GUIDE TO:

Sea State, Wind, AND Clouds

For additional information on the Port Meteorological Officer (PMO) or Voluntary Observing Ship (VOS) Programs contact:

NOAA Voluntary Observing Ship Program
National Weather Service Headquarters
Office of Observations
NOAA 1325 East-West Highway, Room 4162
Silver Spring, MD 20910
301-427-9644
email - myvos@noaa.gov or VOS Program Manager Michael.Potochney@noaa.gov

GUIDE TO SEA STATE, WIND, AND CLOUDS

This booklet is divided into three parts. Part 1 contains sea state photographs to assist shipboard observers estimating wind speed. Part 2 contains cloud photographs for use in determining cloud type. Part 3 is a glossary with terms and definitions.

Wind of 98 knots or less is coded in actual knots as ff in group Nddff of the Ships Synoptic Code. For wind of 99 knots or greater, fff in group 00fff is coded with the actual wind speed in knots, and ff is coded as 99. Cloud type is coded in group $8N_hC_LC_MC_H$ of the ships synoptic code. See the Ships Code Card or NWS Observing Handbook No. 1 for detailed information about coding procedures.

Since most ships do not have a wind measuring instrument such as an anemometer, wind speed is usually determined by noting the appearance of the sea and estimating the Beaufort Force. This method provides a true measure of wind speed. There is no need to factor out the speed of the ship. The most reliable observations of sea state are made by keeping a close, continuous watch on the sea, and being aware of any swell that may be present.

The best way to become proficient in cloud identification is to combine plenty of practice with careful study of the cloud descriptions and photographs. There is a gradual transition between many of the cloud types. Try to keep a close watch on their development and change.

PART 1
STATE OF SEA AND WIND SPEED

The sea state photographs and descriptions that follow are for steady state conditions, which result when the wind has been blowing from the same direction for a relatively long time over a sufficiently long fetch (the distance the wind has blown across the water without interruption). For a given wind speed and duration, the longer the fetch, the greater the sea disturbance. Depth of water also effects the appearance of the sea. Waves running into shallow water become steeper and are more likely to break, which may result in an overestimate of wind speed. The sea criterion is for use over relatively deep water only.

There are other conditions when wind speed may be higher or lower than indicated by the sea state. Heavy rain and floating ice will have a dampening effect on the sea surface. Wind blowing against (opposite) a tide or strong current causes a greater sea-wave height and sea-disturbance than normal, while wind blowing in the same direction as a tide or strong current causes a smaller sea-wave height and sea-disturbance than normal. There is a lag period between the wind increasing or decreasing, and the sea wave height rising or falling. This is especially pronounced during a sudden change in wind speed. The presence of swell may cause more whitecaps to form, because wind waves have a greater tendency to break when superimposed on the crest of swell.

To distinguish sea from swell, remember that sea waves are generated by the wind blowing at the time of observation, or in the recent past, in your local area. Swell waves have travelled into your area of observation, after having been generated by winds in other areas (sometimes thousands of miles away). As sea waves move out from under the wind that produces them and become swell, their character changes. The crests become lower and more rounded, and they move in trains of similar period and height. Swell is more symmetrical and uniform than sea, and will have a longer period.

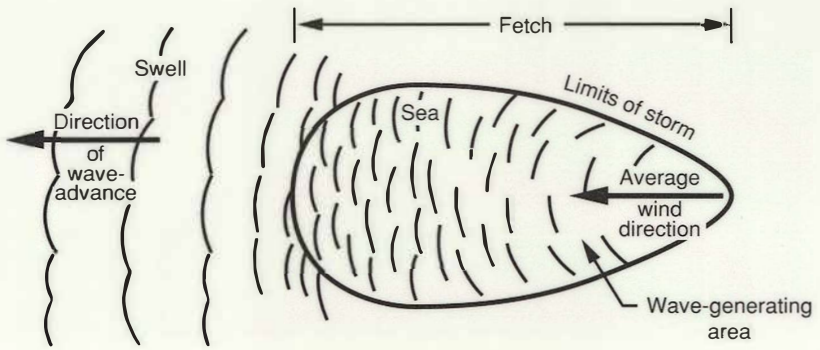


Diagram showing development of wind waves in a storm area and evolution of sea into swell as the waves travel out of the wave-generating area.

BEAUFORT FORCE 0
WIND SPEED: LESS THAN 1 KNOT

SEA: SEA LIKE A MIRROR

BEAUFORT FORCE 1
WIND SPEED: 1-3 KNOTS

SEA: WAVE HEIGHT .1M (.25FT), RIPPLES WITH THE APPEARANCE OF SCALES, BUT WITHOUT FOAM CRESTS

BEAUFORT FORCE 2
WIND SPEED: 4-6 KNOTS

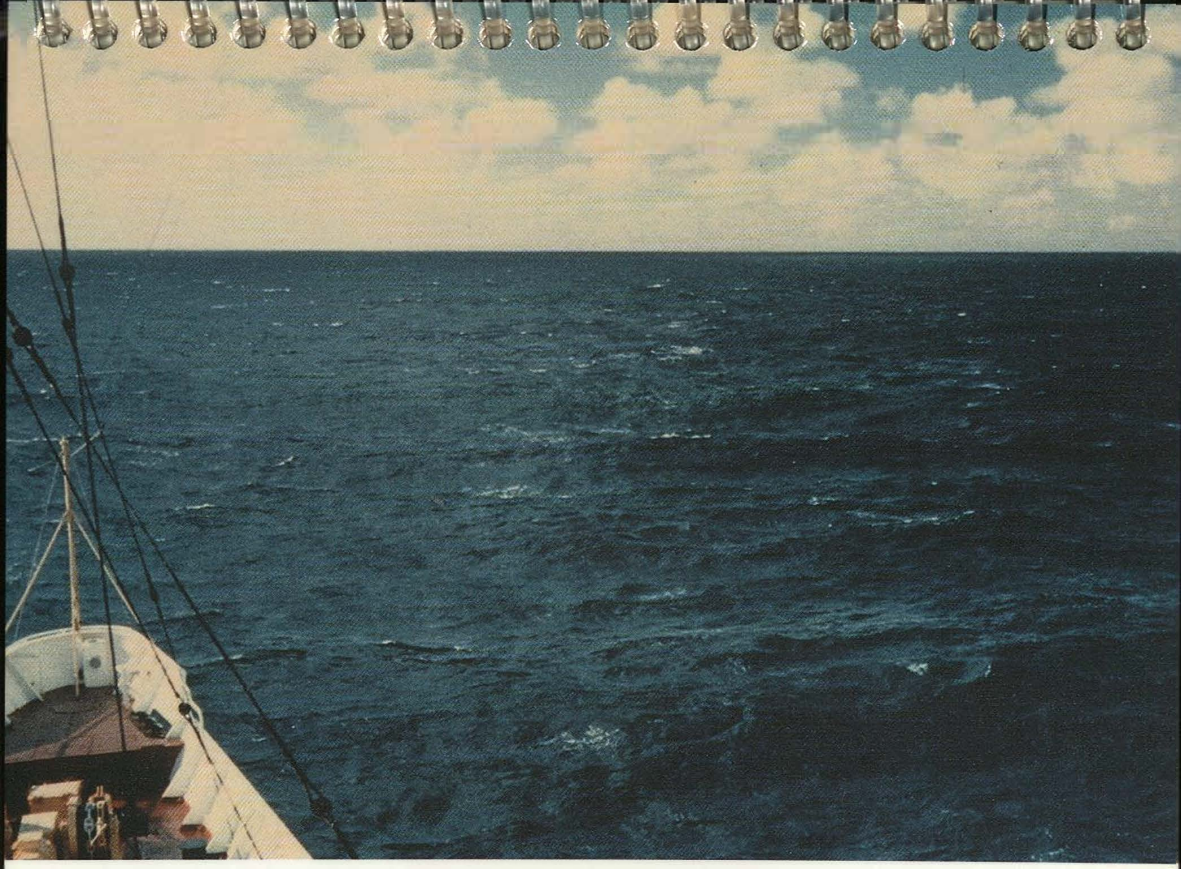
SEA: WAVE HEIGHT .2-.3M (.5-1FT), SMALL WAVELETS, CRESTS HAVE A GLASSY APPEARANCE AND DO NOT BREAK

