BANANA WIND

www.BananaWind.us

"The acquisition of the knowledge of navigation has a strange effect on the minds of men." - Jack London

Basic Navigation

You may be able to sail faster than anyone else or turn your boat on a dime, but all the boat handling skills in the world won't help you if you don't know how to get safely to where you want to go.

Use this page in conjunction with Basic Chartwork.

Navigation Symbols

NAVIGATION SYMBOLS


Estimated position corrected for leeway & current.


Dead reckoning – best estimate without outside data.


Electronic fix – using outside data.


Conventional fix – using outside data.


Course to steer.


Course to steer corrected for leeway.

Track.

Current vector.

Line of position.

Transferred line of position.

T Degrees true.

M Degrees magnetic.

C Degrees compass.

Charts

The scales of nautical charts range from 1:2,500 to about 1:5,000,000. Graphic scales are generally shown on charts with scales of 1:80,000 or larger, and numerical scales are given on smaller scale charts. National Ocean Service (NOS) charts are classified according to scale as follows:

Sailing charts--scales 1:600,000 and smaller are for use in fixing the mariner's position as he approaches the coast from the open ocean, or for sailing between distant coastwise ports.

General charts--scales 1:150,000 to 1:600,00 are for coastwise navigation outside outlying reefs and shoals.

Coast charts--scales 1:50,000 to 1:150,000 are for inshore navigation leading to bays and harbors of considerable width and for navigating large inland waterways.

Harbor charts--scales larger than 1:50,000 are for harbors, anchorage areas, and the smaller waterways.

Special charts--various scales, cover the intercostals and miscellaneous small-craft areas.

Soundings on foreign charts

Most modern charts use the metric system, but old charts use these measures:

English fathom - 6 feet

Danish favn - 6.176 feet

Dutch vadem - 5.905 feet

Norwegian favn - 6.176 feet

Russian sazhene - 6 feet

Spanish braza - 5.492 feet

Swedish famn - 5.844 feet

Bearings

A compass rose on a chart will show both true north and magnetic north, but the magnetic bearings vary with the passage of time, hence the term "variation." A navigator must always know which set of bearings he is dealing with (e.g. true, magnetic, compass). So as to not mistakenly confuse them when navigating, it is often best to choose one system and stick with it. You can convert from one to another by remembering the phrase "True Virgins Make Dull Companions."

True Virgins Make Dull Companions

T + V = M + D = C

True + Variation = Magnetic + Deviation = Compass

When dealing with variation and deviation remember "West is Best" and "East is Least," meaning you add when it is West and subtract when it is East.

Variation is recorded on the compass rose on the chart.

Deviation must be manually calculated for each compass onboard.

Example:

The bearings are 240 degrees True with 7 degrees West variation and 4 degrees East deviation.

T + V = M + D = C

240 T + 7 V (West is Best) = 247 M - 4 D (East is Least) = 243 C

You would then steer 243 degrees using your boat compass in order to proceed 240 true degrees.

Deviation

Large metal objects onboard, such as a diesel engine, generate magnetic fields that will affect the accuracy of a boat compass. This effect is referred to Deviation, and it will change at different points of sail. You can have the deviation of your binnacle compass professionally determined, and you can do it yourself, although it might not be as accurate as having it professionally done. Determining deviation is referred to as "Swinging Ship." The result is a Deviation Card that indicates the deviation at each point of sail.

