5	0.5	0.5	0.75	0.75	1.5 AP	HA	HA	JT-SS	BR-1R	BRR-2R	90
100	0.5	0.5	0.5	0.75	0.75	1.5 AP	1.5 AP	HA	JT-SS	BR-1R	BRR-2R	100
110			0.5	0.5	0.75	1.5 AP	1.5 AP	HA	HA	BR-1R	BRR-1R	110
120				0.5	0.75	0.75	1.5 AP	1.5 AP	HA	BR	BRR-1R	120
130					0.75	0.75	1.5 AP	1.5 AP	HA	BR	BRR-1R	130
135					0.5	0.75	0.75	1.5 AP	HA	HA	BRR-1R	135
140					0.5	0.75	0.75	1.5 AP	1.5 AP	HA	BR-1R	140
145						0.75	0.75	1.5 AP	1.5 AP	HA	BR-1R	145
150						0.75	0.75	1.5 AP	1.5 AP	HA	BR-1R	150
160							0.75	1.5 AP	1.5 AP	HA	BR	160
170								0.75	1.5 AP	HA	BR	170

MAIN

CODE	DESCRIPTION
	Full
1R	1st reef
2R	2nd reef
Try	Storm Trysail

JIBS

CODE	DESCRIPTION
G1	155 3DL genoa
JT	Jib Top, 155%
J3	#3 115% Kevlar
BR	125% Blast Reacher
BRR	Blast Reacher, reefed clew & tack
SS	Upwind Staysail
SJ	Storm Jib
Dr	Drifter

KITES

CODE	DESCRIPTION
0.5	500 Airx
0.75	700 AIRX
0.6	.6/.75 bean bag
1.5 AP	1.5 oz. All-purpose
HA	1.5 oz 2-ply heavy air

When appropriate, depower and secure the sail plan according to the following scheme:

- Flatten the sails with backstay, halyard tension, and foot tension. Ease the traveler down and move the sheet leads outboard.
- Increase mast support by tightening the standing rigging. Set up the intermediate forestay and runners to support the mast.
- Reduce the jib size progressing down your inventory choices as the wind increases. Select flatter, newer sails that are strong enough to survive the blow. Don't use your furling genoa as a storm jib. It will blow out and become impossible to remove, adding dangerous windage aloft.
- Reef the main, according to the advice below.
- Set up gear for storm sails, including proper sheets and leads and bending the storm trysail on its dedicated track. Know your sheet leads and hydraulic settings before you experience storm conditions
- Replace working sails with storm sails.
- Run the leech reef lines. It is safest to have the leech reef lines permanently run, but there are considerations that may make this undesirable, such as sun damage on the lines, chafe on the sail, windage, or the potential of the reef lines to pull tight or catch when hoisting the sail. An alternative is to have messenger lines run up the leech. These are simply loops of light line run between the clew ring of the sail and the reef point on

This is what happens if you try to use your furling genoa as a storm jib.

the leech (or from the first reef point to the second, or second to third) and secured to itself with a bowline, leaving about a 5-inch tail. When you want to run the real reef lines (well *before* you need them), tie your reef line to the 5-inch tail. Then, pull it up through the reef point and then back down to the boom to secure it.

TIP: Whip and sew a small loop into the end of the reef line so it can be pulled through the sail easily. I recommend that all sheets and halyards on boats with jammers have these loops sewn on the end. It is even better if there is a wire tie attached. It is infinitely easier to re-run lines in a hurry.

As a general rule, consider the following progression of sail reduction:

- Smaller headsail and flatter main
- Number 4 jib and reefed main
- Number 5 or storm jib and double-reefed main
- Number5/storm jib only (downwind)
- Storm trysail and storm jib
- Storm trysail only
- Bare poles, with or without a drag device (not ideal)

REEFING TECHNIQUES

When racing inshore, sailors often don't run the reef lines because the chance of needing to reef a high aspect racing main in an afternoon race is slim. Unfortunately, this may mean that when racing offshore, many on board are not familiar with the various reefing systems. Every boat is different, so it behooves sailors to become familiar with how and when to reduce sail on their particular boat *before* it is blowing 60 knots on a cold, dark night, and you are afraid.

Reef in Squall, Mahina photo

The first challenge is to reef as quickly as possible to minimize flogging the sails, shaking the rigging, and possibly damaging equipment and people. The second challenge is to end up with a strong, reliable, smaller sail, which still maintains its aerodynamic shape. It does little good to reduce a sail by 10% while adding 8% more fullness to the shape of the remaining sail.

There are many types of boats, sail plans, and reefing systems, but a general rule of thumb is to reef when you have already reduced your headsail significantly and you are still over powered. If your rail is in the water, you are flogging the main just to keep your angle of heel under control, or you are just uncomfortable, it is time to reef. Some say: reef when it first occurs to you.

To be confident when pressed, practice reefing on a relatively calm day or at the dock if the wind is light. Reefing will reduce the overall load on the rig, but will increase spot-loading at specific and different areas. For instance, the mainsail track will be strained at the new head location and the sail will possibly chafe there; any padeyes you have added for the reef system on the boom, mast, or deck will be loaded; and the mast panel overall will have increased loading. Make sure that all is strong enough for the relocated loads. It is safest to position the reefed mainsail head at a spreader or opposite an inner forestay, if possible, but there are many other considerations like where the battens fall and how much area you want to remove.

Basic principles of reefing:

Carol Hasse Photo

- The tack of the reefed main *must* be pulled forward to the approximate location of the normal tack. This will both reduce the chance that the luff of the sail will rip out of the mast track and will also maintain good sail shape.
- If you are not racing, it is often easier to reef while going close to head to wind with minimal forward motion to reduce the apparent wind speed.
- Once the tack is secured, trim the leech reef line tight. It is prudent to secure the reef clew to the boom with an additional safety line separate from the leech line.
- If you use reef ties, which are often unnecessary, choose a bright, contrasting color to ensure you don't forget to untie one when shaking the reef.

Types of Reefing: There are many different reefing systems, but here are a few.

Slab or Jiffy Reefing: Most modern boats use this system. The preparation is more onerous than the actual reefing. Well before you need it, set up and run the system:

1. Make sure all padeyes and leads are correctly positioned and that any required blocks and tackle (for instance, those used to snug the tack into position and secure the clew) are onboard the boat.
2. Confirm that the outboard (clew) reef lines have been run forward, usually inside the boom, through a stopper cleat and sheave at the forward end of the boom, down to a block at the base of the mast and aft to a winch. Alternatively, the lines may be led to the cockpit.
3. Confirm the inboard (tack) end system is in place. Two options are:
    - "Rabbit ear" hooks or shackles at the gooseneck pin ready to secure stainless rings that are fixed to webbing or lashing passed through a press ring in the luff of the main. When the luff is lowered, you attach one of the two stainless rings to the hook or shackle on that side of the sail. Then the halyard is tensioned to flatten the luff of the sail.
    - An inboard reef line is fixed to the gooseneck or to a padeye on the mast forward of the gooseneck. The latter does a better job of pulling the tack forward. The line is run up the luff, through a press ring, back down to a block at the base of the mast, also

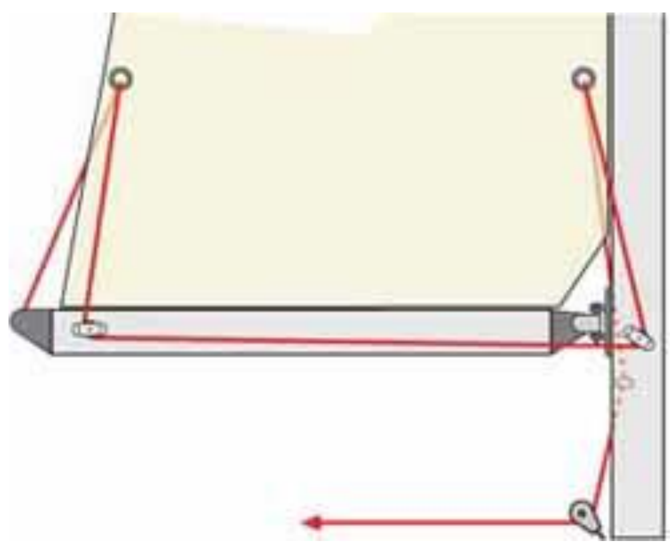
forward of the gooseneck, and then to a winch. Ideally the winch is in the cockpit so the whole operation can be done without going forward.

4. Run the leech reef line (if not already done):
    - Pull the reef line(s) from the end of the boom, up through the press ring on the leech of the sail, back down around the boom, and then tie a bowline around the reef line that has just been led down from the leech (not around the boom). This forms a slipknot around the boom, allowing the reef line to tighten securely in place when tensioned.
    - If you have a carbon fiber or light boom use a "reef diaper," a strong cloth sling with two stainless rings that spreads the load of the leech reef line along the boom, avoiding breakage from point-loading.

Reef clew pulled down to boom, Carol Hasse photo

5. Order of operations for slab/jiffy reefing:
    - Reduce loads on the sail by easing the vang, the mainsheet, and then the halyard.
    - Drop the halyard only a few inches past the reef mark to reduce re-tensioning time.
    - As the halyard is lowered, pull slack out of the leech reef line(s) to prevent them fouling on the boom or other hardware.
    - Re-tension/hoist the sail in this order: secure the tack, tension the halyard, and then tension and secure the outboard end.
    - Trim the sheet and start sailing again.

<u>Single-line reefing</u>: Single-handers favor this system for its simplicity because it involves only one line. It entails a lot of grinding and flogging, but it can be done alone. The reef line is secured at the aft end of the boom, run up through the leech press ring, then back down through a sheave that is secured aft. This can be either a block on the side of the boom, a sheave at the end of the boom, or a diaper, depending on the boat. The line then runs forward to another block or sheave at the gooseneck, up through the press ring on the luff of the sail, down to a block at the base of the mast, and then aft to a winch.



Single-line reefing system

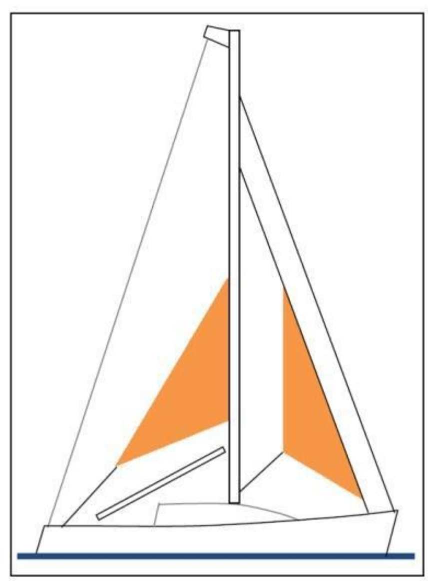
Roller Reefing: External: For boats in the 1960s and ’70s, this was the “new” reefing system. It is less common today. End-fittings allow the boom to roll when cranked by a brave soul at the gooseneck. As the boom rotates, the sail wraps around the outside of the boom the appropriate number of times. The challenge is to keep the leech pulled aft tight enough to flatten the sail as it wraps around the boom. The only way to do this is to sail head to wind, which is unstable and not fast in a race.

In-Mast/In-Boom Reefing/Furling: Most super yachts nowadays have a variation of the roller reefing system. The sail is rolled inside, rather than outside, either the boom or the mast. Both sail design and technology have progressed. The sails are fitted with full-length battens or cut flat enough to reef satisfactorily and the rolling is all done with hydraulics, but the main can still only be reefed when head to wind.

USE PROPER STORM SAILS TO KEEP BOAT SAFE AND VISIBLE

Storm sails (OSR 4.26) will be covered in the next section, but here are a few additional points. Just as reefing needs to be practiced in light conditions, before an emergency situation arises, so does the rigging and use of storm sails. This is so important that many race committees require boats to sail by the committee boat while flying storm sails in the hour before an offshore race starts, thus proving the boat has functional storm sails aboard. It is that important. Storm sails must be strong, brightly colored, and easy to attach and control in survival conditions. If SAR assets are looking for you in these conditions, you want to do everything possible to be seen.

Storm Jibs: Consult your sailmaker to determine the best size storm jib for your particular boat. The OSRs require it be no larger than 5% of the height of the foretriangle squared with maximum luff length of 65% height of the foretriangle (4.26.4). For instance, if the foretriangle height (I) is 50-feet, the maximum area allowed is (50*50*.05) or 125 square feet, but even that may be too big for your boat. A rule of thumb is the sail should be less than 25% the size of your 100% jib. The sail must be able to be attached to a stay easily and quickly and cannot depend solely on a headfoil or other slotted headstay. Run short lines though grommets along the luff if you have a head foil. This allows you to lash the sail to the head foil, to an alternate stay if the head foil has been damaged, or even to a halyard standing in as a stay. (Diagram from The Rigging Company shows relative size of storm jib and storm trysail.)



Relative size of storm jib and storm trysail, OSR 4.26

Storm Staysail: Moving the storm sail aft to a stays’l stay helps to keep the CE centered for more balanced steering. If you have a deployable inner stay for a storm staysail, secure it into position well before you need it.

Storm jibs and storm staysails should be cut with high clews to allow waves to pass underneath. Be sure to know the proper sheet leads before you are in storm conditions.

Storm Trysails: These replace the mainsail, and are specifically designed to withstand the winds (and waves) of a storm. The advantages of a storm trysail over using a deep-reefed mainsail is that the mainsail stresses the middle of the sail and, being dependent on the boom, it leaves more weight and hardware aloft, which adds to heeling moment and the dangers of the swinging boom. The OSRs dictate a maximum area for the storm trysail of 17.5% mainsail hoist (P) times mainsail foot length (E). It must be capable of being sheeted independent of the boom and be attached to the mast. The safest technique is to have a separate mast track for the trysail, independent of the mainsail track. A second track is required if you have in-mast furling. Even if the boom has not broken, it is safer in extreme conditions to lash it on centerline and use a storm trysail.

Whichever systems you establish on your boat, be sure to practice the routines with your crew before you need them. Decide which techniques work for your boat and go over all the details while you are still at the dock, so each crew member has the opportunity to ask questions, become familiar with the gear, and understand the proper order of implementation. For the safety of everyone on board, all must understand and accommodate what their shipmates are trying to accomplish on a cold, dark, windy night.

Thoughts from John Jourdane: Remember, Heavy Weather is Relative

John Jourdane photo

To an 8-year-old in a Sabot, 10 knots is heavy air. In California, 21 knots brings small craft warnings. In the Southern Ocean, crews often see steady 45 knots for days at a time; when it drops to 35 knots, it feels like light air sailing. The more you sail in heavy air, the easier it becomes.

Heavy weather sailing can be exciting and fun up to a point, but then it becomes a matter of crew and boat safety. You can survive most storms if you have the following:

- A solid plan of departure based on the forecast weather
- A sound, well-prepared boat
- The sails and gear to keep the boat under control
- Experienced crew especially good helmsmen
- Good crew morale—no one panics when the weather deteriorates
- A strong command structure—everyone knows what to do as the wind and seas increase.

Crew Capability: Steering is the key to sailing in heavy weather. Let your inexperienced crew steer during the day when visibility is good and conditions are fairly calm. Save your best drivers for nighttime, when visibility is poor and squalls build up. Before the race or cruise, practice in wind with as much sail as you can handle.

Crew Morale: In challenging conditions, the crew must believe in one another and in the group's capabilities. Facing storm-force wind and waves crashing on deck is exhausting. The boat must have bunks that allow rest in all conditions. Know which seasick meds work for you, and take it before the storm hits. Hot food, dry bunks, reliable routines, and timely watch relief are critical for crew morale.

Sailing in heavy air can be fun. Have a positive attitude. Enjoy it, don't fear it.

Chapter 6—Storm Sails and Storm Tactics, Carol Hasse and John Neal

Storm Sails, Carol Hasse

Key Concepts: Have strong, small sails and reliable means of setting them (4.26); stow for easy deployment, set according to established routine; importance of high visibility.

Distinctive colors on storm sails, Carol Hasse Photo

Professional mariners, and those of us involved in sail training, know the drill for handling the three major emergencies: Fire, Crew Overboard, and Abandon Ship. Station bills are created, posted, and regularly practiced. It is prudent for any passage makers to also include "station bills" for what I call "lesser emergencies." Establishing a routine for storm preparedness that includes practicing the setting of storm sails will help you—and your crew—avoid some discomfort (or worse) when doing so in heavy weather. Key factors include proper timing and knowing your vessel's rig. The timing is dictated by the following circumstances: wind speed, wave height and period relative to point of sail, amount of sea room, crew and vessel condition, and the duration of the storm and its anticipated course and intensity. Your vessel's rig determines the exact gear that is required and the entire crew should know the specifics of what is involved. Ideally, you have already posted the (practiced) storm sail setting protocol either on a bulkhead or in the ship's log so an exhausted or less experienced crew member can review the routine before venturing on deck.

STORM HEADSAILS: AN OVERVIEW

A storm headsail is often set before a storm trysail, and flown in conjunction with a deeply reefed mainsail. It is called a storm jib when it is deployed from the jib stay/head stay. It is called a storm stays'l when it is flown from a stays'l stay or inner stay abaft the head stay. A storm jib or storm stays'l is designed and built for gale to storm force winds. The sail's geometry and the stay that it is deployed from may vary, but the size (relative to the rig) and duty do not.

Hand-adjustable turnbuckle allows removable stay to be tensioned, note removable pin at base, Carol Hasse photo

Many storm jibs/storm stays'ls are set on inner stays that are fitted with release levers at their deck ends; that way, the stay—when not in use— may be secured somewhere closer to the mast or shrouds to facilitate tacking the genoa. The stay is installed in its working position during heavy weather to support the mast column and set the storm headsail. Each crew member should know where the inner stay is secured when it is not in its working position. Note on the station bill any tools necessary for its removal from its stowed position, or for its installation in its working position, and make sure those tools are readily at hand. If your vessel is fitted with running backstays, your ship's protocol should dictate how and when to rig them. Once the inner stay is in its working position, it is time to secure and tension the windward running backstay if this was not done earlier.

HOW TO PROPERLY STOW STORM JIBS

Storm jib magazine, Carol Hasse photo

Stow the storm jib in its own bag in a dedicated and easily accessible place, so it is ready to go on deck and be bent on the stay from which it will be set. The sail should be neatly folded with head, tack, and clew at the top of the sail bag. It is useful to keep all of the jib's hanks in order from head to tack by hanking them on to a "magazine" (a short length of wire or rope, say 18–24 inches long) that stays with the sail in its bag. After you have secured the sail bag to the deck with a lanyard (such as a sail tie), and before you remove the sail from its bag, make the magazine fast to the boat, with its bottom or tack end secured to a deck fitting near the base of the stay and its top end to the lifeline or bow pulpit. This positions the hanks for easy attachment to the stay, and keeps the storm jib from going adrift. Ideally, a storm jib is fitted with an 18–30-inch integral tack pennant (of wire, spectra webbing, or rope) with a snap shackle at its deck end for quick attachment to the tack fitting. The tack pennant will lift the storm jib above the lifelines, allowing visibility forward, and minimizing both chafe and the possibility of scooping green water into the foot of the sail. After you have attached the tack pennant to the tack fitting on deck, bend on the storm jib, removing each hank from the magazine in order and attaching it to the stay.

STORM JIB SHEETS AND HALYARD

Secure separate port and starboard sheets to the clew of the storm jib with bowlines (not snap shackles). If possible, keep the sheets in the bag with the sail. To ensure ease of handling and to resist chafe, choose sheets with a diameter as large as lead blocks and self-tailing winches will allow. Double braided polyester is an excellent choice for sheets; high-tech, low stretch line is unnecessary in this application.

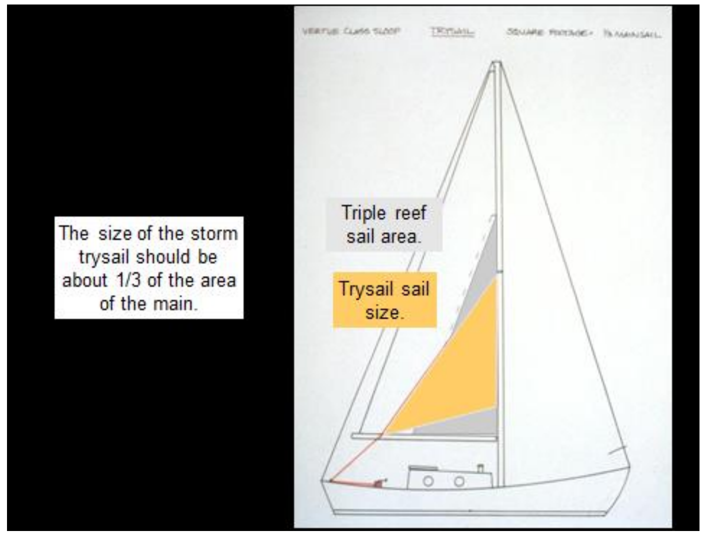
Tie bowline with bitter end turned back for extra security, Carol Hasse photo

Knowing where the storm jib's sheets must be led is critical to the sail's performance and longevity. If the sheet is led too far forward when beating, the sail will contribute unduly to heeling and leeway. If it is led too far aft, the leech of the sail may be damaged from excessive fluttering. To determine the fore and aft position, sight an imaginary line from the middle of the storm jib's luff through the clew and down to the deck. Position the sheet lead at that point or slightly farther aft when beating, and tension the storm jib's leech line to correct any leech flutter. When reaching or running, you must move the sheet lead forward to minimize leech twist and its resultant contribution to a vessel's rolling. Sheeting as far out board as possible is ideal in gale to storm force winds, especially with the wind abaft the beam.

Once you have established the ideal sheet lead position for your intended point of sail, determine the sheet's fairest lead from the storm jib's clew to the sheet lead block and from there to the winch. When beating, you may find a chafe-free path from clew to block by leading the sheet outside the lower shrouds and inside the upper shroud. However, this same path may allow the sheet to chafe on the upper shroud when the sheet is eased for a reach or run. Only practice will reveal how you should lead the storm jib sheets on your boat.

Now is the time to attach the halyard. Know where both ends of it are made fast, and how much you must ease the halyard in order to attach it to the head of the storm jib. Sight aloft to ensure that the halyard has a clear, chafe-free path from halyard block to the head of the storm jib, and make certain the storm jib is free from the constraints of its sail ties or bag before attempting the hoist. Keeping the windward sheet slightly tensioned while setting the storm jib will minimize flogging until the sail is properly trimmed. Proper storm jib trim includes a taut luff (lots of halyard tension), as well as an optimal sheet lead position. Finally, when it comes time to strike the storm jib (either for heaving-to under storm trysail alone or because the wind has abated), it works well to backwind the sail before easing the halyard so the sail can be flaked on deck as it is lowered.

HOW TO SET AND FLY A TRYSAIL



A trysail is a small heavy weather sail that is flown from the mast. The name derives from the old fashioned term for heaving-to: “lying a try.” Ideally, the trysail is flown from a dedicated, secondary track that is roughly parallel to the mast track on which the mainsail is set. The track should start from 6–12 inches above the base of the mast. This allows you to easily bend on the trysail by securing its luff slides from head to tack into or onto the trysail track and then leave the sail bagged and “at the ready” on the cabin top or deck. An in-mast furling main must have a separate trysail track. If it is ship’s protocol to only bend on the trysail when needed, make certain that the trysail track has a gate at its deck end that is both easy to open and has a lanyard so it cannot go adrift.

Designed to be flown independently of the boom, trysails require two sheets that are each secured with bowlines to the clew. The sheet diameter should be as large as lead blocks and self-tailing winches allow, and is comfortable to handle. As with storm jib sheets, polyester double braid is ideal. Trysail sheets are generally led from the clew to blocks in static positions in the stern quarter, one port and one starboard, and from there to winches. Consult a sailmaker if you are uncertain about the ideal sheet lead position. Trysail lead blocks should be chosen to accommodate their working load, which will double if the sheet must make a 180° turn to reach its winch. The windward sheet generally has a relatively direct path to its sheet lead block, but most commonly, the leeward sheet must be led over the boom, abaft the leech of the mainsail, and forward of the topping lift (if rigged) on its way to its lead block. In addition, sheets must be routed around any lazy jacks or Stack-pack “legs.” You should determine a fair lead for both windward and leeward sheets through practice, then record and make this information available to the crew as part of the ship's trysail-setting protocol. The leads must be properly set before hoisting.

