UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

WRIGHTSVILLE BEACH, NORTH CAROLINA:

A DIGITAL SIDESCAN SONAR SURVEY

by

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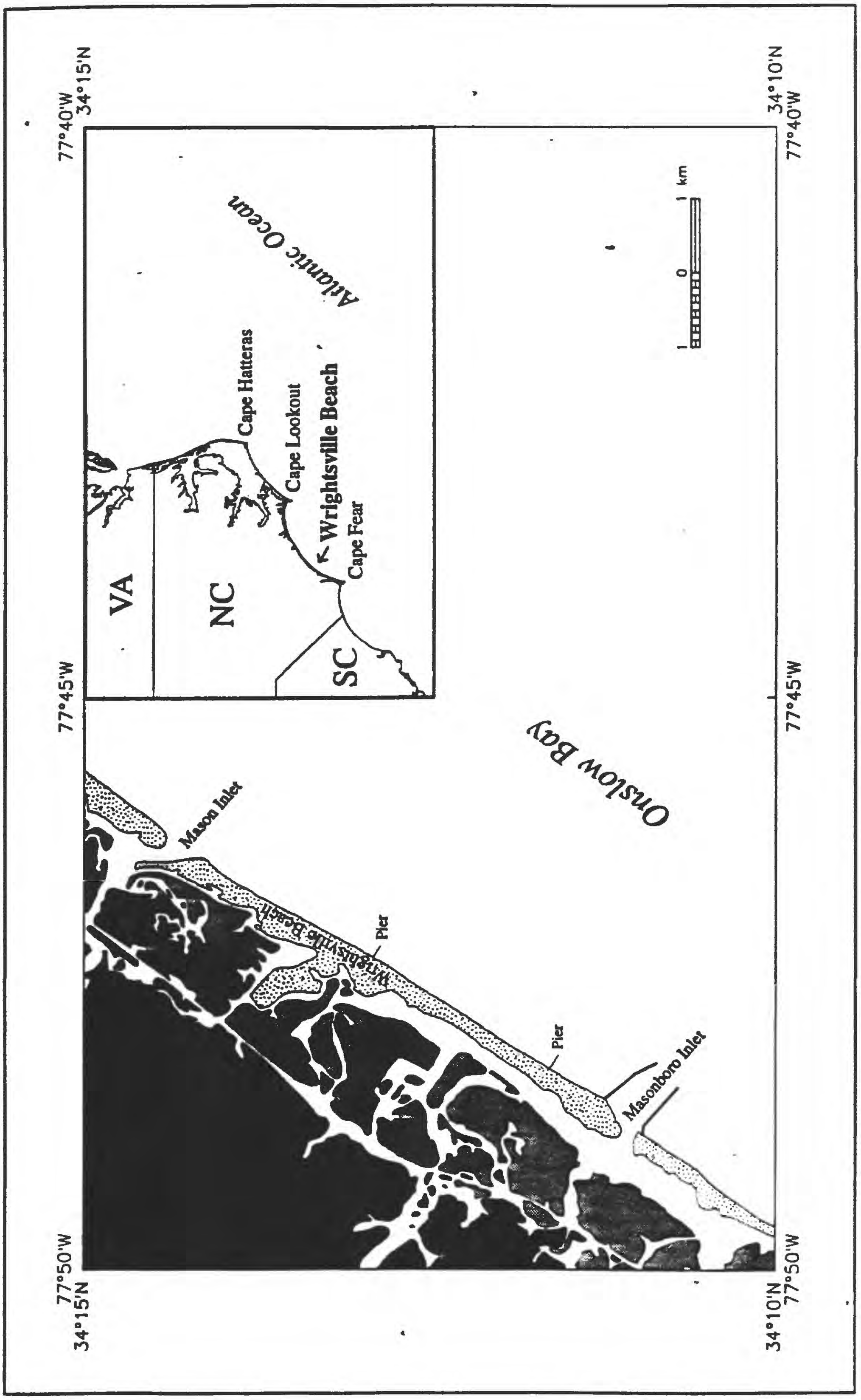
77°40'W 34°15'N
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VA
NC
SC
Cape Hatteras
Cape Lookout
Wrightsville Beach
Cape Fear
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1 0 1 km
Onslow Bay
Mason Inlet
Wrightsville Beach
Pier
Pier
Masonboro Inlet

Figure 1.

with the March 1994 sidescan-sonar survey which used the same acquisition system, navigation system, and processing software, to determine the stability of the shoreface and inner shelf during a moderate time frame (17 months), in the absence of any catastrophic events. The degree and nature of observed changes will yield the beginnings of understanding how changes in a 17-month period integrate over time to produce the long-term, large scale evolution of the coastal plain and shoreface (List and Terwindt, 1995).