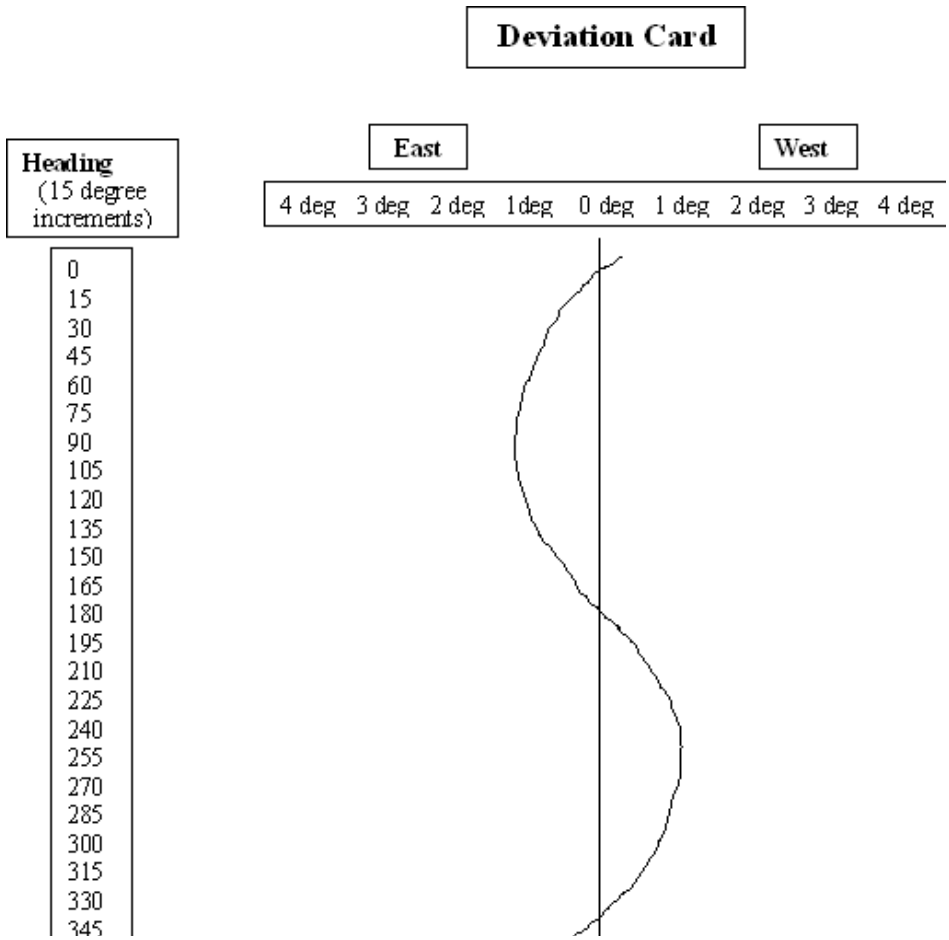
Deviation Card

1. Create a card like the one displayed.

2. Sail the boat at each heading listed on the card using the binnacle compass to determine the correct heading.

3. While on each heading, also record what a hand compass determines the heading to be. Have the person using the hand compass stand as far away as possible from the engine and any other metal object. The best place is at the bow of the boat.

4. After sailing through all the headings (i.e. swinging the ship), subtract the compass reading from the binnacle reading for each heading. If the number is positive, it is West (west is best). If the difference is negative, it is East (east is least). For example: 90 (binnacle) - 87 (hand) = + 3



(West); 240 (binnacle) - 244 (hand) = - 4 (East).

5. Plot the differences for each point of sail on the deviation card and draw a line to connection the points.

Using the Deviation Card

1. Calculate the Magnetic course (True +Variation = Magnetic).

2. Look at the card for the deviation for that particular heading.

3. Add the deviation for a West correction, and subtract the deviation for an East correction.

4. Use the binnacle compass to steer a course based on the deviation calculation (Magnetic + Deviation = Compass). For example, if the course is 90 degrees and the deviation is 3 degrees West, steer 93 degrees.

Dead Reckoning

Dead Reckoning (or Ded Reckoning) is the process of using time and speed to "deduce" (hence the term "ded" reckoning) your position based on advancing from a known position. You chart a course, and then at regular intervals, you determine your position along that course line using dead reckoning.

At some predetermined point (or when circumstances present themselves), you take a "fix" to determine your actual position and compare it to your dead reckoned position. From there you chart a new course from the actual "fixed" position, making allowances for conditions that may have caused you to veer from your original charted course (e.g. current, leeway, etc.)

Time & Distance Calculation

D = ST

Distance (in nautical miles) = Speed (in knots) X Time (in hours)

For example: Traveling at 6 knots for 2 hours = 6 X 2 = 12 nautical miles

If you wish to record time in minutes instead of hours, use the formula 60D = ST

Remember the formula as "60 D Street" (i.e. 60 D = ST)

Minutes per Nautical Mile

To calculate the number of minutes it will take to travel 1 nautical mile, divide 60 by the speed

Speed	Minutes per N.M.
3 knots	20 minutes
4 knots	15 minutes

in knots:

Minutes to travel 1 nautical mile = 60 ÷ speed in knots

For example:

60 ÷ 2 knots = 30 minute nautical mile

60 ÷ 3 knots = 20 minute nautical mile

60 ÷ 4 knots = 15 minute nautical mile

60 ÷ 6 knots = 10 minute nautical mile

4.3 knots	14 minutes
4.6 knots	13 minutes
5 knots	12 minutes
5.5 knots	11 minutes
6 knots	10 minutes
6.7 knots	9 minutes
7.5 knots	8 minutes
8.6 knots	7 minutes
10 knots	6 minutes

Fixes and Lines of Position

To check the accuracy of your calculated position using time & distance (i.e. dead reckoning), you must take a "fix" of your actual position. Fixes can be taken from nearby objects using lines of position. You can also take an electronic fix using a GPS.

Lines of Position from Charted Objects

Fixes are taken using a hand bearing compass.

Fixes are better with nearby objects.

Tangent lines from the sides of islands also serve as good lines of position.