The tack of the trysail must be fitted with a pennant long enough to allow it to clear the head of the mainsail when the mainsail is furled on the boom. The trysail tack pennant can be of rope, webbing, or wire, but its bitter end requires a dedicated belaying point, such as a cleat on the mast or padeye at the mast base, whose position allows the tack pennant to have a chafe-free path when the trysail is set.

Tack requires pennant to clear main, Carol Hasse photo

With trysail bent on, tack pennant belayed, and sheets led, the trysail can be raised. Here again we may run afoul of lazy jacks or Stack-pack legs. Only practice (preferably with lazy jacks engineered to accommodate the trysail) will help you devise a protocol for setting the trysail. The easiest way to hoist the trysail is with the mainsail set (it will likely be reefed). This requires a dedicated trysail or spare mainsail halyard, ideally rigged on the same side of the mast on which the trysail track is installed. Raising the trysail while the mainsail is still working facilitates a controlled trysail deployment, and more importantly, always leaves sail area abaft the mast. This is critical for beating, lying hove-to, or quartering breaking waves.

Once the trysail is sheeted, the mainsail is struck (or peeled) and secured on the boom. It is important also to secure the boom in its gallows, a crutch, or with a combination of rigid vang, topping lift, and quarter tackle. The trysail's port and starboard sheets may be used independently (similarly to a jib's), or they can be used simultaneously to bring the trysail closer to or on the centerline for beating or heaving-to. A vessel with one set of cockpit winches may face sheeting challenges when sailing with both storm jib and trysail. Solutions may include leading trysail sheets to cabintop or mainsheet winches, or "cross sheeting" from a leeward block to a windward winch. Sheets must have chafe-free fairleads. Only practice will ensure a trouble-free deployment of the trysail. Bear in mind that setting the trysail in less than storm force winds can have benefits beyond practice drills. The trysail makes a fabulous steadying sail when motorsailing or in slatting conditions, and saves wear and tear on the mainsail and the rig.

Storm Tactics, John Neal

Key Concepts: Understand possible effects of heavy seas and which sailing techniques are best for your boat. (4.27, 6.02.4)

There are many different techniques for weathering storm conditions. What is the best one? It depends on the design of the boat, skill of the crew (drivers wanted!), gear on board the boat, and the amount of sea room you have (see Options Matrix following this section). There is not one storm tactic that is best for all types of sea conditions and sailboats. Larger, faster, deeper-draft boats of modest beam generally handle serious storm conditions best. Centerboarders or boats with excessive beam tend to roll sooner and stay inverted once rolled. If you're sailing a 30-foot boat in storm conditions, there is a much higher chance that you will need to heave-to or employ storm tactics than if you're on a 50-foot boat.

During the 1994 Queen's Birthday Storm, we found that with a crew of six we were able to safely run off before the storm on our Hallberg-Rassy 42 under small storm jib, hand steering at 180 miles per day. If we hadn't had a full crew, we would have chosen to heave-to or tow warps or a drogue to reduce speed. Jim and Sue Corenman on Heart of Gold, a Schumacher 50 racing boat, were very close to the worst area of the storm and sailed out of the way at over 200 miles per day, with just two very experienced people trading off at the wheel.

The following tactics are listed sequentially as the winds and seas increase:

1. **Hoist Storm Sails**

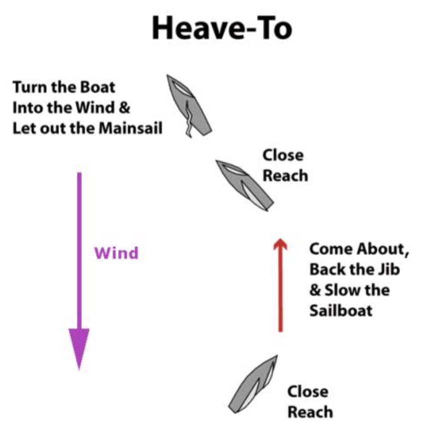
Advantages: In winds over 40 knots, this method reduces heeling, speed, and stress on the crew, rig, and sails. Consider heaving-to to remove a furling headsail. If this isn't possible, wrap the headsail securely with a spare halyard. If two spare halyards are available, "maypole" the furled sail by wrapping halyards in opposite directions. Dismastings have occurred because of headsails unfurling.

Caution: Keep up enough sail area to maintain 5–6 knots of boat speed. Otherwise, the rolling motion makes life on board difficult and you increase the chance of being rolled. This is the time to consider your options; if you don't have enough sea room, start heading further offshore.

2. **Running or Reaching Off**

Advantages: Running or reaching off reduces apparent wind speed (e.g., upwind: 30 knot wind + 6 knot boatspeed = 36 knots apparent wind speed vs. downwind: 30−6=24 knots apparent) and provides more comfortable motion.

Caution: You must have sufficient sea room. Also, a gybing mainsail, even if secured with a preventer, can cause damage to equipment and crew in strong winds. For this reason, many experienced sailors choose to replace a reefed main with a storm trysail if winds over 40 knots are forecast. Modern boats handle offwind boatspeed much more safely and are generally easier to steer at higher speeds than more traditional, heavy, full-keeled designs. For both, there is a danger of pitchpoling or broaching and rolling because of excessive boatspeed. Another danger is "rogue" waves: larger breaking waves coming from a different angle than the predominant direction. You must remain alert to quickly square the stern quarter around to these waves. If you are relying on an autopilot or a windvane, you may be knocked down or rolled. Hand steering in these conditions is physically demanding and requires utmost concentration.



3. Heaving-To

Method: Back a small headsail by tacking without releasing the sheet; adjust the main or trysail for slight drive (forward and to leeward); and tie off the helm somewhat to leeward to cause the boat to head up if it picks up speed. It is safest to take breaking waves 40–60° off the bow, and not on the beam. (Editor's note: consider the Pardey's method of using a sea anchor at the same time.)

Advantages: Heaving-to is one of the safest storm tactics that doesn't require constant steering, as long as winds are less than 50 knots and seas under 25–30 feet. By keeping the boat moving at 1–3 knots hove-to, you can eliminate the chance of broaching out of control or pitchpoling. You can choose to heave-to on either tack. If one tack takes you closer to land, gybe around to the other tack, which should take you away from land.


Mahina Tiare hove to in a squall, John Neal photo

Caution: Some lightweight fin-keel boats with spade rudders may not heave-to properly, but instead continually gybe around in circles. In this case, hand steering while fore-reaching or close reaching into the wind and seas may be the safest storm tactic. Be sure to practice heaving-to in progressively higher winds to see if this tactic works for your boat. You can also heave-to when you want to slow down for daylight landfall, when reefing the main, or just to rest. When hove-to, remember to broadcast a "Securité" message stating your position and lack of maneuverability every 30 minutes on VHF channel 16.

4. Fore-Reaching

Method: Lock the wheel to sail at about 60° off the wind under reefed main or trysail alone.

Advantage: The advantages of this tactic include not having to hand steer, reducing exposure time (because the boat is going toward, not with, the storm), and a surprisingly comfortable ride. This is an alternative to heaving-to in sustained winds over 50–60 knots (with a back-winded storm headsail and triple reefed main or trysail), which places considerable stress on the rig, particularly the windward spreaders. On Mahina Tiare, we have found that dropping the storm headsail (or furling the genoa), sheeting in the triple-reefed main or trysail, and locking the wheel on a close-hauled heading produces a very comfortable ride at 2–3 knots. If the bow falls off to leeward, the main (or trysail) brings it back on course. This tactic proves quieter and more comfortable than heaving-to in higher winds, and doesn't require anyone on the helm.

Caution: This tactic will not work on many modern, flat-bottomed boats with a short keel (fore and aft measurement, not draft). Find out if this tactic will work on your boat by trying it in 30 knots with a double-reefed main. If this tactic doesn't work, you could try #5, **Close Reaching under Storm Sails**, by hoisting the storm headsail and hand steering. Another option is to switch to #7, **Motorsailing**. Check for lines in the water and start the engine, retaining the storm trysail or deeply-reefed main.

5. Close Reaching Under Storm Sails

Method: Fall off between crests to gain speed and then head up toward the approaching wave crest to bleed off speed and prevent pounding.

Pyewacket under storm jib and trysail, John Jourdane photo

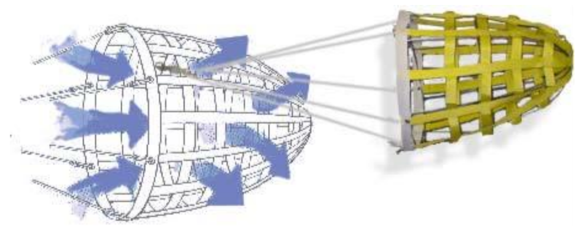
Advantages: It's generally better to take large seas on the bow and close reaching has a wider slot for more directional choices. This tactic is an excellent "ultimate storm" option, and was safely and efficiently used by several boats in the Sydney-Hobart storm. In really large breaking seas (over 20 feet), this tactic eliminates the chance of pitchpoling. It does, however, require accurate upwind steering to avoid the breaking crests. Sailing upwind in nearly the opposite direction to the storm system's movement may be the fastest way to more moderate conditions.

Disadvantage: Requires active sailing and rested drivers.

Caution: Avoid excessive speed by using a storm trysail and staysail. A drogue can be towed astern if necessary. Ideal speed will be fast enough for maneuverability, yet not so fast that the yacht goes flying off the top of waves and crashes down into the following trough. On most boats this will translate into a boat speed of 5–6 knots.

6. Towing Warps or a Drogue Off the Stern

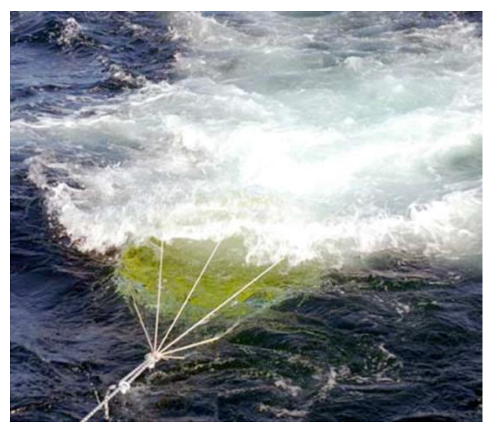
Method for warps: Secure your longest nylon rode (should be 250–400 feet) to stern mooring cleats on each side and let out. Dragging this U-shaped bight of line astern will cut the sea surface tension, creating a visible "slick" astern and reducing the chance of breaking seas crashing aboard. Towing warps also improves steering response by slightly reducing boatspeed. This tactic seems to be more effective with light to moderate displacement boats and multihulls. It works well to tow multiple warps astern, each a different length. I have towed three sets of warps in storm conditions with good results. In extreme cases, tires or anchors with chain and rode have been towed astern successfully.



Method for drogue: A drogue provides more drag and resistance than warps, further reducing boatspeed as conditions deteriorate. The Galerider, manufactured by Hathaway, Reiser & Raymond, and the Fiorentino Shark Drogue are the most versatile and dependable drogues available, based on our experience. A more expensive and much less flexible option is the Jordan Series Drogue, which utilizes a series of 130 small sea anchors permanently spliced into a 300-foot line. Although the Series Drogue produces sufficient drag, this large, bulky, expensive line cannot be used for an anchor rode or stern line ashore. We have found New England Ropes Multi-Plait to be an ideal line for towing a drogue as it does not get hockles or tangles.

Advantages: This tactic reduces boatspeed by roughly half, lessening the tendencies of broaching or pitchpoling from excessive speed. Additionally, it prevents the boat from accelerating to the speed of the wave and keeps the stern into the wind and waves.

Caution: You must actively steer the boat and have adequate sea room. Excess boatspeed with either warps or drogue can result in broaching, rolling, or pitchpoling. You must monitor sea and wind conditions and be ready to recover the drogue and set storm sails to heave-to if conditions warrant. Boats with aft cockpits are more vulnerable than center cockpit designs when riding stern-to large breaking seas. Consider a bridle and monitor chafe on the lines.



Drogue under load

Suggested Galerider Sizes	
Displacement	Galerider Dimensions
<10,000	30" x 36"
10,000 – 30,000	36" x 42"
30,000 – 55,000	42" x 48"
55,000 – 90,000	48" x 54"

7. **Motorsailing Slowly to Windward**

   Method: Sheet storm trysail closely to prevent flogging and provide stability.

   Advantage: This tactic has proven successful for moderate and heavy displacement sailboats and powerboats. Although not usually mentioned as an option for storm management, I have interviewed skippers of the Westsail 43, Por Vida, who survived by motorsailing in 90-knot winds and 40-foot seas during the Queen's Birthday Storm, and the Roberts 50, Swanhaven, who used this tactic in an 80-knot cyclone. These skippers reported no rolling, knockdowns, or other difficulty.

Caution: Water may enter the fuel tank vents or lines may wrap around the prop. Also, if you haven't been meticulous about filtering fuel while filling your tanks, sediment and debris might be stirred up and block fuel filters while motoring in rough conditions. Carry extra fuel filters and know how to bleed your engine's fuel system.

8. **Lying Ahull**

   Method: Bare poles with helm tied off. The motion is violent and the chance of capsize increases as wave height approaches beam. You should only use it as a last resort. It was tried by many in the 1979 Fastnet with poor results

Extreme rolls when lying ahull

   Advantages: Lying ahull is useful only in tropical squalls of short duration with flat seas and for multihulls over 40 feet.

   Caution: This is the fastest possible way to be rolled and dismasted in breaking sea conditions, as happened repeatedly in the Queen's Birthday and December 1998 New Zealand storms. Don't lie ahull if seas are higher than the beam of your boat. Although I have used this technique successfully during some intense tropical squalls, instead of changing sails when the windspeed has gone from 10–60 knots then back to 10 knots in just a few minutes, it doesn't work in other conditions. In 1976, when I was single-handing near the Cook Islands and lying ahull on the edge of a tropical depression, my Vega 27 was rolled to 90°, breaking the rudder. In retrospect, forereaching or heaving-to would have been a safer alternative.

9. **Parachute Sea Anchor**

   Method: This large diameter, high drag device is set off the bow on a rode adjustable from 300 feet to 600 feet while the helm is fixed amidships.

   Advantages: The parachute sea anchor stabilizes the boat and allows time for the crew to dry out, fuel up, and sleep. It also makes possible repairs that require swimming, like clearing lines from the prop.

Caution: You must monitor for chafe at regular intervals. Set a watch schedule, such as every 10 minutes, and broadcast a "Securité" message every 30 minutes on VHF channel 16 stating your position and lack of maneuverability. Using a parachute sea anchor has several serious drawbacks: it must be deployed early, as deployment becomes more difficult in strong winds; it cannot be easily retrieved until storm conditions have abated; and there is an excellent chance of rudder or steering damage in winds over 50 knots and in breaking seas over 20 feet.

Suggested Sea Anchor Sizes		
Boat LOA	Displacement	Sea Anchor Dia.
<20	<4,000	6'
<25'	<8,000	9'
25-33'	<12,000	12'
30—40'	<25,000	15'
35—48'	<40,000	18'
40—90'	<95,000	24'

10. Scudding

Method: Steering straight downwind with no drag device. May be under storm sails or bare poles; target boat speed is Sqrt(WL).

Caution: Since there is less boatspeed control with this method, it can be a bad choice. It is better to try to slow the boat by streaming a drogue. It requires active steering and as the boat accelerates down the wave face; pitchpoling or broaching is common.

Final Thoughts from John Jourdane: When Sailing Downwind in Heavy Weather, Control is the Goal

While the traditional approach is to slow the boat in heavy air, with today's modern designs, speed is good. Higher speed allows more steering control and overtaking waves will have less impact. If you are racing to Hawaii or Mexico, put up your biggest sails, put on your best drivers, and go surfing. If you are cruising or short-handed, reduce sail early and put your best drivers on the wheel. The key is to keep the boat under control. Do whatever it takes on your boat to accomplish that.

Options Matrix for Determining the Best Heavy Weather Technique

FROM CHUCK HAWLEY (AND ORIGINALLY FROM CAPT. JOHN BONDS, USN)

CHOICE DEPENDS ON: THE BOAT DESIGN, THE SKILL OF THE CREW (DRIVERS WANTED!), THE GEAR ONBOARD THE BOAT, AND THE AMOUNT OF SEA ROOM. GENERALLY, CRUISING BOATS WILL HAVE MORE OPTIONS THAN RACING BOATS. (GREEN = GOOD CHOICE FOR THAT BOAT AND CREW, YELLOW= CAUTION, RED = NOT ADVISED)

OPTIONS FOR **HEAVY CRUISING BOATS**:			
PASSIVE TECHNIQUES			
RACING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
CRUISING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
ACTIVE TECHNIQUES			
RACING CREW	FOREREACHING	SCUDDING	DROGUES
CRUISING CREW	FOREREACHING	SCUDDING	DROGUES
OPTIONS FOR **LIGHTWEIGHT CRUISERS**:			
PASSIVE TECHNIQUES			
RACING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
CRUISING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
ACTIVE TECHNIQUES			
RACING CREW	FOREREACHING	SCUDDING	DROGUES
CRUISING CREW	FOREREACHING	SCUDDING	DROGUES
OPTIONS FOR **LIGHT RACE BOATS**:			
PASSIVE TECHNIQUES			
RACING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
CRUISING CREW	HEAVING TO	LYING AHULL	SEA ANCHOR
ACTIVE TECHNIQUES			
RACING CREW	FOREREACHING	SCUDDING	DROGUES
CRUISING CREW	FOREREACHING	SCUDDING	DROGUES

Chapter 7—Damage Control and Repair, Dave Endean

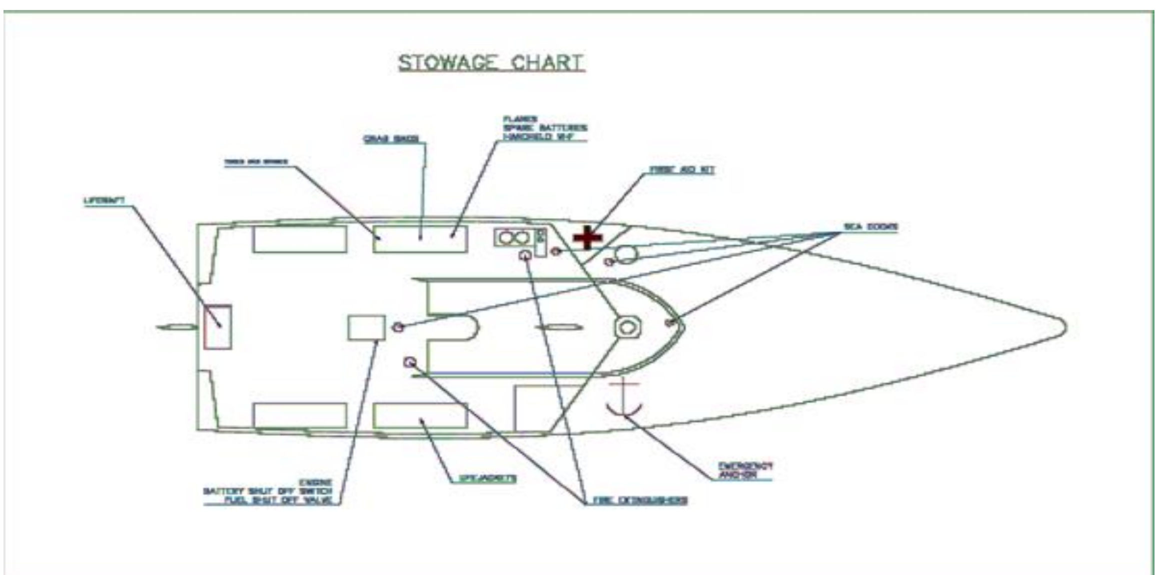
Key Concepts: Plan for self-sufficiency and to minimize damage from: loss of rudder/steering; dismasting; flooding due to collision, seacock failure; severe weather damage; loss of keel and/or capsize; collision with another vessel, a submerged object, sea life, etc. Avoid escalation. Prepare with training (OSR 6.02.3), tools, and materials.

Damage to a vessel happens most often during rough weather. Increased loads and stress combined with difficult conditions can cause small problems to escalate and cause serious damage or endanger the vessel and crew. Appropriate crew and boat preparation can help minimize issues at sea and enable a crew to deal with problems, *without requiring outside assistance*.

Preparation and Training

Prior preparation is critical to a successful voyage, whether it is across San Francisco Bay or across an ocean. Occasionally a situation can develop with unexpected severity. You need to be prepared for it in order to minimize problems, keep the crew and vessel safe, and arrive at your intended destination intact.

Review this handbook with the entire crew as part of the pre-voyage preparations, outlining all safety features together. Indicate where all the safety gear is stowed. Make a chart. Describe the operation of safety equipment. Since there are variations between brands, it is important that all are familiar with what is used on board. Review all systems, designating a specific crew member responsible and spares needed for each area. When discussed with the entire crew, the shared responsibility highlights any overlooked areas. Everyone should be aware of the stowed location of the safety kit, first aid kit, tools and spares. Stowage charts are very helpful, especially in an emergency.



ABN AMRO One, Stowage chart

Preparation –Preparation involves *knowing the boat* inside out, from bow to stern, top to bottom. The more you know the boat, the better you can address problems that arise. The longer the intended journey, the more you must consider. Your goal is to be self-sufficient while at sea. For this you must pack a complete and appropriate toolbox and spares kit. There is no point in carrying tools and spares that don't work on your boat.

Just as you check First Aid kits and safety gear to insure use-by dates are current and that items are not wet, corroded or damaged, you need to *scrutinize your toolbox and spares.* Check all tools are rust free and actually work on your boat's components. Use vacuum bagging or zip lock sealed bags to store your spares to keep moisture from damaging them

Maintenance is crucial before you slip your mooring lines. A boat with regularly checked systems will be much more reliable than one that is not. Know the history of the boat and when each component was last inspected. A thorough hull, keel and rudder check is wise before purchasing a boat and certainly before any long distance off shore sail. Make sure engines, generators, water makers, winches and deck hardware are regularly serviced. Have the mast, rigging and sails checked by a professional. Carefully check all electrical systems and be aware of any signs of corrosion. Electricity and water can be especially problematic on a boat!

Although thorough preparation goes a long way to preventing issues, recent service does not guarantee that problems will not arise later at sea.

Training – There are many courses available to help learn about your boat's components, but with all the systems on board (engines, electrical, water-making, sails, deck ware and so on) there is probably too much information for one person to excel at all, so focus on *information specific to your boat*. Training is not limited to professionally taught classes: if you have an engine mechanic work on your engine, watch and ask questions to learn as much about *your* engine as possible. It's not necessary to know everything about all engines, but if you know about yours specifically it can help if you experience problems at sea. Even though recently checked, carry a collection of the correct filters, belts, spare oil and tools so you can work on the engine if needed. The same can be said for all the systems on board.

Damage Prevention and Minimizing the Disaster

If you start having problems while at sea, *make sure the problems do not escalate*. Address issues as they arise either with repairs or by changing the vessel's situation. A classic and common example is fighting leaks. It is a constant battle on many boats to *keep the water on the outside* of the vessel. Don't become complacent about leaks. The smallest leak can cause problems, especially with a boat's electrical systems. Losing electronics can deem your communication, navigation or autopilot systems useless, which will most likely increase the problems you face.

If you are taking on water during bad weather, you must stay on top of bailing the boat to minime the amount of water that finds its way inside. Keeping water levels under control can fight the knock on effects until you have a chance to address the leaks properly. Ideally, all your electronics and batteries would be securely and safely mounted in a watertight area, but if not, check often and be similarly aware of all your systems.

