CETA 81-5

The Littoral Environment Observation (LEO) Data Collection Program

by

Christine Schneider

COASTAL ENGINEERING TECHNICAL AID NO. 81-5

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The Littoral Environment Observation (LEO) Program provides data on nearshore waves, longshore and rip currents, wind conditions, and beach conditions at low cost. This report presents guidelines and procedures for LEO site selection and LEO data collection.

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PREFACE

This report presents guidelines for making visual surf and nearshore current measurements using Littoral Environment Observation (LEO) techniques. The work was carried out under the data collection part of the coastal engineering research program of the U.S. Army Coastal Engineering Research Center (CERC).

This report was prepared by Christine Schneider, Civil Engineering Technician, under the general supervision of Dr. J. Richard Weggel, Chief, Evaluation Branch. Helpful reviews by Dr. T.L. Walton, D.W. Berg, R.A. Jachowski, C.Miller, G. Bichner, W. Seyle (SAS) and D. Muslin (SPL), are acknowledged.

Comments on this publication are invited.

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TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

CONTENTS

FIGURES

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

THE LITTORAL ENVIRONMENT OBSERVATION (LEO) DATA COLLECTION PROGRAM

by

Christine Schneider

I. INTRODUCTION

Erosion caused by waves and currents acting in the surf zone along much of the coastline of the United States is a constant concern in coastal engineering. Coastal engineers have a continuing need for wind, wave, and nearshore current data in order to describe the sand transport processes in the surf zone and to design coastal works that are both functionally and structurally successful. The use of recording instruments to acquire such data can be very expensive, particularly if the data are required over a broad geographic area and for an extended period of time.

The Littoral Environment Observation (LEO) Program was established to provide data on coastal phenomena at low cost. Volunteer observers obtain daily measurements of breaker height, wave period, direction of wave approach, windspeed, wind direction, longshore current velocity, and beach slope, and record the presence of beach cusps and rip currents. At some LEO sites, monthly sand samples are also collected from the swash zone. Observers use simple, inexpensive equipment and expendable supplies to obtain the data; for some data such as wave height and direction, observers simply record visual estimates.

Obviously, with such simple collection methods and the visual estimates of some variables, an individual LEO data set is subject to error. The skill and biases of individual observers have a significant bearing on the validity of the data. Also, the different LEO collection methods have different levels of reliability. For example, the observations of variables such as windspeed and foreshore slope, obtained with the help of simple instruments, are probably more reliable than the observations of wave height and direction based only on visual sightings.

While individual LEO observations may be of questionable accuracy, a time series of LEO can be useful in statistically describing the environment at a particular site. Statistical descriptions provide valuable information on waves, currents, and longshore sand transport. Observer bias is partially compensated for by reviewing relative changes rather than the absolute value of certain parameters. For example, while the absolute magnitude of longshore transport rates predicted from LEO wave observations may exhibit some error, the relative proportion of upcoast-to-downcoast transport will probably be reasonably correct.

An important application of LEO data is the prediction of longshore sand transport rates resulting from waves breaking at an angle to the shoreline. The waves produce a longshore current which, when coupled with the breaking wave turbulence that suspends sediment, transports large quantities of sand along the shore. An empirical equation that relates longshore sand transport with wave conditions is available in the Shore Protection Manual (Ch. 4 in U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1977)[1]. LEO data can be used in the empirical relationship. Some recent theoretical developments also allow the computation of sand transport based on longshore current velocities collected under the LEO program (see Walton, 1980)[2], making available two separate, although not completely independent, methods for determining longshore transport rates. Comparisons between two independent program observers at a single LEO site suggest that a better (more consistent) agreement exists between transport rates computed from observations of longshore current velocity rather than observations of wave height and angle (Schneider and Weggel, 1980)[3]. This is not an unusual result, considering that the computed transport rate is sensitive to small changes in the wave angle that are difficult to quantify visually. Determination of the longshore transport rate from measured current velocity does not rely on this measured wave angle.

Generally, LEO data are analyzed annually; however, 1 year of data is not usually sufficient to adequately define the coastal environment at a site. Conditions at a site can vary appreciably from year to year and the longer the period of reliable LEO records, the better the description of the physical environment. To be statistically descriptive of a site, observations must be recorded at least 20 days of each month. Observations should be made at the same time each day without regard to tidal stage. An observation should not be omitted simply because a specific schedule cannot be met.

