

Oceanography 2

Lab 1– Location, Distance, and Direction on Charts and Maps

Due by 5 pm on Wednesday February 9.

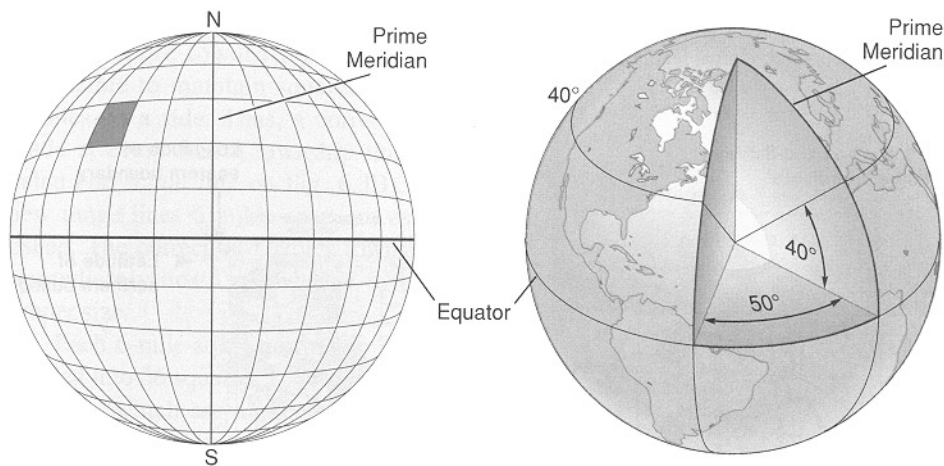
This lab is all about locating yourself on a chart or map and determining how far and in what direction you must go to get somewhere else. These are important skills indeed.

A chart is different from a map in that it shows the bathymetry (submarine topography) of a marine region rather than the topography of an on-land area. The map we will use is the Monterey, Calif. US Geological Survey (USGS) topographic map. The chart we will use is NOAA chart 18685 of Monterey Bay.

Answer the following questions for the Monterey Bay Chart or the Monterey topographic map, as appropriate.

I Location, location, location: all about Latitude and Longitude

Lines of latitude and longitude are used to locate positions on maps and charts. Lines of latitude are imaginary lines that run parallel to the equator. They are labeled by their angular distance north or south of the equator as shown below. Lines of longitude run from pole to pole and are labeled by their angular distance east or west of Greenwich, England. The north-south line that runs through Greenwich, England is known as the Prime Meridian.



Conventions for Describing Angles

The Degree

The degree is the basic unit of measure for an angle. There are 360° in a circle, the three angles of a triangle always add up to 180°, and a right angle is 90°.

Fractions of Degrees

Sometimes, we need to describe fractions of degrees, like when we are describing location on the surface of the Earth in terms of angular measurements. This is done in several different ways, three of which you will encounter in this lab. They are:

1. Decimal Degrees: These are normal decimal units using tenths, hundredths, thousandths, etc... The ArcReader program uses decimal degrees.

2. Minutes: Degrees are traditionally broken into units called minutes. There are 60 minutes in a degree. In other words, a minute is 1/60th of a degree. Minutes are in turn divided using one of two methods:

a. Decimal Minutes: the minutes are broken into decimal units using the usual tenths, hundredths, thousandths, etc... The Monterey Bay NOAA Nautical Chart uses degrees and decimal minutes.

b. Seconds: There are 60 seconds in a minute. In other words, a second is 1/60th of a minute. The USGS Monterey, CA topographic map uses degrees, minutes, and seconds.

Designating East or West of the Prime Meridian and North or South of the Equator

1. Decimal Degrees use

positive numbers to designate areas *north* of the equator,

negative numbers to designate areas *south* of the equator,

positive numbers to designate areas *east* of the Prime Meridian.

negative numbers to designate areas *west* of the Prime Meridian, and

Use of positive or negative signs (“+” or “-“) are **required** when describing angles using the decimal degree system.

