U.S. Department of
Homeland Security
**United States
Coast Guard
Auxiliary**

Surface Guide to Damage Control

National Response Directorate

Disclaimer

- This guide is not a substitute for applicable policy
- The best practices presented in this guide should augment and support the **safe** completion of our surface operations responsibilities
- Applicable instructions and/or local regulations from your OIA and chain of leadership must always be followed

Overview of This Program

- Damage Control on vessels has distinct areas that all need to be addressed
- Preparation – Having the skills and tools available
- Mitigation – Operating your vessel in a manner that will reduce potential damage
- Response – what you do and how you do it when things go bad.
- We will touch on all of these areas in this program

Damage Control

- Concept of Damage Control
  - Keeping afloat a badly damaged ship by procedures to limit flooding, stabilize the vessel, isolate fire and explosions and avoid their spreading
  - Central Goal is to ensure survival of the vessel until it reaches a port where definitive repairs can be safely performed

Prevention

- Damage Control has two major parts
  - Prevent the bad thing from happening
  - Respond and mitigate damage when the bad thing does happen

Anchoring

- Anchoring seems like a simple operation…it's anything but that
- All vessels will swing when at anchor, even stern tied vessels move a bit
- Vessel swing, when coupled with tide changes, can be dangerous
- Think your anchor alarm will save you? Let's find out

Anchor Alarm

- Do you trust your anchor alarm?
- Do you set the alarm radius to match your rode?
- If so you <u>will</u> get false alarms
- Many mariners will set the alarm incorrectly and sound an alarm when no problem exists
- Why? The following steps will explain it

Anchor Alarm

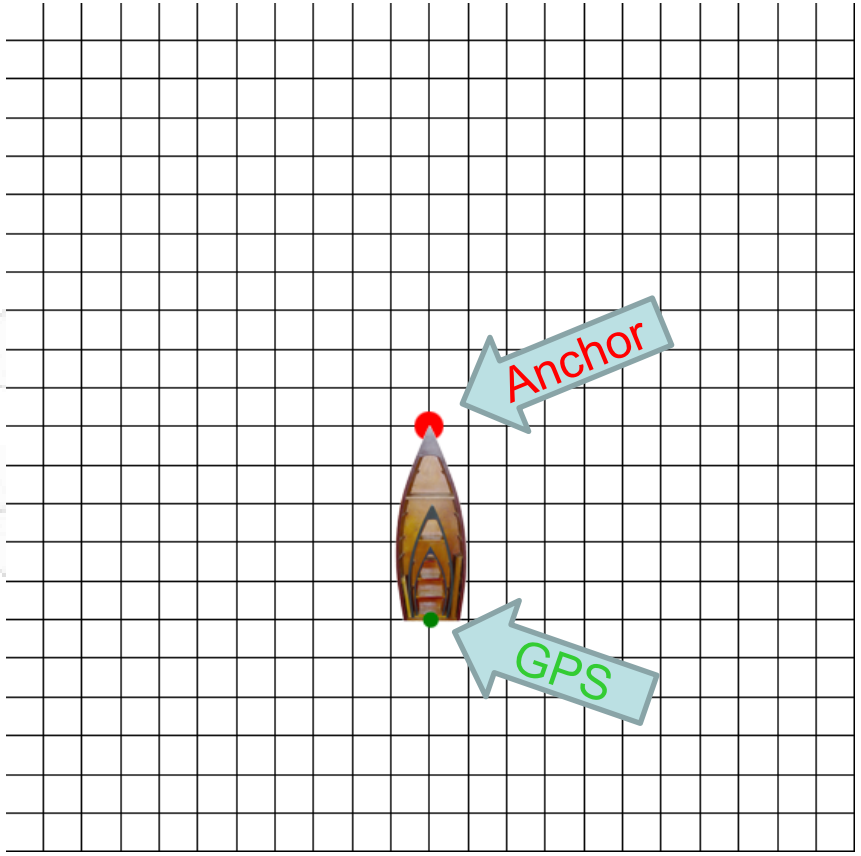
Step 1

The anchor is dropped

The red mark is where the anchor is located. The green mark is where the GPS antenna is located

The GPS is 5 units back from the bow. The anchor alarm would show that you are 0 feet from the anchor which is correct

Let's say you set the anchor alarm for 10 units since you intend to put out 5 units of rode. This would make your alarm double your rode length which you'd think is overkill



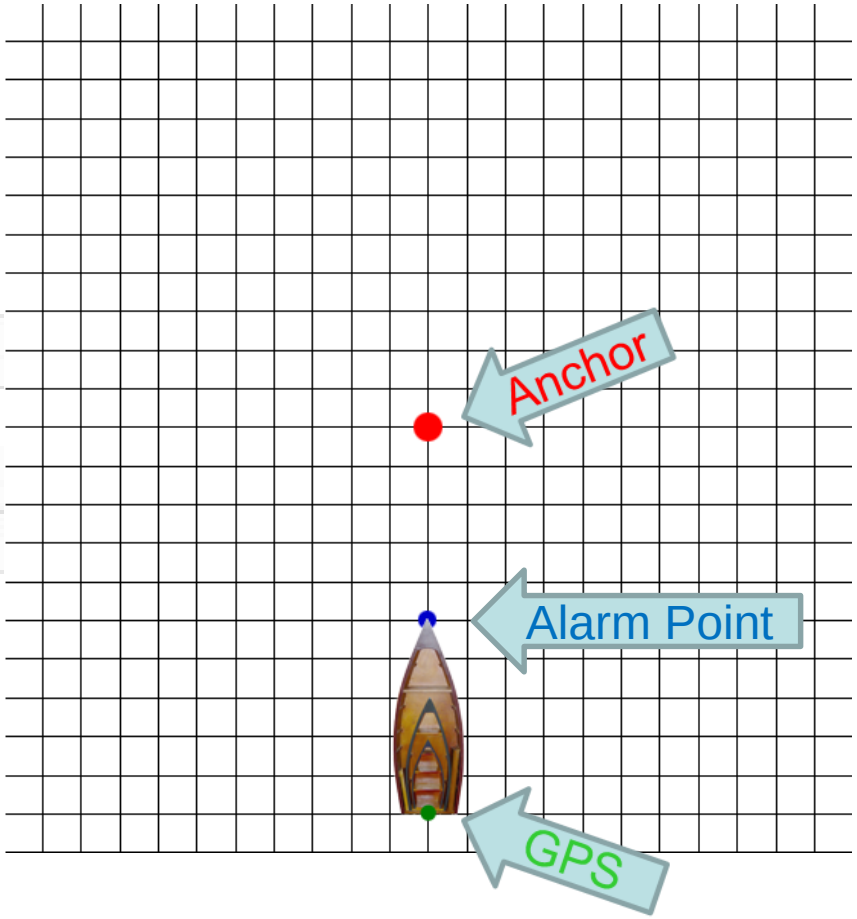
Anchor Alarm

Step 2

You let out 5 units of rode and set the anchor

Although the GPS is 10 units from the anchor, the anchor alarm will show that you are 5 units from the anchor because you are only 5 units from the original position that was recorded when the anchor alarm was enabled (the blue mark)