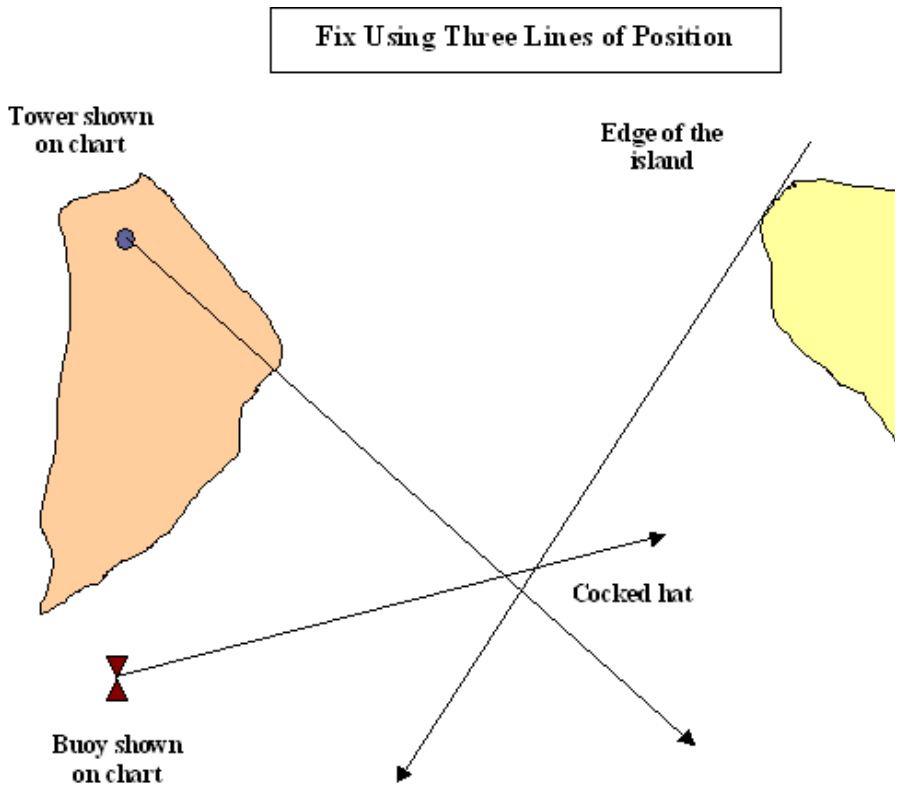
Take fore and aft bearings first.

Take the side bearings last.

Use three lines of position, ideally 60 degrees apart.

The center triangle where they intersect (called a "cocked hat") is the position of the boat.

The average error for a line of position is 5 - 6 degrees, and the error increases with the distance from the objects.



Calculating Current Using Dead Reckoning and a Fix

Currents are usually stronger in deeper water. When moving against a current in a channel, stay to the sides. When moving with a current in a channel, stay in the middle. Many underestimate the strength of a current and its affect on navigation. Thi is especially true of the Gulf Stream that can be 4 knots or more.

By computing a dead reckoned position and taking a fix, you can calculate the set and drift of a current.

1. Plot a course and travel along it for 1 hour.

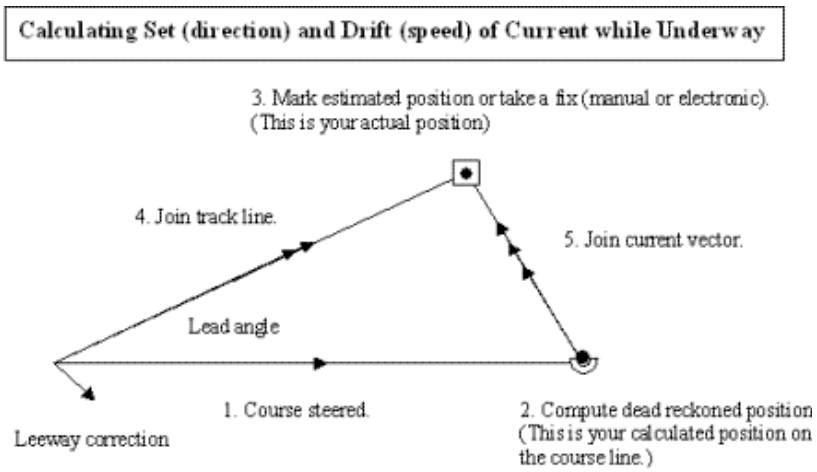
2. Compute a dead reckoned position along that course.

3. Take a fix and mark your actual position.

4. Join a track line to your actual position.

5. Join a current vector from your dead reckoned position to your fixed position. This is the set (direction) of the current.

6. Use your dividers to measure the current vector, and use the latitude markings to determine distance in minutes. Since you've traveled 1 hour, the length of the current vector is the drift (speed) of the current in knots.



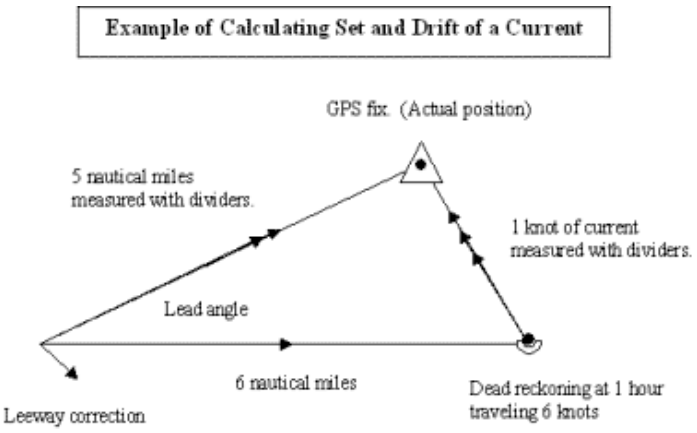
Example

You travel for one hour at 6 knots.

Your dead reckoned position is 6 nautical miles down the course line.

You take a GPS fix and mark your actual position. Your track line shows that you've traveled 5 nautical miles down the track, less than the 6 nautical mile shown on the course line due to the effect of the current.

You connect the current vector and measure it with your dividers. It measures 1 minute of latitude; therefore, its drift is 1 knot.



When the current is 90 degrees to the boat, you can do a quick calculation of the lead angle.

