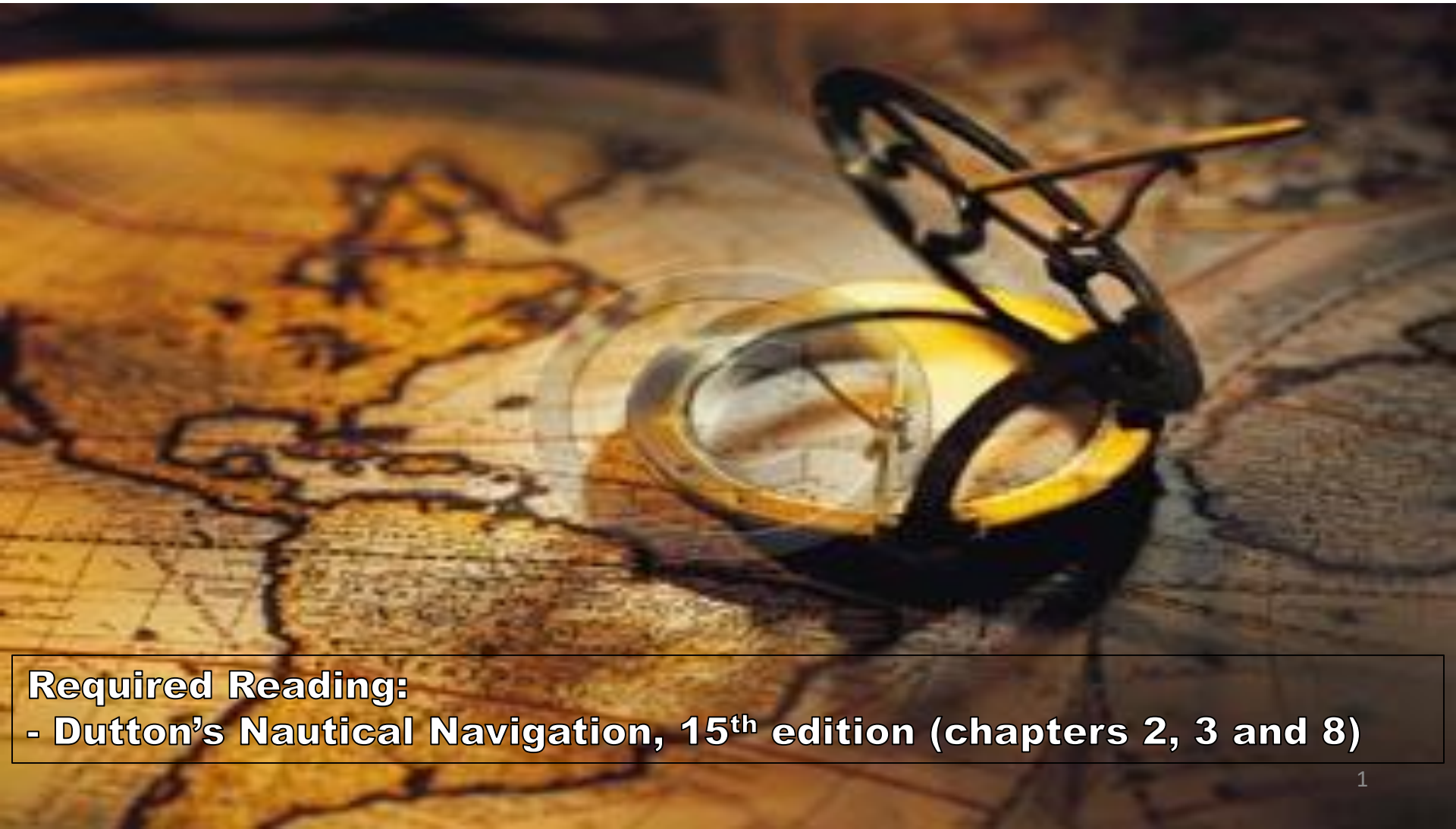
Navigation Principles

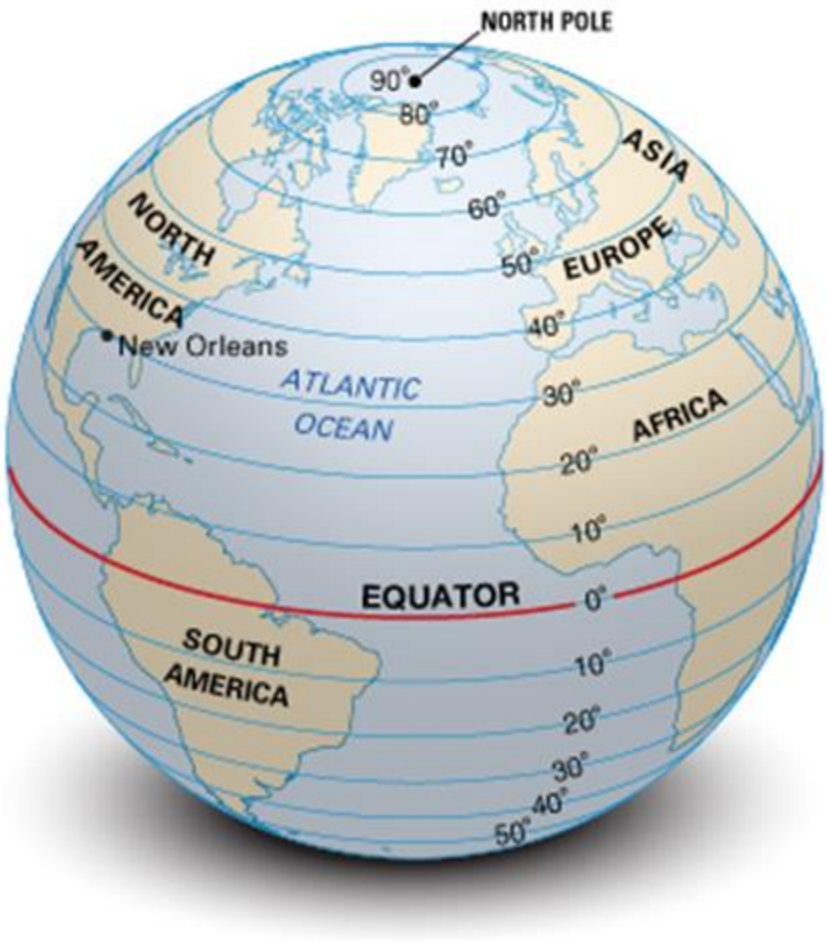


Required Reading:
- Dutton's Nautical Navigation, 15th edition (chapters 2, 3 and 8)

Enabling Objectives

- Know terms associated with the **terrestrial coordinate system**; Equator, Prime Meridian, Great Circle, Small Circle, Parallel, Meridian, Latitude, Longitude, and Rhumb Line
- Understand the concept of **Projections** and the main projections used in Navigation
- Know the advantages and disadvantages of the **Mercator** and **Gnomonic** Projections
- Understand the difference between **Great Circle Routes** and **Rhumb Lines**
- Understand the use of a **Nautical Chart** and the main concepts associated to nautical charts
- Know chart distribution agencies
- Understand the function and use of **Chart One**
- Know how to read directions and latitude and longitude on the nautical chart
- Know the lengths of a degree of **Latitude** and **Longitude**
- Understand the use of basic **plotting tools**

Terrestrial Coordinate System
Latitude



- Equator is the reference for latitude.

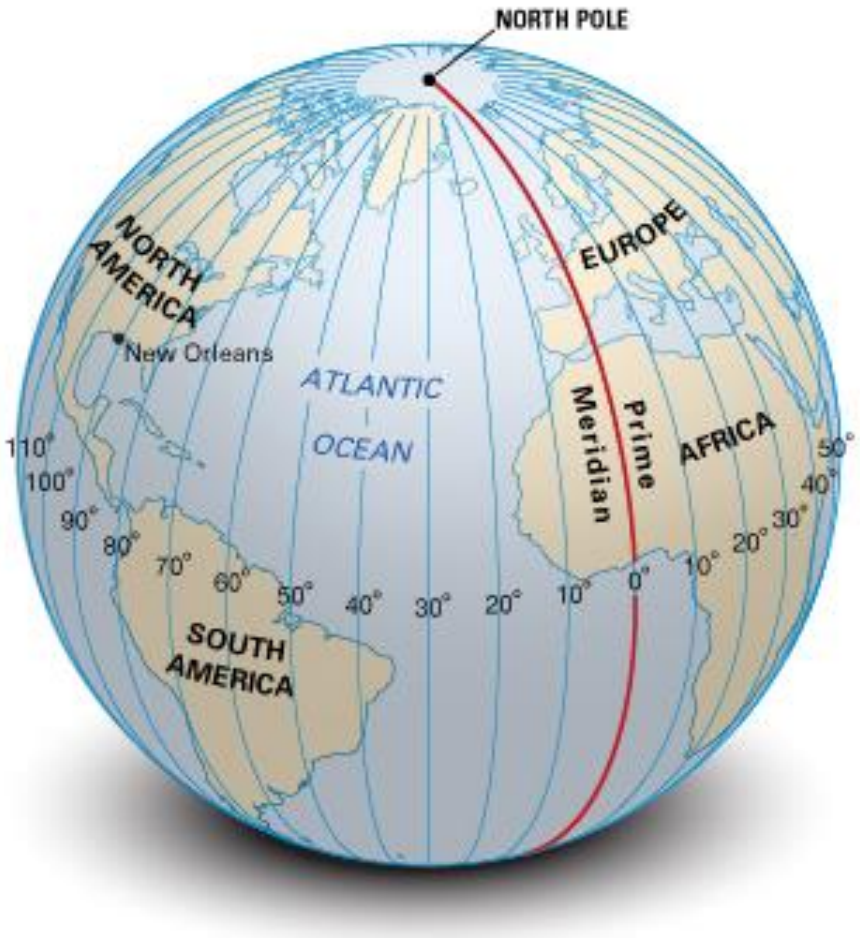
- Mesures **angular distance North or South from the Equator** (0º - 090º)

- Described in degrees, minutes and seconds followed by the suffix N/S.

φ = XXº XX' XX'' N/S

Degrees expressed always in 2 digits!

Terrestrial Coordinate System
Longitude



- **Prime Meridian** is the reference for longitude.
- Measure the **angular distance East or West from the Prime Meridian** (0º - 180º).
- Described in degrees, minutes and seconds followed by the suffix E/W.

