Paper M 18

COASTAL AND SUBMARINE FEATURES ON MSS IMAGERY OF SOUTHEASTERN MASSACHUSETTS: COMPARISON WITH CONVENTIONAL MAPS*

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ABSTRACT

Three ERTS-1, MSS images (28 July 1972, 1 Sept. 1972, and 8 Oct. 1972) of southeastern Massachusetts, including Cape Cod Bay, Cape Cod, and Nantucket Sound, show a variety of dynamic geologic and hydrologic phenomena. Coastal features imaged include the coastline at different times in the tidal cycle, harbors, lakes and ponds, marshes (wetlands), and beach and dune areas; submarine features include tidal flats, shoals, dredged and natural channels, and bars. Comparison with conventional maps at 1:1,000,000 and 1:250,000 scales show many inaccuracies between the ERTS imagery and the two map scales. The discrepancies are caused by cartographic generalization from larger scale maps and, in some instances, actual changes in landforms. The marine geological information shown on the ERTS imagery is not shown on the 1:1,000,000- or 1:250,000-scale maps, nor is other mappable environmental information, necessary to effective resource management decisions, affecting the area. The ERTS-1 imagery of the southeastern Massachusetts area provides two-dimensional coastal and submarine information superior to conventional maps at 1:250,000 or smaller scales. The ERTS-1 imagery can be used to increase the accuracy of these maps, portray additional environmental information, and provide the capability for frequent updating of maps at such scales. ERTS-1 imagery provides a very cost-effective method for provision of certain types of environmental data for Cape Cod and environs.

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EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

1. INTRODUCTION

A preliminary analysis of ERTS-1, MSS imagery of southeastern Massachusetts, including Cape Cod, Cape Cod Bay, and Nantucket Sound, has been completed. Special emphasis has been given to a study of Plymouth and Duxbury Bays because of the availability of imagery from at least three orbital passes (Table 1). Examples of imagery of coastal and submarine features are given at scales of 1:1,000,000; 1:250,000; and 1:125,000, and compared to conventional maps at 1:1,000,000 and 1:250,000 scales, and 1:125,000-scale Ektachrome infrared aerial photography.

Table 1. - Selected ERTS-1 Imagery of Southeastern Massachusetts and Tidal Data for Time of Image Acquisition (Anonymous, 1971)

Date	Image ID No.	Local Time (hrs.)	Tidal Times (hrs.) for Plymouth Bay High	Low	Rise (m)
28 July 1972	E-1005-15005	1001	1240	0643	3
1 Sept. 1972	E-1040-14552	0955	0500	1118	3
8 Oct. 1972	E-1077-15011	1001	1138	0541	3

Coastal areas, such as Cape Cod, represent one of the most difficult areas in which to do accurate geologic mapping and in which to maintain the currency of conventional topographic maps (Williams and Friedman, 1970). The Cape Cod coastline is continually changing from a combination of natural forces (Davis, 1896) and manmade modifications. Offshore bars and shoals; sediment distribution; the water-land contact; areas of beach and dune sediments; position of tidal and river channels; vegetation assemblages; and even cultural features are in a constant state of flux. Small wonder then that our conventional maps of Cape Cod are out of date, and as can be seen by comparison of ERTS-1 MSS imagery at the 1:1,000,000 and 1:250,000 scales, such small-scale maps are inaccurate, particularly in the portrayal of the coastline and lakes.

The key to accurate and timely coastal mapping is the acquisition of optimum imagery (Stringham and Williams, 1970) for the specific purpose to which it will be employed. Optimum imagery implies frequent coverage at specific spectral bands. Aerial spectrophotography (Williams, 1971),

if available, can fulfill these requirements. In most cases, however, aerial photography of an area is infrequently scheduled, usually acquired during one season (summer), and in only one spectral band. ERTS imagery provides the needed data for maps at 1:250,000 scale or smaller. MSS band 4 or band 5 is best for showing shoals and bars on Cape Cod; band 5 is best for cultural features; and band 6 or 7 is excellent for the land-water contact (shoreline), harbors, inlets and marshes, and for lakes and ponds. The remainder of the paper will be directed at describing various coastal and submarine features on the MSS imagery of southeastern Massachusetts under different tidal conditions (different water depths) and comparison of these features with conventional maps of the area.

