THE USE OF AERIAL PHOTOGRAPHY IN SEAWEED SURVEYS*

H. L. Cameron, Chief, Photogrammetry Division, Nova Scotia Research Foundation, Halifax, N. S.

INTRODUCTION

OF LATE years the harvesting and processing of seaweed has become a nearly world-wide industry. From the dried weed, alginic acid is extracted, and from it are manufactured such diverse products as transparent paper, light-weight woolen fabrics, plastics, textile sizes, gelatin for ice cream and cheese, custard powders and soups, medical capsules and dental moulding powders, and soluble surgical ligaments. The potential uses of other constituents of the weeds are being examined. In North America the chief use of the material is for the production of gelatin for cheese and ice cream manufacture. The southwest tip of Nova Scotia is the main seaweed harvesting area in the Province, and since the close of the last war the industry has become an increasingly important part of the seasonal pattern.

In July, 1948, the Nova Scotia Research Foundation carried out experimental aerial photography of selected areas on the north coast of Nova Scotia. These experiments were designed to test the feasibility of vertical aerial photography for seaweed and bottom detail surveys. Red, green, and yellow (minus blue) filters were used on a standard F24 Camera with 8″ lens, using Super XX Panchromatic Aero film. The results of this work were published for private circulation to interested groups. The Royal Canadian Air Force Experimental Photo Establishment became interested, and early in 1949 agreed to carry out photography of areas selected by the Research Foundation, as a combined survey and experiment in coastal photography. The area selected includes the main section where commercial seaweed is harvested in Nova Scotia. The project was known as Operation Seaweed and it was successfully carried out between August 1 and 6, 1949. The author wishes to convey the thanks of the Research Foundation and his own personal thanks for the sincere co-operation and friendly spirit of the R.C.A.F. personnel and in particular to Wing Commander D. Ross, whose interest resulted in the R.C.A.F. offer to participate, and to Flying Officer D. MacKee, who was commander of the group which carried out the work.

AREA

The area photographed is shown in Figure 1. Clarke Harbour on Cape Sable Island is the main center of seaweed harvesting in the Province. A total of 32 flight lines was required to cover the designated areas. In addition, 15 strips of Sonne low-level photography were carried out as an attempt at identification of the weed types. Four of these strips were on color film.

EQUIPMENT AND METHODS

Aircraft. A Mitchell aircraft, modified for aerial photography was employed for all photographic flights. The R.C.A.F. station at Greenwood, N. S., was used as a base. An average of twenty minutes was required from take-off to photographic area.

* Published with the permission of the Nova Scotia Research Foundation and the Royal Canadian Air Force.

NOTE: Comments on this paper are invited. To change consideration for publication in the December issue, receipt before October 15 is necessary.