SETTING

The survey covered a 9.2 x 5.8 km area of the shoreface and inner continental shelf in water depths of 5-15m (Figure 2). Wrightsville Beach, N.C. lies shoreward of the study area and is a low, 10-km long barrier island between Mason and Masonboro Inlets, that is backed by a narrow lagoon (Figure 1). This part of the coast, between Cape Lookout and Cape Fear to the northeast and southwest, respectively, is a transgressive microtidal (0-2m tidal range) high-energy environment (Dalrymple, 1992) and has a relatively large number of modern inlets (thirteen). Core data indicate that these inlets have been migrating during the Holocene (Riggs and others, 1995). The wave climate of Onslow Bay is a mix of storm and swell waves, predominantly from the northeast in winter and southwest in summer.

Wrightsville Beach has roughly shore-parallel bathymetric contours out to a depth of approximately 12 m (Figure 3). Sediment cover is patchy, averaging about 30 cm in thickness (Thieler and others, 1995). The modern sediments that comprise the shoreface are

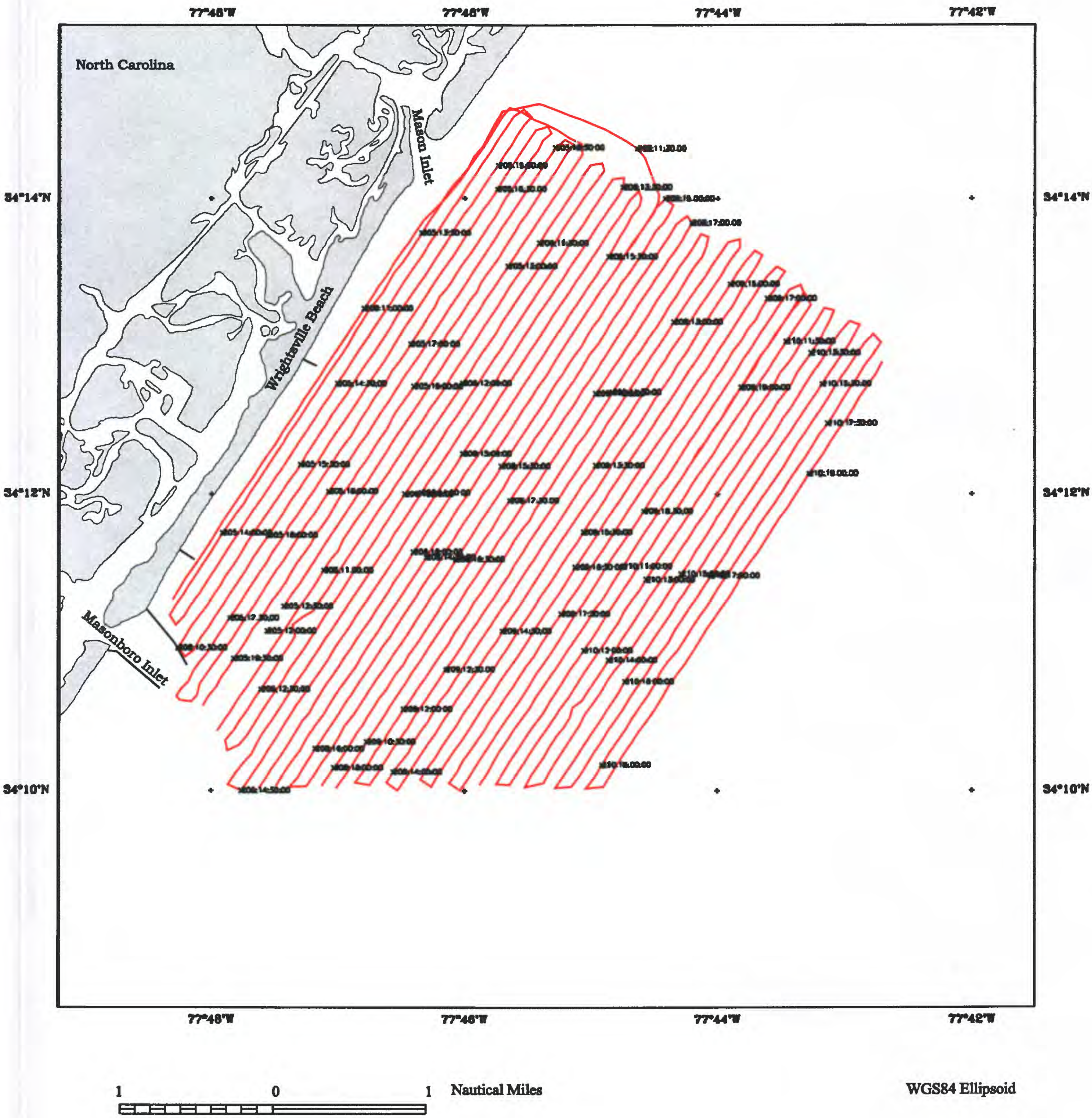

Figure 2. Trackline map for Wrightsville Beach sidescan-sonar survey, July 1995.

