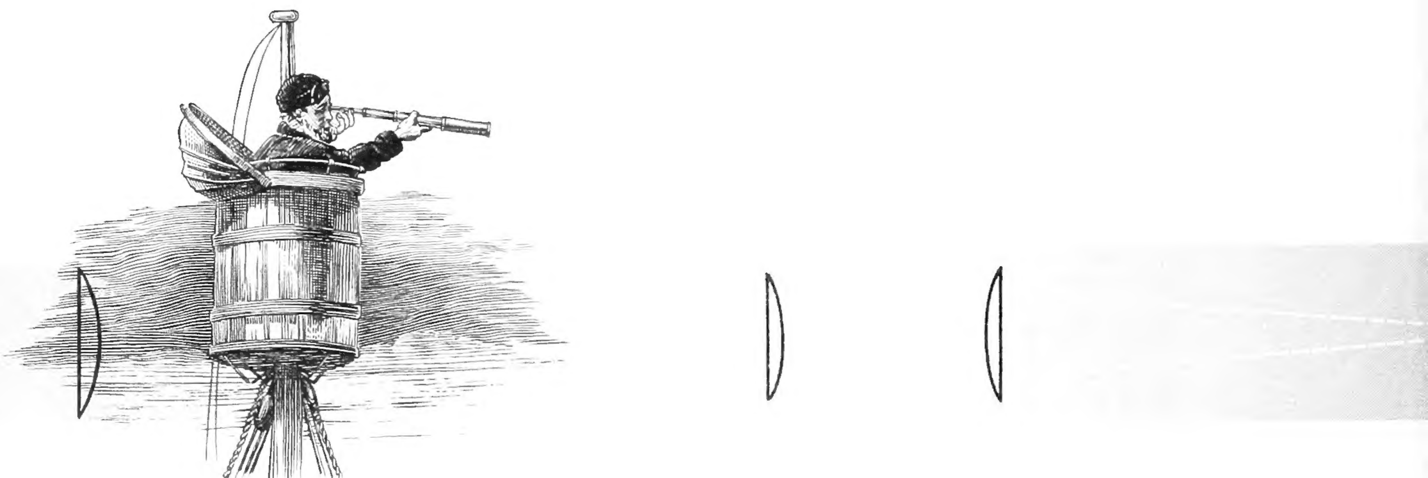
hydrographic office observers manual

H. O. PUB. NO. 606-e

SEA AND SWELL OBSERVATIONS



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HYDROGRAPHIC OFFICE
OBSERVERS MANUAL

SEA AND SWELL OBSERVATIONS

WAVE CHARACTERISTICS

WAVES OF THE SEA

HOW TO MAKE OBSERVATIONS

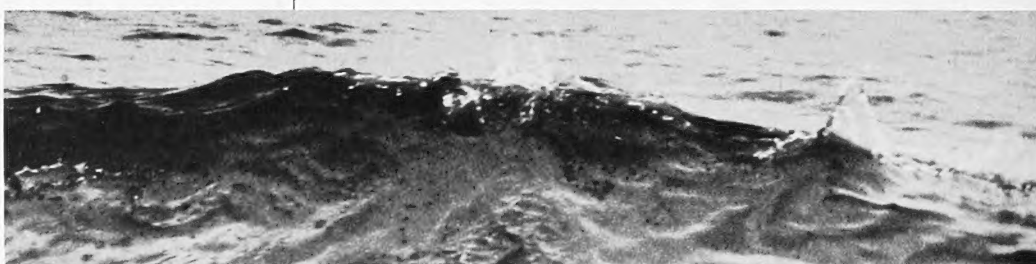
REPORTING PROCEDURE

If you have ever hit the beach with an amphibious force in a high surf or bounced in a rough seaplane landing or only got soaked in a liberty boat in a "fresh breeze," you know the value of accurate sea and swell information. What you may not know is how that information is collected and how you can help collect it.

Although men have been sailing and observing the sea for centuries, there are still many parts of the world where reports of wave conditions are entirely lacking, or at best, are scanty for certain seasons. Strangely enough, even in heavily travelled waters, there is need for more observations under the different kinds of wind and weather conditions found in those waters.