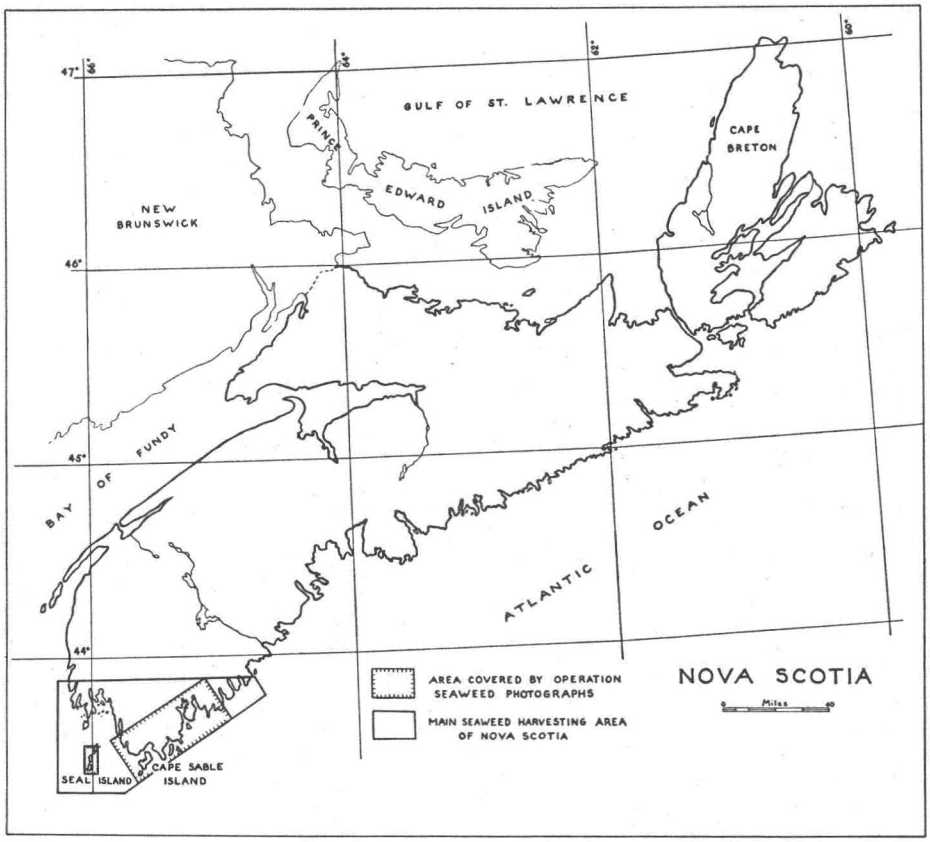

FIG. 1. Map of Nova Scotia showing seaweed harvesting area and area covered by Operation Seaweed.

Cameras. Two F/K cameras with 5″ focal length lens were used, mounted side by side. An XI green filter was used on the left hand camera and an A25 red filter on the right hand camera. Aerographic Super XX film was used.

A *Sonne* camera with 88 mm. stereo cone was used without filters for the low-level photography. Super XX Aerographic was used for eleven and Aero Kodacolor for four strips.

The vertical photography was carried out from an altitude of 5,000 feet with 60% forward and ten to fifteen per cent sidelap. A small number of gaps occurred due mainly to a discrepancy in the base map.

The Sonne work was done at 300 feet much to the discomfort of numerous seagulls, seals, and seamen!

All exposed film was shipped to the No. 1 Photo Establishment at Rockcliffe, for processing. Black and white contact prints of the vertical and Sonne photos were supplied to the Nova Scotia Research Foundation for mapping and interpretation. The color film was retained in Ottawa due to the lack of a Sonne viewer at the N.S.R.F.

RÉSUMÉ OF OPERATIONS

Data on actual photographic missions in various parts of the world are of great interest to both military and commercial groups. Statistics on photo-

graphic flying hours under conditions of weather at various latitudes and times of year are of particular interest. In the present case the state of the tide was another and very restrictive factor. A time-tide chart was prepared during the preliminary planning, on which the permissible hours of photography were plotted for the days allotted to the operation. A margin of one quarter tide was allowed on either side of dead low. This chart is shown in Figure 2. A complicating factor was the lag of $\frac{1}{2}$ to $\frac{3}{4}$ hours in the tide between Yarmouth and Lockeport at the two ends of the area. Coupled with the prevalence of fog in the Cape Sable area, the chances of achieving complete coverage appeared remote.