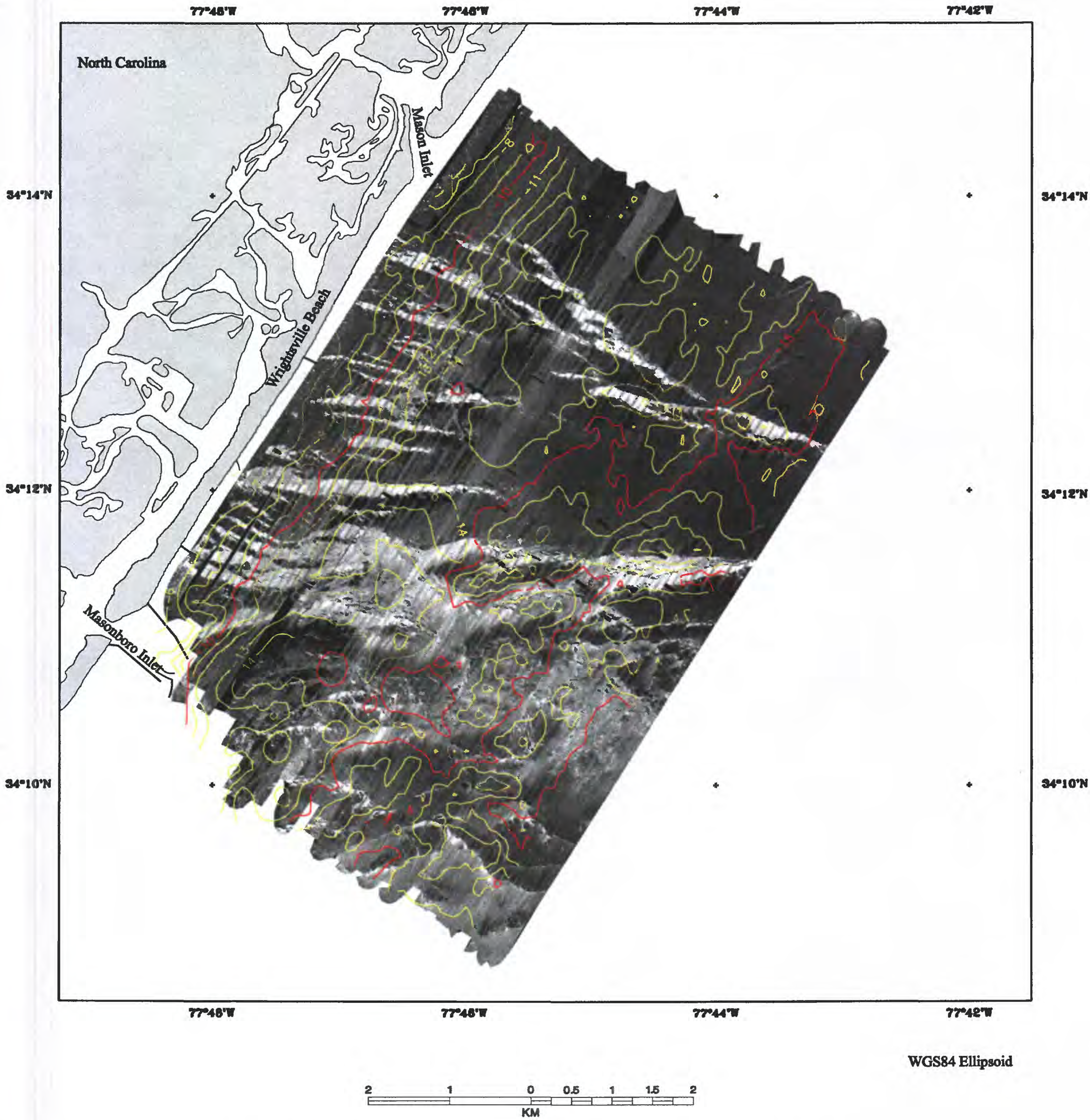

Figure 3. Image-enhanced sidescan-sonar mosaic for the 1995 survey area of the shoreface and innershelf off Wrightsville Beach, N.C. Contour interval is 1 meter.

variably underlain by Plio-Pleistocene arenaceous limestone, Oligocene unconsolidated silt, and Quaternary channel-fill depcsits (Thieler and others, 1996).

METHODS

Approximately 250 km (38 lines) of sidescan-sonar and bathymetric data were collected during a 6-day period in July 1995, aboard the RV Elusive (Figure 2). The sidescan-sonar data were collected through use of a Klein, 100 kHz system (8-bit data). A sample rate of 7.5 pings/second was used, yielding a 200m swath width. Ship tracklines were spaced with roughly 20% overlap to allow for sufficient sea floor coverage. A QMIPS data acquisition system digitally logged the sonar data, resulting in a 0.09 m/pixel resolution in the across track direction.

