N73-28316

ERTS-1 OBSERVES ALGAL BLOOMS IN LAKE ERIE AND UTAH LAKE

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ABSTRACT

During late summer when the surface waters of Lake Erie reach their maximum temperature an algal bloom is likely to develop. Such phenomena have been noticed on other shallow lakes using ERTS-1 and characterize eutrophic conditions. The concentration of the algae into long streamers provides additional information on surface circulations. To augment the ERTS-1 MSS data of Lake Erie an aircraft was flown to provide correlative thermal-IR and additional multiband photographs. The algal bloom is highly absorptive in the visible wavelengths but reverses contrast with the surrounding water in the near-IR bands. The absorption of shortwave energy heats the dark brown algal mass, providing a hot surface target for the thermal-IR scanner.

1. INTRODUCTION

As aircraft flights were being made over Lake Erie on 15 October 1972, underflying ERTS-1, a long dark streamer was observed between Kelleys and South Bass Islands and the Ohio shoreline. Although it was known the ERTS imagery would barely reach this area, the flight pattern was modified on site to provide sufficient coverage of this water-borne material.

2. OBSERVATIONS

The NOAA Buffalo DeHavilland aircraft was equipped with a Spectral Data Corporation multiband camera system, to spectrally simulate ERTS, and a Daedalus Dual-Channel Thermal Scanner. Flying at an altitude of 5.8 kilometers, the photography covered a swath beneath the aircraft of approximately 2.5 nautical miles. The IR-imagery covered a 5 nautical mile swath. Since our main surface truth operations were being conducted along the Canadian shore of the lake, no quantitative measurements have been obtained for the area in question off Port Clinton, Ohio.

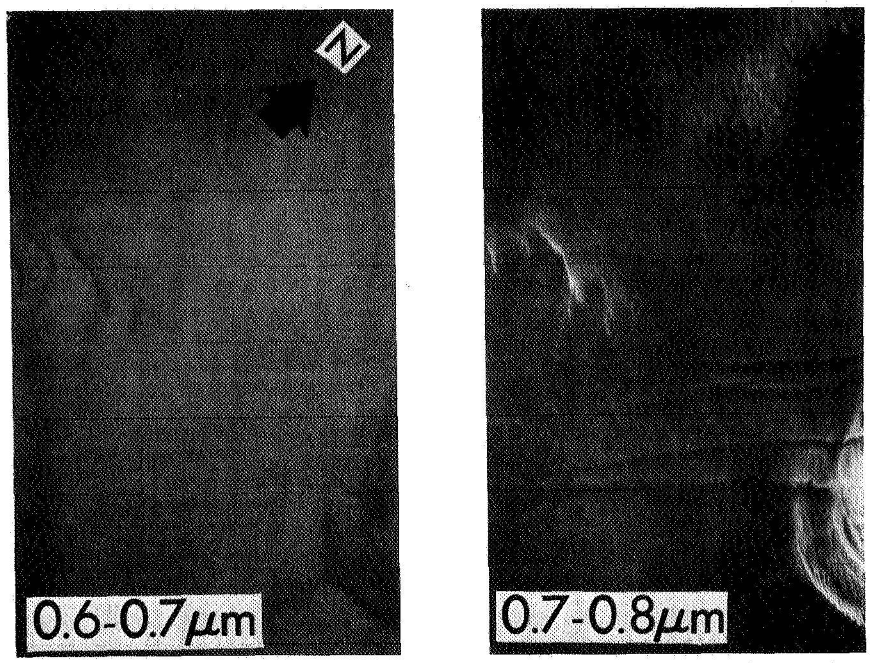

Figure 1. Multiband photography, 15 October 1972. Altitude 5.8 km; Time: 1837 GMT. See Figure 4 for chart locations.

