PHOTOGRAPHIC INTERPRETATION OF COASTS AND BEACHES

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A GREAT deal of World War II was fought along enemy-held coastlines. The battlefields were beaches, painstakingly fortified by the enemy for months in advance. Not one of the thousands of assault troops or landing craft personnel had seen those beaches before H-hour, yet the successful performance of the complex attack plan required that all echelons be thoroughly familiar with the physical conditions to be encountered. Aerial photography was the greatest, and in some cases the only source of this information.

There were several reasons why aerial photography was especially important to amphibious warfare:

1. There was a dearth of other sources of detailed information about the physical characteristics of specific beaches and coastal areas. Except in resort areas, or in the vicinity of coastal cities, coastal areas were lightly populated and infrequently used. There were no ground photographs, few references in geographic literature, and meager and often inaccurate representation on the best available maps and charts. It is generally true that, as Williams (1) states "both maps and charts tend to regard beaches as a kind of 'No man's land' with which neither is greatly concerned."

2. Even where "ground" information was available, it was never able to supply more than a small part of the vast quantity of data required for amphibious planning. Pre-invasion scout and raider reconnaissance, as well as interrogation of natives of the area, valuable though these sources were, provided only "spot" information—the height of a wall at one point, the firmness of a trail across the dunes, etc. The aerial photograph was the medium on which such data was pin-pointed, combined with other intelligence and amplified and fitted into the complete picture.

3. The camera provided the only practical means of obtaining continuously up-to-date information about beaches not accessible for personal reconnaissance. The shoreline, the boundary of water, land and air, is subject to the action of savage dynamic forces. Sandbars and shoals may build up or disappear overnight during periods of storms. In fact, many beaches undergo regular major shifts in position during spring and fall storm periods. Examination of old photographs of a beach area taken at different seasons of the year, will show that such changes are to be expected; successive sorties made during the planning period and carefully studied by amphibious planners, will enable the alterations to be plotted as they occur.

The study of enemy activity, and the interpretation of enemy defensive installations, while not discussed in detail in this paper, is another urgent requirement for obtaining continuous photographic coverage throughout the planning period of an amphibious operation.

Photographic analysis of beaches and coastal areas can provide almost any sort of information covering physical conditions. Research into shore processes and materials continues to provide sign posts whereby more and more detailed information can be gleaned from photographic analysis alone without the necessity of personal reconnaissance or consultation of masses of corroborative ground information. For military purposes, the items listed below comprise the principal types of information desired from aerial photographs of the coastal zone. (See Mason (3) for detailed list of the type of information furnished in an operational beach report.)

1. Coast
   a. Terrain and trafficability
   b. Communications
   c. Local culture and economy
   d. Water approaches and harbor facilities
   e. Enemy activity
2. Beach
   a. Location and dimensional data
   b. Description, materials, consistency, etc.
   c. Offshore approaches
   d. Surrounding area and exits
   e. Defenses

This paper will be limited to a consideration of analysis of natural features of coasts and beaches.

PHOTOGRAPHY

Since in World War II our Photographic planes had to share the sky with enemy aircraft and bursting AA shells, it is not surprising that the photography from which this work was done did not conform to precise mapping specifications. Sometimes the work was done from obliques alone, sometimes from verticals, and sometimes from whatever combination of the two was obtainable. Occasionally submarine periscope photographs were also available. Flying altitudes for most war-time sorties were known only approximately, tilt of varying amount was frequently present in verticals, and reliable ground control usually non-existent.

COASTAL ANALYSIS

As previously stated, pre-war maps and charts of coastal areas of interest to our amphibious forces in World War II were woefully inadequate, except in isolated instances. This was particularly true, of course, in the Pacific where many islands and areas had been incompletely explored. Figure 1, which shows the difference in shoreline delineation between the best available 1942 chart of the New Georgia, Solomon Islands and one of the earliest aerial photographic mosaics laid of the area, is a typical example of the paucity of reliable information existent in many Pacific areas. In European coastal areas, maps and charts were much better and few actual errors in coastal delineation were discovered. Detailed hydrographic and topographic data, of the sort required for military operations, were largely lacking, however, even in that theatre. Spot elevations, given on the topographic maps, were usually fairly accurate indicating satisfactory basic surveys, but, in many areas, amphibious photographic intelligence officers, checking the maps against aerial photographs, were forced to conclude reluctantly that the ten meter contour lines on hills rising from the coast had been sketched in freehand from a comfortable spot on the beach.

