# 4.61 Observing the Weather and Sea State

Wind, air pressure, temperature, precipitation (rain, snow), humidity, clouds, and other phenomena make up what we call weather. Created by complex interactions of solar energy, water, air, and motions of the earth, weather has a profound effect on our lives. It disrupts our plans, determines the abundance of our crops, influences the way we feel and act, and often changes the course of history. For these reasons and many more, accurate measurements and reliable forecasts of the weather are needed.

The oceans play a major role in creating weather. Water evaporates from the surface of the sea, forms clouds and returns to earth as precipitation. Warm water currents, such as the Gulf Stream, result in warmer climates wherever they come close to land. The temperature of the sea changes slowly, which moderates the seasonal temperature swings of coastal communities and gives them warmer winters and cooler summers than their inland neighbors. The difference in temperature between the sea and the land creates winds that blow toward the land in the daytime and toward the ocean at night. Warm, moist air blowing over the cool surface of the sea can create low clouds, which we call fog.

Hurricanes are an example of a particularly severe weather condition that forms on the ocean. They usually begin over the tropical Atlantic when an area of low air pressure becomes encircled by a ring of extremely strong winds, often reaching speeds of over 160 kilometers per hour. The low pressure area and its surrounding winds move northward at about 45 to 90 kilometers per hour (25 to 50 knots). Since the path of a hurricane is primarily over water, it encounters little resistance to slow it down or moderate its winds.

The ocean responds quickly and dramatically to weather conditions. The wind creates waves and currents, which mix oxygen into the water and stir up bottom sediments. Wind and changing barometric pressure can raise the sea level and cause the flooding of shore areas.

Precipitation and evaporation can change the salt concentration of the water. Changes in temperature can generate vertical movements of water and are one of the most important factors affecting marine life.

Man's relationship with the ocean is also influenced by the weather. High seas can sink ships, destroy waterfront property, and kill many people.

Fishermen, waterfront resorts, and beaches may have good or bad seasons depending on the weather. Boat operators may get lost if caught in the fog. Strong winds may cause sailboats to tip over, and no wind at all can ruin a sailboat race.

Knowledge about the weather can make the difference between life and death to anyone on a boat. Weather also has many major effects on the marine environment. This unit describes how to measure important characteristics of the weather: temperature, wind speed and direction, cloud type, cloud cover, air pressure, and relative humidity. You will also find instructions for measuring the effect of weather on the sea and a few simple rules of weather forecasting.

## Procedure

### Air Pressure

1. Above each *square centimeter* of the earth's surface is a column of air that weighs about 2.5 kg. When the atmosphere moves about, it changes in thickness and density. This causes a variation in the weight of the air on the earth's surface and in the pressure the air exerts on objects.

   Atmospheric pressure, or air pressure, is measured using a barometer. The precision barometer used in a laboratory consists of a long tube of mercury sealed off and evacuated at the top (Fig. 1). The open (bottom) end of the tube rests in a dish of mercury. The weight of the air exerts a force on the mercury, pushing it up into the tube. The changing air pressure, can be followed by noting the height of the mercury.

   Another kind of barometer, the kind you will most likely use, detects changes in the shape of a thin, elastic, metal disc that covers a partly evacuated chamber. This is called an aneroid (without liquid) barometer (Fig. 2).

   The outside of the barometer consists of a dial and a needle that points to the correct air pressure measured in millibars or millimeters (or inches) of mercury.

   Read the pressure in both millimeters (or inches) of mercury and millibars. RECORD these readings on your data sheet.

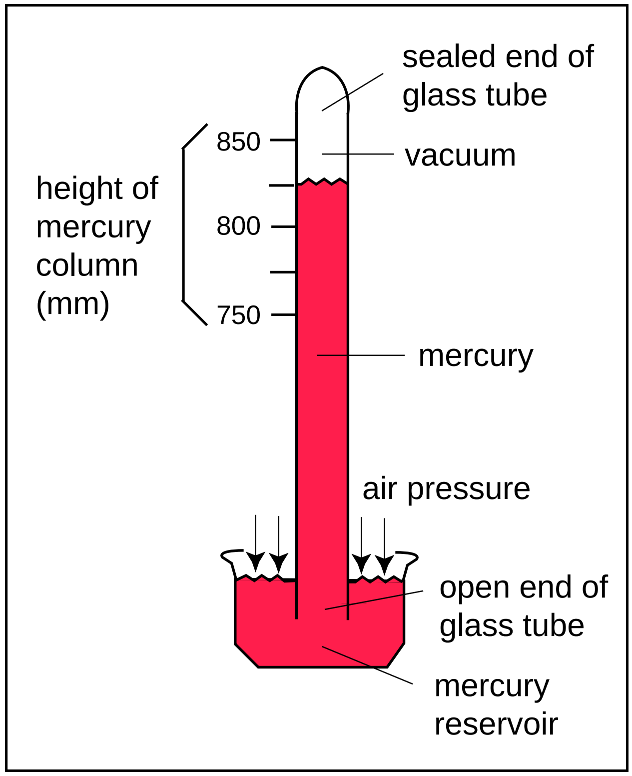



Fig. 1. Mercury barometers show air pressure as height of a column of mercury.

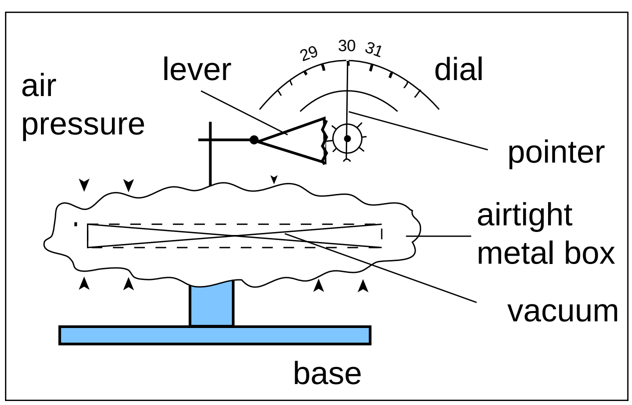



Fig. 2. The aneroid barometer detects changes in the shape of a thin metal disc.

