brated in both meters and feet and can be adjusted in accordance with the model scale by changing gears in the $Z$ wheel movement. The maximum excursion of the $Z$ carriage is 325 mm.

We have found that the instrument can be operated and meet standard map accuracies using $C$ factors of from 1,500 to 2,000, depending upon the type of terrain and control available.

From the operators standpoint, the instrument seems to be very satisfactory. The resolution in the instrument is extremely satisfactory and all of our operators feel that they can obtain as near an absolute orientation as is possible using this instrument.

A fair Multiplex or Kelsh operator can start to produce after approximately 16 hours practice, and will produce with about 50% efficiency for the first 100 hours. After 200 hours he should be able to produce a product of normal requirements.

The instrument requires a floor space of approximately $10 \times 12$ feet and need not be operated in a completely dark room. However, subdued light is advantageous to the operator's eyes.

The Abrams Aerial Survey Corporation of Lansing, Michigan now has in operation two Galileo Santoni Stereocartographs Model IV, and one Stereosimplex Model III. Also on order from the factory in Florence is a Stereosimplex Model III that will be capable of taking 20 degree convergent photography. We expect delivery about the first of the year and have high hopes that it will be possible to plot topographic maps using "$C$" factors of 2,500 to 3,000.

# *A Method of Shoreline Delineation**

FRANK H. MCBETH, *Cartographer, Hydrographic Office U.S.N.*

SYNOPSIS: *This is a presentation of an empirical method of determining the usual (or mean) high water line on both beach and rock shore line. Evidence is presented as proof of the accuracy of the method, and mention is made of the consistency of results when the method is applied. Because the criteria are based on a combination of photographic tone, texture, alignment patterns and small indistinguishable object images and their shadows, it is claimed to be applicable to most circumstances. All the criteria may not be present. Selection of the few illustrations is based upon proximity of beach and rock shore lines with additional evidence in the vicinity presented for verification of the conclusion. The area has been independently compiled from prints of the same exposures a sufficient number of times to afford a check on consistency of interpretation. The above conditions have limited the selection of illustrative material. The illustrations are believed to offer about average difficulties. The text contains the keys to letters and numbers which appear in the illustrations.*

## PURPOSE

A NUMBER of state and federal agencies delineate shore line as part of their photogrammetric compilation responsibilities. Others use such compilation in pursuance of their duties. In addition there are a number of independent map contracting agencies which are faced with the problem of shore line delineation. Finally, a knowledge of a compilation method of this detail

* The opinions and assertions contained herein are the author's and are not to be construed as official or reflecting the views of the Navy Department or the Naval establishment. The Office of Public Information, Dept. of Defence has evidenced that there is no objection to publication on grounds of military security.

may be helpful to anyone interested in photogrammetry as it pertains to surveying and mapping. In view of the above considerations, the following discussion is presented. Also see Note 1.

### Field Inspection

Where actual field inspection of shore line can be made, accuracy can be assured by a suitable number of checks at critical shore line locations. The method of shore line delineation herein described is not intended as a substitute for field identification of the high water line but is, rather, a supplement to that method. Often, however, such practice can not be incorporated in the photogrammetric field work, but the necessity for accuracy in determining this detail is no less important. Under these conditions, it is believed, the use of the described method in the placement of the mean high water line will result in accuracy compatible with accuracy standards stipulated by the Federal Bureau of the Budget.

### Coastal Classifications

Because of the importance of correct identification of the high water line, considerable attention has been given by the photogrammetrist to clues furnished by other agencies dealing with coastal areas. Coastal areas have been classified by a number of different methods.

Geological literature deals with coastal areas, but keys to the actual identification of the water's edge are of no geological importance. The geologist considers the shore line as here today and gone tomorrow. He sees it as a superficial accident passing over the single geological area in which he is interested.