Lead angle = (60 X current in knots) ÷ speed in knots

Dead Reckoning Error

Dead reckoning error is normally about 10%, and you can allow for this by drawing circles of uncertainty on the chart around your dead reckoned positions.

Since a boat covers a nautical distance in one hour equal to its speed in knots, you would allow a 10% margin of error for each hour.

For example:

At 6 knots, you would have a .6 nautical mile error potential in the first hour.

At 6 knots, you would have a 1.2 nautical mile error potential in the second hour.

At 6 knots, you would have a 1.8 nautical mile error potential in the third hour.

That is why you need to take regular fixes because the error potential of dead reckoning steadily increases with time.

Estimated Time to a Mark

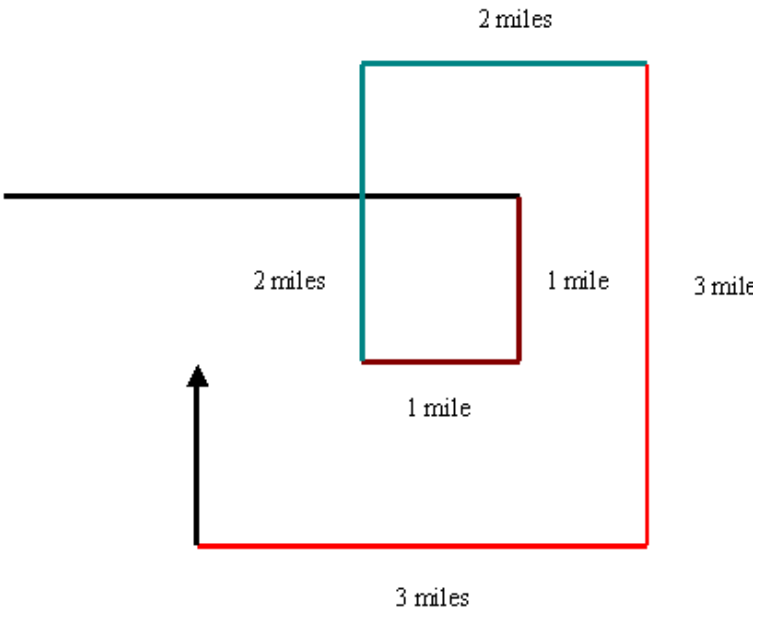
Since dead reckoning is accurate only to 10% of the distance, it is possible that you could miss an mark to which you are sailing.

You therefore need to keep track of your estimated time in route to know when you should be encountering the mark. Before leaving, you should calculate your estimated time to the mark.

When 5 minutes have past and you have not encountered the mark, you need to begin a search pattern to find it (if finding it is crucial to your safe passage).

Searching for a mark (or even for a man overboard) involves an expanding square. You can use the shoreline and water depth contours for reference. With such a pattern, you are never more than one mile from a prior pass.

SEARCH PATTERN



Running Fix

It is also possible to take a "running fix" using only one object. A running fix is not terribly accurate, but it

Running Fix (using one object)

is better than nothing. If there is a current, it is of limited reliability.

A. Take the first line of position (LOP) from a charted object, and record the time.

B. Travel a distance and take a second LOP. Record the time.

C. Pick a point anywhere along the first LOP.

D. Based on speed, direction and time, do a dead reckoning (DR) from the time of the first LOP to the time of the second LOP. Draw a course line from the first LOP to the DR point.

E. Draw a transferred LOP through the DR point parallel to the first LOP.

F. Where the transferred LOP intersects the second LOP is the fix.

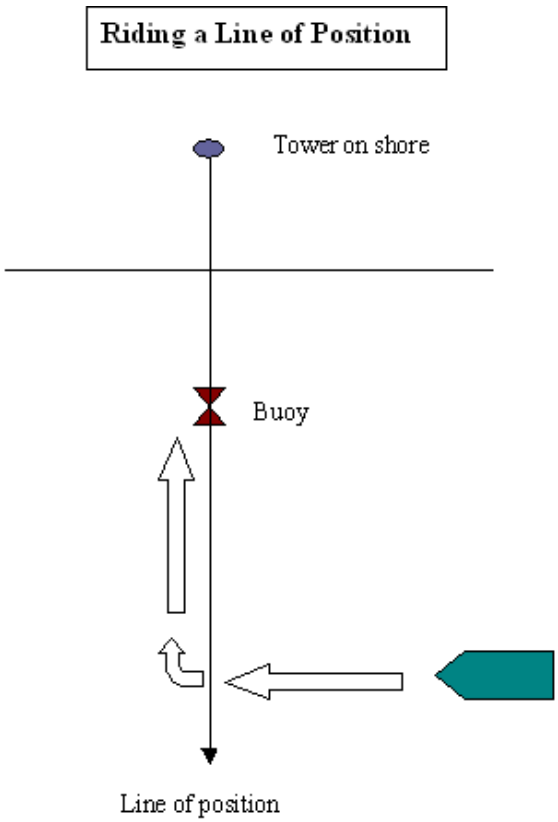
Riding a Line of Position

When unable to find a mark but able to see a charted object on the shore, you can ride a line of position until you find the mark.