Navigation was collected by use of a Differential Global Positioning System (DGPS), resulting in a ±3m accuracy in bathymetric data and ship's position. The sidescan-sonar towfish is towed behind the ship, as a result a rough estimate of the distance behind the ship is known, however, horizontal movement (the distance off-track) of the towfish is not known. Therefore, an additional ±5m error exists in sidescan-sonar data due to uncertainties in towfish position. All bathymetric data were collected with a shipboard fathometer.

The sidescan-sonar data were digitally processed. A median filter was applied to the data, yielding a 0.4 m/pixel resolution

(= 200m swath/512 pixels). A suite of processing routines was used, following the methods of Danforth and others (1991), in order to correct for geometric and radiometric distortion inherent in the sonar data (Table 1).

After processing, the data were oriented in a UTM (Universal Transverse Mercator) projection using a WGS84 reference ellipsoid, and mapped at a resolution of 1m/pixel (Paskevich, 1992a,b). Next, adjacent swaths of sidescan imagery were registered relative to one another by aligning distinctive features in overlapping areas. This theoretically eliminates or reduces offset between swaths due to navigational error. The mosaic was then constructed by digitally stenciling adjacent swaths to incorporate the best resolved parts of both swaths. Each swath was sequentially added to the image to produce the final digital mosaic (Figure 3). Tone matching, accomplished by applying a stretch to the image, was performed to compensate for gain setting changes during acquisition. Black represents low backscatter, and white represents high backscatter in the digital mosaic. Bathymetry was then registered to and overlain on the image.

DISCUSSION

The salient aspect of the sidescan-sonar mosaic is the high-backscatter curvilinear features (Figure 4). They generally are shore-normal in the proximal section, while shore-oblique in the more distal reaches. The width at the broadest point of each