Evaluation of Damage: STOP – THINK – ACT

If your vessel is damaged, first *evaluate the damage* and understand the ramifications. This will help to plan the next steps. Is the damage severe enough to abort your journey and seek external help? If so, alert others (Coast Guard or a nearby boat) immediately, by radio or sat phone. State your situation including boat identification, location, crew aboard, your damage, and a plan to talk again. If the situation deteriorates, you may not have another chance for contact. Can you address the situation fast enough to salvage the boat or do you need to prepare to abandon ship? Is it something you can fix adequately enough to continue with the voyage and make more permanent repairs at your destination? This evaluation could be the tipping point between keeping the situation under control and allowing it to evolve into possible disaster. Never underestimate the situation, especially at sea when a change in the weather could escalate problems quickly. And remember: the FIRST priority should always be crew safety!

If the boat is in grave danger, *focus on the safety of the crew*. Don lifejackets and prepare the liferafts and grab bags on deck. Once you are prepared for the worst, re-address the problems to see if there is more that can be done to save the situation. Abandoning ship is the last solution, but it shouldn't be the last thing to prepare for.

Execution of Repairs

During your evaluation, decide *how urgent the situation is*. Can the problem wait and be solved in better weather or after you have pulled into port or must it be addressed immediately for the safety of the crew and vessel? Will executing your repair work affect the handling and maneuverability of the vessel?

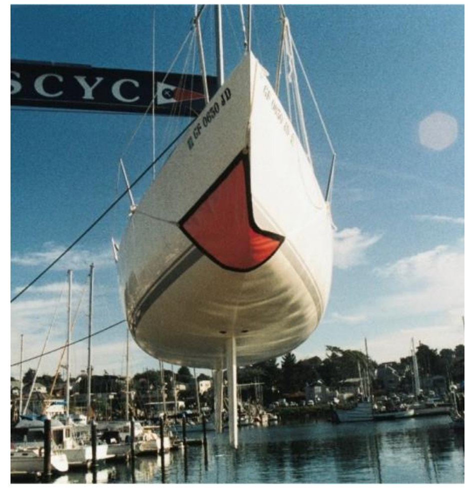
Make sure the *repairs don't have a negative effec*t on the boat's situation. Before starting, note your situation carefully and be properly prepared. For instance, are you on a lee shore and may need to tack soon or are you in a busy traffic channel and may need to negotiate other vessels? Make sure someone on deck stays focused on the sailing to avoid more problems created by distracted crew. Always keep a clear head while working on repairs. There is often some risk involved and it is important to keep the crew's safety as the number one priority.

You may not have enough *spares* on board to complete all repairs, but quick repairs, although perhaps not perfect should help keep the situation from developing further. Have a plan for situations that could incorporate items onboard to make a short term fix. Some examples are:

i. Fenders and buckets to plug rudder bearings. If you lose your rudder, a round inflated fender pulled up from inside will help stem most of the flood of water, or jam a bucket down from the top and prop in place.

ii. If you don't have a collision mat use sails, boom covers, crew bags and bunk cushions as short term seals for a breached hull. If your hull or deck is damaged, strap these materials across the damaged area. It may not stop all the water, but it could reduce the ingress to a level that crew can stay in control with buckets and bailers.

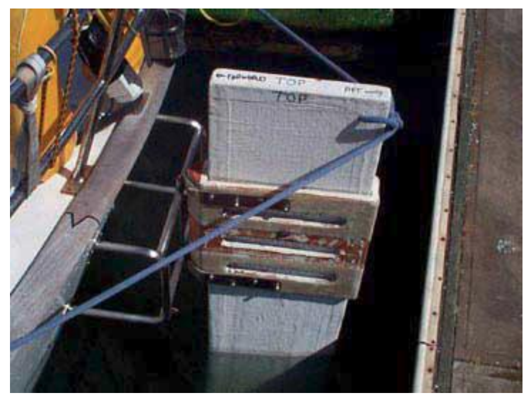
iii. Bunk tops, locker doors and other non-structural components can replace lost hatches or cover holes in the deck. Reinforce these with spare sail battens or other rigid materials for more strength.



Collision Mat, Chuck Hawley photo

iv. Have a set of wooden plugs on board in the event of a seacock failure. Be sure the sizes on board match your seacocks. Tie the proper size wooden plug with a 1 foot lanyard to its paired seacock so you don't have to search for the correct plug if there is a problem.

Have a *backup steering system* in case of steering failures. If you lack a specific emergency steering system, at a minimum have a good plan to set up temporary steering using other boat parts to insure you can steer the boat in the right direction. Test and document your plan so the crew can implement it. Know how to set and steer with a drogue or sea anchor. Most wheel steering systems have a means of inserting an emergency tiller, but if the rudder itself has been damaged you will need to be resourceful with other options on board. A spinnaker pole over the transom will be a difficult system to make effective and likely only work in mild conditions. Plan something robust and mountable in the conditions that broke the initial rudder. If you lose your rudder on a lee shore, you may not have time for experimentation. (See *Uncontrollable Urge* report on US Sailing's website: *http://www.ussailing.org/wp-content/uploads/DARoot/Offshore/SAS%20Studies/2013%20Islands%20Race%20Report.pdf)*



Emergency cassette rudder, Pineapple Sails photo

If *dismasted*, quickly evaluate whether you can keep the rig and rigging or whether it needs to be cut away. This will depend on the size of the rig and whether or not it is causing damage to the yacht. Salvage the rig or parts of it if you can, but not at the risk of hurting someone or damaging the hull or deck, which could make the situation worse. If you need to cut the mast away, be wary of rigging that is under load. Know which direction the parts are likely to 'fly' once cut. If you need the engine for control, check that the propeller is clear before engaging it. With the rig over the side, there is so much gear in the water that it is very easy to foul your propeller, which will create another problem. Ideally, you would not use the prop until the mess is cleared up, but this isn't always possible.

Once you have separated the mast, rigging, and sails from the yacht or have managed to salvage parts back on deck, do a thorough check of the hull from both outside and inside. Check all the water tight compartments to make sure the hull or deck is not taking on water. Only after all is secured should you start to think about a jury rig. Even if it is small, a sturdy jury rig will help you make way in the right direction and will help steady the boat in a bad sea state, which could minimize seasickness. It will also contribute a lot if you decide to motor sail. (See Sparky's story at end of this chapter.)

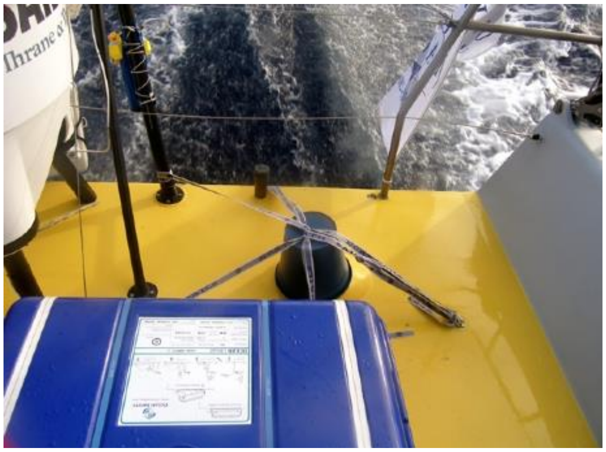
Personal Experience

ABN AMRO One, VOR, Justin Slattery photo

The first generation of Volvo 70 canting keel boats was an incredibly exciting boat, offering a platform that could be pushed to extreme limits. During the 2005-06 Volvo Round the World Race, the hull, deck, structures and systems of these boats were made as light as possible. The more weight saved throughout the yacht, the heavier the bulb on the end of the 4.5m keel. This was fast, but it contributed to structural problems. The lightweight composite structures were tested to their limits and sometimes beyond, while the boats careened through the toughest conditions at record breaking speeds.

ABN AMRO One was a seriously fast and well-built machine. We had the advantage of building two boats, so experience with the first yacht allowed us to refine the second with well-developed systems, sparse composite structures inside the hull, and an agreement among the crew to minimize weight. This allowed the fleet's biggest bulb. But this did not come for free: there were many legs of the race that we needed to make repairs.

During the first night of the first leg of this Volvo race we were forced to make several repairs to the steering system as severe weather wreaked havoc throughout the fleet within 8 hours of the start. While crashing through waves was something we were used to, the waves that first night were especially steep since we were close to the coast. On the verge of control and in pitch black darkness, we broached and then buried the boat immediately into the next wave sending one of the crew through the leeward steering wheel and pedestal. Luckily the steering pedestals were very light and the crew member was not hurt, but this left us with two problems: ingress of water and a lack of steering. We immediately propped up the pedestal and jammed it back on the hole in the deck. While this only stopped a little of the water coming through the deck, it meant that the windward wheel could be used again to steer the boat. We wrapped a headsail bag around *the leeward pedestal and then tied everything off to hold the pedestal in place against the water rushing down the deck. Further investigations below deck highlighted that other carbon fiber components of the steering system had failed during the broach. The list of damaged parts was getting longer. Over the next few dark hours, we began to repair the below deck steering, mainly because it was the first priority to fix but also because the pedestal was going to be impossible to fix during this wet weather and the riggers on deck had done a suitable job of propping up the pedestal and lashing it in place. As soon as the weather allowed the following day we were on deck cleaning up the pedestal and re-bonding it back in place. In the first 24 hours I had used half of my resin and glue spares and a good portion of the threaded rod we carried to mend the tiller arms on both rudders.*



Temporary repair to ABN AMRO steering pedestal hole

Only 20 days to go!

At one stage we had deployed our emergency steering while we repaired our primary steering system. We finished the repairs just in time as the emergency system was starting to show signs of fatigue after just a few hours. That was a sign of how hard our crew were pushing despite the problems we were addressing in the background.

As if all this wasn't enough, we had another bad hand dealt to us. During the rough weather of these first 36 hours, a bolt became dislodged in our battery box and rolled around until it connected our battery bank to the carbon hull. There was a sudden terrible smell inside the boat and before we knew it the battery box and batteries were on fire. A fire on board a yacht can be devastating, but due to quick firefighting and shutting off the battery bank by skipper Mike Sanderson and navigator Stan Honey we controlled the fire before it went any further. Once the smoke had cleared we could address the problems of fried electronics and after a few hours of re-work the boat systems could be turned back on again (minus two of the batteries!) Knowing the boat systems and knowing where all the fire extinguishers were mounted saved the electrical system and the whole yacht from going up in flames.

All these repairs not only kept us in the race when others withdrew but we set a World Speed Record for distance covered in 24 hours and then went on to win the leg. One yacht arrived into Cape Town by plane and another by ship following the events of the first night. After this leg, my spares kit allowance was increased since the crew decided there was a good chance this sort of damage could continue and we should be prepared for it.

Four weeks later, deep in the Southern Ocean approaching the bottom of Australia, skipper Mike Sanderson and I evaluated the most recent problem. We had just days earlier fixed our inner forestay chain *plate after it had collapsed. Now the problem was where our main structural longitudinal joined our keel box. This is a crucial zone, especially on a canting keel boat. The longitudinal acted like the spine of the forward sections of the yacht and it had totally broken free from the keel box. Every time we dove into (or through) another wave at 30 plus knots the spine moved relative to the rest of the structure. If we were to continue the leg we had to fix it. Over the next few hours we dug out our spares and tools and set to fixing the problem, which was made more difficult by the freezing, wet conditions and wild motion. For 30 minutes we asked the crew on deck to slow the boat down while we started the repair. The biggest problem was the surfing. Every time we went down the waves the water pressure outside would push the bow up. While trying to drill holes through the longitudinal and reinforcement plates I had made, my drill would jam as we surfed down the wave. Then when we popped out of the wave, the drill would come free and I would finish the hole. We got used to this method and applied the same theory when bolting the plates together. When we popped out of the wave, Mike would fire the next bolts in and this way we glued and clamped big reinforcement plates on either side of the longitudinal. Once we had hardened the glue with our galley stove burners, we were good to go again and the crew continued to push through the Southern Ocean and on to win that leg into Melbourne. Another satisfying victory.*

It was a great challenge for the whole crew to get the boat through all those legs. We had to learn when to back down on the speed for particularly rough patches of sea or weather, so that we could really push when conditions allowed. Every leg saw us dig out our spares and tool bags, so it was a credit to the whole crew to be prepared in all their individual areas for anything the race threw at us.

Photo from Chuck Hawley

Damage Control Summary, Bruce Brown

Damage Control requires a clear understanding of the boat prior to untying the dock lines. Know where the thru hulls are, how the keel is attached, the mast(s) structure(s) and the rigging plan as well as the equipment on board to prevent a sinking due to massive flooding. During haul out, closely inspect the keel and rudder assembly, including rudder bearings. Lubricate thru hull valves and/or seacocks. Inspect any prior hull damage and repairs. During the voyage, watch standers must note concerns about any element on board, including bilge water monitoring, engine water temperature, electrical battery charge levels, chafe on running rigging and/or sails, standing rigging and spar conditions, navigation systems, fresh water levels, water maker output, steering systems, holding tank level, and all galley systems.

There must be a designated person on board who is familiar with how to replace a shroud to keep the spar upright, stop water from flooding the boat or seal off areas of flooding to save the boat from sinking, rebuild the pumps on board, bleed the injectors for the engine or replace a belt on the motor, splint a broken boom, replace failing winch parts and repair the steering system.

TruPlug, courtesy Forespar

Damage control begins with accounting for the well-being of all crew on board, since incidents can quickly degrade into multiple problems. This is an overview of common failures that require damage control – hull, spar/rigging, deck, systems and people:

1) Hull
    a. Flooding – due to collision, corrosion or system failure. First, control the amount of water entering the boat. Dewatering before slowing the ingress of water will be wasted effort. Foredeck hatch should be strong, watertight and *always* closed. For spinnaker take downs, "letterbox" approach is safest to keep crew and sail aft.

        Helpful tools include:

        i. Soft Wood Plugs for Thru Hulls
        ii. Neoprene fabric (stuff into a hull breech)
        iii. Waterproof fabric (plastic) (hull breech)
        iv. Hose clamps (loss of hose connection)
        v. Toilet wax ring, (medium size hole)
        vi. TruPlug (damage control plugs) (any water intrusion, loss of propeller shaft)
        vii. Rectangular piece of soft lead, 15" x 15", rolled up to store, pre-drilled around perimeter, can be molded to hull shape and fixed with self-tapping screws.
        viii. Collision Mat (large hull breech) – in place of a dedicated

Flooding, water ingress at hull support

Flooding controlled with TruPlug

collision mat, a storm trysail makes a perfect three-corner mat to stretch outside the hull to slow the water flow. Next best is storm jib or the head of any small jib.

ix. Quick Set Polyester or Epoxy putty or resin with filler (Hull breech, bulkhead damage, deck damage)

x. Boards to cover hatch openings (hatch or port light damage)

xi. Be able to remove the water faster than a normal bilge pump. Keep bilges clean, and have high-capacity pump, especially when short-handed – See Water intrusion chart below:

TABLE OF FLOODING RATES (Gallons Per Minute)

Distance below waterline	Diameter of Opening in Hull (Inches)							
	1"	1.5"	2"	2.5"	3"	3.5"	4"	6"
1'	20	44	79	123	177	241	314	707
2'	28	62	111	174	250	340	444	1000
3'	34	77	136	213	306	417	544	1,224
4'	39	88	157	245	353	481	628	1,414
5'	44	99	176	274	395	538	702	1,581
6'	48	108	192	301	433	589	770	1,731
7'	52	117	208	325	468	636	831	1,870
8'	56	125	222	347	500	680	889	1,999
9'	59	133	236	368	530	722	942	2,121
10'	62	140	248	388	559	761	993	2,235

Courtesy of Alaska Marine Safety Education Association

Dewatering Pump

b. Keel attachment loosening or leaking, especially after grounding.

c. Dagger Boards trunk leaks and/or wear

d. Steering

   i. Emergency rudder (replace broken rudder)

      1. Don't believe you can figure it out at sea

      2. Have a system that is engineered, fabricated and tested prior to leaving the dock.

   ii. Emergency Tiller

      1. Be sure you can locate it and practice with it!

      2. Be sure it fits on the tiller head before you need it

      3. Understand what must be removed or added to make the emergency tiller work

   iii. Rudder Bearings

      1. Damage to lower bearing can be fatal to the boat

      2. Insure the bearings are serviced and the bonding to the hull and deck is secure

   iv. Chain assembly

      1. Carry a spare master link and know how to assemble it.

      2. Insure you have access to the chain to repair the steering system

2) Spars, a complete system:

   a. Mast(s)

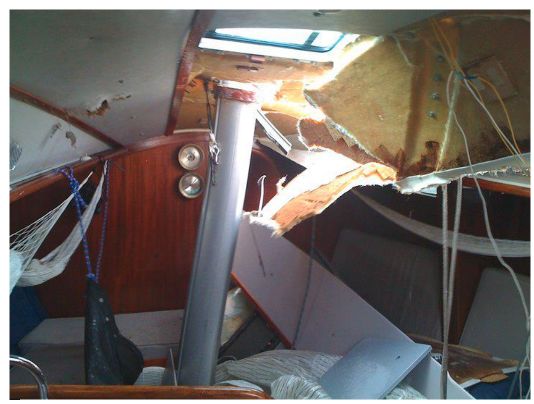
      i. Gooseneck assembly - repair or trim main loose-footed, like a trysail

ii. Spreaders – Are they sound?
iii. Mast Head: sheaves, crane
iv. Track/Cars (dedicated storm trysail track?)
v. Mast boot – secure?
vi. Step – mast through-bolted to step?
vii. Spinnaker pole offset – compression from pole too far from counter force of boom?
viii. Panel strength

b. Boom(s)
i. Outhaul
ii. Reefing system
iii. Main sheet bale/strop
iv. Vang

c. Rigging/Support – Home Depot angle grinder cuts rod, aluminum, and carbon fast. Have spare blades and charged power packs.
i. Standing Rigging
1. Shroud terminals
2. Spreader tips and roots
3. Turnbuckles
4. Clevis Pins/Cotter Pins
5. Plan to remove standing rigging in an emergency: cutters? Knock out pins?
ii. Running rigging – chafe, overrides
iii. Mast Jack
iv. Hydraulics
1. Hoses and connections
2. Reservoir
3. Fluid
4. How to purge the system
v. Electrical
1. Electronics: wind, radio
2. Lights: Windex, steaming, navigation

d. Other effects of dismasting: damage to structure and people below decks



Damage to cabin due to mast butt motion, Chuck Hawley

3) Deck
a. Hatches (gaskets, hinges and latches)
b. Port Lights (gaskets, hinges, latches)
c. Stanchions – loose or cracked
d. Life Lines – tight!
e. Pad eyes – deck leaks
f. Clutches – lines slipping in the clutches
g. Blocks – failure
h. Strops – wear

    i. Traveler – mainsheet to traveler attachment
    j. Jib sheeting system
    k. Sprit – controls for tack line
    l. Winches – spare parts
    m. Cleats – back-up plates and bedding
    n. Cockpit drains – sufficient capacity, clogging

4) Electrical
    a. Battery condition prior to leaving dock
    b. Charging systems – failure
    c. Circuit breakers – all electronics run through breakers?
    d. Back-up running lights and power source
    e. Back-up lighting in case of emergency (flash lights/head lamps in Damage Control kit)

5) Plumbing
    a. Sanitation – Head rebuild kit
    b. Fresh water system
        i. Water maker, water purification materials
        ii. Fresh water pumps (manual) and gauges to measure levels
        iii. Drains for sinks, toilets and showers: another thru hull location

6) Galley
    a. Stove
        i. Propane: Electric solenoid; Leak detector; Fiddles
        ii. Stove gimbal locks
        iii. Consider fire mat in the galley
    b. Refrigeration

7) Engine Problems
    a. Fuel filters
    b. Water strainer
    c. Bleed injectors
    d. Burning oil?
    e. Transmission linkage

Dismasting: insuring hull integrity may require removing the mast completely, including all standing and running rigging, hydraulic lines and the electrical supply cables. In a hull breech, first minimize the water intrusion into the hull. Locate the source of the water before trying to stop it. In any damage situation, call for help early in case escalation leads to loss of communications later. Maintain order and calm through clear directions. Understand that safety considerations may mean you are no longer racing. For example, a broken rudder and subsequent installation of the emergency rudder leaves no alternative if the secondary rudder fails. You must treat the replacement gently to avoid losing all steering options.

Sparky's Dismasting, 668 miles from Hawaii

Excerpts from Ruben Gabriel's Picasa photo album and Lat 38 issue of August 8, 2008.

The Single-handed Transpac race from San Francisco to Hanalei Bay, Kauai rarely takes the 27 days that it took Rubin Gabriel on his Pearson Electra, Sparky. In his case, it was a triumph since the last 12 days were under a self-devised jury rig after he was dismasted in a squall. He was running under twin headsails when the starboard spinnaker pole dipped into the water and the compression bent the pole and buckled the mast a few feet above the gooseneck. The entire rig collapsed in a tangle on the foredeck. Gabriel reported his situation to the race committee, then went to work, determined to handle the situation without asking for outside assistance, which he did. Here are his words and photos:

1 – Mast is disengaged from the step. A few scratches, but no harm done to the deck.

2 – Mainsail in the water. Getting this out of the water and on deck was not fun. I was still in a state of shock dealing with this.

3 – Everything on deck now and I'm feeling much better.

4 – Too much load on the spinnaker pole, as evidenced from the ring.

5 – This is Ugly.

6 – Distance from Hawaii: 668 nm. Going nowhere fast.

7 – This was early evening on the day of the dismasting. I put up the bottom portion of the mast to keep the boat stabilized. Not pretty but it worked.

8 – Top portion of mast that I eyeballed for a few days. I knew I would eventually use it.

9 – Phase II of the jury rig. I opened up the mast and stuck the bent spinnaker pole in. Again, not pretty but it kept me going in the right direction.

10 – Okay, I'm feeling really good now...now that I'm moving forward at about 3 knots.

11 – Phase III of jury rig! Top portion of mast is up and headsails are flying! This rig was stable and took me to the finish line.

12 – Example of some of my lashings on the mast

Other details: Coiled up my shrouds (at the lifelines) to keep them out of the way. Several times a day, I used the winches for tighten the lines holding up the mast. I used the main halyard as my backstay. Headstay: I tied a bowline on a shackle at the masthead, then ran the line down to a block on the bow, then to a rope clutch on deck.

13 – Yippee! Only 400 miles to go!

14 – Skip Allan on Wildflower towing me into Hanalei Bay after I crossed the finish line... yahoo!

Ruben Gabriel and fiancée, Robbie.
Ruben's final thoughts: "I've come to the realization that this wasn't just a sailboat race, but a test of human spirit."

Chapter 8—Giving Assistance to Other Craft, Chuck Hawley & Paul Miller

Key Concepts: Legal requirement (SOLAS 33), moral imperative (RRS 1.1), and communications and log-keeping obligations; maneuvering close to a sinking vessel, recovering personnel from the water or a liferaft; tactics if other vessel is on fire, towing, or being towed.

Artemis Capsized on San Francisco Bay, 9May13 (Photo: AP/Noah Berger)

There are many reasons to provide assistance to a vessel in danger, including legal mandates, racing rules, and moral imperatives. As Robin Knox-Johnston reminds us in a letter published in *Scuttlebutt*, edition 3899, on August 12, 2013, "It has to be remembered that providing assistance to a fellow seafarer is a duty not an option." There is only one exception to this rule: when rendering assistance might endanger your own vessel and crew.

Legally, as a sailor, you are required to help a vessel in need. United States law states: "(a)(1) A master or individual in charge of a vessel shall render assistance to any individual found at sea in danger of being lost, so far as the master or individual in charge can do so without serious danger to the master's or individual's vessel or individuals on board" (46 US 2304). Racing regulations also mandate that racers assist vessels in need. The first Fundamental Rule of the Racing Rules of Sailing (RRS 1.1) states: "A boat or competitor shall give all possible help to any person or vessel in danger." (See Table 1 for more information on legal and racing regulations on giving assistance.)