λ = XXXº XX' XX'' E/W

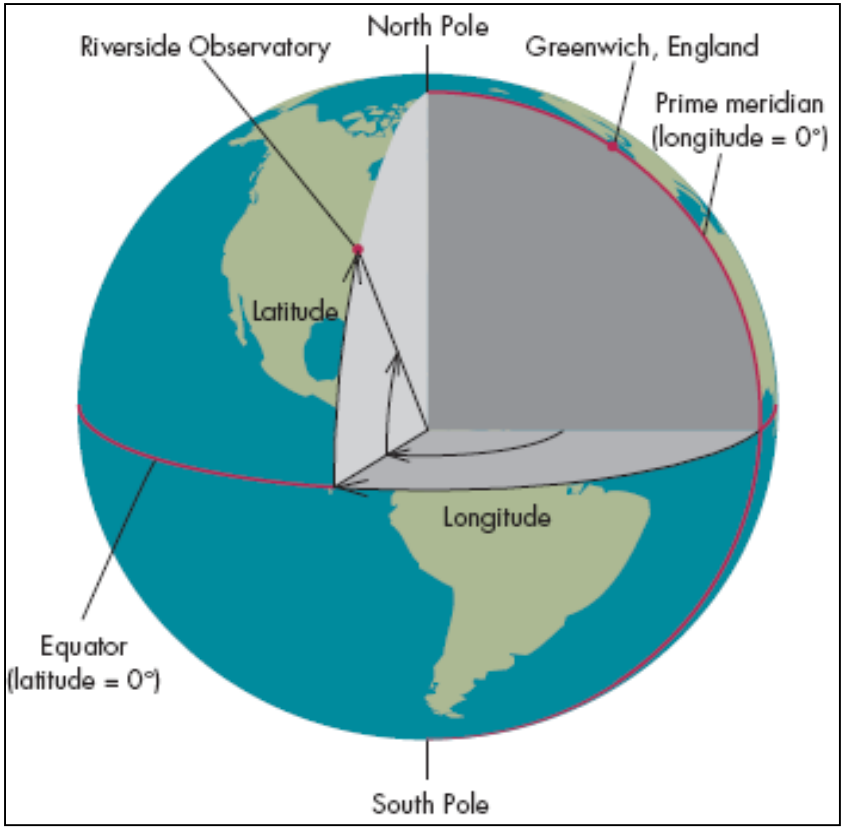
Degrees expressed always in 3 digits!

Terrestrial Coordinate System

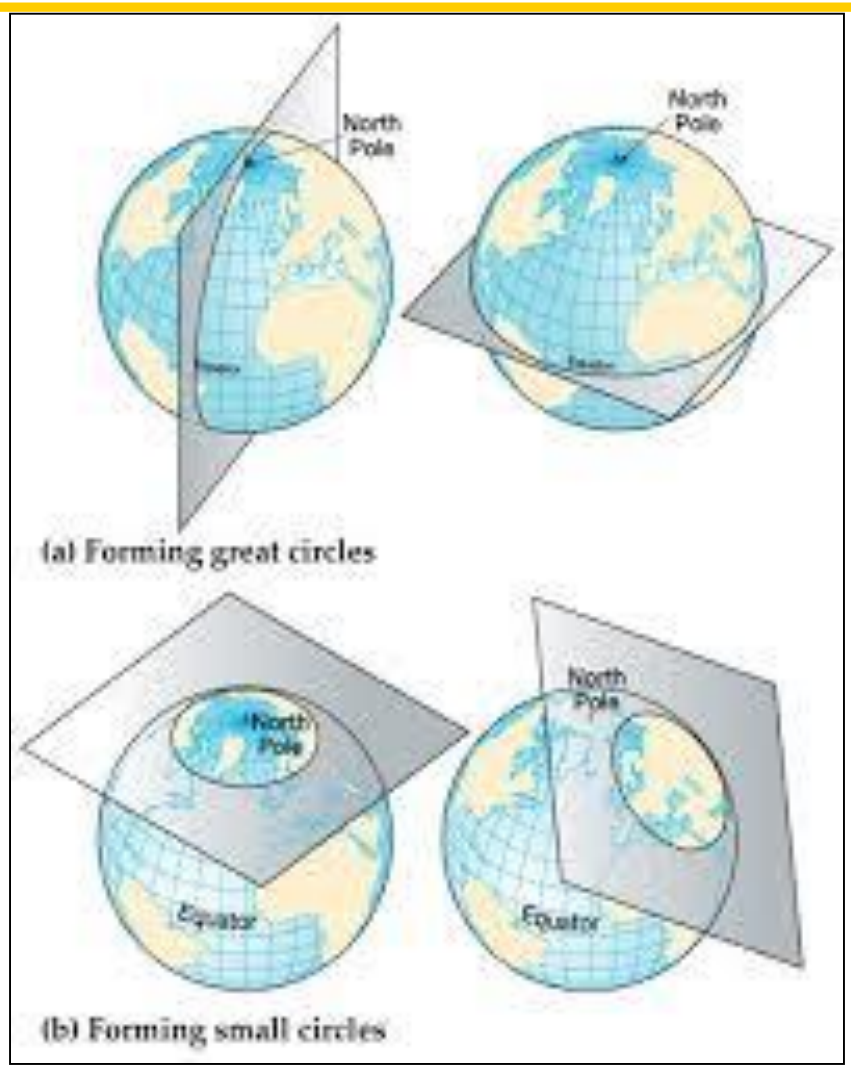
A combination of latitude and longitude is a position on the Earth's Grid.

Example:
Riverside Observatory coordinates:
- Lat. = 33° 57' 12" N
- Long. = 117 ° 23' 46" W

Remember:
1 ° = 60' (minutes)
1' = 60" (seconds)



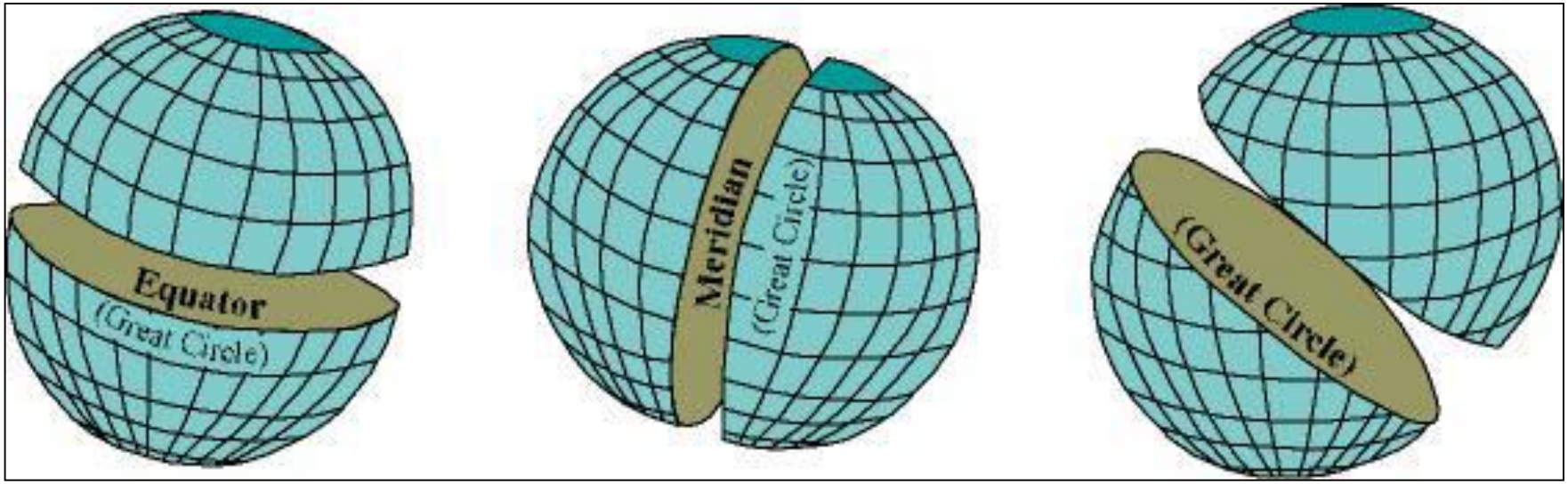
Great Circle and Small Circle



Great Circle is any circle formed on the surface of Earth by the intersection of a plane passing **through the center of the Earth**, thereby dividing Earth into two equal parts.

Small Circle is any circle formed on the surface of Earth by the intersection of a plane ***not*** **passing through the center of the Earth**.

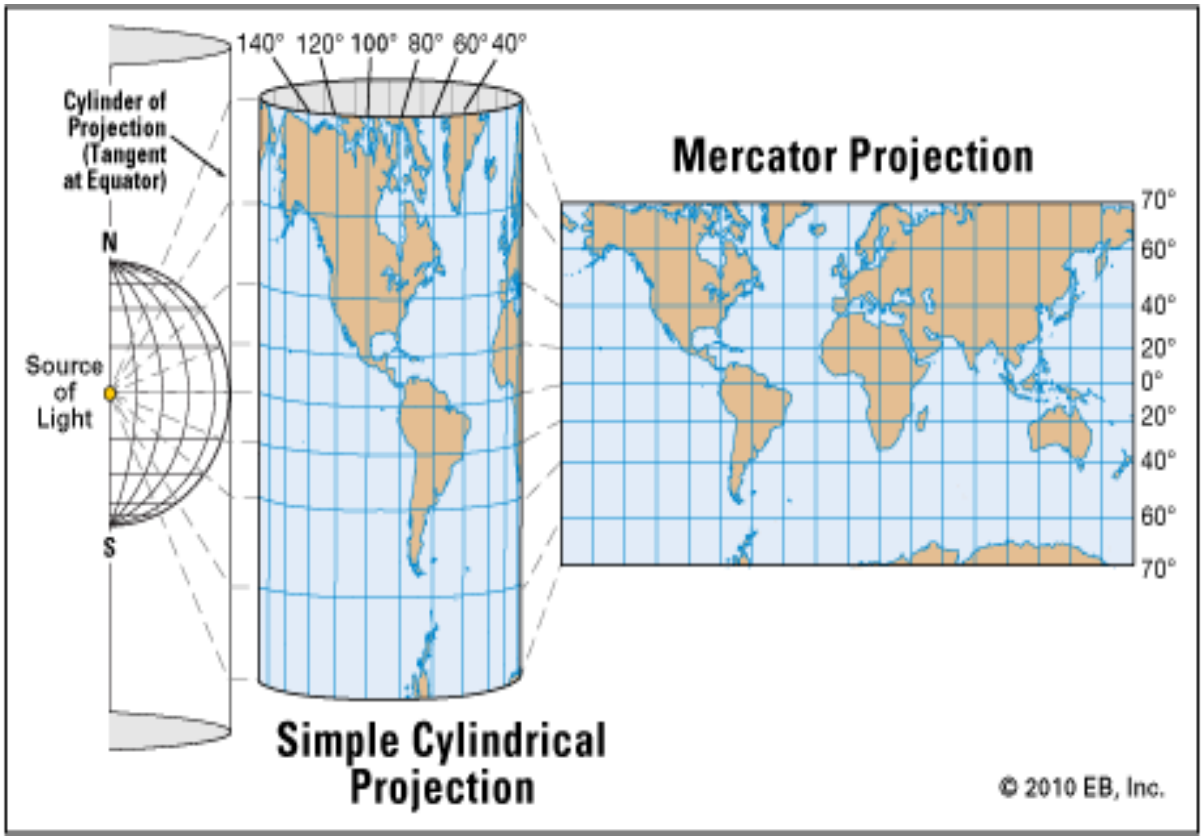
Great Circles



- **Meridian – Great Circle** that is passes through the poles;
- **Equator – Great Circle** that is half-way from the poles;

Projections
Mercator Projection

- Most nautical charts are based on the Mercator Projection.