The first responsibility of the photographic intelligence officer engaged in amphibious planning, therefore, was to examine the coastline as it appeared in aerial photographs in order to verify coastal detail on existing maps and charts.

Procedures varied widely depending on the time available, the photography, and the estimated quality of the existing maps. Whenever possible, some sort of map-control was used in combination with radial line plot or similar method for establishing plan positions of detail. The Canadian Grid was employed with obliques when horizon conditions permitted. Elevations were obtained by means of one of the various makes of stereoscopic height finders using selected map elevations for control when available.

Later in the war, it became possible to obtain coverage of expected landing

FIG. 1. Difference in shoreline delineation of New Georgia, Solomon Islands, between 1942 chart and one of earliest aerial photographic mosaics.

areas months in advance of operations. Photogrammetrically corrected Topographic Maps and Approach and Bombardment Charts, prepared by the Army Map Service and the Navy Hydrographic Office, were forwarded to the theatre before planning had begun. (See McCurdy (2) for an excellent presentation of the procedures used by the Hydrographic Office in coastal delineation from aerial photographs.) This relieved the Naval Amphibious Force Photographic Intelligence Officer of some difficult photogrammetric problems and permitted him to concentrate on interpretation of actual landing beaches.

It was still necessary, however, for him to study photographs of the entire coastline. This was done primarily in order to prepare written coastal terrain analyses to study the coastal road networks, to report on local culture and economy of the inhabitants, and to locate enemy coastal batteries, radar stations and other installations. But it also served the important purpose of achieving familiarity with the geologic materials and configurations, the soil, the vegetative blanket and the general erosion pattern in the coastal zone, all of which form the setting for the beaches themselves.

LOCATION OF BEACHES

Beach areas were usually located and delimited from a study of aerial photography, and their selection was one of the more difficult jobs that confronted the amphibious photographic intelligence officer. A simple defining of the areas where a slope of unconsolidated material rises from the water is not sufficient. Many such areas along any given coastline will lack the minimum characteristics of dimension, susceptibility to approach from seaward, or access to the interior, to be useful for military purposes. A combination of careful study of photographs and a consideration of available ground information on local conditions, with a knowledge of amphibious tactics and the limiting performance characteristics of amphibious equipment, is necessary for the effective selection of beaches for landing purposes.

BEACH DETAIL

The beach is defined by Mason (3) as an area of unconsolidated material between the low water line and the upper limit of wave wash. This narrow strip is of vital importance in amphibious planning, since across it moves every man, vehicle and piece of equipment landed from ships in the assault. It is therefore the subject of intensive study by amphibious photographic intelligence personnel.

As indicated above, the beach can only be understood when it is considered a part of the entire coast. The unconsolidated material forming the beach may have been brought down from the interior by streams, it may have been deposited by winds, or it may have been carried for miles along the coast by current and wave action. The tremendous transporting power of water can be realized when it is understood that water at a velocity of only .4 knot will move ordinary sand along the bottom, and at a velocity of 1 knot will begin to carry gravel (Johnson (5)). Longshore currents of several knots are not uncommon in coastal areas. In order to ascertain the composition of a beach therefore, it may be necessary to study parent geologic forms at considerable distances from the beach itself, either inland or along the coast. Combined with this must be a careful consideration of appearance characteristics of the beach itself, such as tone, slope, capillarity, the size and shapes of cusps, surface breaks, and vegetation types.

Measurements on the beach are made, revised, and re-revised as more photography becomes available. Plan dimensions can be derived with sufficient accuracy from the average sort of reconnaissance vertical obtained under combat conditions and sometimes from good obliques. Beach slopes and elevations of such features as seawalls, beach ridges and dunes are more difficult to estimate. Almost every beach suitable for landing purposes has several features for which precise elevations are desired. And, in amphibious operations, it may make a great difference whether a seawall is four, six or ten feet high.