Although the LEO program provides low-cost data on nearshore waves, longshore and rip currents, wind conditions and beach conditions, the data may not be as reliable as data obtained from sophisticated recording sensors such as wave gages and current meters. The usefulness of the LEO program is best expressed in the statistical descriptions of the environment, often in areas where no other data exist, and in the inexpensive estimations of longshore transport rates. This report provides the current LEO observers and those establishing new LEO sites with information on equipment, data collection and recording procedures, and general guidelines for site selection.

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[1]U.S. ARMY, CORPS OF ENGINEERS, COASTAL ENGINEERING RESEARCH CENTER, *Shore Protection Manual*, 3d ed., Vols; I, II, and III, Stock No. 008-022-00113-1, U.S. Government Printing Office, Washington, D.C., 1977, 1,262 pp.

[2]WALTON, T.L., Jr., "Computation of Longshore Energy using LEO Current Observations," CETA 80-3, U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Fort Belvoir, Va., Mar. 1980.

[3]SCHNEIDER, C., and WEGGEL, J.R., "Visually Observed Wave Data at Point Mugu, California," *Proceedings of the 17th Conference on Coastal Engineering*, American Society of Civil Engineers, 1980.

II. DATA COLLECTION UNDER THE LEO PROGRAM

1. Site Selection.

Unless a specific need is demonstrated elsewhere, LEO sites are normally located in areas whre there are no natural or manmade structures to locally influence the behavior of waves and currents. These sites should also be easily accessible to the observer. An important consideration in locating sites is their proximity to future and existing study projects. The presence of structures such as groins, jetties, and breakwaters can locally modify the wave climate so that observations may not be indicative of the actual wave and current climate. In some cases, however, the effects of such structures may be under study and observations within the range of influence of the structures may in fact be desired.

2. Equipment and Supplies.

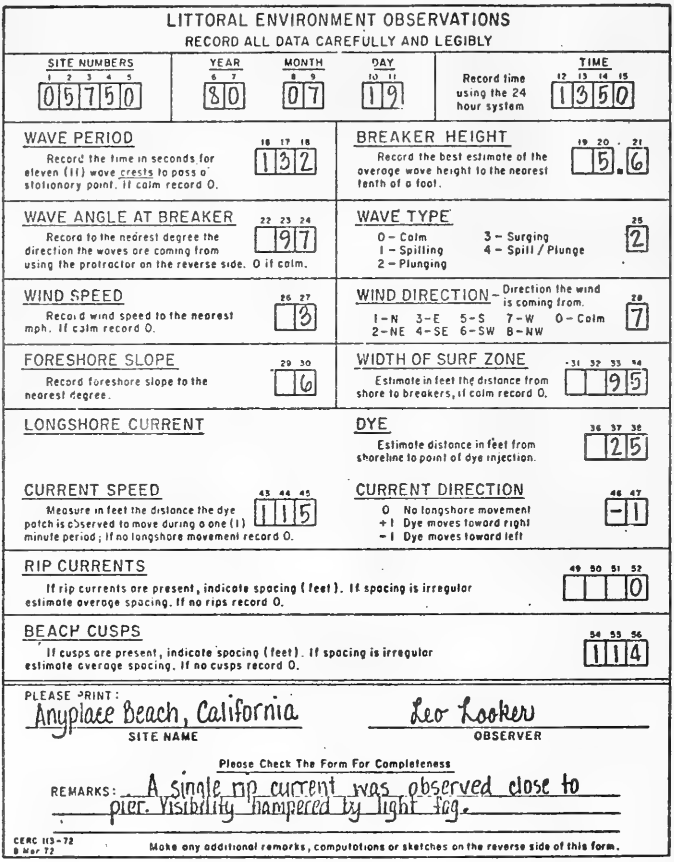
Each LEO observer is provided with the necessary equipment and supplies to make an observation, including recording forms, an instruction form, an Abney topographic hand level, a Dwyer wind meter, sodium fluorescein dye and, when needed, sand sample bags with identification tags (see Fig. 1). The hand level and wind meter must be kept clean and free of sand to ensure accurate measurements and to prevent deterioration. It is recommended that pencil rather than ink be used to record all data entries on the recording forms.

Figure 1. LEO equipment and supplies.

3. Data Collection Methods.

Daily observations are usually made either in midmorning or midafternoon. A one-page instruction form is provided all LEO observers to aid in making observations. With proper training and a few days of practice, an observer can complete a set of LEO observations within a 20-minute period.

The front side of a completed LEO form is shown in Figure 2. All data are entered on the form in the boxes identified by the numbers above them. Each box holds a single number. In cases where there may be more boxes than needed for a given entry, data should be right-justified, i.e., the numbers should fill the rightmost boxes (e.g., entries in Fig. 2 for "breaker height" and "wave angle at breaker").