- Rhumb lines, Meridians and Parallels are represented by straight lines.

- Meridians and parallels are perpendicular to each other, simplifying plotting positions.

Projections
Mercator Projection

- **Advantages**:

  - Lat. and long. appear as a rectangular graticule (easy to plot positions, courses, etc.);

  - Easy to determine lat./long. of a position plotted;

  - Easy to measure distance (lat. scale – 1’ = 1NM); and

  - Easy to locate the four cardinal points.

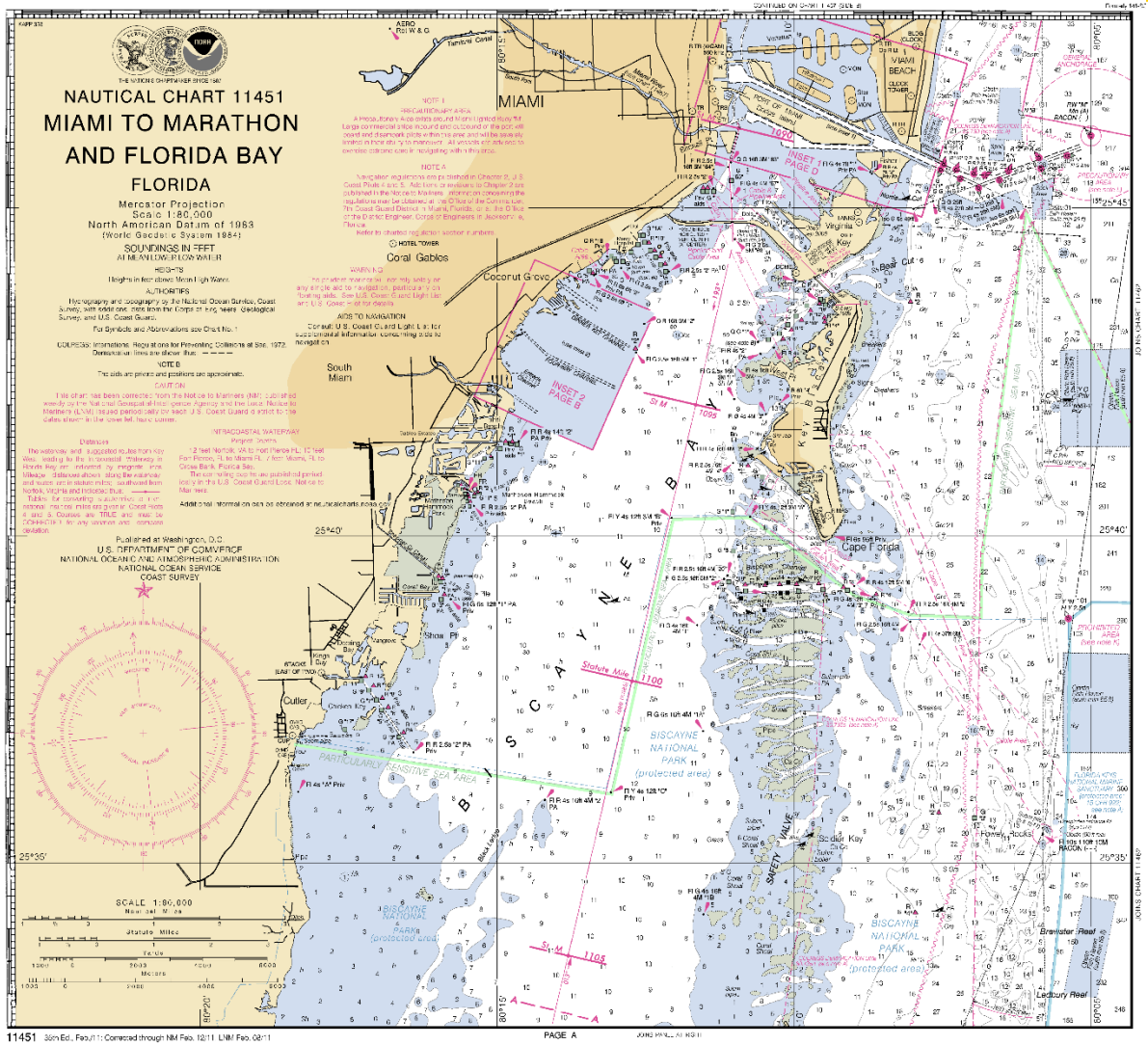
- **Disadvantages**:

  - Great-circle distances and directions are not readily determinable; and

  - High distortion in extreme latitudes.

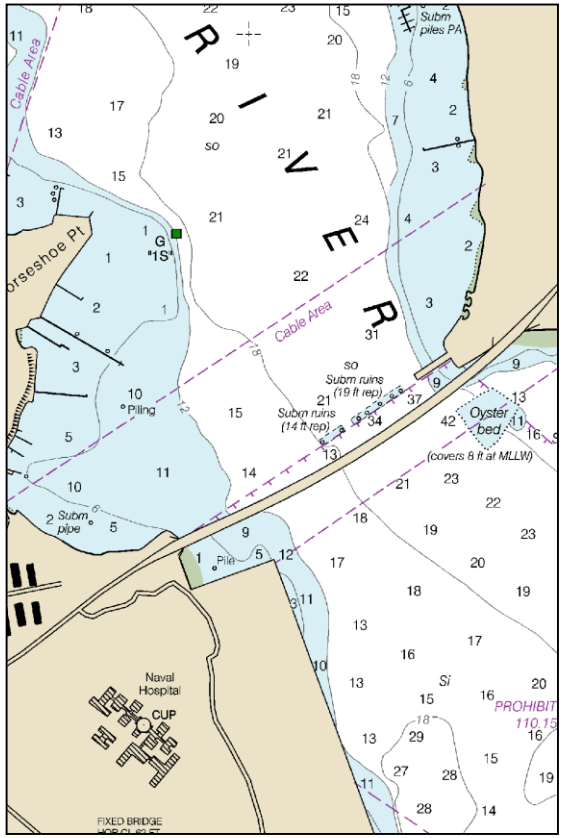
  - No representation of the poles.

Projections
Mercator Projection



Nautical Charts

- Chart is a graphic representation of a maritime area and adjacent coastal regions.
- Charts show:
    - depths of water and heights of land
    - natural features of the seabed
    - details of the coastline
    - navigational hazards
    - location of natural and man-made aids to navigation
    - information on tides and currents
    - local details of the Earth's magnetic field (variation)
    - man-made structures such as bridge and harbours



Nautical Charts
Distribution Agencies

- National Ocean Service (NOS)
    - Division of National Oceanic & Atmospheric Agency (NOAA)
    - Coastal US waters, most rivers and Great Lakes for commercial and civilian use

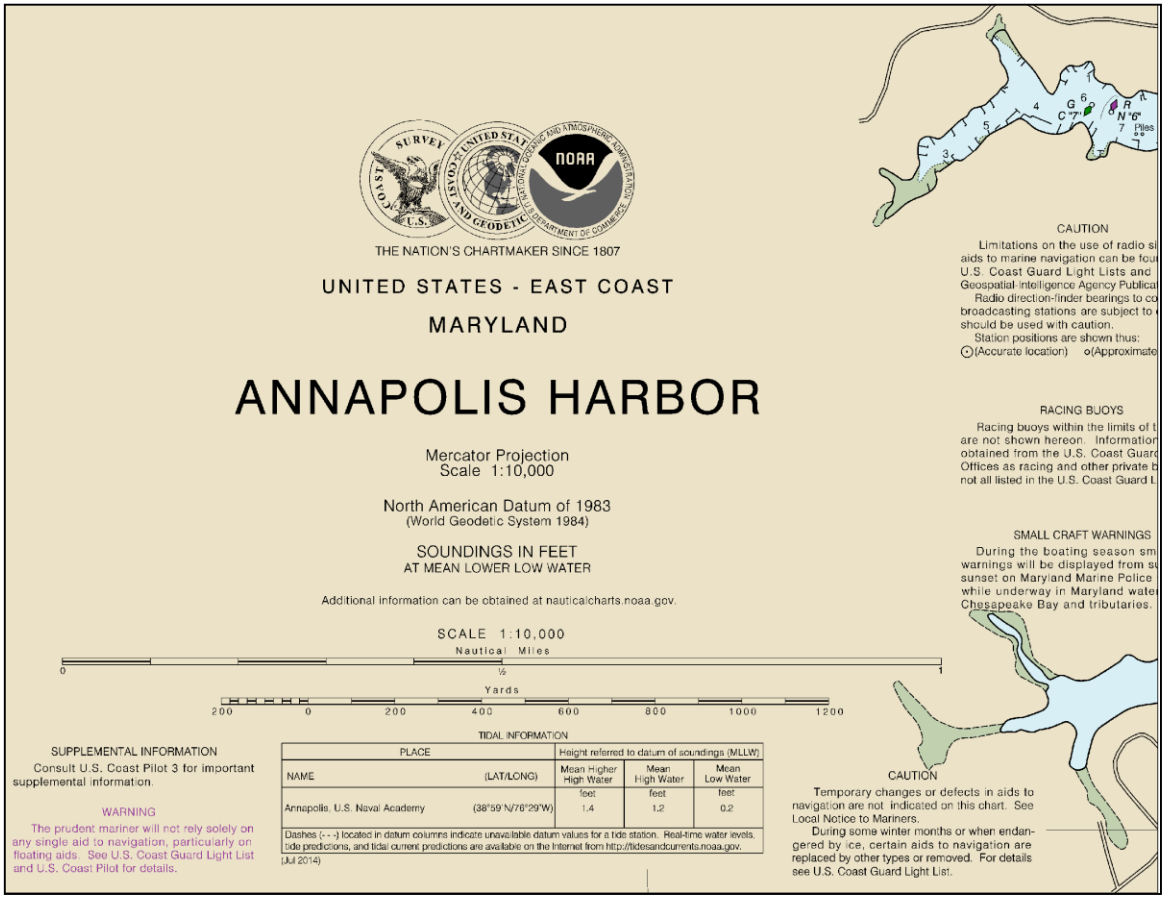
- Army Corps of Engineers
    - Mississippi River (and its tributaries) and some inland lakes

- National Geospatial Intelligence Agency(NGA) - formerly NIMA
    - Department of Defense and International use

Nautical Charts
Title Block

Main information:

- Region identification
- Main title
- Projection and Scale
- Publisher
- Datum
- Depth and elevation notes
- Cautionary notes
- Tidal information



THE NATION'S CHARTMAKER SINCE 1807

UNITED STATES - EAST COAST

MARYLAND

ANNAPOLIS HARBOR

Mercator Projection
Scale 1:10,000

North American Datum of 1983
(World Geodetic System 1984)

SOUNDINGS IN FEET
AT MEAN LOWER LOW WATER

Additional information can be obtained at nauticalcharts.noaa.gov.