Perhaps most importantly there is a moral obligation to provide all reasonable assistance to another vessel in trouble. Assistance may include:

- search and rescue operations,
- communications relay,
- providing essential supplies for repairs or to mitigate an emergency,

- supplying fuel,
- providing technical or mechanical skills,
- providing the endangered vessel with additional crew members,
- removing crew from a compromised vessel, or
- simply standing by to provide comfort and emotional support.

Consider these two things when determining if you should assist a vessel in need:

- you may be the only current source of help and
- you may require similar help in the future.

However, there will be instances when you are not able to help another vessel because it may endanger your own ship and crew. Sometimes, your only options for helping another vessel are to stand by, offer advice or encouragement, or report the situation to others by radio. You must evaluate the situation and consider: What is the nature of the problem? What are the conditions aboard your own vessel? Do you have the ability to render useful assistance? Will you put your crew at an unacceptable risk? In any case, you must make every reasonable effort to do something to assist the vessel in distress.

Safety Laws and Regulations for Giving Assistance

Sailing Authority	**Giving Assistance Laws and Regulations**
U.S. Government	"(a)(1) A master or individual in charge of a vessel shall render assistance to any individual found at sea in danger of being lost, so far as the master or individual in charge can do so without serious danger to the master's or individual's vessel or individuals on board. (2) Paragraph (1) does not apply to a vessel of war or a vessel owned by the United States Government appropriated only to a public service. (b) A master or individual violating this section shall be fined not more than $1,000, imprisoned for not more than 2 years, or both" (46 US 2304).
International Maritime Law's Safety of Life at Sea (SOLAS)	*"The master of a ship at sea which is in a position to be able to provide assistance . . .* ***is bound to proceed with all speed to their assistance****, if possible informing them or the SAR service that the ship is doing so. . .If the ship receiving the distress alert is unable or, in the special circumstances of the case, considers it unreasonable or unnecessary to proceed to their assistance, the master must enter in the log-book the reason for failing to proceed to the assistance of the persons in distress and, taking into account the recommendations of the Organization, inform the appropriate SAR service accordingly."* (Regulation 33) [emphasis added]
Racing Rules of Sailing	*"A boat or competitor* ***shall*** *give all possible help to any person or vessel in danger."* (RRS 1.1) [emphasis added]

If you find that you are in a position to render assistance to a vessel in trouble, it is prudent to stand by at least briefly, if possible, to evaluate the situation before rushing in to help. Just as you would contact the fire department prior to entering a burning building, make contact with SAR authorities before endangering your boat; then if your crew or your vessel also becomes compromised, someone knows where you are and the nature of the distress you are encountering. Assess the situation and prepare your boat and crew to increase the odds that you succeed in your attempts to help. Only rush in if it is an extreme situation.

Whether or not you are able to render physical assistance when requested, you are required to log the event. Your log entry should include all details of the situation: who, what, where, when, how and why you could or could not help, and what calls you made by radio or other means (U.S. law requires that any and all safety-related calls be logged). The entry must include the names of your crew and those rescued or missing, the conditions, course, speed, etc. Record the account while the incident is still fresh. Write in ink with only single-line cross-outs if necessary.

The following rescue scenarios describe a few possible situations you may encounter and how you may best assist an endangered vessel.

Dismasting and/or Capsize: Your assistance may include rescuing the crew and/or salvaging the vessel. Plan your approach and communicate your intentions to the other vessel and the SAR coordinator. Keep them informed as plans change. Act immediately—don't wait! A delay in initiating your response could prove fatal. Prepare to recover rescued personnel from the water or from a life raft. Have blankets ready. Prearrange your course after rescue, airlift, etc. with those involved. Plan your departure from the rescue and communicate your plans to the other vessel.

Photo credit: Ian Mainsbridge/PPL

In general, it is wise to approach a compromised vessel from leeward to avoid drifting lines. Continually judge the relative drift between the vessels and maintain maneuverability. If there are significant waves, consider transfer by liferaft, dinghy, or in the water. Beware of creating two disabled vessels.

Fire: First, evaluate the conditions, including wind, waves, and current. Be mindful of the danger of explosion if the fire is fueled by LPG or gas. Consider transfer options: bow to bow, liferaft, or in-water. How will the wind and sea conditions affect your approach and choice of transfer? For instance, if there is significant smoke involved, approaching from leeward could be hazardous. What other factors are involved? Are there injured or incapacitated crew on the other boat? What are the limitations to your own rescue capabilities? Think, but think fast. Only five minutes elapsed between the two pictures below.

Five

Minutes

Later

Towing: When setting up a stern tow in big waves, use a tow line that is 5–10 times the overall length of the larger boat. Be sure to fix the tow line to very strong points, such as cleats or winches with solid backup pads. Consider using a bridle, with each leg of the bridle longer than the beam of your boat. Towing speeds should be very slow: no more than the square root of the overall length of the smaller boat. Be ready to cut the tow loose if the towed boat becomes a hazard.

Once you are in port, switch to a side tie, with the pushing prop farthest aft. Use every fender you have to cushion the boats. This can be dangerous in waves, especially with a mast and rigging swinging overhead.

Imminent Sinking: Call for backup before you start to help—you may be too occupied later. Keep the SAR coordinator informed of the progress of the rescue. Anticipate escape routes in case things get out of hand. There may come a time when waiting for the experts is the best approach, but remain in contact until the situation is under control, if possible.

On the other hand, you may have to act very quickly. On March 5, 1995, One Australia sank in just two minutes. Are you prepared to rescue multiple people from the water? Practice your techniques for retrieval and establish a rescue plan with your crew. (See *Georgia* story.)

In summary, help when you can, call for backup before you start helping, keep the SAR Coordinator informed during the process, and anticipate escape routes if and when necessary. Keep in mind that waiting for expert help may be the best option, but you may be able to provide psychological support in the meantime.

John Jourdane's Sydney-Hobart Rescue Report

John Jourdane describes his experience aboard the Spencer 65, Ragtime, *during the 2008 Sydney-Hobart Race.* Ragtime *and the Volvo 60,* Merit, *both stopped racing to render assistance to the sinking Farr 53,* Georgia*.*

It was the first night out of Sydney, and the wind was blowing a steady 25 knots with gusts to 30. The seas were 4–6 feet, and we were sailing south under spinnaker with the East Australian Current giving us a 3–4 knot push. The sun had gone down and it was dark. We saw a flare behind us and I went below to listen to the radio. The yacht *Georgia*, a Farr 53 out of Melbourne, came on with a Mayday. They had hit something and lost their rudder. The collision tore a hole in the boat where the rudder had been. They were taking on water and couldn't stop the inflow. They gave their position, and we saw that they were about 3 miles behind us. We called the race's communications boat and told them we were dropping our sails, and were on our way, upwind under power, to help them. The yacht, *Merit*, a Volvo 60 out of Brisbane, came up and said they were close and were heading to *Georgia* also.

Merit arrived first. They were discussing the rescue of *Georgia*'s crew when we came onto the scene. When we arrived, *Georgia* was so low in the water that the navigation lights were occasionally underwater. We saw that *Merit* had the rescue underway, so we said we would stand by. We brought our life raft on deck and prepared to help in any way we could.

Georgia had already inflated their life raft. It was in the water to leeward. *Merit* motored well to leeward of *Georgia.* The *Georgia* crew attached the life raft painter to an anchor rode and seven of their 14 crew members climbed into the raft. The wind and seas blew the raft downwind and *Merit* maneuvered to catch it. The seven crew members from *Georgia* climbed onto *Merit*, then they attached an anchor rode from *Merit* to the raft, and *Georgia* pulled the raft back. Now there was a line connecting the raft to both *Merit* and *Georgia*. The remaining seven crew members climbed into the raft and let out the rode as *Merit* pulled them back. When the entire crew was aboard *Merit*, they detached the line connected to *Georgia*. The rescued crew members were cold and wet, so the *Merit* crew took them all below and gave them warm clothes and hot drinks. About 10 minutes later, *Georgia* sank.

Photo Credit: Ian Mainsbridge/PPL

Merit headed toward the coast to rendezvous with a Coast Guard launch. We, on *Ragtime*, were cleared by the Race Committee to resume racing. We motored to the position we had stopped racing, set sails, and headed for Hobart. It was a perfect rescue of a sinking crew. We can all learn from the calm, professional work of the *Merit* crew.

Chapter 9—Crew Overboard Prevention & Recovery, Peter Isler

Key Concepts: Prevention (5.02), recovery (5.09), and standard search patterns (ISAF OSRs, Appendix D); MOB alarms and locators (4.28)

"Man Overboard" is probably the third most famous nautical hail, after "Land Ho" and "Thar She Blows," but it is by far the most serious and potentially life threatening of the three (unless the whale you spot is a giant white sperm whale and you have a fellow named Ahab on board). All kidding aside, a man overboard/crew overboard (MOB/COB) situation is one that should be avoided at all costs: in 2010, 72% of all boating fatalities were from drowning.

Your mother (or maybe your first sailing instructor) probably provided your first and arguably most valuable golden rules of boating safety: always stay with the boat and always wear your life jacket. These tenets are ubiquitous in the principles of boating safety and they have their application in the man overboard department, too. You can't have a man overboard situation if the crew stays on the boat, but if a sailor does go overboard, a lifejacket will greatly increase his or her chances of recovery and survival.

If, despite all precautions, someone ends up in the water, the challenge is to recover the victim as quickly as possible. Every man overboard situation is unique; though we should learn and practice the general guidelines and principles of a man overboard recovery, we must also know how to be resourceful and flexible. The better prepared and more experienced the crew, the better the chance that they will make the right decisions at crunch time. When the going gets tough, we rely on past training in safety and seamanship. There will be times when decisions affecting life and death must be made in a split second, under extreme conditions. It will be crucial to have the knowledge gained by study and training. The procedures for reacting to and recovering from a man overboard situation should be as familiar to your crew as a tack or a jibe.

AVOIDING MAN OVERBOARD

Here's a scary thought: imagine you are sailing in the Southern Ocean on a 120-foot catamaran, surfing along at 25 knots of boat speed. The water temperature is less than 40°F and your boat is travelling more than 40 feet every second. Suddenly, you fall overboard. The clothes you wore to stay warm on board significantly compromise your ability to swim any distance—even a few feet. In a mere 10 seconds, the boat is ¼ mile away from you and receding fast. Even if the crew is well trained and all are on deck (not likely), it will take at least 10 seconds for them to recognize the situation and begin the ordered reaction of deploying the man overboard gear and turning the boat around. If the waves are big, you are already out of the crew's sight for seconds at a time (assuming you fell over in the daylight). Got the picture? There's a significant possibility that you have enjoyed your last day of sailing.

Though an extreme situation, this scenario highlights the common problems of any crew overboard incident. Even in a less extreme situation—say a 40-footer sailing from the West Coast to the South Pacific—the distance between a person in the water and his or her boat increases at an alarming rate. At night, the visibility becomes zero almost instantly. In any case, you don't want to be watching your boat sailing away from you.

Here is the distance-over-time a boat travels away from a person in the water at various speeds:

Time-Speed-Distance Chart: Boat to Victim					
	5 kts	7 kts	10 kts	14 kts	20 kts
10 sec.	84'	118'	169'	236'	338
20 sec.	169'	236'	338'	473'	675'
30 sec.	253'	355'	507'	709;	1013'
60 sec.	507'	709'	1013'	1418'	2026'
10 min.	0.8nm	1.2nm	1.7nm	2.3nm	3.3nm

The best way to avoid a man overboard tragedy is to stay on board. Use proper techniques when moving around on deck, understand and avoid the danger areas, and wear (and use) tethered harnesses. These all play a role in staying on board. Safety education will provide you with a hefty arsenal in this department, but the biggest weapon should be the attitude of you and your fellow sailors. You should have an underlying respect (it's okay to call it fear) for the danger of going overboard.

If you want a little low-octane reality check, grab a buddy, go down to your local swimming pool wearing your sailing outfit, and jump in the shallow end with all your gear on. While you are there, don't forget to practice the HELP posture (see below) to minimize the loss of body heat. And, if you want a real deterrent, take your life jacket off (make sure your buddy is nearby) and try staying afloat without touching the bottom. You will be convinced: an ounce of prevention is worth a pound of cure.

HELP Position (single victim)

HUDDLE (multiple victims)

MAN OVERBOARD RECOVERY PROCEDURE

Although we should keep in mind that every situation is different, man overboard procedures are often broken down into the following areas:

1. Initial Reaction on Board
2. Safely Turning the Boat Around and Returning to the Victim (I prefer the term "swimmer")
3. Approaching and Recovering the Victim

1 – Initial Reaction on Board

The Dan Buoy

The first priority is to provide the victim with additional flotation to increase his or her odds of surviving until the boat returns. Be sure to also "litter the water" with any other floating paraphernalia that will increase visibility of the location, making it easier to find the victim. From our previous example and the simple speed, time, and distance equation, we know that time is critical when it comes to deploying any sort of safety or flotation gear if we want it to be within dog paddling distance. This requires proper preparation and training so that the right equipment is easily available and deployable by any/every member of the crew.

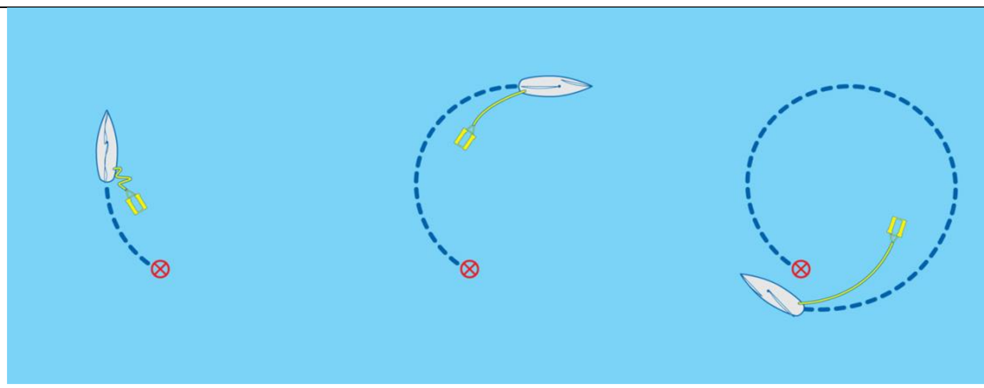
Concurrently, the entire crew must be notified with that bone-chilling hail so the wheels of recovery can begin turning. Meanwhile, the person who first sees the victim in the water must maintain a laser-like focus on his or her location in the water and continually point out that position to the helmsperson. It's the luck of the draw when it comes to the roles being played on board. Although your crew should have default "emergency" positions, a man overboard will alter this because at least one crew is gone from the boat, while another is doing his or her best Superman impersonation to see through the waves and keep the victim in sight. Short-handed crews have an even bigger challenge in a man overboard situation with perhaps half the crew missing.

Other high priority steps include:

- ***Save a GPS location*** to facilitate returning to the scene. If your victim is wearing and has activated an AIS-based personal locator beacon, he or she will be easier to find. Before a man overboard emergency occurs, make sure every member of the crew knows how to operate the hardware (GPS/computer) to navigate back to the AIS beacon and the GPS's man overboard waypoint. Ideally, one of the items your crew "litters" into the water will be a floating AIS locator with a sea anchor.
- ***Call for help.*** Any man overboard situation is life threatening, so there is cause for issuing a "Mayday," or at the very least, "Pan Pan" on the VHF to get nearby boats on your team. The importance of this step must be weighed with the actual situation (e.g., it's blowing 3 knots and you are at anchor in the Virgin Islands with the swim ladder set over the side) and how much it will impact/slow down the crew's ability to turn the boat around as soon as possible.
- ***Position the crew*** to turn the boat around. Ideally, this will follow the procedures that you have determined are ideal for your boat in the current conditions and that you have practiced with your crew.
- ***Immediately turn the boat into the wind, if appropriate for your boat and conditions,*** then tack, and stop/slow the boat. This is the first stage of the "Quick Stop" method that revolutionized sailing's "science" of man overboard a few decades ago (see sidebar). The logic was indisputable: the closer you keep the boat to the victim, the better the odds of a swift and successful recovery. Today, the Quick Stop

remains a valuable rescue option for *most* boats, but like so many of the possible return and recovery techniques, it has its time and place. It may be exactly the right approach for our 40-foot displacement sloop on the way to the South Pacific, but may not work on a boat with different handling characteristics. For example, on a 60-foot racing sloop blasting downwind under spinnaker, a rapid round up could cause significant damage that inhibits the boat's capability to return to the victim. It also risks throwing more crew overboard in the process. Once again, as in any safety-related emergency, it is important to be flexible. Well before any possible MOB, accurately assess the best way to rescue a victim overboard as swiftly and safely as possible. Seamanship, experience, sound judgment, and thorough training all increase your odds of success.

Quick Stop Maneuver with Lifesling: Good short-handed solution. Low skill required.



1: Immediately head into the wind to stay close to victim, reduce speed. Toss Lifesling.	2: Circle victim; drag sling around victim with sails sheeted in until victim has sling.	3: Stop boat. Pull victim to boat and hoist aboard with halyard or tackle.

Every step of the recovery benefits from practice, but this first "reaction" stage is perhaps the most crucial. A real emergency is not the time to figure out where the "launch" button is on the man overboard gear, or how to best organize the remaining crew to safely turn the boat around. Practice safety drills as a team before you need to act.

2 – Safely Turning the Boat Around and Returning to the Victim

The Quick Stop method highlights the ultimate goal of man overboard recovery: stay as near to the swimmer as possible. But you have to do this maneuver safely so that you can successfully complete the rescue. Every situation is different depending on the boat, which sails are set, the crew size and experience, and the conditions.

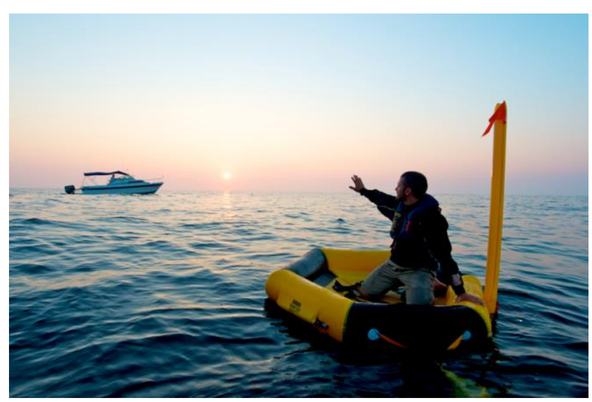
Recently, I attended a US Sailing Safety At Sea course at the US Naval Academy and watched the midshipmen demonstrate some of the overboard recovery variations aboard the Academy's 44-foot sloops. Conditions were ideal: the water was smooth, the winds were light, and the victim was a Navy diver in full wet suit. But it was still impressive watching the crews perform their recovery in swift fashion. Clearly, they had practiced and their demonstration went according to plan. Even as I mentally critiqued the well-rehearsed and simplified presentation, I had to admit, these sailors were pretty darn good—especially the 110-pound female midshipman who singlehandedly steered her 44-foot sloop back to the diver, secured the sails, stopped the boat, and hauled him back on deck with the aid of a block and tackle system and a Lifesling harness. I'd want her aboard my boat if I fell over. Sure, the degree of difficulty increases exponentially when you throw in heaving ocean swells, strong winds, and the element of surprise, but I'd rather go overboard on a boat where the crew has done a ton of recovery training—even if it was only in smooth water and light air.

The bottom line of turning the boat around is that it must be done as swiftly as practical (time is the enemy of the victim in the water) and must be done safely so that the crew can efficiently shift into recovery mode. There will be some trade-offs involved, e.g., making an out of control Quick Stop vs. a controlled dousing of the big sails—and the driver/skipper must make these critical decisions. What sails (if any) should be left flying? Should the engine be employed? And if so, are all the lines clear and out of the water so they don't foul the prop? When can we safely tack the boat? Are the conditions safe for us to jibe the boat? A strong and well-honed chain of command can help in these crucial decisions, but remember the "x-factor" of a man overboard situation: the skipper could be the swimmer!

<u>3 – Approaching and Recovering the Victim</u>

The priorities in this stage of the procedure are:

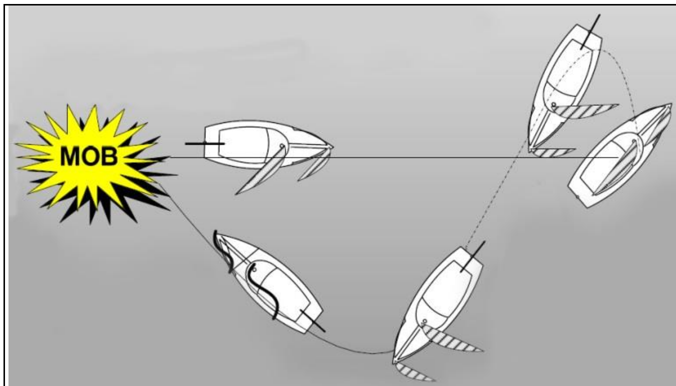
- ***Find the victim.*** This can be extremely difficult and time consuming—and time is not the friend of the victim. If it is daylight and the conditions are mild; if the victim is healthy, wearing a PFD, blowing a whistle, wearing or floating near an AIS-transmitting locator, flashing a light, and has made contact with the boat's man overboard gear; and if the boat has a good man overboard position to navigate back to—then the odds are pretty good



Switlik MOM 600

that you will find him or her, even if it takes a few minutes to get the boat safely turned around. But that's a lot of "ifs" and this highlights why having the boat and crew prepared for a man overboard incident is so important. Locating the victim can be extremely difficult. So, that call you made on the VHF to rally immediate support from nearby boats can be a life-saving step in certain situations.

- ***Approach carefully*** and at a controllable speed. The close reach is by far and away the safest point of sail to make the approach because of the ease at which speed can be increased or decreased without making course changes. Try picking up a mooring on any other point of sail and you will soon agree.

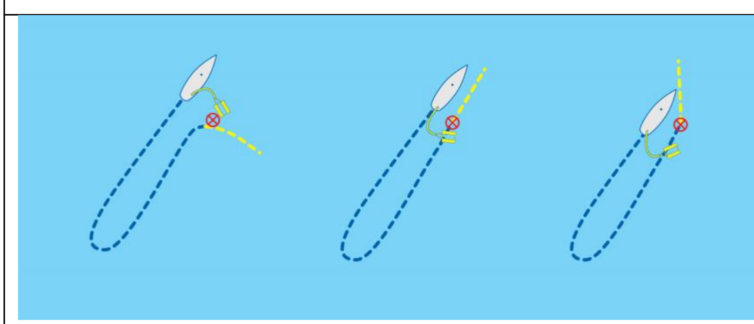


"Figure of 8" MOB Maneuver: Image from U.S. Navy

- ***Make contact*** with the victim. This doesn't mean smashing the victim with your hull or chopping him or her up with your propeller. It means making a connection, most likely by rope and possibly a Lifesling or other lifting/flotation device.
- ***Retrieve the victim*** and get him or her safely on board. There are a number of potential methods that vary in their efficacy depending on the boat, conditions, crew size and strength, condition of the victim, and equipment available (see next section).
- ***Apply appropriate care*** for possible near drowning, hypothermia, or any other injuries.

At this point in your study of man overboard procedure, I highly recommend a mental reality check. I've written and edited a number of books and articles describing the various "classic" recovery patterns and methods, including the aforementioned Quick Stop and the venerable "figure eight" pattern. It all seems so doable on paper.

But let's put ourselves in the shoes of a full crew on one of the US Naval Academy's 44-foot sloops, sailing in 35-knot winds and hail during a thunderstorm. You must quickly revert to good

Deep Beam Reach Alternative: Advantage—No Jibing Required		
Method: From any point of sail, change course to a deep beam reach, tack and return to victim on close reach to control speed of approach.		
		
