The Oceans: Monterey Bay, Metric Units and Charts

Name _____ TA & Section _____

Date _____

Conversion Table

1 fathom = 6 feet
100 fathoms = 1 cable length
10 cables length = 1 nautical mile
1 nautical mile = 1.151 statute miles (length of a minute of longitude at equator)
3 nautical miles = 1 league
1 knot = 1 nautical mile per hour = 1.151 statute miles per hour
10 chains = 1 furlong = 201.17 meters
60 nautical miles = 1 degree of a great circle of earth (latitude)
1 statute mile = 5280 feet
1 nautical mile = 6076.115 feet

The **Metric System** of weights and measurements is used worldwide. In most parts of the world, it is the only system. In the United States, it is used for all scientific work, and occasionally for consumer products as well. The system is based on the following units:

Unit of length: the meter (m)
Unit of mass or weights: the gram (g)
Unit of volume: the liter (L)
Unit of temperature: the Celsius degree (^{o}C)

Metric units are also commonly referred to as SI units, for *Système Internationale* (or International System, in French).

Note: Statute miles is what we know as miles and is a measurement of distance over land. Nautical miles is a measurement over water.

Origin of Nautical Terms—If you saw the movie "Master and Commander", you might remember some of these methods.

Fathom - Sailors use to throw a line into the water, wait until it hit the bottom, pull it back up, while measuring the length of the line from finger tip to finger tip. The arm span of an average sailor was 6 feet and was called a fathom.

Knot - Lines use to be thrown over the sides of ships to determine speed. Each line was divided into 47 ft. 3 in. sections and were called knots. The line was allowed to run over the ship's side while a 28-second sand glass was emptying itself. The length of the knot was derived from the proportion that one hour (3600 sec) is to 28 seconds as one mile (6076.115 ft.) is to the length of one knot (47 ft. 3 in.).

Though it is not part of the metric system, the **nautical mile** (nm) remains a commonly used unit of length for ocean-going crafts. It represents 1/60 of a degree latitude (also known as 1 minute of latitude). We often use the conversion that 1 knot is 1 nm/hour.

PART 1. Unit Conversions. In this class, we will frequently need to convert from one set of units to another. You might also see different units for the same thing (for example, knots versus miles per hour). This first assignment will give you some practice with conversions.

Questions:

1) How many feet are in a nautical mile? How many feet are in a meter?

2) How many feet are in a league? How many nautical miles in a league?

3) What is your height in feet and meters (you can use the meter sticks available in the classroom)?

4) Convert the deepest point in the ocean, the Marianas Trench at a depth of 35,802 feet, to fathoms, leagues, and meters.

5) The largest and fastest marine fish is the bluefin tuna weighing 1,500 pounds and swims up to 55 miles per hour. How fast is this in knots?

6) A typical research vessel travels at a top speed of 12 knots, while a fast ship, such as a ferry, often travels at speeds up to 30 knots. What are those speeds in miles per hour? How does this compare to a Bluefin tuna?

7) Convert 20,000 leagues to miles. Is it possible for such depths to occur in the ocean?

PART 2: Navigating Monterey Bay – latitude, longitude and bathymetry (work in groups of 2 or 3). List co-workers:

_____

_____

_____

For this exercise, we are going to get a little more familiar with where Monterey Bay is, and how we convert 3-dimensional data, such as the Earth, into 2-dimensional maps and charts.

Work in Groups of 2-3. Take a map and the additional materials back to your lab bench. Please return the map and materials to the station when you have finished. Though it is not part of the metric system, the nautical mile (nm) remains a commonly used unit of length for ocean-going crafts. It represents 1/60 of a degree latitude (also known as 1 minute of latitude). The knot is also commonly used for velocity and signifies a speed of 1 nm/hour.

1) What island does the prime meridian (0 longitude) pass through? _____ How many degrees longitude is the earth divided into? _____ How many degrees latitude? _____ Where is 0 degrees north latitude? _____ What is the latitude of the South Pole? _____

2) Find Santa Cruz on the map. At what longitude _____ and latitude _____ is Santa Cruz (approximately) located?