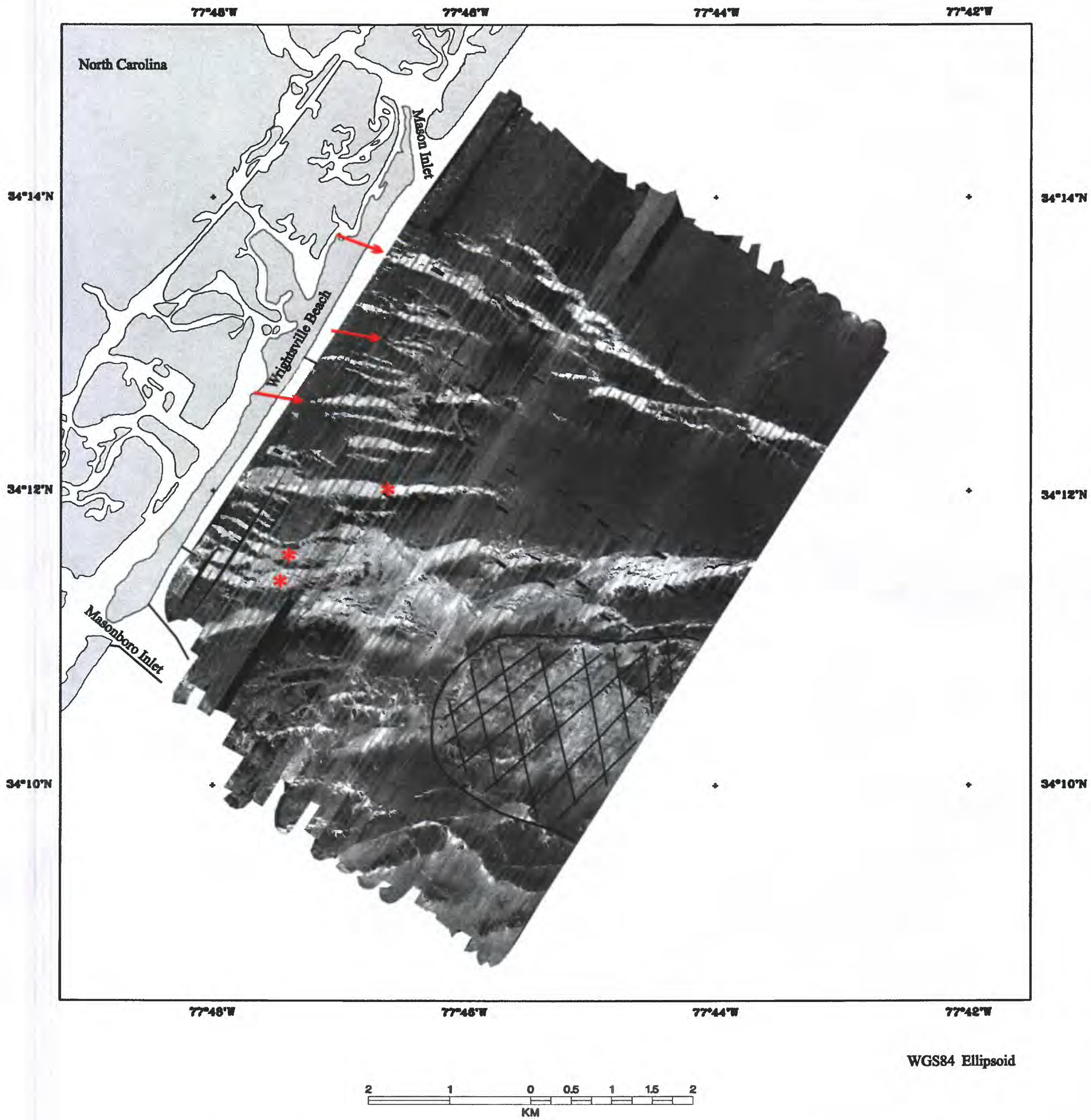

Figure 4. Annotated view of sidescan-sonar mosaic, showing locations referenced in the text. Arrows denote origin of three high-backscatter curvilinear features. Cross hatch area shows outcrop location. Asterisks mark greater curvature sections.

feature varies from 40 to 300m, and total length from 350 to 3300m. Length and width tend to vary in a complementary mode. The longest and most continuous curvilinear features are located atop subtle, long wavelength ridges, even though diver observations of the features indicate that they are (relative) depressions, with up to 1 (possibly 3) m relief (Schwab and others, 1995; Thieler and others, 1994). Previous studies have referred to similar features as rippled scour depression (Schwab and others, 1995; Thieler and others, 1996) or channels (Aubry and others, 1982). The location of these features atop even subtle, ridges in this study area, raises the question as to whether they are the channel-like features described before. The data presented herein are not sufficient to make that determination. Other ongoing studies are investigating the question in detail (Thieler, 1997).

The high backscatter curvilinear features are more numerous in the nearshore, where many start in less than 1m water depth and continue offshore to about 14m, with a maximum termination depth of about 20m. Some of the features start (i.e. the shoreward end lies) in water depths that exceed the termination depth of others. In an earlier study at Nauset Inlet off Cape Cod, MA, similar features have their seaward termination at 18m, correlating to the boundary between finer nearshore sediments and coarser offshore sediments (Aubry and others, 1982). Further research and groundtruthing will determine if such a correlation exists in the Wrightsville beach area (Thieler, 1997). At Wrightsville Beach, the distal termination is always tapered in character, but the shoreward end is either broad or tapered, with no direct correlation to the overall breadth of the individual feature (Figure 5A). At the scale resolvable in this survey, the features appear to be continuous.

Primarily in the central alongshore area, midway between Masonboro and Mason Inlets, some of the curvilinear features have a paired appearance, with a wider and longer curvilinear feature to the north and a generally parallel, but much thinner and shorter curvilinear feature to the south (Figure 5B). This suggests the possibility of a wider initial feature, which has subsequently been modified by wave and current activity, leaving the smaller trace at the former southern boundary of the original feature. In the Nauset area, some of the features are broad in the nearshore and bifurcate farther offshore (Aubrey and others, 1982), possibly representing an intermediate stage in the development of the features. Unlike Nauset, the features at Wrightsville do not cluster in the nearshore.

At Wrightsville Beach, the curvilinear feature density is greater to the south, nearing Masonboro Inlet. In that southern area, the distal, obliquely-oriented part of the features has greater curvature, almost appearing to converge seaward toward a basin-type area (Figure 4).

As noted in the 1994 image, on each individual feature, the northern contacts between the predominantly fine sediments (low-backscatter) and coarse (high-backscatter) sediments are sharp, while the southern contacts are more feathered in character, with