The Sonne continuous strip camera, in standard use in the Navy for low-level beach reconnaissance work, provides extremely accurate elevations of small features. This camera is a shutterless instrument in which the film moves continuously past an open slit in synchronization with the speed of the aircraft. By employment of two lenses, two continuous strip images are produced side by side, running the length of the film. The resultant images may be examined stereoscopically to provide a large scale three-dimensional view of the beach. The Sonne camera is used at low altitudes and high speeds, and distinguished itself under combat conditions at Okinawa (4) by enabling seawall heights and other detail to be measured with an accuracy of less than a foot plus or minus.

As can be seen in Fig. 3, the beach, on the aerial photograph, appears as a gray-white, characterless band. Were the area surrounding it in the photograph cut away, the most experienced interpreter could tell little about it. Yet the importance of this strip is such that detailed information on beach composition, firmness and the character and location of all breaks in the surface are urgently required. Each change in tone or texture of the beach is examined carefully by photographic intelligence personnel for it is axiomatic that no visible phenomenom is without significance. The precise meaning of marks on the beach, however, is often difficult to determine. For example, a dark line might indicate a change in beach composition, it might be a sign post pointing to an unsuspected sub-surface feature, such as a peat deposit, or it might be a swath of debris thrown up by the tide. Before deciding which, the interpreter must carefully examine the entire area for clues. Answers to questions about the beach may be found in the parent material of the beach as visible in rock outcrops, the types of vegetation in the beach area, the exposure and prevailing surf conditions, the slope and capillarity of the beach material, and a dozen other visible phenomena.

OFFSHORE APPROACHES TO THE BEACH

The derivation of underwater depths from aerial photographs is a technique sufficiently complicated to be the subject of a separate paper. It will not be discussed here except to state that it is an integral and vital part of the process of preparing military intelligence of coasts and beaches. But aerial photography provides considerably more information about the bottom than where it is. Rocks, shoals and other hazards to navigation can be identified and pinpointed and much information obtained about the character of bottom sediments, the firmness of the bottom in the touchdown area and the location of vegetative growths.

Calm, clear water is, of course, the ideal medium through which to observe the bottom. Common bottom phenomena such as rocks, bars and marine vegetation can be readily identified directly from aerial photography if the water is transparent. Scientific research in beach sedimentation and oceanography is constantly providing more data which will enable the photographic intelligence officer to evaluate more precisely the bottom conditions he sees.

When the water is not clear, indirect methods of bottom evaluation must be used. Underwater rocks, shoals and bars are frequently defined by breaking surf. Scattered rocks near the surface cause a characteristically patchy, irregular surf; shoals and bars produce more regular surf areas which will follow the outline of the feature. There is, of course, some danger in a comparatively unknown area of confusing some of these indicators. A line of surf due to a fairly regular, submerged rock ledge for instance, may resemble that produced by an underwater sand bar, but consideration of the general characteristics of the coastline, together with some knowledge of the geology of the region will usually eliminate one of the possibilities.

ADJACENT TERRAIN

From the beach itself, the examination expands inland. The first objective of study behind the beach is the area of transition between the beach and the coastal terrain: "The cliff, whether large or small which usually marks the landward limit of effective wave action" (Johnson (5)). Except in these rare cases where the beach surface is tailored smoothly into whatever land lies behind, the break in surface occurring at the point where erosion due to wave action