2. COASTAL FEATURES

Figure 1 compares three ERTS-1, MSS images from the same scene (1 Sept. 1972, E-1040-14552), bands 4, 5, and 7, with a 1:1,000,000-scale map [IMW, NK-19, Boston, North America, 1969; compiled by Army Map Service in 1955 from 1:250,000 maps (1947), 1:506,880 maps (1939), and USC&GS charts (1947 and 1949)]. The images were acquired at 0955 hrs. local time about 1 1/2 hrs. before low tide in Plymouth Bay, Wellfleet Harbor, Provincetown, and Barnstable Harbor (Beach Point) (Anonymous, 1971). In an area as large as Cape Cod, with different bottom configurations, etc., the times of high and low tide vary from place to place. For instance, low tide in Pleasant Bay was not reached until 3 hrs. later (4 hrs. after passage of the satellite) than Plymouth Bay.

Many inaccuracies are apparent when the ERTS-1, MSS images are compared to the 1:1,000,000-scale map, which shows the shoreline at time of mean sea level. How many of the discrepancies are due to actual changes in the coastline since time of mapping and how many are due to the subjective generalizations by the cartographer who drafted the original map is impossible to say. With the ERTS image, however, it is not necessary to generalize, since the original scale of the image "pre-processes" the data for the cartographer. There should also be less subjective variation between different cartographers, hence a better "fit" between different areas within a map or between different maps becomes possible. See the "fit" between the two 1:250,000-scale maps in Plymouth