2. Minutes use

the letter “N” to designate areas *north* of the equator,

the letter “S” to designate areas *south* of the equator,

the letter “E” to designate areas *east* of the Prime Meridian, and

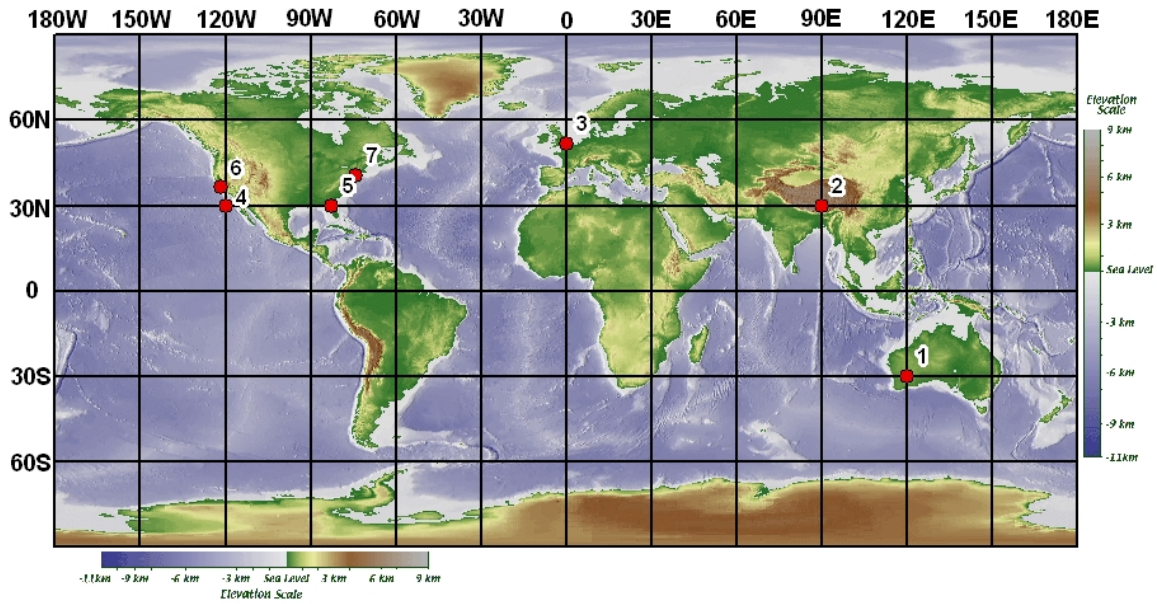
the letter “W” to designate areas *west* of the Prime Meridian.

Use of the letters “N”, “S”, “E”, or “W” are **required** when describing angles using the minute system.