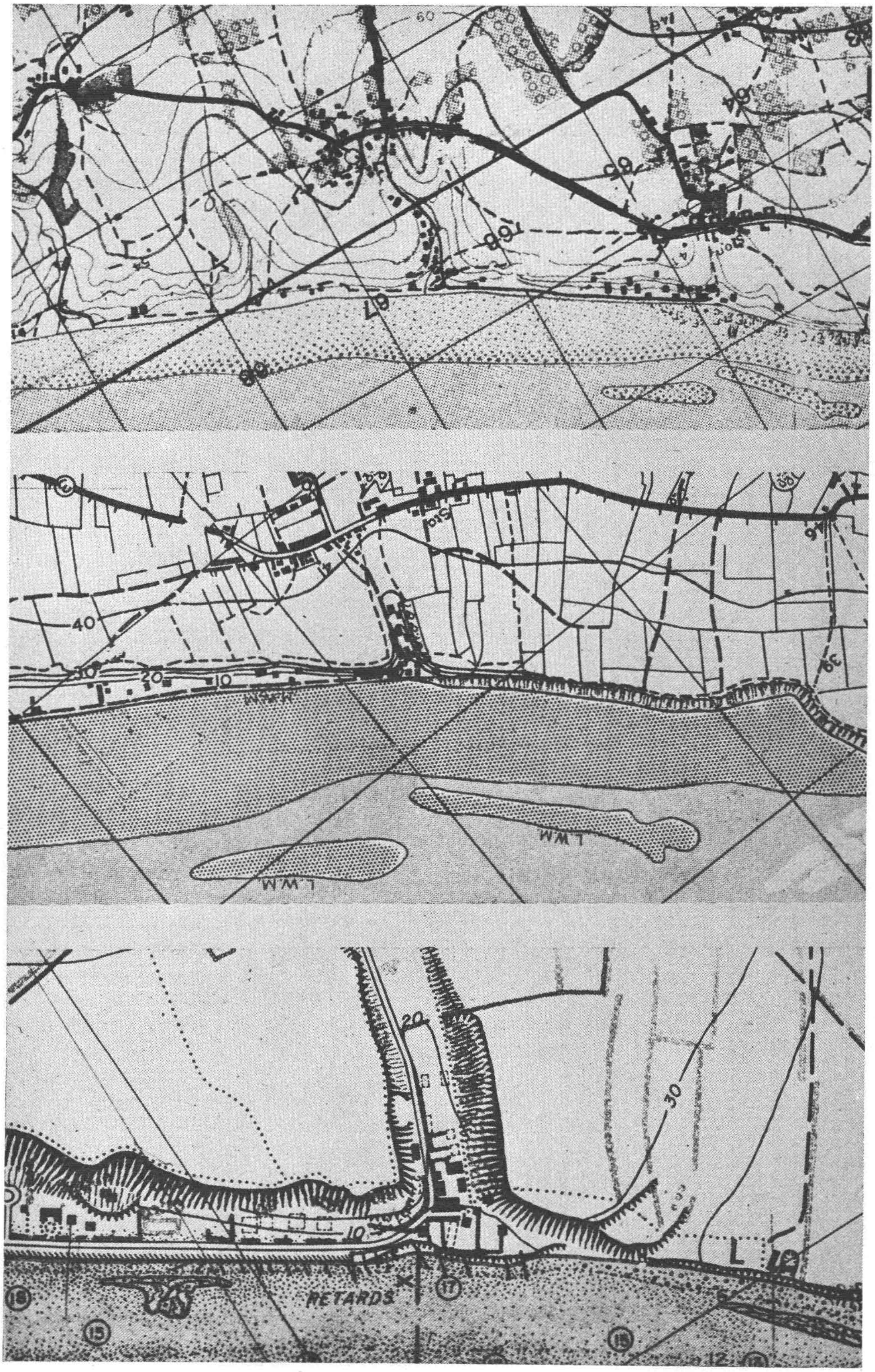

FIG. 2. Comparison between approach chart, a topographic map and the amphibious force-produced beach-landing chart.

ceases is likely to prove troublesome to invading forces. Therefore the photographic intelligence officer must expend considerable perspiration over this area.

Further inland, he is interested in the configuration of the terrain, its composition, its trafficability (including the resistance offered by vegetation, stone walls, etc.) its possibilities for cover and concealment, the size and condition of the road exits, and the location of such natural corridors to the interior as may exist.

The conditions behind the beach vary widely in various parts of the world; in fact, somewhere in the world, almost every type of terrain can be found in a coastal area. In analyzing this area, the photographic analyst must employ techniques of geologic, soils and vegetation interpretation as well as general terrain analysis. Here too he is likely to find more ground information to assist him in the form of geologic and soils maps, cultural information and publications on agriculture, vegetation and geography.

PRESENTATION OF DATA

In addition to conventional typewritten reports, the information derived from photographic analysis of the beach and environs for military purposes is made available to planners and operating forces by means of graphic aids such as annotated photographs and mosaics, terrain models, and large scale beach landing charts. Terrain models are made in large, rear area model shops by specially trained personnel, but mosaics and beach landing charts are generally prepared and produced in the fleet by Naval amphibious-force photographic intelligence officers.