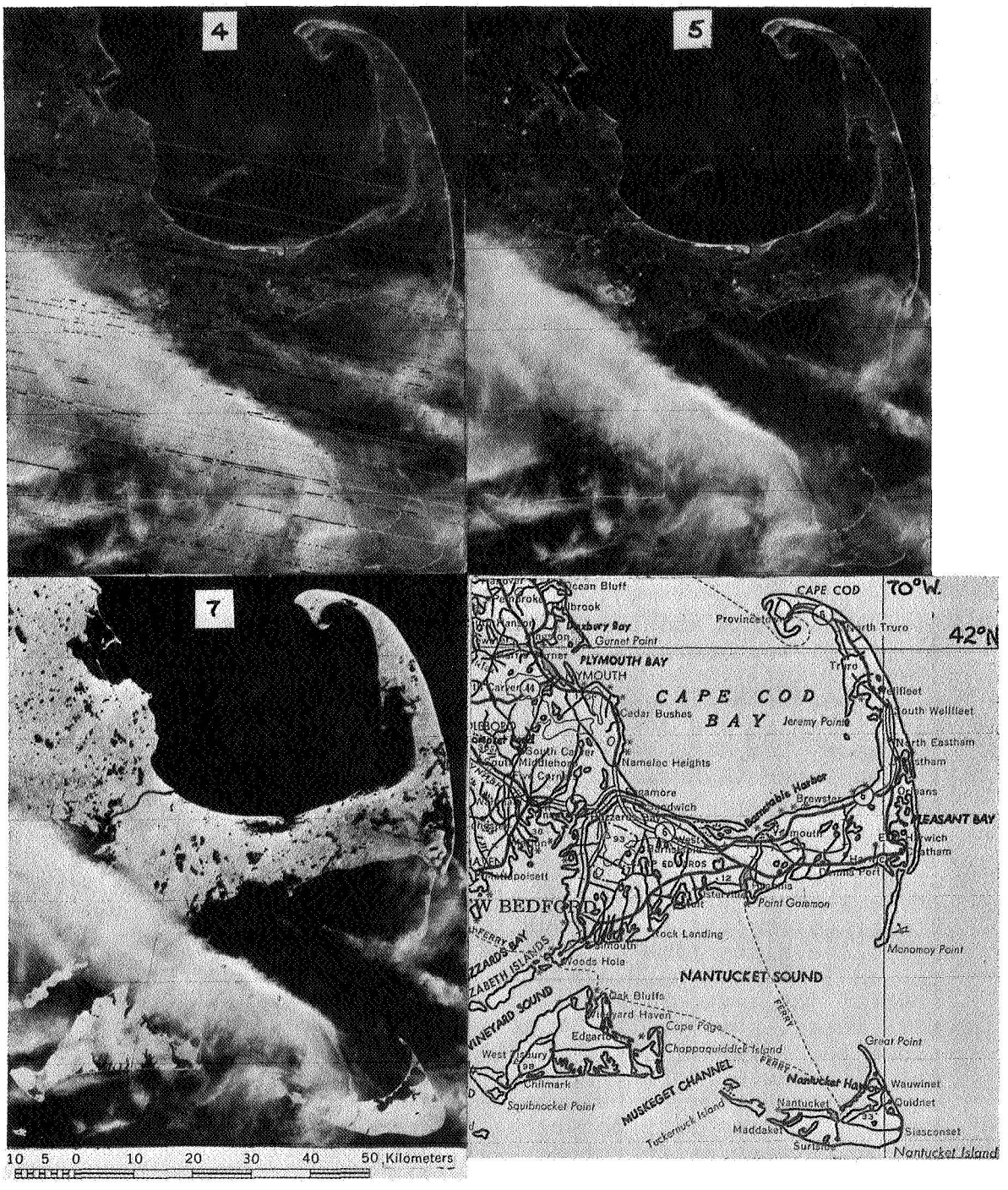

Figure 1. - Comparison of 1:1,000,000-scale ERTS-1, MSS imagery (1 Sept. 1972, E-1040-14552, MSS bands 4, 5, and 7) with 1:1,000,000-scale map (IMW, NK-19, Boston, North America, 1969) of southeastern Massachusetts, showing coastal and submarine features. Note the inaccuracies in the portrayal of the coastline and inland lakes on the map when compared with the MSS images. For much of Cape Cod Bay the tide will ebb 1 hr. 23 min. after image acquisition.

Harbor 3km east of long. 70°45'W. for a striking example of subjective inaccuracy (Figure 2). A comparison of the coastline configuration of the tip of Cape Cod (Provincetown area), Jeremy Point on the western side of Wellfleet, Point Gammon south of Hyannis, Barnstable Harbor, Great Point and the cuspate bar on Nantucket Island, Monomoy Point and Island south of Chatham (Oldale, Friedman, and Williams, 1971) between the MSS image (band 7) and the map graphically portray the differences.

The portrayal of lakes and ponds on the 1:1,000,000 map shows a decided lack of cartographic precision. Almost no lakes or ponds are portrayed on the map with their accurate shape when the map is compared with the MSS image (band 7). Although some of the lakes may have changed in size or shape the representation of most of these is grossly inaccurate. There is no question that ERTS imagery will permit a far superior 1:1,000,000 map of southeastern Massachusetts.

Figure 3 and 4 show enlargements of ERTS-1 MSS imagery of the Plymouth and Duxbury Bay areas. Discrepancies and inaccuracies are present on the 1:250,000-scale maps (NK 1904, Boston, 1956, revised 1970; and NK 19-7, Providence, 1947, revised 1969), although not to the degree of the 1:1,000,000 map. Note the shoreline around Saquish Head and the configuration of inland lakes and ponds. The 1:250,000-scale MSS images (bands 4, 5, and 7) of Figure 3 and the 1:125,000-scale MSS images of Figure 4 (bands 5 and 7) were acquired on 28 July 1972 (E-1005-15005) at 1000 hrs. local time or about 2 hrs. 40 min. before high tide.

Also of particular interest on band 5 of MSS imagery is the distinction of dune areas, particularly in the Province Lands area northeast of Provincetown and along Sandy Neck north of Barnstable Harbor. Areas of marshes (wetlands) can be delineated, particularly in western Wellfleet and around Barnstable Harbor.