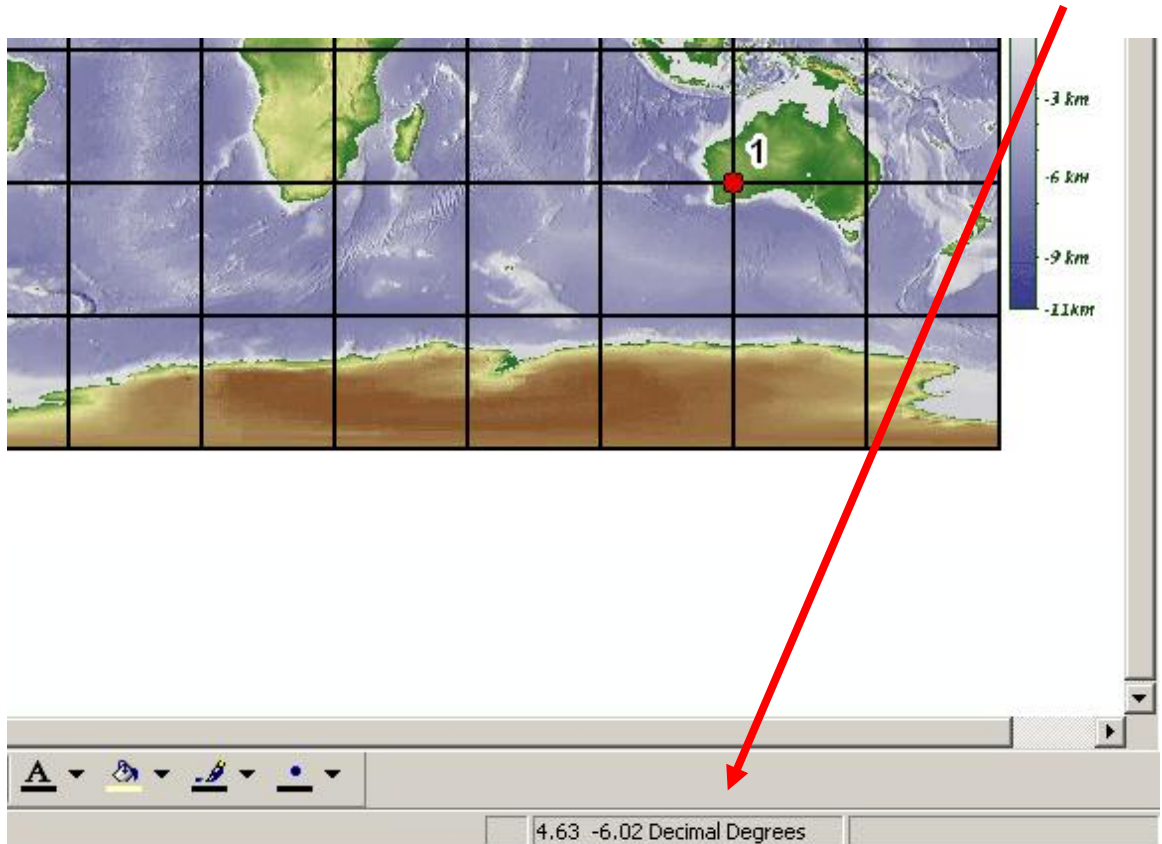
The table below shows three examples of longitudes using each of the three systems.

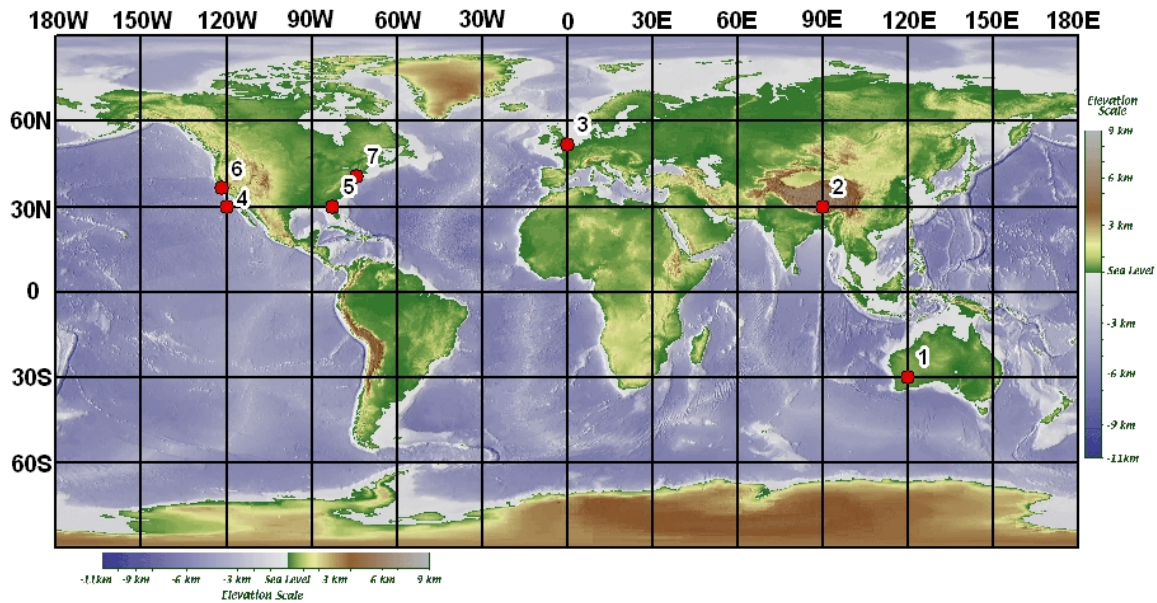
	Decimal Degrees	Degree--Decimal-Minutes	Degree-Minute-Second
Where used	GIS/GPS computer programs	NOAA Nautical charts	USGS topographic maps
	-121.5°	121° 30.0' W	121° 30' 0"W
	-121.75°	121° 45.0' W	121° 45' 0"W
	-121.7625°	121° 45.75' W	121° 45' 45"W