Specially prepared charts are required because the vast amount of detailed information to be shown can not possibly be packed into normal scale hydrographic charts and topographic maps. Fig. 2 shows, at actual size, the comparison between an approach chart, a topographic map and the amphibious force-produced beach-landing chart of the same area. The largest regular issue military chart or map is usually 1/25,000; the normal scale of beach mosaics and landing charts is 1/5,000 or larger. On the beach landing chart is put the detailed hydrographic data derived from depth determination and bottom studies. Inland of the waterline, the terrain data are shown in great detail, degree of slopes are shown in symbol and such features as hedgerows, walls, ditches and dikes are precisely spotted from photography. Figs. 3 and 4 show a beach mosaic and landing chart for the same area.

Preparation of such a chart requires a close harmony of photogrammetric and photographic interpretation techniques. Control can be derived by simple pantographic enlargement of existing maps and charts where such exist; a mass of accurate detail is then supplied from the latest aerial photographs. A certain amount of error may be introduced by enlarging map control five times, but this is not usually great. In any case, more accurate data on enemy-held beaches are seldom available to the amphibious-force photographic intelligence officer.

The completed Beach Landing Chart can be used as a base on which to overprint information trafficability, defenses and so forth in any required number of special-purpose issues.

The water-level view below the plan view on the chart in Fig. 4 is provided to assist coxswains in recognizing the beach, and is also prepared from the topographic map and from vertical and oblique photography. One of several simple graphical or analytical methods can be used to determine what the apparent height of peaks and landmarks would be when viewed from water-level at a known distance offshore. The actual drawing of the water-level view is