SCALE 1:10,000

Nautical Miles

0 ½ 1

Yards

200 0 200 400 600 800 1000 1200

SUPPLEMENTAL INFORMATION

Consult U.S. Coast Pilot 3 for important supplemental information.

WARNING

The prudent mariner will not rely solely on any single aid to navigation, particularly on floating aids. See U.S. Coast Guard Light List and U.S. Coast Pilot for details.

TIDAL INFORMATION

PLACE		Height referred to datum of soundings (MLLW)		
NAME	(LAT/LONG)	Mean Higher High Water	Mean High Water	Mean Low Water
		feet	feet	feet
Annapolis, U.S. Naval Academy	(38°59'N/76°29'W)	1.4	1.2	0.2

Dashes (- - -) located in datum columns indicate unavailable datum values for a tide station. Real-time water levels, tide predictions, and tidal current predictions are available on the Internet from http://tidesandcurrents.noaa.gov.

(Jul 2014)

CAUTION

Limitations on the use of radio si
aids to marine navigation can be fou
U.S. Coast Guard Light Lists and
Geospatial-Intelligence Agency Publica
Radio direction-finder bearings to co
broadcasting stations are subject to
should be used with caution.
Station positions are shown thus:
⊙(Accurate location) ○(Approximate

RACING BUOYS

Racing buoys within the limits of t
are not shown hereon. Information
obtained from the U.S. Coast Guard
Offices as racing and other private b
not all listed in the U.S. Coast Guard L

SMALL CRAFT WARNINGS

During the boating season sm
warnings will be displayed from su
sunset on Maryland Marine Police
while underway in Maryland water
Chesapeake Bay and tributaries.

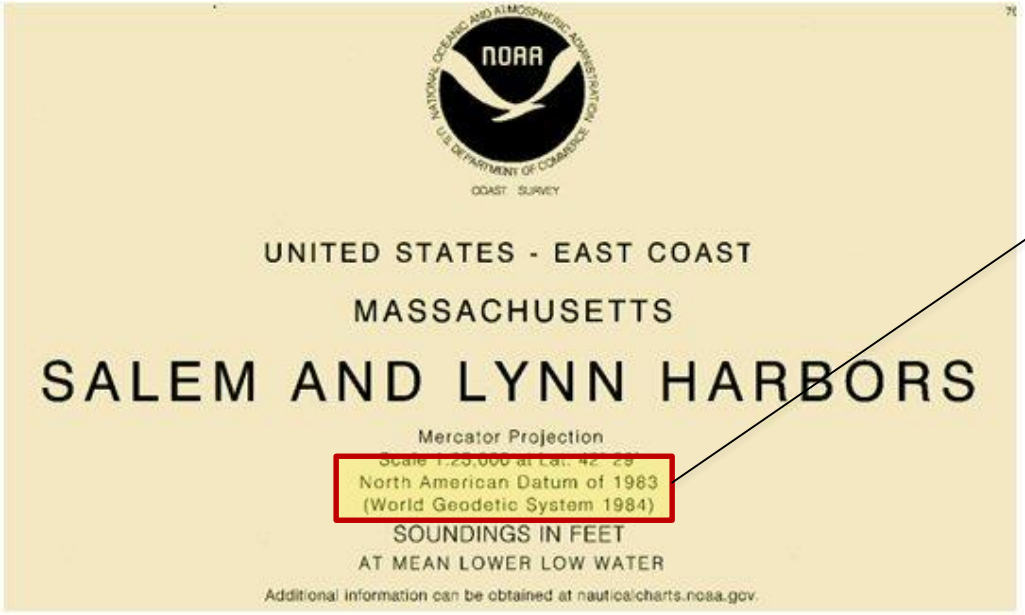
CAUTION

Temporary changes or defects in aids to navigation are not indicated on this chart. See Local Notice to Mariners.

During some winter months or when endangered by ice, certain aids to navigation are replaced by other types or removed. For details see U.S. Coast Guard Light List.

Nautical Charts
Datum

- Reference point in which measurements are made.
  - Horizontal Datum: Reference used for distance
  - Vertical Datum: Reference used for height (sounding)

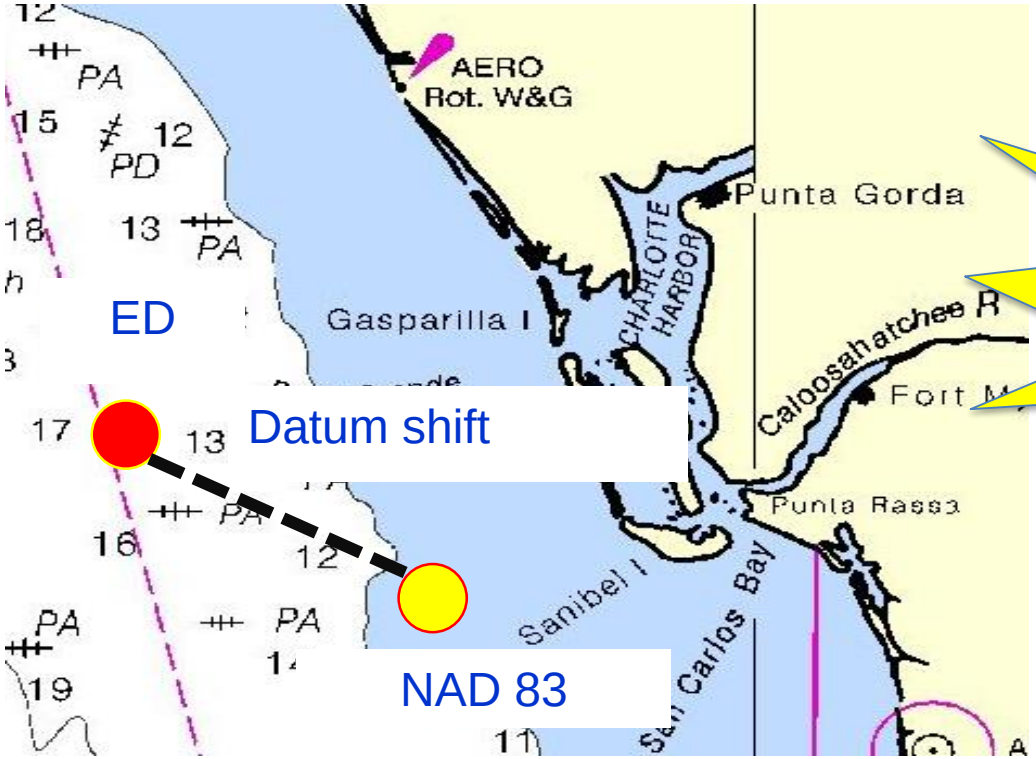


Datum used can be easily found in the Nautical Chart. (*datum note*)

Ex.: ED, NAD 83

Nautical Charts
Datum

- Datum shift: difference between actual and plotted position when using different datum (chart and GPS).



Always check chart and GPS datum!!!

Nautical Charts
Chart Scale

- Ratio of a distance unit on the chart to the actual distance on the surface of the Earth.

Ex.: Scale 1:20,000 (one unit of distance on the chart represents 20,000 units on the Earth).

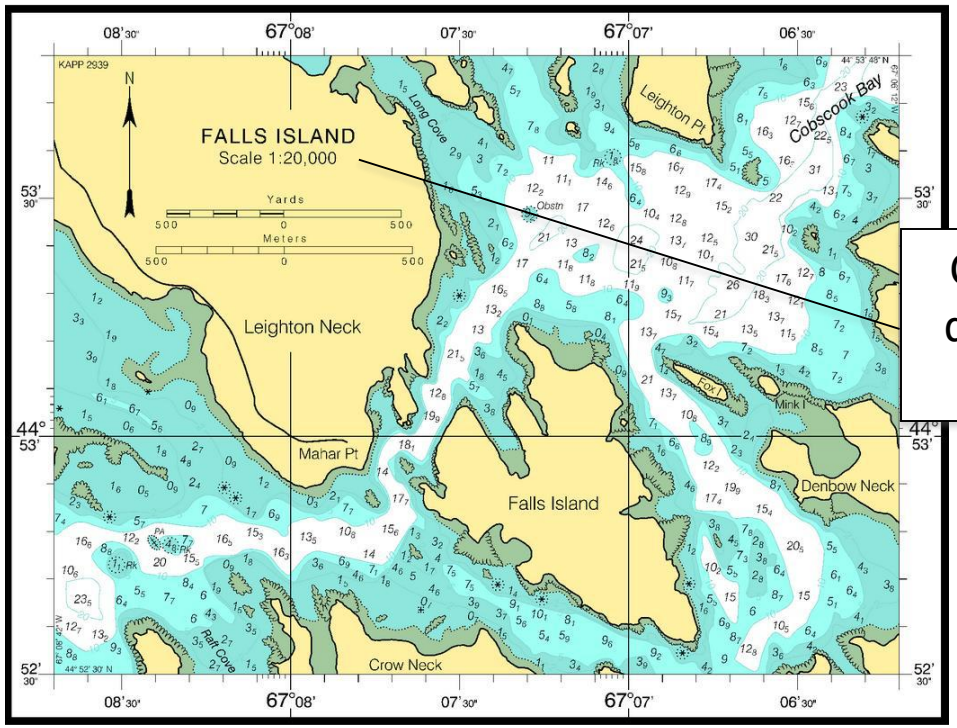


Chart Scale is always described in the Title Block.

Nautical Charts
Chart Scale

- Comparing Scales – 1:5,000,000 x 1:5,000

Seems bigger, but is smaller.
Remember fractions!