During World War II, our knowledge of waves and swell increased greatly, particularly as regards the mathematical theory of waves. This theory now needs to be checked by on-the-spot observations. Thus, because of both the practical and theoretical aspects it is important for you to make and record observations of sea and swell whenever possible.

WAVE CHARACTERISTICS



Before you make your observation, you should know something about wave characteristics.
A wave is described by

its *length* — the distance from crest to crest,

its *height* — the vertical distance from trough to crest,

its *period* — the time between two consecutive crests,

and its *velocity* — the speed with which it travels.

Some very useful theoretical relationships, which have been checked by observation, exist between the length, the velocity, and the period of waves in deep water. If you know the wave length in feet, or the velocity in knots, or the period in seconds, you can figure out the approximate values of the other two.

$$\text{Velocity} \approx 1.3\sqrt{\text{Length}} \approx 3\ \text{Period}.$$

$$\text{Length} \approx 0.6\,(\text{Velocity})^2 \approx 5\,(\text{Period})^2.$$

$$\text{Period} \approx 0.4\sqrt{\text{Length}} \approx 0.3\ \text{Velocity}.$$

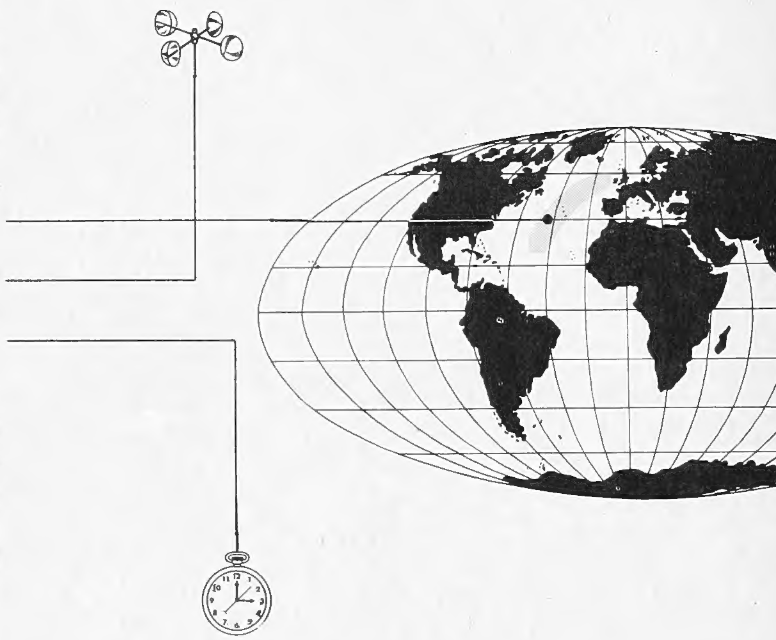
Unlike the length and velocity, the wave *height* bears no definite relationship to the wave period.

WAVES OF THE SEA

WIND WAVES

Watching a passing "cat's paw" as it ruffles the surface of a calm sea, you can see the first stage in the formation of waves. As the wind grows stronger, the ruffles grow into ripples ,and the ripples into waves. Waves which are still growing under the force of the wind are known as sea or wind waves. The height and length of these waves are determined by:

1. The fetch or distance over which the wind is blowing.
2. The average wind velocity over the fetch.
3. The length of time the wind has been blowing.