BEAUFORT FORCE 3
WIND SPEED: 7-10 KNOTS

SEA: WAVE HEIGHT .6-1M (2-3FT), LARGE WAVELETS, CRESTS BEGIN TO BREAK, ANY FOAM HAS GLASSY APPEARANCE, SCATTERED WHITECAPS

BEAUFORT FORCE 4
WIND SPEED: 11-16 KNOTS

SEA: WAVE HEIGHT 1-1.5M (3.5-5FT), SMALL WAVES BECOMING LONGER, FAIRLY FREQUENT WHITE HORSES



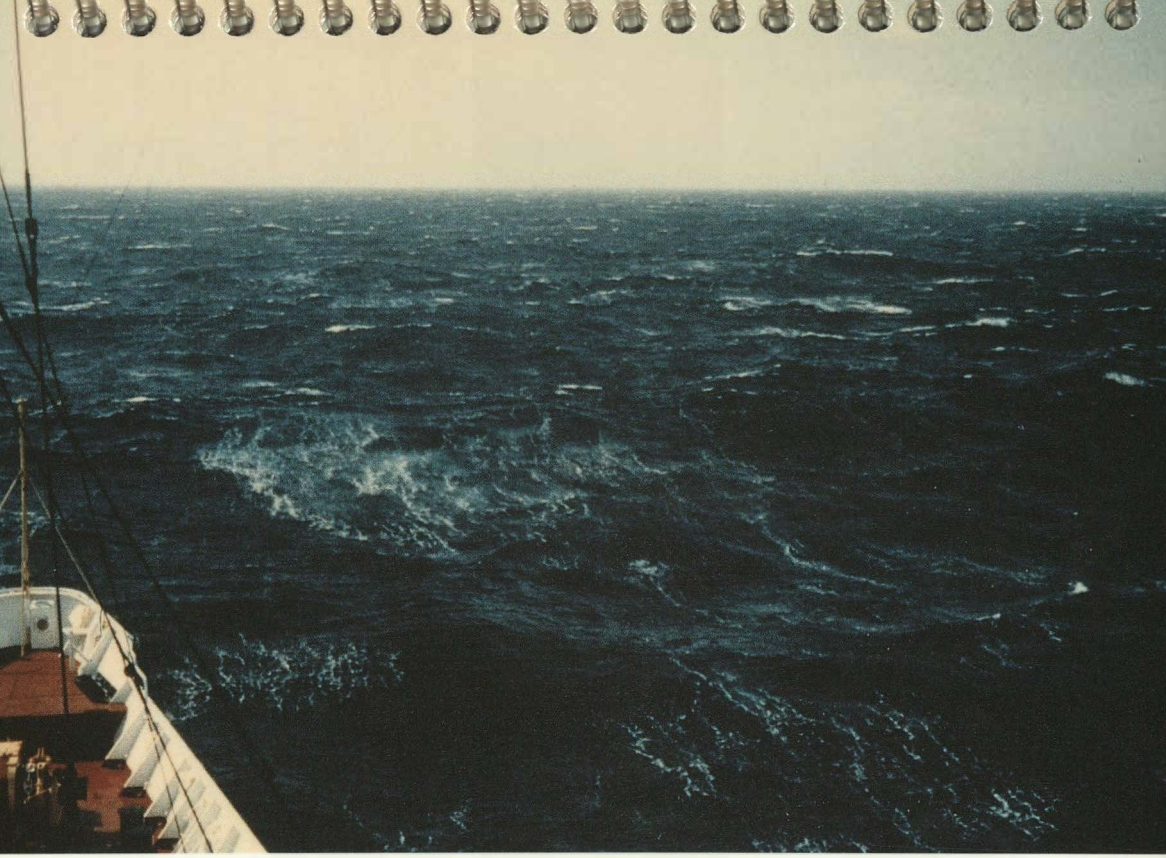
BEAUFORT FORCE 5

WIND SPEED: 17-21 KNOTS

SEA: WAVE HEIGHT 2-2.5M (6-8FT), MODERATE WAVES TAKING MORE PRONOUNCED LONG FORM, MANY WHITE HORSES, CHANCE OF SOME SPRAY