From Upwind	From Broad Reach	From Running

seamanship, simple and basic sailing tactics—no jibes in 35 knots! And you will have your hands full even getting close to the victim as the keel loses grip and the boat blows sideways at low speed. There's no way you can heave a line any distance upwind, but it's so rough that you don't want to approach within a quarter boat length to windward of the victim for fear of smashing him or her to bits as the bow bucks in the waves. Again, this is where practice, good seamanship, and sailing experience are essential to stand any chance of recovering the victim.

The Sailing Foundation's Lifesling

In extreme conditions or when shorthanded, the "waterski tow rope" method of making contact with the victim is invaluable. A few decades ago, the Sailing Foundation of Seattle developed the Lifesling device and its unique method of victim recovery. Although the hardware has been refined over the years, it remains an icon in man overboard training with a long history of success, especially assisting small people in rescuing large people on boats of all sizes and types. The Lifesling employs the same method the driver of a water ski boat uses to return the tow rope to a fallen skier for another try. It involves circling safely and slowly around the victim until they grab the floating tow rope and work their way to the floating harness that can double as a lifting sling—pretty nifty.

But if the victim is injured or if it's too windy to jibe (a sailboat can't circle without doing a jibe), you will have to adjust your tactics. You may even have to break another "rule" of man overboard and send a second crew member into the water (firmly tethered to the boat) to help the victim. (Editor's note: Not recommended unless the victim has serious injuries or is a child.)

Do I sound like a broken record yet? It's all too easy to discuss man overboard theory and practice in a vacuum, extolling the virtues of a certain piece of equipment and/or sailing technique. But every situation is unique. In all likelihood, the crew will not be able to follow a perfect, cookie cutter method. They will be forced to adapt and make important decisions very quickly under pressure. This is where training, practice, good seamanship, and boat sense all play a crucial role.

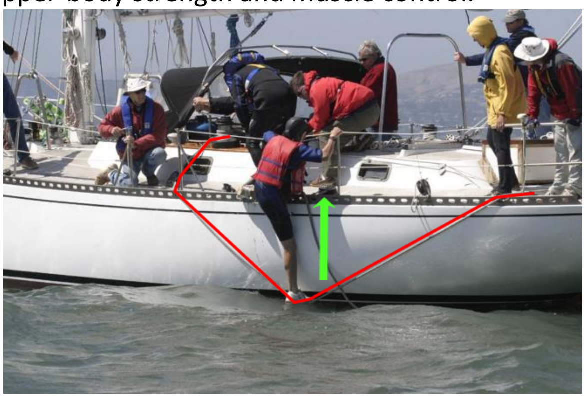
In summary, read books and take courses. Go to the chandlery and look at the latest equipment. Get your crew together and practice, practice, practice. Then cross your fingers you'll never have to learn whether you have the right stuff to save a life because everybody on the crew remembers that lesson their mother taught them: always stay with the boat!

Possible methods of retrieving a COB from the water:

Hoisting with a Lifesling is a reliable, easy retrieval method.

Hoisting a victim with a Lifesling:
Note that the Lifesling fiddle block is hoisted at least 10 feet off the deck of the sailboat before the retrieval tackle is attached to Lifesling to hoist the victim.

The Elevator Method has pros and cons. Pros: it's fast, powerful (requires minimal strength of the rescuer), and uses available gear. Cons: it is difficult to balance in rough conditions, and the victim needs upper-body strength and muscle control.



Elevator Method:
Line leads from the stern, over the side to the victim, back to the cockpit. Any winch will do. It may help to put a line around the back of the victim when hoisting—it's easy to fall backwards.

Crew Overboard Prevention, Michael Jacobs and Chuck Hawley

Following these rules can prevent virtually all man-overboard incidents:

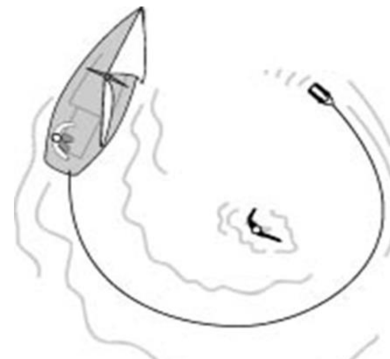
1. Remain sober, especially if you expect to go on deck for any reason.
2. Wear nonskid footwear when working on deck and have nonskid paint or pads in critical work areas.
3. Walk or crawl on the uphill windward side in a crouched position with a low center of gravity and wide-based stance when the boat is rolling, heeling, or pitching.
4. If the boat's motion is too violent to allow a person to stand, then crawl or slide along the deck.
5. Use a safety harness (with two shackles) as a "third hand," secured to a strong attachment point, with a quick release shackle at the body end of the harness.
6. Use a safety harness whenever going aloft in the rigging or climbing any superstructure.
7. Avoid leaning overboard with all your weight on a lifeline or stanchion.
8. Know the location of secure handholds and grab rails so you can find them at night.
9. Know the safe routes to avoid tripping on deck hardware, vents, and hatches, especially at night.
10. Do not urinate from the afterdeck in rough weather unless you are kneeling and attached with a safety harness.
11. Wear a safety harness whenever seasick; vomit into a bucket rather than leaning overboard.
12. In heavy weather, sleep in the harness and be ready to attach the tether to a cockpit padeye before coming on deck.

From Auerbach, Wilderness, Chapter 83, "Safety and Survival at Sea"

Crew Overboard Procedure Summary, Chuck Hawley

1. Have one person in charge:
    a. Chain of command should be established in advance; identify at watch change
    b. Captain (or helmsman) should coach the crew through the rescue, clearly, with authority
2. Challenges of COB rescues:
    a. Victim staying afloat
    b. Delivering flotation to victim
    c. Returning the boat to the victim
    d. Finding the victim
    e. Contacting the victim
    f. Reboarding
3. Traditional MOB gear:
    a. Horseshoe PFD
    b. MOB pole with strobe light, drogue, dye marker, whistle, launcher
    c. Dan Buoy/MOM (Man Overboard Module)

4. Difficulty finding victim increased by:
    a. Large seas
    b. Reduced visibility in fog, night, squalls
    c. Long distance between boat and victim
    d. Fewer or no spotters to maintain visual contact with victim
5. Challenges of downwind crew overboard recovery:
    a. Spinnaker, poles, preventers in use
    b. Reduced number of crew (possibly half) remaining on the vessel
    c. High speeds increase distance quickly
    d. Delicate sails; carbon rigs may fail
    e. High seas, winds make maneuvering difficult
    f. Night sailing impairs visibility
    g. Squalls reduce both maneuverability and visibility
6. Strategies for successful rescues:
    a. Victim: wear flotation
        i. Increase visibility with: strobe light, laser flare, flashlight, headlamp, pocket flares, and retro-reflective tape. Bright colors on upper body.
        ii. Don't panic—take action ASAP before losing full use of your hands; don't swim unnecessarily; minimize movement if wearing a PFD; and conserve heat (HELP posture)
    b. Rescuers: immediately throw flotation, alert crew, point at COB, and shout encouragement
        i. Mark location with GPS; use locators
        ii. Minimize distance away—return quickly, but safely
        iii. Use gear to make contact; anticipate reboarding



Circle with line

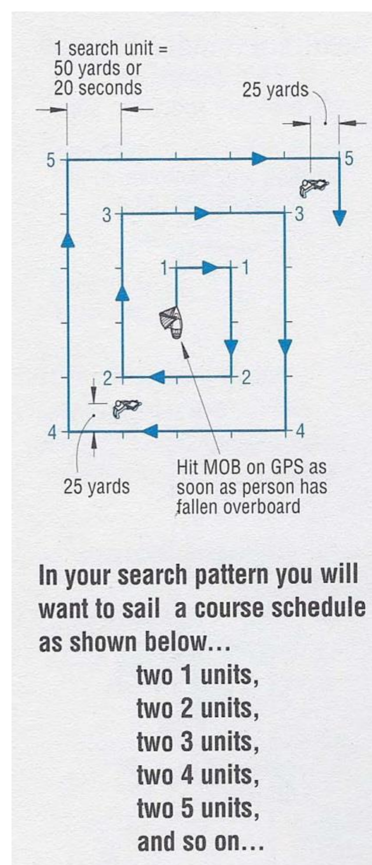
iv. Have a good command structure

v. Practice

7. Use a COB recovery maneuver appropriate for the boat and situation:
   a. Circle with trailing line/Lifesling
      i. Boat can be sailing in a circle without tending sails
      ii. Boat does not get close to victim
      iii. Stop boat when victim contacts line or Lifesling: don't tow!
      iv. Somewhat slower than direct approach
      v. Boat can run over retrieval line
   b. Approach and throw
      i. Generally used by boats under power
      ii. Quicker to find victim
      iii. Danger of hitting victim or prop strike
      iv. Can retrieve Lifesling if throw is bad
      v. Can also use a throw rope bag (OSR 4.24)

Approach and Throw

   c. Upwind Quickstop Maneuver (see diagram above)
      i. Shorthanded
      ii. Low skill requirement
   d. Deep beam reach (see diagram above)
      i. Easy to teach, but requires tacking
      ii. From any point of sail, change course to a deep beam reach
      iii. Tack and return on a close reach to the victim
   e. Spinnaker on heavier, slower boat
      i. Round the boat into the wind immediately
      ii. Ease the pole to the headstay
      iii. Let the halyard run when the boat is head to wind
      iv. The spinnaker should drop (mostly) on deck
      v. Sail upwind to the victim
   f. Spinnaker on sled or other planning boat
      i. Douse sails while keeping boat under control
      ii. Reduce sail area as needed to sail upwind
      iii. Consider maneuvering under power
   g. If contact is lost and other data unavailable, use the expanding square search method: increase the legs of your square search pattern incrementally to gradually expand the area covered.



Expanding Square

8. Acquiring contact with the victim:
   a. Approach on a close reach to allow speed control
   b. Don't tow the victim
   c. Consider having the engine running for more options, especially in

light air; beware of propeller strikes or fouled lines

   d. Contacting methods: throw rope bags, heaving lines, running rigging, and Lifesling

9. Reboarding challenges:
   a. Greater weight of water-soaked victim
   b. No equipment for reboarding
   c. Insufficient strength from crew or victim
   d. Difficulty coming close enough to victim
   e. Effects of hypothermia
      i. Loss of: motor skills in hands, coordination
      ii. Failure to keep face out of water or time breathing
      iii. Reduction of mental skills, judgment, and (eventually) consciousness
      iv. Colder water acts faster and greatly reduces time available for recovery.
   f. Victim or crew panics causing inability to make decisions or follow directions.
10. Reboarding methods:
   a. Elevator Method: (see photo above)
      i. Pros: fast, uses available gear, powerful—does not require much strength on part of rescuers
      ii. Cons: difficult balancing in rough conditions; victim needs upper-body strength and muscle control
   b. Rope Ladders:
      i. Difficulty with fingers and feet pinched between ladder and hull
      ii. Not reliable for hypothermic victims
   c. Lifesling and Lifesling Inflatable (see photo above)
      i. Reliable
      ii. Easy to use

Conclusions:

1.	Minimize distance to victim, if possible, with orderly take-down and return.
2.	Use debris field to calculate drift.
3.	Practice with your crew and customize for your boat/situation.
4.	Have a trustworthy command structure.
5.	Increase crew visibility with lights, flares, retro-reflective patches.
6.	Use alarms and carry personal signals capable of storing waypoint, providing range and bearing to COB.
7.	Finally, remember prevention is easier than rescue. Use harnesses/tethers, deck shoes, and good practices.

Crew Overboard Alarms and Locators (also, see Chapter 2)

Understand the difference between alarms and locators. An alarm only notifies you that someone has gone overboard, while a locator tracks and communicates the location of the person in the water. The technology in both categories of devices is advancing quickly, so rather than list specific products with their advantages and disadvantages we will provide some guidelines for you to keep in mind when choosing a solution to suit your needs.

For offshore races (category 1 and 2), ISAF now requires a COB button be available at the helm to immediately record the position where the person fell overboard (OSR 4.28). This is not necessarily a part of a COB alarm system and also does not require a tracking system on the person in the water.

There are four categories of COB tracking devices:

- **406 Personal Locator Beacon (PLB):** The signal emitted from the person in the water goes directly to the SAR authorities via satellite. The coordinates of the person in the water are not available to those on the boat trying to return to the spot, or to other nearby vessels.
- **DSC PLB:** The signal goes to the boat and other nearby vessels in the form of Lat-Lon coordinates, which appear on the VHF and may have to be entered into a chart plotter to ascertain range and bearing from the boat's current position. A few VHFs are able to communicate the DSC position to a chartplotter automatically, and a few chartplotters are able to receive this information and plot the position automatically. Further, a few VHFs can even display range and bearing to the COB themselves. If you choose to use DSC PLBs, make sure you know how you are going to determine the range and bearing to the DSC coordinates. A COB incident would be a stressful time to enter coordinates into a chartplotter.
- **Beacon on the COB used in conjunction with a direction finder on the boat:** This system has limited range from a person in the water compared to an AIS or DSC receiver using a masthead antenna. It requires practice and specialized direction finding equipment. It is a direction finder only: it does not provide the range to the COB and provides bearing information only to the operators of the direction finder, not additional SAR help.
- **AIS PLB:** For boats that already have an AIS receiver or transponder in use, interfaced to a chartplotter, this device provides a ready view of the range and bearing to the person in the water. Nearly all current chartplotters are capable of being interfaced with an AIS receiver or transponder and display AIS positions. The position of the person in the water is also visible to other AIS-equipped vessels within range. To enable maximum range to an AIS PLB, a yacht should use their masthead VHF antenna for their AIS receiver or transponder via an AIS VHF antenna splitter.

Whichever system you choose, it is essential to practice its use before needing it. As with any emergency situation, when you are frantically dealing with a life-or-death crisis is not the time to pull out the instruction manual to learn how to use the equipment.

Further resources:

For an excellent review of COB methods conducted on San Francisco Bay, see FINAL REPORT: 2005 CREW OVERBOARD RESCUE SYMPOSIUM By John Rousmaniere, found at: http://offshore.ussailing.org/Assets/Offshore/SAS/Images/Photos/Final+Report.pdf.

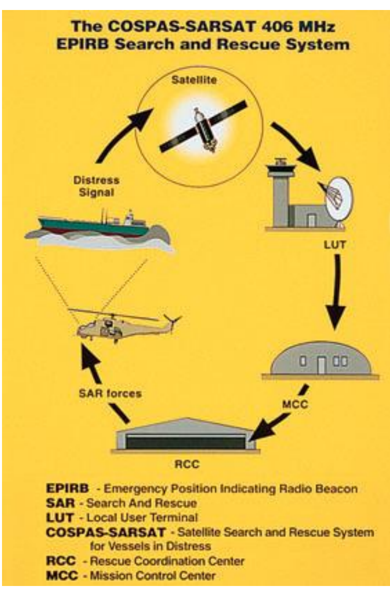
This study reviews the challenges for a successful recovery, required skills of the crew, preferred recovery maneuvers, and equipment that can be helpful in locating and retrieving the victim. It is a must-read for every boater.

Chapter 10— Search & Rescue Organization and Methods, Michael Jacobs and Chuck Hawley

Key Concepts: Identifying services of local SAR authorities (OSR 6.02.8); AMVER or helicopter rescue; radio frequencies used for direct contact; global SAR organization.

When you encounter a difficult situation at sea, you may be tempted to contact search and rescue (SAR) authorities. Before you take that step, however, consider the severity of your emergency; SAR operations are not a taxi service. There is risk for everyone involved: the rescuers, those being rescued, and even the boat. Do not call unless someone is in grave danger of dying. If you, or your crew, are in serious danger and require outside shore side assistance, you have several options to transport them there: by land (return to port), sea (transfer to another vessel), or air (helicopter evacuation). Returning to port is the safest option if time allows, while transferring personnel from a boat or a life raft to a rescue ship or helicopter entails risk for everyone and may be the most dangerous aspect of the survival situation.

Once you have determined that your situation requires outside assistance, you have two options to call for help: one-way communications (406-MHz emergency position-indicating radio beacon, abbreviated EPIRB) or two-way communications (either by radio—VHF or SSB—or mobile phone). Both are described in detail in chapter two.



Anatomy of a rescue: the 406-MHz emergency position-indicating radio beacon (EPIRB) sends a digitally coded signal to a low-Earth-orbit satellite, which relays the signal to a nearby ground receiving station (LUT). The location of the EPIRB is calculated and forwarded to the nearest mission control center (MCC), which matches the EPIRB user's registration with the specific signal. This data is relayed to the local rescue coordination center (RCC), which initiates the search and rescue (Diagram courtesy of ACR Electronics).

PREPARING YOURSELF FOR SAR COMMUNICATIONS

Before leaving port, become familiar with the specific options and operations for the local SAR authorities, including their landline number, how to call them, and their available facilities. SAR capabilities vary considerably around the globe. The range and time of response depends on the specific assets and training of the respondents; the local authorities will determine the best options for your rescue. Prepare yourself, and your crew, in advance for these possible SAR protocols:

1. Transfer to a ship in the area or, if within range, helicopter rescue.
2. If a helicopter is used, know the local sea-rescue system:
    a. Hi-line, basket pick-up, winch man bridle, etc.
    b. Whether pick-up from the deck, the water, or a liferaft is preferred.
3. Know which radio frequency to use for direct contact with the pilot.
4. Determine which fixed-wing aircraft may be deployed and which search patterns will be used.
5. Understand which signal flares to use and when to use them.
6. If rescued by a passing ship, communicate with the captain to understand what is expected of you.

DSC DISTRESS COMMUNICATION FORM

Post this form by each permanently installed radio equipped with DSC

Fill in Items 5, 6, 11 and 13 prior to getting underway.

SPEAK SLOWLY – CLEARLY – CALMLY

1. Make certain your radio and GPS are turned on and the **radio is on high power**.
2. Send DSC distress call: **press red Distress Button for 5 seconds.** Wait for a DSC Distress Acknowledgement and then shift to VHF Ch 16 or SSB 2182 kHz (USB) for voice instructions.
3. If no DSC Acknowledgement is received select **VHF Ch 16 or SSB 2182 kHz (USB)**
4. Press microphone button and say: **"MAYDAY -- MAYDAY -- MAYDAY"**
5. Say: **"This is** (your boat name, MMSI or call sign)"
6. Repeat once: **"MAYDAY** (your boat name)"
7. Tell **where you are** by either**:**
    a. Latitude and longitude ____
    b. Navigation aids or landmarks nearby ____________________________________
    c. Direction and distance to a prominent landmark ___________________________
8. State the **nature of your distress** and the kind of assistance required:
   ____
9. Give the **number of people aboard and condition of any injured** ________________
10. Estimate **present seaworthiness** of your boat ______________________________
11. If time allows -- **Briefly describe your boat:**
    a. **Type** – (Sail or Power) ________________
    b. **Length in feet**-- ______________________
    c. **Hull color**-- __________________________
    d. **Trim color**-- __________________________
    e. **Masts**-- _____________________________
    f. **Other Identifying Info**-- ______________________________________
12. Say: **"I will be listening on channel 16 or 2182 kHz upper sideband**"
13. Say: **"This is** (your Boat Name, MMSI or Call Sign) **OVER"**
14. Release microphone button and **Listen for an Answer**.
15. **Activate 406 MHz EPIRB** by following directions on beacon body. Ensure EPIRB remains vertical, antenna pointing upward. Take EPIRB to survival craft if abandoning ship.
16. If you do not receive an answer **repeat call beginning at Item 3**.
17. If no answer again **check to see if radio is turned on and VHF is on CH 16, high power or shift SSB to 4125 kHz (USB) or higher emergency frequencies for communications with distant shore stations.**

Two possible evacuation scenarios: rescue by passing ship and rescue by helicopter.

EVACUATION BY SHIP

In a ship-to-ship rescue, the greatest risk is collision. Be prepared to lose your vessel in this situation. The typical ship-to-ship rescue scenario involves a large merchant ship with very limited maneuverability approaching a smaller vessel in distress with almost no maneuverability. Because you cannot practice bringing a small boat alongside a commercial ship in a gale, this rescue tactic can prove difficult. "Even under ideal circumstances, it is highly dangerous, heart in the throat, adrenaline-fueled action," said a transpacific racing sailor who abandoned ship and was aided by a huge container vessel.

In rough seas, never secure a boat or raft to the rescue vessel. The constant battering of the two hulls is likely to damage, and may sink, the smaller craft. Unless the rescue craft is designed for rescue work, the captain and crew experienced, and the seas relatively calm, it is much safer to use a smaller craft to transfer personnel between the boats. Transfer options include a rigid-hull inflatable boat (RHIB), lifeboat, or even a life raft. The transfer of personnel between ships is especially hazardous if sick, injured, or exhausted crew members are required to climb a cargo net or pilot ladder. Under the best of circumstances, it can be extremely difficult even for a healthy crew member.

AMVER: The Automated Mutual Assistance Vessel Rescue System (Amver) provides resources to help any vessel in distress on the high seas. Amver, sponsored by the U.S. Coast Guard, is a unique, computer-based, and voluntary global ship reporting system used worldwide by search and rescue authorities to arrange for assistance to persons in distress at sea. With Amver, rescue coordinators can identify participating ships in the area of distress and divert the best-suited ship or ships to respond. Some 12,000 ships from over 140 nations participate in Amver. An average of over 2800 ships is on the Amver plot each day. These merchant ships are not designed for SAR and their crews may not be trained for recovering survivors from small boats or life rafts under storm conditions. Offshore, however, they may be the only rescue option. For more details see amver.com.

Whether to approach the rescue vessel upwind or downwind depends on the wind, sea, and size and relative drift of the two vessels. The advantages and disadvantages are similar to those for retrieving a person overboard (see Chapter 9). Becoming pinned and capsizing are risks when sitting in the lee (downwind) side of a large, rolling ship. Nevertheless, a large rescue ship most often approaches upwind of the distressed craft, unless the ship's rate of drift is much greater than that of the craft. This relative positioning creates a calmer sea in the lee of the rescue vessel as it slowly drifts down to the survivors' craft. If you have deployed a sea anchor, pull it in to prevent entanglement in the rescue vessel's propeller.

Once both vessels are situated, remain calm, and do not rush to board the ship. Follow these recommendations:

- Wait to see if a lifeboat or rescue swimmer is lowered to facilitate the transfer.
- Attempt to communicate on channel 16 with the rescue craft to coordinate the rescue.
- Clarify and follow instructions carefully to ensure safety.
- If the raft is to be lifted aboard with injured survivors, be sure the floor is fully inflated. Attach the lifting lines to the towing bridles on both sides of the raft, and attach two steadying lines to each side as well.

Never attempt to scramble up a net, pilot ladder or Jacob's ladder without a safety line. When transferring to a rescue ladder, wait until the craft you are departing is on the crest of a wave. At that moment, you will be as high as possible on the ladder and the craft you are leaving will drop down while you ascend the ladder. This eliminates the danger of the craft rising up on a wave and striking you. Your safest option is to be hoisted up to the deck in a harness by a deck cargo crane.

EVACUATION BY HELICOPTER

Helicopter emergency evacuation and rescue is now commonplace within 483 km (300 miles) of the coastline. The pilot will radio a detailed briefing to you when the helicopter is en route to your location. Assign a crew member to monitor the radio and listen for the pilot's radio briefing, usually on VHF channel 16, or SSB at 2182 or 4125 kHz. Maintain radio contact with the pilot until the evacuation is complete.

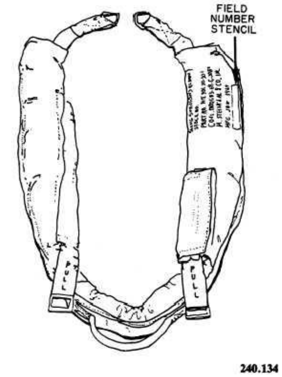
Secure all loose gear onboard, including cockpit cushions, coils of line, winch handles, dive gear, hats, and clothing. Any gear not secured on deck will become a flying missile in the 161 km/hr (100 mph) downdraft generated by the helicopter. This debris may be sucked into the intake of the helicopter's engine or become tangled in the rotor blades.