1. Identify a charted object on shore.

2. Draw a line of position from the object on shore through the mark.

3. Move to the bearing of the line of position and steer toward the object until the mark is located.



Deliberate Miss

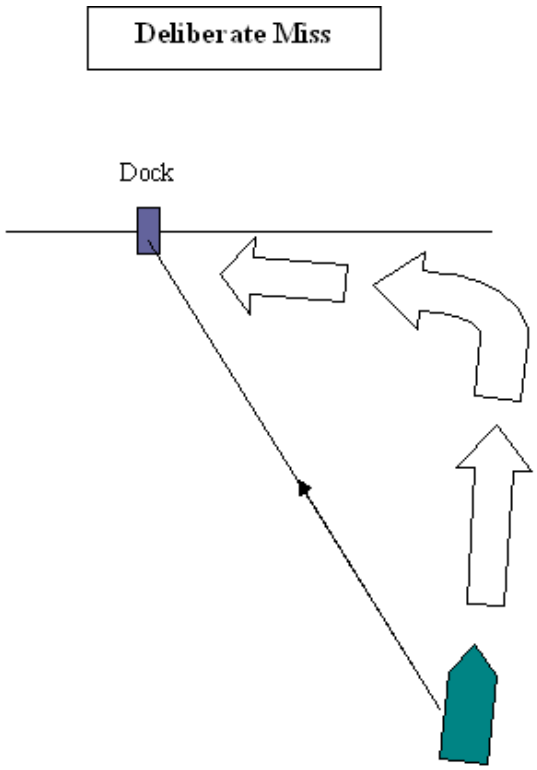
When sailing directly toward a destination, an error might put you off course, and make you miss your mark. You then might not know which way to proceed.

Instead, you can deliberately miss the mark and then know in which direction to proceed.

1. Set a course directly to a destination.

2. Veer off shortly before arriving.

3. Follow the shoreline to the destination.

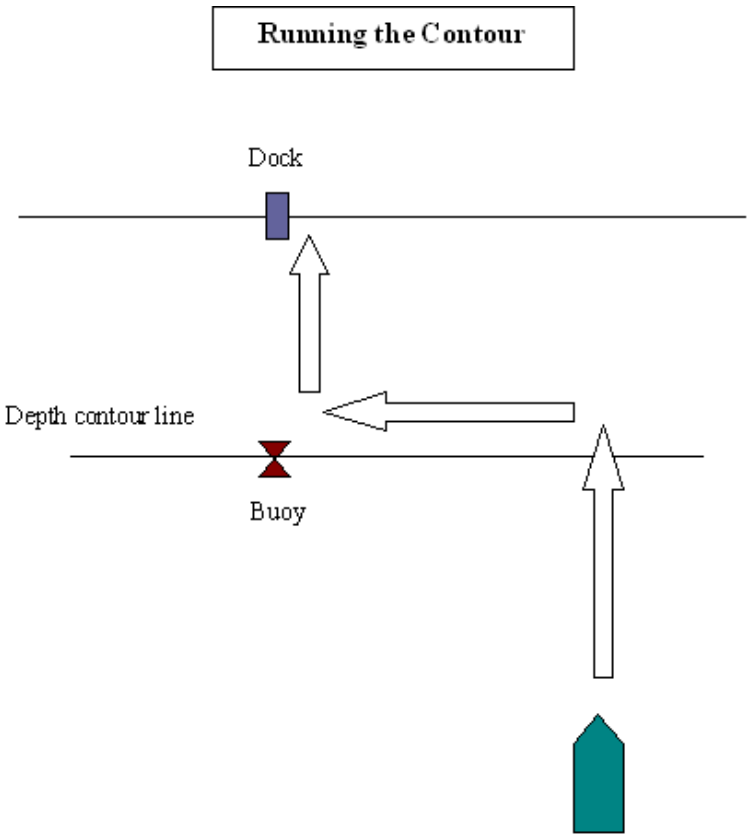


Running the Contour

Running the contour is especially helpful when navigating in times of low visibility, such as fog.

1. Perform a deliberate miss of the destination, but know which side of the mark you are on.

2. Use the depth sounder and the depth contour lines of the chart to proceed along the shore to the destination.



Circle of Visibility

In times of low visibility, it is often difficult to find a mark.