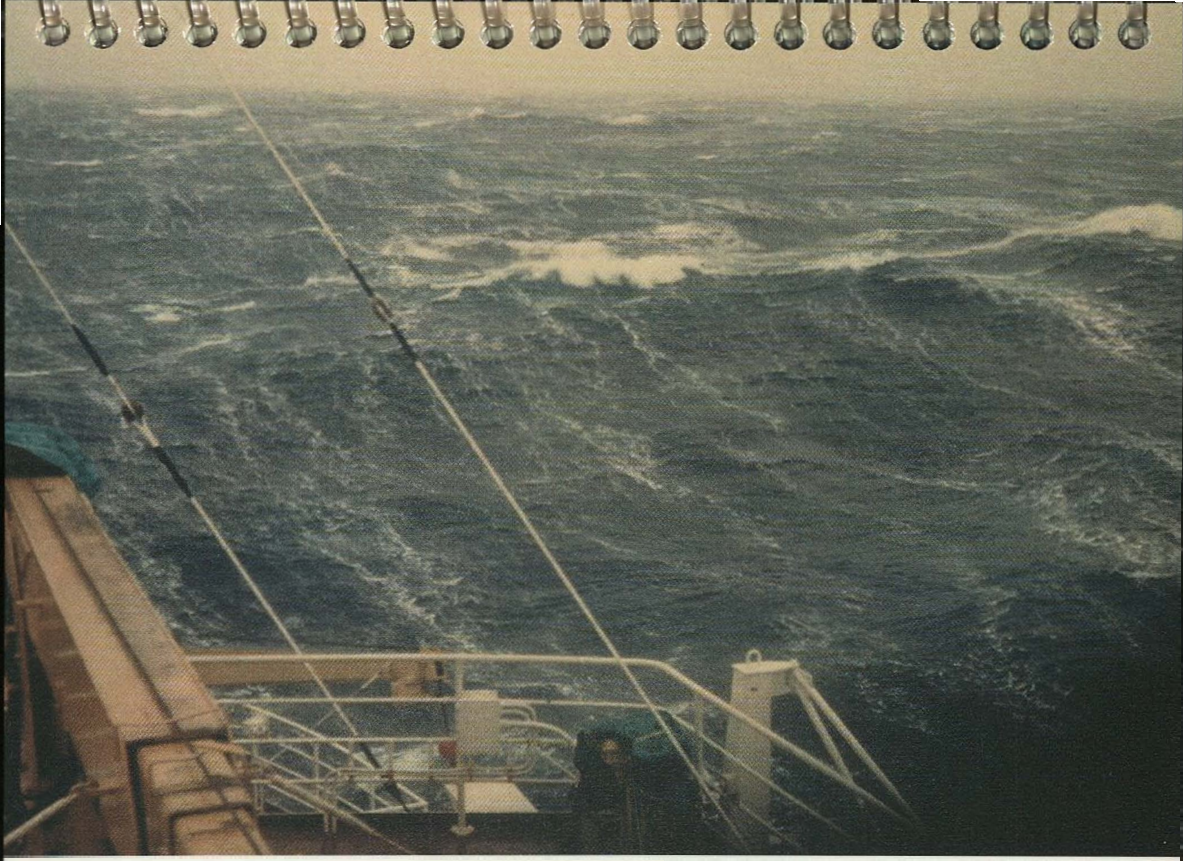
BEAUFORT FORCE 6
WIND SPEED: 22-27 KNOTS

SEA: WAVE HEIGHT 3-4M (9.5-13 FT),
LARGER WAVES BEGIN TO FORM, SPRAY IS PRESENT,
WHITE FOAM CRESTS ARE EVERYWHERE



BEAUFORT FORCE 7
WIND SPEED: 28-33 KNOTS

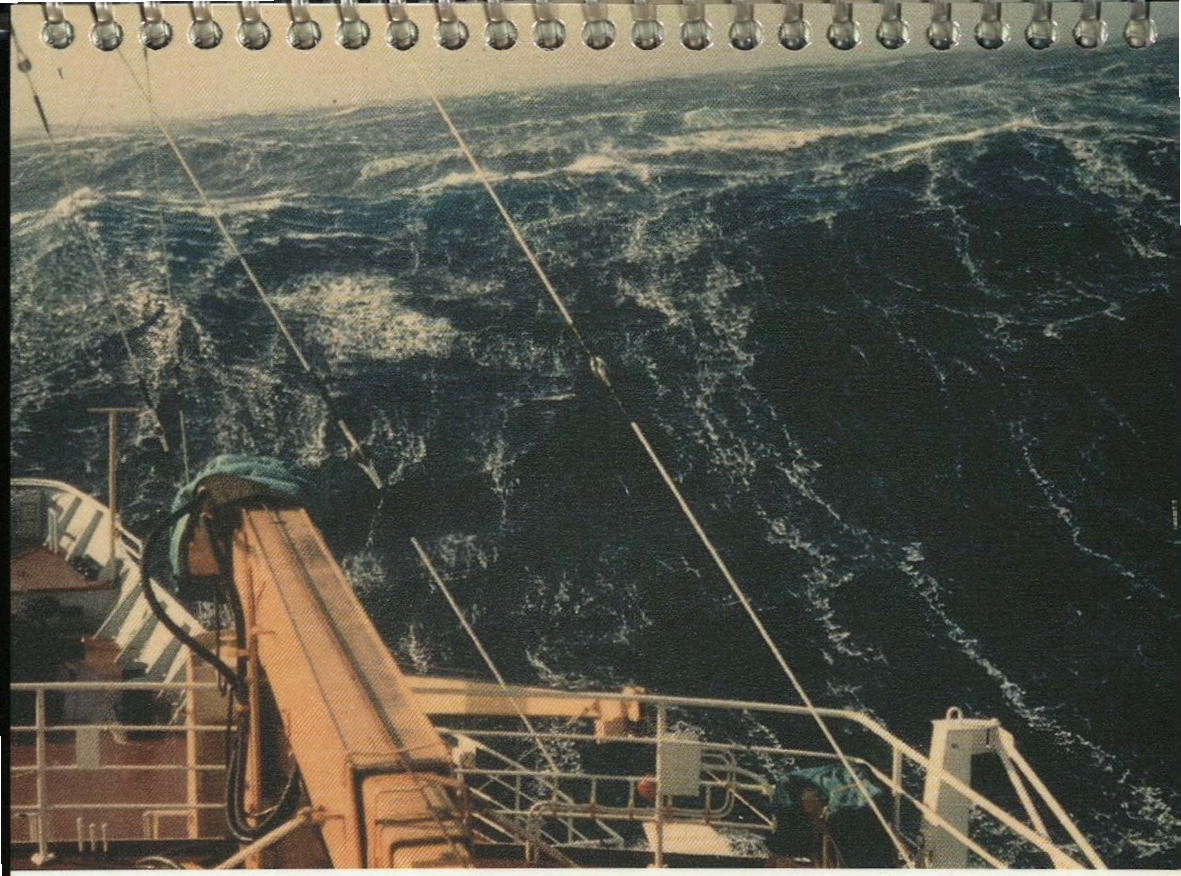
SEA: WAVE HEIGHT 4-5.5M (13.5-19 FT), SEA HEAPS UP, WHITE FOAM FROM BREAKING WAVES BEGINS TO BE BLOWN IN STREAKS ALONG THE WIND DIRECTION