No alarm will go off and everything is working well



Anchor Alarm

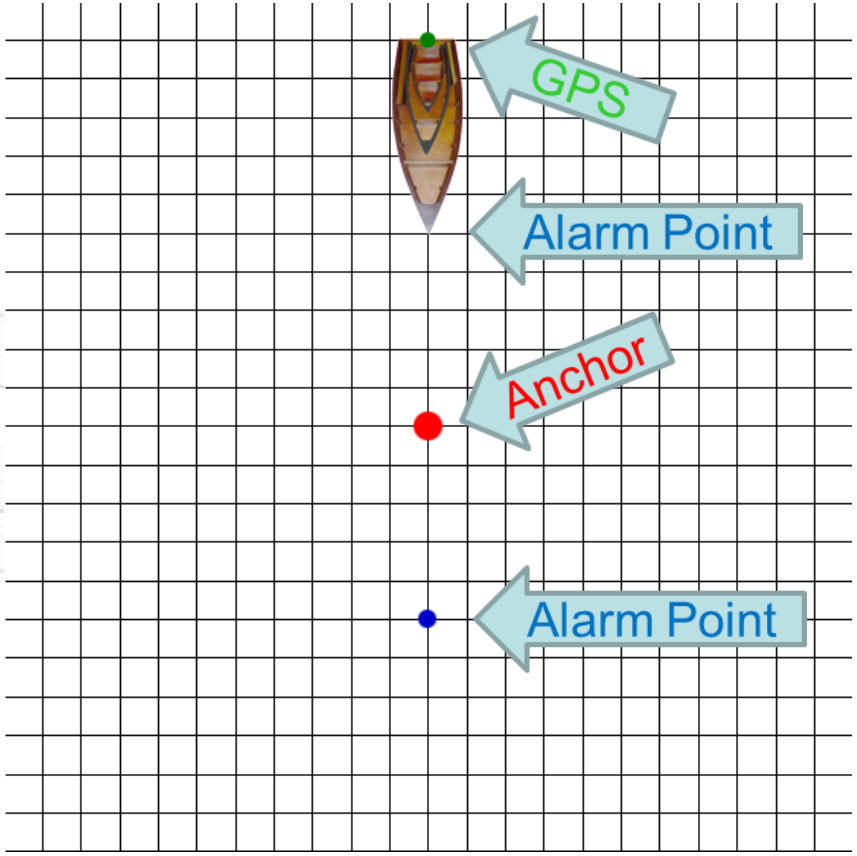
Step 3

Here's where it gets interesting. You swing around and pull back the same 5 units from the anchor. This shouldn't trigger the alarm because you are only 5 units from the anchor

But the measurement is between the position where the GPS was when the anchor was dropped (blue dot) and the position where the GPS is now (green dot). If you count the squares, you'll find that the anchor alarm will show that you are 15 units away from the anchor

Your alarm goes off – you wake up in terror because you know that you way overset the alarm length to 10 with only 5 let out. And yet, you haven't dragged at all. The distance reported, 15, is the 5 units you really are back from the anchor plus 2 times the distance that the GPS is from the bow (2 x 5 = 10)

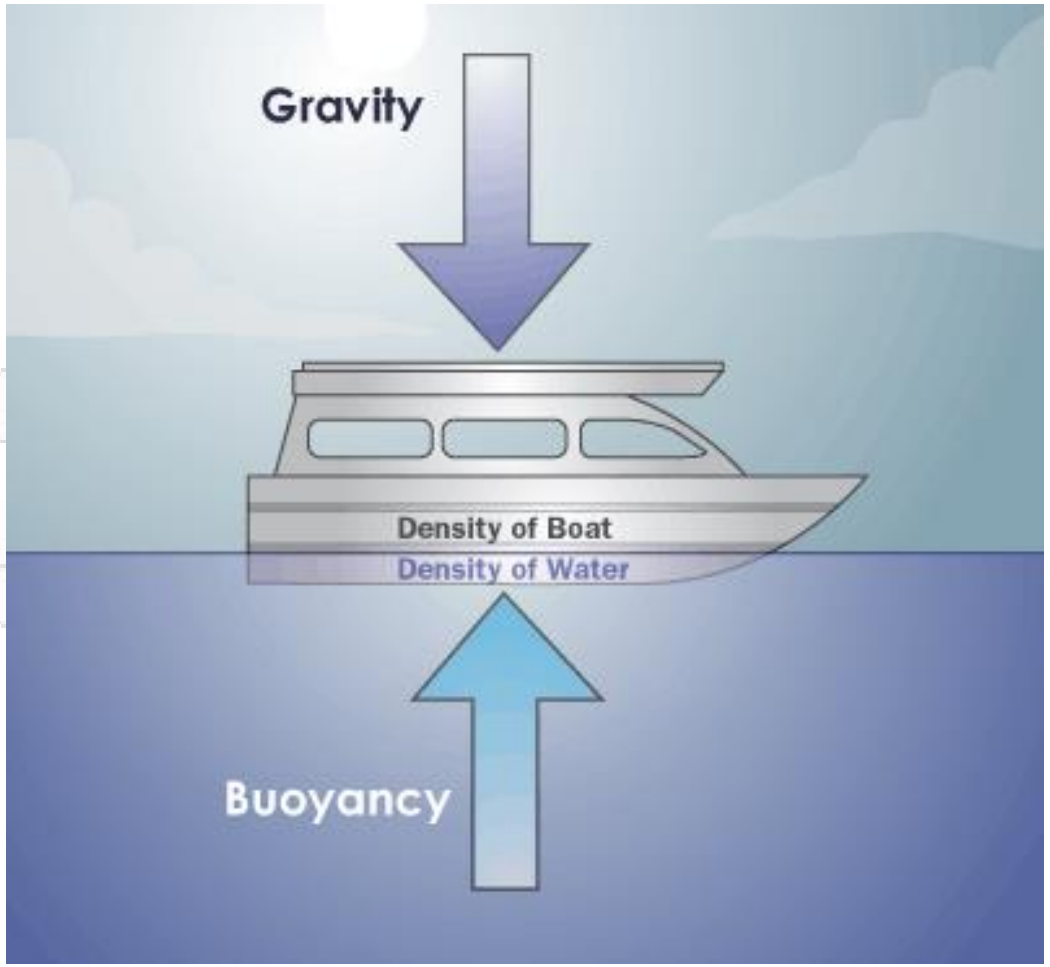
The error is 2 times the distance between the GPS and bow