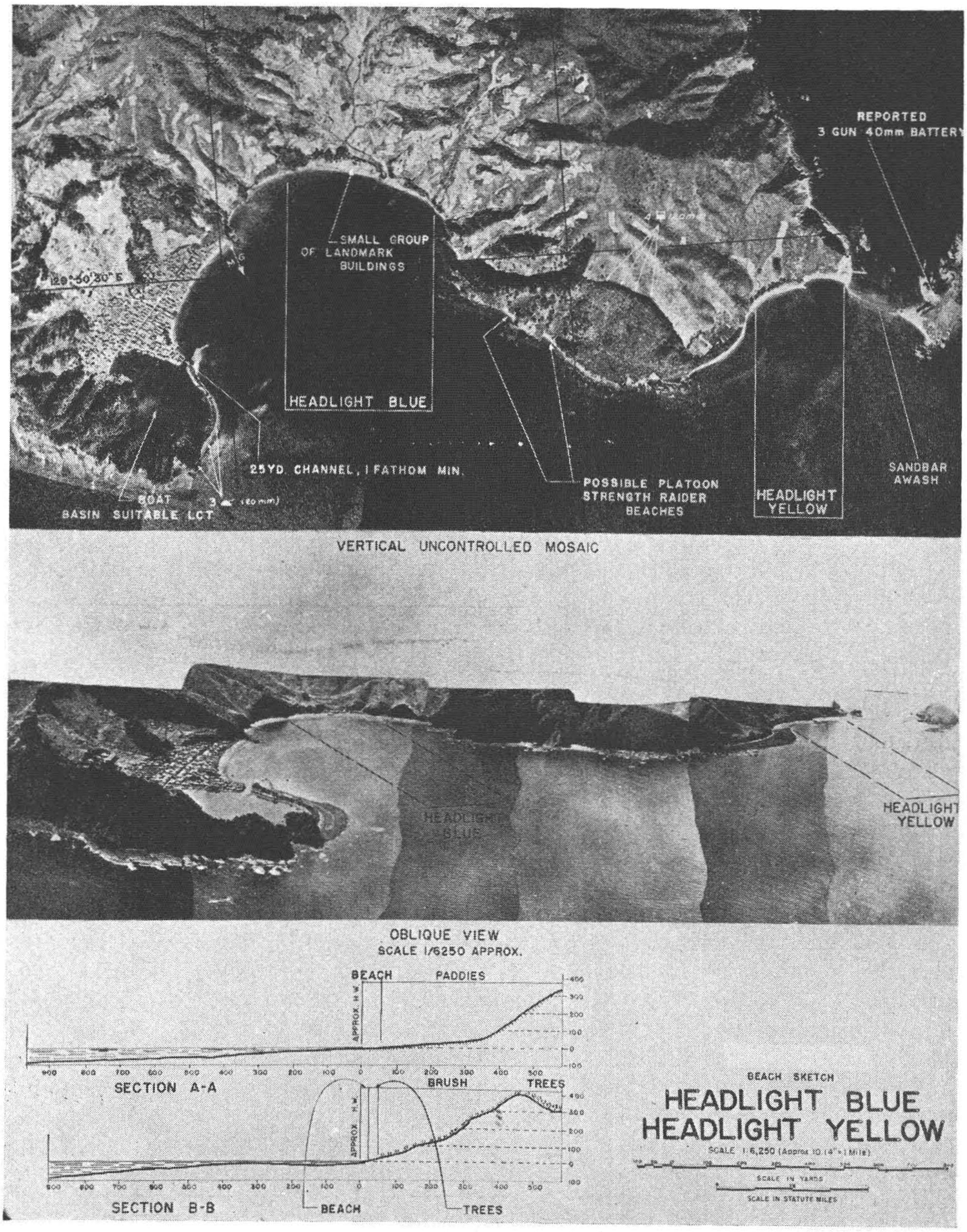

FIG. 3. Beach Mosaic.

done in soft pencil and can be successfully reproduced by either half-tone or line lithography.

Beach mosaics, models and other graphic aids are used extensively in briefing sessions prior to amphibious operations. Beach Landing Charts, which can be produced in quantity by photo-lithography, can be issued to all interested parties—coxswains, platoon leaders, beachmasters, men of landing ships and underwater demolition teams.

