A Flow Study Of Drum Inlet, North Carolina

Paul R. Blankinship

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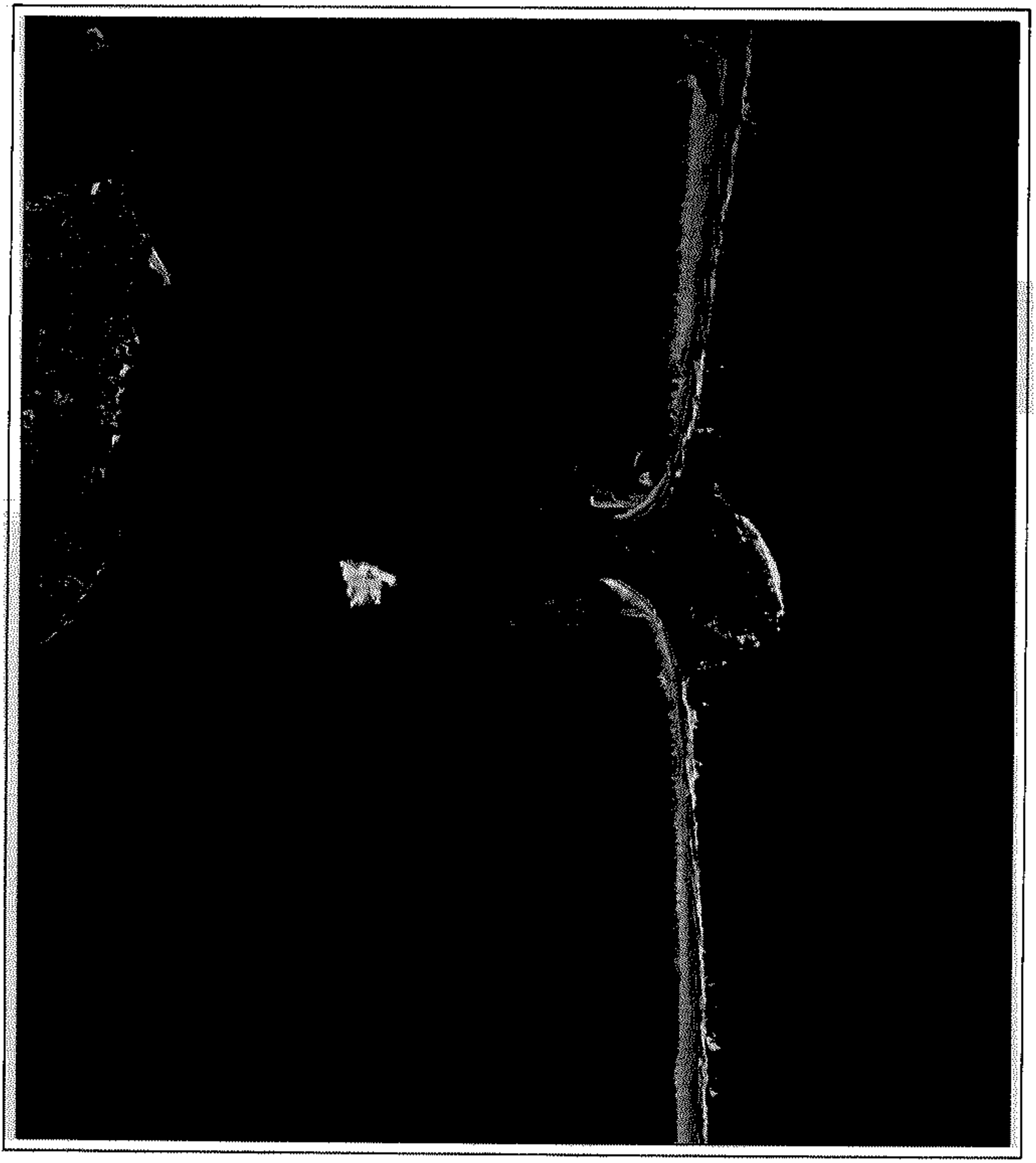

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by

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ABSTRACT

Drum Inlet was opened in December 1972 by the Army Corps of Engineers to provide access for commercial and sports fishermen through the Core Banks and raise the salinity of Core Sound. The purpose of this research was to study the flow dynamics of an inlet to determine what influence it had on the salinity, tidal dynamics and circulation of Core Sound and to suggest where dredging should be done to keep the inlet open.

Trips were made in July and September 1972 and during both periods the inlet was unstable and widening at a rate of about 150' feet per month. At the inlet, maximum flood currents occurred at high water and maximum ebb currents at low water (with a volume flow of 25,800 ft^3/sec and a speed of 3.8 ft/sec). Three channels extended from the inlet into the sound with 84% of the flow in the straight main channel and 105 in the eastern lateral channel. During an ebb, flow commenced in the western lateral channel before it did in the main or eastern. The sea water entering through Drum Inlet penetrated only about half the width of Core Sound and did not significantly alter the normal south westerly flow in the Sound. The sea water entering through the inlet appears, however, to control the salinity of the deeper water of the central Sound and the salinity is high enough (20-28$^\circ/_{\circ\circ}$) so that Core Sound is now a salt water environment. Most of this water appears to flow in a northerly direction from the inlet into the sound. To keep the channel open it is suggested that the main (straight line) channel be dredged.

The opening of the inlet has provided a salinity source for shellfish in Core Sound to flourish, but has not provided a convenient access route for fishermen to transit between Core Sound and the Atlantic Ocean as was hoped.

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DRUM INLET

1. Introduction

Inlets occur worldwide and are of two general types, those draining a river system and those along barrier islands draining sounds or tidal creeks. Of these two types the latter is susceptible to closure due to shoaling. When shoaling, the inlet chokes itself by filling gradually with littoral drift material. Often inlets develop for short periods of time, from a few days to a year, after a storm has caused a portion of the barrier beach to be breached.

Storms produce the high energy conditions necessary to open inlets initially. Subsequently, tidal currents are the dominant energy source for maintaining inlets. It appears from historical charts (Cummings, 1966) of the North Carolina coast that only a certain number of inlets can be maintained through time along any stretch of barrier island, though the number and position may fluctuate due to changing energy conditions and frequency of storms.

Inlets provide an access for salt water to mix with the sound water and thus to maintain a salinity level required for many organisms to survive. They also provide an access to the ocean for commercial and recreational purposes.