Ship Stability

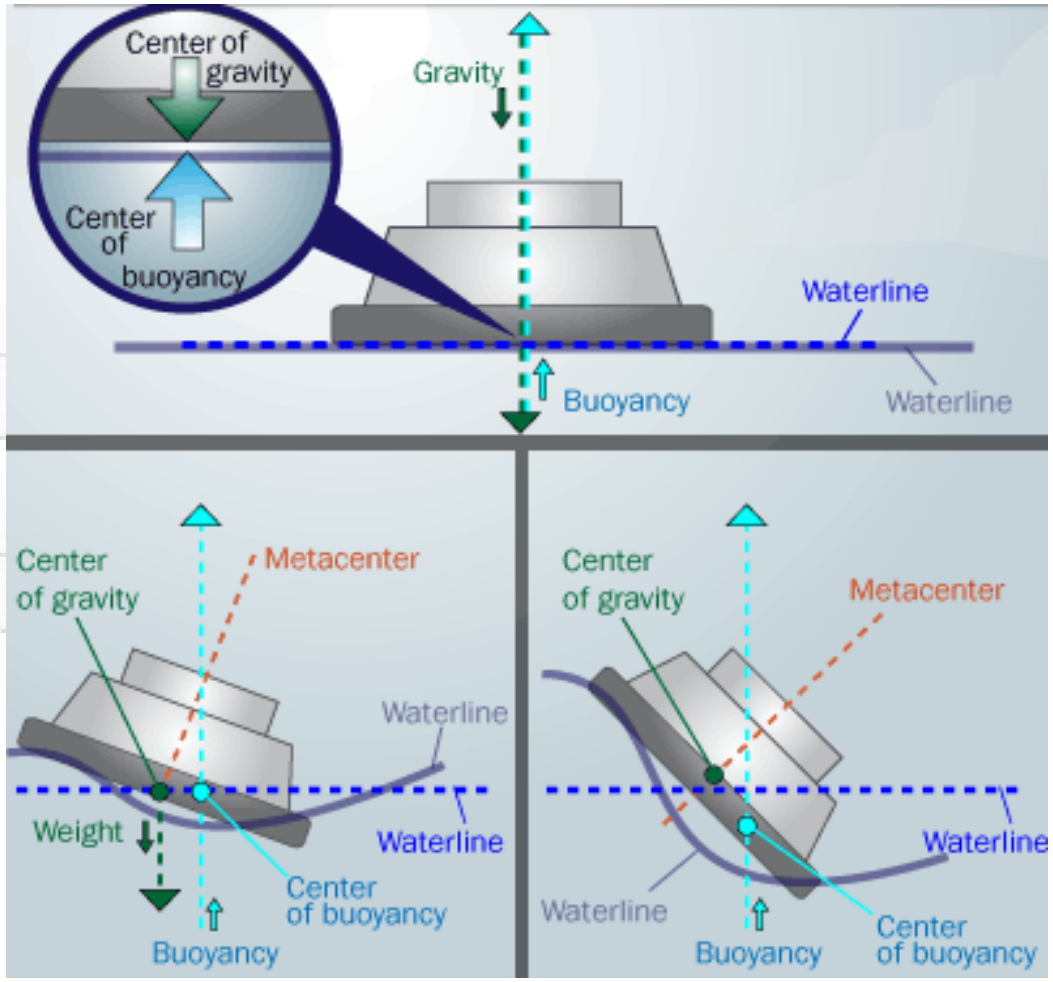
Stability

- Ok, it's time to get a little technical
- A boat has two centers
  - Center of Gravity (CG)
    - Force the pulls the boat down into the water
  - Center of Buoyancy (CB)
    - Force that pushed the boat back up



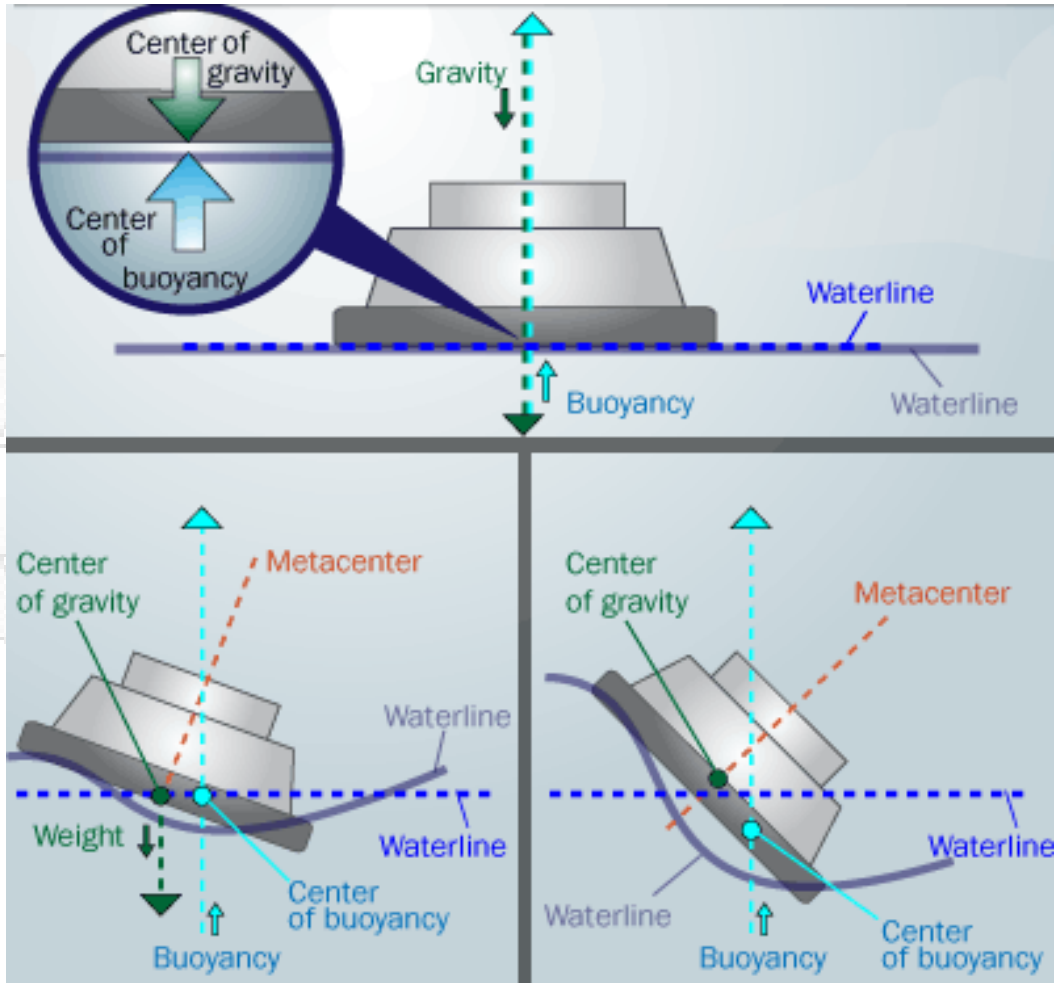
Stability

- If a boat tips to the right it's center of buoyancy shifts to the right also
- The water is pushing up on the boats right side instead of it's centerline