UP
DOWN

2. Most barometers have a movable pointer in addition to the indicator needle. Line this pointer up with the indicator needle (Fig. 3).

   Look at the barometer again (in an hour, for instance). If the indicator needle is lower than the pointer, you will know the air pressure has dropped. In this case, RECORD the new pressure and draw an arrow pointing down next to it (indicating falling pressure). If the indicator needle is higher than the pointer, the pressure is rising. RECORD the new pressure and draw an arrow pointing up next to it. If the pointer and needle line up, the pressure has not changed.

   If possible, measure air pressure at regular intervals over a period of time. Make sure you RECORD the exact time you take a reading .

### Air Temperature, Relative Humidity, and Dew-Point Spread

1. Relative humidity is the ratio between the amount of moisture in the air and the amount of moisture the air is capable of holding. When air is completely saturated with moisture (relative humidity = 100%), the air is said to be at the dew point and the water vapor will begin to condense and form water droplets.

   The warmer the air is, the more water vapor it will hold before it becomes saturated. The cooler the air is, the less moisture it will hold before it becomes saturated. If a body of warm air only partially saturated with water vapor is cooled, it may eventually reach the dew point, and the moisture will condense as fog or precipitation. The difference between the actual temperature and the dew-point temperature is called the dew-point spread.
2. Air temperature, relative humidity, and dew-point spread are determined using a sling psychrometer (Fig. 4) or a hygrometer (Fig. 5). Both instruments have two thermometers. The bulb of one is wrapped in gauze and soaked in fresh water. When the water evaporates from the gauze, it cools the thermometer. If the air is quite humid, the rate of evaporation will be slow, and the temperature on the wet bulb will be close to

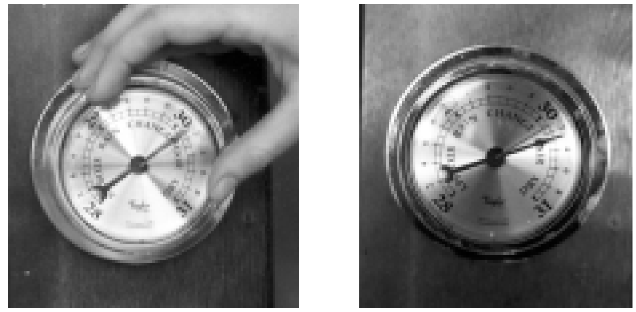


Fig. 3. Line up the pointer with the needle. Later, note the change.

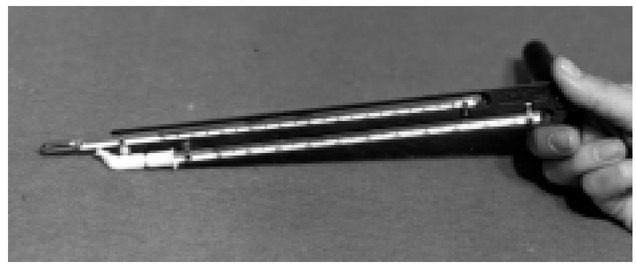


Fig. 4. Air temperature and humidity are measured with a sling psychrometer. . .

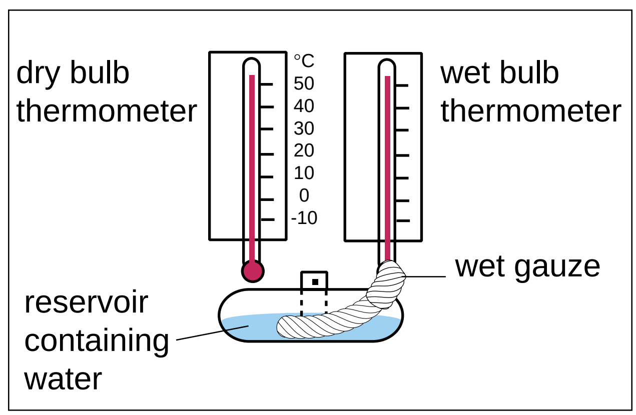



Fig. 5. or a hygrometer. Both have wet and dry bulb thermometers.

Fig. 6. To use a psychrometer, dip the gauze in fresh water ...

the reading on the dry bulb thermometer. If the air is very dry, the rate of evaporation will be rapid, and the temperature of the wet bulb thermometer will be much lower than the reading on the dry bulb thermometer.

By comparing the readings on the two thermometers, you can determine the relative humidity and dew-point spread.

The psychrometer is whirled overhead before taking a reading. This ensures air circulates around the wet gauze, allowing evaporation to take place at a maximum rate. The hygrometer, on the other hand, is a stationary instrument. Psychrometer readings are usually more accurate than readings taken with a hygrometer.

If you are using a sling psychrometer, dip the gauze in fresh water (Fig. 6). Hold the handle firmly and whirl the psychrometer rapidly over your head for one minute (Fig. 7). Read the temperature on both thermometers. If you are using a hygrometer, simply read the temperature on both thermometers. (Make sure the well under the wet bulb thermometer is filled with fresh water.)

RECORD the readings on your data sheet.

3. Subtract the wet bulb reading from the dry bulb reading. Now, use Table 1 to determine relative humidity. RECORD this number on your data sheet underneath the two temperature readings. Use Table 2 to determine the dew point spread. RECORD this number on your data sheet.

### Wind Speed and Direction

1. Wind speed is determined with an anemometer. Wind direction is measured with a wind vane or by observing the effect wind has on smoke or on light objects such as flags.

   Hold the anemometer up so the revolving cups are just above your head (Fig. 8). Read the wind speed (in kilometers or miles per hour) on the dial. RECORD speed on your data sheet.
2. To determine the direction of the wind, look for a flag waving in the breeze or smoke rising from a stack (Fig. 9). You can also feel the wind on your face, hold up a piece of light material,

Fig. 7. and whirl the instrument over your head. Read both thermometers.

Fig. 8. Hold the anemometer over your head and read wind speed on the dial.

Fig. 9. To determine wind direction, look for a flag or smoke blowing in the breeze.

Fig. 10. Use a compass to determine the direction the wind is coming from.