3. SUBMARINE FEATURES

Figure 1 shows considerable detail of submarine features along the coastal and bay areas of southeastern Massachusetts. MSS band 4 shows the greatest submarine detail, but the wavelengths needed for water penetration

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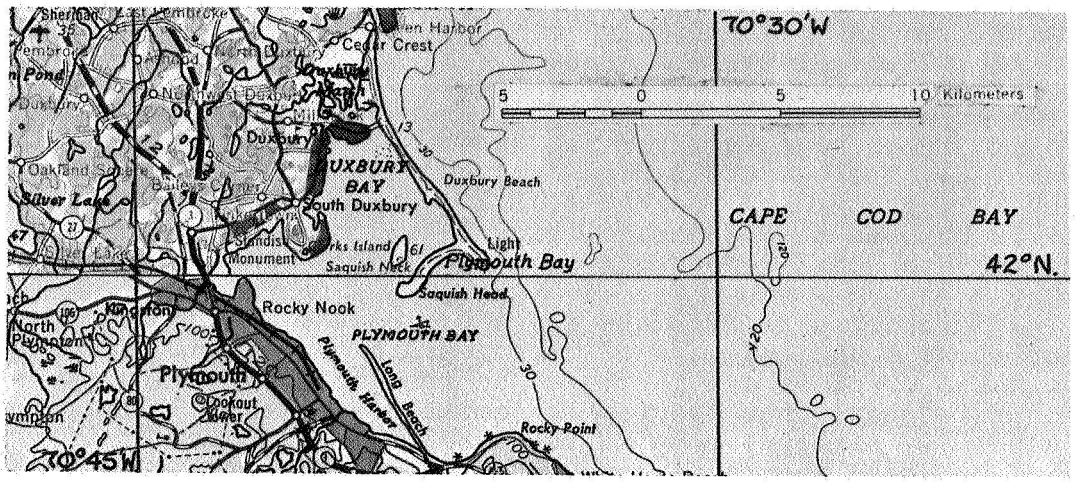

Figure 2. - 1:250,000-scale map (NK 19-4, 1956, rev. 1970; NK 19-7, 1947, rev. 1969) of the Plymouth and Duxbury Bay areas, Massachusetts. Compare with Figure 3. Datum reference is mean sea level.

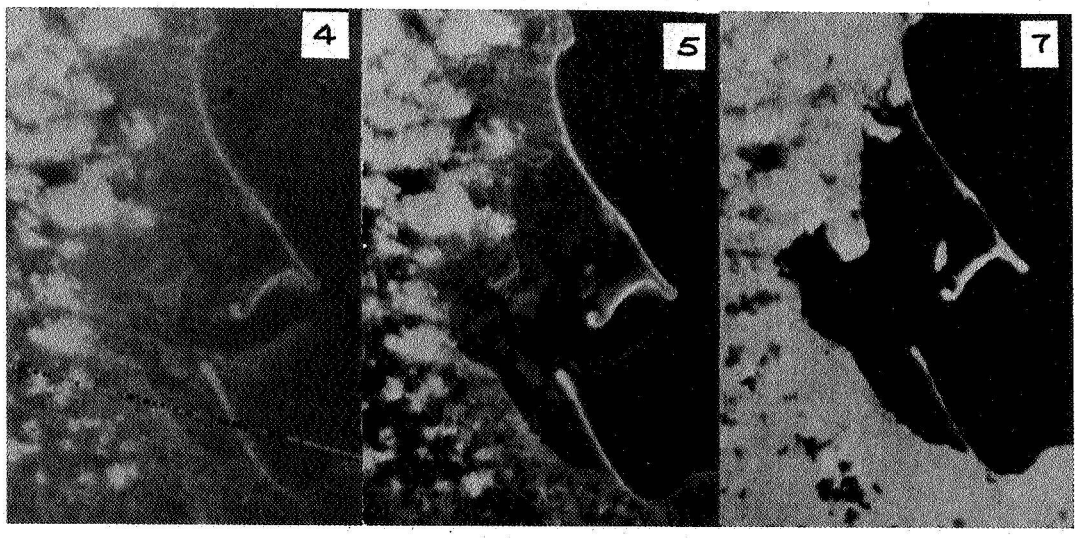

Figure 3. - Enlargement of ERTS-1, MSS imagery (28 July 1972, E-1005-15005, bands 4, 5, and 7) to 1:250,000 scale. Compare with Figure 2. Image was acquired 2 hrs. 40 min. before high tide.

