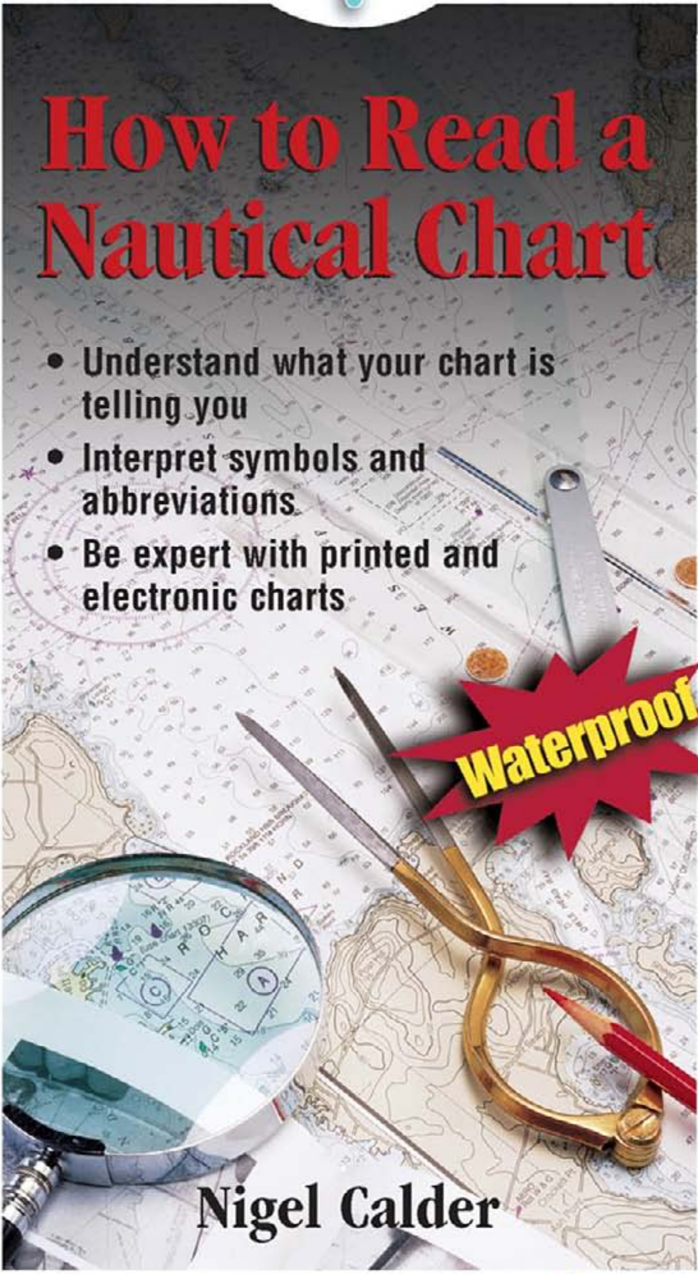
Captain's QUICKGUIDES

How to Read a Nautical Chart

- Understand what your chart is telling you
- Interpret symbols and abbreviations
- Be expert with printed and electronic charts

Waterproof



Nigel Calder

☐ Power Boats ☐ Sail Boats ☑ Both

INTERNATIONAL MARINE

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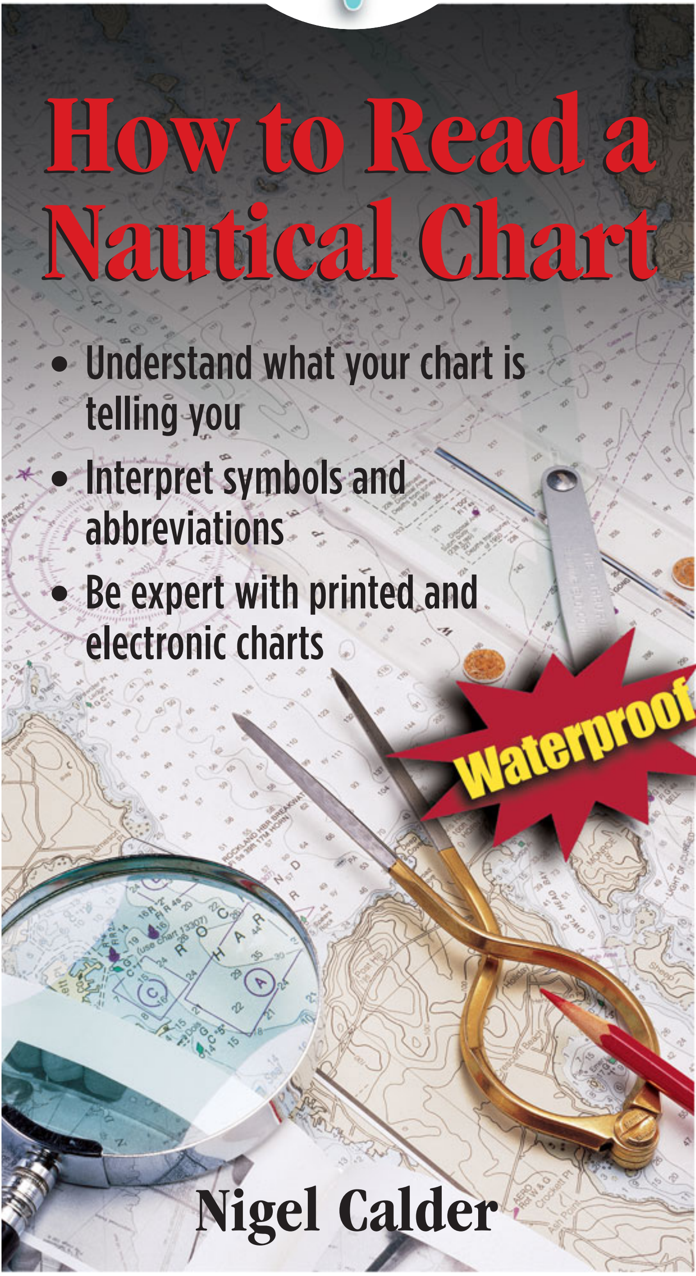