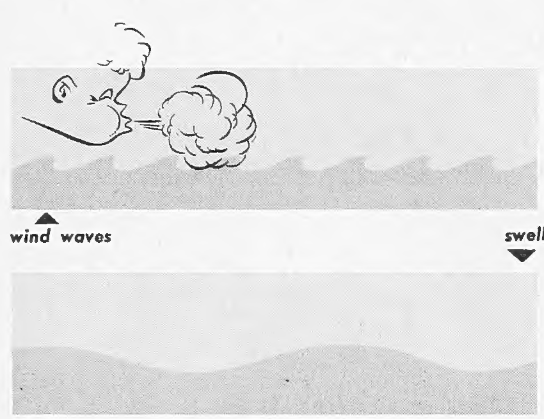


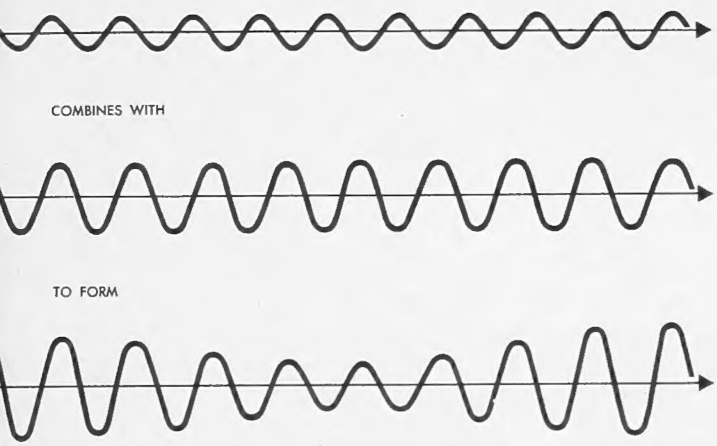
In general, wind waves travel in the same direction as the wind that formed them. Sometimes, if the waves are still in the process of formation, the sea will be choppy and difficult to describe. However, as the waves grow under the influence of the wind, they form themselves into a regular series of crests and troughs at right angles to the wind direction. Their length varies from about 12 to 35 times their height.

SWELL

When wind-raised waves travel out of a stormy or windy area, they advance as swell and their form undergoes a change. Their height decreases as they advance, their crests become rounded, and their surface smooth. Their length increases until it is generally between 35 and 200 times their height.

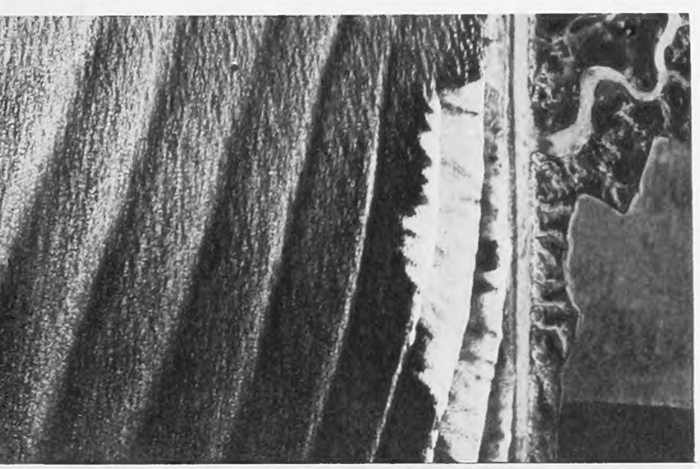
Often you will find both sea and swell or two or more systems of swell present in the same area. Sometimes a system of wind waves travelling in the same direction on top of a long low swell will almost obscure the swell. However, the swell can usually be felt in the roll of a heavy ship. In extreme cases, the component may be so poorly defined that it is impossible to separate them, and they can only be reported as confused.





When two systems of waves cross each other at a considerable angle they form a cross sea. In place of long continuous crests, the wave systems meet to form a very irregular surface of unrelated short-crested peaks and hollows.

When two or more wave trains combine, the result may be a complicated wave form caused by interference. At some points, the waves are in phase (one crest on top of another crest) and the two waves reinforce each other. At other points the waves are out of phase (a crest on top of a trough) and the two waves tend to cancel each other. As a simple case, when two wave trains moving in the same general direction have the same height and nearly the same velocity, the result of their combination or interference will be a group of waves roughly twice the height of the original waves with regions in between where the waves disappear. The figure at the left shows graphically how this can happen.



SURF

As swell travels across the ocean away from the storm area which generated it, it grows flatter and longer. The waves lose roughly one third of their height each time they travel a distance in miles equal to their length in feet. And their apparent period, wave length, and velocity increase. The waves are further flattened by an opposing wind. Eventually, the waves, growing flatter and longer, reach shallow water. Here the bottom restricts the motion of the water particles and the wave is slowed down. The wave train is telescoped together, the wave length decreases, and the wave height increases. When the height-length ratio reaches a critical value, the crest topples forward, and the wave breaks. Theoretically the breaking occurs when this ratio reaches 1:7, but observations indicate that it usually occurs when the ratio becomes 1:12 to 1:10.