The multiband camera observations are presented in Figure 1. An abrupt reversal in contrast is evident between the ERTS-simulated MSS bands "5" and "6". The material that absorbs shortwave energy in the visible wavelengths reflects incident radiation in the near-IR wavelengths. Due to the strong solar absorption in the visible it was not surprising to find an associated high surface temperature in the thermal-IR. This simultaneous information is presented in Figure 2. The near-surface manifestation of this material is made evident as small boat wakes normal to the streamer appear to cut both the visible, reflected-IR and thermal-IR features.

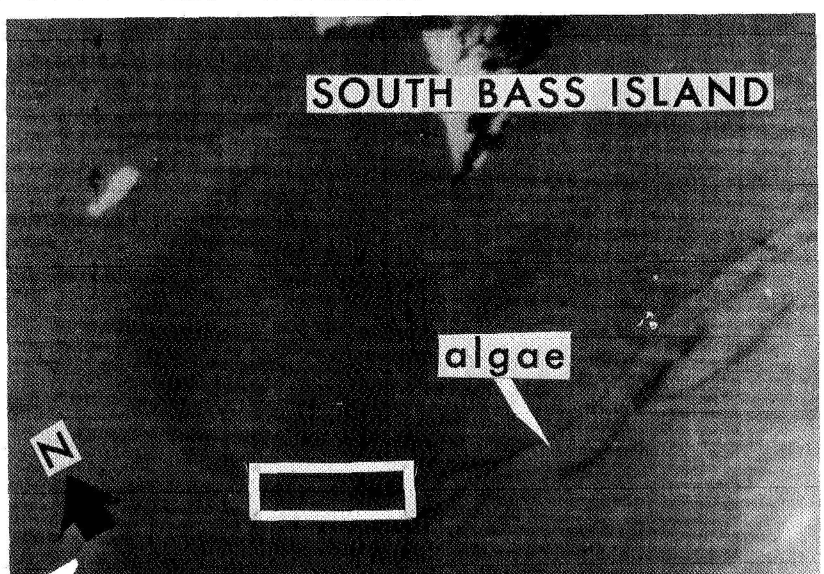

Figure 2. Thermal imagery over same area as Figure 1. Darker tones are warmer temperatures. Spectral wavelength is 9-14μm. Box locates area covered by Figure 1.

A portion of the ERTS-1 MSS data has been redisplayed on our Digital Muirhead Device (DMD) at the National Environmental Satellite Service. Use of the DMD makes it possible to enhance the lower radiances characteristic of water. It has been seen that considerable information is available from ERTS altitudes from what initially appears in the original unenhanced imagery as a uniform black tone. A reprocessed 7.2 nautical mile north-south DMD swath of the original MSS imagery is illustrated in Figure 3. The "chip" begins at Point Pelee on the north shore of Lake Erie and terminates at Marblehead, just north of Sandusky, Ohio. Although the 15 October ERTS-1 imagery barely covered the phenomenon observed in Figures 1 and 2, the high reflectance of the westernmost portion can be seen in MSS-6 (Fig. 3c) immediately west of Kelleys Island and more faintly in MSS-7 (Fig. 3d). A chart locates the information in Figure 4.