Drum Inlet, which is of the second general type, is located between Cape Hatteras and Cape Lookout, North Carolina, through a stretch of barrier islands known as Core Banks (Figure 1.1). It is the only major connection between Core Sound and the Atlantic Ocean. The sound is a shallow body of water, averaging four to six feet deep, although at some locations it becomes eleven feet deep. A waterway runs the length of the sound connecting Pamlico Sound (to the northeast) with Beaufort (to the southeast), and has a controlling depth that is maintained at seven feet. Core Sound is 28 miles long and varies from 1.9 to 3.8 miles in width. In the past Core Sound was apparently blocked in the north by a land bridge (N.C. Fisheries Com. Bd., 1923, p. 29). Today the sound has free connection with Pamlico Sound to the northeast and somewhat restricted connection with Back Sound to the southwest.

Ocracoke Inlet is the nearest major inlet northeast of Drum Inlet, lying 23 miles away. An unnamed inlet, probably Sand Island Inlet, is shown on C.&G.S. chart #1233 (June 1973) 8.7 miles to the northeast of Drum Inlet. It is stated on the chart that the inlet is "awash at MHW" only. Swash Inlet, on Pamlico Sound, is 12.9 miles to the northeast of Drum Inlet, and is also "awash at MHW" only. Adjacent to Swash Inlet and 12.7 miles northeast of Drum Inlet, Core Sound joins Pamlico Sound. The major inlet to the south is Barden Inlet. This navigable inlet is located in the Lookout Bight, 18.9 miles southwest of Drum Inlet.

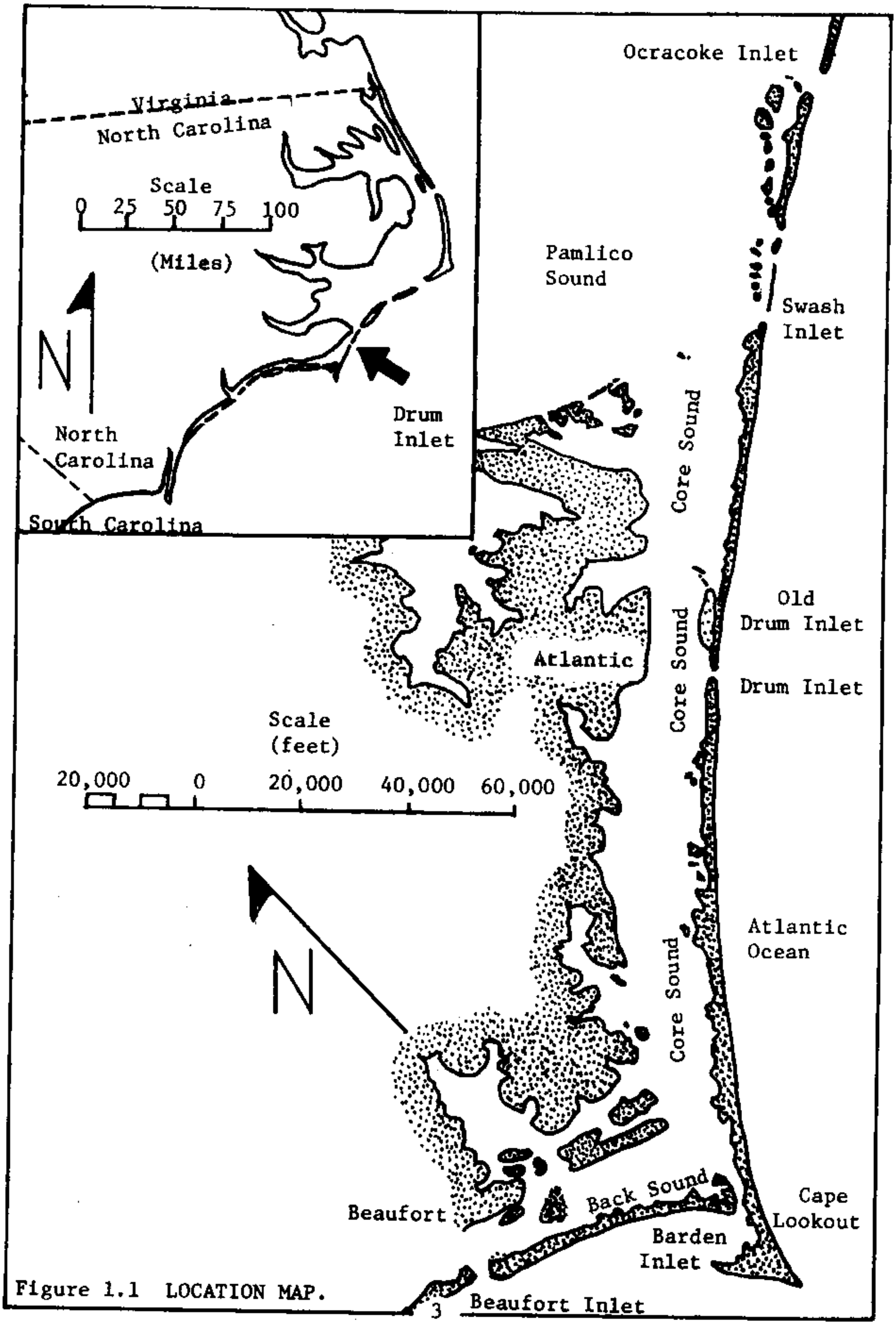

Figure 1.1 LOCATION MAP.

Several areas along Core Banks are subject to washover during storms. These areas are quick to shoal once the storm has passed so that they do not contribute significantly to the exchange of sound water with ocean water. Approximately 24 small creeks, but no major rivers, empty into Core Sound.

Winslow (1887) felt that the tributaries on the western side of Core Sound contributed much fresh water to the sound. He also found that Beaufort Inlet, which he identified as part of Core Sound, was the sound's chief source of salt water. Roelofs and Bumpus (1953) found that with a northerly wind, water from Pamlico Sound moved south on the surface into Core Sound and covered the more saline Core Sound water. This resulted in a vertical gradient of 14.8 ^{o}/oo on one occasion. They also found that the surface salinity increased from Pamlico Sound to Beaufort Inlet. This was apparent in a later report (Williams, _et_ _al_, 1973) where isohalines were plotted at the surface and at the bottom of the sound on a monthly basis from data collected over an eighteen year period, and showed during July, for example, a surface gradient along the entire length of the sound of 14 ^{o}/oo and in September of about 8 ^{o}/oo. Each of these two months, however, showed a distinct gradient across the sound, particularly in the northern half. Fresher water was on the mainland side with the isohalines sloping from the barrier to the mainland from north to south. Bottom plots showed similar trends, although salinities were generally higher.