Use the computer to look at the ArcReader file LatLon.pmf. It will look like this:



In ArcReader, move the cursor around to see how the latitude and longitude changes throughout the map. To see the longitude, look at the box on the bottom of the screen.





1. Using the computer, and/or the image above, record the latitude and longitude for each of the locations above (also presented in the ArcReader layer “locations”). Record them using both the decimal degree system and the degree-minute system. For this problem only, assume all the minutes in the answers are equal to zero. The first one is done for you.

Location	Decimal Degrees (like in ArcReader)		Degrees-Minutes (like on the NOAA Charts)	
	Longitude	Latitude	Longitude	Latitude
1	+120.0°	-30.0°	120° 0.0'E	30° 0.0'S
2	90.0°	30.0°	90° 0.0'E	30° 0.0'N
3	0.0°	52.0°	0° 0.0'E/W	52° 0.0'N
4	-120.0°	30.0°	120° 0.0'W	30° 0.0'N
5	-82.0° or -83.0°	30.0°	82(3)° 0.0'W	30° 0.0'N
6	-122.0°	36.0°	122° 0.0'W	36° 0.0'N
7	-74.0°	41.0°	74° 0.0'W	41° 0.0'N

The exact same lines of latitude and longitude from the image on the previous page are shown in this view, as if the Earth were seen from space.



3. On the image above, label the equator and the prime meridian. **The equator is the east-west line that runs through the northern part of South America; the prime meridian is the north-south line that runs through the western part of north Africa.**

4. On the image above, label all visible lines of longitude and latitude using the degrees north or south of the equator and degrees east or west of the Prime Meridian. They are the exact same lines of latitude and longitude as shown on the images on the previous page.

(this answer is not shown at the present time.)

If you need help, open the ArcReader file LatLonGlobe.pmf and use the cursor to help you figure out the latitudes and longitudes.

Get the Monterey Bay Chart

5. What are the latitudes and longitudes of the boundaries of the Monterey Bay chart? Note that on the Monterey Bay chart, the divisions of minutes are given in tenths of minutes, not seconds. Complete the table. Be sure to include a “N” or “S” for latitudes and an “E” or “W” for longitudes, as appropriate. These letters are part of the answer.

Map boundary	Monterey Bay chart
Western	Longitude: 122°06.4'W
Northern	Latitude: 37° 02'N
Southern	Latitude: 36° 34.6'N

6. Why do the longitude numbers increase to the west on the chart?

Because Monterey Bay is West, not East, of Greenwich, England.

7. On the Monterey Bay Chart, what is the latitude and longitude of the following places? Don't forget the “N”, “W”, “E”, or “S” where appropriate.