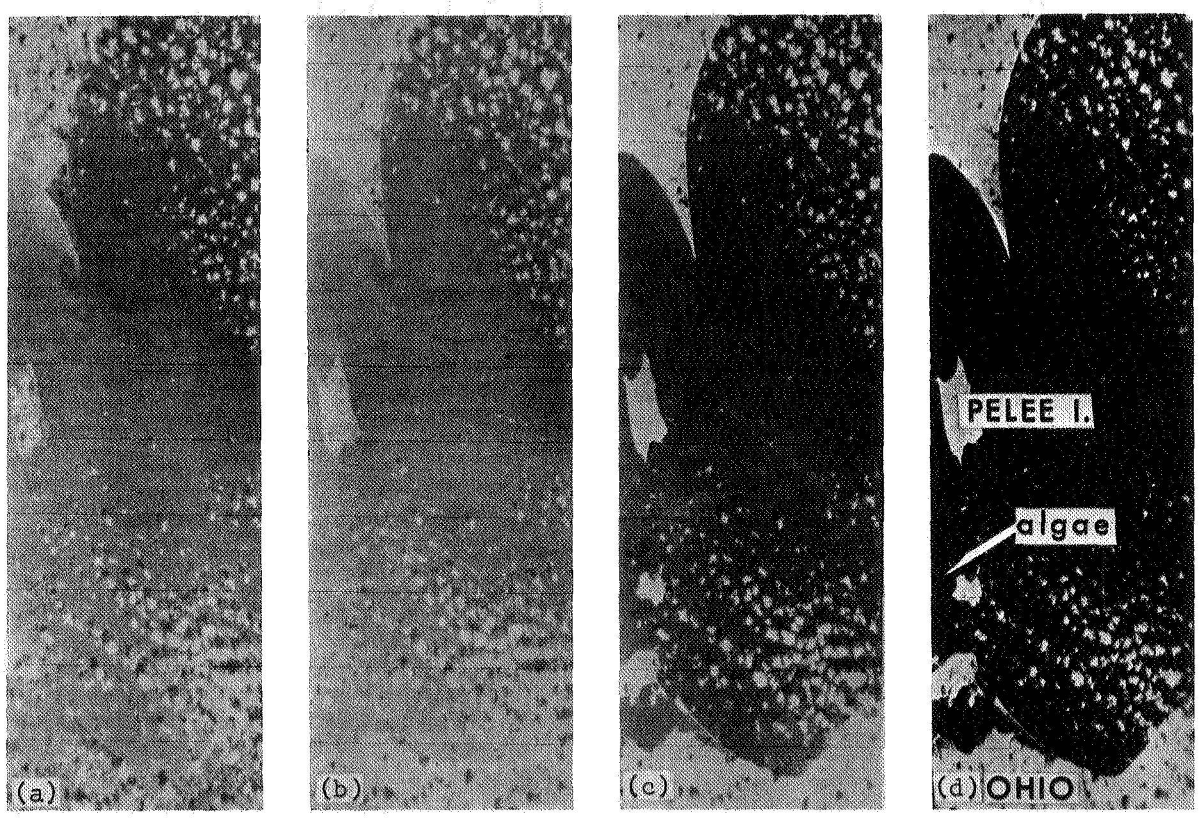

Figure 3. Digital enhancement of ERTS-1 image taken on 15 October 1972 at 1541.3 GMT. Swath is from western edge of image and covers approximately a 7.2 nautical mile width. Enhancement is greatest in the first five radiance levels (counts)-(a) MSS-4, (b) MSS-5, (c) MSS-6 and (d) MSS-7.