LITTORAL ENVIRONMENT OBSERVATIONS

RECORD ALL DATA CAREFULLY AND LEGIBLY

SITE NUMBERS (1–5): 0 5 7 5 0 | YEAR (6–7): 8 0 | MONTH (8–9): 0 7 | DAY (10–11): 1 9 | TIME (12–15): Record time using the 24 hour system 1 3 5 0

WAVE PERIOD (16–18): Record the time in seconds for eleven (11) wave crests to pass a stationary point. If calm record 0. — 1 3 2

BREAKER HEIGHT (19–21): Record the best estimate of the average wave height to the nearest tenth of a foot. — 5.6

WAVE ANGLE AT BREAKER (22–24): Record to the nearest degree the direction the waves are coming from using the protractor on the reverse side. 0 if calm. — 9 7

WAVE TYPE (25): 0 – Calm, 1 – Spilling, 2 – Plunging, 3 – Surging, 4 – Spill / Plunge — 2

WIND SPEED (26–27): Record wind speed to the nearest mph. If calm record 0. — 3

WIND DIRECTION – Direction the wind is coming from. (28): 1-N 2-NE 3-E 4-SE 5-S 6-SW 7-W 8-NW 0-Calm — 7

FORESHORE SLOPE (29–30): Record foreshore slope to the nearest degree. — 6

WIDTH OF SURF ZONE (31–34): Estimate in feet the distance from shore to breakers, if calm record 0. — 9 5

LONGSHORE CURRENT

DYE (36–38): Estimate distance in feet from shoreline to point of dye injection. — 2 5

CURRENT SPEED (43–45): Measure in feet the distance the dye patch is observed to move during a one (1) minute period; If no longshore movement record 0. — 1 1 5

CURRENT DIRECTION (46–47): 0 No longshore movement, +1 Dye moves toward right, −1 Dye moves toward left — −1

RIP CURRENTS (49–52): If rip currents are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no rips record 0. — 0

BEACH CUSPS (54–56): If cusps are present, indicate spacing (feet). If spacing is irregular estimate average spacing. If no cusps record 0. — 1 1 4

PLEASE PRINT: Anyplace Beach, California (SITE NAME) — Leo Looker (OBSERVER)

Please Check The Form For Completeness

REMARKS: A single rip current was observed close to pier. Visibility hampered by light fog.

CERC 113-72, 8 Mar 72 — Make any additional remarks, computations or sketches on the reverse side of this form.

Figure 2. Typical completed LEO form.

a. <u>Station Identification (Blocks 1 to 5)</u>. Each LEO site is assigned a five-digit station identification number by CERC. The first two digits indicate the geographical location of the site, the latter three digits are unique to each LEO site.

b. <u>Date and Time of Observation (Blocks 6 to 11 and 12 to 15)</u>. The last two digits of the year and the numerical order of month and day are entered into the appropriate boxes. The time of the observation is by the 24-hour system.

c. Wave Period (Blocks 16, 17, and 18). Wave period is recorded as the number of seconds it takes for 11 wave crests to pass an arbitrary, fixed point in the surf zone (Fig. 3). Timing begins when the *1st* crest passes the point and ends when the *11th* crest passes the point; the time for 10 waves to move past the point is then recorded. All waves, whether large or small, should be counted. If no waves are present, a zero representing calm conditions is recorded.

d. Breaker Height (Blocks 19, 20, and 21). This observation is based on the observer's visual estimate of the average height of the breaking waves (Fig. 4). Natural or manmade features with known dimensions along the shoreline or in the surf zone can be used to aid in making this estimate. A visual estimate of the average breaker height representative of conditions in the seawardmost major breaking zone is recorded to the nearest tenth of a foot. Observers should also attempt to estimate the breaker height of the seawardmost line of breakers. These are generally the largest breakers. Under some

Figure 3. Timing the wave period.