Biologically, the marine flora off the eastern coast of the United States is said to be of the Arctic variety north of Long Island. Due to sand and the absence of ledges on which to obtain a footing, vegetation is almost absent from Long Island to the Carolinas. To the south of the Carolinas the marine flora is described as southern. That there will be no seaweed driftings along the shores of the middle Atlantic states seems to be the principal idea presented, for shore line delineation purposes.

Other coastal discussions may be classified as follows: morphological, physiographic, descriptive, vegetational and regional. All such classifications are irrelevant for the purposes of cartographic delineation of the mean high water line.

Not much attention has been given to the actual position of the mean high water line. The problem is one which has been left to the cartographer, and his interest in it has been largely in its consideration as a datum plane. See Note 2.

### The Problem

This is an attempt to establish some evidence by which the location of the high water line may be determined, regardless of the tidal stage at the time of the photography. All the research in the world is meaningless unless its findings can be summarized to aid in properly delineating a line through an expanse of sand. After all the advice of authorities in their various fields on coastal conditions and their ramifications has been utilized, the problem boils down to the evidence which can be gathered along a line in a single stereo model. Any criterion selected for the solution of shore delineation will be practical only in proportion to its simplicity. The less involved these criteria are, the more certainly they can be applied in the interests of both accuracy and uniformity.

### Solution

If the problem can be reduced to considering the contrasts between air and water on shore line materials, the answer will be in its simplest form.

Shore lines are formed of only two classes of materials:

1. Clastics
2. Rock

The distinction, for shore line delineation purposes, is between those materials moved by surf and those which break before forces engendered by wave action. See Note 3.

Criteria for shore line delineation on these two classes of materials may be said to fall into three categories which may be referred to as:

1. Physical characteristics
2. Vegetation
3. Aligned banded appearance

Complete data in any of these three categories may be lacking. Careful scrutiny of photography will reveal evidence distributed in the vicinity, on which to base a reliable recovery of the more important information, which concerns the identification of the high water line. That line can