BEAUFORT FORCE 8

WIND SPEED: 34-40 KNOTS

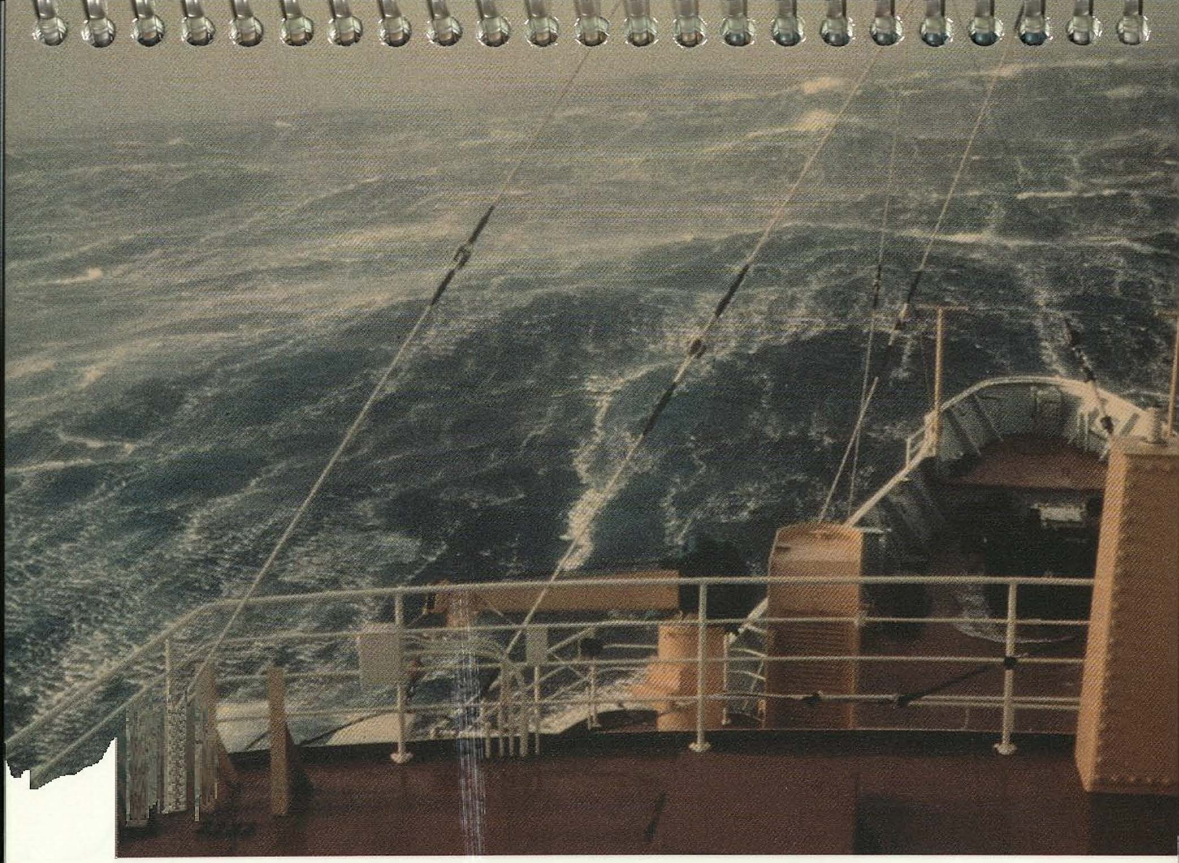
SEA: WAVE HEIGHT 5.5-7.5M (18-25FT), MODERATELY HIGH WAVES OF GREATER LENGTH, EDGES OF CREST BEGIN TO BREAK INTO THE SPINDRIFT, FOAM BLOWN IN WELL MARKED STREAKS ALONG WIND DIRECTION.



BEAUFORT FORCE 9

WIND SPEED: 41-47 KNOTS

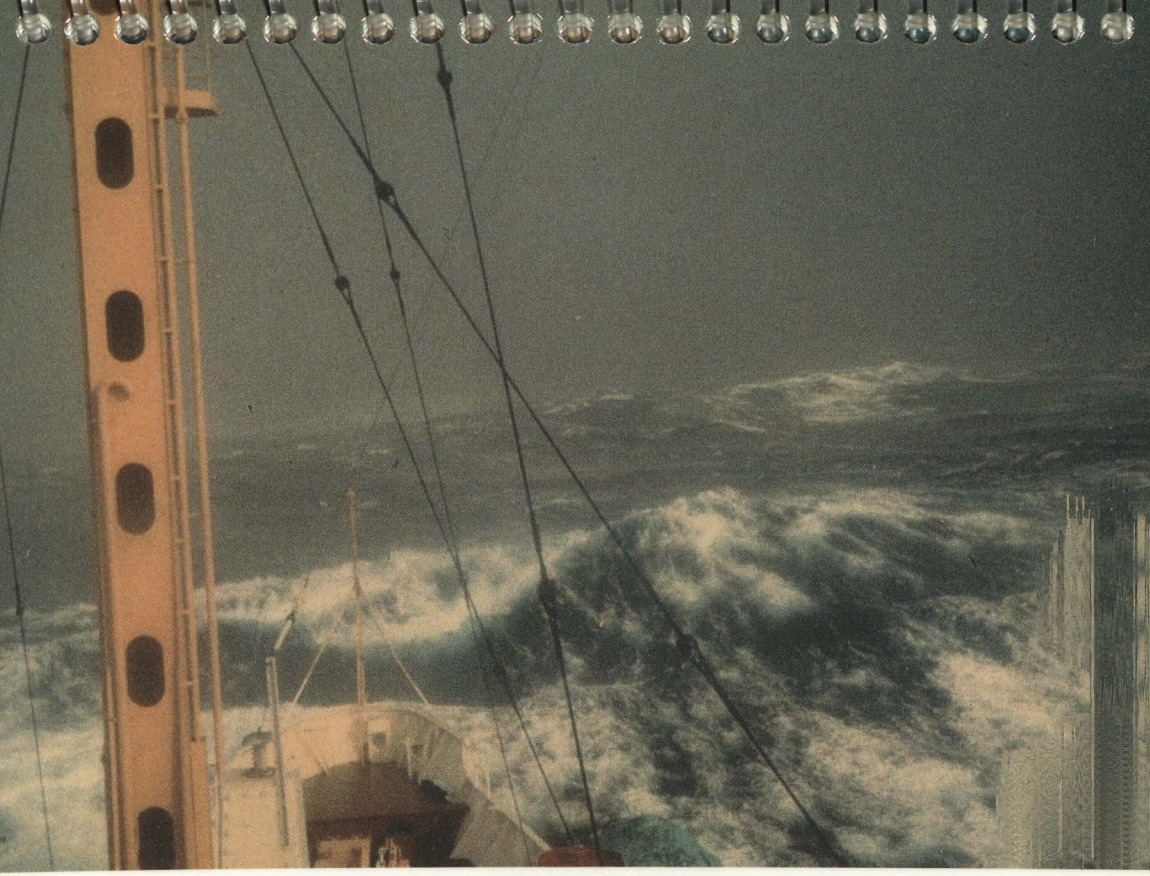
SEA: WAVE HEIGHT 7-10M (23-32FT), HIGH WAVES, DENSE STREAKS OF FOAM ALONG DIRECTION OF THE WIND, WAVE CRESTS BEGIN TO TOPPLE, TUMBLE, AND ROLL OVER. SPRAY MAY AFFECT VISIBILITY.