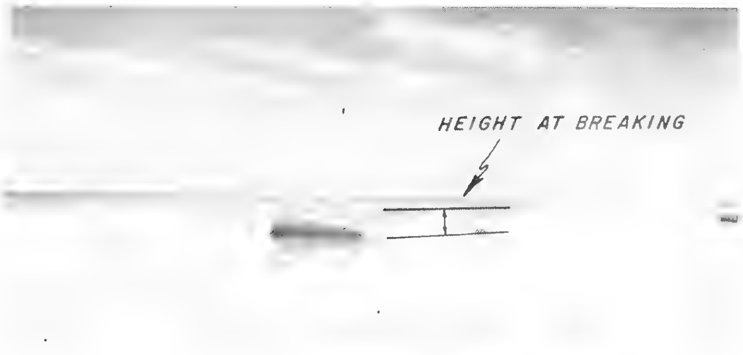


Figure 4. Visually observed estimate of breaker height.

surf conditions, these waves after breaking will re-form and result in another line of breakers near the shore. The height of the breakers *farthest from shore* should be recorded. When the breakers are low and relatively close to shore, it is fairly easy to estimate breaker height to the nearest tenth of a foot. It is considerably more difficult, however, where the breakers are high and the surf zone is wide. If it is not possible to estimate the breaker heights because the waves are too large and too far from shore, this fact should be noted in the "remarks" section of the LEO form. Special care should be exercised by the observer to provide his best estimate since breaker height is the primary parameter used for designing shore protection and coastal structures and is also used in mathematical expressions to predict longshore sand movement.

e. Wave Angle (Blocks 22, 23, and 24). The angle of wave approach at breaking is determined by using the protractor provided on the reverse side of the LEO form (Fig. 5). The protractor is held horizontally with the 0° to 180° line oriented parallel with the shoreline. The observer then sights along the direction from which the breaking waves are approaching shore and records the appropriate angle from the protractor (Fig. 6). (The direction of approach is perpendicular to the breaker crest.) The observer should be as close to the shoreline as practical in order to make this observation; however, at times a better perspective can be obtained from a bluff or pier. When making observations from the deck of a pier an alternative sighting procedure can be used. The protractor is placed on the pier railing adjacent to the breaker region and alined so that the 0° to 180° line is oriented perpendicular to the shoreline. (This is usually along the axis of the pier if the pier is perpendicular to the beach.) The observer then sights along the crest of a breaking wave and records the appropriate angle (see Fig. 7). Note that this sighting will give the same angle as obtained on the beach sighting described earlier.

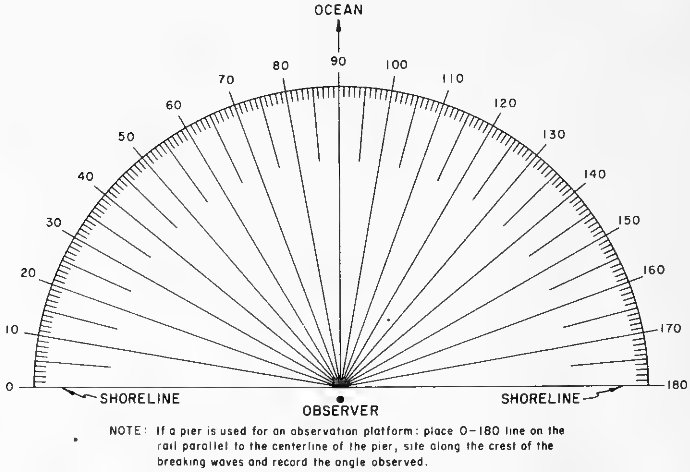


Figure 5. Protractor on reverse side of LEO form.

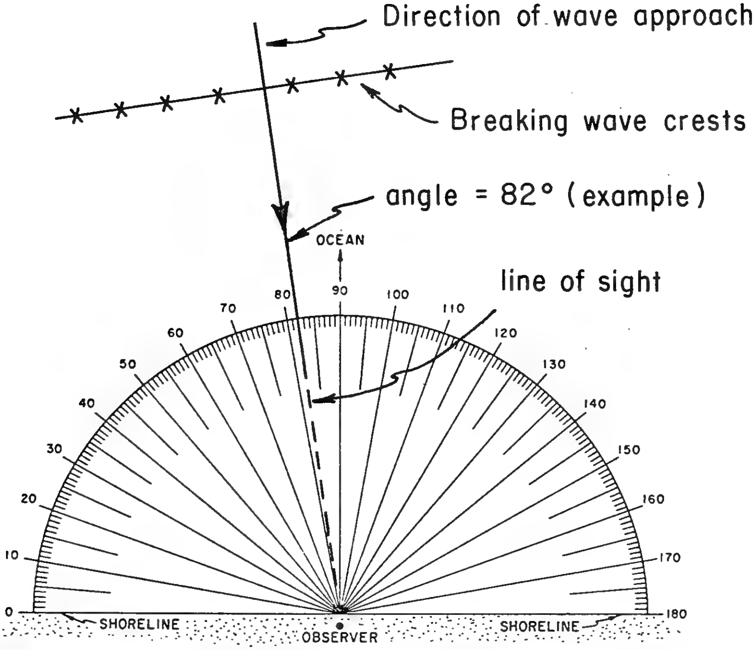


Figure 6. Measurement of wave angle from beach using protractor.