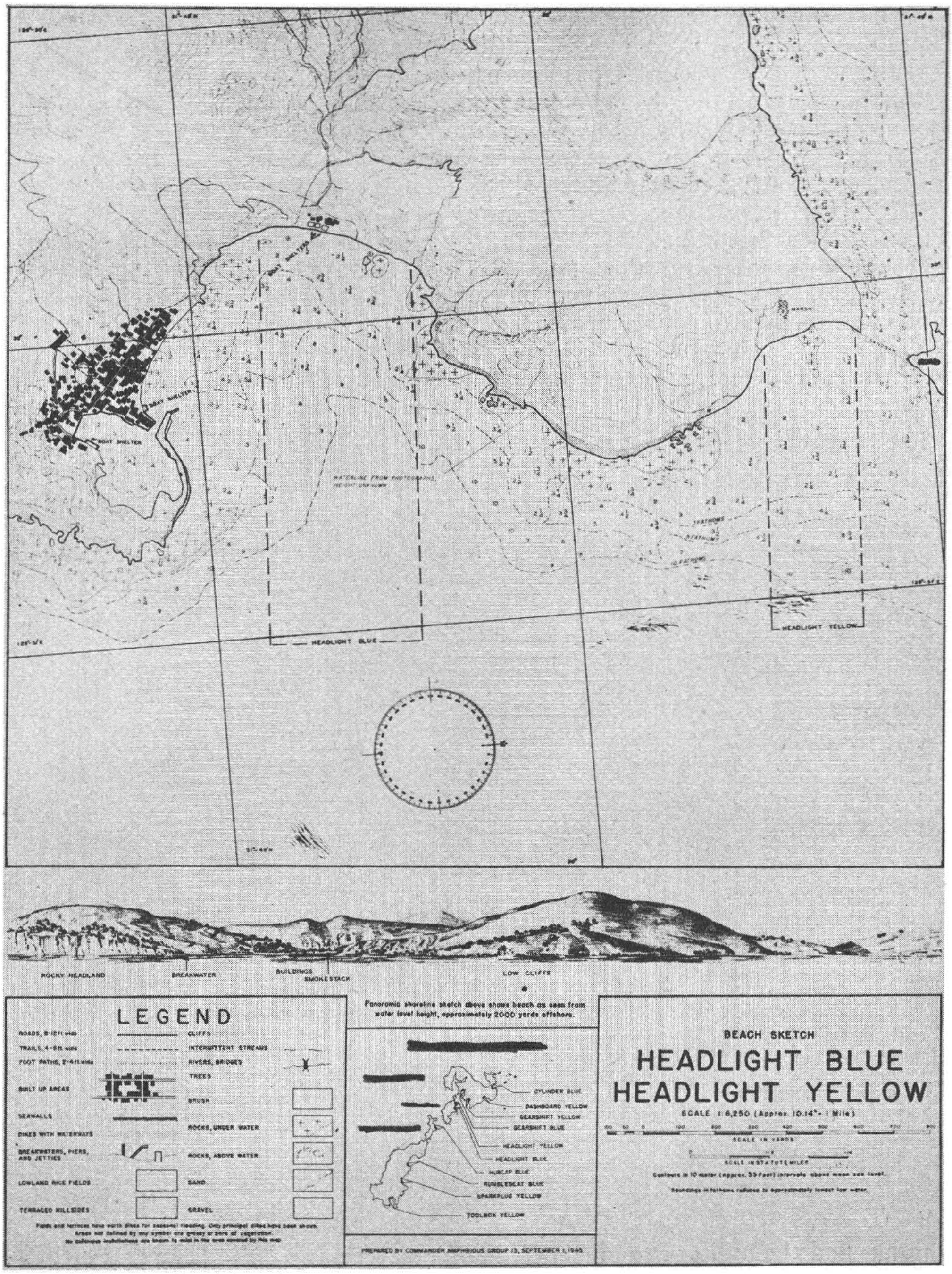

FIG. 4. Landing Chart for same area as in Fig. 3.

CONCLUSIONS

Like any other sort of military terrain intelligence, the aim of military coast and beach analysis from aerial photography is merely the production of complete and detailed "scientific information expressed in military terms so that it may be of use in the field" (Wilson (6)). It is achieved by a fine blending of photogrammetric and photographic interpretation techniques with scientific knowledge in geography, geology, vegetation, soils and engineering, tempered with a thorough understanding of amphibious tactics. This collaboration of civil and military science has proven beneficial to both; while it is true that photographic intelligence was vital to the success of World War II Amphibious Operations, it is equally true that wartime development has stimulated greater peacetime employment of aerial photography. The accomplishments of amphibious photographic intelligence have emphasized the known value of aerial photography in coastal and oceanographic investigations in soils analyses, in erosion studies and in certain types of vegetation research and have provided impetus for its more extensive employment in these fields in the future.

REFERENCES

(1) W. W. Williams, "The Determination of Gradients on Enemy Held Beaches."
(2) P. G. McCurdy, H.O. Pub. 592—"Manual of Coastal Delineation from Aerial Photographs."
(3) Martin A. Mason, "Beach Intelligence," *Journal Washington Academy of Sciences*, Sept. 15, 1947.
(4) LCDR C. C. Snyder and LCDR R. R. Frame, USNR, "How Deep Is the Ocean," *Popular Mechanics*, May 1946.
(5) Douglas William Johnson, "Shore Processes and Shoreline Development," John Wiley and Sons, New York, 1919.
(6) Major James E. Wilson, "The Fourth Dimension of Terrain," *Military Review*.

AERIAL PHOTOGRAPHIC INTERPRETATION OF VEGETATION FOR MILITARY PURPOSES

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THERE are four important ways in which vegetation may affect military operations: (1) it may facilitate or impede the movement of foot soldiers and motorized equipment; (2) it may accentuate or conceal evidence of military activity; (3) it may determine the ease with which clearings can be made for the construction of airfields and roads; and (4) it may serve as a source of construction material, fuel, or food. It follows that detailed information as to the type, density and distribution of vegetation within areas of contemplated military operations is essential to the intelligent planning and execution of such operations. Aerial photographs are an excellent source, and for enemy-held territory frequently the only detailed source, of this vital information.

Most of the examples given in the following pages are from tropical or subtropical regions wherein the density and complexity of plant growth are very great, thus perhaps offering greater problems to both the photographic interpreter and the military commander than does vegetation in other parts of the world.

In recognizing vegetation types on aerial photos, the photographic interpreter relies on such characteristics as size, shape, tone, texture, shadow, and topographic location. Stereograms appearing in Figures 1 and 2 well illustrate the use of these characteristics in identifying wild and cultivated types of vege-