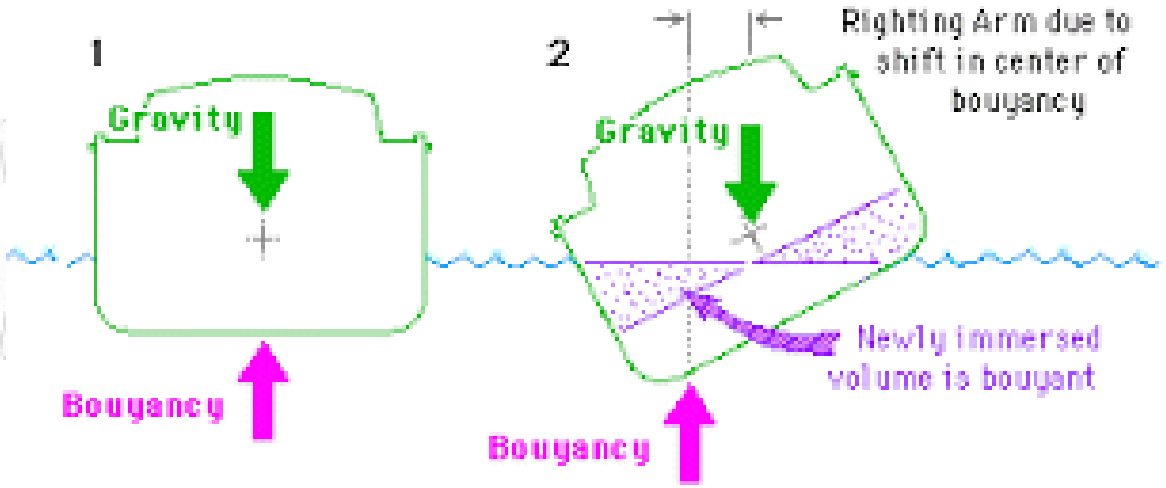
Stability

- The CG and CB intersect at what's called the Metacenter
- The lower the metacenter is the closer the boat is to rolling over
- Once the metacenter points below the CG the boat will roll over



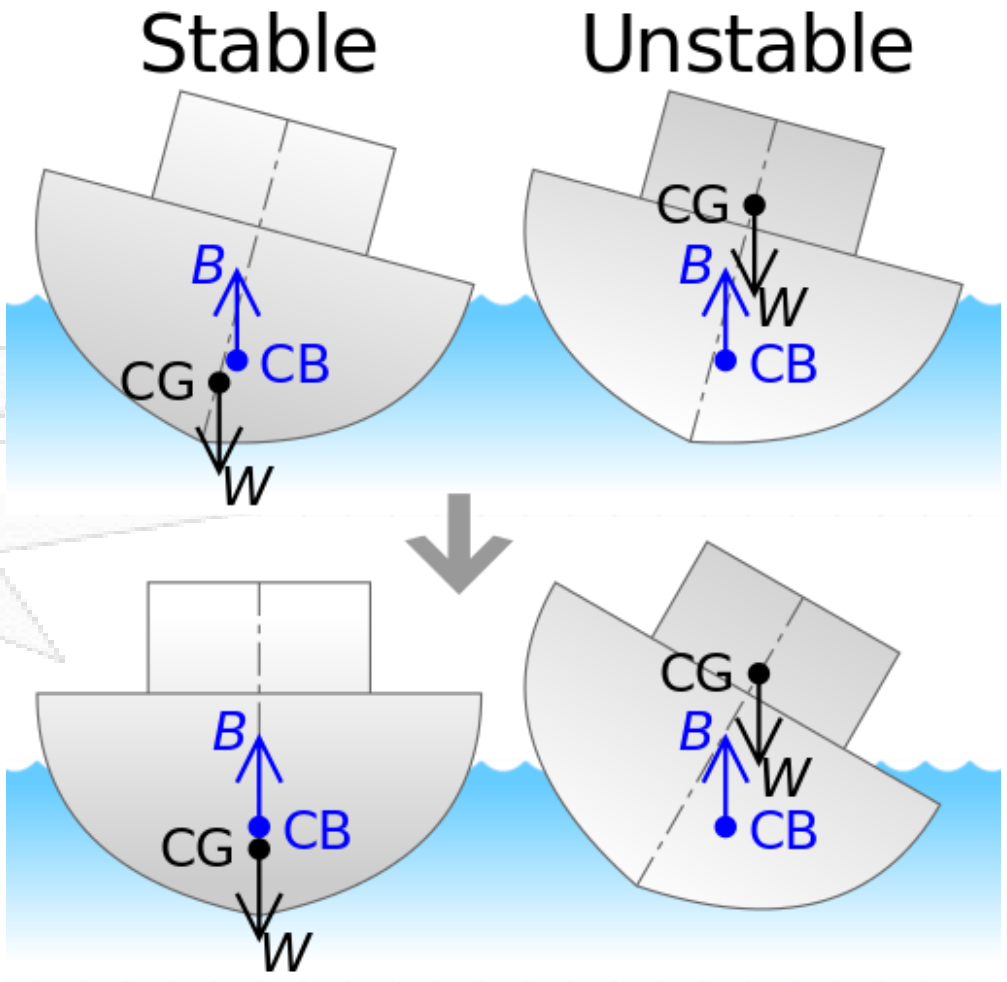
Stability

- Another force is the righting moment
- You can express the righting moment mathematically, it's simply the weight of the CG x the distance between the two centers
- If a boat weighing 15,000 lbs shifted its CB out 3 feet the force applied by the righting moment would be 45,000 lbs per foot