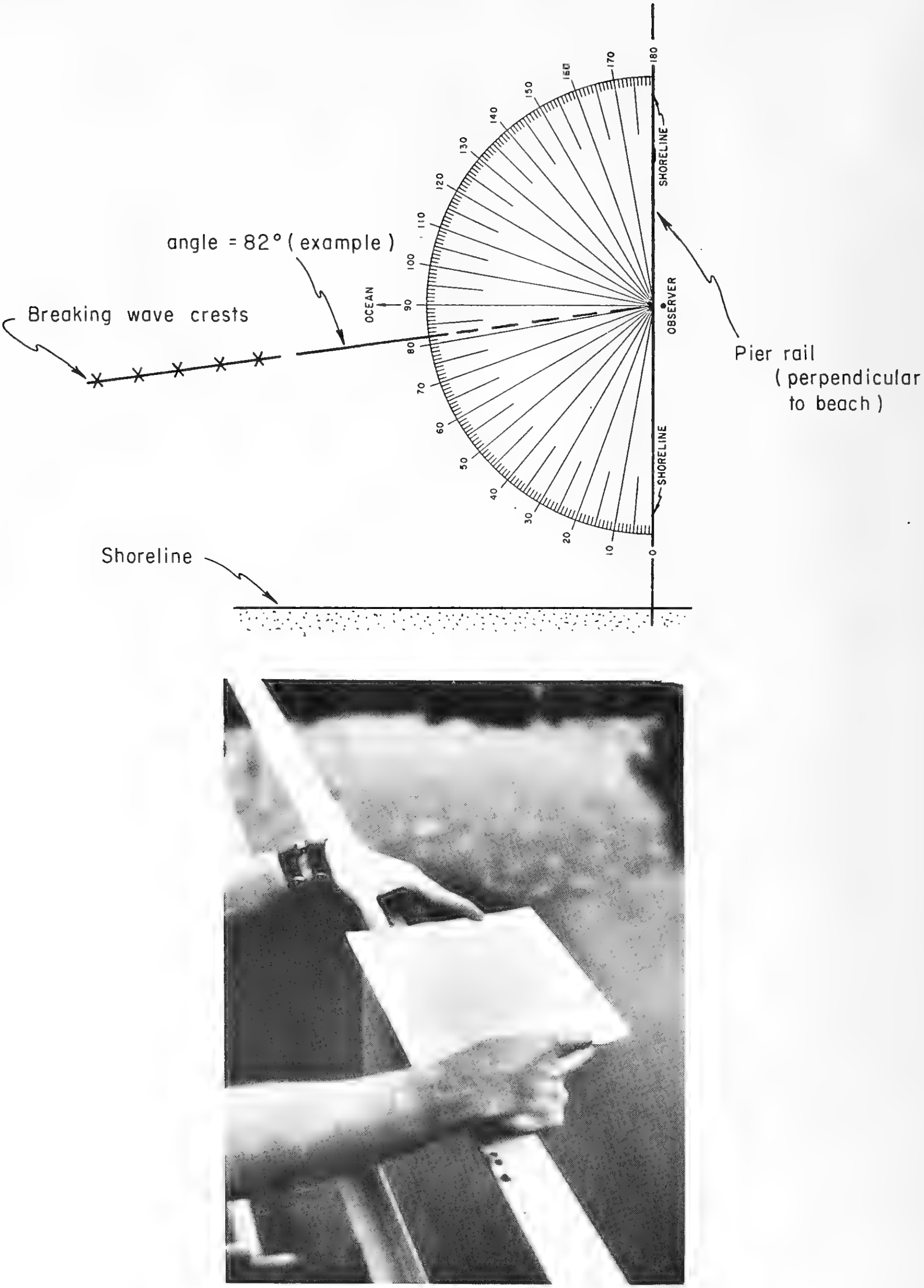


Figure 7. Measurement of wave angle from pier using protractor.

f. Wave Types (Block 25). Waves are classified into the following four types:

(1) A *spilling breaker* occurs when the wave crest becomes unstable at the top and breaks to flow down the front face of the wave producing a foam surface (Fig. 8).

Figure 8. Spilling breaker.

(2) A *plunging breaker* occurs when the wave crest curls over the front face of the wave and falls onto the base to produce a high splash and much foam (Fig. 9). This hollow part under the curled-over crest is sometimes termed the "pipeline."