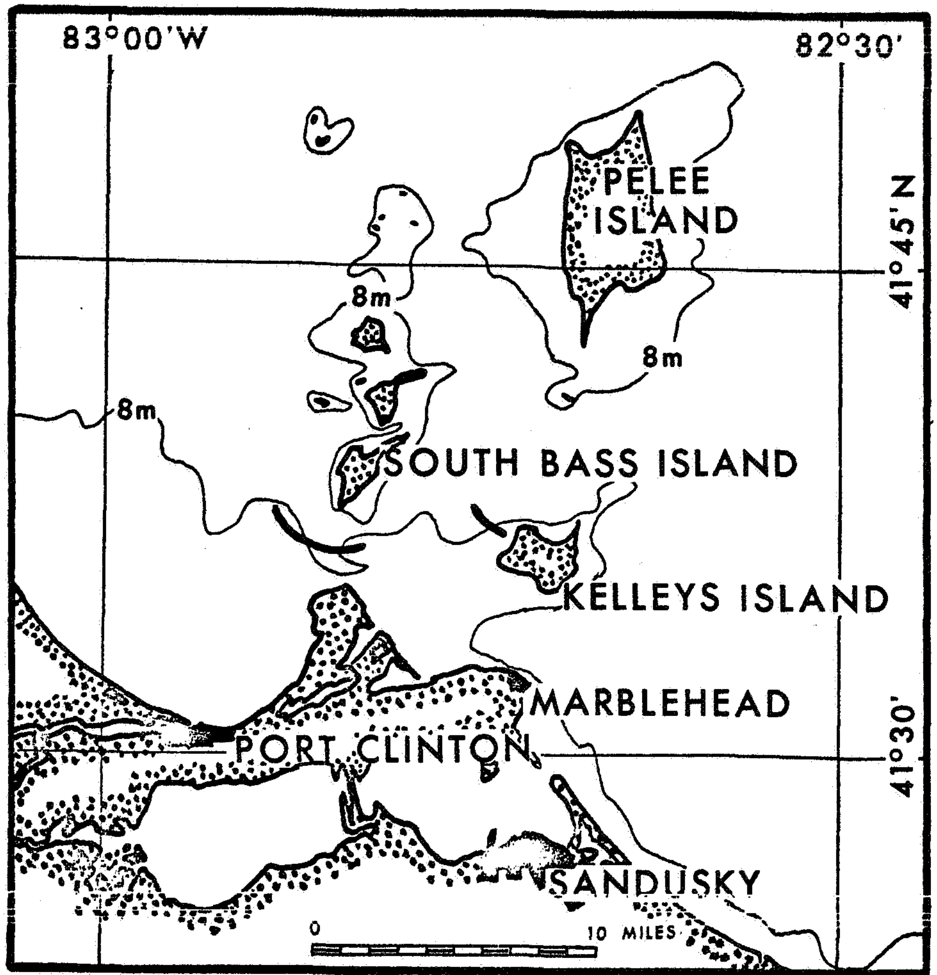

Figure 4. Chart of Lake Erie locations under discussion. Information from ERTS-1 and aircraft have been located using the Bausch and Lomb Zoom Transfer Device.

A much superior observation of an identical phenomenon has been located in the ERTS imagery. This is of Utah Lake during September 1972. Figure 5 shows anticyclonic gyre in this shallow (ca 3m) and highly eutrophic lake ($PO_4^{=}$ca. 0.5mg/l) that reverses contrast at 0.7µm and covers a large percentage of the surface of this lake (lake-surface area is ca. 375 km^2). ERTS-1 imagery acquired on both 12 and 29 September 1972 showed this feature. Utah Lake is known for its high turbidity and during summer months algae blooms frequently follow calm periods. (Dr. David White, Brigham Young University, personal communication)

3. RESULTS AND CONCLUSIONS

Based on the success of ERTS MSS to resolve a strong chlorophyll reflectance on Utah Lake, it is our contention that an algae bloom has taken place on Lake Erie. The vigorous growth of this resulting biomass is rich in chlorophyll, and provides a strong reflection of radiant energy in the near-IR bands. The dark green or brown color of this phenomenon is likely to render the algal surface darker at visible wavelengths than surrounding high turbidity coastal waters as was observed in MSS bands 4 and 5. Algae blooms can be expected to occur during periods of low surface winds, warm water conditions and substantial insolation. These conditions preceded both Lake Erie and Utah Lake observations. Although most Great Lake algae blooms can be expected to be on a scale barely resolved by ERTS resolutions, a careful interpreter and some judicious computer processing should reveal many more algae bloom situations that have previously gone unnoticed. Monitoring these blooms and their distributions not only provides information on the quality of the water that supports them but also valuable information of circulation of the water supporting this rich biomass.