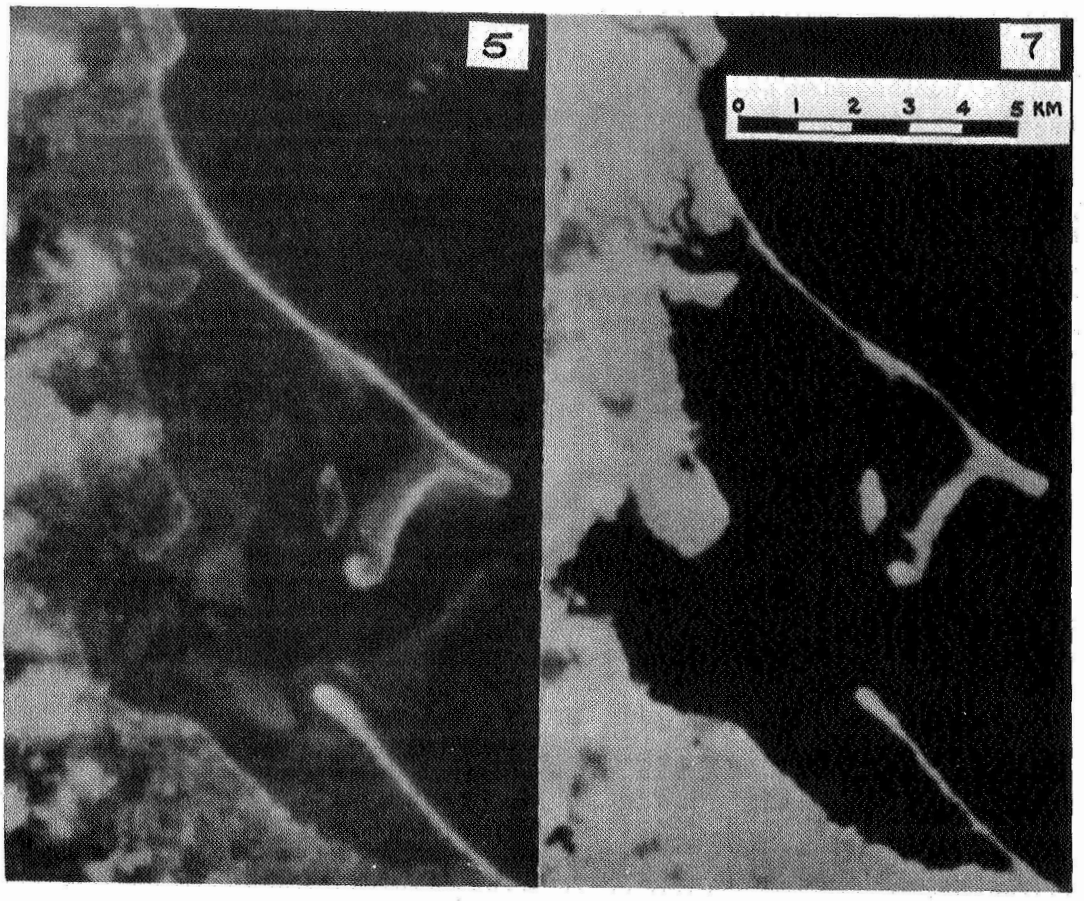

Figure 4. - Enlargement of ERTS-1, MSS imagery (28 July 1972, E-1005-15005, bands 5 and 7) to 1:125,000 scale. Image was acquired 2 hrs. 40 min. before high tide.

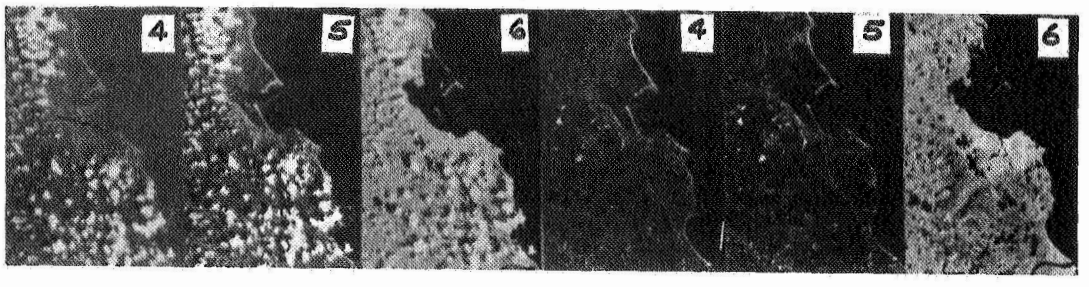

Figure 5. - ERTS-1, MSS imagery (1:1,000,000 scale) of Plymouth and Duxbury Bays, Massachusetts. Images A-F (left to right). Images A-C (28 July 1972, E-1005-15005, bands 4, 5, and 6; image acquired 2 hrs. 40 min. before high tide). Images D-F (8 Oct. 1972, E-1077-15011, bands 4, 5, and 6; image acquired 1 hr. 39 min. before high tide)