Figure 9. Plunging breaker.

(3) A *surging breaker* is characterized by a wave crest that remains unbroken while the base of the front face advances up the beach to break totally at the shoreline (Fig. 10).

Figure 10. Surging breaker.

(4) Certain breaking waves may appear to have characteristics common to both spilling and plunging breakers. Such breakers are recorded as a *spill-plunge* type (Fig. 11).

Figure 11. Spill-plunge breaker.

Once the wave type has been determined, the proper code (0 to 4) is recorded on the LEO form.

g. Wind Observations.

(1) Windspeed (Blocks 26 and 27). A Dwyer wind meter is used to determine windspeed. The instrument is held slightly above head level, and slowly rotated in a 360° arc until the maximum windspeed is found. The meter contains two scales. When the windspeed is less than 10 miles (16.1 kilometers) per hour, the hole on the top of the meter should be open and the windspeed is read from the left scale (Fig. 12). The two holes at the bottom on the back of the meter must be kept clear to obtain an accurate reading. When the windspeed exceeds 10 miles per hour (i.e., when the windspeed indicator ball in the meter exceeds the top of the scale) the hole on top of the wind meter should be closed by placing a finger over it (Fig. 13). The windspeed is then read from the right scale on the meter. Windspeed is recorded to the nearest mile per hour with an average windspeed selected by watching the movement of the indicator ball.

Figure 12. Using Dwyer wind meter for windspeed less than 10 miles per hour.

Figure 13. Using Dwyer wind meter for windspeed greater than 10 miles per hour.

(2) Wind Direction (Block 28). Wind direction is observed by noting the direction on the eight-point compass, i.e., NE., N., NW., N., etc., from which the maximum speed the wind is blowing. Initially upon establishing a LEO station, a compass should be used to determine the orientation of the shoreline. When the orientation of the shoreline is known, wind direction is determined by reference to the shoreline. Note, however, that the compass direction is recorded on the LEO form, not the orientation with respect to the shoreline as is the case for the wave direction.

h. Foreshore Slope (Blocks 29 and 30). The steepness of the foreshore slope is a measure of the energy of the breaking waves. This parameter is measured using the Abney topographic hand level. The foreshore slope, located in the nearshore area, is the part of beach wetted by the wave uprush. The level is used in combination with a straightedge such as the length of a 2-by-4 flat board or some suitable substitute. The board is placed on the foreshore, or upper wetted part of the swash zone, pointing seaward. The board smooths minor irregularities across the slope and also keeps the hand level out of the water and sand. Figure 14 shows the Abney level being used with a clipboard to determine beach slope. The level is placed on the straightedge and leveled by turning the knob on the calibrated scale on one side of the instrument until the bubble in the level is centered. The angle is recorded on the LEO form to the nearest degree. Note that there are no plus or minus readings.

Figure 14. Measurement of foreshore slope using Abney hand level.

i. Width of the Surf Zone (Blocks 31 to 34). The observer is required to visually estimate the distance from the shoreline to the seawardmost line of breakers. For this measurement, the shoreline is taken to be at the upper limit of the wetted part of the beach, as shown in Figure 15. It is important that offshore whitecaps are not confused with breaker activity. The width is recorded on the form in feet.

j. Longshore Current. The longshore current flows parallel to the shoreline, primarily within the surf zone, generated by waves breaking at an angle to the shoreline. The LEO observer is supplied with fluorescein dye to estimate the speed and direction of the current. Small dye packets are made by wrapping a teaspoon of dye in several layers of paper tissue and wrapping the packet with a rubber band or tape.

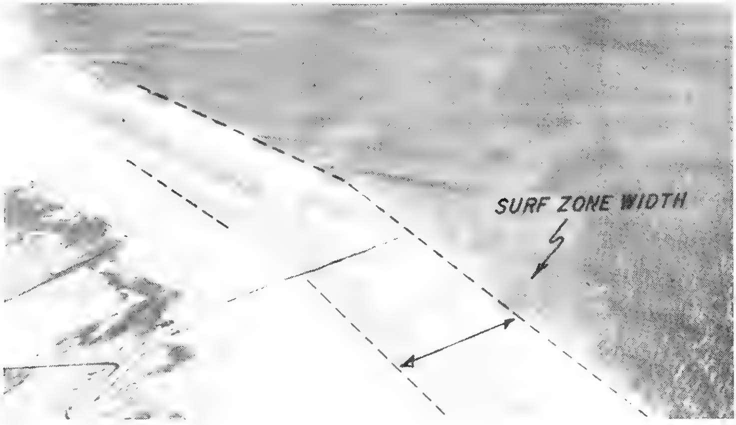


Figure 15. Surf zone width.