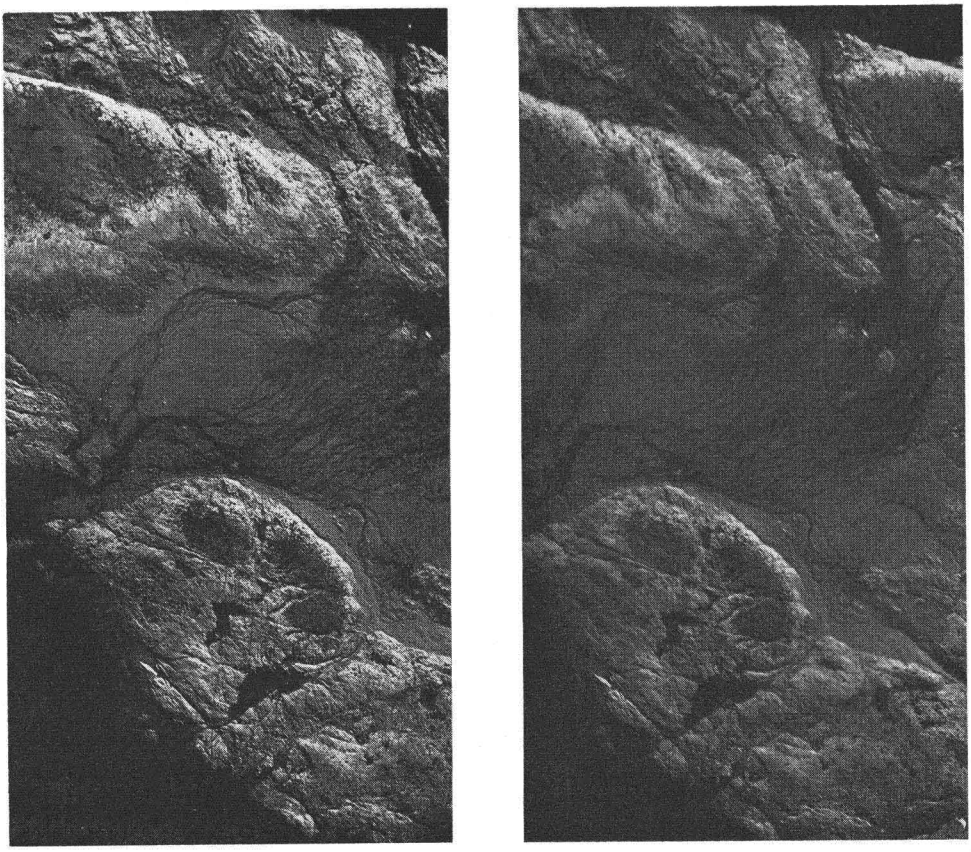

FIG. 1. Stereo pair known to be taken at low tide.

be accurately interpolated between positive identifications by combining sterometry and a consideration of the criteria as herein demonstrated.

## APPLICATION OF CRITERIA ON ROCK SHORES

### 1. PHYSICAL CHARACTERISTICS

Rock shores are broken by forces generated by wave action (hydrostatic power, pressure and abrasion) and have a jagged appearance.

### 2. VEGETATION

Vegetation appears on rock shores in all but the coldest waters. The banded appearance on such shore lines is due to vegetation or to the lack of it.

### 3. ALIGNED BANDS

a. Vegetation—back shore and extending inland.

b. Light colored salt sprayed on shore area.

c. Darker toned fore-shore area subject to tidal washing.

d. A still darker off-shore area extending into deep water (See Figures 1 and 7).

## APPLICATION OF CRITERIA TO BEACHES

### 1. PHYSICAL CHARACTERISTICS

Beach materials are shifted or transported by wave action; the shore line on such material is either straight or appears as smooth curves. The exception to this rule is the temporary disarrangements resulting from storms; the resulting irregularities are soon removed through wave action at normal tides.

### 2. VEGETATION

There is no evidence of this type on the beach except as residues appearing along the border lines of aligned bands. Where vegetation appears on clastic materials the