3) In your boat you decide to head on a direct course to Pt. Sur. How far is it to Pt. Sur in nautical miles? _____ in statute miles? _____ in km? _____

4) If you travel at 5 knots, how many statute miles/hour are you traveling? _____ How many meters/second? _____ How long does it take you to reach your destination? _____

5) Over what major feature of the ocean floor do you pass along the way? _____ Roughly, how deep is the deepest point along your journey (in m)? _____

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Part-2: HOMEWORK- due next section

NOTE: it is to your advantage to stay and start these problems in section if you can- get TA's help to make sure you understand them!

YOU MUST SHOW ALL WORK TO RECEIVE FULL CREDIT!

Activity 1: Metric System and Scientific Notation

1) The Metric System

Table 1: Common conversion factors

gallons/liters	1 U.S. gal. = 3.8 L
yards/meters	1 yd = 0.914 m
ounces/grams	1 oz = 28.35 g
pounds/grams	1lb = 454 g
miles/kilometers	1 mi = 1.609 km
hectares/acres	1 ha = 2.47 acres
square miles/acres	1 square mile = 640 acres

To convert areas you can square the length units. For example to convert 3 square yards to square meters use the following conversion:

$3yd^2 \times (0.914m / 1\,yd)^2 = 3yd^2 \times 0.914^2 m^2/1^2 yd^2 = (3 \times .835)m^2 = 2.506\ m^2$

Similarly, you can convert volumes by cubing the length units.

1) Convert 5 yd^3 to cubic meters.

2) Using the fact that 1000 L = 1 cubic meter, convert your answer in (1) to liters.

Table 2: Metric System conversion factors

kilometers/meters	1 km = 1000 m
meters/centimeters	1 m = 100 cm
centimeters/millimeters	1 cm = 10 mm
millimeters/micrometers	1 mm = 1000 μm
metric tonne/ kilograms	1 metric tonne = 1000 kg
kilograms/grams	1 kg = 1000 g
grams/milligrams	1 g = 1000 mg
cubic meters/liters	1 cubic meter = 1000 L
liter/ milliliters	1 L = 1000 ml

3) How many micrometers in a meter?

4) How many grams in a metric tonne?

5) How many liters in a cubic centimeter?

6) How many acres in a square kilometer?

Scientific Notation

We convert very large or small numbers to scientific notation in order to shorten them and to make them easier to manipulate in expressions. For example:

$19{,}000{,}000 = 1.9 \times 10^{7}$
$0.0000000756 = 7.56 \times 10^{-8}$

7) Write one billion (1,000,000,000) in scientific notation.

8) Write 276,000,000 in scientific notation.

9) Write 0.00000000602 in scientific notation.

We can also use metric prefixes to express numbers. Some common metric prefixes are in Table 3 below.

Table 3: Metric prefixes

1,000,000,000,000,000	10^{15}	Peta (P)
1,000,000,000,000	10^{12}	Tera (T)
1,000,000,000	10^{9}	Giga (G)
1,000,000	10^{6}	Mega (M)
1,000	10^{3}	kilo (k)
0.01	10^{-2}	centi (c)
0.001	10^{-3}	milli (m)
0.000001	10^{-6}	micro (μ)
0.000000001	10^{-9}	nano (n)

10. Expressing your answers in scientific notation, convert 4.19 mm to:

A. nm

B. μm

C. cm

D. m

E. km

Be sure that you know how to multiply, divide, add and subtract numbers in scientific notation. You may use a calculator.

<u>Activity 2: Presentation of data</u> – Time series and contour maps (work independently)

The National Oceanic and Atmospheric Administration (NOAA) operates the National Data Buoy Center (NDBC) which maintains a network of moored buoys along our coast and in the open ocean. Several instruments are mounted on each buoy to collect data for various oceanographic and atmospheric studies and improve weather forecasts. An example of a buoy and a map of the buoys for a region of the central California coast is shown below.