All crew on deck should wear lifejackets. Add extra clothing layers because the helicopter's downdraft creates a wind chill effect. Avoid shining flashlights on the helicopter; the light may blind the pilot and rescue team. For the same reason, never fire aerial flares in the vicinity of a helicopter.

Coast Guard HH-60 Jayhawk helicopters carry a wide variety of gear to hoist victims and to assist crews in saving their vessels.

The rescuers will use either a rescue basket or a Stokes litter to lift the victim into the aircraft (Figure 1). Selection depends on the victim's medical condition and his or her need to remain horizontal during the hoist. The horizontal position is particularly important for persons with spine injuries or severe hypothermia. Rescuers prefer the basket for lifting. It is easy to enter, especially in rough weather, and has positive flotation to prevent sinking. The basket will settle on the sea surface, enabling someone in the water to float into it and fasten the straps.

In some situations, however, rescuers may prefer to use a “horse collar” sling (Figure 2), a padded loop that is placed over the body, around the back, and underneath the armpits. During the hoist, the line remains in front of the victim’s face. Regardless of whether the rescuers use a basket or hoist, the victim should always wear a PFD and follow directions for securing the safety straps.



"Horse Collar" sling
Navy aviation image

The helicopter builds up static electricity traveling to the rescue scene, and the charge is transferred down the cable to the basket or sling. Allow the device to touch the deck or the water to discharge any static electricity before grasping the support cable; otherwise, you will experience a strong, but nonlethal, electric shock. The orange steadying line, which is lowered first, is safe to handle and will not produce any shock.

Unhook the hoist cable only if it becomes necessary to move the basket/litter below decks; once unhooked from the basket, release the cable to be hauled back to the helicopter. When it is time for the cable to be lowered again, allow the hook to ground on the vessel, and then reattach it to the rescue device. *Never attach the hoist cable or the steadying line to any part of your vessel or life raft*, even temporarily. The winch operator, who is intently watching the hoist cable, will instantly sever the cable from the hauling winch to prevent disaster with the helicopter.

If a Coast Guard helicopter picks up survivors from a life raft, the downdraft from the chopper’s blades may capsize the raft, especially if the raft has small ballast pockets. Similarly, rafts loaded to capacity with crew become increasingly unstable as the occupants are removed and winched aboard the helicopter. The survivors should sit on the roof and on the inflated support arch to decrease the amount of surface exposed to the downdraft. Evacuate the strongest crew from the raft last. A rescue swimmer from the helicopter crew will assist when a sick or injured crew member is transferred from the ship, or crew are required to jump into the water to be hoisted aloft.

You may also use a raft as an intermediate rescue platform between your distressed vessel and the helicopter. This is especially useful if your boat’s mast and rigging interfere with the positioning of the helicopter or threaten to entangle the basket hoist. In this situation, allow the raft to drift downwind, attached to your vessel by a line. The helicopter pilot cannot see the raft directly below; therefore, the winch operator guides the rescue operation. When being winched up by cable and harness, follow directions to secure yourself, and wear your life jacket. Since it is much easier to put on the helicopter’s rescue harness when not encumbered by a bulky life vest, if you are wearing an integrated safety harness and inflatable life vest, it may be preferable to leave the vest uninflated when being hoisted from the ship.

The helicopter has enormous potential for safe and effective SAR. The U.S. Coast Guard operates two types of helicopters detailed in the following table:

Coast Guard SAR Helicopters		
Model	**HH-60 Jayhawk**	**HH-65 Dolphin**
Crew	Pilot, co-pilot, rescue swimmer, flight mechanic	
Maximum takeoff weight	9926 kg (21,884 lb.)	4300 kg (9480 lb.)
Engines	2 × 1890-HP gas turbines	2 × 934-HP gas turbines
Maximum speed	180 knots	165 knots
Range	700 NM	365 NM
Duration	6.5 hours	3.5 hours
Capacity*	4+6	4+5

*Capacity refers to additional people (i.e., passengers).

To view an excellent instructional video for recreational boaters on helicopter rescue, go to the Cruising Club of America web site: http://www.cruisingclub.org/seamanship/seamanship_safety_heli.htm.

The C-130 Hercules is the largest of the U.S. Coast Guard SAR fleet, with a range in excess of 1609 km (1000 miles). It can air drop an enormous amount of lifesaving equipment, including dewatering pumps, life rafts, and survival and signaling equipment. The most recognizable airplane in the CG fleet is the Falcon jet. This medium-range, fast-response plane flies at 350 knots and has a 2000-nautical-mile range. Sophisticated onboard electronics, including infrared scanners and surface search radar, allow the jet to fly a variety of search patterns on autopilot.

(Credit to Michael E. Jacobs and Charles G. Hawley for their chapter 83, Safety and Survival at Sea, in *Wilderness Medicine*, edited by Paul S. Auerbach)

Chuck Hawley's Helicopter Evacuation Rules:

1. Assign crew to monitor radio and listen for pilot's radio briefing on channel 16. (See DSC Distress Communications Form, earlier in chapter.)
2. Activate EPIRB and notify the CG (see sidebar for DSC Communication Form).
3. Secure all loose gear on deck, lower poles, and remove snags.
4. Personnel on deck should wear PFDs (and survival suits, if available).
5. Avoid shining flashlights at helicopter.
6. Never fire aerial flares in direction of helicopter.
7. Maneuver boat so wind is 45° off port bow.
8. Follow commands of CG rescue swimmer.
9. Tend the orange trail line: it's safe!
10. Discharge static electricity: allow litter or basket to touch water or boat.
11. Unhook hoist cable if moving the litter.
12. **Never** attach hook or any other line to the vessel.

Pilot’s Eye View, Chris Branning, USCG rescue helicopter pilot

When it comes to search and rescue, the most important thing to remember is that the one being rescued has the greatest control over how the rescue will unfold. It took me a lot of midnight launches followed by six or more hours in a helicopter, wearing a survival vest, helmet, and night vision goggles to fully understand that the person who needs help has the most influence over how we fly our search patterns and how quickly we can take off for a rescue.

In this section, I describe the search and rescue process—including potentially life-saving tips for sailors—from the perspective of a helicopter pilot.

EMERGENCY COMMUNICATIONS: VHF AND EPIRBs

I cannot stress enough the importance of an EPIRB signal in initiating a rescue. EPIRBs enable rescuers to eliminate the "search" part of search and rescue by providing an accurate position of your location. In addition, an EPIRB signal verifies the validity of the emergency. The Coast Guard responds to countless hoaxes, empty Maydays and person in water (PIW) alerts where no one is there, and "red flare" sightings on the 4th of July. We treat every alert seriously, but when an EPIRB call comes in, we know it's the real deal: someone really needs our help, and this is a mission that will likely have a good result.

Once an emergency rescue is initiated, VHF communications play a key role in SAR efforts. Clear and accurate communications are crucial throughout the procedure. You can help ensure a smooth rescue by clearly describing your position, medical condition, and intentions on the radio as the rescue evolves. Communications may become redundant at times when talking to the Rescue Coordination Centers (RCCs) and later, our aircraft, but you must nevertheless try to maintain regular, clear communications. When talking on the VHF, stay out of the wind and keep the VHF microphone dry to prevent voice distortion.

LOCATING THE VICTIM—FROM THE SKY

When approaching the rescue scene, aviators prefer to navigate off of latitude/longitude coordinates, rather than positions relative to landmarks. If, for example, you were being rescued by a surface asset (Coast Guard boat or ship) and you said "Mayday, we are 25 nautical miles southeast of Block Island," they would immediately consult a maritime chart, which would have Block Island clearly labeled. Then they would walk out the distance and direction, determine your lat/long, and be on their way to you.

However, if we helicopter pilots heard that same distress call, we would pull out our aviation chart—not a maritime chart—which probably would not have Block Island labeled. We would fold it this way and that, because there isn't much space in the cockpit, and then call our RCC to have them double-check the position if we weren't sure. To further complicate matters, we would likely be flying in bumpy conditions, at night, while wearing night vision goggles (NVGs) and using a tiny, NVG-compatible flashlight to read the chart.

But if we get a clean and accurate lat/long we would simply enter the waypoint into our navigation computer, cross-reference it with the chart, and be on our way to you. The rescue begins to happen much sooner.

Clear and powerful VHF communication helps update positions to the incoming helicopter or fixed wing asset. Handheld VHFs are only good for line of sight communications, to the horizon at best. Helicopters fly lower—*much* lower—than airplanes, so they won't be able to pick up your VHF calls as far out as fixed wing assets. If your mast is down, try setting up your spare VHF cable as high as safely possible. If your mast is up, always use your masthead VHF antenna. If your boat doesn't have a masthead VHF, you should install one. It will make you safer in the event of an emergency.

Once we have your position (EPIRB, GPS, or tracker) and communications are established, you must make yourself visible to aircraft. It's a big ocean, but by taking a few small measures, you can help yourself be noticed. With the help of NVGs—perhaps one of the most powerful and useful tools we have—aviators can find victims who use visibility aids, even in the darkest ocean. Consider this: at 500 feet over Government Cut in Miami (lower than some condos and buildings), at night, we can see light pollution and radio tower beacons on the island of Bimini, Bahamas—almost 50 nautical miles away. We can even see someone light a cigarette on the ground from altitude. Imagine how easy it would be to spot a strobe in a pitch-black ocean at night. You will stand out!

Conserve smoke and flares until you know a rescue asset is in your immediate vicinity. Use smoke only in the daytime; flares, however, can be used during the day or night. Never point a flare at an aircraft. Instead, point it straight up so it goes up and down over the horizon, which is the best way for aircraft to see it. A simple strobe, chemical light stick, or waving flashlight—anything to make a target at night—is all we need. Strobes, however, are the best by far. To increase visibility, our rescue swimmers use this trick: they tie a small piece of string (about 3 feet/1 meter long) to the end of a chemical light and then swing it around their head. That way, the chemical light makes a glow-in-the-dark disc, which is much more visible than a light waving back and forth.

CONSERVING HELICOPTER FUEL SUPPLY

Our biggest challenge when we conduct a search and rescue is preserving fuel. Fuel is everything—without fuel, there can be no rescue. This is why an accurate position, strobes, flares, smoke, and good communications are so important. They help us use less fuel during the "search" and allow us to burn more fuel on the "rescue." When you and your crew have the right gear, you help us keep valuable fuel in our tanks. This is one way those being rescued control the search and rescue. Being squared away for our arrival is equally important. While in a hover, a helicopter is in its most demanding flight regime and consuming its highest rate of fuel. Beating the air into submission to suspend a hoist above your boat takes a lot of effort, concentration, and jet fuel. Clearing your deck and stowing loose rigging and sails helps ensure a smooth rescue. If we have good communications with you, you'll know when we are 15, 10, and five minutes away. We use VHF to communicate with the boat and hand signals with our rescue swimmer. Again, protect your VHF mic from wind and water.

CHALLENGES OF HOISTING FROM A SAILBOAT

When hovering a helicopter, the best conditions are smooth seas, a little bit of wind (8–10 knots), a stable platform, and a big vessel with no antennas or obstructions above deck. Hovering over a boat is like flying in formation with an uncooperative aircraft. It is dangerous. As pilots, we use our periphery vision to maintain position relative to the boat and our flight mechanic (crew member who operates the hoist) talks us into the best position to place the basket on deck. The lower in altitude we are, the more of the vessel the pilot can see peripherally to help conduct a smoother hoist.

Since sailboats have masts, we must come up in altitude to avoid any possibility of contact. This makes the boat so much smaller in size (relatively) that it’s hard to see since it's directly under the helicopter. Only the flight mechanic will be able to see it. To maintain position, the pilot has to change focus to scan the horizon and anything visible in the water (sea weed, sea foam, debris, etc.); we then rely on directions from the flight mechanic. We also have to put the basket or litter on a very small target. Murphy's law will have the mast going back and forth below, at night, with lots of wind and bumpy seas. This type of hoist from a sailboat is what we like to call "sporty."

To reduce power (and therefore fuel consumption), helicopters prefer to hover with our noses pointed directly into the wind. With the pilot in the right seat of the aircraft (that is the hoisting pilot because the hoist is on the right side of the airframe), we need the boat to have at least some way of moving forward with the breeze approximately 30–45° off the port bow. This will help settle the boat out with constant movement and give the pilot the best "sight picture.” A boat that is dead in the water (DIW) is much more unstable and unpredictable than one underway on a constant heading.

PREPARING FOR A MEDEVAC

A medevac is a stressful event for a patient; in some instances, it does them more harm than good. Accordingly, you should have the SAT phone number of the RCC readily available so you can paint the full picture of the patient’s condition to our flight surgeon (CG doctor). Most of our medevacs are from cruise ships or big merchant ships. These rescues are relatively easy and straightforward compared to medevacs from commercial fishing vessels and sailboats with masts and rigging. In fact, it is much easier to hoist someone out of the open ocean than from the stern of a sailing vessel. However, it is unlikely that someone needing a medevac could be safely transferred to the water.

The following list describes a typical medevac rescue:

1. Call goes out from vessel.

2. CG RCC gathers information, medical information, and consults flight surgeon.
3. Aircraft launch. Fixed wing asset may launch to find the vessel first, obtain more accurate position to further smooth the process for the helicopter, and become a communications relay platform.
4. Helicopter arrives on scene.
5. Helicopter lowers rescue swimmer to water near vessel and they swim to vessel and climb aboard.
6. Helicopter delivers litter or basket to vessel, then recovers litter or basket with patient in it
7. Rescue swimmer jumps back in the water, moves away from sailboat, and is recovered by helicopter.
8. Helicopter takes patient directly to helicopter landing pad of nearest hospital or airport to be met by emergency medical services.

In rare instances, and only when the patient is able, a life raft either from the helicopter or vessel is inflated at the stern of the vessel. Next the patient is placed in the raft and the vessel moves away. Then the rescue swimmer and helicopter conduct the hoist from the raft at a safe distance from the sailing boat.

HELP US HELP YOU

Finally, you should know that our work is done before you need it. The result—your safety and getting to see your loved ones—is largely decided before you call for help. The Coast Guard trains every day, to very high standards, to develop and hone the skills necessary to perform difficult rescues at sea. It's our job to keep you safe. If you do your part, we will do ours and you *will* get home—we promise.

Chapter 11 – Submersion & Hypothermia, Kent Benedict

Key Concepts: Hypothermia Symptoms; treatment. Protective clothing: (5.04) immersion suits, thermal protective aids (TPA's)

DEFINITIONS

Submersion Incident:

- Drowning: Submersion in water that results in respiratory impairment
- Fatal Drowning: Submersion in water that results in death within 24 hours

Cold Water Shock:

- Sudden/Unexpected Immersion in Cold Water: Results in gasp reflex, rapid breathing, and heart arrhythmias with marked slowing or speeding of heart rate

Hypothermia:

- Mild: Rectal temperature below 37°C (98.6°F), higher than 34°C (93°F)
- Moderate: Rectal temperature between 34°C (93°F) and 30°C (86°F)
- Severe: Rectal temperature lower than 30°C (86°F)

Submersion Incidents

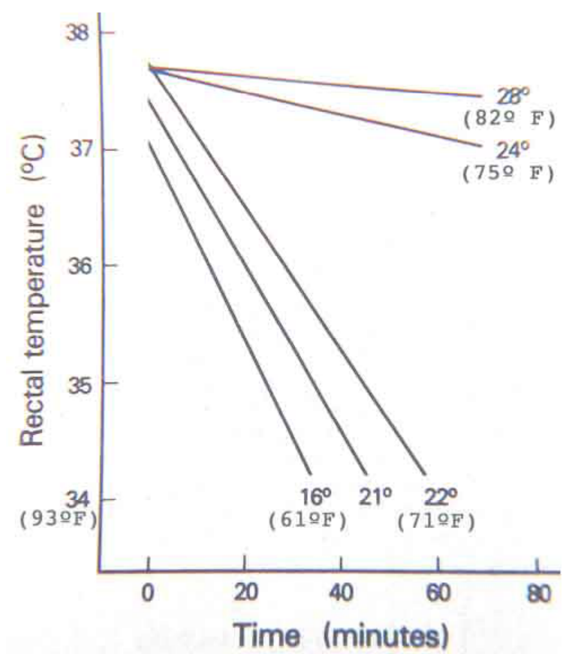
Drowning is the most immediate survival problem following water entry**.** The whole drowning process, from submersion or immersion to cardiac arrest, usually occurs within a few seconds to a few minutes, but in unusual situations, such as hypothermia or drowning in ice water, this process can last for an hour. Sudden cold water immersion has profound physiologic responses including immediate gasp reflex, hyperventilation, and increase in heart rate. The danger of the gasp reflex is uncontrollable inhalation of water. When the heart rate suddenly increases, life-threatening cardiac arrhythmias may occur. If drowning is avoided in the first few minutes, then prevention of hypothermia is critical.

Human Submersion Sequence Leading to Drowning

- Violent struggle to reach the surface
- Period of calmness and cessation of breathing
- Swallowing large amounts of water
- Gasping respirations and aspiration of water
- Convulsions, coma, and death-like appearance

Body Heat Loss in Cold Water

When a person enters cold water, heat loss begins: the colder the water, the faster the heat loss. Water conducts heat approximately 25 times faster than air. Hypothermia occurs when the heat loss is greater than the body's ability to generate heat. The



Rectal Temperature at Various Water Temperatures (Lightly Clothed Swimmer) following graph demonstrates how quickly the body temperature drops in various water temperatures.

Insulation Shells

Thermal Insulation Shells

Think of the body as a series of layers capable of insulating and protecting the vital internal organs (heart, lungs, liver, and kidneys). In cold water, these outer layers cool in the following order: skin, subcutaneous tissue, and lastly, muscles. Thus, when measuring body temperature, the skin temperature would be lower than the internal organ temperature (core temperature). The usual measurement of the core temperature is performed with a rectal thermometer. Maintaining the core temperature is the critical factor in survival.

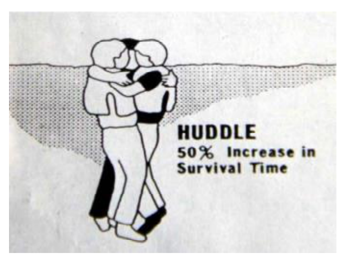
Cold Water Immersion Factors affecting chance of Survival

● **Ability to Swim**: Important because swimmers have more confidence in the water environment and are less likely to inhale water or panic.

• **Sea State**: No matter how strong a swimmer may be, the rougher the sea, the more difficult it is to keep the head above water.

• **Use of PFD:** Wearing a PFD markedly increases the chances for survival, decreasing the need to struggle to keep the head above water, lessening physical activity in the water (which causes a more rapid loss of heat), and allowing the victim to assume the HELP or HUDDLE positions.

HELP Position (single victim)



HUDDLE (multiple victims)

• **Availability of Life Raft**: Exiting the water is critical to avoid drowning or hypothermia. Sometimes the quickest procedure is to enter a life raft rather than attempt to reboard the vessel.

• **Availability of Other Objects**: Any floating object (cushions, throw rings, etc.) which can be used as a support for the victim helps reduce the effort of staying above water.

• **Water Temperature:** Very cold water contributes considerably to drowning or hypothermia due to rapid loss of muscle strength and coordination, confusion and disorientation, heart arrhythmias, and reflex hyperventilation (rapid breathing) leading to greater chances of water inhalation.

Survival Suit

• **Physical Characteristics of Victim:** Children are especially prone to hypothermia because of their high skin surface to body mass ratio. For the same reason, tall skinny people are far more susceptible to hypothermia than short, fat, or highly muscular types.

• **Protective Clothing**: Clothing which is buttoned, buckled, and zipped causes a layer of water to be trapped inside, which helps insulate and thereby slows body heat loss. Survival suits can be lifesaving in extremely cold water.

• **Behavior in the Water**: It is critical to avoid panic and struggling, and to limit excess motion.

• **Use of Signaling Devices**: PLBs, whistles, lights, and reflective tape on PFDs as well as the rapid deployment of signaling devices from the vessel (smoke or light flares) all help in locating a victim more quickly and thereby reducing hypothermia.

Hypothermia Signs and Symptoms

Knowing the signs and symptoms of hypothermia is very important because it is not always possible or appropriate to take a rectal temperature. Familiarity with the clinical picture of hypothermia allows the rescuer to judge the degree of hypothermia with reasonable accuracy.

Mild hypothermia: Hypothermia is considered mild if the core temperature is below 37°C (98.6°F), higher than 34°C (93°F). Uncontrollable shivering is the main sign, along with a gradual loss of judgment and fine motor coordination. In addition, when the victim is rescued, a stumbling gait and slurred speech is often noticed.

Moderate hypothermia: When the core temperature drops between 34°C (93°F) and 30°C (86°F), the victim is suffering from moderate hypothermia. Shivering has usually stopped by 32°C (90°F) and the victim shows signs of profoundly altered mental status, is markedly apathetic, and lacks gross muscle coordination and strength.

Severe hypothermia: By this time, the victim's core temperature is below 30°C (86°F). Loss of consciousness and marked susceptibility to heart arrhythmias characterize severe hypothermia. The victim's body may have taken on the appearance of death—pale, rigid, unresponsive, absent pulses and respirations, and dilated pupils, which are not responsive to a light shined in them. **But the responder should never assume the hypothermic victim is dead unless these signs persist after warming.**

Goals of Rescue & Management of Cold Water Immersion Victims

- Prevention of Cardiopulmonary Arrest
- Stabilization of Core Temperature
- Call for Medical assistance as soon as possible
- Transport to Advanced Care if Indicated

General Principles of Rescue

These principles apply for all cases of immersion hypothermia. Retrieve the victim with caution and in the horizontal position. Gentle handling and keeping the victim lying down helps prevent sudden drops in blood pressure and reduces the risk of a sudden heart arrhythmia in the moderate or severely hypothermic victim. It is important to minimize the victim's physical activity, preventing the afterdrop phenomenon. Afterdrop is when the core temperature continues to decrease even though the victim has been removed from the cold water. Even some mild hypothermic victims can have an afterdrop of several degrees core temperature, thus putting them at risk for the more serious consequences of moderate or severe hypothermia.

Examination and Life Support

• **Take the vital signs for at least a minute:** Many victims of moderate or severe hypothermia will have very weak and slow pulses—as slow as 4–6 beats per minute—and these victims could be mistakenly called pulseless if the pulse was taken for only a few seconds. The same is true when evaluating the respiratory effort and rate. At times the blood pressure is unobtainable, but it should not be assumed that circulation is not present.

• **When to start CPR:** As noted above, some very cold hypothermic victims have markedly diminished pulses and respirations, yet there still is viable cardiac output. Performing CPR on these victims could produce a lethal heart arrhythmia such as ventricular fibrillation. Only when the responder cannot find any pulses or respirations after the full minute of evaluation, should CPR be initiated.

As in all potentially serious or life-threatening situations, the responder must follow the ABCs—airway, breathing, and circulation. Cardiac arrest from drowning is primarily due to lack of oxygen. For this reason, it is important that CPR follow the traditional airway–breathing–circulation (ABC) sequence, starting with five initial rescue breaths, followed by 30 chest compressions, and continuing with two rescue breaths and 30 compressions until signs of life reappear, the rescuer becomes exhausted, or advanced life support becomes available.

• **Defibrillation:** Some vessels now carry automatic external defibrillators (AEDs) and crews have learned how to use these life-saving devices. The recommendations for using defibrillators in the hypothermic victim are similar to other types of victims, with one major exception: do not give up CPR and defibrillation until the victim is warm and there are still no signs of life. This is because the cold heart is much less responsive to defibrillation shocks and may only respond later in the resuscitation process.

• **Evaluate for trauma:** Victims who have entered the water may have had an **injury,** which caused them to fall off the ship. Others may have sustained an injury in the process of falling or after hitting the water. In any case, responders need to perform a careful trauma evaluation, looking especially for signs of spinal cord trauma, head injuries, chest injuries, lacerations, or extremity fractures.