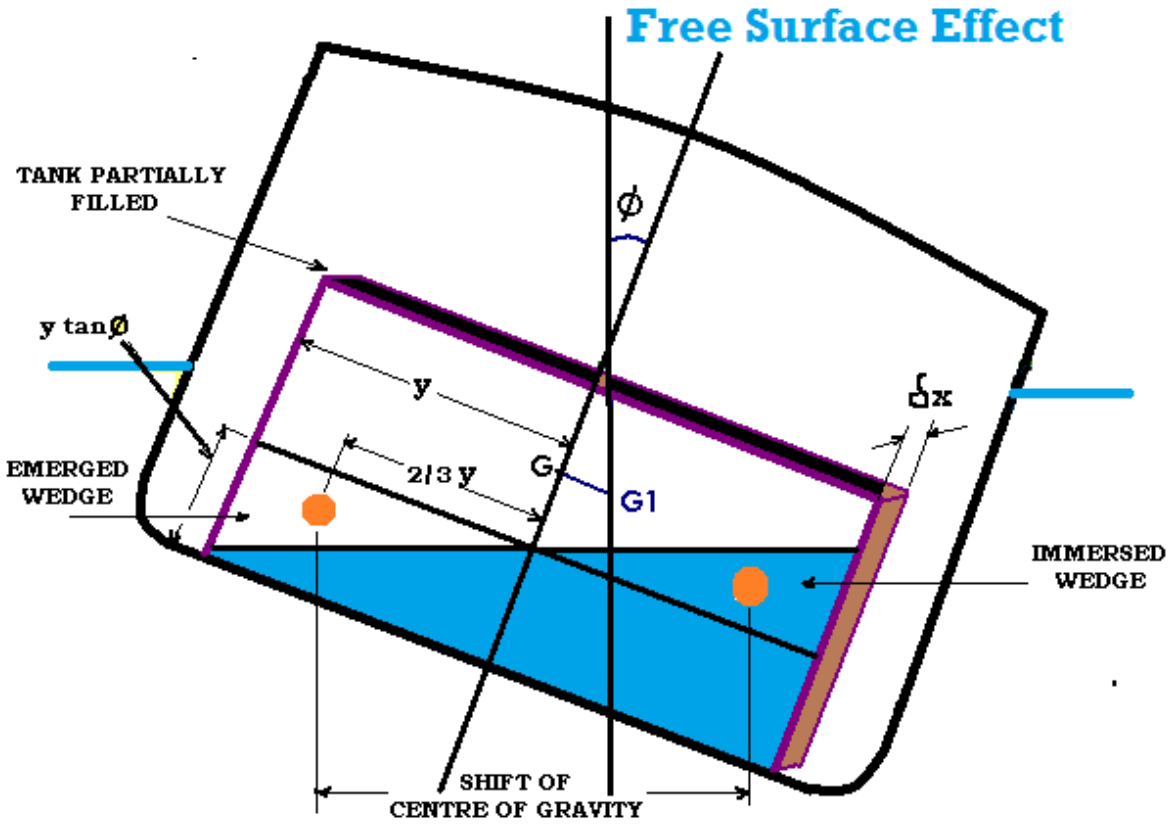
Stability

- We want to keep the CG low in the boat to keep the CG and CB near each other
- If we raise the CG due to loading (everyone on the flybridge) the CG can move out over the CB and make us unstable



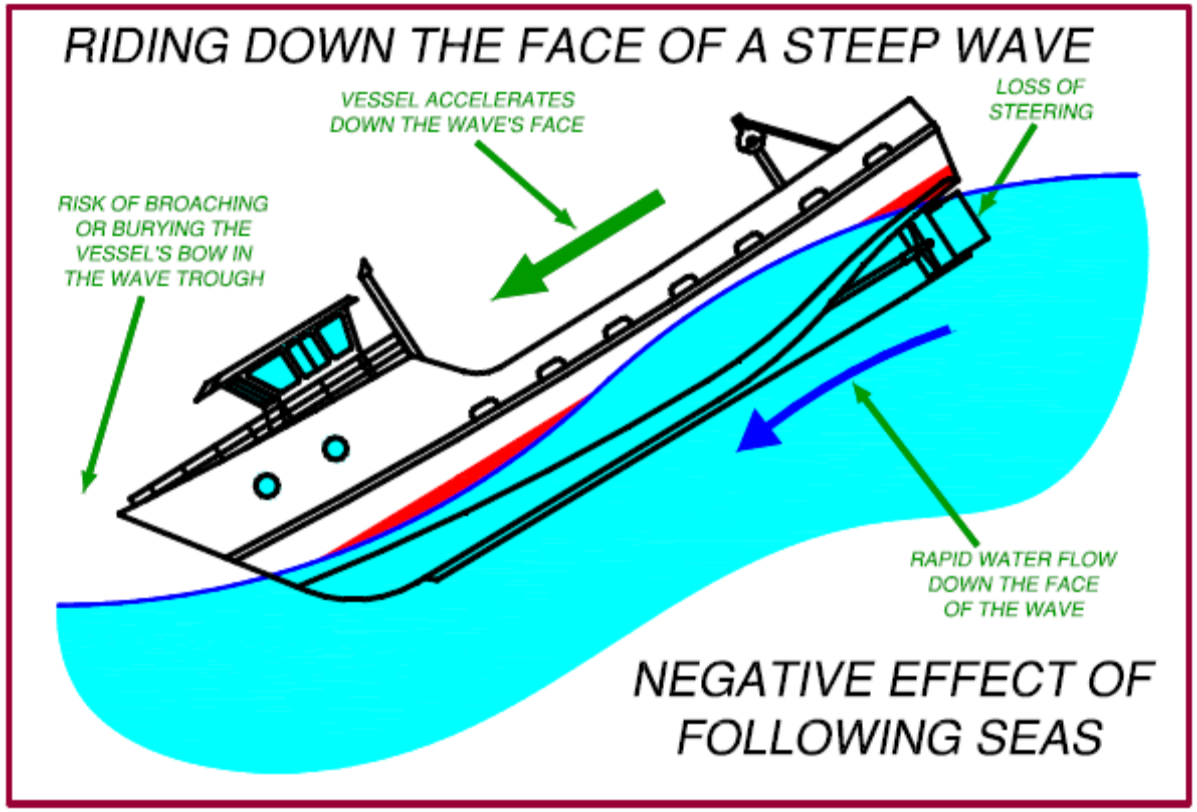
Free Surface Effect

- Any liquid tank that is between 10-90% full produces Free Surface Effect
- If a mass inside the vessel moves in the direction of the roll it counters the righting effect by moving the CG towards the lowered side