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About Charts

A nautical chart, whether paper or electronic, is an extraordinarily detailed representation in two dimensions of a three-dimensional world. It uses a precise, multilayered symbology that can orient you at a glance yet reward each additional increment of study with new information. Nautical charts are the starting and ending points of navigation. GPS coordinates do you little good until plotted on a paper chart with dividers or on an electronic chart through GPS interface. Compass courses steered and bearings to navigation buoys or landmarks won't tell you where you're going or where you are until plotted on a chart. And you can't unlock the messages of surrounding landforms, navigation aids, and ledges until you can relate what you see on deck to what you see on a chart.

This Quick Guide summarizes key charting conventions. Most paper charts use symbols standardized by the International Hydrographic Office (IHO), but the U.S. sometimes differs. Where this is so, this guide shows both.

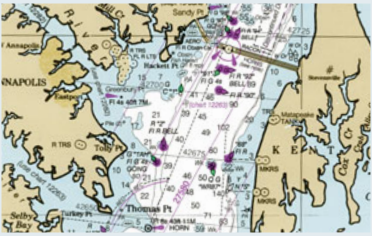
There are two types of electronic charts—*raster* and *vector* (Panels 13 – 14). A raster chart is a scan of a paper chart and thus employs identical symbols. Vector charts employ their own symbols and conventions, but these are typically similar to those on paper charts.

Scales and Accuracy

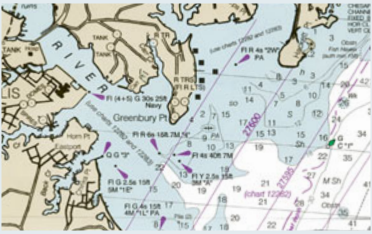
Small-scale charts show large areas with little detail. For example, 1 inch on a 1:200,000-scale chart represents 2.743 nautical miles in the real world. Large-scale charts show small areas in greater detail. For example, 1 inch on a 1:25,000-scale chart represents just 0.342 nautical mile. The bigger the second number in the ratio, the smaller the scale. Scales of 1:200,000 and smaller are appropriate for route planning but not for navigation. Scales of 1:60,000 to 1:150,000 are appropriate for coastal piloting. Large-scale charts of 1:5,000 to 1:50,000 are best for harbor navigation. Always use the largest-scale chart available to you, especially in restricted waters.

A paper chart's accuracy is around 1.0 mm x the chart scale. Thus, features on a 1:80,000 chart are drawn within 80,000 mm = 80 meters (88 yards) of their actual locations. All GPS receivers provide a higher level of positional accuracy than was used to make our charts. Additionally, over

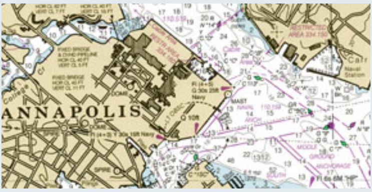
In this series of chart extracts of the same area, note how the small-scale chart shows all inshore waters as "shoal" (blue) and provides no soundings. The area of coverage decreases downward in this series. The detail and accuracy of the coverage increase downward.



Chesapeake Bay, NOAA chart #12280, scale = 1:200,000



Chesapeake Bay, NOAA chart #12263, scale = 1:80,000



Chesapeake Bay, NOAA chart #12282, scale = 1:25,000

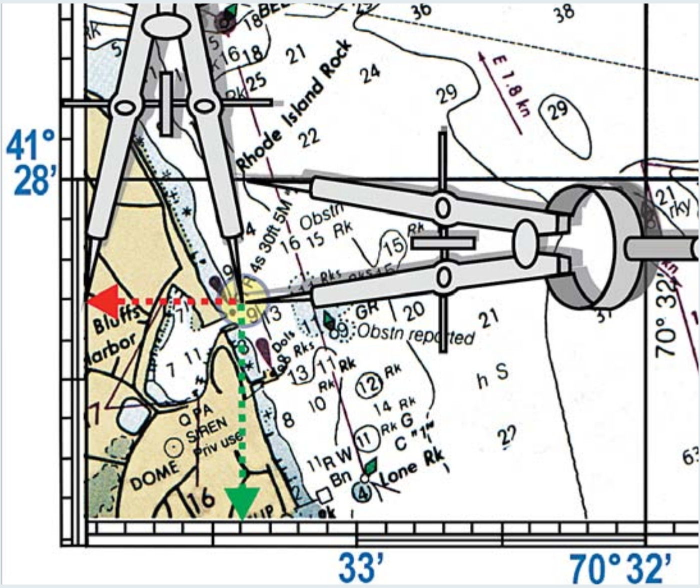
Chesapeake Bay, NOAA chart #12283, scale = 1:10,000

50% of the soundings in use on modern charts were collected before 1939. (The age of data is often given in a small *source diagram* printed somewhere on the chart.)

Electronic charts are "zoomed in" when compared with their equivalent paper charts. This gives the false impression that the chart has been compiled at a larger scale than it was, and is more accurate than it is. Use appropriate caution when navigating with GPS and electronic charts (see Panels 13 – 14).

Latitude scales are shown on a chart's left and right margins, and lines of latitude run east to west across the chart. *Longitude scales* are shown on a chart's top and bottom margins, and lines of longitude *(meridians)* run from north to south. One minute of latitude = 1 nautical mile anywhere on the globe. One minute of longitude = 1 nautical mile only at the equator. Thus the latitude scale (but not the longitude scale) can be used to measure distances on a chart.