Table 1. Relative Humidity Chart

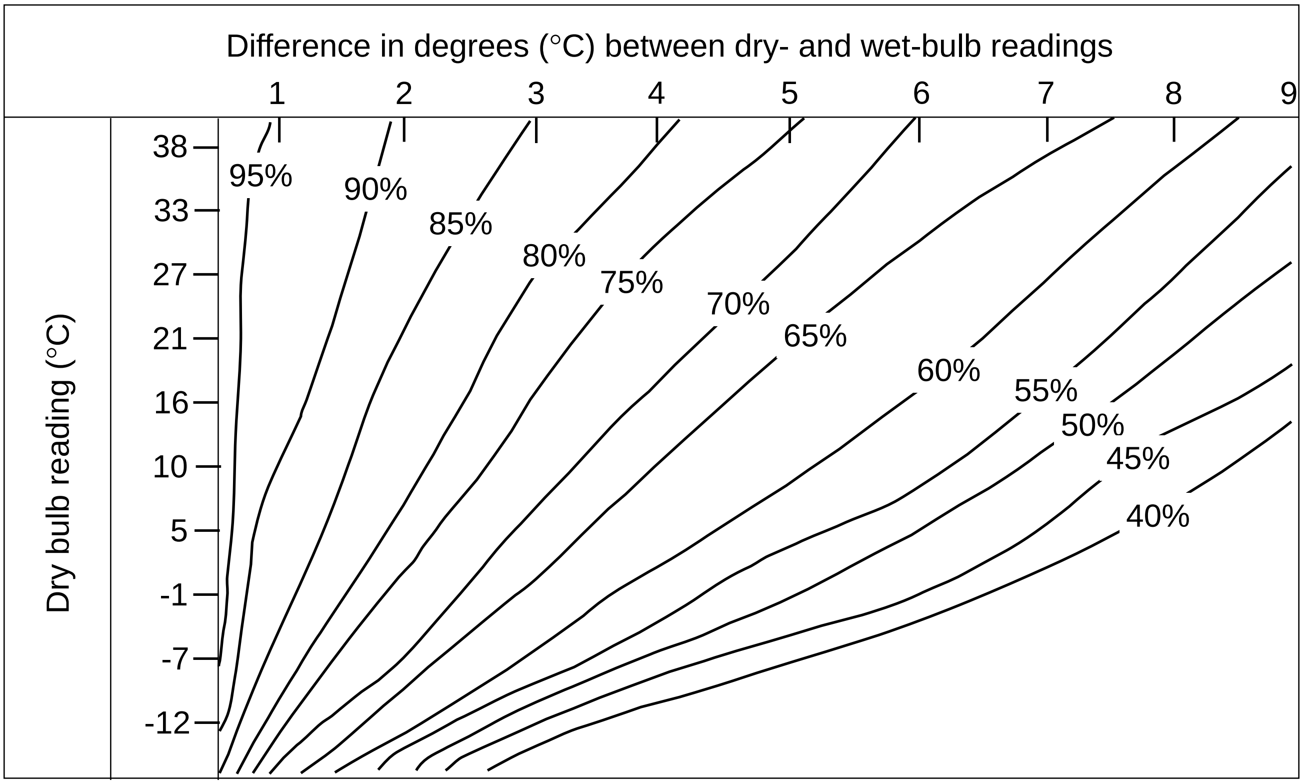


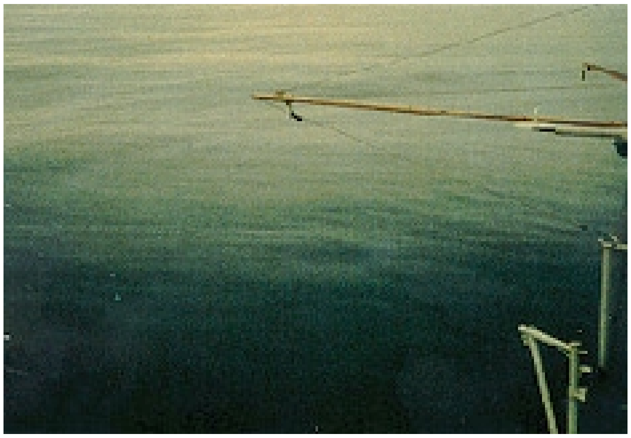

Table 2. Air Temperature —Dew-Point Spread
(All figures are in degrees Celsius)

| Difference dry-bulb minus web-bulb | Air Temperature Shown by Dry-Bulb Thermometer | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 25 | 30 | 32 | 35 |
| 1 | 2.5 | 2.2 | 1.9 | 1.8 | 1.7 | 1.6 | 1.5 | 1.5 | 1.4 | 1.4 | .13 | 1.2 | 1.1 |
| 2 | 5.5 | 4.7 | 3.9 | 3.7 | 3.5 | 3.3 | 3.2 | 3.1 | 2.9 | 2.8 | 2.6 | 2.6 | 2.5 |
| 3 | 9.3 | 7.3 | 6.2 | 5.8 | 5.5 | 5.2 | 4.9 | 4.7 | 4.5 | 4.3 | 4.0 | 3.9 | 3.8 |
| 4 | 14.6 | 10.3 | 8.8 | 8.1 | 7.6 | 7.2 | 6.8 | 6.5 | 6.2 | 5.8 | 5.4 | 5.2 | 5.1 |
| 5 | 24.2 | 14.3 | 11.5 | 10.8 | 10.0 | 9.3 | 8.8 | 8.3 | 7.9 | 7.5 | 6.8 | 6.8 | 6.7 |
| 6 | — | 20.2 | 14.6 | 13.6 | 12.7 | 11.7 | 11.0 | 10.4 | 9.8 | 9.2 | 8.4 | 8.3 | 8.2 |
| 7 | — | 32.1 | 18.7 | 16.9 | 15.6 | 14.5 | 13.4 | 12.6 | 11.9 | 11.0 | 10.0 | 9.6 | 9.3 |
| 8 | — | — | 24.5 | 21.1 | 19.0 | 17.5 | 16.2 | 15.0 | 14.1 | 13.0 | 11.6 | 11.1 | 10.7 |
| 9 | — | — | 36.0 | 27.5 | 24.5 | 21.0 | 19.3 | 17.9 | 16. | 15.1 | 13.4 | 12.1 | 11.8 |

Opposite — Difference Dry-Bulb Minus Wet-Bulb and
Under — Air Temperature Shown by Dry-Bulb Thermometer
Read — Value of Spread = Air Temperature minus Dew-Point Temperature
Based on U.S. Weather Bureau Psychrometric Tables.

or observe the direction from which the smallest ripples on the water are coming. Use a compass to determine the direction the wind is blowing from (not the direction it is blowing toward) based on your observations (Fig. 10). RECORD this direction on your data sheet.