1) Using the website www.ndbc.noaa.gov, Which NDBC buoy is located closest to Santa Cruz (note that there are non-NDBC buoys also)? _____

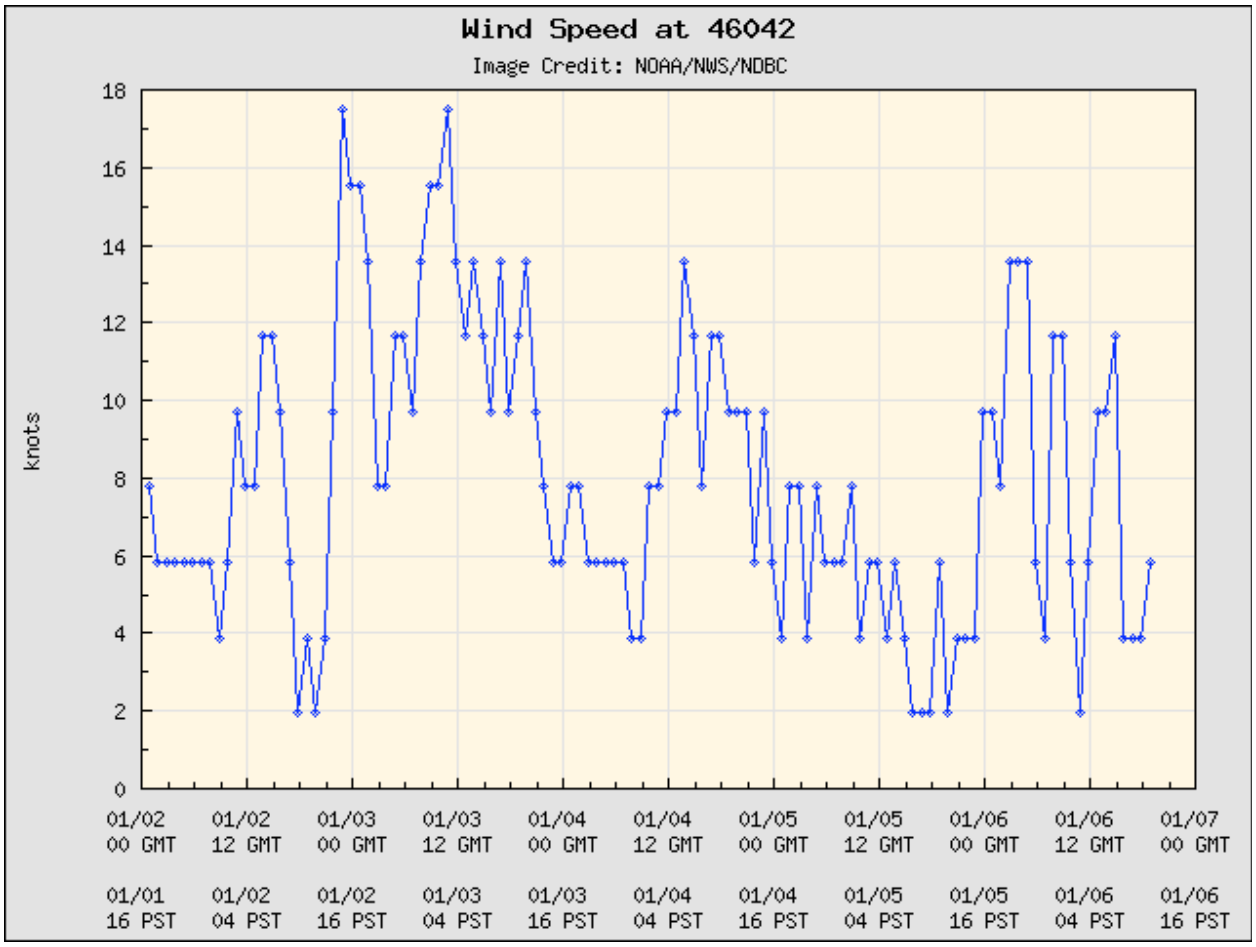
2) One way to represent data collected at such buoys is called a **time series**, in which a quality is plotted versus time. A time series of wind speed at one buoy is shown on the next page. This data was collected last week from a buoy moored just outside of Monterey Bay.

   In **m/s**, what was the maximum wind speed recorded at this buoy during the 5 day period? (Recall: 1 knot = 0.51 m/s)

   What is the minimum wind speed recorded in **m/s**?