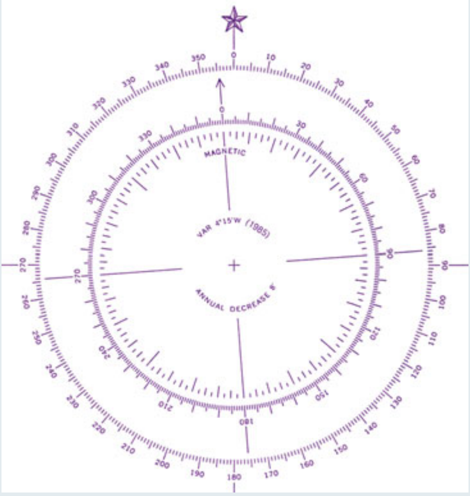
The latitude and longitude scales of this chart are in degrees, minutes, and tenths of a minute. Using dividers to find the coordinates of a location just outside Oak Bluffs Harbor, you set one point of the dividers on the location and the other point on the nearest line of latitude. Lock the dividers and move them to the latitude scale, where you measure latitude 41˚ 27.7′ north. Again place one point of the dividers on the location in question, this time placing the other point on the nearest line of longitude. Lock the dividers and move them to the longitude scale, where you measure 70˚ 33.4′ west. If you know your latitude and longitude from GPS and wish to locate your position on the chart, reverse this procedure. *(Reprinted with permission from* The Weekend Navigator, *by Bob Sweet.)*



Degees True Versus Degrees Magnetic

Longitude lines point to *true north*—the direction of the geographic north pole—whereas compasses give *bearings* (directions to charted objects) and *headings* (courses steered) with respect to *magnetic north*. For any given location, magnetic north changes slowly and predictably over time. It may be west or east of true north from your location. If it's west of true north, your local magnetic *variation* is westerly; if it's east of true north, your variation is easterly.

Most charts include one or more (often three or four) compass roses printed in magenta. The outer ring of a rose shows directions relative to true north, and the inner ring shows directions relative to magnetic north. The local variation as of the year the chart was published, together with its annual rate of change, is given at the center of each rose.



The note in the center of this compass rose tells us that the variation for this chart was 4°15′ west as of 1985, with an annual decrease of 8′. In 2008 the accumulated decrease would be 23 x 8′ = 184′, or 3°4′, and the remaining westerly variation is 4°15′ - 3°4′ = 1°11′. (In practice you should rarely have to use a chart this old.)

All bearings and courses are measured relative to true north on charts from official hydrographic offices but are relative to magnetic north on private-label charts. If you use a *hand-bearing compass* or sight over your ship's compass to get the bearing to a navigation buoy or landmark and want to convert that to a true bearing for chart plotting, you would subtract a westerly variation or add an easterly. To convert a plotted course from degrees true to degrees magnetic for steering, you would add a westerly variation or subtract an easterly. Since compasses orient to magnetic north and GPS receivers can be initialized to give directions in either true or magnetic degrees, most small-boat navigators work solely in degrees magnetic so as to avoid conversions. (Compass *deviation*, if present, should also be considered, but this Quick Guide is about chart reading, not piloting techniques.)

	Magnetic Variation	
	Westerly	Easterly
To go from true to magnetic	Add variation	Subtract variation
To go from magnetic to true	Subtract variation	Add variation

Chart Colors and Conventions

Blue is used for shallow-water areas—the deeper the blue, the shallower the water. (Some private-label charts reverse this convention.)

Gold, buff, or gray is used for land areas above the high water line.

Green is used for the intertidal zone between low and high water.

White is used for deep water and dredged channels (except on some private-label charts).

Black is used for precisely located features and those that constitute a permanent physical obstruction.

A black dot inside a circle or triangle or added to the base of a symbol indicates the feature's precise location.

A small circle without a dot indicates an approximate location. When used with an anchored navigation buoy, it is called a *watch circle* and represents the buoy's swinging radius.

CAPITAL LETTERS indicate an accurately known position or conspicuous feature.

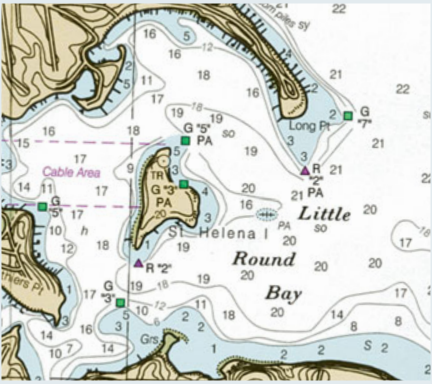
Initial Capital Letters indicate an approximate position or less conspicuous feature.

Upright (vertical) letters denote shoreside features and those firmly attached to the bottom.

Sloping (italic) letters indicate hydrographic features (anything below the high water line) and all floating objects.

Dotted lines indicate danger.

Dashed lines and T-shaped dashes delineate zones, tracks, and uncertain shorelines.



Selected features: PA = Position Approximate. **TR** = Tower, with the capital letters and the dot inside the circle both indicating an accurate position. Blue denotes shoal water (on this chart, less than 10 feet).