A look at the history of Core Banks shows that natural inlets have been able to sustain themselves at various locations along the banks. A report in 1923 (N.C. Fisheries Com. Bd., 1923, pp. 33-34) traced the opening and closing of Drum Inlet as recorded on historical maps dating from 1585. This report stated that four inlets at different locations along the banks have been open at some time in the past. These were New, Norman's, Cedar and Old Drum Inlets. Occasionally several of these were open at the same time. Old Drum Inlet, open in the 1700's, was closed during the 1800's. It reopened in 1899 but was closed to navigation by 1923, reopening in a storm in 1933. This opening was accomplished by a breaching of the barrier from the sound as a result of the shift of winds as the storm passed through (House Doc. 763, 1948, p. 10). These winds set up a 15 foot tide on the sound side of the barrier near Old Drum Inlet. It apparently remained open until shoaling closed it in December 1970. During a storm on February 10-11, 1973, the inlet once again opened. It thus appears that while inlets along Core Banks do periodically open, the flow through them over a period of days to years is not sufficient to prevent their shoaling and closing.

Up to this point in the paper, the inlets that have been examined were opened and closed by natural processes.

In 1971, with Old Drum Inlet closed, it was determined by the U.S. Army Corps of Engineers that an artificial opening should be made in Core Banks. The purpose of the new opening was to provide an access for commercial and sport fishermen to the ocean and also to maintain the salinity in the sound to promote the growth of shellfish. The U.S. Army Corps of Engineers was in charge of the project. At 1:29 P.M. on December 23, 1971, New Drum Inlet was opened, some 2.9 miles southwest of Old Drum Inlet. In this paper New Drum Inlet is termed Drum Inlet.

Prior to the opening a channel was dredged directly from Core Sound near channel marker # 23 to Core Banks (Figure 1.2). The resulting channel was eight to twenty-one feet in depth with most of the channel being ten to twelve feet deep. Twenty-six one-ton charges of TNT breached the banks to a width of 80 feet. The opening was timed with the tides to provide maximum flow from sound to ocean following the blast. The time chosen was mid-ebb tide. Immediately, the inlet began eroding its banks, widening and shoaling the inlet mouth. The sand from this erosion and also some reworked dredge spoil in Core Sound began to fill the main channel, eventually causing it to shoal to the point where the inlet became impassible to commercial size fishing vessels. Then the main channel began to meander from its initially straight course and

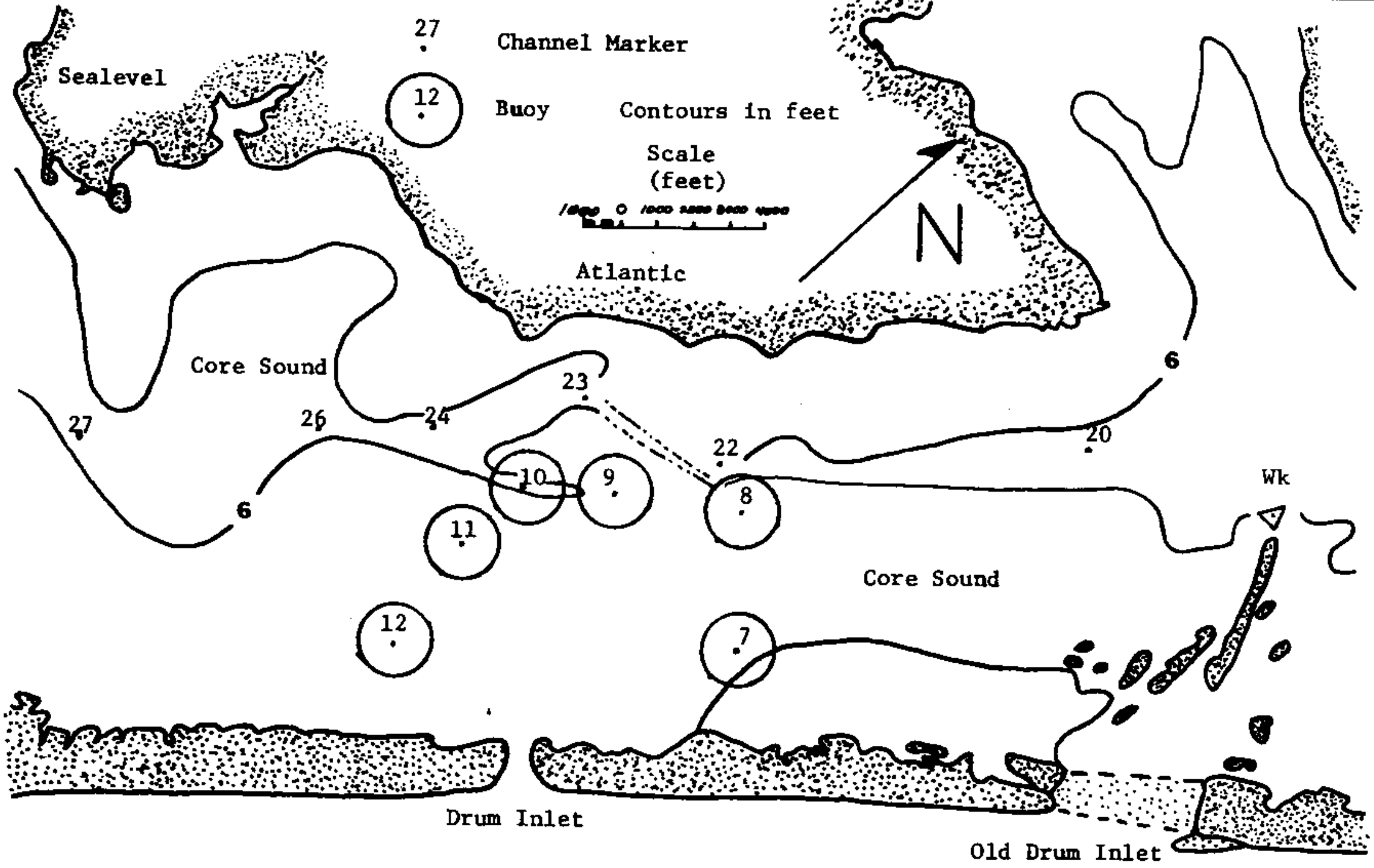

Figure 1.2 DRUM INLET AND ADJACENT WATERS.

two lateral channels formed just inside the inlet and on either side of the main channel.

A preliminary trip in May 1972 showed that the main channel would be at best a difficult area in which to navigate because of the shoal conditions that existed adjacent to this channel. By July the main channel had shoaled to a low water depth of about three feet at its junction with Core Sound, approximately 5000 feet from the inlet mouth. The water depth increased from this point going into the sound to a depth of eight feet at the Core Sound Waterway.