1. Determine the distance of visibility for an object subject to the current conditions.

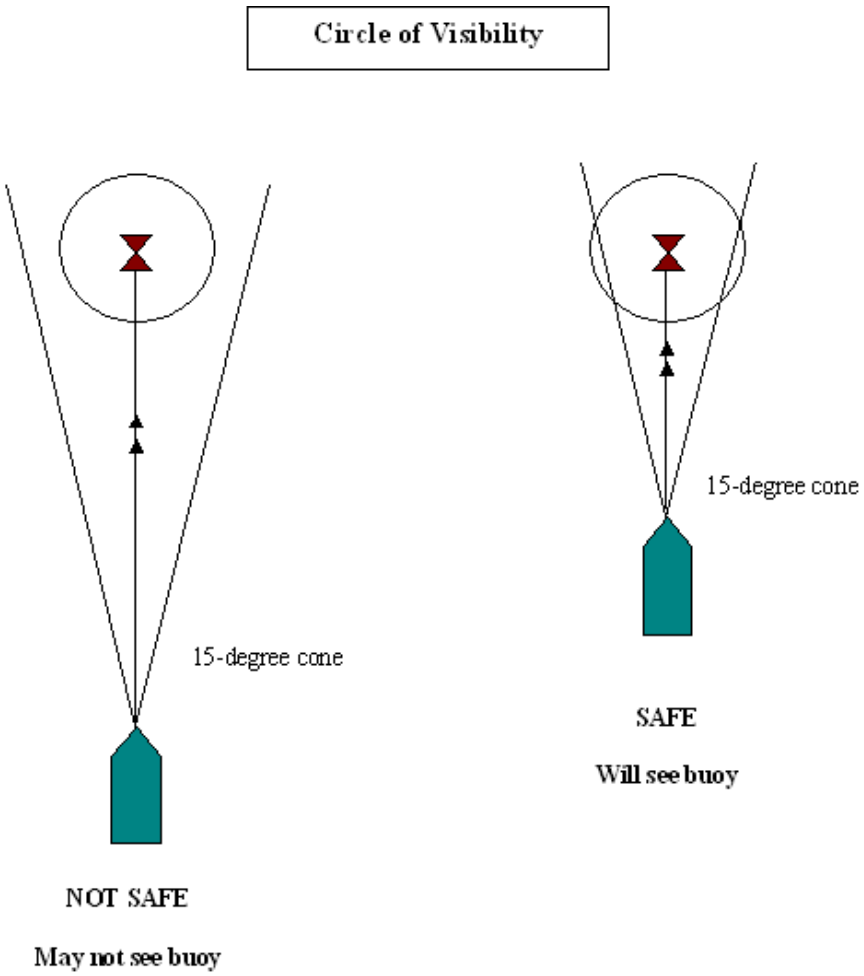
2. Draw a circle around the mark equal to the area of visibility.

3. Plot a course to the mark.

4. A boat normally sails 7 - 8 degrees to either side of a track line creating a cone of 15 degrees.

5. Plot a 15 degree arch from the boat on either side of the track line.

6. The cone must pass within the circle of visibility of the mark if you expect to see the mark.

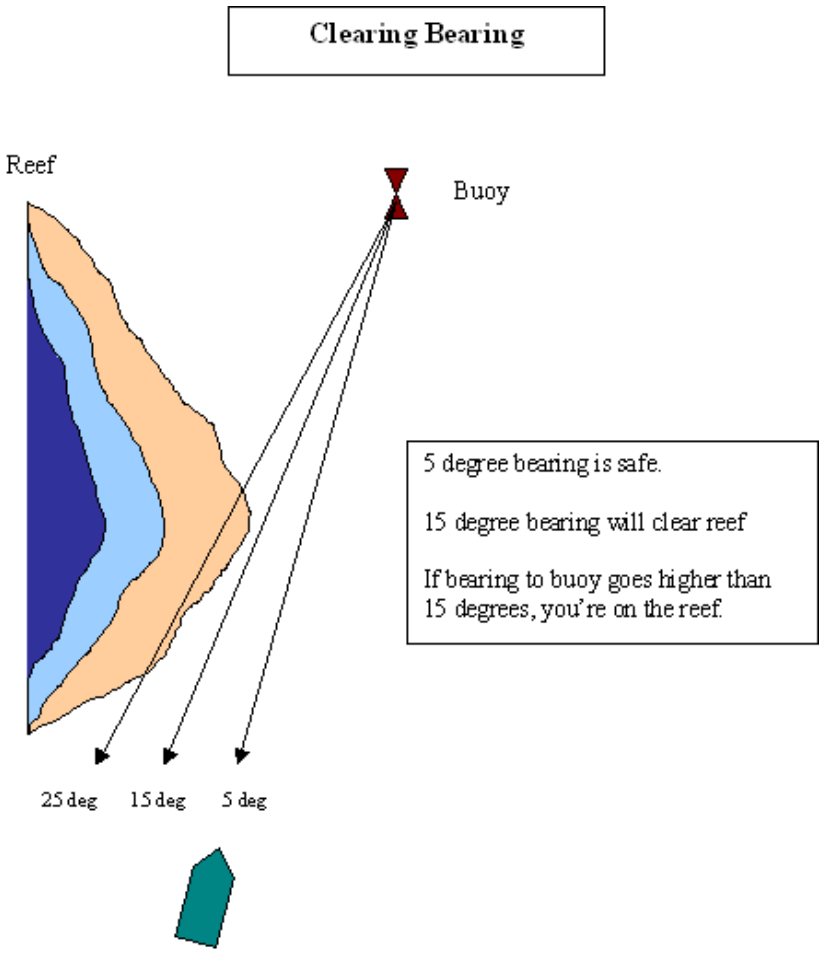


Clearing Bearing

When it is necessary to stay clear of a reef or an underwater obstruction, calculate three bearings to the mark: safe, clear, danger.

By knowing these bearings, you can sail to the mark and only be concerned that the mark stay below the unsafe bearing you calculated.

In the example to the right, as long as the mark does not go higher than 15 degrees, you are okay. It must remain between 15 & 5 degrees for you to reach the mark safely. If it goes to 25 degrees, you're on the reef.