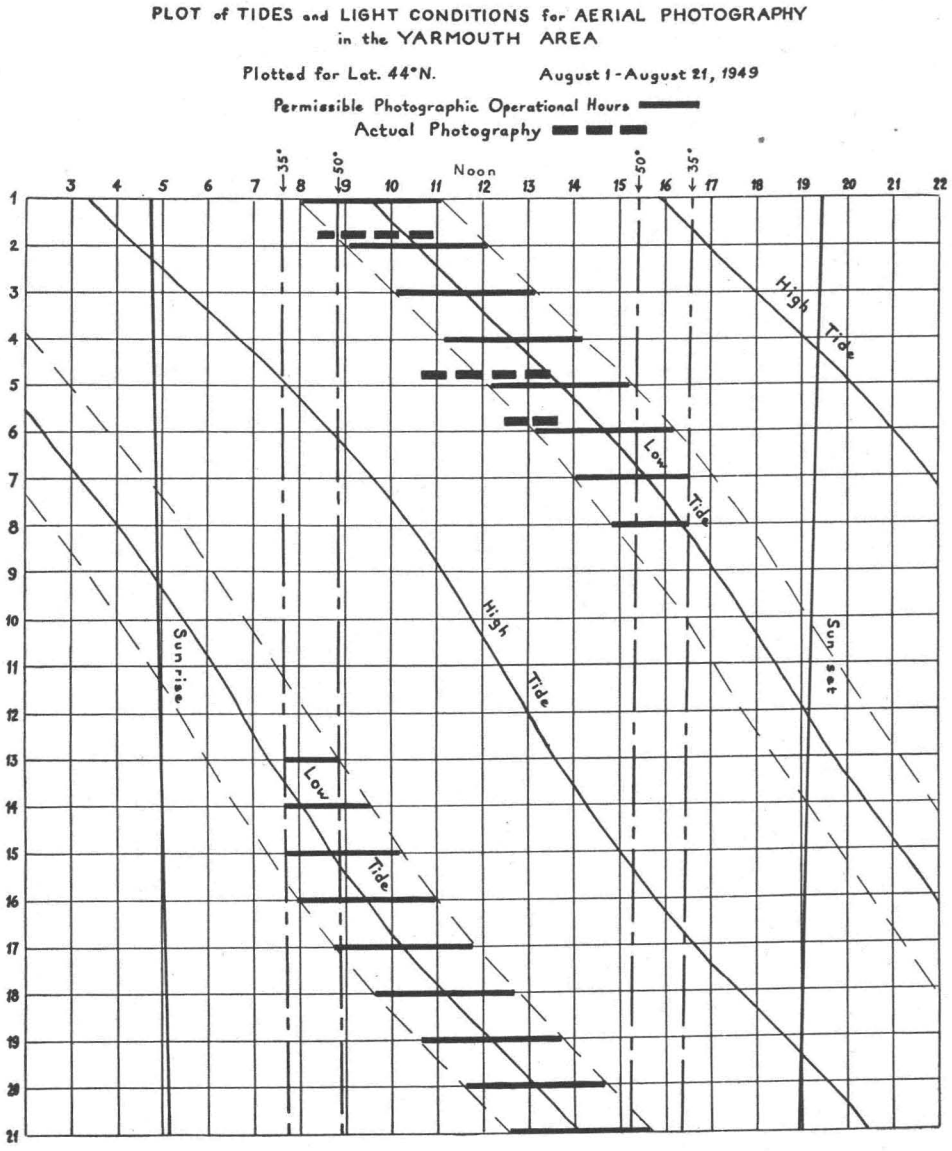

FIG. 2. Time-Tide Chart showing permissible photographic hours.

Theoretical considerations of angles of incidence and reflection indicate that the best period for photography, with a view to the elimination of specular reflection from the water surface, is when the sun is between 35° and 50° above the horizon. A glance at the chart indicates the great restriction of permissible time which this would cause. It was decided to use the lower limit of 35° because of light conditions, rather than considerations of reflection. Experience indicates that if one print shows excessive reflection the adjacent overlapping print is almost invariably clear. It is amazing how the latent image, lost in the white burst of reflection, will contribute to the stereo image when the pair are examined under the stereoscope.

The best general light conditions are produced by a high overcast which gives diffuse light conditions.