(1) Dye Distance (Blocks 36, 37, and 38). A dye packet is thrown into the surf zone between the shoreline and the outermost line of breaking waves, i.e., into the surf zone proper and if possible just landward of the breakers. Injecting the dye packet will not be possible if the surf zone is very wide, as might be the case on flat beaches or when breakers are large. If the surf zone is very narrow, the dye packet may be injected on the seaward edge of the breakers. The distance from the shoreline, i.e., the landward limit of wave uprush, to the point of dye injection is estimated and recorded in feet.

(2) Current Speed (Blocks 42 to 45). As shown in Figure 16, the observer marks a line with his foot on the beach at the point of dye injection and begins to time the dye movement to determine current speed. The center of the dye patch is followed alongshore for a 1-minute period. The distance the dye traveled in 1 minute is then paced off parallel to the shoreline (Fig. 17). The number of paces is then converted to feet and recorded on the LEO form. (The length of the observer's pace (in feet) must be established to make this conversion.)

(3) Current Direction (Blocks 46 and 47). Facing seaward, if the dye patch moves to the right, a "+1" is recorded on the LEO form; if the dye patch moves to the left, a "-1" is recorded. If no movement occurs, or if the dye moves directly offshore, a "0" is recorded. If the dye moves seaward, it is noted in the remarks section of the form.

k. Rip Currents (Blocks 49 to 52). Rip currents, the strong surface currents tht flow seaward from the shore, are the seaward return movement of water piled up on the shore by the incoming waves and wind; they appear as bands of agitated water. Identifying characteristics are a seaward-moving strip of foam or debris, usually found where there is a low in the wave activity, or a strip of muddy water moving seaward through the incoming breakers (see Fig. 18). If rip currents are observed, the spacing between the currents is estimated by pacing along the beach with the distance recorded in feet on the form.

Figure 16. Observer marking point of dye injection on beach.

Figure 17. Observer pacing off distance traveled by dye patch in 1-minute period.

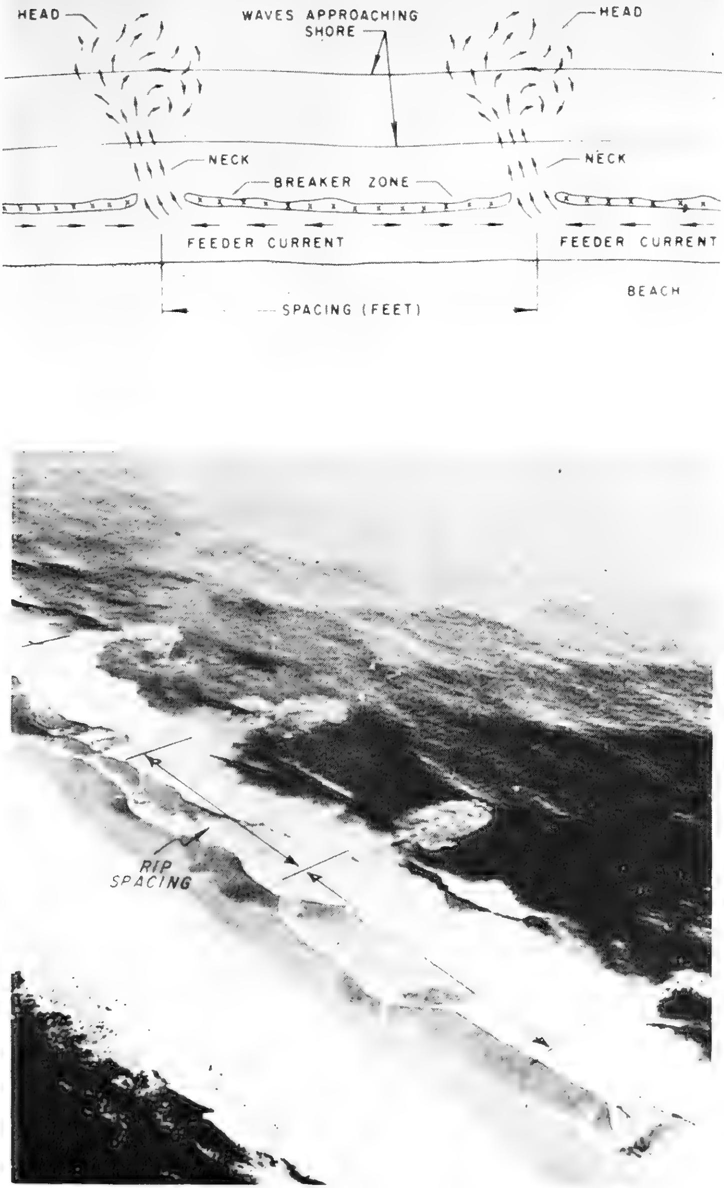


Figure 18. Rip currents.