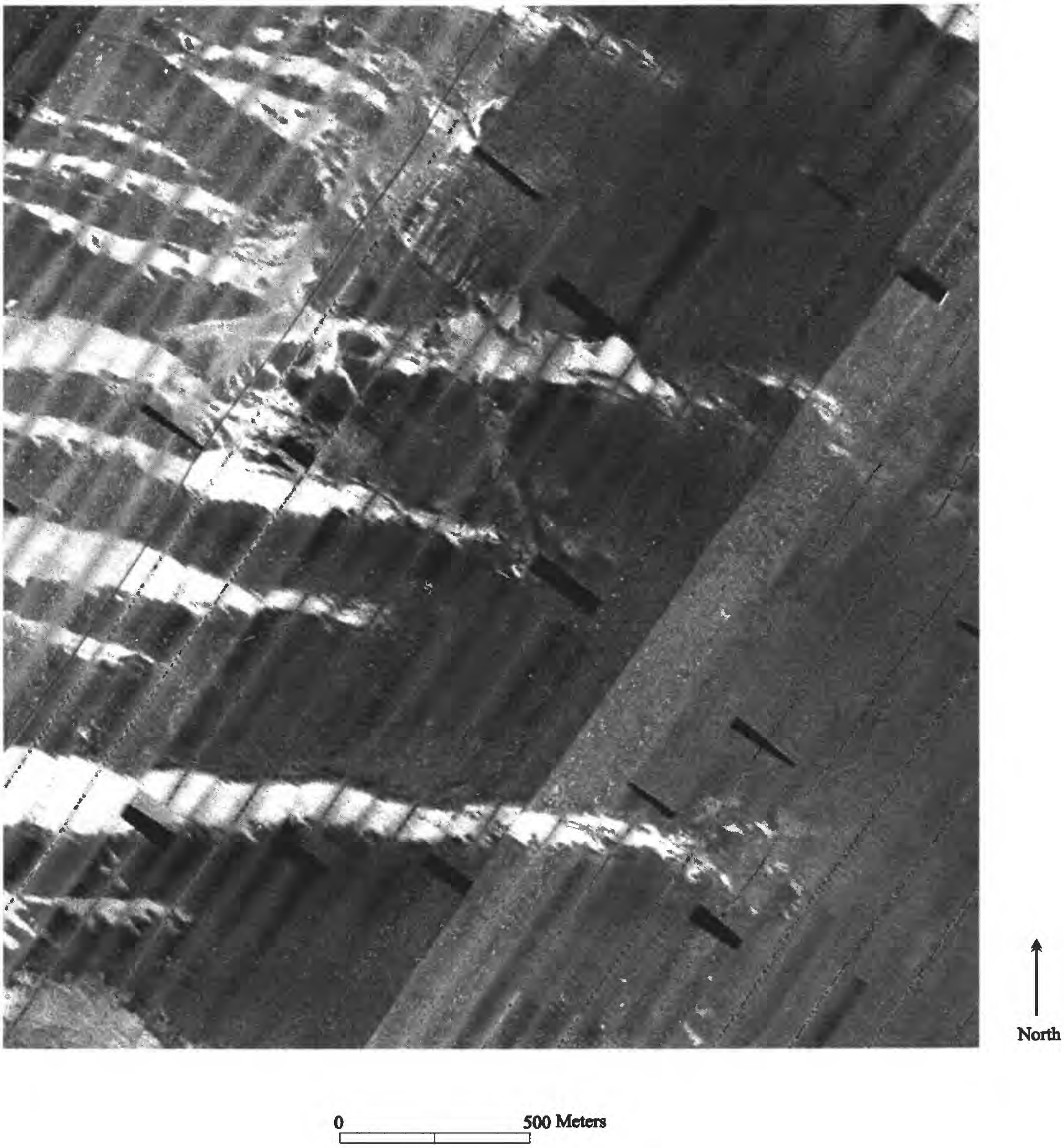

Figure 5a. Tapered ends of the high-backscatter curvilinear features.