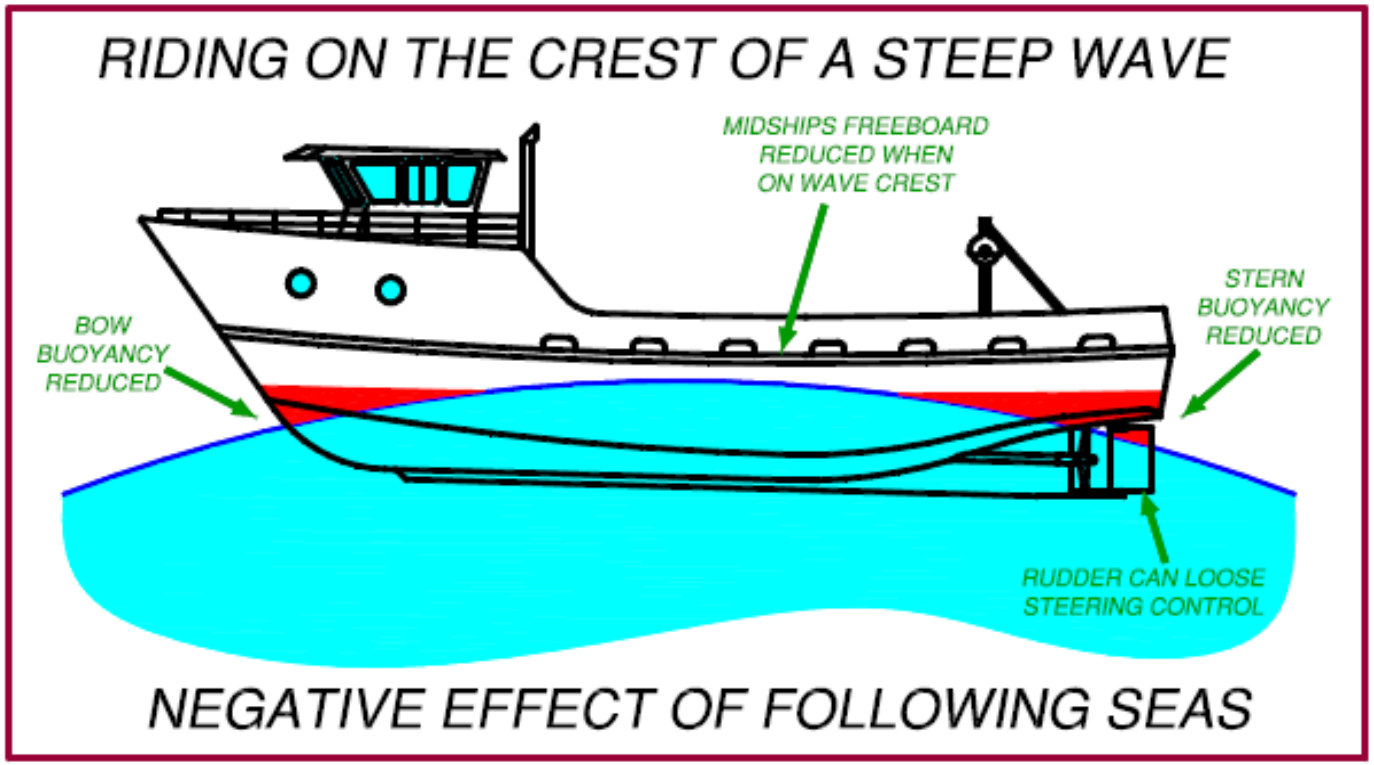
Following Seas

- Riding down the face of a steep wave can lead to sudden capsizing of the vessel
- If the vessel surfs and accelerates down the wave there is a chance of burying the bow
- Because the natural flow of the water in the wave is the same direction as the vessel the rudder may lose effectiveness



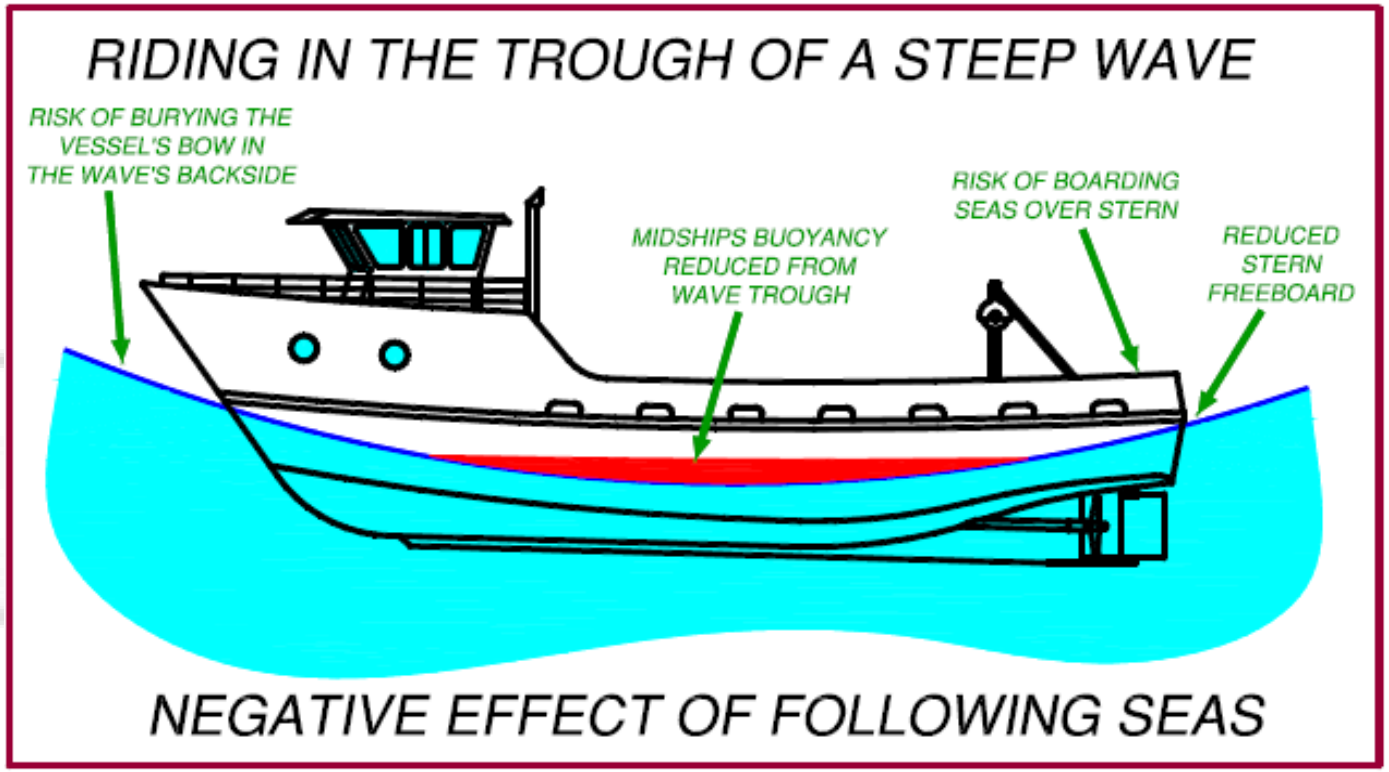
Crest of Steep Wave

- Critical stability provided by the stern is severely reduced when the stern is lifted clear of the water and no longer provides any righting forces
- Reduction in the vessel's amidships freeboard further reduces the overall stability levels and may lead to direct capsize of the vessel