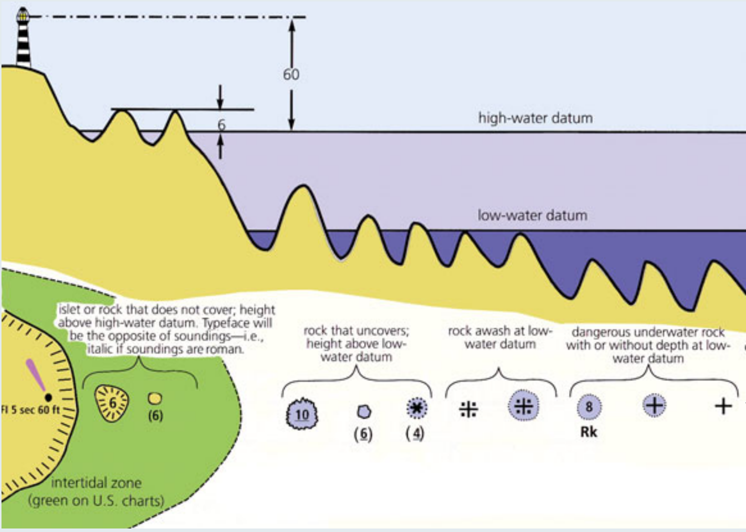
Chesapeake Bay, NOAA chart #12282, 1:25,000

Topographic labels are vertical, **hydrographic** italic. **Beacons** (which are fixed to bottom) have vertical labels. **Buoys** (which are anchored) are italic.

Penobscot Bay, NOAA chart #13305, 1:40,000

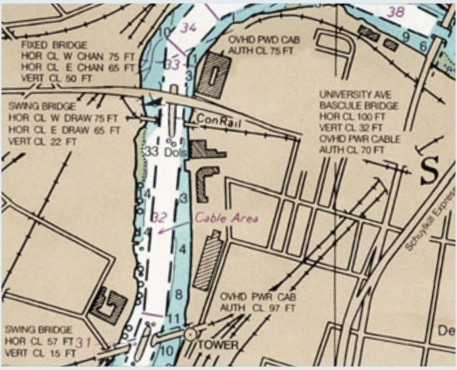
Do You Have Enough Water?

Soundings are relative to a low-water datum—the chart datum, or CD, which is always noted in the chart's title block. The IHO uses lowest astronomical tide (LAT) as the CD. Even at the lowest state of the tide, there is generally more water than is charted. U.S. charts use mean lower low water (MLLW). At extreme low tides (such as low-water spring tides) there is almost always less water than is charted. With U.S. charts, it is important to navigate conservatively when at or close to low tide.



Shoreside Features

Shoreside features are critical for position-fixing using traditional piloting techniques such as *crossed bearings* and *ranges* (also called *transits*). GPS-based electronic navigation eclipses these techniques, but you should know traditional piloting in case the GPS shuts down.



Delaware River, NOAA chart #12313, 1:15,000

Selected features: HOR CL = channel width at bridge. **VER CL** = height of bridge (when closed) above high-water datum. When the southern swing bridge is open, its limiting height becomes the overhead power cable, which is 97 feet above high-water datum. When the more northerly swing bridge is open, the limiting height becomes 50 feet, the clearance of the adjacent fixed bridge. Major buildings are drawn to scale. Note roads and railways. Dashed lines mark channel sides.

U.S. charts, with a few exceptions, show depths in feet. The rest of the world uses meters.

Dangerous underwater (submerged at all tides) rocks are shown by a cross. If a depth is given (off to one side in parentheses), it is the depth over the rock at low water.

Rocks that are awash (i.e., break the surface) at low water have a dot in each corner of the cross.

Rocks that dry out at low water are shown by an asterisk. The *drying height* (how high the rock is above low water) may be given, in which case it will be underlined (to distinguish it from a sounding).

A wreck any portion of which is above low-water datum *(a stranded wreck)* is shown with a half-hull schematic symbol.

Sunken wrecks (completely and always submerged) are shown either symbolically (a line with three crossed lines) or with a *Wk* abbreviation with or without a least depth sounding, and generally with a dotted line around the sounding.

If the area inside a dotted line is blue, the wreck is considered dangerous (generally, less than 60 feet over it), but if it is white it is considered not dangerous (generally, more than 60 feet over it).

Other potentially hazardous obstructions are indicated by a dotted circle labeled *Obstn*, with or without a sounding.

Seabed obstructions that are not dangerous to navigation but may cause anchoring problems are indicated by the # symbol or labeled *Foul*.

PA = Position Approximate; PD = Position Doubtful; ED = Existence Doubtful (the feature itself is in question); SD = Sounding Doubtful; Rep = Reported Hazard (not surveyed or officially confirmed).

The high-water line is a solid black line.

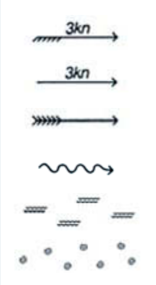
A dotted line shows poorly surveyed or uncertain coastlines.

Bridge, lighthouse, and other heights are given in meters or feet (U.S. charts) above high-water datum, which is *mean high water (MHW)* in the U.S. and *mean high water springs (MHWS)* elsewhere. Actual clearances at high spring tides are often less than shown.

Tides and Currents

Most tide information is given in tide tables, not shown on charts, but the following may be shown:

- Flood (incoming) tidal current with its speed =
- Ebb (outgoing) tidal current with its speed =
- Relatively constant current =
- Variable current =
- Overfalls, tide rips, and races =
- Eddies =



Navaids

Leave it to Port or Starboard?

In the *lateral system* of buoys and beacons (which are collectively termed *aids to navigation* or *ATONs*, or simply *navaids*), the characteristics of marks vary according to whether they should be on the left-hand or right-hand side of a vessel returning from seaward. Buoys (floating navaids) and beacons (fixed to the ground or seabed) may be lighted or not; an unlighted beacon is a *day beacon*.

When it is not clear what constitutes an approach from seaward, the relevant authority makes an arbitrary decision. "Returning" is considered clockwise around the U.S. seacoasts, and a boat on the Intracoastal Waterway on the U.S. east coast is deemed to be returning when headed south. Some charts have *direction of buoyage* arrows, but most don't. Never guess on which side to leave a buoy; always check the chart if unsure.

In Region A (Europe, Asia, Africa, and Australasia) of the International Association of Lighthouse Authorities (IALA), leave red marks to port and green to starboard when entering a channel from seaward.