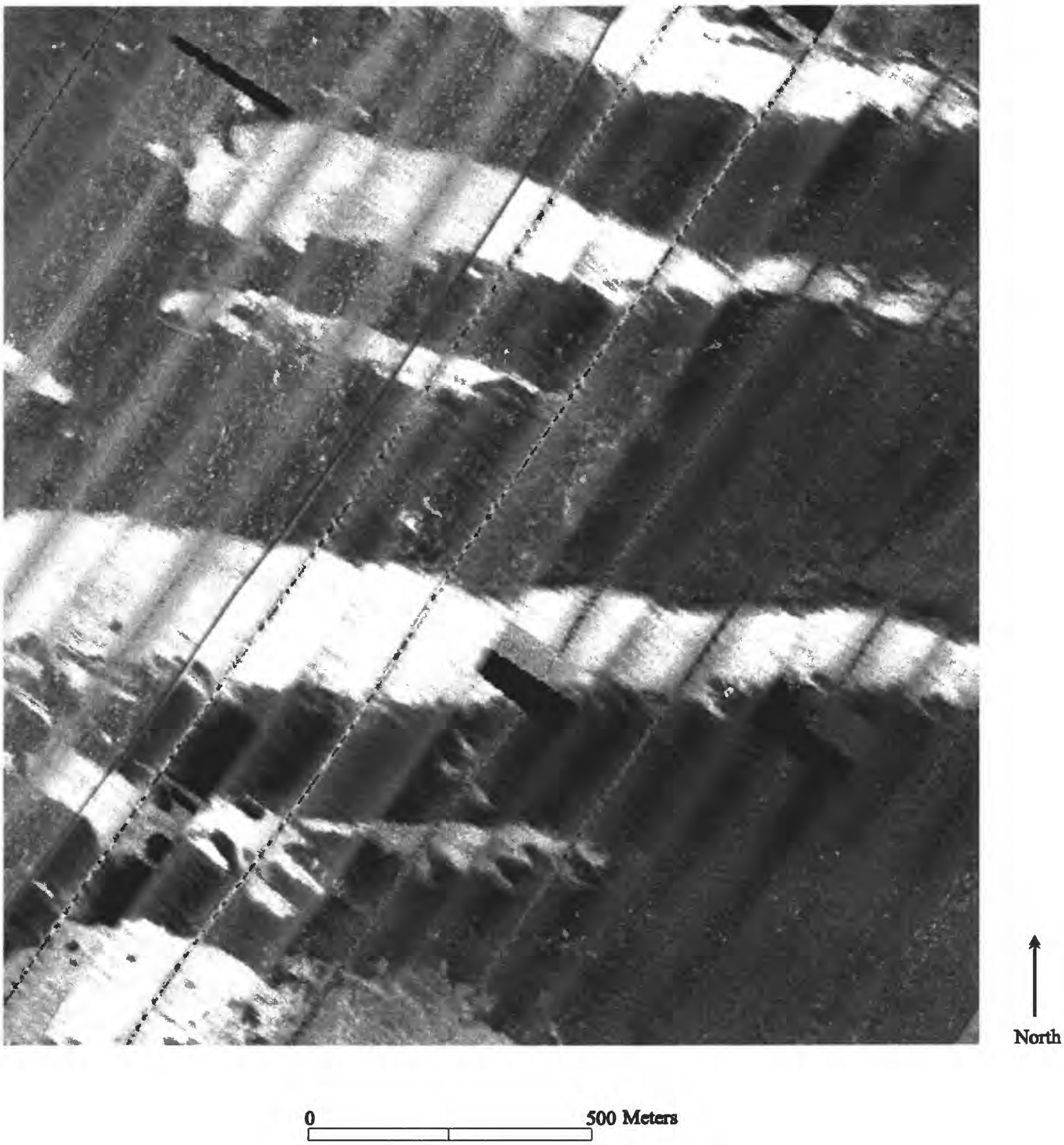

Figure 5b. Example of paired features.

coherent wisps formed in some segments suggesting modification by waves and currents (Figure 5c; Thieler and others, 1996). The surrounding finer sediment cover (low-backscatter) appears to be rather featureless.

Divers have observed coarse grained sediments flooring these features, which correlates with the high backscatter on the image. Also, they observed the presence of active symmetric ripples oriented transverse to the strike of the features, which suggests active local onshore-offshore transport (Thieler and others, 1994).

In the southern offshore area, there is a large outcrop zone, seaward and generally south of the high-backscatter curvilinear features described above (Figure 4). Samples verify the Plio-Pleistocene limestone composition for these exposed rocks (Thieler and others, 1996; Riggs and others, 1995).

When compared to the March 1994 image, the survey area appears to have been quite stable during the intervening 17-month period (Schwab and others, 1995). There is no definitive change apparent; no measurable shifting or altering of any of the sedimentary features within navigational accuracy (±5m). The only subtle change is in the southern, high-density area where the high-backscatter curvilinear features have possibly become more distinct on the distal end relative to the interlying sediment. Also, there appear to be more outcrops visible within the high-backscatter areas in this outer part of the image. Since both data sets were collected with analog systems, it is not possible to make an absolute comparison of backscatter strength, so such relative