Waves can also steepen to the breaking point in deep water by meeting a strong opposing current in a short narrow channel or by the action of strong gusts of wind which add energy rapidly to the wave form causing it to become unstable. Such short-crested waves breaking in deep water are the familiar white-caps. Whitecaps occur only with wind velocities greater than 12 knots.

HOW TO MAKE OBSERVATIONS

Four items are to be measured and reported: these are wave height, wave period, wave length, and direction from which the waves approach. Aboard ship, the height and direction must be estimated, the period can be measured, and wave length either calculated or measured. In addition, certain observations of the general sea conditions should be made.

The following methods of observing are for use on a moving vessel. No special procedures will be given for use when the ship is hove to or not underway, since the job then is greatly simplified.

WAVE HEIGHT

Estimating wave heights from shipboard is complicated by the rolling and pitching of the ship, its rising and falling with the waves, and the presence of high local winds. Low waves tend to be underestimated; high waves, overestimated. The best estimate can be obtained by observing another ship in company. The height from trough to crest of a wave against her side can be estimated as a part of some known vertical distance. For example, a wave might be ¼ of the bridge height of 28 feet or seven feet high.

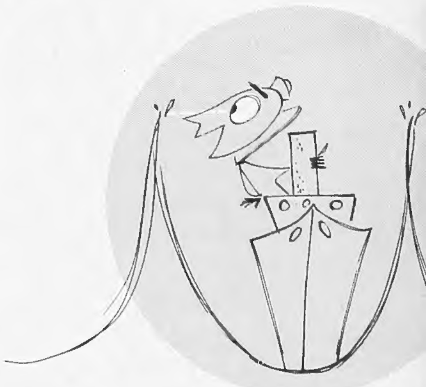
Without the aid of another ship, you must make your observations at times and positions when your own ship's motions are as small as possible. Observations should be made amidships and near the center line. If possible, the ship should be heading into the waves. If not, choose a time when the rolling and pitching is at a minimum.

if waves are shorter than the ship:

Estimate the wave height by looking over the side — using as a yardstick the relative heights of two known points along the side. For example: the sea-ladder fittings, the loading ports, the rubbing strake.

if waves are longer than the ship:

Wait until the ship is in the trough of a wave and vertical. By trial and error, move up and down on the superstructure until the wave crests are on a line with the horizon. Then the distance your eye is from the ship's water line is the height of the wave. If the ship is rolling, care should be taken to line up the wave crest with the horizon at the instant the ship is vertical, otherwise the height estimate will be too large.



The heights of waves usually vary considerably. Observations should be made for at least five minutes and mental estimates made of the higher waves in each wave system. If two observers are available, one can make the estimates and the other record the observed values. The wave height to be recorded is not that of the highest wave nor the lowest nor the average of all the waves. What is needed is the *significant wave height*, which by definition is the average of the highest third of the waves observed in a certain time.

When both sea and swell or two systems of swell are present at the same time, observations will be more difficult. You should estimate the higher system of waves first, then repeat the process for the lower system.

WAVE PERIOD

The simplest way of measuring wave period is with a stop watch. Pick out an object floating on the water at some distance from your ship as a reference point. You can use a piece of sea weed, a piece of wood thrown overboard, a bird on the water, or a patch of foam which will remain identifiable for a few minutes. If possible choose an object on the bow, as far off as possible. Then with the watch, measure the time of successive appearances of the object on the crest of a wave. You should take your readings as long as the reference object remains in sight. The average value of the period observations is used for the record.

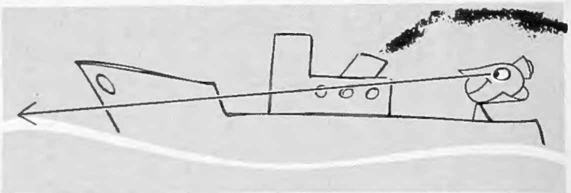
Although both wave length and wave velocity can be computed from the wave period by the formulas on page 2, independent measurements of wave length are desirable as a check on the accuracy of the wave period.