The dominant littoral drift direction is to the southwest along this stretch of beach (Langfelder, et al, 1968). Since the inlet was opened, much of the drift material has passed through the inlet and been deposited in the sound forming a flood tidal delta. This loss of sand to the beach resulted in a distinct recession of the beach line on both sides of the inlet. So, in addition to the trapping of littoral drift material, the inlet also caused erosion of the shoreline. As of July 1973 the inlet throat was 2600 feel wide. Figure 1.3 illustrates the widening of the inlet with time. These U.S. Army Corps of Engineers' data (Carmen, 1973) show that the inlet was still in a transition phase. The inlet, for this phase, followed a linear rate of widening.

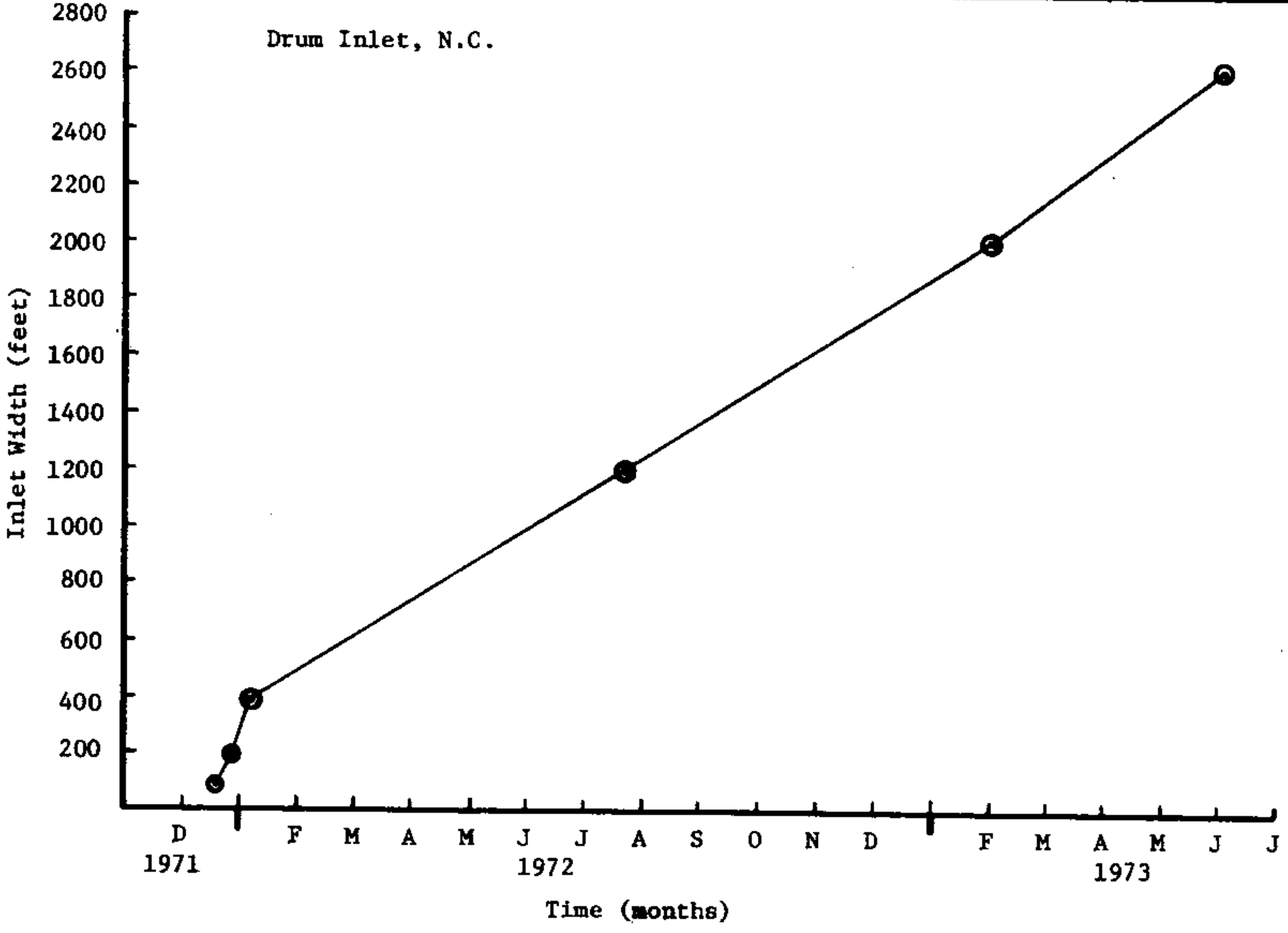

Figure 1.3 WIDENING OF DRUM INLET, N.C. FOR A 17 MONTH PERIOD.

Salinity, tidal and circulation conditions in the months just prior to the opening of the inlet were not known.

2. Purpose of Study

The main purpose of this field research was to study the flow dynamics of a newly opened and unstable inlet to determine what influence it had on the salinity, tidal dynamics and circulation of Core Sound. A secondary purpose was to determine where, if necessary to keep the inlet open, dredging would be most benificial.

3. Research and Data Analysis Procedures

3.1 Research Trips

Two trips were made to Drum Inlet to collect data. The first was in July and the second in September of 1972. Portable sensors were used to collect current, conductivity, temperature and bathymetry data during both trips.

On the July trip sites were established and marked with buoys to provide stations for the collection of data. These sites were selected on the sound side of the inlet and no farther than one-half mile from the inlet as shown in Figure 3.1. Four buoys were placed in the main channel in two sets of two; one buoy on either side of the main channel. Two buoys (ACN and ACS), already marking the main channel, were also used as stations. One buoy was placed at the entrance to each of the two smaller lateral channels just inside the inlet. This arrangement of