BEAUFORT FORCE 10

WIND SPEED: 48-55 KNOTS

SEA: WAVE HEIGHT 9-12.5M (29-41FT), VERY HIGH WAVES WITH LONG OVERHANGING CRESTS, THE RESULTING FOAM, IN GREAT PATCHES, IS BLOWN IN DENSE WHITE STREAKS ALONG WIND DIRECTION. ON THE WHOLE, SEA SURFACE TAKES A WHITE APPEARANCE, TUMBLING OF THE SEA IS HEAVY AND SHOCK-LIKE, VISIBILITY AFFECTED.



BEAUFORT FORCE 11

WIND SPEED: 56-63 KNOTS

SEA: WAVE HEIGHT 11.5-16M (37-52FT), EXCEPTIONALLY HIGH WAVES, SMALL-MEDIUM SIZED SHIPS MAY BE LOST TO VIEW BEHIND THE WAVES. SEA COMPLETELY COVERED WITH LONG WHITE PATCHES OF FOAM LYING ALONG WIND DIRECTION. EVERYWHERE, THE EDGES OF WAVE CRESTS ARE BLOWN INTO FROTH.

BEAUFORT FORCE 12
WIND SPEED: 64 KNOTS

SEA: SEA COMPLETELY WHITE WITH DRIVING SPRAY, VISIBILITY VERY SERIOUSLY AFFECTED. THE AIR IS FILLED WITH FOAM AND SPRAY

SWELL

Swell are ocean waves that have travelled beyond the generating area. They are produced by distant wind, and not by local wind. This is a prominent swell with a long straight crest and a relatively long period. The sea state is characteristic of Force 4.

PART 2
DETERMINING CLOUD TYPE

There are three primary cloud forms, (1) the heap cloud, known as Cumulus, formed from strong vertical air motion (convection), (2) the layer cloud, known as Stratus, formed from more gradual horizontal and vertical ascent of air, and (3) the streak cloud, known as Cirrus, composed of ice crystals. The three basic cloud forms are subdivided into ten important modifications or principal cloud types based on cloud base height:

DESIGNATIONS	TYPICAL HEIGHTS	
Cirrus Cirrostratus Cirrocumulus	High	3-18 Km (10,000 - 60,000 Ft.)
Altostratus Altocumulus	Middle	2-8 Km (6,500 - 25,000 Ft.)
Stratus Stratocumulus Nimbostratus	Low	below 2 Km (to 6,500 Ft.)
Cumulus Cumulonimbus	Vertical development (Low to middle and high levels)	

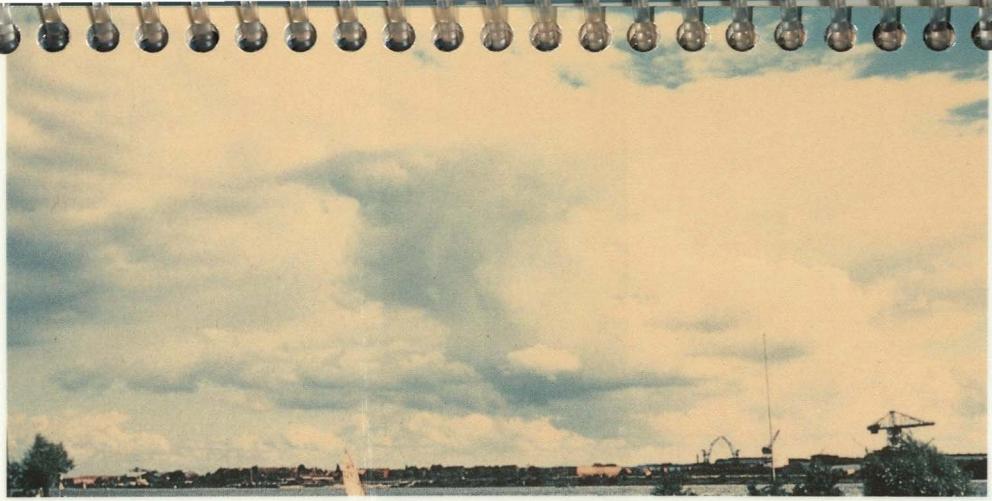
C_L = 1

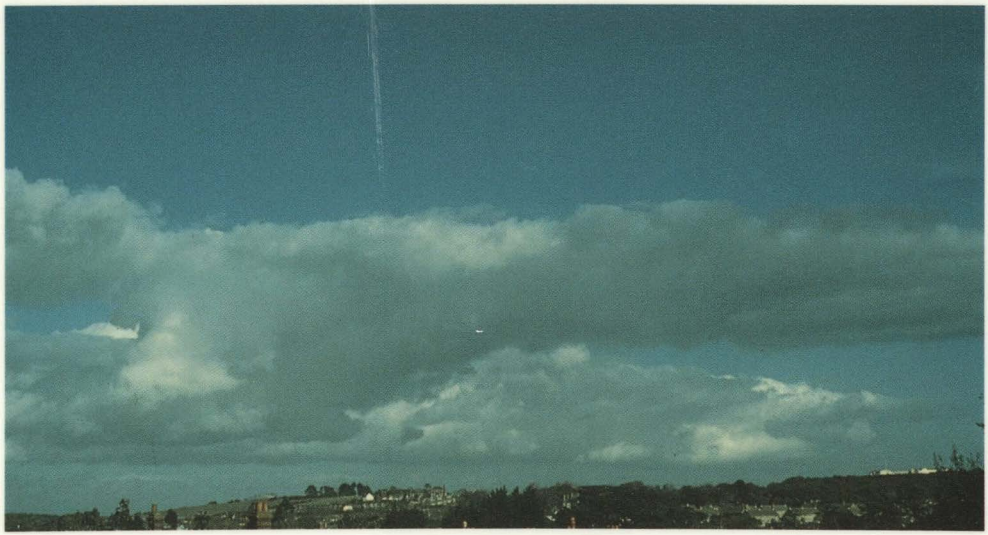
CUMULUS WITH LITTLE VERTICAL EXTENT

C_L = 2
CUMULUS WITH MODERATE OR
GREATER VERTICAL EXTENT

C_L = 3

CUMULONIMBUS, TOPS NOT FIBROUS,
OUTLINE NOT COMPLETELY SHARP, NO ANVIL.