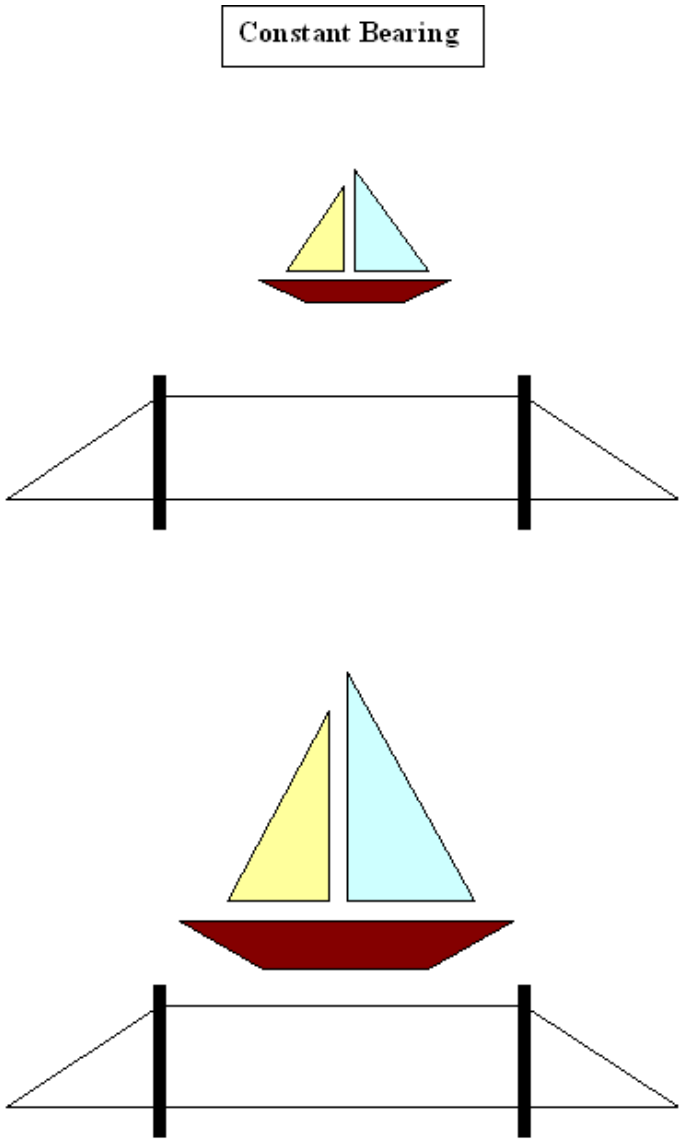


Constant Bearing

When the compass bearing of another boat remains unchanged but the boat continues to get closer, you are on a collision course.

You can use the lifelines

and stanchions (or any other stationary object onboard) to align with the boat in order to gauge its bearing change. If it remains aligned with the object and continues to get closer, you should consider altering course.



Frozen Range

If an object doesn't move fore or aft with respect to the shoreline, the boat is moving directly toward the object.

Leading Mark

It is better and easier to steer toward a mark rather than try to steer a compass course.