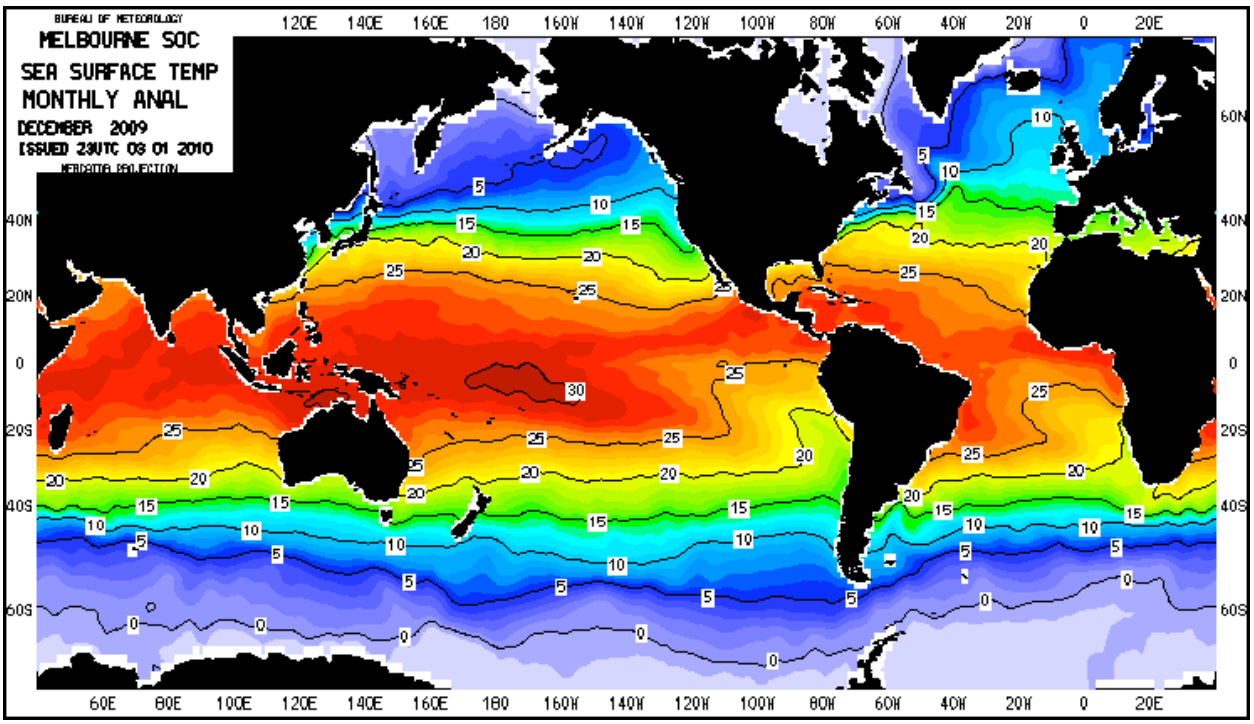
   When did they FIRST occur in local (Pacific) time? _____ (max) _____ (min) (Note that GMT stands for Greenwich Mean Time, and represents the time in Greenwich, England which is 8 hours ahead of us in Santa Cruz, so you'll have to convert from GMT to local time.).

Roughly, what was the average wind speed recorded at the buoy? _____ _____



More information about the buoys can be found at
http://www.ndbc.noaa.gov/rmd.shtml

Sometimes, data is collected along 2 spatial dimensions, and is presented in the form of a **contour map**. You have already used one example of such a map, of bathymetry, in Activity 2. But maps are also useful in presenting other forms of data. On the next page is an example of the average sea surface temperature (in ^{o}C) over the global ocean for the month of December, 2009. Note that if you printed it out in grayscale (rather than in color) dark shades correspond to both cold and warm temperatures. To get precise readings of temperature, use the contour intervals and notice that grayscale shades vary every 1 degree, which provides additional information. If you are having trouble seeing this, visit the website below for a color version of this map: http://www.bom.gov.au/climate/current/meansst.shtml



3) Approximately, what are the warmest _____ and coldest _____ temperatures shown and at what *latitudes* _____ (warm) _____ (cold) do they occur? At what *longitudes* do the warmest waters occur? _____

Why do you think the sea surface temperature contours roughly follow lines of latitude?