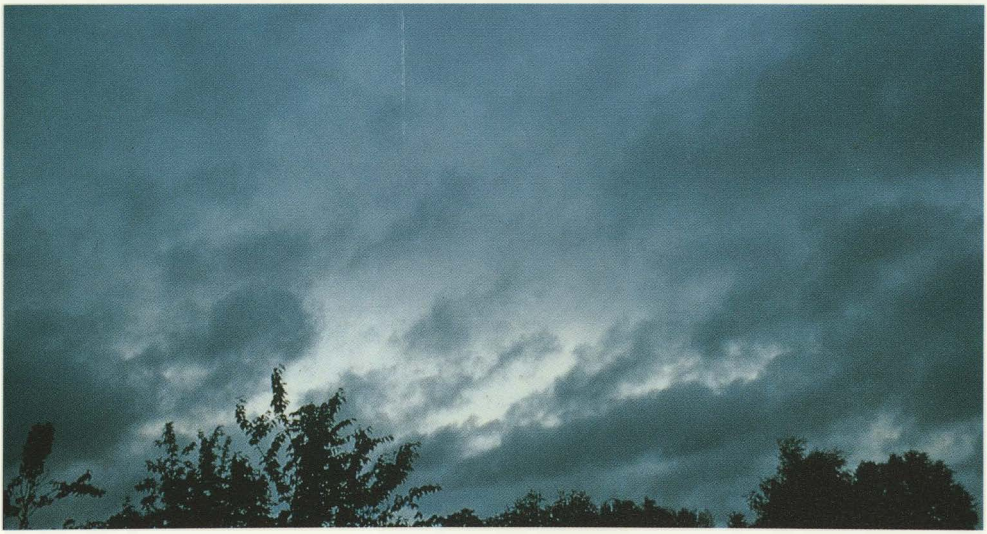


C_L = 4

STRATOCUMULUS FROM THE SPREADING OF CUMULUS.

C_L = 5
STRATOCUMULUS NOT FORMED FROM
SPREADING CUMULUS.

C_L = 6
STRATUS IN A SHEET OR LAYER.

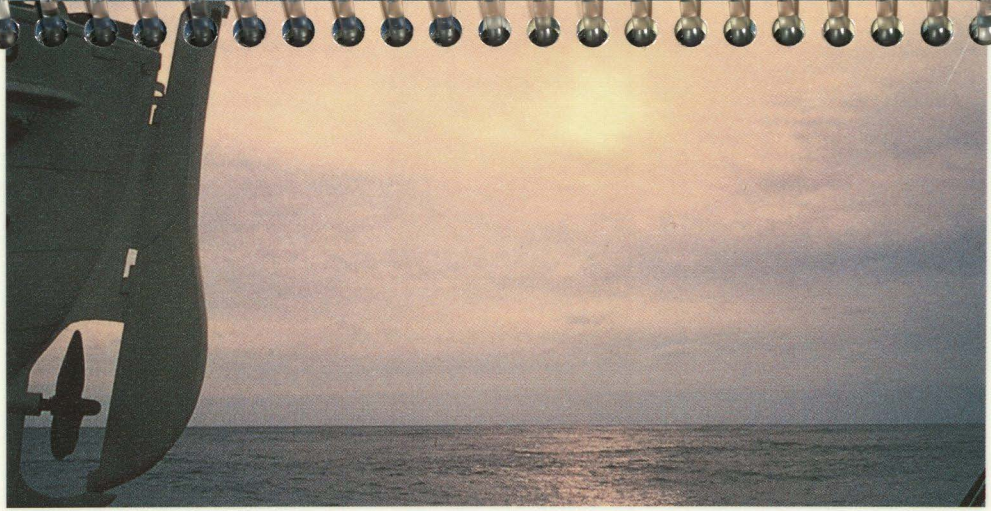


C_L = 7
STRATUS FRACTUS AND/OR CUMULUS FRACTUS OF BAD WEATHER.

C_L = 8

CUMULUS AND STRATOCUMULUS (NOT FROM SPREADING CUMULUS), BASES AT DIFFERENT LEVELS.

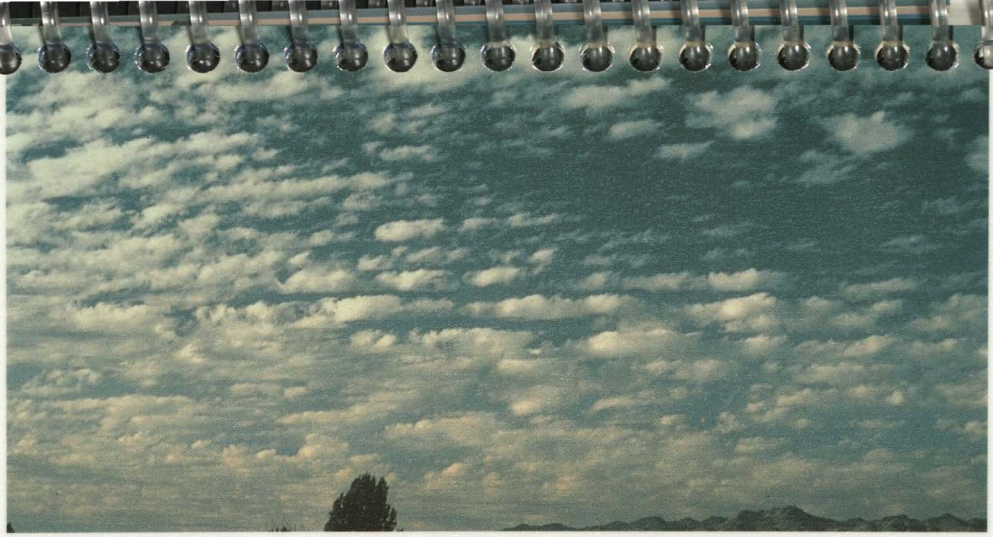
C_L = 9
CUMULONIMBUS WITH FIBROUS TOP,
OFTEN WITH AN ANVIL.



C_M = 1
ALTOSTRATUS, SEMI-TRANSPARENT, SUN
OR MOON DIMLY VISIBLE.