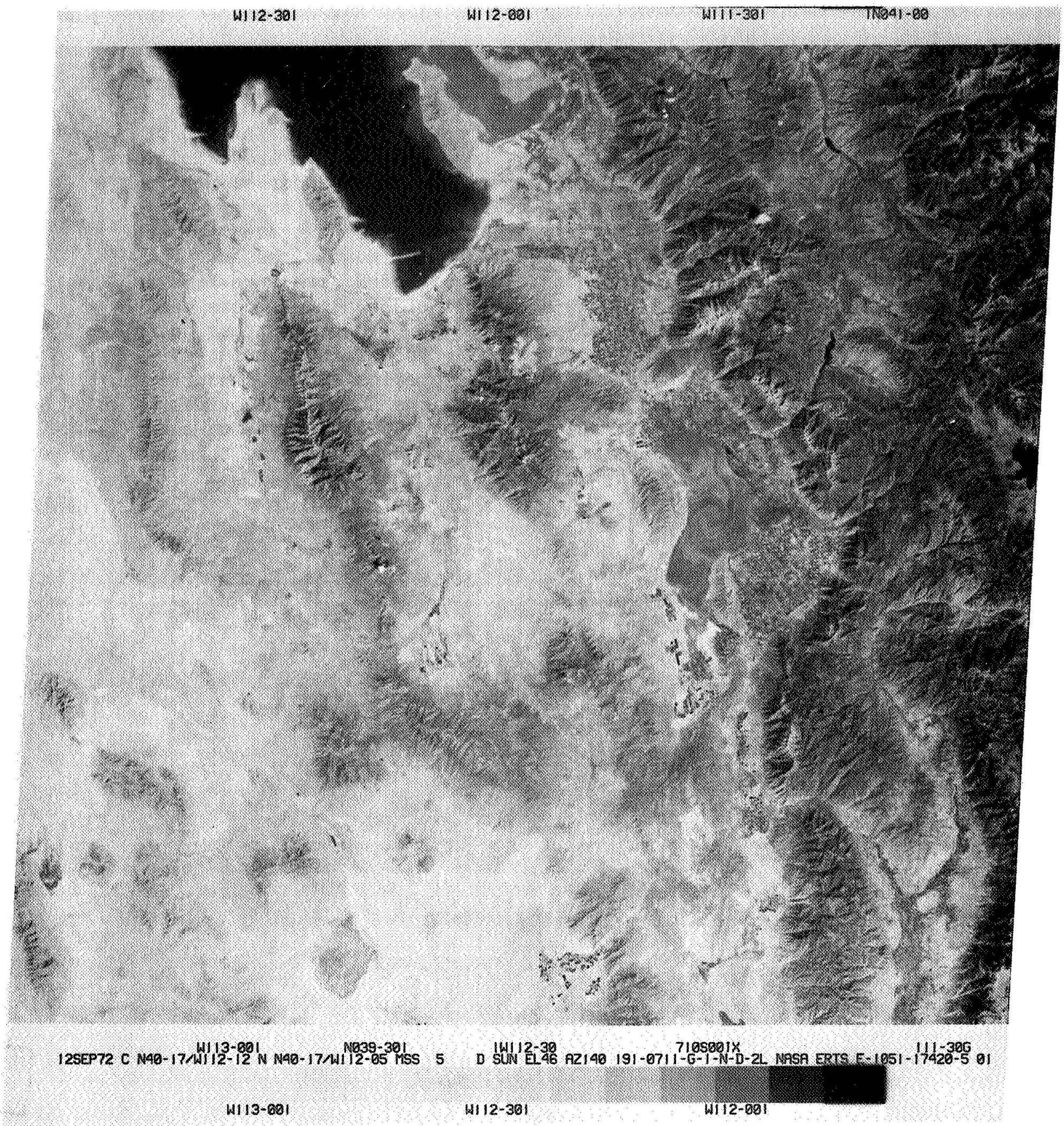

Figure 5a. Utah Lake, 12 September 1972, Time: 1742 GMT. MSS-5.