The time assigned by the R.C.A.F. for the operation was from August 1 to August 21 inclusive. The aircraft arrived at Greenwood on July 31, and all equipment and personnel were ready for operations on the first of August. A brief log of the next six days follows:

Aug. 1. Weather was unfavourable for photography. Cumulus cloud and ground mist. A reconnaissance of the area was carried out just prior to the permissible time of photography. (An interesting side-light was the spotting and reporting of a forest fire northeast of Yarmouth.)
Aug. 2. Weather favourable: High overcast gave diffuse light conditions. Lines 10 to 19 were completed within permissible period. Fog cut off southwest ends of lines 10 and 11.
Aug. 3. Weather unfavourable. Fog and rain.
Aug. 4. Weather unfavourable during permissible hours. Cleared in late afternoon.
Aug. 5. Weather favourable. High overcast with some cumulus. Lines 1 to 9, 19 to 32, and ends of 10 and 11 completed to finish vertical photography. Sonne lines 35 to 43 completed in black and white. Seal Island area was foggy.
Aug. 6. Completed Sonne lines 33 and 34 in black and white. Landed at Yarmouth to change film. Did lines 33 and 34, 39 and 43 in color. Operation completed. The total flying hours, including reconnaissance, were 14 hours and 11 minutes.

The weather during the operation was exceptionally hot for August in Nova Scotia. This resulted in much cumulus formation, especially in the afternoon. However, the usually heavy coastal fog in the Yarmouth-Cape Sable area burned off early, rendering favourable the morning permissible period.

It will be noted that some of the photography was carried out outside the strictly permissible tide range. In all cases of this type, the tide appeared to be very low, and as it was known that lags and gains occur in this area, photography was carried out. However, the overwhelming factor which always weighted our judgement was the usual prevalence of fog and haze in this region. As the Gods of the Weather would have it, about 50% of the remainder of the 21 days was favourable for photography, but he would have been a rash mortal who would have predicted this at the time.

RESULTS

Because of priorities, prints did not become available until the end of September, 1949. They were checked and it was decided to have double size enlargements made of key areas using the point source light.* This work was done in Victoria, British Columbia, and its story is a bright spot in a world supposedly beset by red tape. An air mail letter containing a list of 733 negatives was dispatched to the Air Survey Division of the Department of Lands and Forests in Victoria on December 15, 1949. The R.C.A.F. was also sent the same list on the same date. On January 17, 1950, the completed 10″×10″ enlargements were dispatched from Victoria. The weather did not co-operate, however, and

* "The Concentrated Arc Lamp as a Primary Light Source in Projection Printing," by T. H. Bell, PHOTOGRAMMETRIC ENGINEERING, Dec. 1948, Vol. XIV, No. 4.