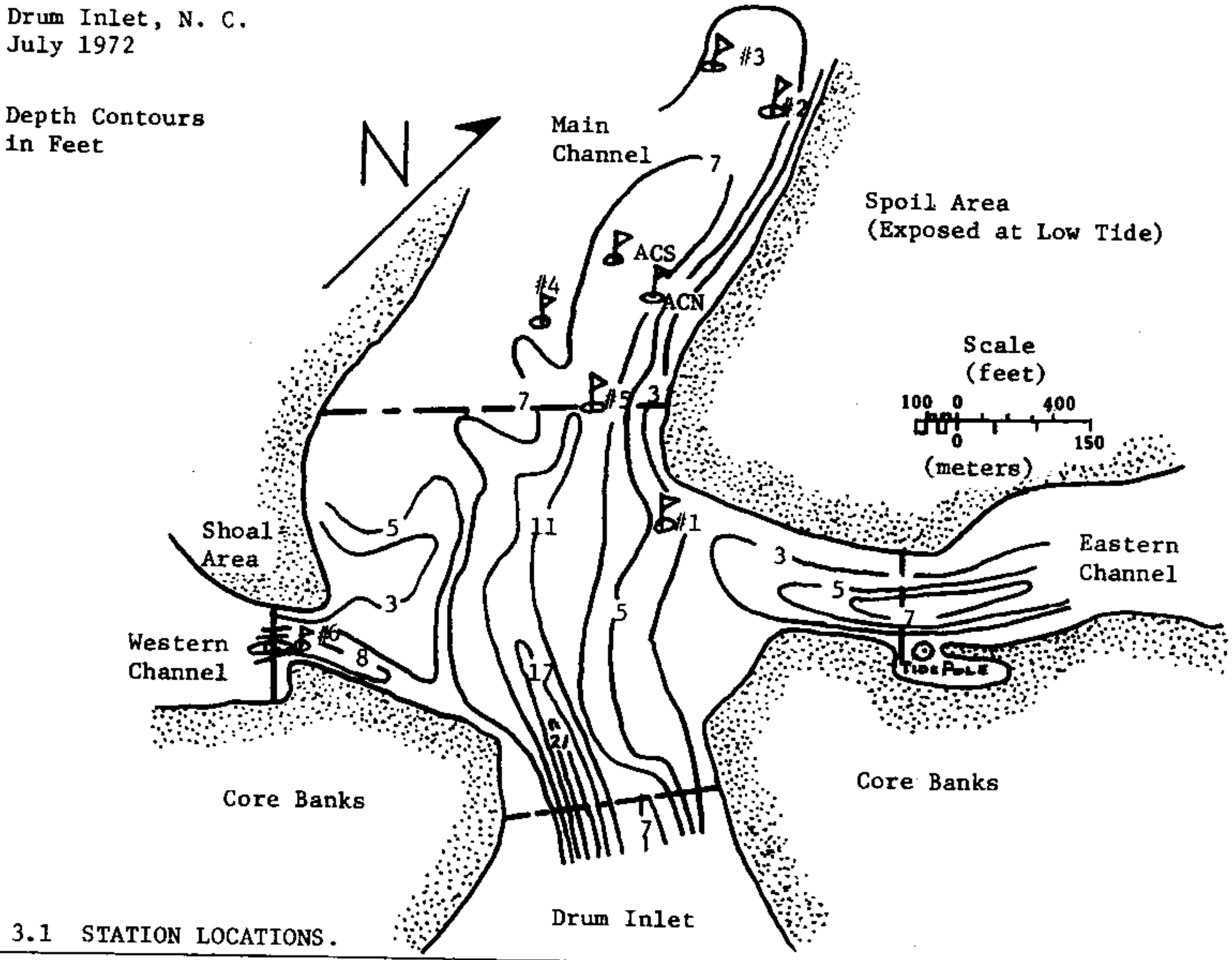

Figure 3.1 STATION LOCATIONS.

stations, it was hoped, would give an adequate representation of the flow through the inlet. The location of each of the eight stations (buoys) was accurately established by triangulation using a transit and survey maps and markers provided by the U.S. Army Corps of Engineers. The four cross-sections represent the locations where fathometer traces were made (see Figure 4.4).

3.2 Equipment

The bathymetry data were obtained with a Raytheon model DE 719 precision survey fathometer depth recorder over a period of three hours on 15 July 1972. Cross-sections were run between all of the buoys in the main channel and the two smaller lateral channels and the inlet gorge. No tidal data at the inlet were available during the survey period and, therefore, the bathymetry data could not be corrected to reflect the phase of the tide.

A Martek Mark II, model A water quality monitoring system was used to obtain the temperature and the conductivity data.

A Bendix model Q-15 current meter with a model 233 speed and direction readout instrument were used to obtain the current data. This current meter has a ducted impeller and a ten foot long stabilizing fin.

3.3 Data Acquisition

The method of data acquisition at the eight stations around the inlet was to run a circuit of the stations approximately once each hour. Nine circuits were made on July 17 and seven on July 19. The conductivity and temperature data were converted to salinities numerically using a program and algorithim (Knowles, 1973) that is based upon normal sea water conductance data (Reeburgh, 1967) and UNESCO salinity-conductivity tables (Cox, et al, 1967).

3.4 Data Analysis

The study was hampered somewhat by the lack of sufficient current, temperature and salinity sensors to cover the entire study area continuously for more than one tidal period at a time. Because of the types of instruments available and the limitations imposed by the availability of only one boat, the time interval between observations was long, usually an hour. This made the use of statistical manipulation of the data of questionable value.

The data collected as described above was discontinuous in time; so for each station they were plotted and smoothed by drawing a curve that represented the best fit. An example of such a curve is given in Figure 3.2, for Station 3, July 17, 1972. Other stations have similar curves. Thus, the data could be looked at in a more synoptic way than would otherwise be possible. This is not the most desirable method of reducing data, however, it does permit one to compare two or more stations at the