In IALA Region B (the Americas and Caribbean), leave red to starboard ("red, right, returning") and green to port.

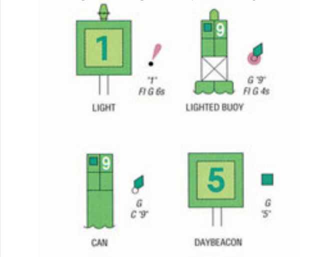
In both regions:

- Red marks have even numbers and green have odd. Numbering starts from the outermost buoy and begins anew with each sequence of buoys.
- Marks to be left to port when returning are cans, *pillars* (such as bell buoys and gong buoys), or spars.
- Marks to be left to starboard when returning are nuns (conical), pillars, or spars.
- A red mark, if lighted, has a red light; a green mark, if lighted, has a green light.
- Lighted marks on straight channel stretches use a single flash every 3 to 10 seconds.
- Lighted marks on channel bends or dangers use a quick (once per second) or very quick flash.
- A *composite group* flash of two flashes together followed by a single flash (2 + 1), with a longer interval before this pattern is repeated, is used where a channel divides, with the color of the light indicating whether the preferred channel is to port or starboard.
- Midchannel or landfall buoys surrounded by navigable water are termed *safe-water marks* and have red and white vertical stripes. If lit, they carry a white light with an *occulting* (more light than dark), isophase (equal light and dark), single long flash, or Morse code "A" (dot, dash) characteristic. (See Panel 11.)

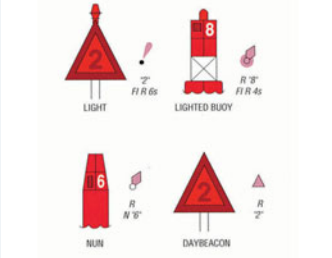
IALA Region B

(Region A reverses the red and green)

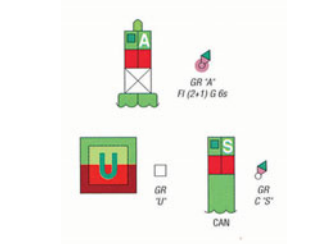
PORT SIDE
ODD NUMBERED AIDS



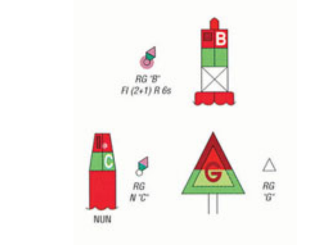
STARBOARD SIDE
EVEN NUMBERED AIDS

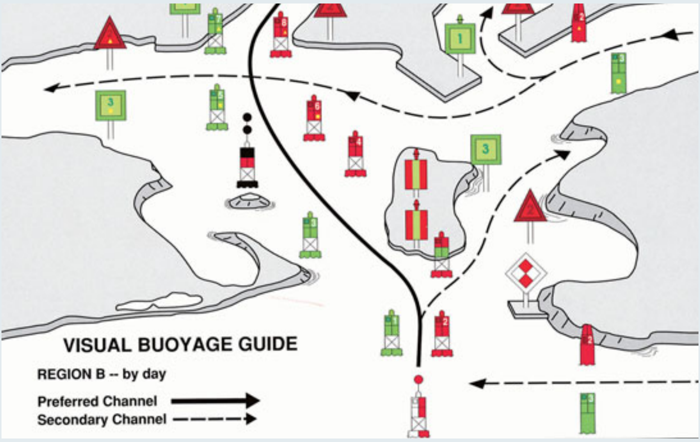


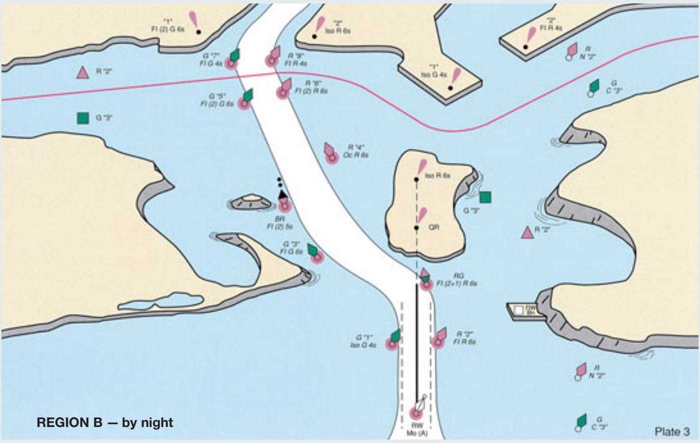
PREFERRED CHANNEL TO STARBOARD;
NO NUMBERS—MAY BE LETTERED



PREFERRED CHANNEL TO PORT;
NO NUMBERS—MAY BE LETTERED







Lights

Strategically placed fixed lights and major floating lights complement lighted buoys for nighttime navigation. They range from small lighted beacons, or *minor lights*, to lightships and lighthouses visible many miles. All charts use a magenta flare to symbolize a fixed or major floating light. (IHO charts also use a flare for lighted buoys, whereas U.S. charts use a magenta watch circle for these.) The flare emanates from a black dot marking the light's position. On IHO charts a black star instead of a dot marks the location of a lighthouse. The chart description may include the following:

- Flash characteristic (sequence and timing)
- Period (total time, in seconds, to complete one full sequence)
- Color (if none given, it is assumed to be white)
- Height of the light above high-water datum in meters (IHO) or feet (U.S.)
- Range in nautical miles (distance the light can be seen on a clear night unless obscured from the viewer by earth's curvature)
- Ancillary information (e.g., number or letter assigned to the light; associated foghorn; etc.)