3. You can also determine wind speed using the Beaufort scale (Table 3). This is an older, less-accurate method. Observe the sea state or the effect of the wind on trees, smoke, people, and structures. Use the Beaufort scale to correlate these observations with wind speed. RECORD the Beaufort number on your data sheet.



**0 Calm.** Wave height: 0. Wind speed: 0-1 mph. Sea like a mirror.

**Table 3. Beaufort Scale**

| Beaufort number (wind force) | Wind speed kph (mph) | Wind Speed designa-tion | Sea conditions | Land conditions | Probable* wave height m (ft) |
|---|---|---|---|---|---|
| 0 | 0-2 (0-1) | calm | Sea smooth and mirrorlike | Calm, smoke rises vertically | — |
| 1 | 2-5 (1-3) | light air | Scalelike ripples, no foam crests | Wind moves smoke, but not wind vanes | 0.08 (1/4) |
| 2 | 6-10 (4-6) | light breeze | Small, short wavelets; crests glassy, do not break | Wind felt on face, leaves rustle, wind vanes move | 0.15 (1/2) |
| 3 | 11-16 (7-10) | gentle breeze | Large wavelets; some crests; glassy foam; some white foam | Leaves & small twigs in mo-tion; light flags extended | 0.6 (2) |
| 4 | 17-26 (11-16) | moderate breeze | Small waves; becoming longer; white foam frequent | Wind raises dust and loose paper; small branches move | 1.2 (4) |
| 5 | 27-34 (17-21) | fresh breeze | Moderate waves; many white foam crests; occasional spray | Small trees w/leaves sway | 1.8 (6) |
| 6 | 35-43 (22-27) | strong breeze | Large waves form; many white foam crests; some spray | Large branches move; um-brellas are difficult to hold | 3.10 (10) |
| 7 | 44-54 (28-33) | near gale | Sea heaps up; white foam from breaking waves blown in streaks | Whole trees sway; walking into wind is difficult | 4.3 (14) |
| 8 | 54-64 (34-40) | gale | Moderately high waves; foam is blown in marked streaks | Twigs break off trees; cars veer on roads | 5.5 (18) |
| 9 | 65-76 (41-47) | strong gale | High waves; dense streaks of foam; crests of waves topple & roll over | Slight structural damage occurs (chimney pots, roof slates blown away) | 7.0 (23) |
| 10 | 77-89 (48-55) | storm | Very high waves w/overhanging crests; sea appears white as foam is blown in dense streaks; rolling is heavy | Trees are uprooted; consid-erable structural damage is done | 8.8 (29) |
| 11 | 90-101 (56-63) | violent storm | Exceptionally high waves; sea covered w/foam; wave crests blown into froth; visibility reduced | Widespread damage | 11.3 (37) |
| 12 | 102-114 (64-71) | hurricane | Air filled w/foam & spray; sea completely white; visibility v. low | Extreme damage | 13.7 (45) |

*The effect of wind on sea state is reduced in protected bodies of water such as bays, sounds, and estuaries.

**1 Light Air.** Wave height*: 8 cm. Wind speed: 1-3 mph. Ripples with appearance of scales; no foam crests.

**2 Light Breeze.** Wave height*: 15 cm. Wind speed: 4-6 mph. Small wavelets, crests of glassy appearance, not breaking.

**3 Gentle Breeze.** Wave height*: 60 cm. Wind speed: 7-10 mph. Large wavelets; crests begin to break; scattered whitecaps.

**4 Moderate Breeze.** Wave height*: 1 m. Wind speed: 11-66 mph. Small waves becoming longer, numerous whitecaps.

**5 Fresh Breeze.** Wave height*: 1.8 m. Wind speed: 17-21 mph. Moderate waves, taking longer form; many whitecaps, some spray.

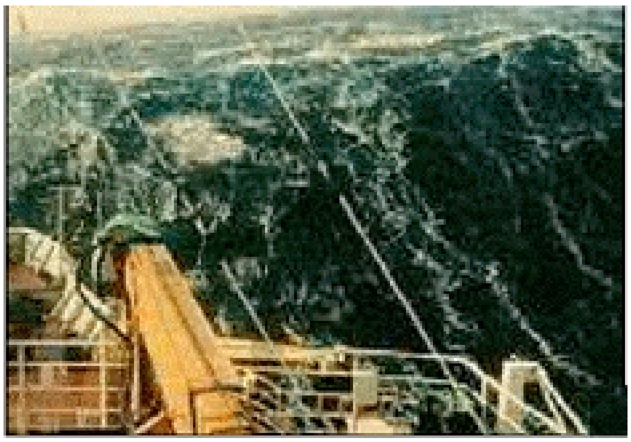
**6 Strong Breeze.** Wave height*: 3 m. Wind speed: 22-27 mph. Larger waves forming; whitecaps everywhere; more spray.

Beaufort Scale photos courtesy the National Oceanic and Atmospheric Administration (NOAA).

*Wave heights are considerably less in bays, sounds, and other protected coastal waters.

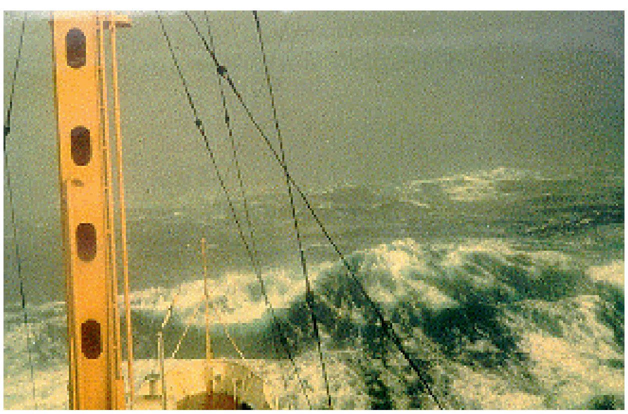
**7 Near Gale.** Wave height*: 4 m. Wind speed: 28-33 mph. Sea heaps up; white foam from breaking waves begins to blow in streaks.