1. Beach Cusps (Blocks 54, 55, and 56). Beach cusps are a series of low mounds of beach material separated by crescent-shaped troughs spaced at about regular intervals along the beach face (see Fig. 19). If these beach features are found, the spacing between the mounds is paced off and the distance recorded in feet on the form.

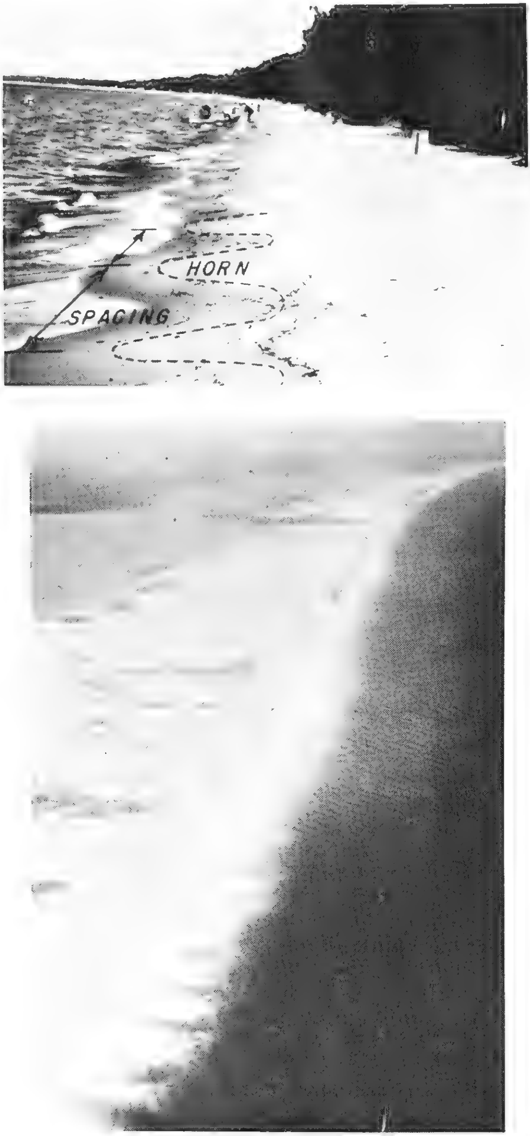


Figure 19. Beach cusps.

m. Miscellaneous. The observer's name and the LEO site name are recorded in the spaces provided at the bottom of the form. A remarks section is also provided for the observer to note any unusual occurrences, such as waves approaching the shore from more than one direction or a significant amount of erosion which occurred recently.

When required, sand samples at a LEO site are collected from the foreshore slope once a month (Fig. 20). The sample should be taken from the swash zone where the sand has been wetted by the wave uprush. A 4- by 4-inch zip-lock bag full of sand is sufficient for analysis. Identification tags with the recorded beach name, site number, date, and time of sampling are affixed to the sandbags.

Figure 20. Observer collecting sand sample from foreshore slope.

III. SUMMARY

The LEO Program can provide reasonably reliable wind, wave, and nearshore current data, useful not only for estimating longshore sand movement but also for the preliminary design of coastal projects, if observers conscientiously obtain measurements in accordance with established techniques. Individual observations may deviate from actual conditions; however, when considered statistically, LEO data can give a very good general picture of the physical environment at a site. In applying the data, careful consideration should be given to its limitations; when used with reasonable caution, the data can provide information not usually available from other sources and at low cost.

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The Littoral Environment Observation (LEO) Data Collection Program / by Christine Schneider.--Fort Belvoir, Va. : U.S. Army Coastal Engineering Research Center ; Springfield, Va. : available from NTIS, 1981.

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The Littoral Environment Observation (LEO) Program provides data on nearshore waves, longshore and rip currents, wind conditions, and beach conditions at low cost. This report presents guidelines and procedures for LEO site selection and LEO data collection.

1. Beach changes. 2. Coastal morphology. 3. Meteorological data. 4. Observations. 5. Wave data. I. Littoral Environment Observation Data Collection Program. II. Title. III. Series.

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