Examples

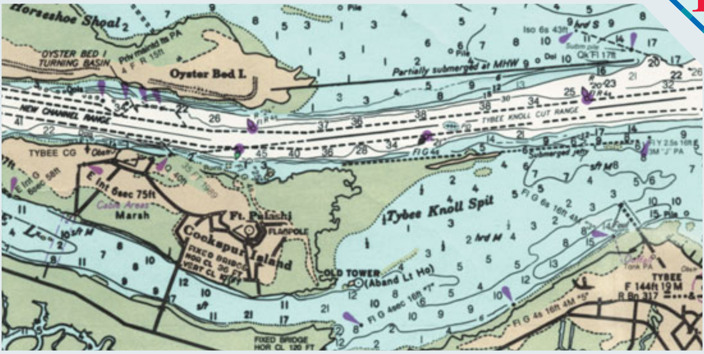
Oc(1 + 2) 15s 65ft 16M HORN = Occulting light, one flash followed by two close flashes, full sequence taking 15 seconds. Light is white (since no color given), 65 feet above high-water datum, with a *nominal range* of 16 nautical miles. (But horizon distance from 65 feet is 9.4 miles. If your eye height is 10 feet, your horizon distance is 3.7 miles, and the light will be below the horizon at distances greater than 9.4 + 3.7 = 13.1 miles.)

Fl(2) WR 7s 16m 13/12M = Flashes twice every 7 seconds. There is a white and a red sector, with the white visible up to 13 miles away and the red up to 12 miles away. The light is 16 meters above high-water datum.

Occulting (total duration of light longer than total duration of darkness)	
Oc	Single-occulting
Oc (2)	Group-occulting
Oc (2+3)	Composite group-occulting
Isophase (duration of light and darkness equal)	
Iso	Isophase
Flashing (total duration of light shorter than total duration of darkness)	
Fl	Single-flashing
Fl (3)	Group-flashing
Fl (2+1)	Composite group-flashing
LFl	Long-flashing (2s or longer)
Quick (repetition rate of 50 to 79—usually either 50 or 60—flashes per minute)	
Q	Continuous quick
Q (3)	Group quick
IQ	Interrupted quick
Very quick (repetition rate of 80 to 159—usually either 100 or 120—flashes per min)	
VQ	Continuous very quick
VQ (3)	Group very quick
Mo (A)	Morse Code
FFl	Fixed and flashing

Selected common light characteristics.

Leading lights are two lights that, when kept in line (the front one is usually lower than the back one), guide a vessel through a channel. On a chart the associated range line is drawn seaward from the lights; the portion in the channel is solid, and the portion that runs out of the channel is dashed. (See example of leading lights in the bottom illustration on Pnael 8 and top illustration on Panel 10.)

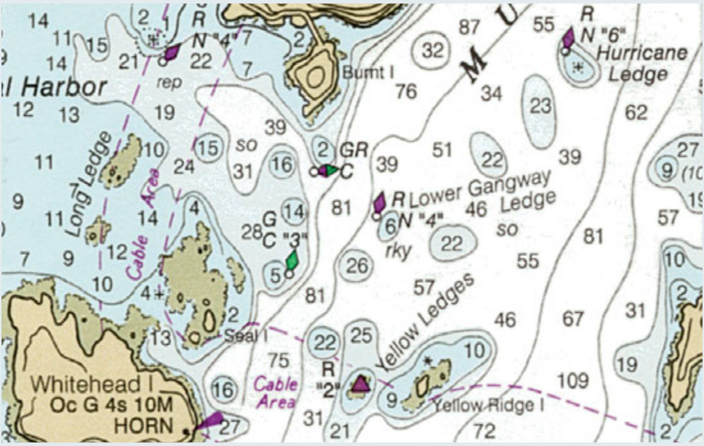


Savannah River and Warsaw Sound, NOAA chart #11512, 1:40,000

Selected features: Leading lights (left of center) for Tybee Knoll Cut Range. Note that the **range line** changes from solid to dashed where it runs out of the channel. The breakwater to the north of the channel is partially submerged at mean high water (MHW); the **jetty** to the south is submerged at all tides. The **dangerous wreck** in the channel definitely exists, but its position is doubtful. The **abandoned lighthouse** (OLD TOWER, bottom center) has a positioning dot and all-cap label, so its position is accurate and it is conspicuous. Note the **uncertain coastline** (dashed outline) at some points around marsh, and the use of solid black outline to delineate the visible edge of the marsh as seen from vessel.

Complex sectored lights off the north coast of France. The Rohein light has eight distinct sectors, with a very quick flash pattern.

Channel Islands (South Sheet), 1:122,600



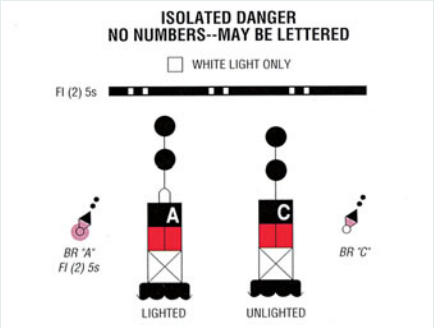
Penobscot Bay, NOAA chart #13305, 1:40,000

Selected features: Whitehead Island Lighthouse has a foghorn and an occulting green light with a 4-second cycle and a range of 10 miles. No height is given, which is unusual. If this were an IHO chart, the lighthouse positioning dot would be a star. **Red beacon** "2" is the first starboard-side mark encountered by vessels entering Muscle Ridge Channel from seaward. (On an IALA Region A chart this mark would be green and its number would be "1.") This beacon is unlighted—i.e., a day beacon. The **green and red can** (center) can be passed on either side, but the preferred channel for returning vessels leaves it to port.