**8 Gale.** Wave height*: 5 m. Wind speed: 34-40 mph. Moderately high waves of greater strength; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.



**9 Strong Gale.** Wave height*: 9 m. Wind speed: 41-47 mph. High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.

**10 Storm.** Wave height*: 9 m. Wind speed: 48-55 mph. Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks.



**11 Violent Storm.** Wave height*: 11 m. Wind speed: 56-63 mph. Exceptionally high waves; sea covered with white foam patches.

**12 Hurricane.** Wave height*: 14 m. Wind speed: 64-71 mph. Air filled with foam; sea completely white with driving spray.

Beaufort Scale photos courtesy the National Oceanic and Atmospheric Administration (NOAA).

*Wave heights are considerably less in bays, sounds, and other protected coastal waters.

### Cloud Type and Percent Cover

1. Using the pictures in Table 4, try to identify the clouds you see. RECORD the predominant cloud type (from Table 4) on your data sheet.
2. Estimate how much of the sky is covered by clouds. To make this easier, imagine the sky is divided in half, and then into quarters. How much of each quarter is covered by clouds? Add up the percentages for the four quarters and divide the result by four. This is the percent cover for the whole sky. RECORD this number on your data sheet.

### Weather Code

Pick out the description in Table 5 that best describes present weather conditions. RECORD the number next to this description on your data sheet.

### Visibility

Identify the farthest point you can clearly see. Find this point on a nautical chart and try to determine its approximate distance from you. RECORD this distance (in kilometers or miles) on your data sheet.

### Wave Direction, Period, and Height

1. With a compass, determine the direction from which the waves are coming (not where they are going). (See Figure 11.) RECORD this direction on your data sheet.
2. Determine the wave period. Observe the waves as they pass a fixed point, such as a dock, railing post, anchored boat, buoy, or rock. Use a stopwatch or a watch with a second hand to measure the time required for 10 wave crests to pass this fixed point (Fig. 12). Divide this time by 10. RECORD the result on your data sheet.

Table 5. Weather Code

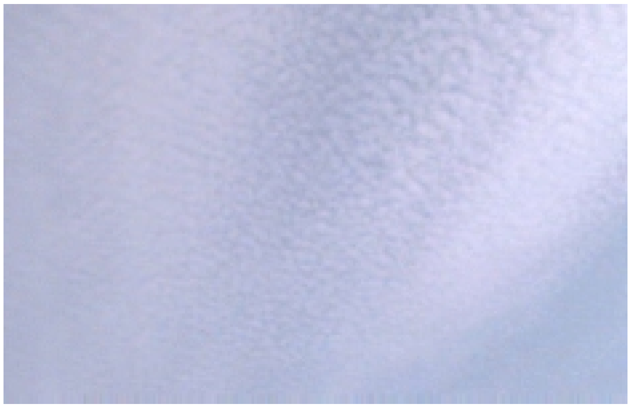
Choose the best description for the present weather, then RECORD it.

1. Sky clear; no clouds in sight.
2. Sky generally clear, some clouds in sight.
3. Mostly cloudy.
4. Overcast; no precipitation.
5. Hazy.
6. Light mist.
7. Heavy mist.
8. Fog present in patches.
9. Thick fog.
10. Very thick fog; sky not visible.
11. Distant precipitation seen.
12. Drizzle.
13. Light showers.
14. Heavy showers.
15. Thunderstorm.
16. Hail.
17. Freezing rain.
18. Rain and snow mixed.
19. Snow, intermittent.
20. Snow, continuous.

Fig. 11. Use a compass to determine the direction the waves are coming from.

Fig. 12. Time how long it takes a wave to pass a fixed point (crest to crest).

Table 4. Clouds



**Cirrocumulus (Cc)**, 6-18 km. A thin white sheet composed of cottonlike masses regularly arranged in rippled groups or lines. Look for wind and rain if they change to cirrostratus. These clouds can also appear wavy.

**Cirrus (Ci)**, 6-18 km. Feathery or fibrous (hairlike) in appearance, they form white patches, tufts, plumes, or curved wisps. Often seen during fair weather but at times may serve as the first visible indication of an approaching storm, bringing steady rain.

**Cirrostratus (Cs)**, 6-18 km. Forms a translucent, whitish veil with fibrous or smooth appearance. It is made up of tiny ice crystals too thin to mask the sun. These clouds create a halolike ring around the sun or moon that, according to folklore, predicts rainfall within 24 hours. If these clouds thicken and change to altostratus, the prediction is likely to come true.

**Altocumulus (Ac)**, 2.5-6 km. Forms a canopy of white or gray flakes, bands, long rolls, or rounded masses. Sometimes a sign of rain or thunderstorms, especially when some clouds are higher than others.

**Altostratus (As)**, 2.5-6 km. Forms a gray or bluish, fibrous haze or sheet through which the sun can be seen only diffusely. If these clouds increase, expect steady rain or snow.

Cloud photos courtesy the Plymouth State College Meteorology Program.

Table 4. Clouds

**Cumulus (Cu)**, base 300 m, top: 14 km. Forms sharply outlined, billowing mounds and towers, bright at the top and dark at the bottom. Generally fair weather clouds unless they become cumulonimbus.

**Stratocumulus (SC)**, below 6 km. A continuous sheet made up of long flat layers, irregular folds or long parallel rolls. These clouds usually produce no precipitation.

**Stratus (St)**, below 6 km. A very low, thick, generally uniform, dark gray cloud layer forming a horizontal "ceiling." Often produces a fine drizzle, mist, fog, or sprinkling of snow.

**Nimbostratus (Ns)**, below 6 km. Thick, dark cloud layer that blots out the sun. These clouds release almost continuous rain or snow, which gives them a diffuse appearance.