Trough of Steep Wave

- Increased chance of being swamped by a boarding wave
- The added weight of the water on deck raises the vessel's CG and creates a sizeable free surface capsizing moment



Recommendations

- In severe sea conditions change course to put the bow into the seas
- If the vessel must run with the seas, riding on the backside of the preceding wave minimizes the dangers
- Do not overload the vessel
- Keep cargo secured at all times

Recommendations

- Minimize the number of partially filled tanks to decrease free surface effects
- Keep all bilges, compartments and spaces dry and free of standing water
- Maintain your vessel’s watertight envelope

Flooding

Flooding

- The volume of water that enters a boat is proportional to the square root of the depth of the hole and the square of the holes radius
- A 2 inch hole that is 1 foot below the waterline can fill a 55 gallon drum in 42.4 seconds
- Each gallon of salt water weights approximately 8.5 pounds

Flooding

- A 1” hole that is 2 feet below the water line is forcing your boat’s weight to increase at 240 pounds per minute or 4 pounds per second
- As the boat fills with water the effective hole depth increases, forcing faster water ingress
- A 1600 GPH bilge pump in perfect conditions can remove 26.7 gallons per minute

Flooding

Boat Flooding Rates in Gallons per Minute							
Depth of Hole Below Waterline	Diameter of Opening or Hole						
	1 in	1.5 in	2 in	2.5 in	3 in	3.5 in	4 in
1 ft	19.4	43.8	77.9	121.7	175.3	238.6	311.6
2 ft	27.8	62.5	111.1	173.6	250	340.2	444.4
3 ft	33.9	76.3	135.7	212	305.3	415.6	542.8
4 ft	39.3	88.4	157.1	245.3	353.5	481.2	628.4

Damage Control

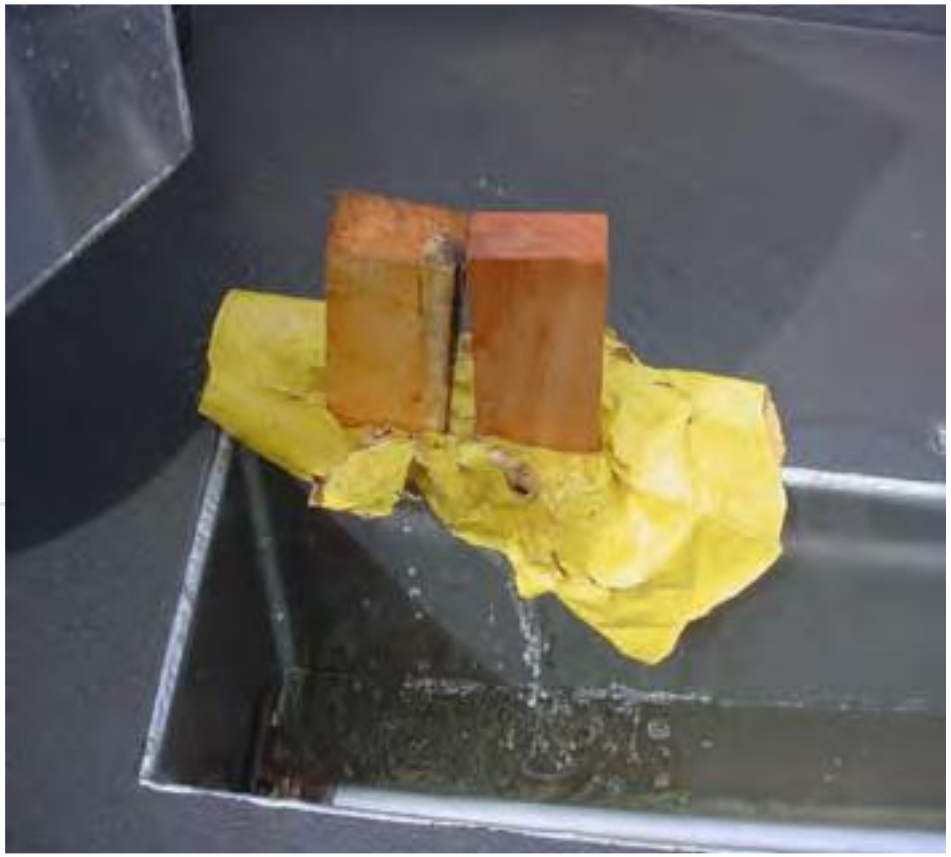
- The problem:
  - Small Hull Breach
  - Hull failure usually associated with impact with logs or other floating debris
  - May also be caused by structural failure of wood hulls

Damage Control

- The Tools
  - Soft wooden wedges are used to plug cracks and other small hull breaches
  - Pine and fir are idea for wedges because the wood is more likely to conform to the shape of the hull breach, will absorb water and swell increasing the effectiveness of the plug
  - An old sleeve from rain gear to stuff into the crack

Damage Control

- The Solution:
  - Pound wedges into the breach with a hammer
  - Soft wood wedges are easiest to split with a hatched for filling small spaces
  - The wedges may be sawed off at the base to prevent inadvertent removal
  - It’s always a good idea to put some kind of stuffing into a crack first. This will provide a much better watertight seal



Damage Control

- The Problem:
  - Chafed Hose
  - Vibrations can cause engine cooling hoses or water wash down hoses to wear and crack

Damage Control

- The Tools:
  - We have found that bicycle inner tubing works great when it come to repairing torn hoses
  - Rescue Tape is outstanding for repairs of all types

Damage Control

- The Solution:
  - Wrap the bicycle inner tubing or Rescue Tape tightly around a chafed hose