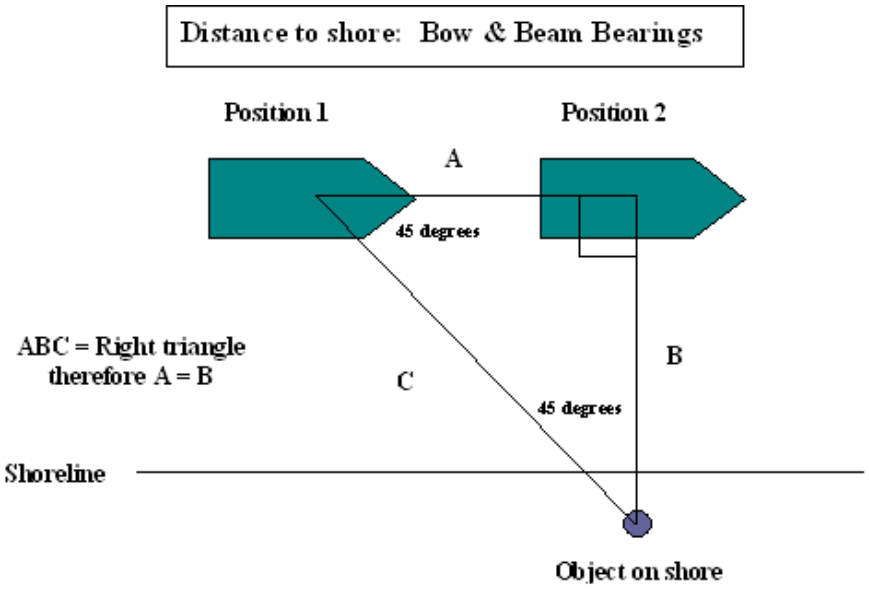
Estimating Distance from Shore

Bow & Beam Bearings

1. Record the time when a charted object onshore is 45 degrees from the boat.

2. Record the time when the object is abeam of the boat (i.e. 90 degrees).

3. The distance traveled (A) computed from time and speed is the distance from the object (B).



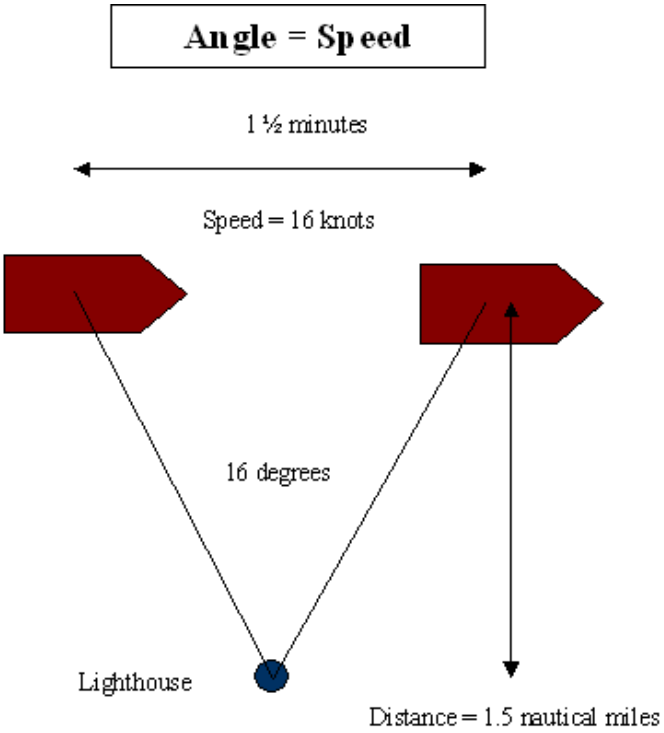
Angle = Speed

1. Take a bearing with a hand bearing compass as you pass a charted object onshore.

2. Record the time in minutes that it takes the bearing change to equal the boat speed in knots.

3. The time in minutes will equal the distance from the object in nautical miles.

4. If you combine the calculation with a line of position from the object to the boat, it provides you with a good estimated position.



Finding an Estimated Position using a GPS

Set a waypoint at your starting point when beginning a voyage, and continue setting waypoints at each turn in the voyage. You will then be able to refer back to these waypoints and use them to help establish

an estimated position. It is also helpful if you already know the waypoint of your destination.

1. Use the GPS to determine the direction and bearing of two or three prior waypoints.

2. Draw lines of position from these waypoints.

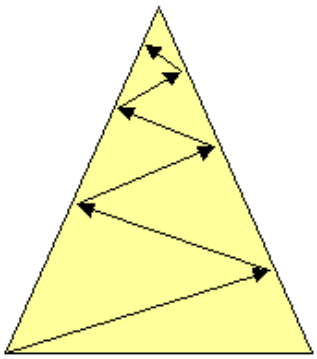
3. Where they intersect is your estimated position.

Navigation Strategies

1. Plan to arrive upwind or up current.

2. When possible, take the favored tack. The favored tack is the one that takes you closer to your destination. You should always start on the favored tack when beating upwind. That way, if the wind unfavorably alters course, you will have gained some ground at the start.

Narrowing Cone



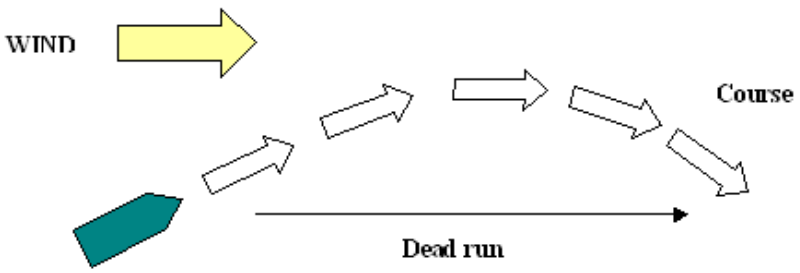
Upwind Tactics.

3. When beating upwind, do so in a narrowing cone.

Beating upwind increases the distance by 1/3.

Downwind Tactics.

Avoid Dead Run

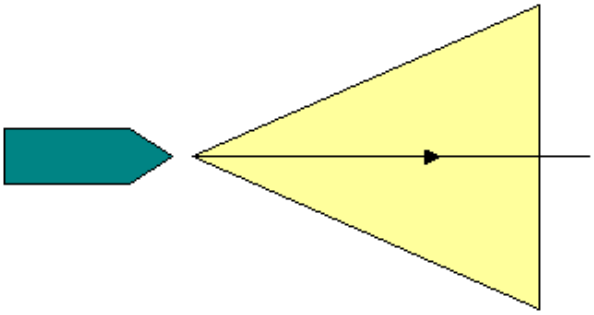


4. Avoid dead run with the wind behind you.

Alter course 35 degrees from rhumline. The extra speed may make up for the extra distance traveled.

Heavy Weather Tactics

Safety Cone



Safety Cone

1. Assume a 20 degree cone (10 degrees on each side.

   Don't let the cone pass too close to any obstructions.

Circle of Probability

2. Draw a circle of error around a dead reckoned position.

   Assume you are in the circle in the position closest to danger.

Taking a Bearing

3. When the weather is too rough to site a hand bearing compass, aim the boat at the mark and record the bearing using the binnacle compass.

   Likewise, steer abeam of the bearing and record the bearing using the boat's binnacle compass.

Leeway

4. An average 35 foot sailboat sailing close hauled will experience leeway up to 7 degrees in 20 knot winds.

   It will experience leeway of not less than 10 degrees in 30 knots of wind.

Top of page

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