● **Estimate the severity of hypothermia:** Taking a rectal temperature is the standard for documenting hypothermia, but usually cannot be performed onboard. In addition, very few vessels carry "hypothermic" thermometers, which can accurately measure below 34°C (93°F). Most often the responder will have to rely on the signs and symptoms alone. Remember one important point—vigorous shivering means the victim has only mild hypothermia, and thus a good outcome can be expected.

Insulation and Stabilization

Once the victim has been rescued, the first action is transport to a warm and secure environment aboard the vessel in order to prevent further heat loss. Wet clothing should be carefully removed and the victim dried, avoiding any unnecessary jostling.

• **Passive Rewarming:** Placing the victim in blankets or a sleeping bag can minimize convective or conductive heat loss. A vapor barrier such as a space blanket or plastic sheet may be added around the blankets or sleeping bag to stop evaporative heat loss. Warm drinks can be given to the mild hypothermic victim who is fully awake and not showing signs of nausea or vomiting. Victims suffering only mild hypothermia usually need no additional rewarming assistance.

• **Active Rewarming:** In general, these techniques are reserved for moderate to severely hypothermic victims. The simplest technique for active rewarming is body-to-body contact (mainly used for moderately hypothermic victims), consisting of another person entering the sleeping bag or blankets and pressing the side of the bare chest next to the victim's bare chest, thus transferring body heat. For severely hypothermic victims, hot water bottles, warmed towels in plastic bags, or chemical heat packs can be applied to the chest, neck, armpits, and groin. Caution must be used. Make sure a cloth barrier is between the heating device and the victim's body. Hypothermic skin is injured skin and can be further injured by too much heat. An additional technique is to use warm/humidified oxygen. This can be accomplished by bubbling the oxygen through warm water. Do not rub the body of the moderate or severely hypothermic victim since heart arrhythmias can result.

Activation of Support Teams and Transportation

Mild hypothermic patients can be allowed to stay onboard once they have been rewarmed and demonstrate normal mental status. Moderate to severe hypothermia must be considered a life-threatening incident, so these victims should be transported to a higher level of care as soon as practical. The vessel needs to access medical direction early, by radio or telephone, in order to prepare for the evacuation. All transport should keep the victim in the horizontal position.

Trauma Incidents Aboard Sailing Vessels

Fortunately, major trauma is uncommon aboard sailing vessels. The December 2010 issue of *Wilderness & Environmental Medicine* published a survey of over 1000 sailors who reported 1715 injuries of which only about 70 were major injuries.

- Trauma to arms and legs accounted for over 80% of all injuries.
- Minor injuries such as cuts, bruises, and sprains were most common.
- The most serious injuries were fractures, torn tendons, concussions, and dislocations.
- Tacking and jibing maneuvers, as well as sail changes and winch handling, contributed to most injury incidents.
- Only about 4% of all injuries required medical evacuation and/or hospitalization.

Tele-Medical Consultation at Sea

Purpose of contacting medical experts is:

- To determine the advisability of medical evacuation
- To obtain specific advice in evaluation and treatment when symptoms are serious or confusing
- To advise in management of major trauma victims

Record the call for legal documentation. A written report and voice recording (if equipment is available) of the call should be archived with the vessel's log. (See Call Format/ Documentation.)

Documentation of a Medical Event

Date of report:
Name of boat:
Name of captain:
Location of boat at time of incident:
Patient name (first name, middle initial, last name):
Sex: male female
Date of birth:
Details of illness or injury:

- Date/hour of onset of illness:
- Date/hour of injury:
- Date/hour of first examination/treatment:
- Location on boat where injury occurred:
- Description of accident or exposure:
- Subjective complaints (symptoms):
- Objective findings from physical exam:

Tele-medical consultation:

- Communication method: (radio, phone, fax, other)
- Date/hour initial contact:
- Medical advisor:
- Advice (details):

Clinical impression:
Treatment received on board:

Call-in Format

- Identify boat, location, local time, name, and responsibility (job) of caller
- Specify why the call is being made—be explicit about what information is needed. Don't make the doctor guess what you are trying to do.
- Declare the Status Level of the patient:
    - Minor Illness or Injury—nature of condition should result in rapid recovery.
    - Moderate Illness or Injury—condition should be able to be treated on board, but injured crew will have limitation of duties.
    - Serious Illness or Injury—it is unlikely the condition can be managed on board. Evacuation is recommended.
    - Severe, Life-threatening Illness or Injury—a true emergency where the condition is likely to result in permanent disability or death unless rapid evacuation occurs.
    - Critical Illness or Injury—survival of the patient is uncertain even with optimal treatment and rapid evacuation.
- Identify patient (name, date of birth, and gender)
- Report the patient's Clinical Details:
    - Chief complaint, major symptoms, and relevant events associated with the illness/injury.
    - Objective findings from the physical exam.
    - The assessment (diagnosis or clinical impression) of the patient's condition.
    - Initial treatment and plan for continuing care including possible need for evacuation.

Seasickness—Prevention and Treatment, John Neal

Key concepts: Seasickness prevention and treatment.

Preventing Seasickness

Some level of seasickness is normal during the first 1–4 days of an ocean passage, even if you have never been seasick while coastal sailing. For a speedy recovery, stand regular watches and join the crew at mealtime, even if seasick. Sustained seasickness incidents aboard Mahina Tiare, even in heavy weather, have dropped to nearly zero for crew members who follow the above suggestions. You should also remember these tips for your next offshore passage:

- **Seasickness results from sensory conflict and/or stress,** both of which produce histamine. Nausea results when histamine reaches the brain. Some people are more susceptible than others, but everyone can become seasick in the right conditions.
- **Seasickness can occur anytime afloat**, but these conditions increase susceptibility: feeling anxious or fearful, change of motion, navigating or reading, heavy weather, pitching or rolling motion of the vessel, chop, fatigue, smells, or eating.
- **Continual seasickness results in incapacitation,** if left untreated. On passages of more than 24 hours, preventing or effectively treating seasickness is therefore a health and safety issue.
- **Helping crew overcome seasickness** as quickly as possible must be the focus and responsibility of everyone on board. Frequently, a seasick crew will ask to be left alone, saying they don't feel like drinking or eating. However, leaving them is a mistake! It is important to keep them sipping fluids and regularly eating something. Good choices include bananas, canned fruit, crackers, or cookies.
- **The responsibility for the safety of the boat doesn't diminish if you're seasick**. It is mandatory to continue to watch for vessels, navigate, and monitor the weather.
- **Avoid coffee, colas, alcohol, and fatty foods** for a week before departure and increase your water intake to 2-3 liters per day. Start appropriate seasickness medication 24 hours before departure. Catch up on sleep. Sleep removes histamine from the bloodstream. Prepare everything before departure to minimize time below decks once underway: have meals planned and ready, bunks made, navigation organized, and appropriate clothing laid out.
- **Maintain hydration and blood sugar levels** once underway by drinking Emergen-C or a similar vitamin-mineral mix containing potassium and electrolyte replacement minerals. Snack on fruit, crackers, ginger snap cookies, or hard candies.
- **If you start to feel queasy**, take the helm, steer the boat, and focus on the horizon. If the boat is overpowered, reduce sail. If you are sailing close-hauled, ease sheets and fall off. Minimize time working below (e.g., take your foulies off in the cockpit before going below). The faster you either get back on

deck or lie down, the better you'll feel. Lying down prevents histamine from reaching the brain, which decreases nausea. Have a two-liter bowl with tight fitting lid handy in case you need to vomit. This is safer than hanging over the side of the boat to be sick. Don't be afraid to vomit; you'll feel better once you do.

- **Prolonged vomiting can cause dehydration** (surprisingly quickly), dizziness, low blood sugar, low blood pressure, hypothermia (even in the tropics), anxiety, confusion, depression and shock. Drink fluids to rehydrate.

Choosing the Best Treatment Method

When selecting a treatment method for your seasickness, try non-prescription methods before prescription drugs. Here's a breakdown of some of the best ways to ward off seasickness.

Over-the-Counter and Natural Remedies

- **Anecdotal remedies** include ReliefBand, acupressure wristbands, ginger, and nonprescription formulas, including vitamin C and antihistamines. No one method works for all, so try others if one fails.
- **Vitamin C:** Recent European research indicates that 1–3 grams of Vitamin C disrupts histamine production. Emergen-C packets (available at health food stores) contain 1 gram Vitamin C and 31 mineral complexes plus fructose, which act as an electrolyte replacement and keep blood sugar levels up. Drinking one liter with a packet two hours before and an hour after getting underway has proven to be effective for most people. Berocca tablets are an alternative widely available outside of North America.
- **Antihistamines:** Most antihistamines provide little help and frequently cause serious drowsiness, making them inappropriate drugs for sailors needing to maintain an alert watch. To be effective, antihistamines should be taken the night before departure and again right before departure. Oral tablets are difficult to keep down once vomiting has started.
- **Stugeron** (cinnarizine 15 mg tablets) appears to be by far the most effective of any non-prescription drug. Although widely used outside of North America, it is not FDA approved, but is available from www.CanadaDrugsOnline.com or over the counter in Europe and Mexico. But Dr. Kent Benedict warns, "However, there is some controversy as to the safety of cinnarizine because of serious complications at dosages that are often sold over the internet or OTC in foreign countries. For example, the Canadian website has 15mg, 25mg, and 75mg pills available. Other sites have pills up to 150mg. The 15-30mg dose range appears safe and effective for most individuals in preventing seasickness. Higher dosages, e.g. 75mg tablets or 150mg capsules should not be used—problems

with dangerously lowered blood pressure and even unmasking Parkinson's disease have been reported."

Prescription Anti-Nausea Drugs

- **Compazine** (prochlorperazine), available in 10 or 25 mg. suppositories, is the prescription drug I have found most effective in my 35 years and 313,000 miles of ocean testing research. Phenergan, a similar drug, does not work as well. Suppositories are far superior to tablets once vomiting has started. This drug is used to treat anxiety as well as nausea. Since anxiety causes nausea in many instances, this is important to have aboard. Compazine may occasionally have side effects, so do your research.
- **Scopolamine**, available as Transderm Scop 1.5 mg patches, has proven very effective. But one **MUST** first try this drug out on land as potential side effects include extreme drowsiness, blurred vision, hallucinations, psychosis, and anxiety. Beware of these possible symptoms before entrusted with a vessel and crew.

CAUTION! With any drug, prescription or non-prescription, there are published side effects. Do your research; ask your physician and pharmacist and Google each drug. If you have heart, blood pressure, or prostate problems, your physician may not be able to recommend some of the prescription drugs described in this chapter. Try any anti-seasickness drug on land well before departure to check for side effects.

Remember that to become an accomplished ocean sailor, one of the disciplines you must master is seasickness response—if not for yourself, then perhaps for your fellow crew members.

Chapter 12 – Fire Precautions and Fire Fighting, Michael Jacobs and Chuck Hawley

Key Concepts: Fire theory: most common causes and prevention; equipment: fire extinguishers (4.05) and fire blankets (4.05.4); fire suppression training (6.03.2)

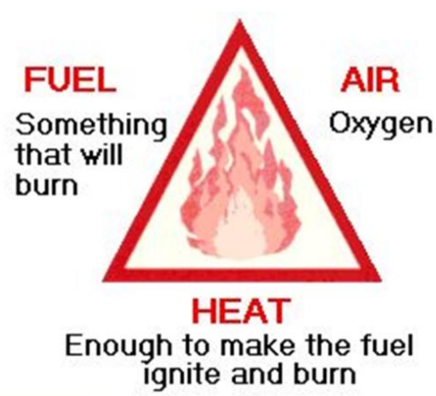
Boat U.S. Insurance

Uncontrolled fire is a disaster aboard ship. After uncontrolled flooding, fire is the second reason for a crew to abandon ship for a life raft. A boat fire spreads very quickly. You must attack it immediately and effectively; otherwise, you will deplete your extinguishing resources before you put it out. Fire management is especially important on wood and fiberglass boats, as fires aboard these vessels can double in size every 10 seconds. Approximately 7500 pleasure boat fires and explosions occur annually; of those vessels affected, 10% are declared total losses.

For a fire to exist, it must have: fuel, heat, and oxygen to complete the chemical chain reaction. If you eliminate one of these elements, you can put out a fire.

To effectively extinguish a fire, remember the acronym **FIRE** and follow these steps:

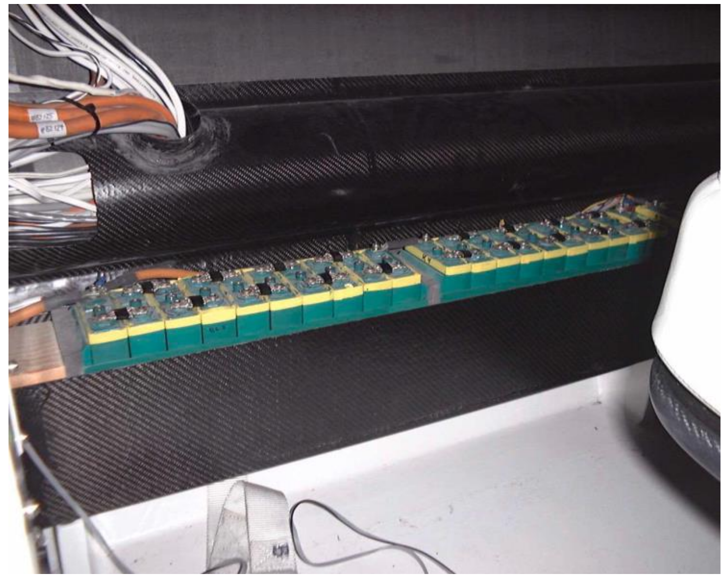
- **F**ind the fire, pinpoint its source, and determine its size
- **I**nform the skipper and crew immediately
- **R**estrict the fire
    - If possible, disable the cause of the fire
    - De-energize electrical systems in affected space
    - Shut off fuel supply and ventilation
- **E**xtinguish the fire
    - Account for crew and assess for possible burns or injury
    - Follow-up communication with Coast Guard and other vessels



Boat U.S. Insurance

Fires are divided into **four classes**, depending on the type of fuel feeding them. Each class requires a different chemical to extinguish it. The chart below provides an overview of each class, its cause, related concerns, and effective extinguishers.

FIRE CLASS	**CAUSE**	**CONCERNS**	**EFFECTIVE EXTINGUISHERS**
A	Rely on materials which leave an **ash**, such as wood, cotton, fiberglass, cushion, and sails.	The source of the fuel may be deeply embedded in the materials.	• Water • Tri-class extinguishers • Carbon dioxide
B	Flammable liquids (that **boil**), such as oil, gasoline, resin, paint, kerosene, and diesel.	Water may spread the fire; liquids with high flashpoint may re-ignite.	• Sodium bicarbonate (baking soda) • Tri-class extinguishers • Carbon dioxide • Halon replacements
C	Heat of an electrical short igniting wire insulation and adjacent materials.	Hazard of shock, especially with salt water.	• Break the **circuit** (turn off main switch, have circuit protection) • Extinguish fire according to materials involved
D	Burning metals, such as flares and Nickel Metal Hydride batteries (see *PlayStation* story).	China Syndrome—get the fire source off the boat!	**None—**though you may use dirt or other material to try to cool and isolate the heat.



Nickel Metal Hydride batteries near carbon fiber fuel source

COMMON CAUSES OF FIRE

Poorly Installed Electrical Systems

According to 2012 BoatUS Marine Insurance claims investigations, (which can be found at: www.boatus.com/seaworthy/fire/default.asp), the leading cause (55%) of boat fires is faulty AC and DC wiring. The most common electrical problem is related to chafed wires. Battery cables, bilge pump wires, and even instrument wires chafing on hard objects like vibrating engines or sharp-edged bulkheads start many fires.

Engine and Transmission Overheating

Nearly one-quarter of boat fires (24%) were started by overheated propulsion systems. Frequently, an intake or exhaust cooling water passage was obstructed, causing the engine to overheat and begin to melt down hoses and impellers. These fires tended to be less serious, but because of the amount of smoke and the fact the fires come from areas with flammable fuels, they appeared more threatening. Often the fires were simply smoldering rubber, which dissipated once the engine compartment was opened and fresh air allowed to circulate.

Gasoline Fuel Leak

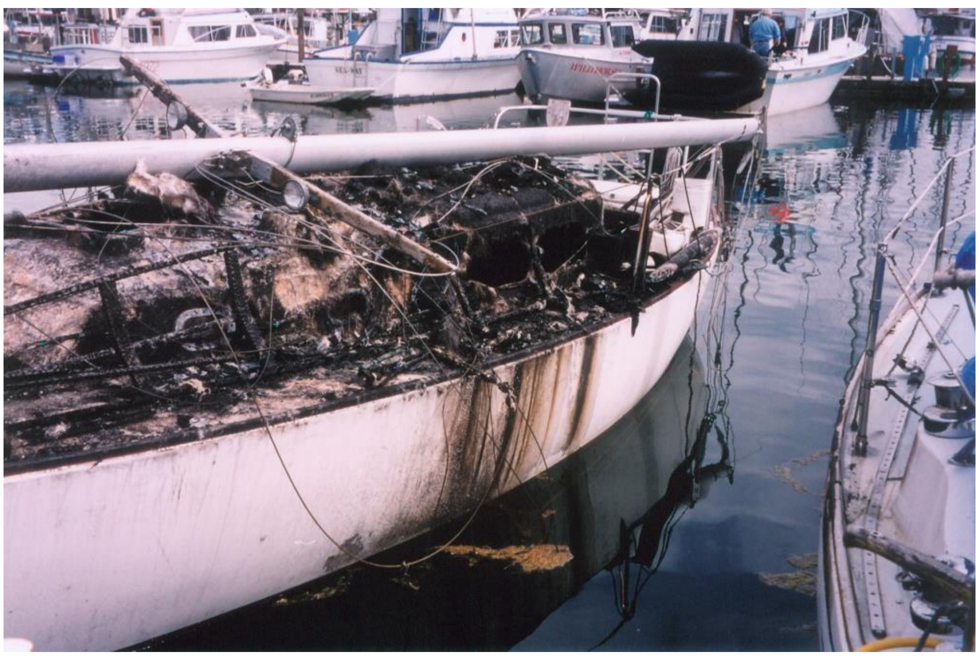
The explosive potential of fuel depends on its chemical properties and where the vapors accumulate in enclosed, unventilated spaces. Hazardous liquids are classified according to flash point, the lowest temperature at which a liquid releases enough vapor to sustain burning. Flammable liquids, such as gasoline, turpentine, lacquer thinner, and acetone, have flash points below 38°C (100.4°F), meaning they release enough vapor at common ambient temperatures to form burnable and explosive mixtures. Combustible liquids, such as diesel oil, kerosene, and hydraulic fluid, have flash points above 38°C (100.4°F).

BoatUS Insurance statistics on Sources of fires on boats:

- 55% Poorly installed electrical systems (C)
  - 30% DC shorts and wiring
  - 12% DC engine voltage regulator
  - 4% AC appliance/heater
  - 4% AC shore power system
  - 2% AC wiring/panel
  - 2% DC battery charger
- 24% Engine and Transmission Overheating (A, B, or C)
  - 19% engine overheating
  - 2% turbocharger overheat
  - 2% transmission overheat
  - 1% backfire
- 8% Gasoline fuel leak (B)
  - 95% of fuel-related fires involve gasoline
- 1% Galley stoves (B)
  - Declining compared to when alcohol stoves were popular
- 12% Unknown or miscellaneous

Gasoline is the most hazardous fuel: 95% of fuel-related fires are caused by gasoline. Typical problem areas include fuel lines, connections on the engine, and leaking fuel tanks. Typically, the first warning sign is the smell of gas. Vapors can ignite from heat in the engine compartment and from liquid spills over hot engine parts. 5 mL (1 tsp.) of gasoline can vaporize and cause an explosion, and 237 mL (1 cup) of gasoline has the explosive potential of several sticks of dynamite. Vaporized gasoline is heavier than air, so it accumulates in the lowest part of any enclosed space. That is why it is critical to run the bilge blower for at least 4 minutes before starting the engine.

Diesel fuel, on the other hand, is much less explosive. However, pressurized diesel fuel spurting from a burst fuel line will ignite and burn when it strikes something hot, such as the exhaust manifold. When charging, batteries generate hydrogen, which accumulates in the battery compartment or in the compartment overhead; the gas is lighter than air, highly flammable, and potentially explosive. Sparks from a nearby electric motor may set off an explosion from excess hydrogen produced by overcharging.



Fire Damage

FIRE MANAGEMENT TIPS

Install automatic discharging extinguisher systems to prevent engine fires.

The best way to manage a fire is to install a properly sized, automatic discharging extinguisher system, which interrupts combustion with chemical materials or gases. Fire-suppressing alternatives to halon gas (which is now banned because it breaks down atmospheric ozone) are fluoropropane and fluoroethane (FM 200 and FE-241, respectively). These fire suppressants can be automatically discharged from extinguishers by devices that sense ultraviolet radiation or temperatures above 79°C (174.2°F). Dedicated engine extinguishers can put out a fire before you even know it exists.

Automatic systems should also have a manual trigger for activation. Halotron is a new “no residue” agent for portable extinguishers and a good alternative to the older dry chemical powders, which leave a messy, highly corrosive, and destructive residue. When using portable extinguishers, discharge them into the engine compartment through small fire ports to avoid introducing large quantities of fresh air to the fire. Remember to shut down the engine either automatically or manually when fighting fire in the compartment. Automatic shutoff for diesel engines, generators, and engine room blowers are now required in the event of an extinguisher discharge. Diesel engines consume large volumes of air when running and can quickly deplete the extinguishing agent. Let the area cool before opening hatches or inspection ports to prevent the entry of air, which can restart the fire by diluting the concentration of extinguishing agent or by introducing oxygen.

Mount extinguishers throughout the vessel, monitor pressure gauges, and check for gas leaks to prevent other than engine fires.

For other than engine fires, be sure to mount extinguishers in locations that will allow the crew to escape and extinguish the fire. This may mean the extinguisher location will be removed from areas that are likely fire sources; you may also have multiple ways to flee or fight the fire. For example, a fire blanket close at hand may be the best way to immediately smother a galley fire.

However, there may be other concerns depending on your cooking fuel. For instance, a popular galley stove fuel is liquefied petroleum gas (LPG), either propane or butane. Both are highly explosive, heavier than air, and may accumulate in the bilge. Free propane in the bilge, like gasoline, is a bomb waiting to explode. Proper LPG tank installation requires a completely self-contained vapor-tight locker that opens only above decks. A drain should be located at least 51 cm (20 inches) from any opening to the boat’s interior and should not be submerged while the boat is underway. A pressure gauge connected to the LPG cylinder valve will help indicate a leak somewhere in the system; it is not, as many believe, intended to show the quantity of LPG in the tank. A regulator to reduce the pressure in the gas line to the stove and an electric solenoid valve complete the delivery system. Seek expert professional assistance when installing the complete fuel supply system. As of April 2002, propane cylinders must be equipped with an overfill protection valve because overfilled cylinders may explode if overheated.

An electronic gas detector or “sniffer” installed in the bilge and beneath the stove can detect leaks in the line. If the alarm sounds, turn off the LPG solenoid, and turn on the blower and run it until gas is no longer detected by smell or an electronic sensor. Periodically pressure-test the system for leaks, especially after rough weather or repairs or maintenance to the system. To check for a leak, open the cylinder valve with the solenoid switched on and all appliance valves closed, and record the pressure gauge reading. Next, close only the cylinder hand valve to see if the pressure drops over intervals of 3–5 minutes; if it does, there is a leak. Use soapy water to look for the source of the leak. Needless to say, never look for the source of a leak with an open flame.

Use the stove and other appliances carefully and correctly.

To avoid accidents after cooking, switch off the solenoid first, let the burner continue to flame until the line is cleared of gas, and then turn off the burner. When appliances are not in use or the boat is unattended, close the cylinder valve. Never use the stove as a cabin heater; the flame can deplete a cabin of oxygen and asphyxiate the sleeping crew. Carbon monoxide, a colorless and odorless gas, is a by-product of incomplete combustion; severe exposure can be lethal. Mild early symptoms include fatigue, sleepiness, headache, malaise, nausea, vomiting, and ataxia—which are also the symptoms of seasickness. Carbon monoxide detectors are the most effective defense against this potentially fatal problem. Install them in each cabin.