Place	Latitude	Longitude
Pt Pinos lighthouse	36° 37.0'N	121° 56.0'W
Pt Santa Cruz lighthouse	36° 57.1'N	122° 1.5'W

8. What feature is described by the following latitudes and longitudes?

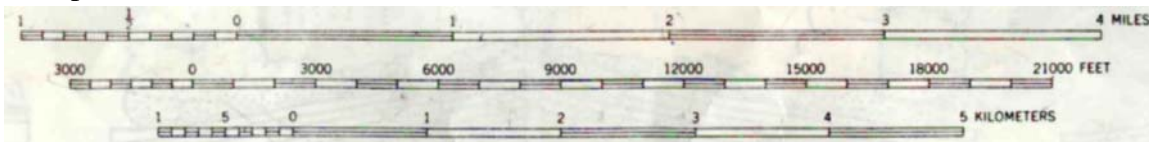
Latitude	Longitude	Location
36° 36.7'N	121° 57.4'W	Pt. Joe
36° 57.6'N	121° 58.5'W	Soquel Point
36° 36.3'N	121° 53.5'W	Fisherman's Wharf (or Municipal Wharf #1)

II Scale -- Measuring distance

The ratio of distance on the map to actual distance on the earth's surface is the **scale**. Three kinds of scales are typically used.

The first is a **fractional scale** such as 1:100,000 where the first number on the map is equal to the second number on the Earth using any scale of measurement. As an example, 1:100,000 means that 1 inch, foot, millimeter, or finger length on the map is equal to 100,000 inches, feet, millimeters, or finger lengths on the surface of the Earth.

The second is a **bar scale**. The bar scale shows graphically how far some measure of distance is on the map. They can be used like a ruler. The diagram below is an example of a bar scale.



A third type of scale, not provided on map legends, is a **verbal scale**. A verbal scale relates a unit of measure useful on the map itself (inches, centimeters, millimeters) to a unit of measure useful on land (feet, miles, yards, kilometers). Note that on the example above, each mile measures about an inch on the printed page. Thus, the verbal scale would be “an inch to a mile.” The verbal scale is more informal than a fractional or bar scales.

8. Using ArcReader, look at the map in LatLon.pmf. Go to View>Bookmarks>Full View. Look at the fractional scale box near the top of the screen (please ask if you can't find it). What is the fractional scale of this view? [On my computer it is 1:207,562,128.](#)

9. Enter the number 1:100,000,000 into the fractional scale box. What happens? Do you see more detail, or less? [The view zooms in. I see more detail.](#)

10. Enter the number 1:50,000,000 into the fractional scale box. What happens? Do you see more detail, or less? [The view zooms in. I see more detail.](#)

Comparing these two scales to each other....		Circle one
smaller scale,	1:100,000,000, shows	More detail OR less detail
Larger scale,	1:50,000,000, shows	More detail OR less detail

Note the correspondence between “smaller scale” and “larger scale” as the “fraction” gets bigger (i.e., goes from 1/100,000,000 to 1/50,000,000).

11. What is the fractional scale Monterey Bay chart [1:50,000](#), and the Monterey topographic map [1:24,000](#)?

12. Find the United States landform map on the left side of the classroom (near my office). What is its fractional scale? [1:3,500,000](#) Does it show more or [less detail](#) per square mile than the Monterey Bay chart or the Monterey topographic map?

13. Is the landform map a larger scale or [smaller scale map](#) than the Monterey Bay chart and the Monterey topographic map? Why? [Because the fraction 1/3,500,000 is smaller than 1/50,000 or 1/24,000; the landform mp shows less detail than either of the Monterey area maps.](#)

14. What might be a useful verbal scale for the Monterey Bay chart? You can use either nautical miles or yards.

[1.5"=1 nautical mile, or 2 cm = 1000 yards](#)

For the following three questions, use a ruler or your fingers, and the bar scale, to *estimate* the distance between the two given points.