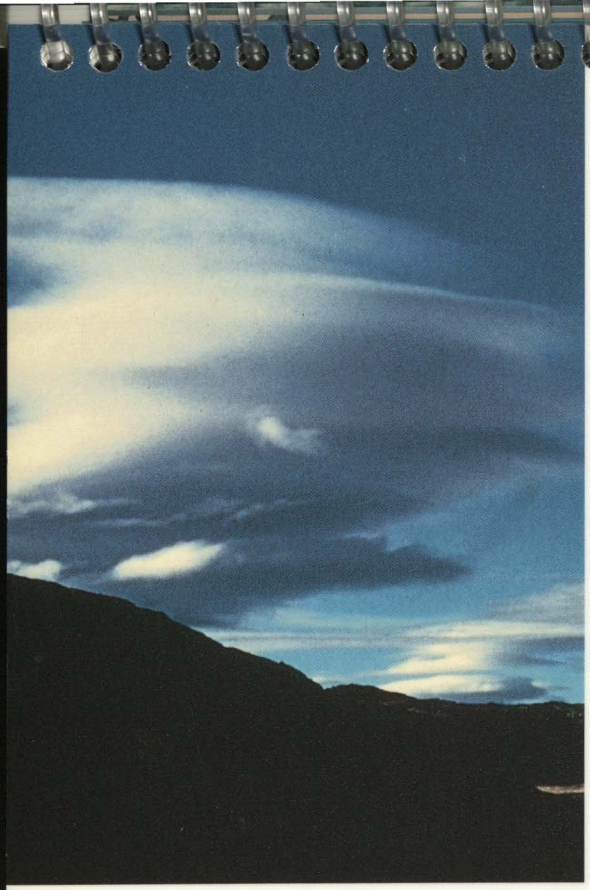
C_M = 2

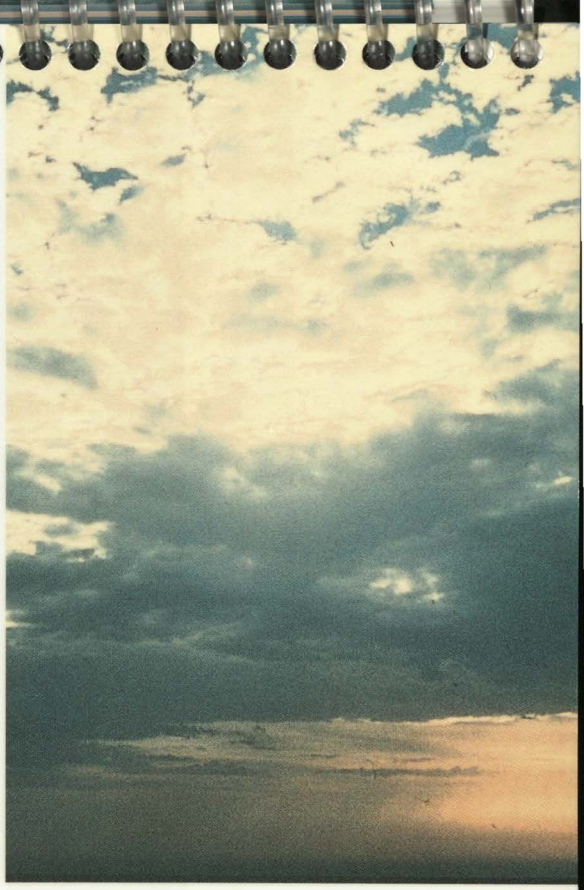
ALTOSTRATUS, DENSE ENOUGH TO HIDE SUN
OR MOON, OR NIMBOSTRATUS.



C_M = 3

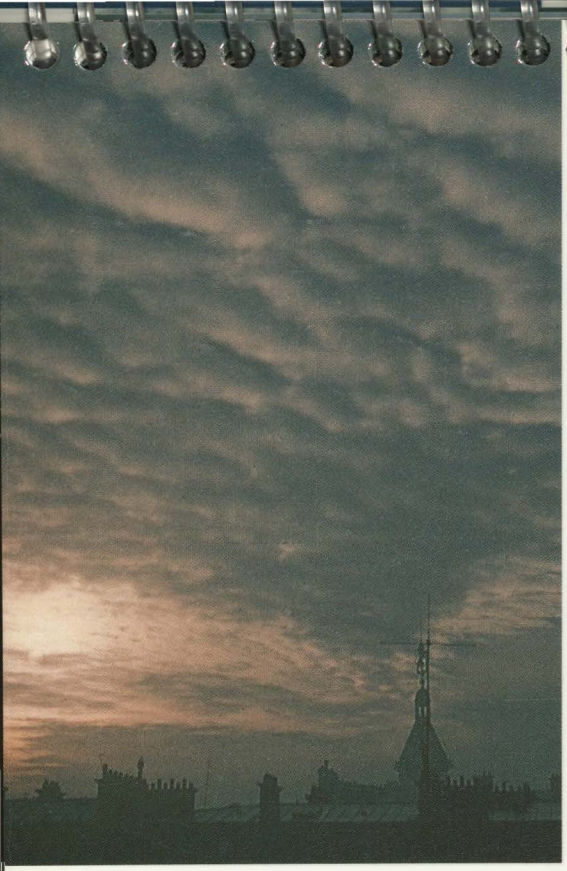
ALTOCUMULUS, SEMI-TRANSPARENT, CLOUD ELEMENTS CHANGE SLOWLY, ONE LEVEL.





C_M = 4

ALTOCUMULUS PATCHES, SEMI-TRANSPARENT,
MULTILEVEL, CLOUD ELEMENTS CHANGING.
ALSO ALTOCUMULUS LENTICULAR.



C_M = 5

ALTOCUMULUS, ONE OR MORE BANDS OR LAYERS, EXPANDING, THICKENING.

C_M = 6
ALTOCUMULUS FROM THE SPREADING OF
CUMULUS OR CUMULONIMBUS.

C_M = 7

ALTOCUMULUS, ONE OR MORE LAYERS, MAINLY OPAQUE, NOT EXPANDING, OR ALTOCUMULUS WITH ALTOSTRATUS OR NIMBOSTRATUS.

C_M = 8
ALTOCUMULUS WITH TOWER LIKE SPROUTINGS.

C_M = 9

ALTOCUMULUS OF A CHAOTIC SKY, USUALLY WITH HEAVY BROKEN CLOUD SHEETS AT DIFFERENT LEVELS.

C_H = 1

CIRRUS FILAMENTS, STRANDS, HOOKS, NOT EXPANDING.

C_H = 2

DENSE CIRRUS IN PATCHES OR SHEAVES, NOT INCREASING, OR CIRRUS LIKE CUMULIFORM TUFTS.

C_H = 3

DENSE CIRRUS, OFTEN THE ANVIL REMAINING FROM CUMULONIMBUS.

C_H = 4

CIRRUS HOOKS OR FILAMENTS, INCREASING, BECOMING DENSER.

C_H = 5

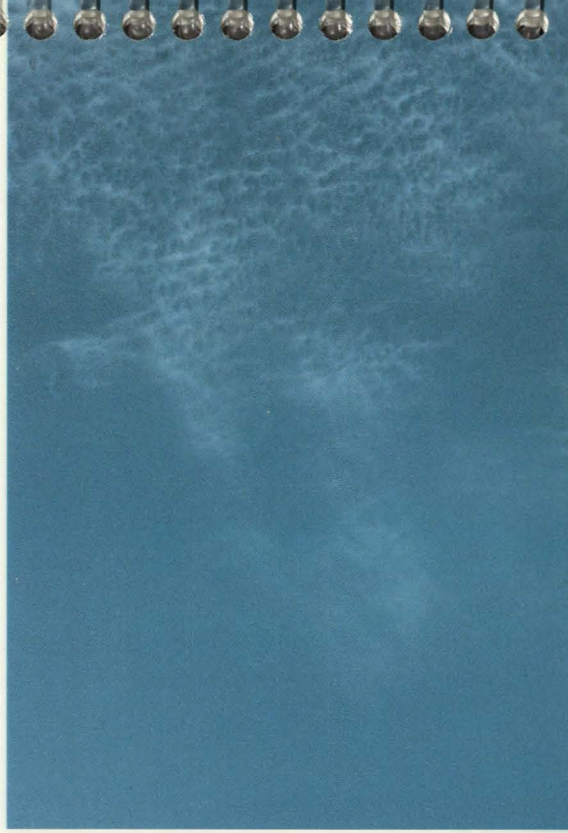
CIRRUS BANDS AND/OR CIRROSTRATUS, INCREASING, GROWING DENSER, VEIL BELOW 45°.