4) Roughly, at what latitude do you find 15° C water in the eastern North Pacific? _____
Roughly, at what latitude do you find 15° C water in the eastern South Pacific? _____
Explain why these differ (hint is in map legend)?

Activity 3: Working with Bathymetry.

Use the chart and plotting paper attached below. Express your answers to one decimal place and round appropriately. Be sure to include all units.

A contour map shows the three-dimensional features of the Earth's surface in two dimensions. Topography (on land) and bathymetry (at sea) can both be shown with contours. Contour lines shown in a bathymetric map are also called **isobaths**. Contours are lines that connect points of equal elevation. Thus if you were walking on a mountain (or on the bottom of the ocean) and stayed on a contour, you would not climb higher or lower as you walked. If a contour is labeled 100 m, then all points on the contour have an elevation (for a topographic map) or a depth (for a bathymetric map) of 100 m. The **contour interval** is the difference between two adjacent contour lines. For example, if there is one contour showing depth of 100 m and the next contour shows a depth of 150 m, then the contour interval is 150-100 = 50 m. Some maps use more than one contour interval so that they can show very detailed features that occur in one area, and coarser features that occur in other areas

1. The relative spacing of contour lines on a bathymetric map can be used to interpret the shape of the sea floor. What does the spacing of contours indicate about the slope of the seafloor in these three cases:

closely spaced contours indicate:

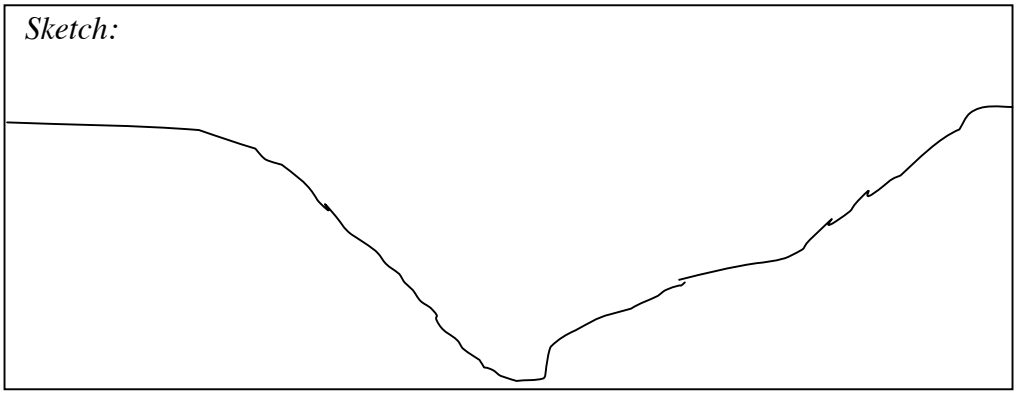
widely spaced contours indicate: .

change in contour spacing indicate:

2. A cross section drawn from a bathymetric chart represents a plot of **changing depth** on an X-Y graph, where the X- axis is distance along the profile, and the Y axis is depth. The cross-section shows you what a "slice" through the bathymetric chart would look like.

a. Look at the attached chart of Monterey Bay and in the space below sketch a rough cross section across Monterey Bay, from Monterey to Santa Cruz (along line A-B). Don't worry about getting depths exactly right; just show the basic shape of the profile. Mark the North and South ends of your cross section.

Sketch:



What is the primary bottom feature in the middle of the cross section:

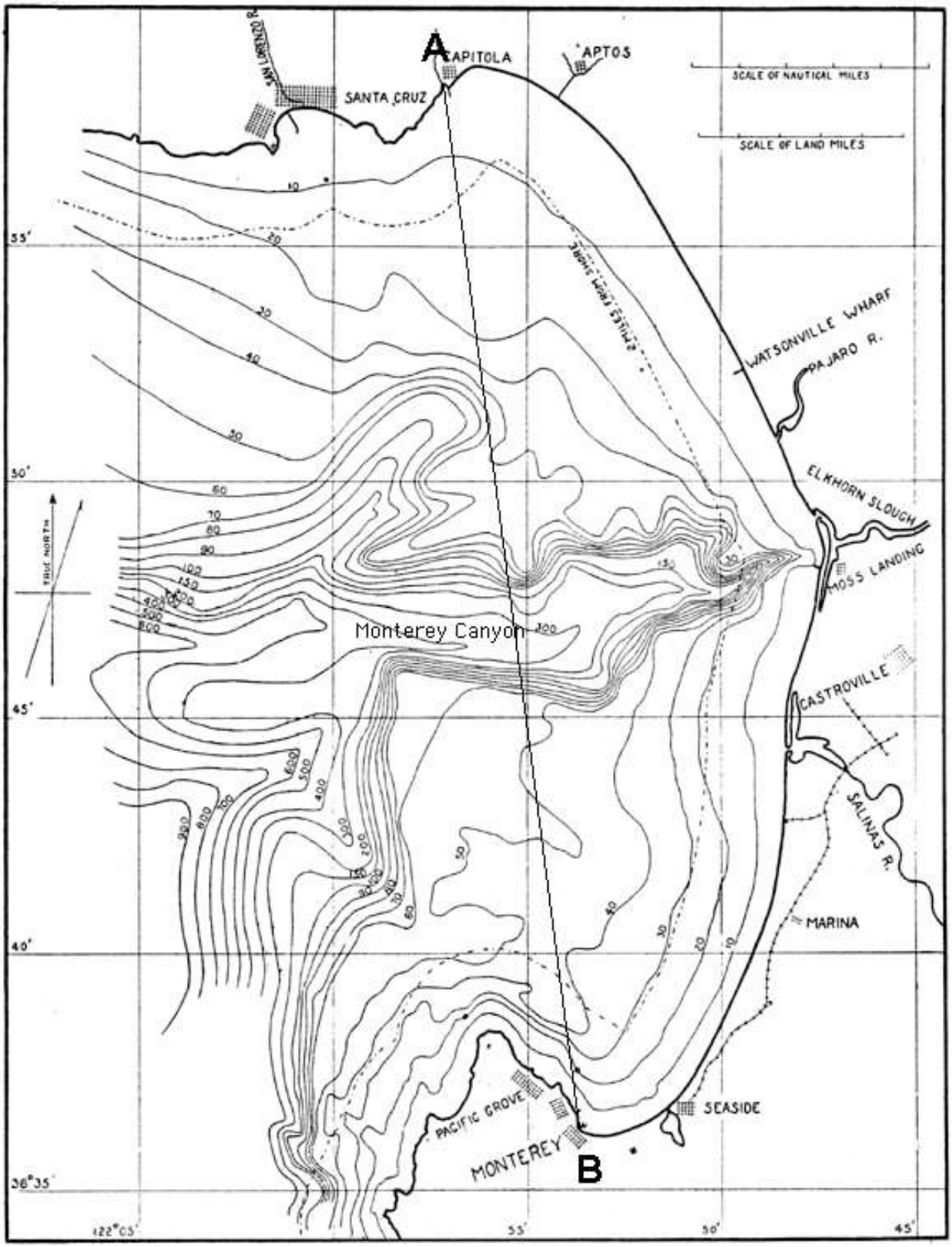
Approximately how far offshore from Moss Landing does this feature extend? Give your answer in kilometers and also in nautical miles.

Nautical mile:

Kilometers:

3. Now draw an accurate cross section showing the bathymetry of the sea floor along line A-B in the chart. This is the same feature you should have sketched in Question 2a, but this time use the labeled graph paper provided with this problem set.

The best way to complete this cross section is to use a ruler to find the distance along the transect at which you cross each contour, convert that to kilometers, then mark each of these locations with a dot on the graph paper. When you are done plotting all the dots, connect them with lines. Be sure to use all of the contour lines along profile A-B. Note that YOU MUST CONVERT THE DISTANCES AND DEPTHS TO KILOMETERS AND METERS!



Contour interval is 10 fathoms from shore to 100 fathoms, then every 50 fathoms to 200 fathoms, then every 100 fathoms.

For Plotting M. Bay Bathymetric data