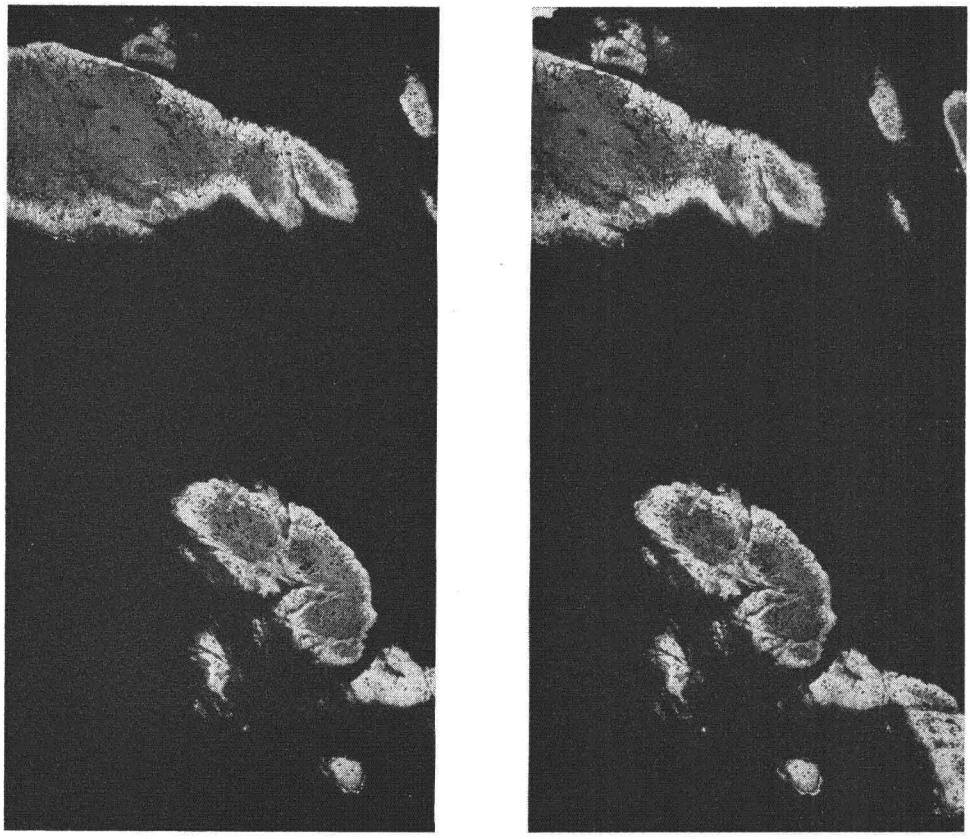

FIG. 2. High tide at Fig. 1. The high water line at base of bare rock, as seen in Fig. 1, is evident.

shore line, for delineation purposes, is taken to be the seaward edge of such vegetation.

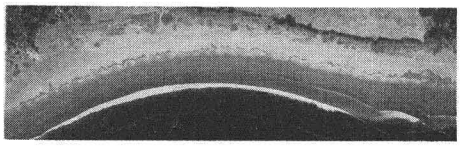

FIG. 3. Wet sand forming cusps along high water line.

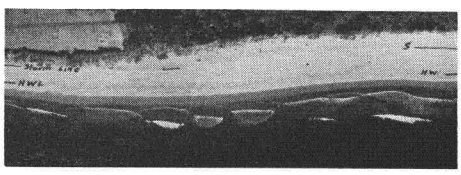

FIG. 4. Wet sand has dried, leaving residual forms as evidence of high water line. Tone differences between fore-shore, on-shore and back-shore areas are distinct.

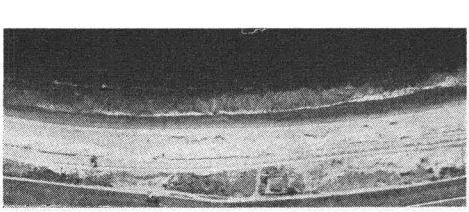

FIG. 5. Dried sand banked against high water line of last high tide.

3. ALIGNED BANDS (with accentuated borders)

a. *Back shore beach.*—The appearance of this area is due to wind action upon beach materials. The sand is loosened, and its surface is disturbed with depressions and ridges ranging in size from a few inches to dunes. The photographic texture of this area may present a mottled pattern; its tone is usually distinct.

b. *Storm line.*—This is the high water line left by the last storm. It is identified by residuals which vary in occurrence both

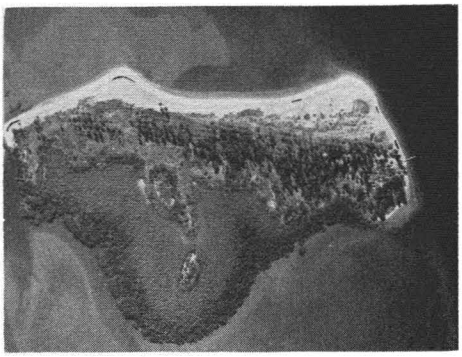

FIG. 6. Small pier based at high water line. The line can be followed throughout the beach area.

FIG. 7. Rock shores and silted beach showing high water line on two types of shore materials.

locally and over larger distances, and consist of sticks, branches, weed clumps and their shadows. The objects can not be identified but their resultant points of tonal differentiation are discernible. When partially connected by a fine line of dashes, the tone or texture between bands *a* and *c* becomes more noticeable.

c. *On shore beach.*—Wind action and resultant features mentioned for band *a* have been interrupted by flooding during last storm. Tone and texture due to wind are less pronounced than in band *a*, but are often distinct when compared with band *e*.

d. *Water line of last high tide.*—There are occasional residues identified by points of darker tone. Cusps and sand banked along this line are assumed to be caused by wind action blowing sand seaward. When interrupted at the high water line the sand is banked, and capillary action and splash wet the sand over a short distance shoreward. This feature holds an identifiable seaward edge after drying and with recedance of the tide.

e. *Fore-shore area.*—This area presents a surface compacted by waves and the washing of water in contrast to the wind action on areas *a* and *c*. The tone and texture distinction is usually noticeable.