Damage Control

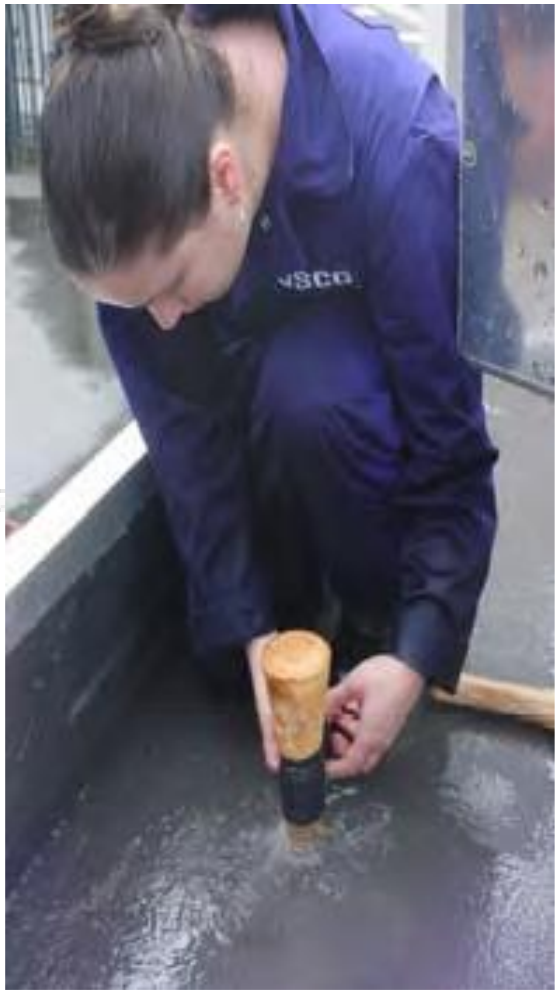
- The Problem:
  - Damaged Through Hull Fitting
  - Through hull fittings may flood a vessel because they are damaged by corrosion or because of improper hose connections

Damage Control

- The Tools:
  - Conical soft wood plugs are available from most marine suppliers
  - They should be sized according to the vessels seacocks

Damage Control

- The Solution:
  - Pound the cone tightly into the through hull fitting to stop the flooding
  - Add bicycle inner tube around the plug and fitting to strengthen



Damage Control

- The Problem:
  - Split Piping
  - Wet exhaust line may split and cause flooding
  - This is usually associated with collision damage or freezing in extreme climate conditions

Damage Control

- The Tools:
  - A variety of fabrics may be used to cover large pipe cracks
  - Wood wedges will work well with manila twine stuffed into the crack

Damage Control

- The Solution:
  - Stuff the manila twine into the crack
  - Place the wood wedges tightly over the manila twine and tap securely into place with the hammer

Damage Control Kit

- Suggested materials and tools for small vessels:
  - Conical soft plugs, sized for boat's seacocks.
  - Softwood wedges
  - Bicycle inner tubing
  - Manila twine
  - Sheet rubber
  - Simple hand tools
    - Hatchet
    - Hammer
    - Screwdriver
    - C Clamps
    - Small hand saw
    - Disposable flashlights
  - Spare hose clamps
  - Water impervious material, such as sections of discarded survival suits or rain gear

Damage Control Kit

- Shown is the authors damage control kit
- Most items were purchased at a local hardware store
- Orange cloth is sleeves cut off of decommissioned dry suits (waterproof)
- Items don’t have to be top quality, only used to get you to a safe harbor

Firefighting

Firefighting

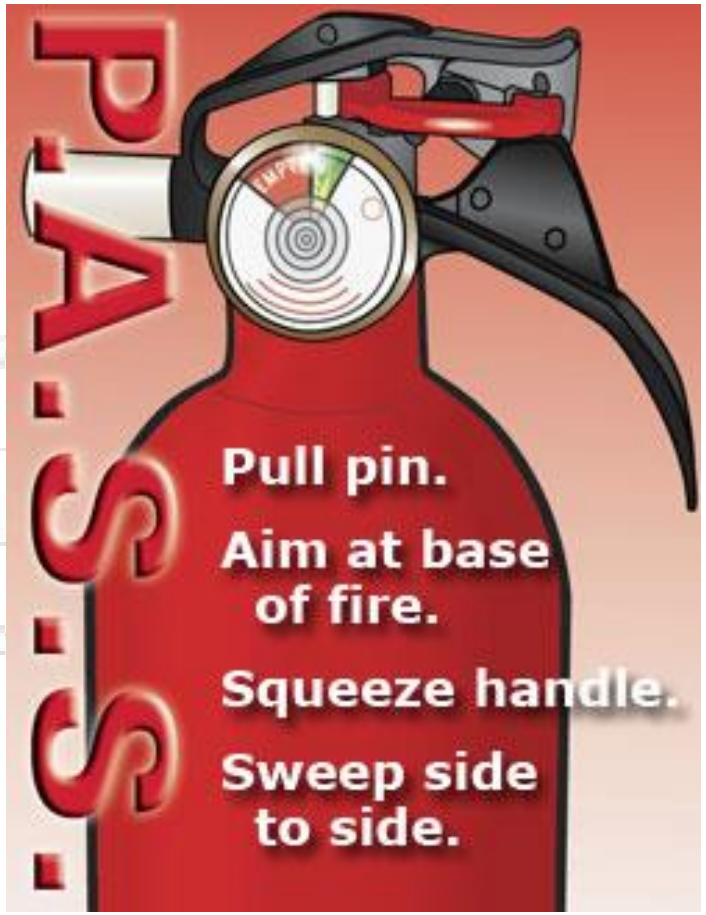
- Fiberglass burns ferociously
- Wood, particularly dry, resin-soaked wood, burns quickly
- Spraying fuel, diesel or gas, creates in inferno
- Fumes quickly fill spaces below decks making them inaccessible and deadly

Classes of Fires

- Remember the classes of fires
  - Class A, common combustibles (wood, paper)
    - Remember “Ash”
  - Class B, flammable liquids (oil, grease, gasoline)
    - Remember “Boil”
  - Class C, electrical
    - Remember “Cable”
  - Class D, flammable metals (magnesium, zinc)
    - Remember “Danger”

FireFighting

- If underway, stop the boat.
- Position the boat so the fire is downwind
- If the fire is in the engine room shut off the fuel supply
- Aim your extinguisher at the base of the fire and sweep side to side



Firefighting

- If at the dock, get off the boat
- If you can’t put it out with one extinguisher you aren’t going to. Let the professionals handle it

Firefighting

- If underway, call for help fast (they take time to arrive)
- Remember the red button on your DSC-VHF radio, hit it and concentrate on the fire. If you have a spare person have them make the voice radio calls
- Stop the boat paying attention to your surroundings
- If the fire is in the engine room, DO NOT OPEN THE HATCH! You will only let in oxygen
- Don’t delay the decision to abandon ship

Thank You

Please send your comments to:

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