**Cumulonimbus (Cb)** are very tall, dark clouds, often anvil shaped with flattened tops. Almost invariably bring thunderstorms.

Cloud photos courtesy the Plymouth State College Meteorology Program.

3. Wave height is defined as the distance between the top of a wave crest to the bottom of the next trough (Fig. 13). Estimate the height of the waves by observing them as they pass some object having a known height. You can also lower a staff marked in centimeters into the water and measure the height of the waves as they pass it.

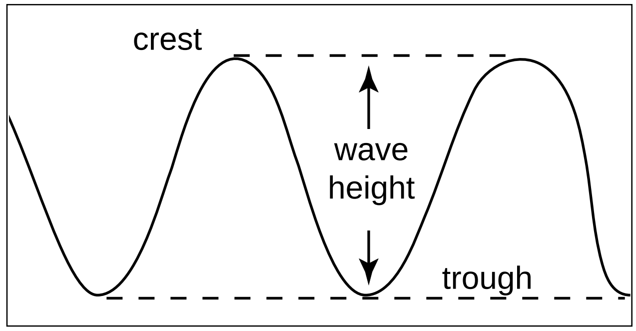



Fig. 13. Use a staff or ruler to measure the height of waves from trough to crest.

## Analysis

1. Weather conditions often have an important effect on the physical and chemical properties of the sea, as well as on marine life. Storm- and wind-driven waves can stir up the bottom, increasing turbidity and changing the color of the water. Thick clouds can block the sun and reduce the productivity of phytoplankton. Heavy rain dilutes the surface water, altering its salinity and temperature. Wind can mix life-giving oxygen into the water.

   Try to relate your weather and sea state data to other oceanographic measurements you have made. For instance, graph measurements of wave height taken over a period of time against Secchi disc readings, against percent cloud cover, and against phytoplankton counts.
2. The biggest challenge is to use weather data to predict the weather. It requires accurate measurements, patience, and luck. You can use some of the information you collected in this procedure along with an up-to-date weather map from the newspaper to make weather predictions. Do not make any bets on your forecast, however. Even the United States Weather Bureau is accurate only two-thirds of the time.

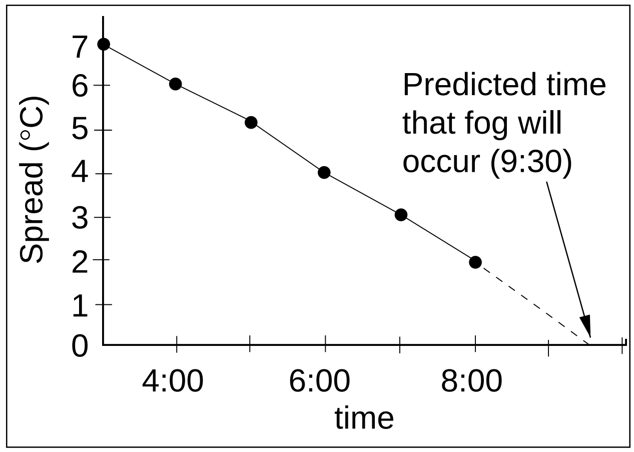



Fig. 14. Plot dew-point spread every hour. Fog forms when the line crosses zero.

Fig. 15. Fog often forms over the ocean, a source of moisture and cool air.

### Predicting Fog

Fog is likely to occur if the dew-point spread is steadily decreasing. You can predict when fog is most likely to occur by measuring the dew-point spread every hour and plotting this data on a graph as shown in Figure 14. Draw a smooth line connecting the data points and continue the line until it reaches zero. Fog usually forms when the dew-point spread is zero.

Fog may form when moist, warm air is cooled. It also may form when relatively dry air is moistened. Fog often forms over the ocean in the spring and summer because the ocean is both a source of moisture and a cooling agent (Fig. 15).

### Using Air Pressure and Wind Direction to Predict Weather

Together, wind direction and air pressure provide a reliable hint about approaching weather. Refer to Table 6 for some guidelines.

As a rule, fair weather is indicated by rising or unchanging air pressure readings. If the barometric readings are dropping, bad weather is probably on the way. The faster the air pressure falls, the more severe the weather will probably be.

A slow rate of change for air pressure is about 0.5 mm (0.02 in.) per hour. A rate of change more than 1.27 mm (0.05 in.) per hour is fairly high.

Air pressure normally changes cyclically over the course of a day. It reaches its maximum at 10 a.m. and at 10 p.m. and is at its minimum at 4 a.m. and 4 p.m. Variation between maximum and minimum may be as much as 1.27 mm (0.05 in.). Keep this in mind when you analyze your barometer data.

### Using Cloud Type to Predict Short-Term Weather

Clouds are often an indication of weather to come. Table 4 illustrates some of the most common cloud types and what they mean. Note in particular the cumulonimbus cloud (Table 4). This is commonly known as a thunderhead.

"Building over a summer landscape or . . . sea, these clouds almost invariably bring thunderstorms and heavy rain; occasionally they produce hail. The tallest cumulonimbus thrust their heads into the cold upper air, and their tops assume the form of anvils, with trailing wisps of cirrus" (Thompson and O'Brien, 1968).

Thunderstorms can often be disastrous at sea. Striking quickly and often without warning, they bring high winds, heavy rain, and lightning. Head for shore at the first appearance of anvil-topped clouds.