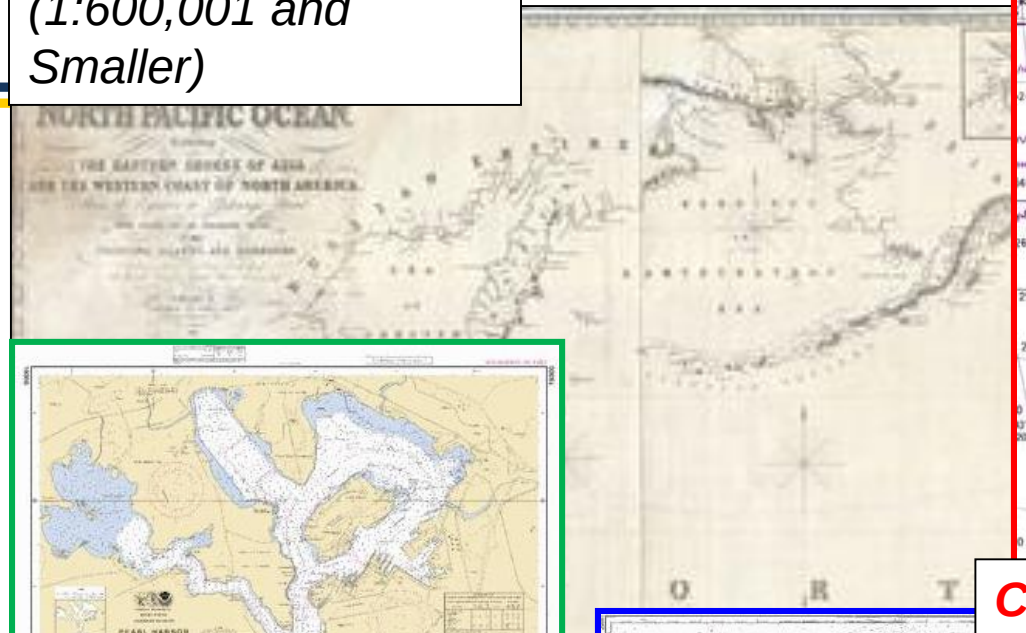
- Use the larger scale when near dangers (harbor entrance).

- Use the smaller scale when clear from danger (underway at sea).

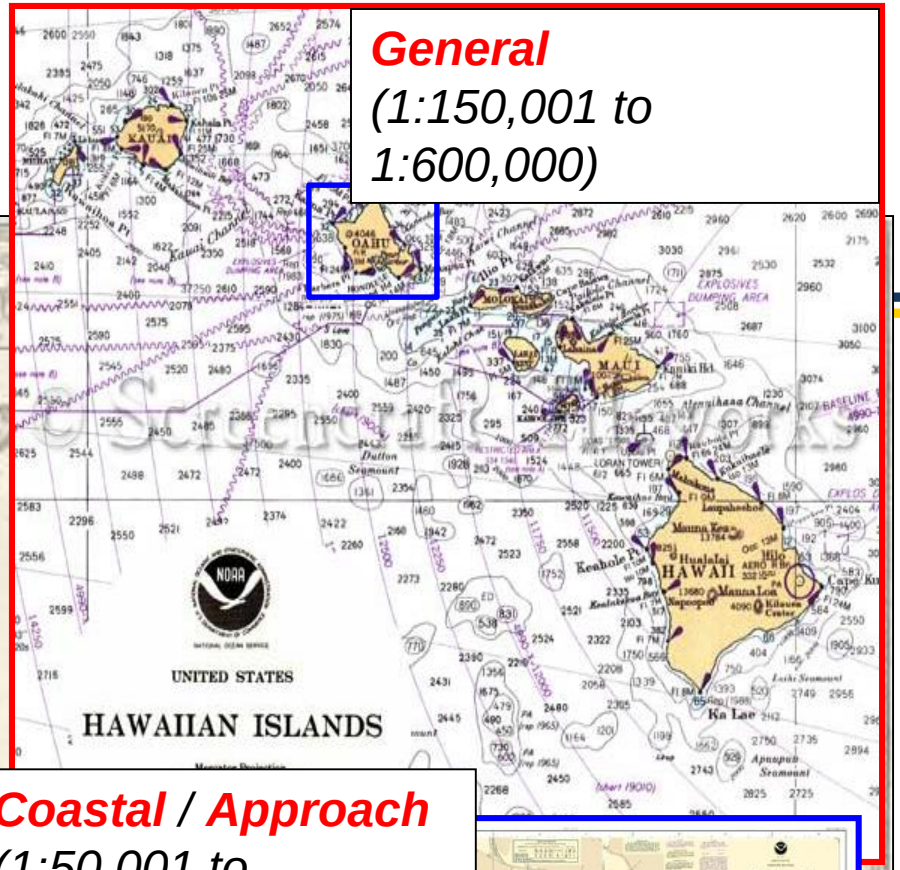
- If in doubt, always use the larger scale!

Charts Series

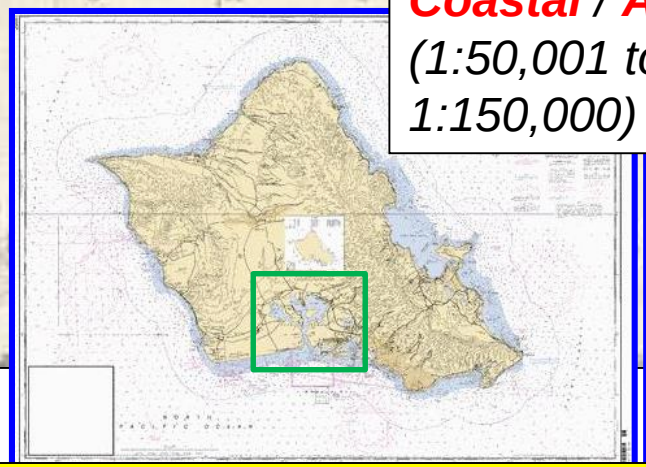
Sailing
(1:600,001 and Smaller)

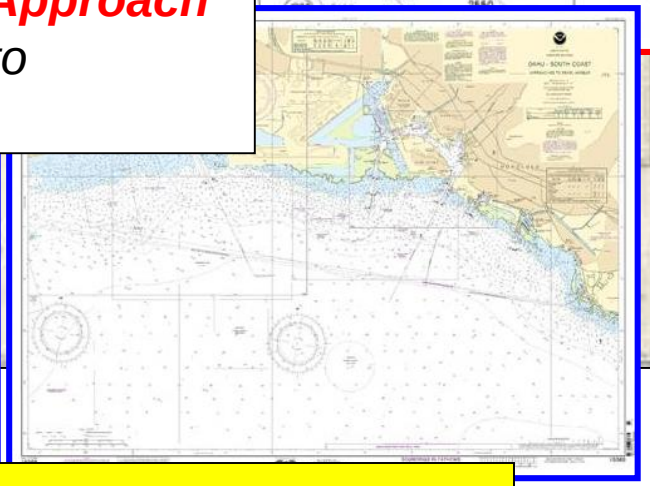


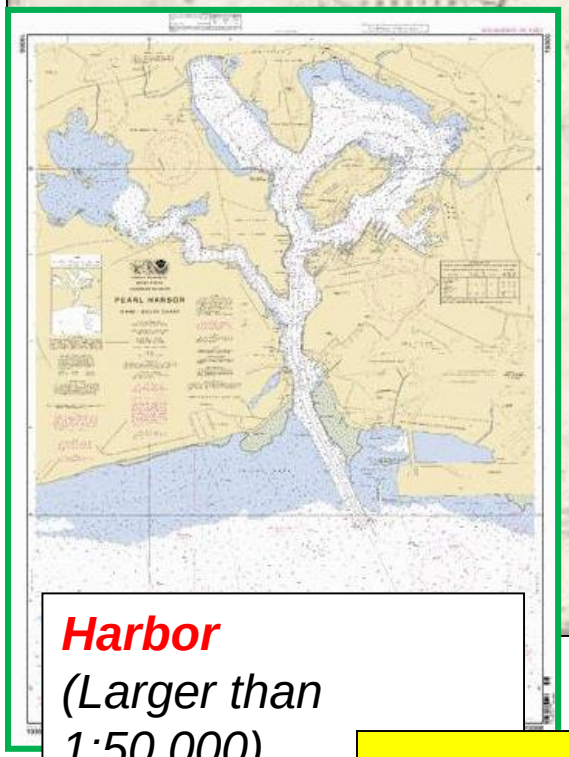
General
(1:150,001 to 1:600,000)



Coastal / Approach
(1:50,001 to 1:150,000)



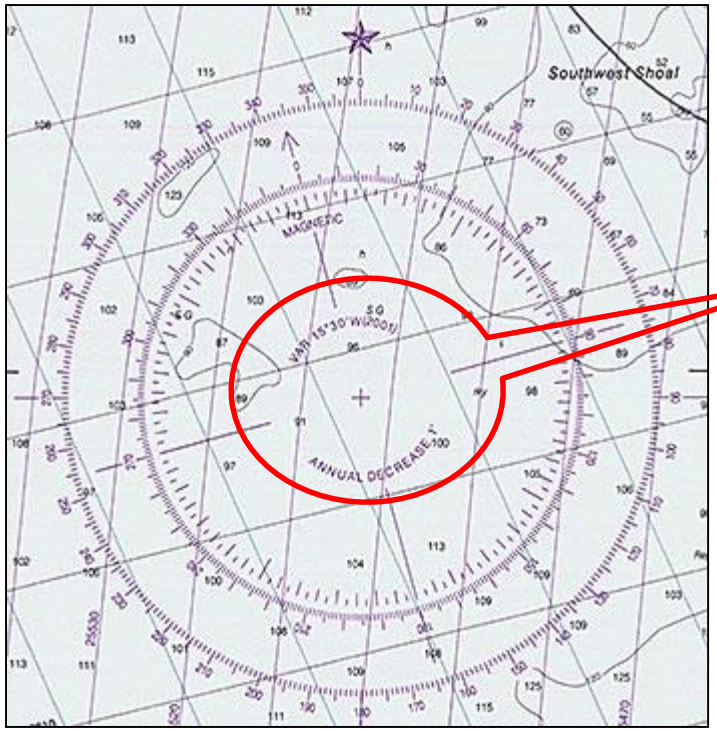




Harbor
(Larger than 1:50,000)

Larger scale ➔ smaller area ➔ more details!

Nautical Charts Components

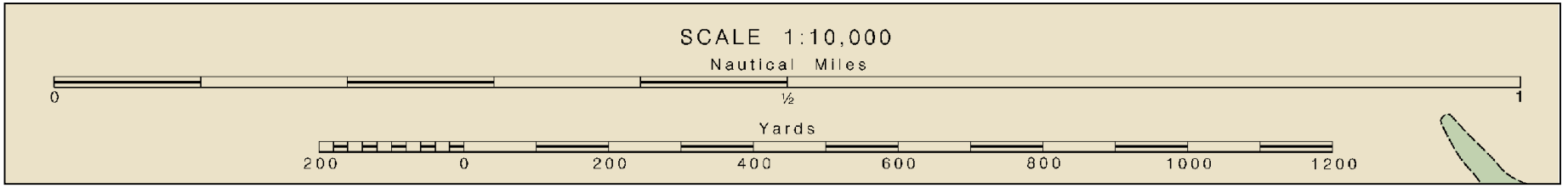


Compass Rose:

- Used to measure directions (true or magnetic) using slider/parallel ruler
- Contains the local variation and annual change (increase or decrease).