are also affected by atmospheric moisture. (Note the difference in thin cloud penetration between bands 4, 5, and 7; particularly the difference between 4 and 7.) An offshore bar can be seen extending the length of the outer Cape, all along Nauset Beach from Chatham to North Truro and Provincetown. It becomes two offshore bars northwest of North Truro. Shoals can be seen in Cape Cod Bay between Provincetown and Jeremy Point (Wellfleet). Note the extensive shoaling west of Jeremy Point and the low tide expanse of Billingsgate Island, nearly covered at high tide and once the site of a thriving fishing community. The shoal areas in Cape Cod Bay off Eastham, Orleans, and Brewster are well delineated. The channel entrances to Barnstable Harbor, Plymouth Bay, and Wellfleet Harbor, and the configuration of tidal flats in Barnstable Harbor and Plymouth and Duxbury Bays are also visible.

Tidal flats and channels can be seen in Plymouth and Duxbury Bays on three different ERTS-1, MSS frames. On Figure 1 the time of image acquisition was 1 hr. 23 min. before low tide. On Figures 3, 4 and 5A-5C, the image was recorded at 2 hrs. 40 min. before high tide. On Figure 4D-4E the image shows the harbor at 1 hr. 39 min. before high tide.

Figure 3 shows the configuration of tidal flats, channels, bars, and shoals in Plymouth and Duxbury Bays at an enlargement scale of 1:250,000. Figure 4 shows the same features at 1:125,000. These submarine features are not shown on the conventional 1:250,000-scale map even though these features can be portrayed. Comparison of the 1:125,000-scale enlargement of the ERTS-1, MSS image (band 5) with a 1:125,000-scale Ektachrome infrared aerial photograph (NASA, RB-57F photograph acquired on 13 Sept. 1969 at 1020 hrs., film type S0117; Photo No. 6293), taken 1 hr. 40 min. before high tide, showed similar features in Plymouth and Duxbury Bays.

Although the ERTS-1, MSS imagery of submarine features in harbor and coastal areas gives only the two-dimensional view, with precise depth information still to be measured by conventional means, periodic analysis of such imagery can be employed to determine when changes in position of tidal flats, bars, and shoals occur. This information could then be used in the scheduling of bathymetric surveys of specific areas when new surveys are needed.

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4. CONCLUSIONS

The ERTS-1, MSS imagery of southeastern Massachusetts provides important geologic and hydrologic information necessary for the frequent and accurate updating of conventional 1:1,000,000 and 1:250,000 maps of the area, and perhaps even for map scales of 1:125,000. Because various types of maps provide an important source of environmental information for resource management decisions, it is important that such maps be current and accurate. Based on a preliminary analysis of MSS images of Cape Cod, the ERTS imagery provides environmental information not available from conventional sources (chiefly aerial photography), except at very high cost. ERTS-1 imagery provides the following advantages both from type of data acquired and low relative cost:

1. Synoptic, nearly instantaneous coverage of a large area at different times in the tidal cycle of a coastal area (over several orbital cycles).

2. Repetitive, cyclic, and frequent coverage at relatively low cost.

3. Permits the regional mapping of marshes (wetlands), tidal flats, shoals, bars, and harbor channels, not normally shown on 1:250,000 and smaller scale maps.

4. Avoids the subjective differences in cartographic representation by the same cartographer on one map or between different cartographers on separate maps caused by generalization of features by portraying the environmental data at the correct scale initially.

5. By periodically recording specific types of environmental information, and if converted to a map or other form of presentation in a timely manner, ERTS imagery provides relevant and current data to resource managers necessary to accurate decisions.

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