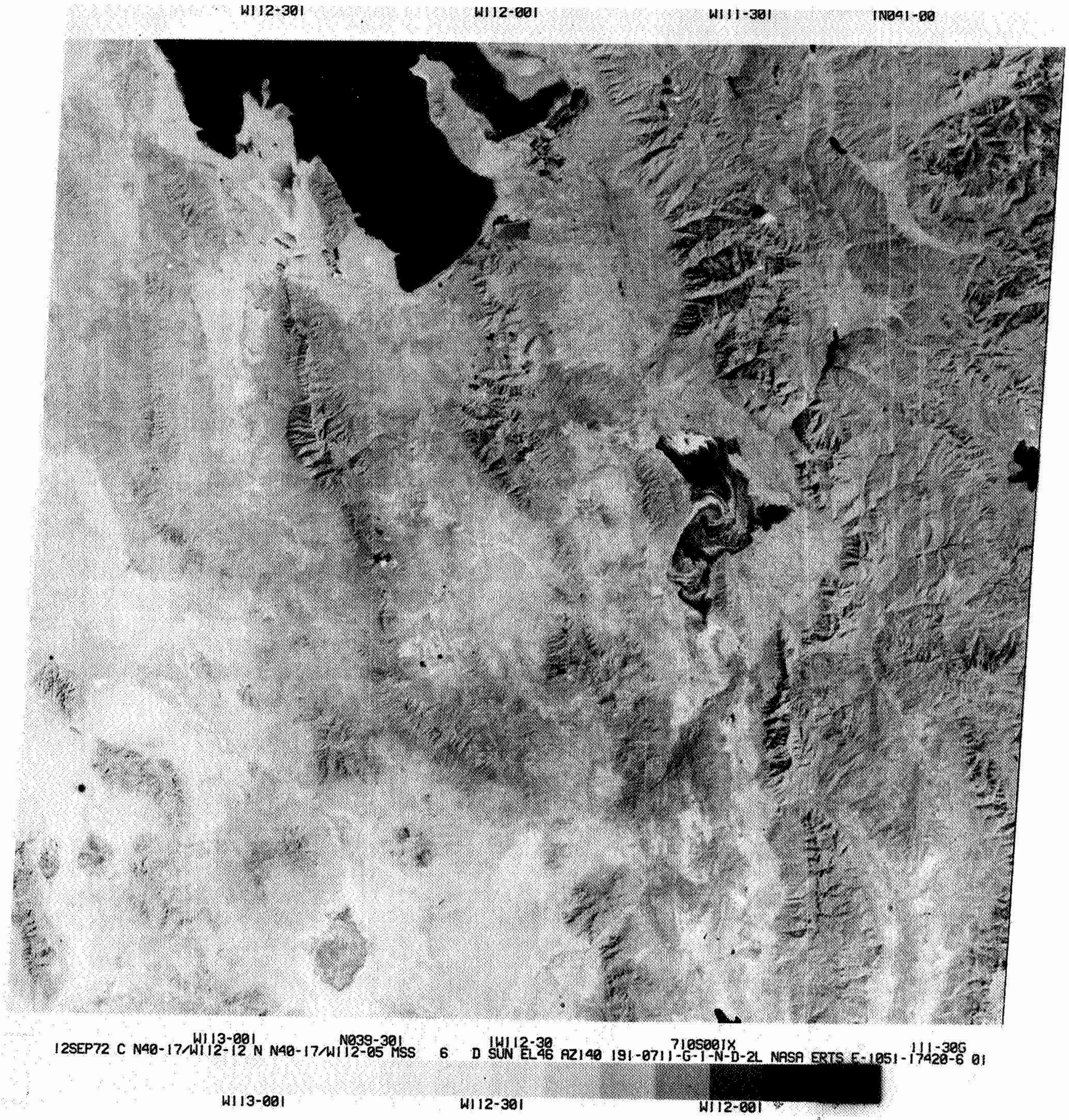

Figure 5b. Utah Lake, 12 September 1972, Time: 1742 GMT. MSS-6.