Distance Scale:

- Used to measure distances using compass or divider



Nautical Charts
Chart One

- United States of America Nautical Symbols Abbreviations and Terms.

U.S. Chart No. 1

Symbols, Abbreviations and Terms
used on Paper and Electronic Navigational Charts

12th Edition
April 15, 2013

Prepared Jointly by

Department of Commerce
National Oceanic and Atmospheric Administration

Department of Defense
National Geospatial-Intelligence Agency

Rocks, Wrecks, Obstructions, /

No.	INT	Description	NOAA	NGA	Other NGA	
Wrecks and Fouls						
Plane of Reference for Depths → H						
20	Mast (1.2) Wk	Wreck, hull never covers, on large scale charts	Hk		Hk	
21	Mast (1_2) Wk	Wreck, covers and uncovers, on large scale charts	Hk		Wk Wk Wk Wk	
22	5_2 Wk 6_2 Wk	Submerged wreck, depth known, on large scale charts			8 Wk	Distributed remains of wreck
23	Wk	Submerged wreck, depth unknown, on large scale charts		Hk	Wk Wk Wk	Submerged wreck with depth less than the safety contour or depth unknown
24		Wreck showing any portion of hull or superstructure at level of chart datum			Wk Wk Wk Wk	Wreck showing any portion of hull or superstructure at level of chart datum
25	Masts	Wreck of which the mast(s) only are visible at chart datum	Masts	Mast (10ft) Funnel		
						Underwater hazard with

Nautical Charts
Chart One

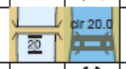
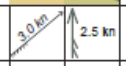
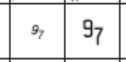
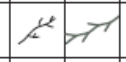
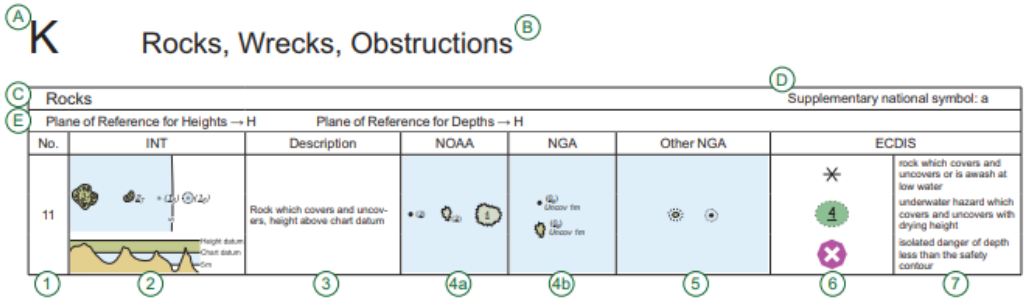
A		Chart Number, Title and Marginal Notes
B		Positions, Distances, Directions and Compass
C		Natural Features
D		Cultural Features
E		Landmarks
F		Ports
H		Tides and Currents
I		Depths
J		Nature of the Seabed
K		Rocks, Wrecks and Obstructions
L		Offshore Installations
M		Tracks and Routes
N		Areas and Limits
P		Lights
Q		Buoys and Beacons
R		Fog Signals
S		Radar, Radio and Satellite Navigation Systems
T		Services
U		Small Craft (Leisure) Facilities

Chart No. 1

- "Nautical Chart Symbols, Abbreviations and Terms" is a reference publication depicting basic chart elements and explains nautical chart symbols and abbreviations associated with National Ocean Service and NGA charts
- A valuable aid for new chart users and a useful tool for all mariners

Nautical Charts
Chart One

Schematic Layout of U.S. Chart No. 1:



(A)	Section designation
(B)	Section
(C)	Sub-section
(D)	Reference to "Supplementary national symbols" at the end of each section
(E)	Cross-reference to terms in other sections
(1)	Column 1: Numbering system following the "Chart Specification of the IHO". A letter in this column indicates a supplementary national symbol or abbreviation for which there is no international equivalent.
(2)	Column 2: Representation that follows the "Chart Specifications of the IHO" (INT 1 symbol)
(3)	Column 3: Description of symbol, term, or abbreviation
(4a)*	Column 4a: Representation used on charts produced by the National Oceanic and Atmospheric Administration (NOAA)
(4b)*	Column 4b: Representation used on charts produced by the National Geospatial-Intelligence Agency (NGA)
(5)	Column 5: Representation of symbols that may appear on NGA reproductions of foreign charts
(6)**	Column 6: Representation used to portray ENC data on ECDIS
(7)**	Column 7: Description of ECDIS symbols

* When columns 4a and 4b are combined then NOAA and NGA both use the same symbol. When either column 4a or 4b is blank then the respective agency uses the INT 1 symbol shown in column 2.

** When columns 6 and 7 have several rows for the same symbol number, then ECDIS portrays this feature differently depending on the ship's draft and other conditions as defined in ECDIS by the mariner (as is the case for K 11). When columns 6 and 7 combine rows to span across several symbol numbers then ECDIS portrays all of the grouped symbol numbers the same way (see C 5–C 7).

† Signifies that this representation is obsolete, but it may appear on older charts.

Signifies that a feature attribute value, such as a height, distance or name, may be obtained through an ECDIS cursor pick report. There are many attribute values that may be obtained in this manner, but the cursor pick icon is only used to note values that are specifically referred to in the description of symbols column and that ECDIS does not display next to the symbol. Height of trees in C 14 is an example.

Navigation Tools
Compass Vs Divider

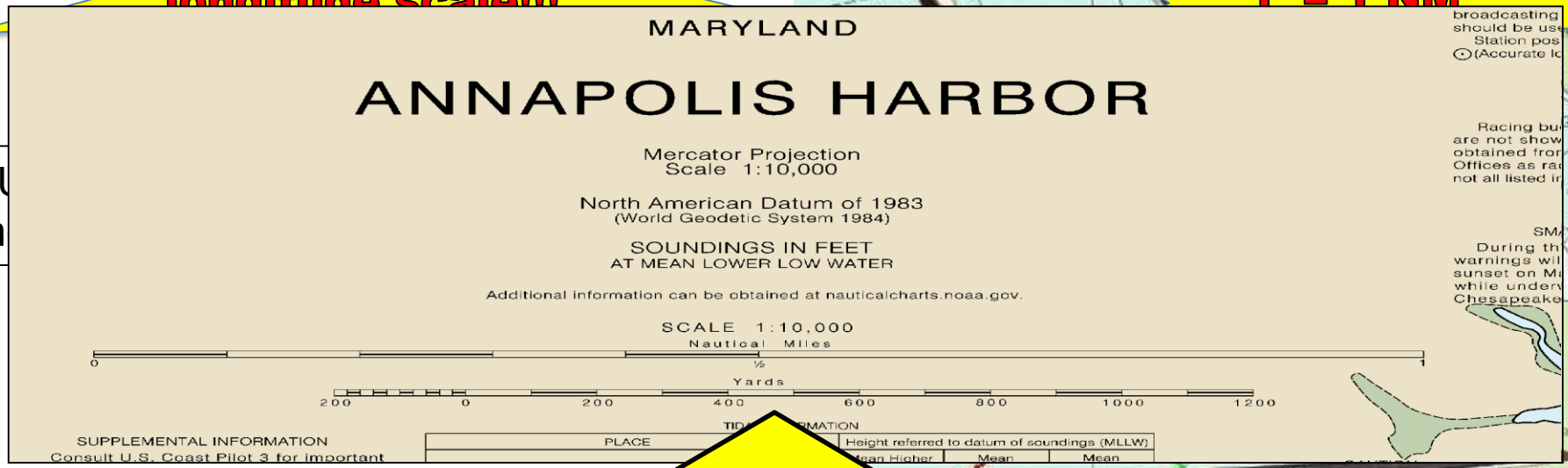
Compass: Used for plotting and measuring distances or latitude and longitude.

Divider: Used for measuring distances or latitude and longitude.

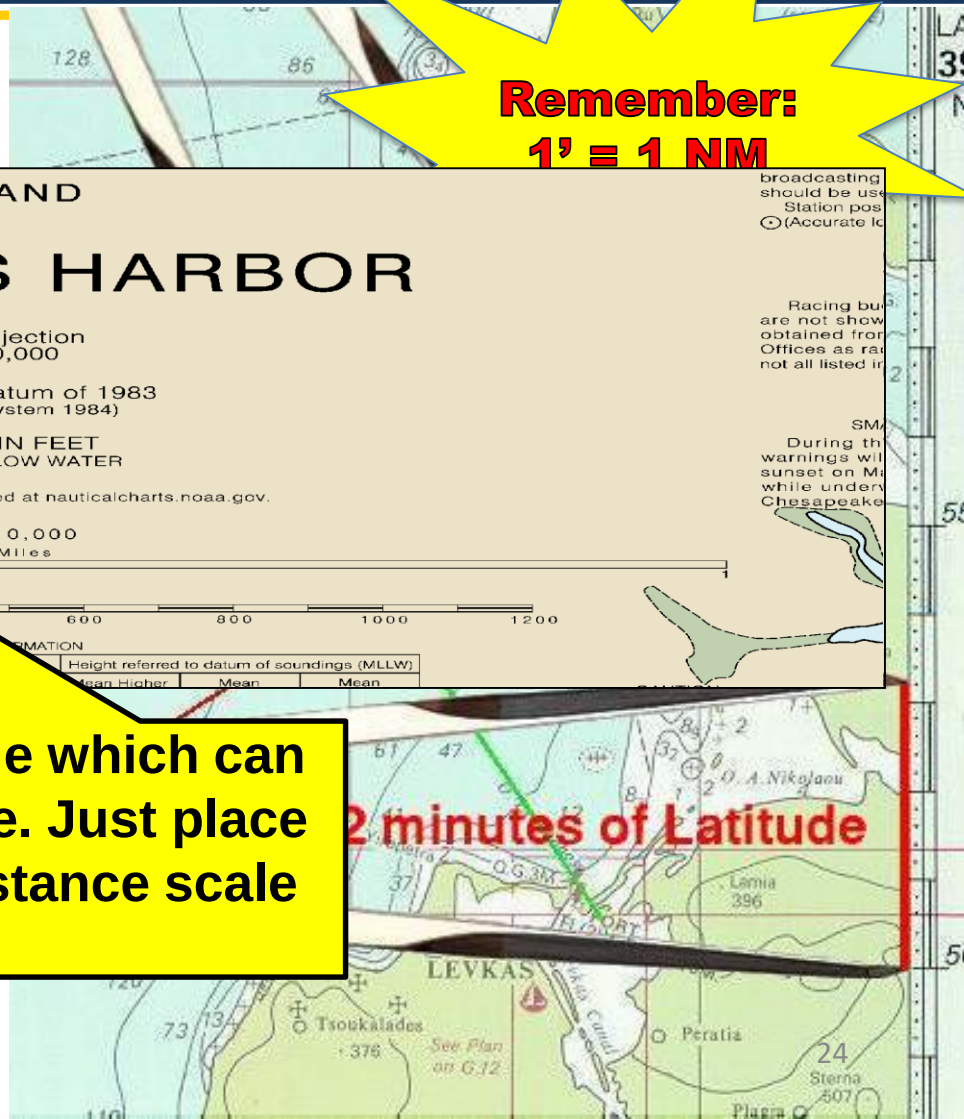
Reading Distance

Don't use the longitude scale!!!