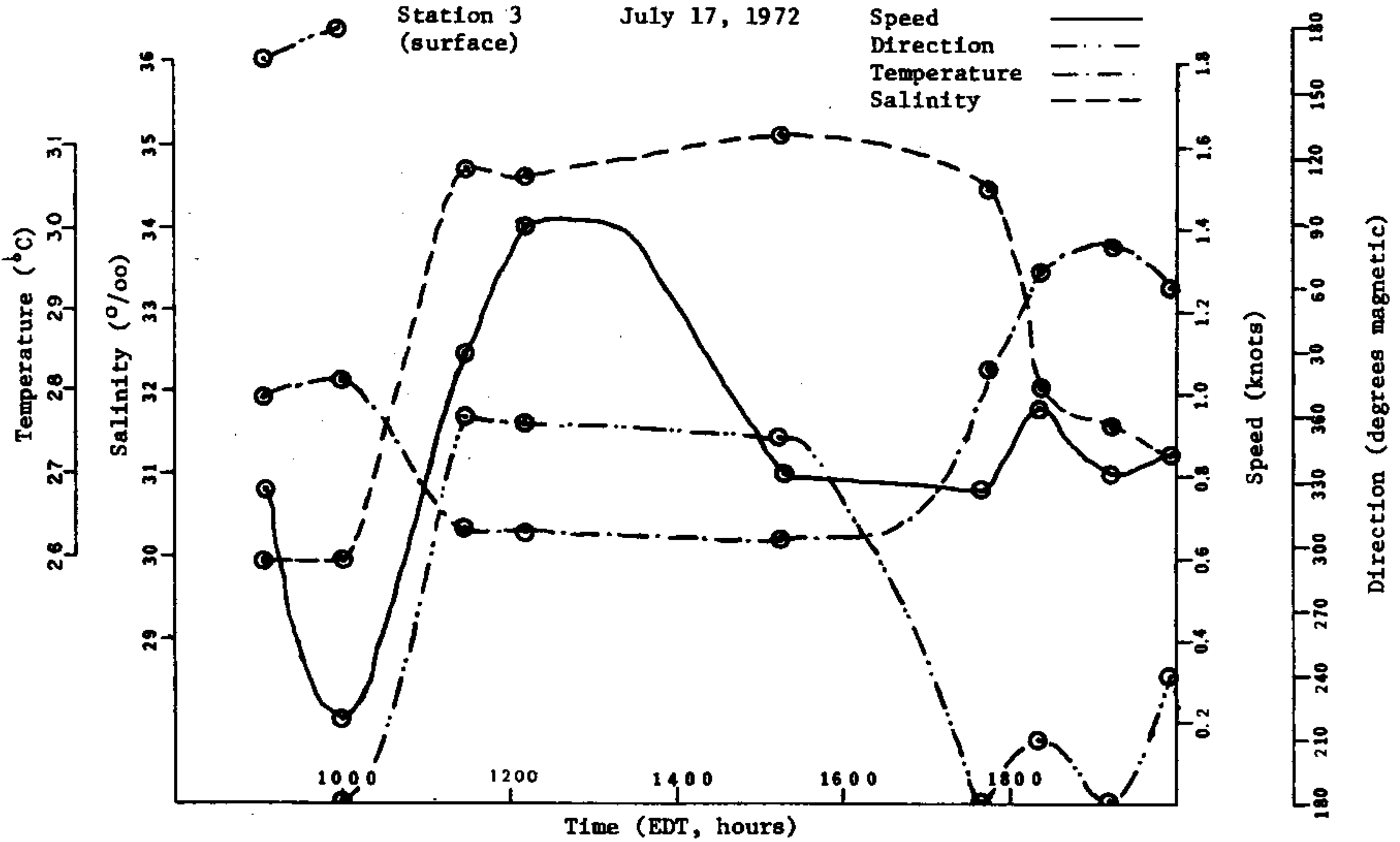

Figure 3.2 TYPICAL GRAPH OF VELOCITY AND WATER QUALITY.

same point in time if one bears in mind the limitations of the data.

4. Results

4.1 July Research Trip

On July 17, 1972, the first day of data collection at the eight buoy stations, nearly twelve hours of data were obtained. Most of July 18 was spent occupying station ACN on the north side of the main channel monitoring the flow reversal and the salt water penetration. July 19 was again spent making rounds for twelve hours to the eight stations. July 20 was spent at stations in Core Sound for half the day with the remaining time spent at ACN. July 21 was the last data collection day and was spent in the sound at stations at the channel markers in the Core Sound Waterway.

4.1.1 Climatological Data

The wind speed and direction for the area was taken to be that of the nearby weather station at Ocracoke, 24 miles to the northeast. Thirteen percent of the three-hourly reports were calms for the July 10-18, 1972 period. For the three days following this, July 19-21, eighty-two percent of the reports were calms. The weather for the July 10-18 period is presented in Figure 4.1 as a wind rose. From this figure it is evident that the dominant wind direction was from the west. This wind direction, combined with the shallowness and orientation of Core

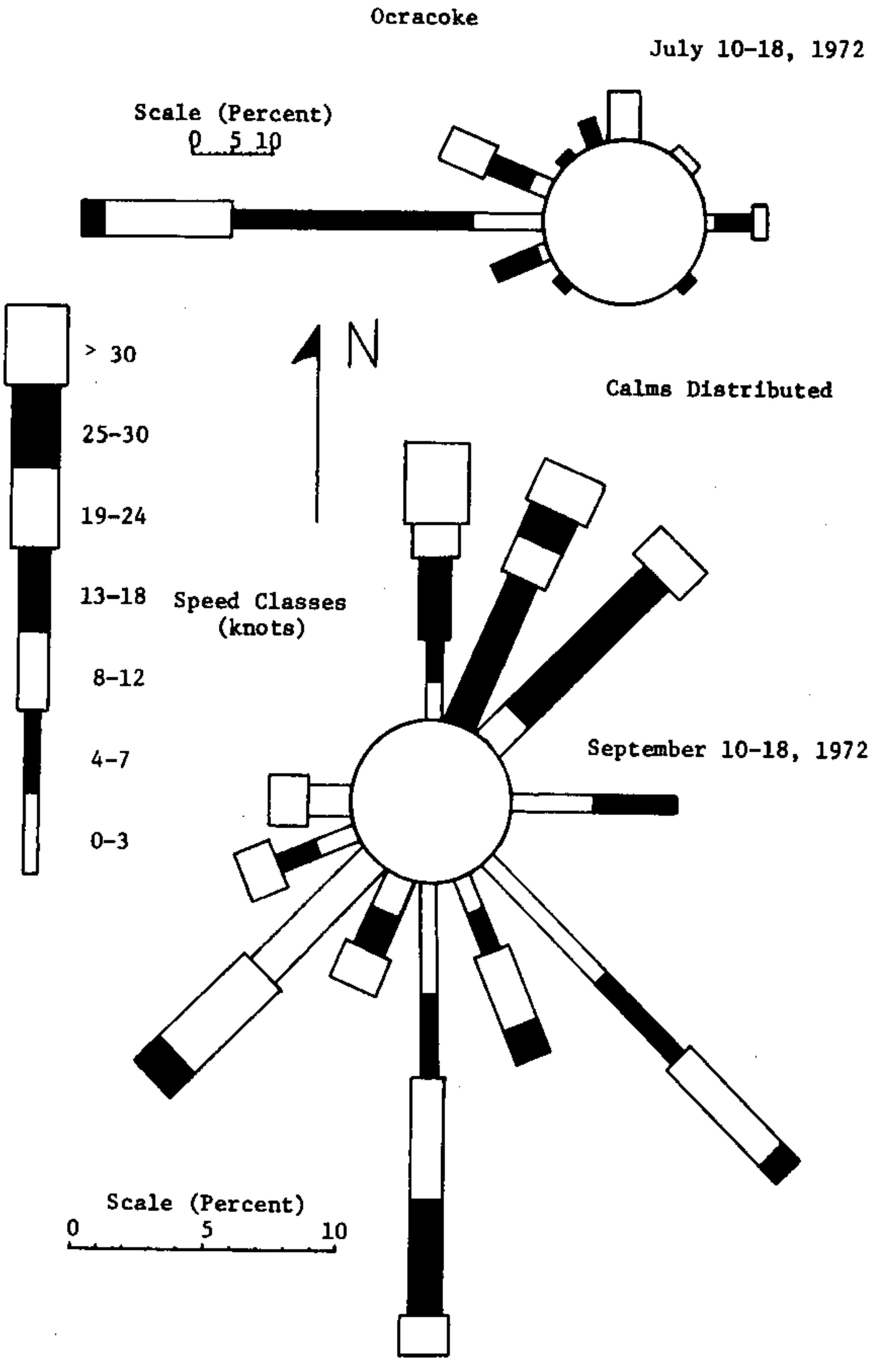

Figure 4.1 WIND ROSES FOR OCRACOKE, JULY AND SEPTEMBER, 1972.