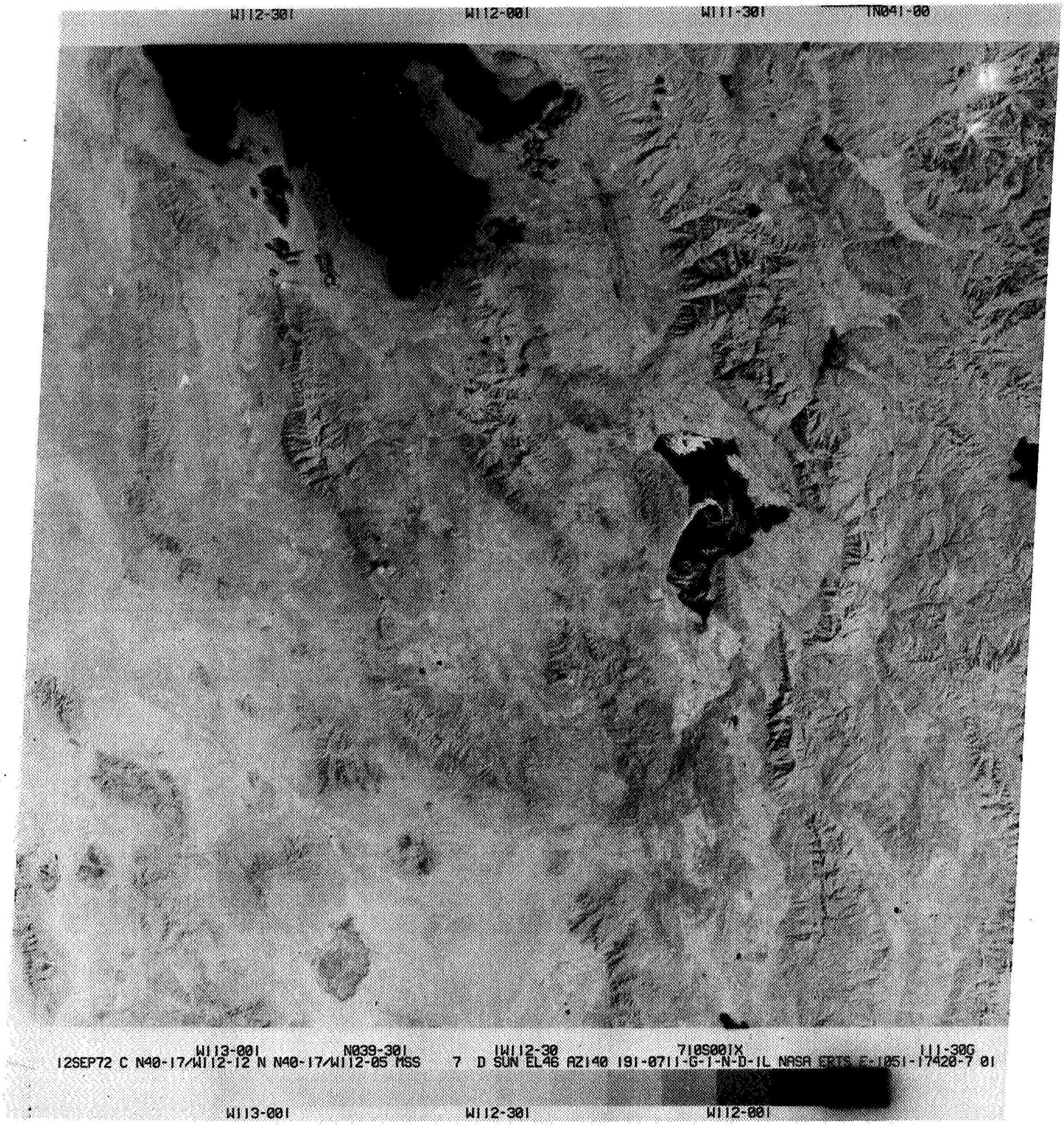

Figure 5c. Utah Lake, 12 September, Time: 1742 GMT. MSS-7.