Remember: 1' = 1 NM



Some charts have a distance scale which can be easier than using latitude scale. Just place the compass or divider on the distance scale to measure.



Plotting Latitude and Longitude

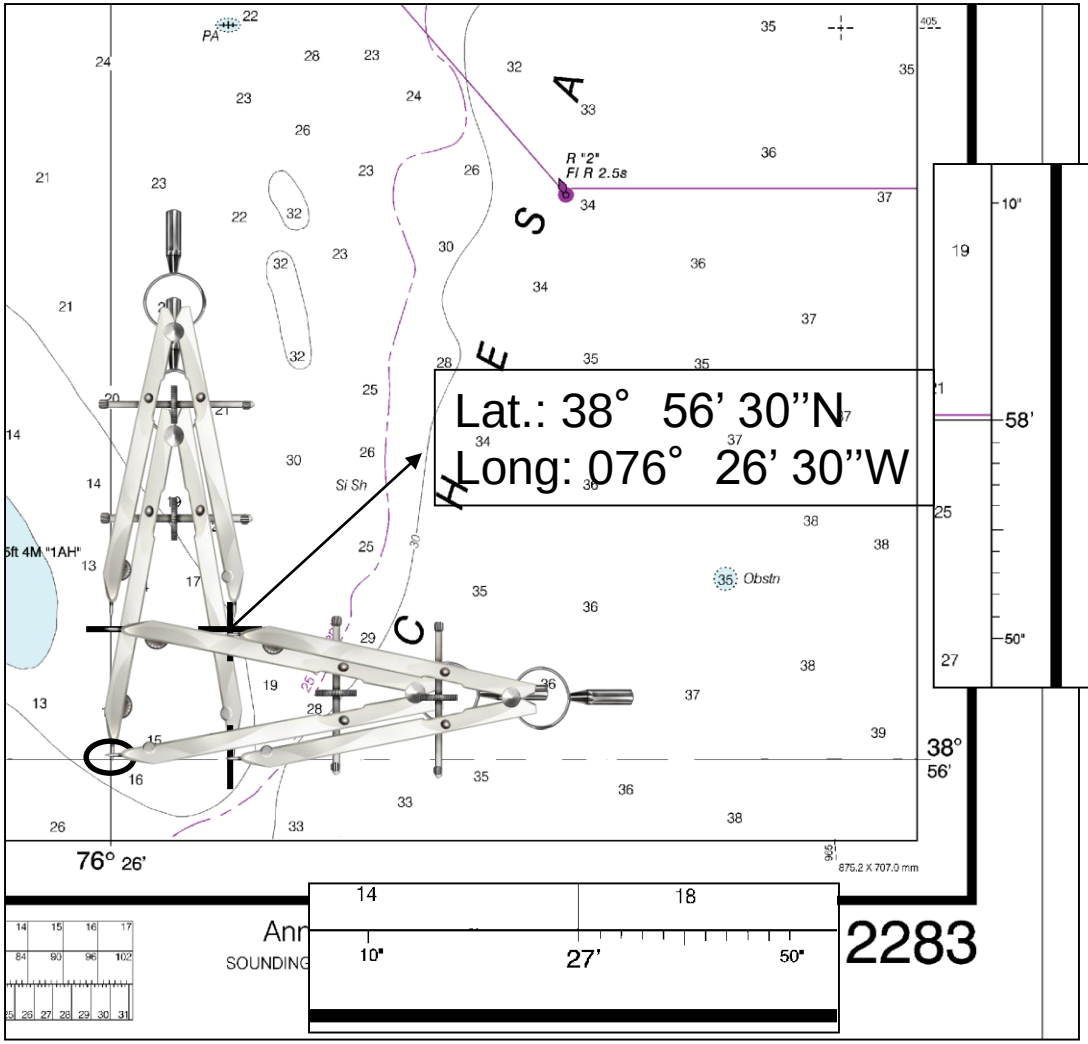
Plot: Lat.: 38° 56’ 30”N
Long: 076° 25’ 30” W

1 – Locate the closest intersection of a major meridian/parallel.

2 – Measure the longitude using minute/second scale and plot on the parallel.

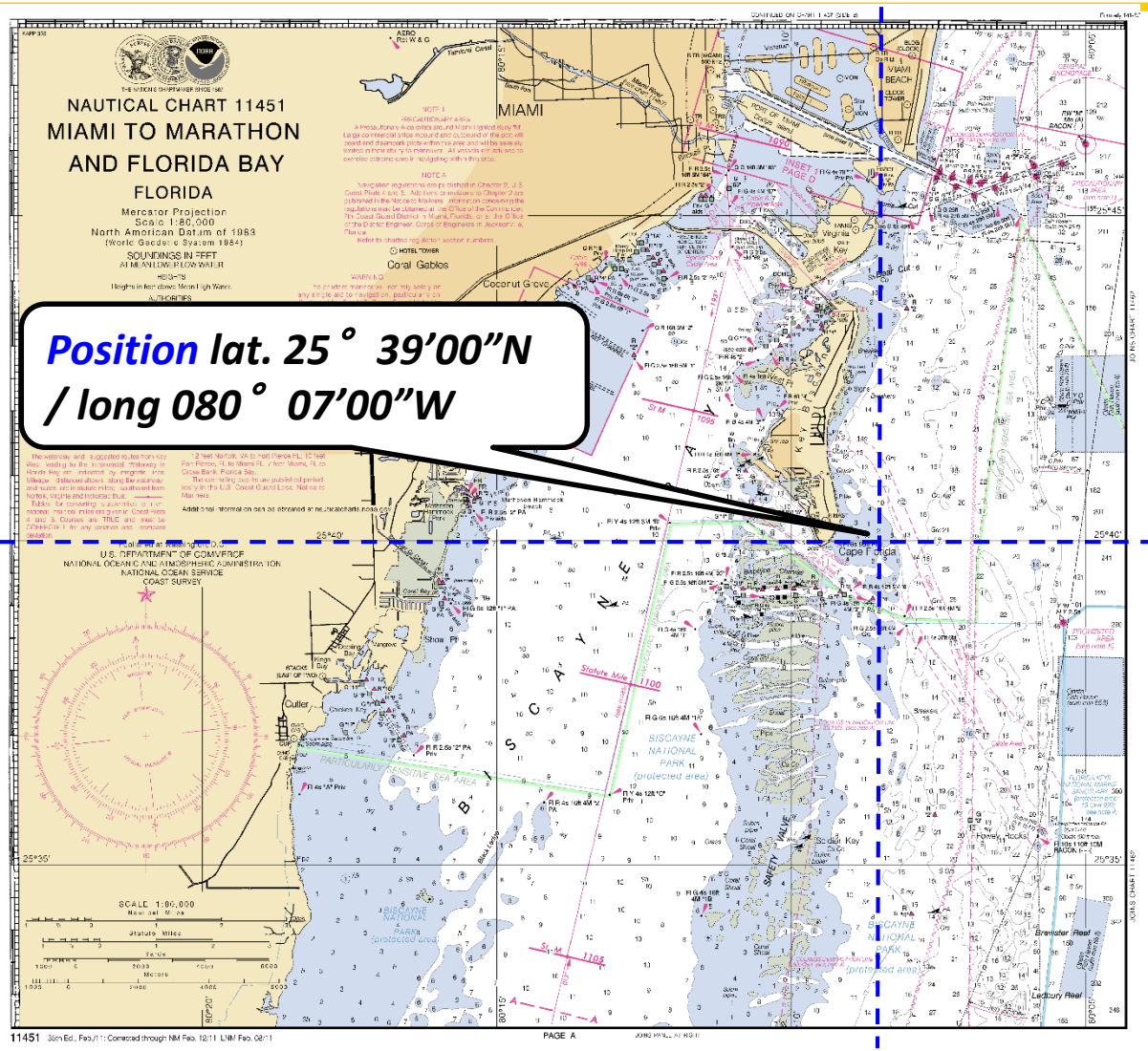
3 – Measure the latitude using minute/second scale and plot on the meridian AND from your previous mark.

4 – Using your longitude mark, plot the longitude from the latitude mark.



Reading Latitude and Longitude

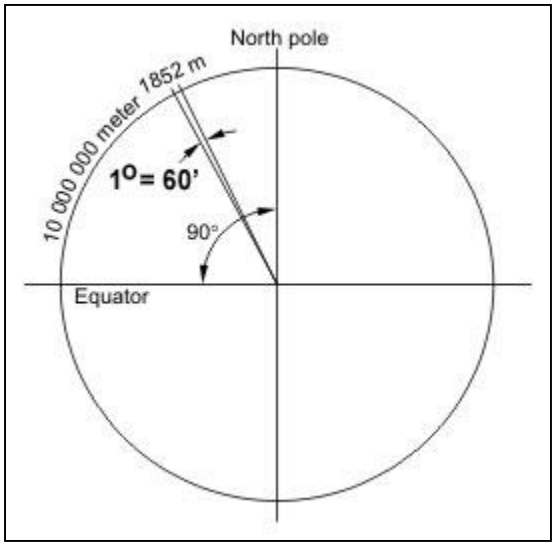
1° = 60’
1’= 60”



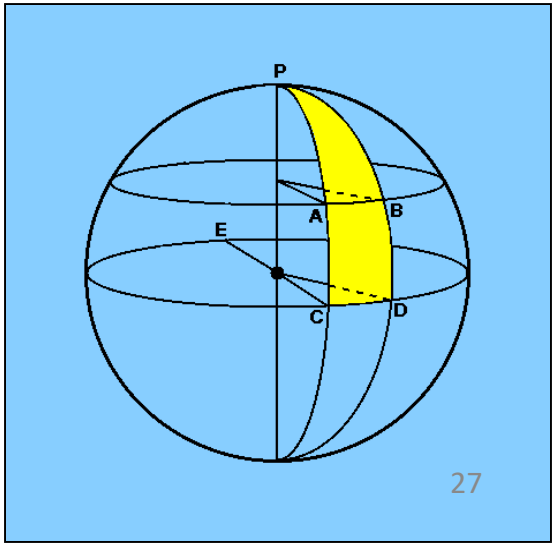
Reading Distance
Length of a Degree (Lat. / Long.)