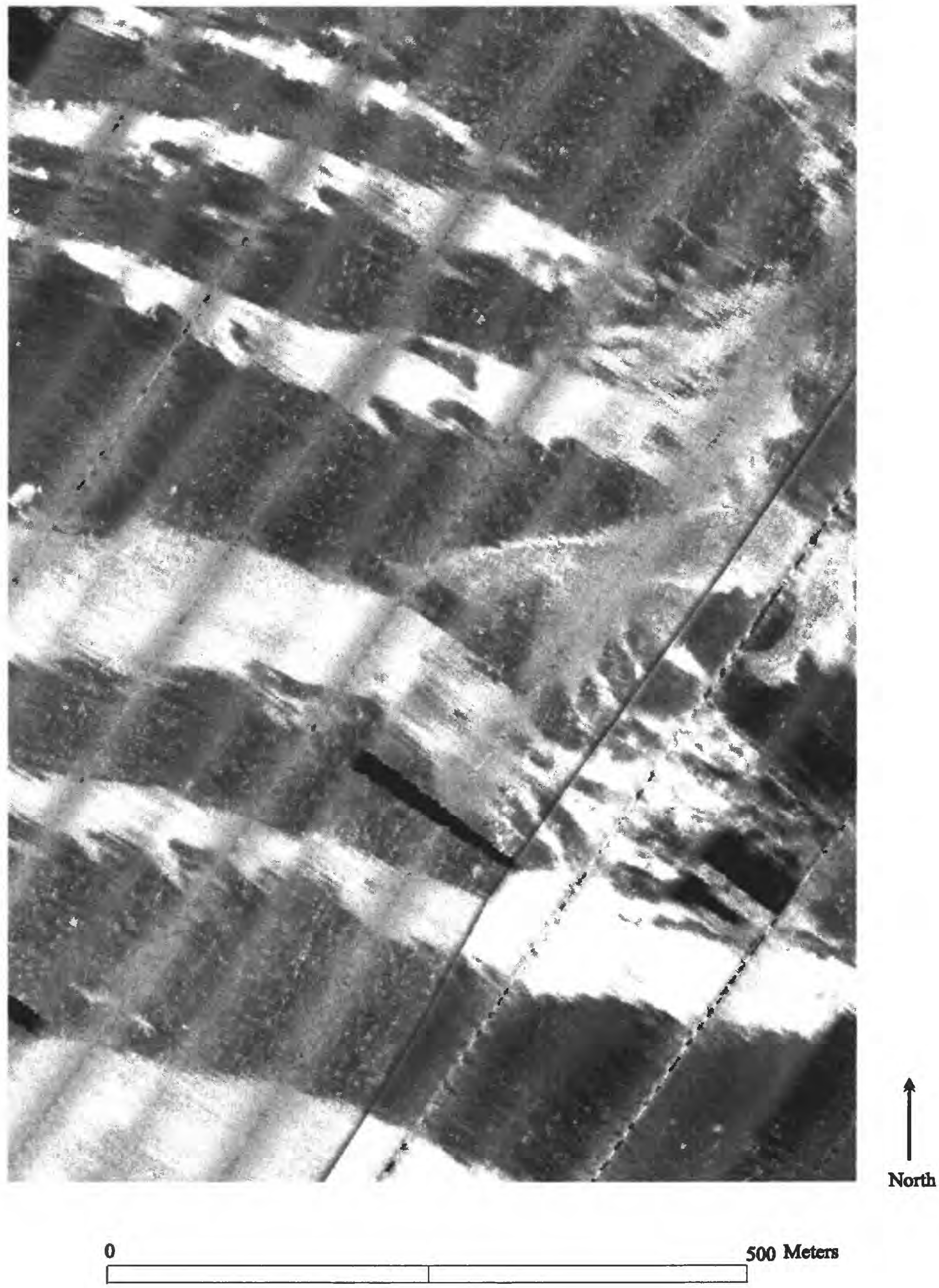

Figure 5c. Sharp northern contact contrasted with a feathered southern contact.

observations need substantiation with sampling. However, the images can be normalized with respect to each other and if the change is still apparent, it would warrant some investigation as to whether there may have been some overall removal of the coarse fraction (brighter material) or input of fine material (darker material) to the southern part of the study area.

Studies at other locations suggest that coastlines with limited sand supply are significantly influenced by the geologic framework of older stratigraphic units that underlie the shoreface and inner shelf (Hume and Hicks, 1993; Riggs and others, 1995). In North Carolina there is an ancient drainage system now filled with coastal sediments separated by interfluvial zones of older stratigraphic units (Riggs and others, 1995) which may exert some control on modern sedimentation. Alternately, the rapid migration of modern inlets suggests that the shoreface is a system underlain by channel sands and gravels deposited by a series of rapidly migrating Holocene inlets (Riggs and others, 1995). Lastly, the role of riptides in creating the features is unknown (Needell and others, 1982).

CONCLUSIONS

The major morphologic units on the Wrightsville Beach shoreface and inner shelf, high-backscatter curvilinear features, are relatively unchanged over a 17-month period. Their genesis is indeterminate from the two sidescan-sonar surveys. The stability of the features between survey periods does establish that they are not transient in the short term, i.e. they are not altered significantly by average wave and climatic forcing functions. Since no major events (hurricanes, tropical storms, etc.) occurred in the interim period, the effects of high intensity events are unknown.

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TABLE 1: PREPROCESSING SEQUENCE (for a more detailed discussion, see Denny, 1995; Johnson and Helferty, 1990; and Chavez, 1986)

*Altitude correction: Insures that the sonar is tracking bottom (sediment/water interface) and not strong acoustic anomalies within the water column.

*Demultiplex: Median filter: median value of every 4 pixels along track and every 3 pixels across track is output, yielding an average 1:1 aspect ratio for each pixel for the given ping rate and swath width, reducing the size of the raw data file, and removing anomalous high and low amplitude values.

*Slant Range Correction: Converts straight line distance from the sonar to seafloor (slant range) to true (horizontal) ground distance from nadir. Additionally, the water column travel time is removed, and pixel duplication in the near range is performed to prevent image distortion.

*Beam Pattern: Accounts for beam intensity degradation with respect to range due to attenuation and grazing angle effects, yielding a more coherent image from near to far range.

*Destripe: Corrects for low amplitude returns for individual pings due either to system anomalies or tow-fish vertical motion.

*Merge Navigation: After editing the navigation for spurious data points, the navigation file (interval = 2 min.) is merged with a sonar file, assigning unique latitude-longitude values to each pixel.

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