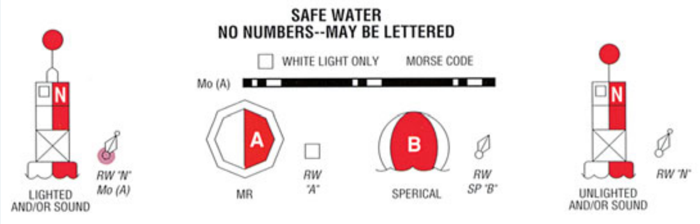
More Navaids

Avoiding Hazards

Isolated danger marks are placed over tightly confined dangers with safe water all around. A light, if present, is white with a group of two flashes (two spheres on the topmark, two flashes).

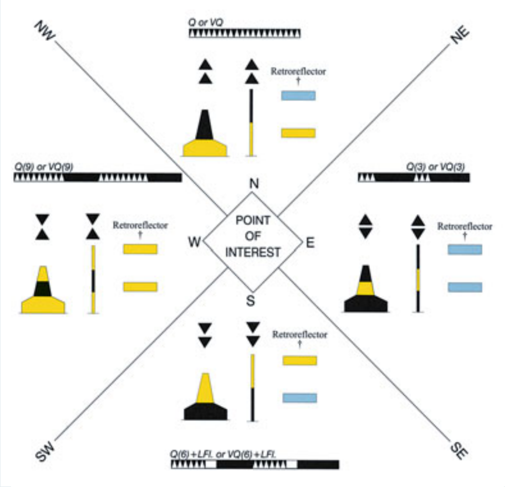


The surest way to avoid hazards is to keep to the centers of channels. Midchannel and deepwater buoys are collectively called *safe-water marks*. These have red and white vertical stripes and are either spherical or, if a pillar buoy, have a spherical topmark. (See also Panel 8.)



Outside of channels, *cardinal marks* are widely used in IALA Region A but not in Region B. These indicate on what side a hazard may safely be passed. A *southern cardinal mark* is set to the south of the hazard and must be passed to the south; *a northern cardinal mark* must be passed to the north; etc. When lit, cardinal marks have white quick-flashing lights. A north mark flashes continuously; an east mark flashes in groups of three (3 o'clock); a south mark shows six flashes (6 o'clock) followed by a long flash; and a west mark flashes in groups of nine (9 o'clock).

Special marks alert mariners to other dangers (e.g., spoil grounds, military firing ranges, cables). These are yellow with a yellow "X" topmark and have yellow lights when lit.



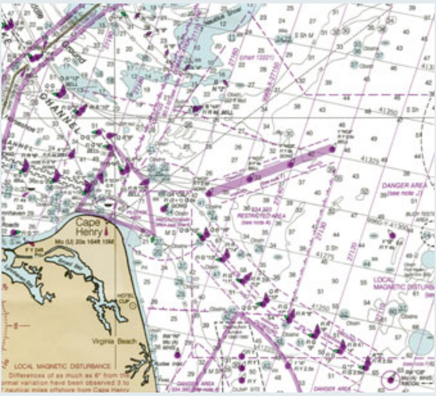
Cardinal marks. These may be pillar buoys (of varying shape) or spars. Color banding, orientation of the two cones in the topmark, and light patterns (when present) distinguish north, east, south, and west cardinal marks.

More Chart Conventions and Symbols

Routes, Areas, and Limits

Routes for big ships are shown by dashed magenta lines and include *traffic separation schemes (TSSs)*, safety fairways, deepwater routes, and recommended routes. Mandatory direction arrows are drawn with solid lines, recommended arrows with dashed lines. When in a route, it is important to follow the designated direction. If crossing a route, cross at or close to a right angle. Ships generally have the right of way.

Dashed magenta lines also designate areas within which certain activities are discouraged or prohibited (anchoring within cable or pipeline crossing areas, for example), or from which certain classes of vessels are excluded. T-shaped dashes have the stems pointing into the area in question. The route of a power or communications cable may be delineated with a squiggly magenta line.



Chesapeake Bay Entrance, NOAA chart #12280, 1:200,000

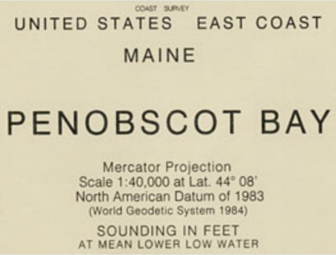
Selected features: Note the two converging **TSSs** with a roundabout (traffic circle) area. The northern route separates inbound from outbound traffic with a shaded magenta **separation zone**. At the seaward end of the southern route is a **radar transponder buoy** (RACON), which returns an unmistakable "dash, dot, dash" pattern to any transmitting radar. Ships are likely to be slowed or stopped in the **pilotage area** off Cape Henry. Various other area limits are defined by dashed and T-dashed magenta lines.

Seabed Characteristics for Anchoring

Sand	*S*
Mud	*M*
Clay	*Cy; Cl*
Silt	*Si*
Stones	*St*
Gravel	*G*
Pebbles	*P*
Cobbles	*Cb*
Rock; rocky	*Rk; rky*
Coral and coralline algae	*Co*
Shells	*Sh*
Two layers; e.g., sand over mud	*S/M*
Weed (including kelp)	*Wd*
Kelp; seaweed	
Mobil bottom (sand waves)	
Freshwater springs in seabed	

Electronic Charts

Charts are constructed using a mathematical model of the world known as a horizontal datum. There are various datums in use, and these locate latitude and longitude lines differently with respect to charted features. Electronic charts are based on the WGS 84 datum, but many paper charts, especially older charts, are not. The datum will be given in a note on the chart or at the bottom.