15. On the Monterey topographic map, how far is it, in miles, from Whalers Knoll at Pt Lobos to Fisherman's Wharf? [About 7 miles](#)

16. On the Monterey Bay chart, how far is it, in nautical miles, from Pt Pinos to Pt Santa Cruz? [About 19 nautical miles](#)

17. On the Monterey Bay chart, how far is it, in yards, from the tip of Municipal Wharf #1 to the tip of Municipal Wharf #2. Use the inset in the lower right corner for this question. [~250-275yards](#)

III Direction

Directions are traditionally given as an angle measured in degrees clockwise from true north. Thus, 0° is north, 90° is east, 180° is south, 270° is west, and so on. A specific direction is often referred to as a **bearing**. A bearing refers to the direction from one specific place to another specific place. Use the parallel rulers and the rose diagram on the Monterey Bay Chart to answer the following questions.

18. What is the bearing from the Pt. Pinos lighthouse to the mouth of the Salinas River?
42 degrees

19. What is the bearing from the stacks at Moss Landing to Lovers Point?
210 degrees

20. What is the bearing from Lovers Point to the stacks at Moss Landing?
30 degrees

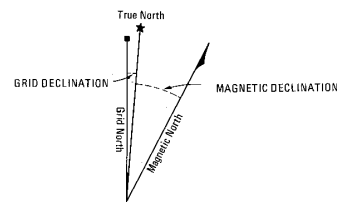
IV Declination

The magnetic north pole is located northern Canada, near Hudson Bay. It is not located at the pole of rotation (i.e., the imaginary line around which the Earth rotates), commonly referred to as “true north.” Thus, compass needles do not point directly to true north. Instead, they point towards the magnetic north pole. At any point on the globe, the difference in the direction between true north and the magnetic pole is called the **declination**. The declination is an angle and is expressed in degrees. Note how declination is shown on the Monterey topographic map and the Monterey Bay Chart.

21. Reproduce in a sketch here the diagrams used to depict the declination on the Monterey Bay Chart and on the Monterey topographic map.



The diagram on the left is similar (but not identical) to the declination diagram on the marine chart (it is called a compass rose). The diagram on the right is from a USGS topographic map.



22. The magnetic north pole is located at latitude $+82.7^\circ$ and longitude -114.4° . What process causes the magnetic north pole to be located at this location?

The Iron core of the Earth simulates a bar magnet with a pole that is not exactly at the Earth's pole of rotation. The flow of liquid iron in the Earth's outer core influences the position of the magnetic poles.

23. What is the latitude and longitude of the true north pole?

Latitude = 90 degrees North. Longitude: any of them; they all meet at the true north pole.

24. What process causes the true north pole to be located there? It is the location of the imaginary pole or axis around which the Earth rotates.



In the image above, the positive numbers show areas where the declination is to the *east* and the negative numbers show where the declination is to the *west*. (There is a color version of this image available from the class website.)

25. Please complete the table below, listing the declination for various North American regions. The first one is done for you.

	Declination (in degrees)	Drawing of Declination (Like on the USGS topo map)
Greenland	35°W	See instructor for answer here; Haven't gotten a drawing into this document yet.
Boston	16°W	See instructor for answer here; Haven't gotten a drawing into this document yet.
Cabo San Lucas	10°E	See instructor for answer here; Haven't gotten a drawing into this document yet.
Monterey Bay	16°E	See instructor for answer here; Haven't gotten a drawing into this document yet.
Valdez	24°E	See instructor for answer here; Haven't gotten a drawing into this document yet.

26. The diagram above shows that the declination varies from place to place on Earth in a regular and predictable way. Why does the declination vary so predictably as shown here? Please explain. The magnetic and rotational (or true) north poles are in specific and known places; they do not move. Thus we can predict and calculate the angle between the directions between the two locations (i.e., the declination) for any place on Earth. The variation in the declination is thus predictable. Along the western United States, the declination angle is to the east, and it will get bigger as the distance to the north or west is increased. In the eastern United States, the declination angle is to the west, and it will get bigger as the distance to the north or east is increased.