Sound, would cause the water to flow in a northeasterly direction into Pamlico Sound. The restricted southern portion of Core Sound, combined with its limited depth, forms an effective hindrance to the flow of water that could replenish this wind-induced lowering of the water level in the sound. Indeed, this lowering of the water level was apparently due to a loss from the sound rather than a piling of water up on the eastern side. This latter conclusion is based on the observation that the water level remained at 0.37 feet below its mean for five days after the wind calmed.

The precipitation (NOAA, 1972) for the period of July 10 to 21 is presented in Figure 4.2. The closest of the five rainfall collection stations to Drum Inlet is Cedar Island, 11.5 miles to the north. The intense rain on the eleventh and twelfth of July brought as much as 4.85 inches of rain for a one-day period to Cedar Island. The rain ended for the most part on the fourteenth, three days before the first sampling period. Despite this input of fresh water, the level of the sound as noted earlier was below normal. This may be attributed to the limited effective drainage area adjacent to Core Sound.

4.1.2 Tidal Data

The normal mean tide range on the ocean side of Old Drum Inlet has been reported to be 3.8 feet (House Doc. 414, 1937). At the town of Atlantic, directly across Core

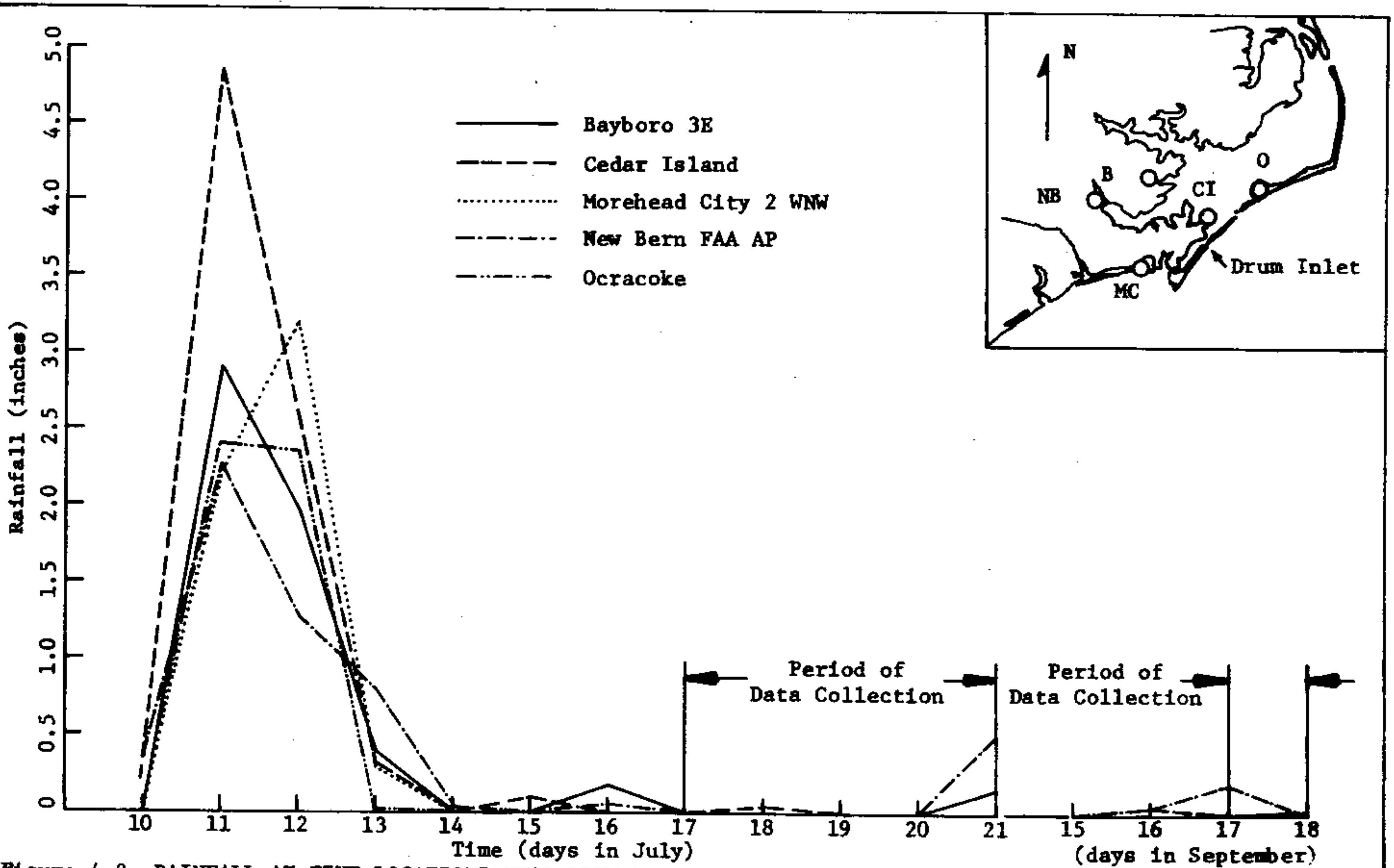

Figure 4.2 RAINFALL AT FIVE LOCATIONS NEAR DRUM INLET.

Sound from Drum Inlet, the tide range calculated by CERC for the six month period from February 28 to August 18, 1972 was 0.35 feet, and the mean tide range at Atlantic during the five day period from July 17 to 21, 1972 was 0.25 feet (Mason, personal communication, 1972). Furthermore, during this five day period, the mean tide level was 0.37 feet below the mean tide level at Atlantic calculated over the six month period. Therefore, at the time of this study at Drum Inlet, the water level in Core Sound in the vicinity of Atlantic was lower than normal and the tide range was somewhat less than the normal range.