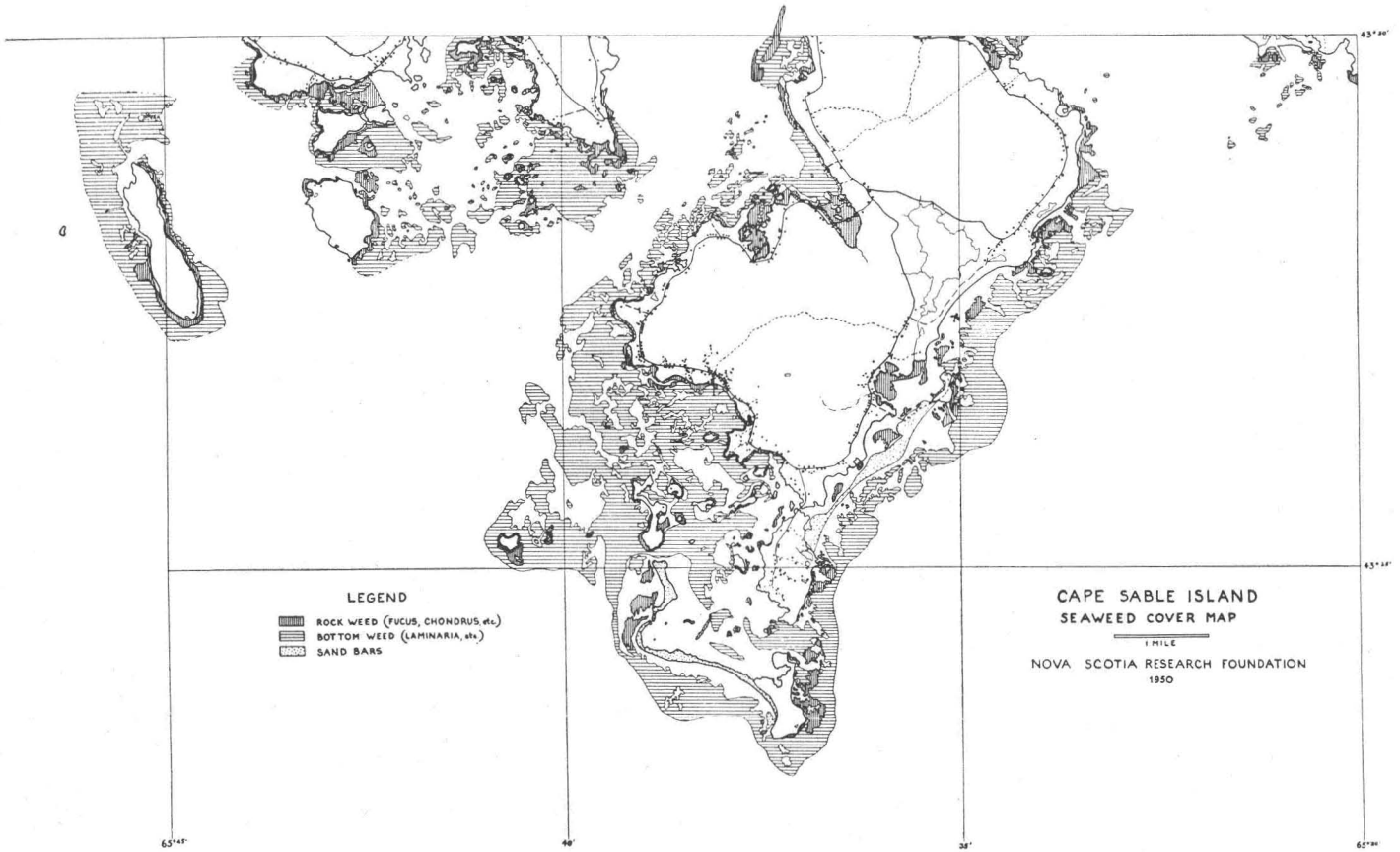

FIG. 3. Seaweed cover map, Cape Sable Island area, prepared from aerial photographs.