Table 6. Rules of Thumb for Forecasters in the Northeastern U.S.

| Wind Direction | Barometer at Sea Level | Kind of weather to be expected |
|---|---|---|
| SW to NW | 30.10 to 30.20, steady | Fair with little temperature change for 1 of 2 days |
| SW to NW | 30.10 to 30.20, rising fast | Fair, followed by rain within 2 days |
| SW to NW | 30.20 or above, steady | Continued fair with little temperature change |
| SW to NW | 30.20 or above, falling slowly | Slowly rising temperature; fair for 2 days |
| S to SE | 30.10 to 30.20, falling slowly | Rain within 24 hours |
| S to SE | 30.10 to 30.20, falling fast | Wind rising in force; rain in 12 to 24 hours |
| SE to NE | 30.10 to 30.20, falling slowly | Rain in 12 to 18 hours |
| SE to NE | 30.10 to 30.20, falling fast | Rising wind; rain within 12 hours |
| E to NE | 30.10 or above, falling slowly | In summer, light winds, rain not immediately likely; in winter, rain in 24 hours |
| E to NE | 30.10 or above, falling fast | Rain probably in summer within 24 hours; in winter, rain or snow and windy |
| SE to NE | 30.0 or below, falling slowly | Steady rain for 1 or 2 days |
| SE to NE | 30.0 or below, falling fast | Rain and high wind, clearing within 36 hours |
| S to SW | 30.0 or below, falling slowly | Clearing within a few hours; fair for several days |
| S to E | 29.8 or below, falling fast | Severe storm imminent; clearing within 24 hours; colder in winter |
| E to N | 29.8 or below, falling fast | Severe northeast gale; heavy rain; in winter, heavy snow and cold wave |
| Going to W | 29.8 or below, rising fast | Clearing and colder |

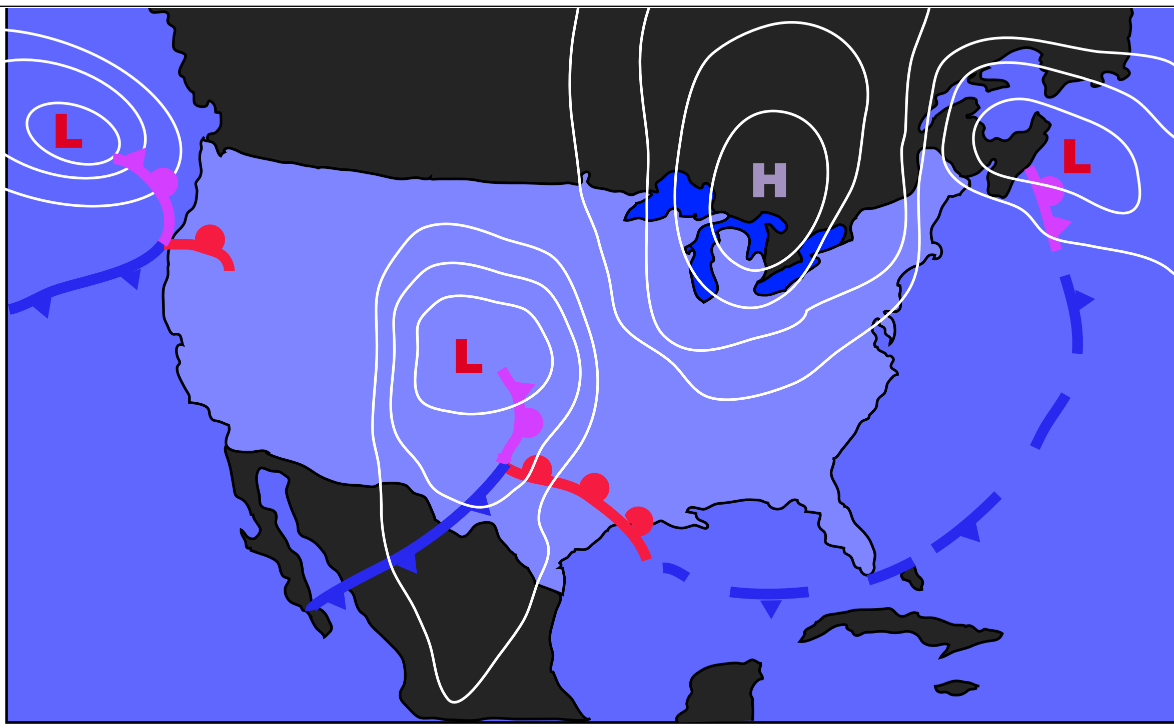
## Using a Weather Map

To make your forecast more accurate, you must know what is happening over the rest of the nation. You can find this out from the weather map published daily in your local newspaper, on the Internet, or your local The Weather Channel station. The two most important things to look for on this map are areas of equal pressure and weather fronts. The map will also tell you wind speed and direction. These give you a rough idea of how fast an approaching weather storm is moving. Table 7 shows a typical weather map and an explanation of some of the symbols.

A weather map is a picture of the weather at a particular time. It can tell you where major weather systems are and what types of conditions (air temperature, wind speed and direction, precipitation) are associated with them. Since weather tends to travel from west to east across the United States, this can warn you of the weather to come.

Modern weather forecasters depend on a sophisticated and extensive data-collecting system and base their forecasts on careful analysis of this data. Before meteorology became a science, however, many people made weather predictions on the basis of maxims and old wives' tales, some of which may be fairly accurate indications of upcoming weather. We have summarized a few of these in Table 8.

Table 7. Weather Map




| Cold Front | Warm Front | Stationary | Occluded |
|---|---|---|---|
| Line between cold and warm air masses usually moving, southward and eastward and bringing brief storms and cooler weather. | Line between a mass of warm air and retreating cold air, usually moving northward and eastward and led by rain or snow. | Line between two air masses of similar temperature, moving only slightly. It often brings lengthy periods of precipitation. | Line on which a warm front has been overtaken by a cold front. It usually moves eastward, bringing precipitation. |

**H** Area of high pressure. **L** Area of low pressure.

## Problems for Further Investigation

1. Microweather is defined as local variations in wind, temperature, and precipitation due to geographical or man-made features. These include mountain ranges, trees, houses, or fences. How is the local weather of the coastal area affected by local topography? How can you measure these effects?
2. Take weather measurements along the shore, on the water, and inland over a period of time. What effect does the ocean seem to have on weather?
3. Build your own weather station and use your instruments to make weather forecasts. Much of the equipment you will need can be made by hand. Ask your teacher for assistance.

The United States Weather Bureau has information on weather forecasting, as well as weather maps, cloud pictures, and up-to-date weather data. For information, contact:

U.S. Department of Commerce
Environmental Science Services Administration
Environmental Data Service
Silver Springs, Maryland 20910
or
The National Weather Service at
http://www.nws.noaa.gov

There may be a small fee for some information.