Stove alcohol is also hazardous, especially if one burner is accidentally extinguished and liquid alcohol—used in priming the burner—spills onto an adjacent flaming burner, causing a flare-up. A non-pressurized burner can also re-ignite if refilled with alcohol while still hot. Fire blankets or wet towels can extinguish alcohol fires. These same items, along with a liberal sprinkling of baking soda, can extinguish a grease fire on the stove. As a precaution, place a kettle of water on the burner before lighting it; this helps contain any high flames arising from excess alcohol used in priming the burner.

Supply your vessel with approved portable extinguishers.

Cat 1 requires 2 dry powder extinguishers, 2 kg each

The OSRs and the Coast Guard require all recreational vessels to have portable fire extinguishers. Dedicate one portable extinguisher to the engine compartment, a second to the galley, a third to the area under the fore hatch, and place the fourth (and largest size practical to stow) in a cockpit locker. A crew member should never have to walk more than one-half the boat's length to reach an extinguisher. The ideal location for a portable extinguisher in a closed compartment is next to the exit door to allow you to escape from below. Have a plan for how you would exit every stateroom and head. Install extinguishers above the floor to keep them away from water.

The standard multipurpose dry chemical extinguisher (filled with monoammonium phosphate) and the newer dry chemicals discussed previously can be used on three fire classes: A, B, and C. They extinguish and suffocate the fire by cutting off oxygen. A major drawback is the extremely brief window of opportunity to put out the fire. The common B-1 extinguisher discharges completely in just 10–13 seconds, and units with greater capacity simply deliver more chemical over the same period. Because of the short discharge time, ensure you have more than one fire extinguisher available to manage a large blaze. Dry chemical fire extinguishers should be inspected to ensure the pressure gauge indicates a full charge and should be inverted regularly to unpack the extinguishing agent.

Tri-class extinguishers fight type A fires by forming a crust of material over the burning materials, thereby isolating the fuel from oxygen—and making a hard-to-clean mess. Remember the **A-PASS** method: **Alert, Pull, Aim, Squeeze, Sweep.** Alert all to the danger. Pull the extinguisher from its bracket. Aim the extinguisher low. Sweep across the base of the flames. Make sure you have a crew member close at hand with the extra extinguishers! Stay low to avoid smoke and don't forget to plan your escape: fires extinguished with dry chemicals should be considered a hazard until the source cools down to room temperature.

Remember that different fires require different extinguishing methods.

Dry chemical extinguishers are not always the only—or best—way to manage a fire.

- **Water:** You can control fires involving common combustible solid material by cooling them with large amounts of water. And though water does not extinguish electrical fires, it may be effective on the resulting class A fire after the electrical circuit has been disconnected. See table summary for fire-fighting guidelines.
- **Fire blankets** can smother and cut off oxygen from fires involving flammable or combustible liquids. Electrical fires can be difficult to extinguish because the source of the heat (a shorted wire) can re-ignite the fire even after an extinguisher has been used.
- **Terminate electric power** to help control electrical fires, especially when a short circuit is generating sufficient heat to cause other materials to combust. Every boat must have a main battery switch and/or AC breaker to turn off the entire electrical system. More complex boats may have other sources of ignition, like AC generators, turbos on engines, and forced air heaters.

In summary, adhere to the following guidelines from Michael Jacobs and Chuck Hawley for fighting fire at sea:

1. Attack the fire immediately at the source. Detection and reaction time must be immediate, before the fire burns out of control. Prepare and share a plan with the crew so that everyone knows the location of equipment and their responsibilities.

2. Initiate a mayday call immediately if this can be done without exposing the crew to the fire. The purpose is to alert ships in the area in case the crew needs to abandon ship.
3. When fire is discovered, all crew should be on deck as quickly as possible with life jackets and fire extinguishers in hand. Ensure that the life raft is away from the fire. This is another good reason to store life rafts on deck or in a deck-accessible locker.
4. Slow the boat to reduce relative wind, and steer to keep smoke and flames clear of the crew and vessel. Keep the fire on the downwind side of the ship, exposing the smallest amount of the boat's structure to the flames.
5. The crew should always have a clear escape route when fighting a fire.
6. Cut off the source(s) of the fire (e.g., fuel supply, electric current, and ventilation system). Turn off blowers, and stop the engine.
7. Shut off the air supply to the fire. Close the hatches, doors, and vents to all compartments free of people.
8. If you must open a hatch to discharge a portable extinguisher, beware of burning your hands or face. As fresh air enters the compartment, the fire will rise to the air source and flare up. The safest way to open a hatch is to wear gloves and stand on the hinged side of the hatch while it is opened. A "fire port" that allows a fire extinguisher to be discharged without opening an engine compartment can be retrofitted to boats easily.
9. If the fire is too large or out of control, abandon ship before the fuel tanks explode.
10. Check the engine compartment frequently to detect smoke/fire.

PlayStation Fire, Ben Wright

In April, 1999, the 120-foot catamaran, *PlayStation*, suffered from a major fire caused by Nickel Metal Hydride (NiMH) batteries.

When PlayStation was first commissioned, we used Nickel Metal Hydride (NiMH) batteries developed for electric cars. This type of battery is capable of accepting large amounts of input charge, which is one reason they appealed to us. The batteries comprise metal-cased cells with each cell bound by steel straps to the following cells to make a 12 volt battery. They are not vented as such, but they have a very small pressure relief valve that should release at 120 psi. When operating normally, this should never be required to function.

Since the battery company was running late on delivery, it initially sent loaner batteries from the test lab to use until the next generation batteries were available. On this day, PlayStation was tied up at the dock with no exceptional use or demand on its NiMH batteries; they were being charged per normal procedure. These batteries always warm up when charged, as they did this time, and to combat this, the battery box has small fans to create a draft within the box to aid cooling. The charge cycle finished normally, but approximately one hour later the batteries exploded.

A small short circuit, along with the energy and heat that had already built up in the batteries, allowed the batteries to set off on an exothermic reaction—and the only way to stop it was to cool the batteries. We were unaware of this short circuit, so the batteries themselves continued to feed heat energy into this point of the short circuit. This created more heat, which then spread to the nearby cells, ultimately creating a massive explosion.

In this “meltdown” process, the batteries outgassed hydrogen and oxygen, among other things. The temperature, estimated to have been as high as 300 degrees, caused the resin in the surrounding carbon hull to ignite. (It is the resin that burns, not the carbon.) The situation was compounded by the fact that there was a continual draft of air flowing through the boat, entering at the foredeck hatch and the hull escape hatch and exiting thru the companionway. The situation escalated almost instantly, with massive flames leaping quickly from the companionway. Closing the foredeck hatch helped immensely, but with the hull escape hatch still open, the flames continued to burn intensely. The burning resin gave off lots of black smoke, which along with the batteries and other burning objects produced a very nasty smell.

After this incident, I was surprised to learn how many others had some kind of battery failure. Their stories generally involved lead acid batteries, but batteries nonetheless.

Had we been at sea, it would have been a *very* serious affair—a sobering thought for the *PlayStation* crew. The fast-spreading fire and thick smoke made it clear that at sea you would have little chance to fluff about. Thankfully, since PlayStation was tied to the dock, the local fire brigade eventually arrived to control the fire.

This fire also served as a technology lesson. Remember that new kit, whether batteries or other gear, may often be new to—and insufficiently tested by—the supplier, too. Spend sufficient time and money to understand what you have purchased, rather than simply trusting the supplier. A new and exotic item may not be properly tested and may require additional controls and sensors. Remember that, in the end, you are responsible for your purchase and the consequences of using it.


NEW ZEALAND HERALD 4/24/99

3laze casts pall over catamaran's racing schedul

ire ripped through the hull of world's biggest ocean racing amaran in Auckland yesterday rnoon, sending crew scrambling safety and putting the immedi- racing plans of the $8 million t in doubt.

ire broke out aboard Play- tion while it was moored on the tern side of the Viaduct Basin r the Team New Zealand com- nd. The extent of damage was lear last night.

upert Kirby, a tourist catching e sun with his wife, said he rd two small explosions, then crew members scrambling from the starboard cockpit and for- ward hatch, sec- onds before flames shot out.

The crew tried to fight the blaze with ex- tinguishers but were forced back by the heat.

Steve Fossett

Senior Sta- tion Officer Bar- ox of the Fire Service said it k firefighters about 10 minutes ring the fire under control. They n flooded the hull.

he catamaran, owned by Ameri- adventurer Steve Fossett, was t in Auckland last year with the of taking on ocean racing rds.

n March, it set the record for the t distance travelled in 24 hours 80 nautical miles.

n attempt to break the record crossing the Atlantic, scheduled June, may have to be put off use of the fire.

he catamaran was due to be ped to America next weekend.

— Tony Wall

FLASH FIRE: The $8 million catamaran that caught fire in Auckland yesterday holds the world record for sailing the longest distance in 24 hours. The New PlayStation was due to be shipped to the US next weekend. The blaze has cast doubts over a challenge to the Atlantic crossing record in June.

New Zealand Herald, 24Apr99

PlayStation fire damage

Chapter 13—Life Rafts: Choice and Use, Bruce Brown

Key Concepts: Life raft standards, care, service, and use (4.20); grab bag contents (4.21); boarding a life raft; crew organization, psychology of survival.

Barely visible life raft at close range in clear daylight

"Abandon ship!" is one of the scariest phrases you can hear at sea. The command cannot be issued without considerable thought. Leaving your vessel prematurely is more dangerous than staying on board until she sinks out from under you. There are dangers in both entering the life raft in heavy seas and being rescued from it later—should you be lucky enough to have that opportunity. When conditions are difficult on board, you may be tempted to leave the boat prematurely, but beware: conditions will likely be worse in a raft. So when should you give the order? What steps should you take to abandon ship? And if you do abandon ship, what gear should you take with you?

A critical element in safely executing any emergency action is to have a clear plan and to practice it before you need to use it! Attend a Safety At Sea Seminar, where you'll learn valuable emergency survival skills. You should also practice launching a life raft. Finally, develop procedures appropriate for your vessel and communicate them with the entire crew before they are needed.

RECOGNIZE

When the vessel itself becomes a threat to the crew on board, a skipper must consider abandoning ship. In almost all cases, the vessel represents the best shelter available for the crew, so choosing to leave the boat's assets and stores is a serious decision.

There are two reasons one might consider abandoning ship: unquenchable fire or unchecked flood.

These two emergency situations can make the vessel itself a threat to those on board. When the vessel becomes a threat, make ready to abandon ship!

Who makes the decision? The captain. The skipper or owner may assume that role, but the captain is the only person with the responsibility and authority to order an abandonment of a vessel. Once decided, it is imperative to follow the practiced procedures using the available equipment.

The following guide provides an overview of the steps you should take in the event that you must abandon ship. By preparing yourself to assess and react to an emergency situation, you can improve your chances of safely escaping an endangered vessel.

Seven Steps for Survival

Courtesy of the Alaska Marine Safety Education Association

RECOGNIZE	Determine the emergency and react as if it is an emergency. DON'T DELAY this important step!
EQUIPMENT	Inventory your assets and begin to gather the gear you need to address the emergency.
SHELTER	Do what is necessary to locate shelter from the hostile environment that surrounds you. The boat is the best shelter you have, so don't abandon ship until the boat is a threat to you and the crew. A life raft is the next best shelter you have from the water.
COMMUNICATE	Tell the crew the nature of the emergency. Contact SAR agencies to advise them of the situation and your location. Stay in touch! Use any assets you have to communicate that there is an emergency.
WATER	Consider the need to replace 1 liter of water per person per day. Don't ever drink seawater or urine! Survivors can go 3-7 days without water.
FOOD	Food is not as important is water. Don't eat any food unless there is water to digest the food. Emergency rations found in life rafts require a minimal amount of water to digest.
PLAY	Creating the will to survive is important. Giving jobs to everyone in the emergency keeps a focus on survival. Jokes become important as a technique to keep spirits up.
REPEAT THE STEPS ONCE YOU GET TO THE LAST ONE – YOUR SITUATION MAY HAVE CHANGED!	

EQUIPMENT

Offshore vessels should carry life rafts with a minimum capacity for the entire crew on board. Since many survivors describe life raft conditions as cramped, experts often recommend a life raft with capacity for two more than the complement of crew. This allows space for additional equipment inside the life raft.

Tenders, dinghies, and inflatable boats do not qualify as lifesaving equipment (although they may be helpful in addition to a purpose-built raft). These devices do not include features that aid in orientation to the waves (such as a sea anchor) or stability in high winds (such as ballast pockets). The best abandon ship solution is a purpose-built life raft. OSR 4.2 specifies equipment that is required to be packed inside a life raft, but some rafts carry more than the minimum. Be sure you know what is packed in the life raft you have on board. Although you may add extra equipment, you need to speak with your raft manufacturer or service station before doing so. You should also prepare an additional "grab bag" to hold items not packed in the raft.

SHELTER

You can choose from several types of available life rafts. Select your raft and other safety equipment based on how long it might take rescue agencies to arrive at your location. These are the three categories available: close to shore, coastal, and offshore.

1. **Close to Shore Platforms, Pods, and Inflatable Buoyant Apparatus (IBA):** These devices are created for use very close to shore. They allow an immediate escape from immersion in the water, which can help limit hypothermia and drowning, but they lack canopies and safety equipment. These devices are short-term solutions to be used in the expectation that rescue agencies will arrive within a few hours (see Figure 1).

MOM 600 Platform

2. **Inshore or Coastal Life Rafts**: Inshore or coastal life rafts are designed for use where you can reasonably expect rescue within 24 hours. These rafts usually have a single tube with one or two chambers containing the CO_2 used to inflate the raft. The coastal life raft will include a minimum safety pack and may or may not have a self-erecting canopy. *Do not consider these rafts for offshore passage making*. The coastal raft does not offer survivors the same protection from a hostile ocean environment as an offshore life raft (see Figure 2).

Switlik Coastal Life Raft

3. **Offshore Life Rafts:** These rafts have twin buoyancy chambers, a complete offshore equipment pack, and an insulated floor. They will support the rated capacity of the life raft with only one chamber full of air and the second chamber deflated. US Sailing recognizes the ISAF standards for offshore life rafts, defined in Appendix A, Part 1 of the US Edition of the ISAF Offshore Special Regulations (see Figure 3).

ISAF Compliant Offshore Life Raft (Switlik)

ISAF compliant life rafts must be of offshore design and capable of carrying at least the entire crew. Many survivors recommend having a raft with even greater capacity. These must be purpose-designed life rafts, not a tender or dinghy. They must have a self-erecting canopy. ISAF compliant life rafts vary in price, size, and construction. They are available in hard canisters for storage on deck or in valise packs for storage below or in a watertight locker (see Figure 4).

Offshore raft in hard container (Viking) and Coastal raft in valise pack (Viking)

4. **Ballast Systems:** Various ballast systems have been developed over the years. This usually adds weight to the life raft, but it makes the raft significantly more stable, especially when empty during deployment and boarding. Examples are shown in Image 5a, 5b, 5c, 5d from AMSEA.

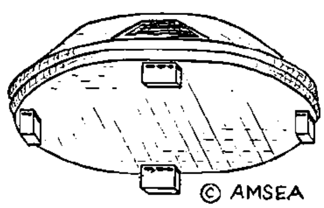


Image 5a: Old Ballast System

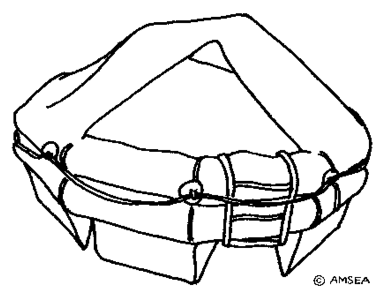


Image 5b: Icelandic Ballast Pockets

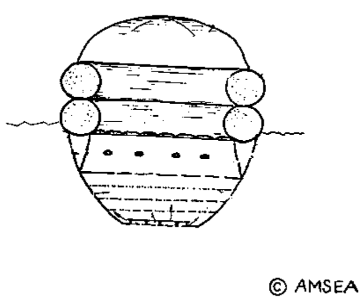


Image 5c: Given's Hemispheric Ballast

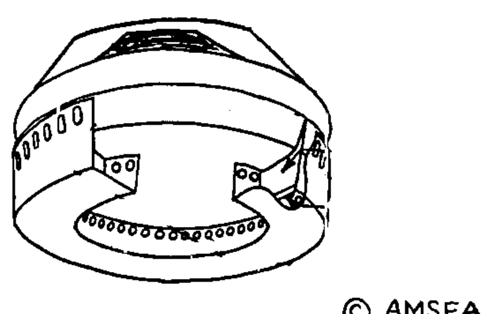


Image 5d: Switlik Torroidal Ballast System

COMMUNICATE

Once the captain/skipper has decided that abandoning ship is a possibility, communication among the entire crew is paramount. The life raft should be readied for deployment. The following list describes how to respond in this situation.

- Call May Day: report your position and that you are abandoning ship. State the number in your crew and how many life rafts you are using.
- Entire crew must don life jackets and, ideally, survival suits.
- Assign a crew member to handle the EPIRB.
- Assign a crew member to collect the abandon ship/grab bag(s).
- Collect the boat's first aid kit; the kit packed in the raft is incomplete.
- Collect additional signals, water, clothing/blankets, and carbohydrate-rich food if time permits.

STEPS FOR DEPLOYING A LIFE RAFT:

ISAF OSRs specify the raft should be capable of being readied at the lifelines or launched within 15 seconds.

1. Locate the painter line. Make sure the painter is attached to a strong spot on the boat (preferably a mooring cleat on the leeward side of the boat).
2. If the raft is in a hard container, remove it from the cradle and move it to the leeward rail (you do not need to cut the bands that hold the container together).
3. If the raft is in a valise, move the raft to the leeward rail.
4. Once the order to abandon ship is given, check that there is no wreckage in its path and **throw the raft in the water**. **Do not** attempt to deploy the life raft on deck.
5. Pull on the painter line. There will be about 30-feet until it reaches the end and you feel resistance.
6. **Now pull hard on the painter line**. It may take 40 or 50 pounds of pull to activate the CO_2 cylinder firing mechanism.
7. There will be a small explosion as the CO_2 in the cylinder inflates the life raft.
8. When the raft is fully inflated the canopy will pop up and excess gas will escape from the pressure relief valves in the raft. This will make a hissing sound. Don't be alarmed.
9. The raft is safe to board at this time. Pull it close to the leeward side to protect it from damage. It is best to board directly from the boat to avoid getting wet. From the water, you can use the boarding platform on one side of the life raft. Just put your knee on the ramp, grab a strap, and pull yourself up. Then climb into the raft. Remember to take the grab bag, water, and your other assets into the life raft with

Photo courtesy Switlik

you. Tether all assets when possible to prevent inadvertent loss in the event of turbulent waves or capsize.

10. If you deploy multiple life rafts, tie them together if possible. It makes a larger search target for rescuers. Throw all floating debris overboard and tie what you can to the life raft to create a bigger visual pattern in the ocean.

If possible, board the raft directly from the vessel to reduce the dangers of hypothermia and to avoid bringing a lot of water aboard. Protect the raft from damage when alongside the vessel.

Boarding a raft from water, SLH photo

WATER, FOOD, AND PLAY

Once inside the life raft:

- Cut the painter line with the provided "safe" knife. Beware of cutting the raft.
- Stream the sea anchor to reduce drift and to orient the raft's door downwind.
- Close the canopy; balance the crew to stabilize the raft.
- Take roll call, appoint a leader.
- Collect all sharp objects to protect the raft.
- Take stock. Check for damage.
- Check for injuries and treat them.
- Ensure EPIRB is on, that SART and strobe work.
- Establish a routine for lookout/watches.
- Watch for shivering; huddle to keep warm.
- Bail water with one sponge/bucket to make the interior of the raft as dry as possible.
- Reserve second sponge to collect fresh water.
- Maintain personal health: take anti-nausea medication and be sure to urinate.
- Understand and account for the debilitating effects of hypothermia and fatigue.
- Stay as close to your last reported position as possible to aid SAR efforts.
- Collect water if it's raining. Store in bags or tins, then drink as much as possible.
- Maintain a positive attitude.

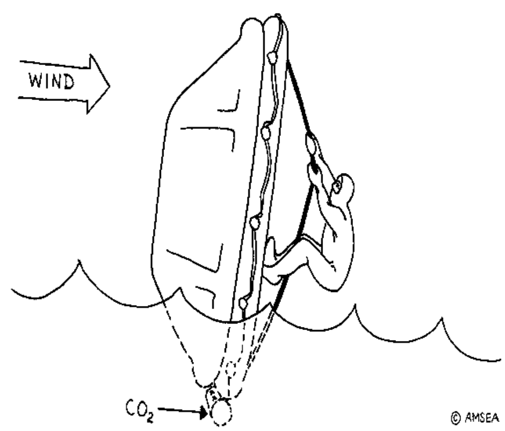
This last step is perhaps the most important. It makes a huge difference in your chances of survival. Talk, read, joke, and record your navigation, health, water, and food monitoring experiences. Stay as warm and dry as possible. Assuming you get to shore, you must consider starting the Seven Steps for Survival again. This means repurposing the life raft, so be sure to pull it with you away from the water. The raft can function as a shelter and it contains many resources you may need to survive.

OTHER CONSIDERATIONS:

Righting an overturned life raft

You can find instructions for re-righting the raft after capsize on one of the raft's outside tubes. Swim to that side of the life raft and locate the righting strap on the bottom of the raft. With your feet on the tube where the instructions are located and legs bent, hold on to the righting strap (**do not wrap the righting strap around your hands or arms**) and extend your legs until straight. This should bring the raft over. It will fall on top of you. Hold out an arm to create an air pocket. Work along the righting strap until you are out from under the raft (see Figures 8 & 9).

Righting a raft from water, SLH photo



Righting an overturned life raft (AMSEA)

Life Raft Service

Check with the manufacturer and have the life raft serviced according to the manufacturer's recommendations at a **factory-authorized service station**. Service intervals vary according to the manufacturer. Service extends the life of a raft. The service station will replace equipment when it expires or becomes non-functional and will inspect the raft to ensure the inflation system is operational and the raft olds air according to the manufacturer's requirements.


Mahina Tiare raft repack

Raft owners should be able to watch their life raft being serviced. Familiarize yourself with the equipment packed in the raft and understand how it operates. Pack grab bag contents to complement the items packed within the raft.

Buying Used Life Rafts

It is a “buyers beware” world. A life raft must have a current certificate of inspection to be compliant with ISAF regulations. Prior to purchase—and certainly prior to voyaging—a used life raft should be inspected by a factory-authorized service station to verify that the raft is functional.

Renting Life Rafts

Life rafts are available for rent in many locations. They must be inspected by an authorized service station to ensure proper operation. A valid certificate of inspection must accompany a life raft to meet ISAF requirements. A current certificate provided by the renter along with a copy of a rental agreement should suffice for inspection.

Summary:

- Understand the situations that may require abandoning ship.
    - Know the Seven Steps for Survival
- Have an abandon ship plan—and practice the plan!
- Know how to place a Mayday call and what information to communicate. Practice this procedure.
- Select a life raft that is appropriate for your intended use.
- Store the raft in a sensible location.
- Learn about the raft that is on board the boat.
- Inspect the canister or valise regularly to ensure there is no damage.
- Ensure the painter line is made fast to the vessel–**before** you need to use it.
- Be familiar with the steps to deploy a life raft.
- Know how to board the raft.
- Understand what steps to take after abandoning ship.
- Have your life raft serviced according to the manufacturer’s recommendations.

Life raft in breaking seas—sea anchor turns opening downwind. Bail raft often. Tether all assets.


_VIK4970 X


_VIK4812 X


_VIK1610 X