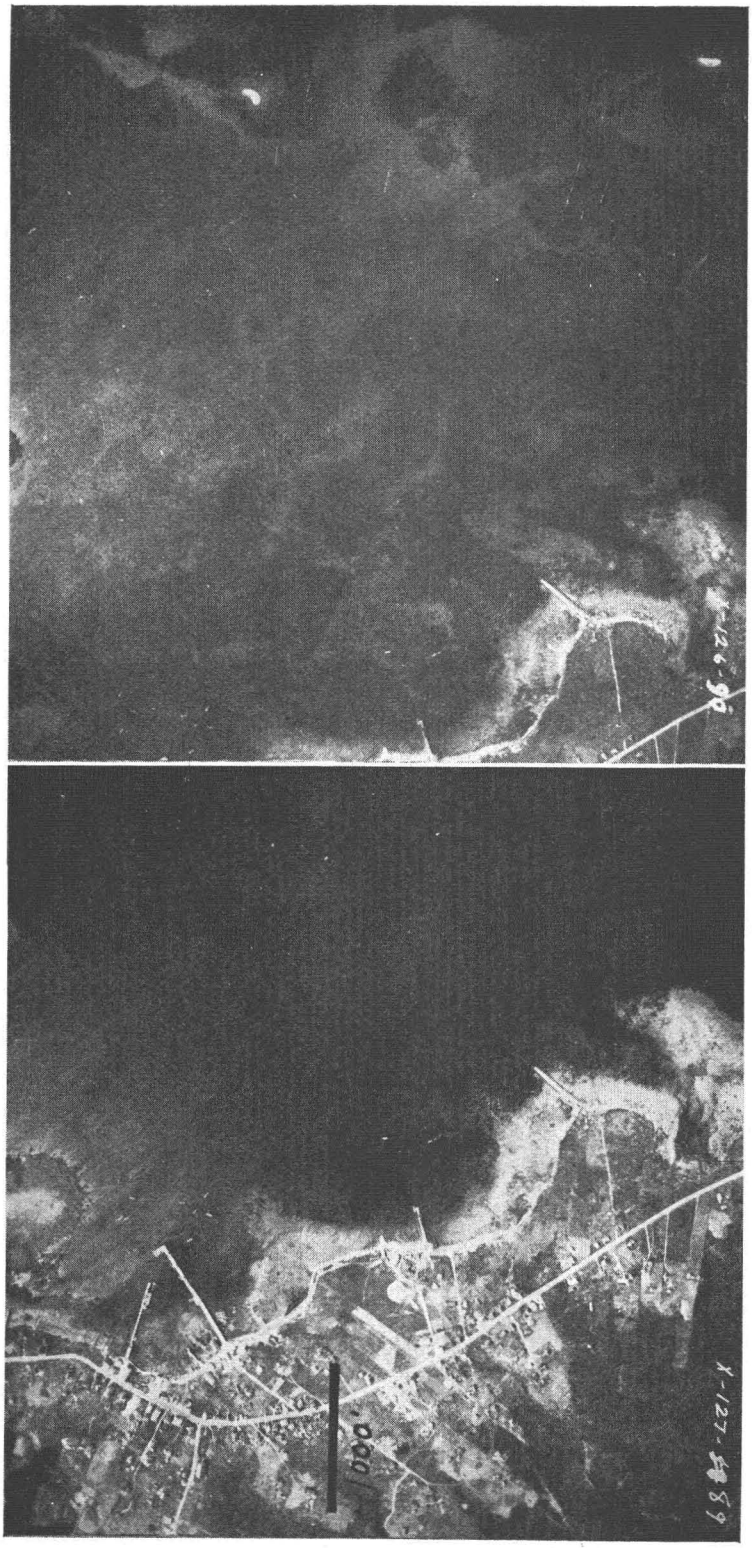

FIG. 4. Stereo pair red filter and green filter prints, Clarke Harbour area, Nova Scotia. (R.C.A.F. photographs)

snowslides and bad weather in the Western mountains delayed their arrival until February 6. The enlargements proved to be excellent and were used to plot the seaweed areas on base maps on a scale of 1″ = 2,640′. Maps of the entire Yarmouth area were prepared, using R.C.A.F. 1″ = 1,320′ photographs (1945–46) where Operation Seaweed photographs were not available. In all, eight sheets have been prepared and are now being used by Miss MacFarlane, the Research Foundation Algologist. The Cape Sable Island sheet is reproduced in Figure 3.

PHOTOGRAPH INTERPRETATION

The photographs were studied in alternate right hand red, and left hand green, pairs using a *Ryker* mirror stereoscope and an *Abrams* lens stereoscope with corresponding filters in the eyepieces. Photographic filters of red and green types approximating to the A25 and X1 were first tried, but the colors were too deep. Colored cellophane discs were tried and were found to give good results. A physiological or possibly psychological factor became apparent here, as the writer found that two thicknesses of cellophane gave good results, whereas an assistant required only one thickness. A stereo pair of the alternate red and green is reproduced in Figure 4. A red twin of the right hand green is shown in Figure 5. It is doubtful if any effect can be obtained from the cut, but the difference in resolution of detail can be clearly seen. The green photograph shows all visible seaweed patches with great clarity, whereas the red photograph exposed at the same instant shows much less underwater detail. It is very difficult to assess the value of this technique. The author honestly believes that the sum total of the two high lights seen through their respective color filters is