- The length of a degree of latitude (measured along a meridian) is the same everywhere on Earth, and equals 60 NM (nautical miles).

1^o = 60 NM ➔ 1’ = 1 NM

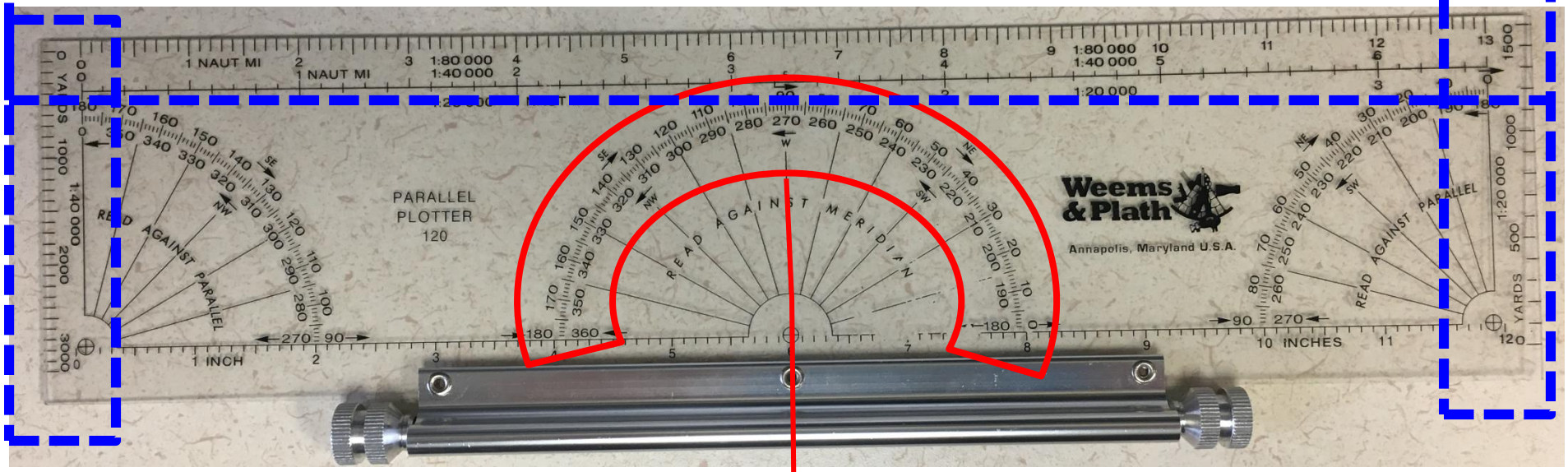


- The length of a degree of longitude (measured along a parallel) changes depending on the latitude.



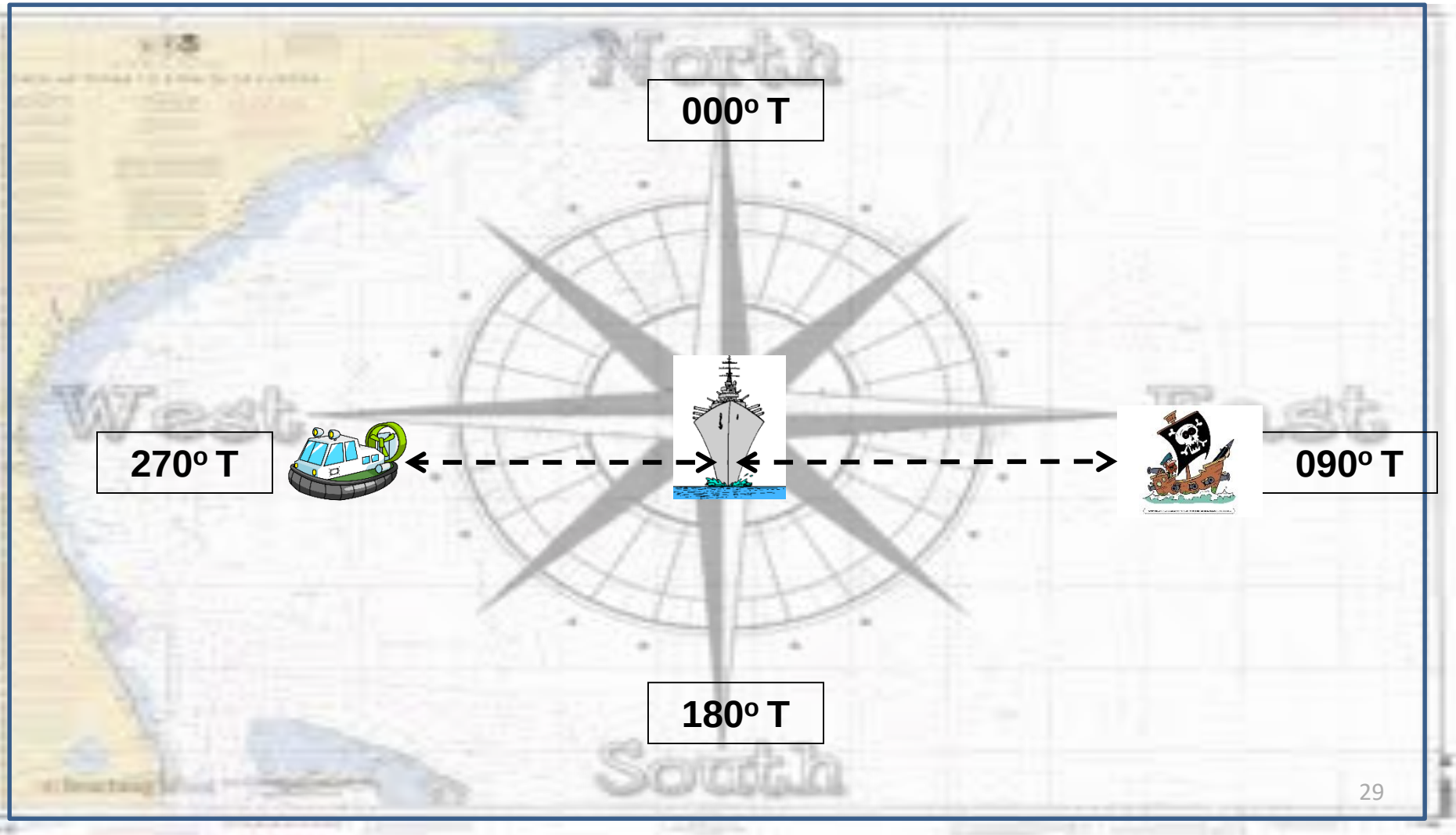
Navigation Tools
Slider Ruler

Scales for reading distances
(if it matches the scale of the chart)

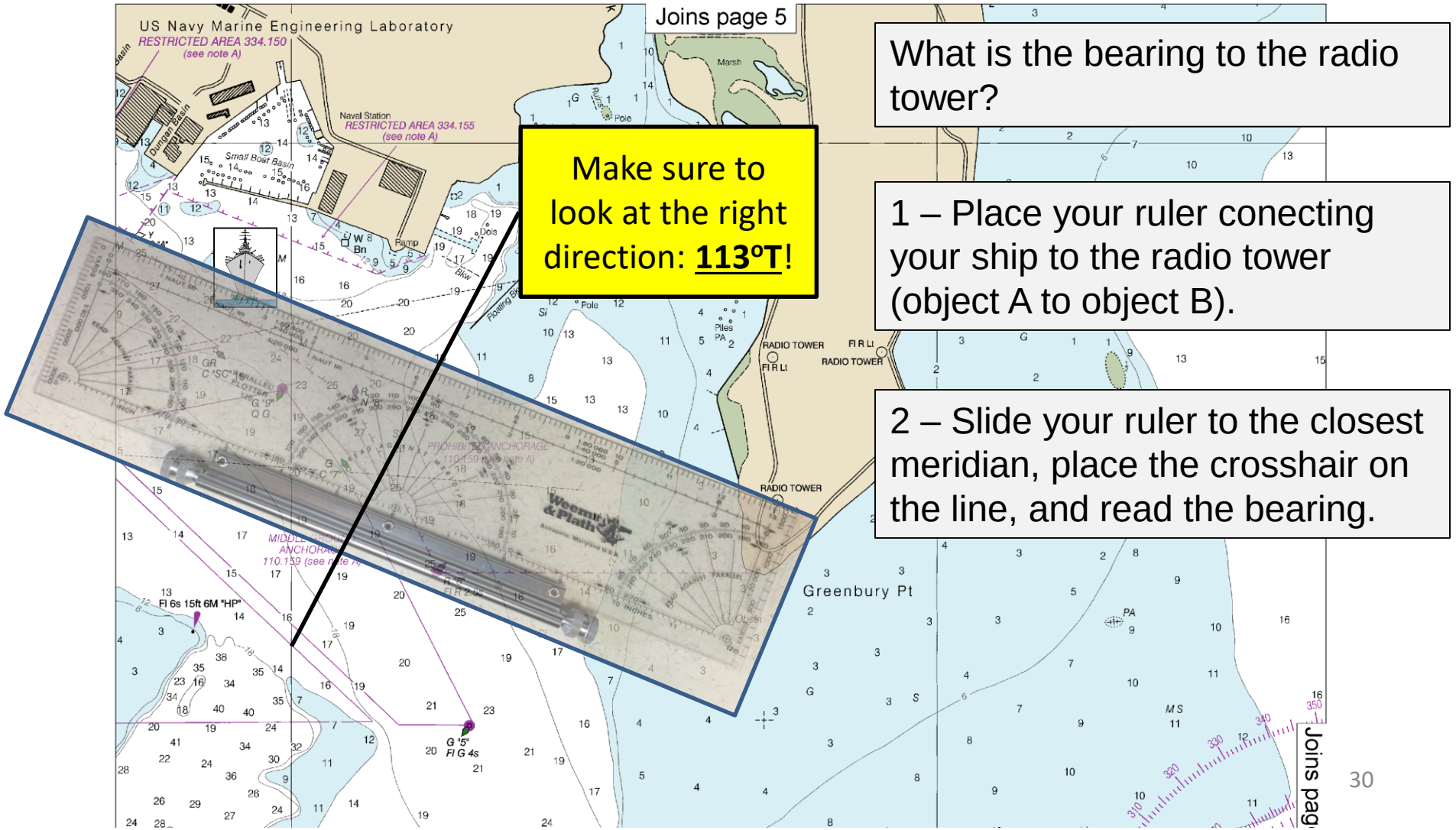


For reading direction in
DEGREES TRUE!

Reading Directions



Reading Directions



Make sure to look at the right direction: **113ºT**!

What is the bearing to the radio tower?

1 – Place your ruler conecting your ship to the radio tower (object A to object B).

2 – Slide your ruler to the closest meridian, place the crosshair on the line, and read the bearing.

Questions ?