WAVE LENGTH

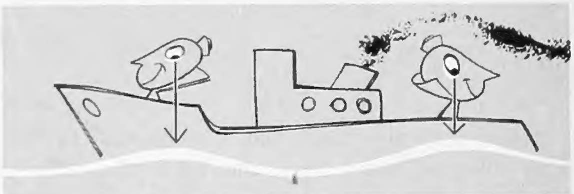
Different procedures must be used for measuring wave length, depending on the direction from which the waves approach the ship. They may be coming from dead ahead or dead astern, at an angle on the bow or quarter, or from abeam the ship. The procedures which should be used in each of the three cases are described below:

waves from dead ahead or dead astern:

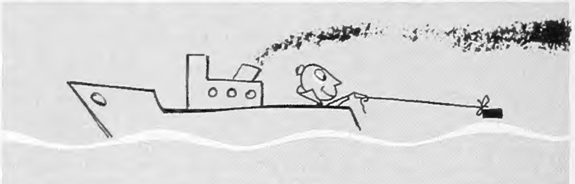
1. The easiest way to measure wave length is to compare the distance between two wave crests with the length of the ship. However, experience has shown that this method usually results in wave lengths that are too short since the observer is apt to take the crest of the wave at a point somewhat short of the true summit.



If the waves are not as long as the ship, two observers can get accurate measurements of wave length by stationing themselves along the side of the ship a wave length apart and noting the distance between them.



2. You can also determine the wave length by streaming a buoyant object on a line. If you pay out the line until the floating object is on one crest and you are on the next, the length of line you have out will give you the wave length.



3. In a special case when your ship is travelling along with the waves at a speed equal to the wave velocity, the wave length can be found from the equation:

$$\underset{\text{in feet}}{\text{Wave Length Units}} = 0.5\,(\underset{\text{in knots}}{\text{Wave Velocity Units}})^2$$

In this case, the wave velocity is the same as the speed of the ship.

waves at an angle on the bow or quarter:

1. The wave length measured by comparing the distance between two crests with the length of the ship or by streaming a buoyant object astern as described earlier must, in this case, be multiplied by a correction factor to get the true value of the wave length. Observed length × correction factor = true length. This correction factor depends on the *relative bearing* from which the waves are approaching the ship. The table at the right gives the values for the correction factor for bearings from 005 to 355.

2. Another method of measuring wave length is possible by using the ship's length and the angle at which the waves are approaching the ship. If you determine the time it takes to pass two consecutive crests and the time it takes for one wave crest to run the length of the ship, the following formula will give you the wave length.

TABLE OF CORRECTION FACTORS

RELATIVE BEARING OF WAVE DIRECTION				CORRECTION FACTOR
005	175	185	355	1.0
010	170	190	350	1.0
015	165	195	345	1.0
020	160	200	340	0.9
025	155	205	335	0.9
030	150	210	330	0.9
035	145	215	325	0.8
040	140	220	320	0.8
045	135	225	315	0.7
050	130	230	310	0.6
055	125	235	305	0.6
060	120	240	300	0.5
065	115	245	295	0.4
070	110	250	290	0.3
075	105	255	285	0.3
080	100	260	280	0.2
085	095	265	275	0.1

$$\text{Wave length} = \frac{\text{Time to pass 2 crests} \times \text{Ship's length} \times \text{Correction factor}}{\text{Time for crest to travel ship's length}}$$

If you cannot see the wave passing the entire length of the ship, choose any two visible points along the side, for which the distance between is known, and substitute these values in the formula for those involving the ship's length.

waves from abeam:

1. In this case, determine the period as described on page 6 and calculate the wave length from the equation:

$$\text{Wave length} = 5.1\ (\text{Period})^2.$$

WAVE DIRECTION

The direction from which the waves are moving can be best determined by sighting with a pelorus along the crests and then adding or subtracting 90° as appropriate. The ship's heading can also be used as a guide to determining the direction from which the waves are approaching. The higher the observation point the easier it is to determine wave direction. The average of several observations should be used as the reported wave direction.