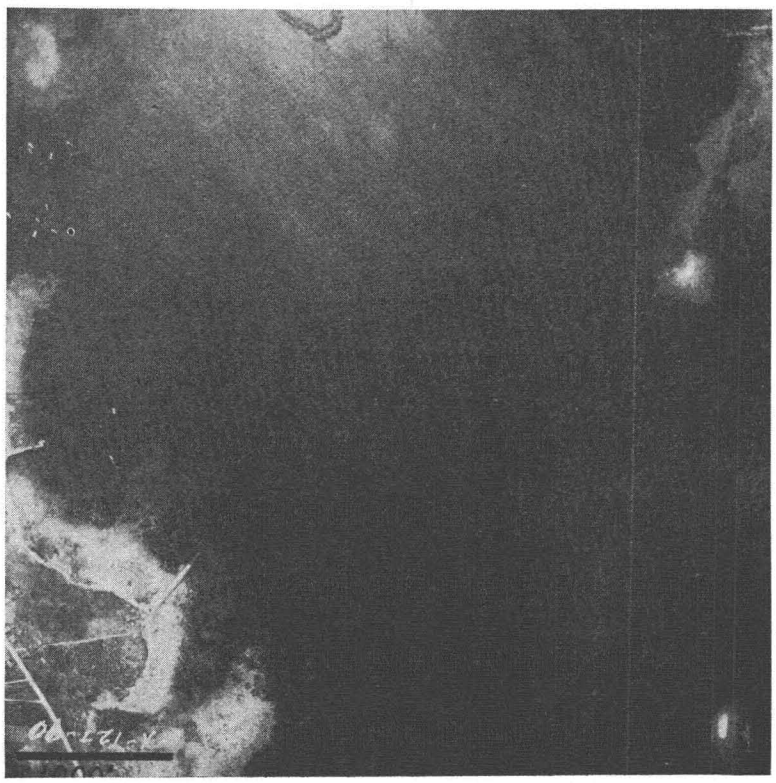

FIG. 5. Red print—right hand photograph of Fig. 4. (R.C.A.F. photograph)

a more complete rendition of detail. However, if the work in hand is commercial and limited by cost considerations, then the use of a green filter and normal survey procedure is recommended for the best over-all definition of underwater detail.

The actual plotting was carried out using a *Multiscope*, plotting at a 2.64 reduction from 5″×5″ contact prints and a *Duoscope* plotting at a 5.28 reduction from the 1″=500′ enlargements. Interpretation was carried out previous to plotting using both lens and mirror stereoscopes. The base maps at 1″=2,640′ were produced by the Topographic Survey Branch Department of Mines and Technical Surveys from R.C.A.F. photographs.

SONNE PHOTOGRAPHY

The Sonne flight lines were designed to be sampling strips of key areas. With the 88 mm. cone and a 300′ altitude the resulting photographs had an approximate scale of 1″=86′. Because no Sonne viewer was available the photographs were printed in 10″ lengths on 9″ wide paper. When these are cut along the center line they can be viewed using an ordinary mirror stereoscope.

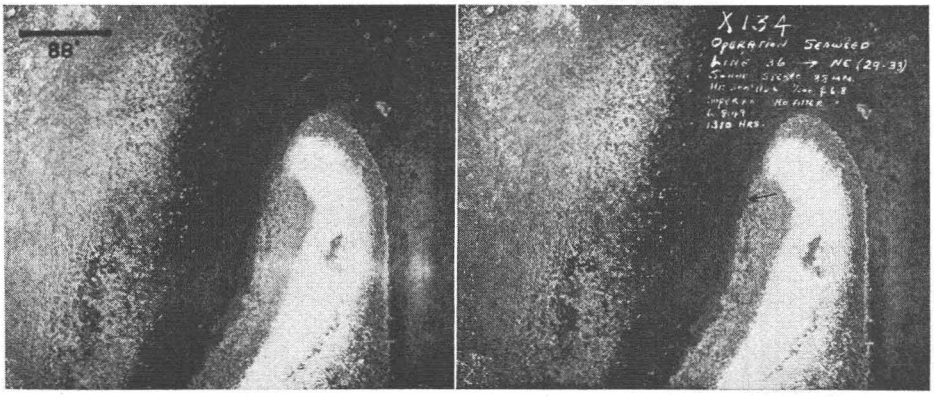

FIG. 6. Sonne stereo pair, showing kelp (Laminaria) and rockweed (fucus serratus), St. John Island, Nova Scotia. (R.C.A.F. photographs)

This could not be done in the case of the four lines taken with Kodacolor. These color transparencies were studied later using the standard Sonne viewer.