C_H = 6

CIRRUS BANDS AND/OR CIRROSTRATUS, INCREASING, GROWING DENSER, VEIL ABOVE 45°.

C_H = 7
CIRROSTRATUS COVERING WHOLE SKY

C_H = 8
CIRROSTRATUS, NOT INCREASING,
NOT COVERING WHOLE SKY.



C_H = 9
CIRROCUMULUS ALONE, AND/OR
CIRRUS AND CIRROSTRATUS.

PART 3
GLOSSARY

Alto-	Cloud prefix meaning middle level
Altocumulus	Middle level white or gray patch, sheet, or layer of cloud, composed of rounded masses, rolls, etc., which may or may not be merged. Mainly composed of water droplets, sometimes partly fibrous (ice).
Altostratus	Middle level grayish or bluish sheet or layer of striated, fibrous, or uniform appearance.
Anemometer	An instrument for measuring wind speed and direction. Typically 3 or 4 rotating cups measure speed, and a vane indicates direction.
Beaufort Wind Scale	A numerical scale of wind force originally designed by Admiral Francis Beaufort in the mid-19th century. It consists of sea-state descriptions correlated with ranges of wind speed.
Cirro	Cloud prefix meaning high level.
Cirrocumulus	High level thin white patch, sheet, or layer of cloud, composed of very small elements like ripples, grains, etc.
Cirrostratus	High level transparent, whitish cloud veil of fibrous (hairlike), or smooth appearance, often producing a halo.
Cirrus	High level clouds of ice crystals in the form of delicate white filaments, or white patches or narrow bands, with fibrous appearance of silky sheen.
Cloud Height	The height of the base of the cloud or cloud layer above the sea or land surface.
Cloud Layer	A grouping of clouds whose bases are at approximately the same level.

Convection	Vertical air movement in unstable air masses resulting in the development of cumulus clouds.
Cloud Type	A cloud form identified as distinct according to the World Meteorological Organization.
Crest	The highest part of the wave.
Cumulonimbus	A heavy, dense cloud with considerable vertical extent, in the form of a mountain or huge tower. Part of the upper portion may be smooth or fibrous.
Cumulus	Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes, or towers, of which the bulging upper part may resemble a cauliflower. The sunlit parts are brilliant white, the bases can be dark and nearly horizontal.
Fetch	The distance the wind has blown across the water without interruption.
Fracto	Cloud prefix meaning torn, ragged, or scattered appearance due to strong winds.
Freak Wave	A wave of great height and steepness, much higher than other waves in the prevailing sea or swell system.
Gust	Sudden brief wind increase followed by lull or slackening.
Knot	One nautical mile per hour or .5 meters/second.
Lenticular	A type of cloud formed in the ascending portion of an airstream, which remains stationary while the air blows through it.
Nimbostratus	Gray cloud layer, often dark, thick enough to block out the sun, which appears diffuse by falling precipitation.
Period	See "wave period".
Ripple	A small wavelet that forms at wind speed of 1-3 knots.

Sea	Locally generated waves produced by the wind.
Sea Disturbance	Waves, whitecaps, spindrift, foam, etc. on the sea surface.
Strato	Cloud prefix referring to cloud sheets or layers.
Stratocumulus	Lower level gray or whitish patch, sheet, or layer of cloud, usually with dark parts, with rounded masses or rolls, which may not be merged.
Stratus	Generally gray lower level cloud layer with a fairly uniform base, which may produce drizzle or snow grains.
Swell	Ocean waves which have traveled beyond the generating area, which have not been produced by the local wind. They have longer periods than sea, and are more regular and uniform.
Trough	The lowest part of the wave.
True Direction	Direction measured in degrees clockwise from true north, where north is 0°.
Wave Height	Distance from trough to crest, averaged for the better formed waves in the group.
Wave Length	Distance from trough to trough or crest to crest for adjacent waves.
Wave Period	Time, in seconds for the passage of successive wave crests. Normally computed as an average value for several waves.
Whitecap	The breaking crest of a wave, usually white and frothy.
Wind	The horizontal motion of the air past a given point.
Wind Direction	The true direction from which the wind is blowing at a given location.
Wind Speed	The rate at which the air is moving horizontally past a given point. Wind speed estimates are usually made by relating the state of the sea to the Beaufort Scale of wind force.

BEAUFORT WIND SCALE

Beaufort number or force	Wind Speed			Sea Wave Height		World Meteorological Organization (1964)	Effects observed on sea
	knots	mph	meters per second	feet	meters		
0	under 1	under 1	0.0-0.2			Calm	Sea like mirror.
1	1-3	1-3	0.3-1.5	.25	.1	Light air	Ripples with appearance of scales; no foam crests.
2	4-6	4-7	1.6-3.3	.5-1	.2-.3	Light breeze	Small wavelets; crests of glassy appearance, not breaking.
3	7-10	8-12	3.4-5.4	2-3	.6-1	Gentle breeze	Large wavelets; crests begin to break; scattered whitecaps
4	11-16	13-18	5.5-7.9	3.5-5	1-1.5	Moderate breeze	Small waves, becoming longer; numerous whitecaps
5	17-21	19-24	8.0-10.7	6-8	2-2.5	Fresh breeze	Moderate waves, taking longer form; many whitecaps; some spray.
6	22-27	25-31	10.8-13.8	9.5-13	3-4	Strong breeze	Larger waves forming; whitecaps everywhere; more spray.
7	28-33	32-38	13.9-17.1	13.5-19	4-5.5	Near gale	Sea heaps up; white foam from breaking waves begins to be blown in streaks.
8	34-40	39-46	17.2-20.7	18-25	5.5-7.5	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.
9	41-47	47-54	20.8-24.4	23-32	7-10	Strong gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.
10	48-55	55-63	24.5-28.4	29-41	9-12.5	Storm	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.
11	56-63	64-72	28.5-32.6	37-52	11.5-16	Violent storm	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.
12	64 and over	73 and over	32.7 and over	45-	14-	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced.

NWS PORT METEOROLOGICAL OFFICERS

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service