REPORTING PROCEDURE

A printed form NHO-1192 for recording shipboard observations has been prepared to standardize the items to be recorded and the manner in which they are to be recorded. These forms may be procured from the U. S. Navy Hydrographic Office, Washington 25, D. C.

So that the data which you collect can be analyzed by an IBM machine, the values for the observed items must be coded according to the accompanying code tables. It is important that no items be omitted.

The basic reporting code is in the following form:

MMddy $yQL_aL_aL_a$ $L_oL_oL_oGG$ ddffE $Sd_wd_wH_wH_w$ $P_wP_wL_wL_wL_w$ $Xd_wd_wH_wH_w$ $P_wP_wL_wL_wL_w$.

The data groups $Xd_wd_wH_wH_w$ and $P_wP_wL_wL_wL_w$ may be repeated as many times as necessary to describe all swell systems present, or omitted entirely if no swell is present.

Groups $Sd_wd_wH_wH_w$ $P_wP_wL_wL_wL_w$ may be omitted if no wind waves are present. (Note. In this case wind should be reported as calm.)

After the items have been encoded, they are written in the shipboard wave observation log, any special remarks are added, and the log is initialed by the observer.

The completed log is forwarded at monthly intervals to:

The Hydrographer
U. S. Navy Hydrographic Office
Washington 25, D. C.

MMddy
$yQL_aL_aL_a$ $L_oL_oL_oGG$ ddffE
$Sd_wd_wH_wH_w$ $P_wP_wL_wL_wL_w$
$Xd_wd_wH_wH_w$ $P_wP_wL_wL_wL_w$

MM
MONTH OF THE YEAR

	CODE
January	01
February	02
March	03
April	04
May	05
June	06
July	07
August	08
September	09
October	10
November	11
December	12

dd
DAY OF THE MONTH

Use two figures in reporting day of the month. For example: the fifth day is reported as 05.

yy
YEAR

Report only the last two figures. For example: 1949 is reported as 49.

Q
OCTANT OF THE GLOBE

	CODE
North latitude:	
0° W to 90° W	0
90° W to 180° W	1
180° W to 90° E	2
90° E to 0° E	3
South latitude:	
0° W to 90° W	5
90° W to 180° W	6
180° W to 90° E	7
90° E to 0° E	8

$L_aL_aL_a$
LATITUDE

Report in degrees and tenths, the tenths being obtained by dividing the number of minutes by 6 and neglecting the remainder.

$L_oL_oL_o$
LONGITUDE

Report in degrees and tenths. Omit hundreds when the longitude is greater than 100°.

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GG

HOUR OF THE DAY (Greenwich Mean Time)

dd or $d_w d_w$

TRUE DIRECTION FROM WHICH SURFACE WIND IS BLOWING OR FROM WHICH WAVE SYSTEM IS APPROACHING, IN 10's OF DEGREES

Direction	CODE
Calm	00
5° to 14°	01
15° to 24° NNE	02
25° to 34°	03
35° to 44°	04
45° to 54° NE	05
55° to 64°	06
65° to 74° ENE	07
75° to 84°	08
85° to 94° E	09
95° to 104°	10
105° to 114° ESE	11
115° to 124°	12
125° to 134°	13
135° to 144° SE	14
145° to 154°	15
155° to 164° SSE	16
165° to 174°	17
175° to 184° S	18
185° to 194°	19
195° to 204° SSW	20
205° to 214°	21
215° to 224°	22
225° to 234° SW	23
235° to 244°	24
245° to 254° WSW	25
255° to 264°	26
265° to 274° W	27
275° to 284°	28
285° to 294° WNW	29
295° to 304°	30
305° to 314°	31
315° to 324° NW	32
325° to 334°	33
335° to 344° NNW	34
345° to 354°	35
355° to 4° N	36

ff

WIND SPEED

Report speed in knots using two figures. For example: a 9-knot wind is reported as 09. Use the Beaufort Scale below when no anemometer is available. Speeds above 99 knots and unusual gustiness should be noted in "Remarks" column.