The results were good in all cases where the actual area designated was covered by the photography. This was in about seventy-five per cent of all cases. The difficulty of aiming a high speed aircraft at a pin point is thus amply demonstrated.

Figure 6 shows both rockweed (fucus serratus) and kelp (Laminaria). The types can be distinguished under magnification with either a lens or mirror stereoscope.

The color Sonne was in every way superior to the black and white. Detail was excellent and the different parts of the thallus plants were brought out by their color differences. The use of transmitted light was another factor favoring the color photographs. If time permits, we hope to have some black and white transparencies made from the green negatives to check their value against the black and white prints. It may be, that as long as the present color processes are too expensive for commercial work, a considerable improvement in detail can be obtained through the use of black and white transparencies.

One phenomenum was noted during the examination of the Sonne photo-

graphs which may be of interest to photogrammetrists. While examining the strips with a lens stereoscope, a patch of weed was noted in the section which could not be viewed without excessive separation of the images. In order to obtain magnification without having to close one eye, the two strips were placed side by side as they were before being cut apart. The resultant fused image was very clear and should have lacked any third dimensional effect. It was noted, however, that some stereo effect was present and a close examination revealed a series of wavelike corrugations at right angles to the line of flight. These undulations are very regular and are spaced at $\frac{1}{4}''$ intervals. They are undoubtedly related to the winding of the film on the spools, which produced the Y parallax.

CONCLUSION

The present work has shown that aerial photography provides a rapid method for seaweed cover survey. In fact it is the only method which will give the actual outline of all weed beds to a depth of four fathoms. Low level strip photography can be used for weed typing on a sampling basis, whereas actual tonnage per square mile and finer differentiation of weed types remain for the slow and costly boat work. However, the latter work is reduced to a minimum; relieved of the necessity for mapping the outline of weed beds, the work can proceed at an economic pace.

From the technical standpoint, only standard techniques and equipment are required for this type of survey. One unexplored field is that of orthochromatic type film which will be more sensitive to green and less sensitive to red. An improvement in resolution of underwater detail may be obtained through use of such film, but losses in other directions may cancel out any improvement. It may be possible to substitute moving magazine type cameras for the Sonne work, or if the area involved is limited, the survey photographs may be taken at larger scales using such equipment.

BIBLIOGRAPHY

1. Bell, T. H., "The Concentrated Arc Lamp as a Primary Light Source in Projection Printing." PHOTOGRAMMETRIC ENGINEERING, Vol. XIV, No. 4, Dec. 1948.
2. Cameron, H. L., "Report on Experimental Aerial Photography of Shallow Water Zones of Nova Scotia," N.S.R.F. 1948. (Private publication.)
3. Cameron, H. L., "Sub-Sea Faulting in the Lismore Area, Nova Scotia," *Bull. Can. Instit. of Mining and Metallurgy*, Trans. Vol. LII, 1949, pp. 87–88.
4. Colwell, Robert N., "Aerial Photographic Interpretation of Vegetation for Military Purposes," PHOTOGRAMMETRIC ENGINEERING. Vol. XIV. No. 4, Dec. 1948.
5. Moore, J. Grange, "The Determination of the Depths and Extinction Coefficients of Shallow Water by Air Photography Using Color Filters." *Roy. Soc. of London, Series A. Mathematical and Physical Sciences*. No. 816, Vol. 240, pp. 163, 217-21 January, 1947.
6. Thomson, R. H., Ft. Lt., RAAF, "The Transparency Method of Depth Determination." R.A.A.F. Directorate at Technical Services. May, 1946.