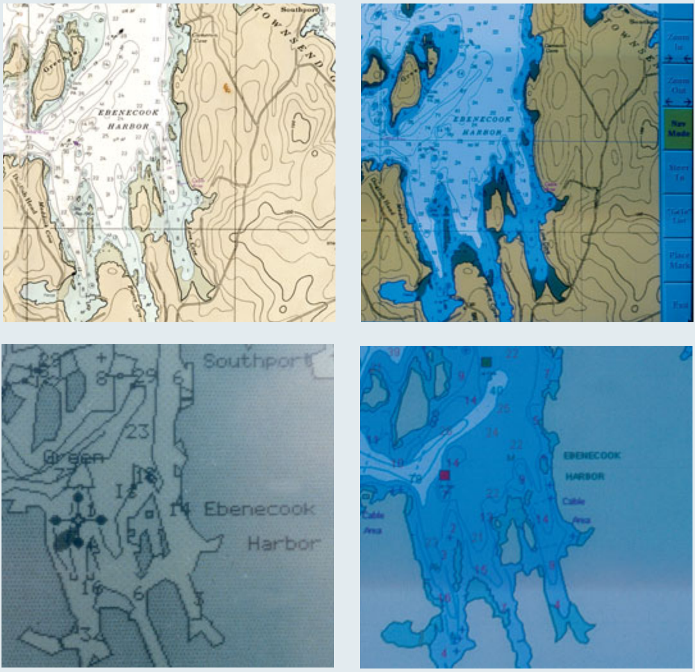


The title block of this NOAA chart tells us that its horizontal datum is the "North American Datum of 1983" (in practical terms, the same as WGS 84).

The most fundamental rule of electronic navigation is to ensure that the boat's GPS is set to the same datum as that of the chart in use.

GPS gives a higher level of positional accuracy than that used to survey and display most chart data. Although a boat's position may be precisely fixed on an electronic chart, there is an element of uncertainty concerning the placement of soundings and features.

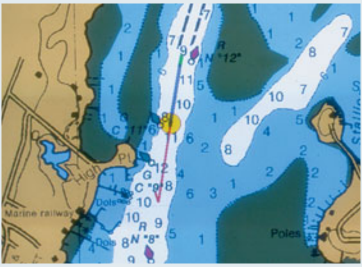
Electronic navigation systems can be set to show courses and bearings in degrees true or magnetic. The same convention must be used for deriving and plotting courses as is used for steering the boat. Typically, courses are read from GPS in degrees magnetic to match the ship's steering compass.

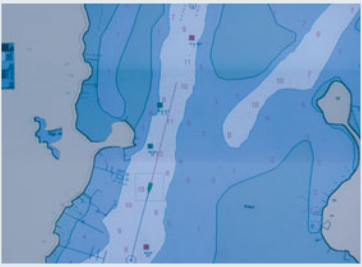


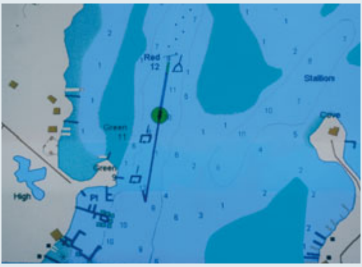
The colors in the raster chart at top right are a little different from the paper chart at top left, but otherwise the two are the same. On a low-end vector chart plotter (bottom left), all the detail is missing. A higher-end vector chart captures much of the detail of the paper chart, though the symbology is a little different.

A *raster nautical chart (RNC)* is a scanned electronic version of a traditional chart. Dozens of RNCs can be scanned onto a CD or DVD for use in a laptop or onboard computer, which displays the chart and drives the associated navigation software, but raster charts are too memory-hungry for most electronic chart plotters. Zooming in on a raster chart will magnify features and labels with corresponding loss of resolution.

A *vector-based nautical chart* (which NOAA calls an electronic navigational chart or ENC) is not simply a scanned version of a traditional chart, but rather a database recreation of a chart. Though it contains the same critical information as its traditional counterpart, it may or may not closely resemble the corresponding paper or raster chart. Noncritical land features may be much less detailed, but critical navigation features such as channel boundaries may be more precise than on traditional charts because the vector input files can include detailed survey data not included in standard charts. Further, vector charts are “smart,” meaning that they can, for example, look ahead at the course you’re following and alert you to charted hazards in your path. A vector chart can also “turn on” lighted navaids to give you a nighttime view of surrounding waters. And vector charts require less computing power than raster charts and are thus more compatible with chart plotters. Such advantages are propelling vector charts ahead of raster charts in popularity, though they look “different” and therefore off-putting to some longtime mariners. Zooming in on a vector chart will magnify features without attendant loss of resolution in outlines or labels, making the chart appear more accurate than it is.







The incredibly precise real-time positioning of a boat that is possible with electronic charts and navigation systems can tempt a navigator to follow a course closer to hazards than was typical in the past. These three electronic charts of the same area (**top to bottom:** NOAA raster scan; NIMA vector chart; Transas vector chart) all display the boat’s position with greater precision than applies to the surrounding charted features.

Chart Corrections

Hydrographic offices issue periodic corrections for their charts. These can be downloaded from the internet. With paper charts, the corrections must be made by hand. With electronic charts, sometimes new charts must be bought (which can be expensive) and other times the corrections can be downloaded and applied to existing charts (which is much to be preferred).

Captain's QUICK GUIDES

Unlock the full power of nautical charts:

- Translate chart labels for navigation buoys and lights
- Negotiate buoyed and unbuoyed waters
- Find good ground for anchoring
- Chart scales and datums and why they're critical
- Understand raster and vector electronic charts
- Relate what you see on deck to what your chart shows

Nigel Calder is the author of the bestselling book *How to Read a Nautical Chart*, from which this Quick Guide is taken. A veteran navigator of U.S., European, and Caribbean waters, he is also the author of *Boatowner's Mechanical and Electrical Manual*, *Nigel Calder's Cruising Handbook*, and other bestselling nautical books.

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