		CODE
Calm	Less than 1 knot	00
Light airs	1-3	01
Light breeze	4-6	02
Gentle breeze	7-10	03
Moderate breeze	11-16	04
Fresh breeze	17-21	05
Strong breeze	22-27	06
Moderate gale	28-33	07
Fresh gale	34-40	08
Strong gale	41-47	09
Whole gale	48-55	10
Storm	56-63	11
Hurricane	64 and above	12

E

ELEVATION OF WIND MEASUREMENT ABOVE SEA SURFACE

	CODE
0-9 feet	0
10-19	1
20-29	2
30-39	3
40-49	4
50-69	5
70-89	6
90-130	7
Greater than 130	8
Wind strength by Beaufort Scale (no anemometer)	9

S

DESCRIPTION OF WIND WAVES

	CODE
CALM — Sea like a mirror.	0
SMOOTH — Small wavelets or ripples with the appearance of scales but without crests.	1
SLIGHT — Short pronounced waves or small rollers. Crests have a glassy appearance.	2
MODERATE — Waves or large rollers. Scattered whitecaps on wave crests. Sea produces short rustling sounds.	3
ROUGH — Waves with frequent whitecaps. Chance of some spray. Sea noise is like a dull murmur.	4
VERY ROUGH — Waves tend to heap up. Continuous whitecapping. Foam from whitecaps is occasionally blown along by the wind as spindrift. The waves produce a continuous murmur.	5
HIGH — High waves having extensive whitecaps from which foam is blown in dense streaks. The sea begins to roll and its noise is like a dull roar.	6
VERY HIGH — High waves heaping up with long frothy crests that are capping continuously to make a roaring noise. The great amount of foam being blown from the crests causes the sea surface to take on a white appearance and may affect visibility. Rolling of the sea becomes heavy and shock-like.	7
MOUNTAINOUS — Waves are so high that ships within close distances drop so low in the wave troughs that they are lost from view for a time. Wind bodily carries off the crests of all waves, and the sea is entirely covered with dense streaks of foam. The air itself is so filled with foam and spray as to seriously affect visibility. The rolling of the sea is tumultuous.	8
CONFUSED — Waves cross each other from many and unpredictable directions, developing a complicated interference pattern difficult to describe. Waves may partially break upon occasion.	9

$H_w H_w$

HEIGHT OF THE SIGNIFICANT * WIND WAVES OR SWELL

Report height in feet using two figures. For example a 5-foot wave is reported as 05.

$P_w P_w$

PERIOD OF THE SIGNIFICANT * WIND WAVES OR SWELL

Report period in seconds using two figures. For example a 6-second wave is reported 06.

$L_w L_w L_w$

LENGTH OF THE SIGNIFICANT * WIND WAVES OR SWELL

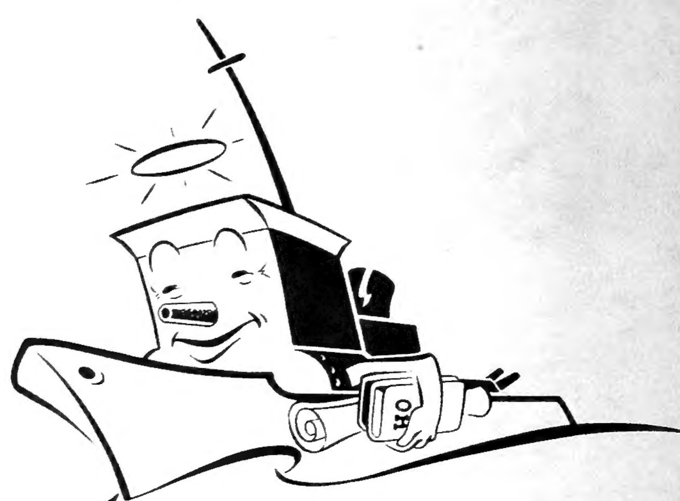
Report length to nearest 10 feet, using three figures, with final zero omitted. For example, a 50-foot wave length is reported 005, a 210-foot wave length is reported 021, etc.

If observations are made to nearest foot, drop final figure if less than 5, and add one to 10's figure if 5 or more. For example, a 63-foot wave length is reported 006, a 155-foot wave length is reported 016, etc.

X

SWELL INDICATOR. SHOWS THAT NEXT TWO GROUPS REFER TO SWELL

* See p. 6.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