## OBJECTIONS

1. It may be observed that the above discussion involves nothing more than the various shore zones mentioned by other writers on shore line identification. The criteria add no new features but are, rather, a more detailed consideration of ground previously covered. In all but unusual circumstances, identification of the shore zones is sufficient for reliability of delineation.

2. The criteria are not applicable in all instances. Relying as they do on alignment, tone, texture, shadows and position, uncertainty is believed to be minimized.

3. The discussion may be considered an over-simplification of the difficulties involved. It is here contended that shore line delineation in usual instances is more largely dependent upon a thorough analysis of fundamental details than upon more technical discussions of coastal classification.

4. The identification is only of the last high tide water line with no provision made for actual delineation of the mean high water line. Map specification photography flown over a shore line is taken under weather conditions believed to assure no significant deviations between the last high tide and the usual or normal high tide conditions. The distinction between the usual and the mean is insignificant for map detail purposes.

## CONCLUSION

In the above discussion the uncertainty of identifying each feature has been inferred. In criteria evaluation the few positive identifications can be associated with observations of less certainty; the summation results in an accurate interpretation.

The accompanying illustrations are portions of projects which have been used for training in photogrammetric compilation. Variations in interpretation of shore line detail, with few exceptions, have been within the limits specified for Standard Maps at the scale of compiling. Devia-

tions from such accuracy have not occurred in any consistent pattern or location.

NOTES

1. The last two wars have been intercontinental as contrasted to the continental nature of previous modern warfare. In the First World War the one amphibious action attempted was a failure. In the Second World War every action in which the full strength of the participating American Army was engaged began as a beach head activity (North Africa excepted). It may well be that the decisive battles of future wars may occur at beach heads. The cartographer need not consider the shore line in the light of its adaptability for military or other specific purposes. His primary interest and obligation is the accuracy of his presentation.

2. Foreign charts usually refer to "mean sea level" as the origin of their vertical control. The objection to the practice is that the mean tidal level is no physical feature identifiable, as such, on any shore. Knowing the tidal range, it can be delineated stereoscopically provided the foreshore area is covered by half or less of the depth of tidal range. Such a line follows no observable detail. Even where such a "mean sea level" notation appears on foreign maps, the actual shore line delineation appears to follow the mean high water line.

3. Vegetation, man made, tundra, glaciated, etc.; all shore lines follow the characteristics of rock or clastic material.

# *The Use of Photogrammetry In Highway Work**

REX H. FULTON, *Senior Highway Engineer, California Division of Highways*

THE California Division of Highways has utilized photogrammetry (aerial surveys) to a limited extent for the past 25 years. However, our first serious effort began three years ago.

Photogrammetry, especially in large-scale mapping, has been developed rapidly since World War II, bringing substantial savings in cost, time, and manpower. In general, it has a distinct advantage over ground surveys by providing wider coverage and enabling the engineer to see possibilities which otherwise might be overlooked.

Our expanded highway program developed mapping problems faster than the available supply of engineers could handle them by conventional ground survey methods. In conformance with the policy of the Division of Highways in contracting work whenever practicable, and because the transfer of engineers from ground to aerial surveys would not solve our manpower shortage, we contract almost all our photogrammetric work to private industry. We have practically no equipment of our own, and our organization is the minimum required for administration and for checking completed work.

Photogrammetry may mean a lot of things to different people. By definition the word means "the science of obtaining reliable measurements by photography." It can be used to measure the amount of crown rust in grain fields, the size and velocity of stars, or the diameter of microbes. As used in this paper, however, the definition is limited to aerial land surveys and may be considered as an improvement thereon.

Such aerial surveys fall in two general classes: (1) aerial photographic pictures,

* Paper read at the Society's Semiannual Convention and Trade Show, Statler Hotel, Los Angeles, Calif., Sept. 8, 1955.