Table 8. Weather Folklore

- A red sky at sunset means fair weather ahead; a red sky at sunrise means bad weather — wind and perhaps rain. A gray sky at sunrise means fair weather.
- When a sunset occurs close to the horizon, the weather will be fine. When the dawn breaks above a bank of clouds, the day will be windy.
- Rings around the moon or sun foretell rain.
- When sea birds fly far out to sea, expect moderate wind and fair weather. When they hug the land, bad weather is ahead.
- Unusual twinkling of the stars, a haziness in the moon or clouds, and halos or fragments of rainbows near clouds indicate the approach of a rainstorm.
- On days when the sky is unusually clear and the hills and islands appear to stand above the horizon, expect wind and rain.

# 4.61 Observing the Weather and Sea State

## TO THE INSTRUCTOR

### Additional Background

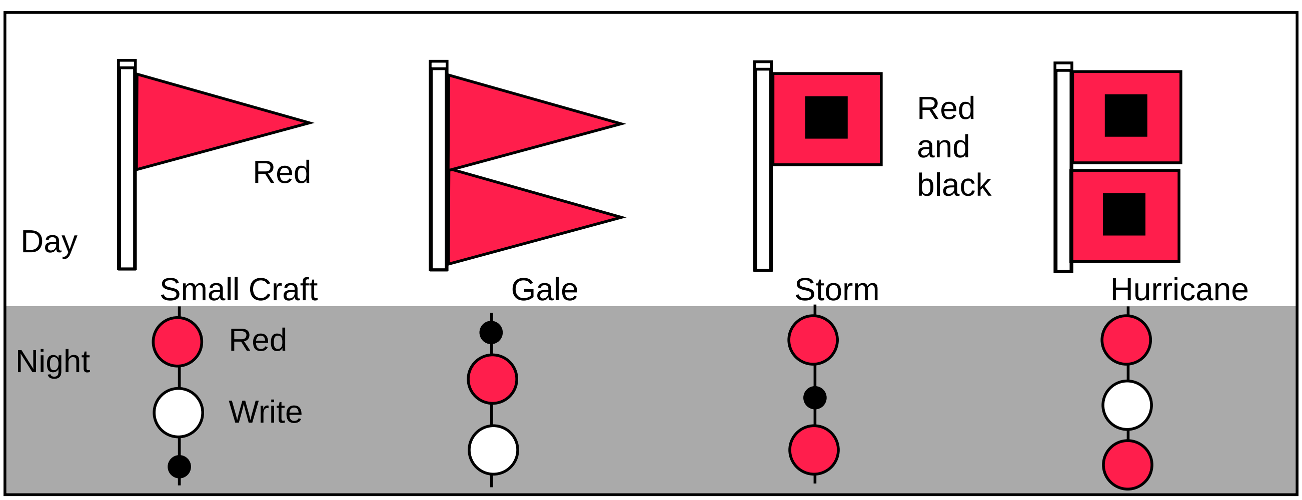
Though weather is one of the most important phenomena in oceanography, it is perhaps the least understood. It shapes the coastline, affects the lives and livelihood of coastal residents, and plays an important role in the behavior and ecology of marine life. A study of weather should be included in any general introduction to oceanography.

For more information on weather and activities pertaining to it, see any recent book on weather. We have included a few in the bibliography. See the latest edition of Chapman for a discussion of the importance of weather to mariners. This book also has excellent sections on the formation of fog, the development of hurricanes and thunderstorms, and the proper use of a weather map.

It is essential to check up-to-date weather forecasts before going on a field trip. Local newspapers, radio stations, television stations, and the Internet are all good sources of weather information. The National Weather Service (NWS) has a network of radio stations that broadcast conditions and forecasts continuously. These broadcasts usually contain marine weather information. The NWS broadcasts on seven frequencies (162.400, 162.425, 162.450, 162.475, 162,500, 162.525, and 1262.550). These stations can be picked up on MF-band radiotelephones and on most multiband radios. The NSW web site lists frequencies for specific areas.

Some marinas, Coast Guard stations, and Coast Guard vessels fly warning flags to inform mariners of approaching bad weather. These flags and what they mean are shown in Table 9. Also shown are the light signals used as warnings at night.

Table 9. Small craft, Gale, Storm and Hurricane Warnings




UP
DOWN

## Apparatus *(Appendix 3 lists suppliers.)*

There are many fine books about weather and homemade weather equipment. Consult Thompson (1968) and Trowbridge (1973) for ideas on how to construct your own weather instruments.

**1. Barometer.** Barometers are available from just about every scientific supply house. Barometers are basically of two types, mercury and aneroid. Mercury barometers indicate changes in air pressure by variations in the height of a column of mercury. They are very accurate and expensive. Aneroid barometers record changes in the shape of a partially evacuated metal bladder. Though not as accurate as the mercury type, they are affordable. Aneroid barometers are also preferable because they do not pose a potential contamination threat, as any instrument containing mercury does.

**2. Sling psychrometer.** Available from scientific supply houses. Relative humidity can also be measured with a hygrometer. These are usually less expensive and fairly accurate.

**3. Anemometer.**

**4. Compass.** For measuring the direction of wind and waves.

**5. Watch with second hand.** For timing wave periods.

**6. Meter stick or staff.** For measuring wave height.

**7. Weather Data Sheet** in Appendix

**8. Weather maps, other forecasting equipment** (optional).

**9. Beaufort Scale.** A wall-poster-size Beaufort Scale, with photographs of each sea state, is available from: Defense Mapping Agency Hydrographic Center, Washington, D.C. 20390. It is published on the back of the Pilot Chart 110, dated July 1975.

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Webster, P. J. and J. A. Curry. 1998. The oceans and weather, *in* The Oceans. *Scientific American Presents.* 9(3)(Fall 1998):38-43.

## Internet Sites

Beaufort Scale
http://www.crh.noaa.gov/lot/webpage/beaufort/

National Data Buoy Center
http://seaboard.ndbc.noaa.gov

National Weather Service
http://www.nws.noaa.gov/

NOAA Weather Radio
http://www.nws.noaa.gov/nwr/

The Weather Channel
http://www.weather.com/