No tidal data were available for Drum Inlet during the period of this study. The tide and currents at Ocracoke Inlet, 24 miles to the northeast, are predicted in the tide and current tables of the National Ocean Survey (U.S. Dept. of Commerce, 1972a, 1972b). The currents listed are the maximum flood and ebb and the slack water times. These data were plotted and the slack water times compared with the observed slack water times at Drum Inlet obtained from current meter data. The average difference between all these times was twelve minutes. If the one large time difference of 47 minutes is excluded, the average time difference would be only four and one-half minutes. Thus as an indicator, the times of the tides at Ocracoke Inlet serve as a good approximation of the times at Drum Inlet.

CERC collected the record at Atlantic on the mainland during the July study period. This record shows about a three to five hour phase lag over the predicted tide at Ocracoke Inlet for the July 17 to 19 period. The data on July 20 have a one to three hour lag.

In general the tides at Drum Inlet, during this study, acted in the following manner. During a flood tide the level of the water on the ocean side of the barrier island would rise to its highest point and then begin to fall. At this maximum level, high tide, the maximum flood currents were observed. As the water level began to fall, the currents would diminish until at some point between high and low tide the current slacked, then reversed and began to ebb. This ebb current would increase in velocity as the ocean water level continued to fall until around low tide where maximum ebb was observed. The ebb current then began diminishing as the ocean tide rose and slack water occurred as the ocean tide changed from ebb to flood.

The reason behind this tidal behavior at Drum Inlet can be seen by looking at the head differential set up by the ocean tide. The inlet was a narrow opening into a shallow sound and the elevation of the sound was just slightly affected by the ocean tide. As the ocean tide rose a pressure head was established from the ocean to the sound. This drove the water through the inlet on a flood. The maximum head would occur at high tide, and thus the maximum flood currents would be expected at this time, as was the case. The ocean tide then fell, reducing the head differential until at some point between high and low water the sound and the ocean were at the same level. At this moment the currents should be slack. As the ocean tide continued to fall the water level in the ocean dropped below that in the sound, setting up a pressure head from the sound to the ocean driving the ebb current. As low tide was approached, the head from the sound to the ocean should be its greatest and a maximum velocity in the ebb current should be observed. As the ocean began to rise, the pressure head would decrease and slack tide would occur, as was observed. The cycle could then repeat. The tidal information is shown in Figure 4.3. The curves for the current and the tidal height for Ocracoke Inlet were smoothed from the data presented in the tables from the National Ocean Survey (U.S. Dept. of Commerce, 1972a, 1972b).

4.1.3 Channel Cross-sections and Tidal Prism Calculation

The cross-sectional area of the inlet, as shown in Figure 4.4, was 6,837 ft^2, the western lateral channel was 1,224 ft^2, the eastern lateral channel was 1,594 ft^2 and the main channel was 7,929 ft^2. The maximum flow through the inlet was 25,800 ft^3/sec. The two lateral channels had an ebb flow of 1,570 ft^3/sec and 2,520 ft^3/sec for the west and the east channels respectively and 21,400 ft^3/sec,

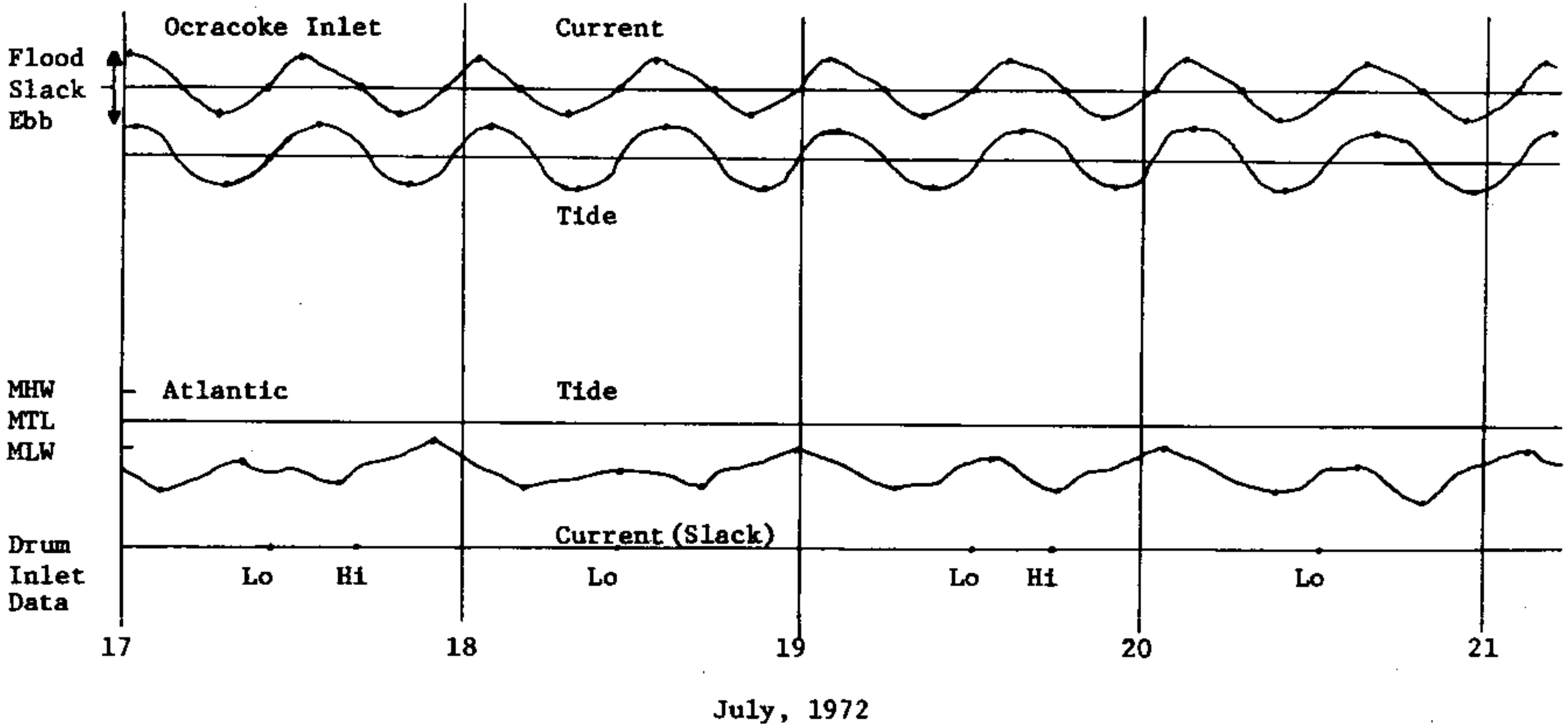

Figure 4.3 TIDES AT OCRACOKE INLET, ATLANTIC, AND DRUM INLET.

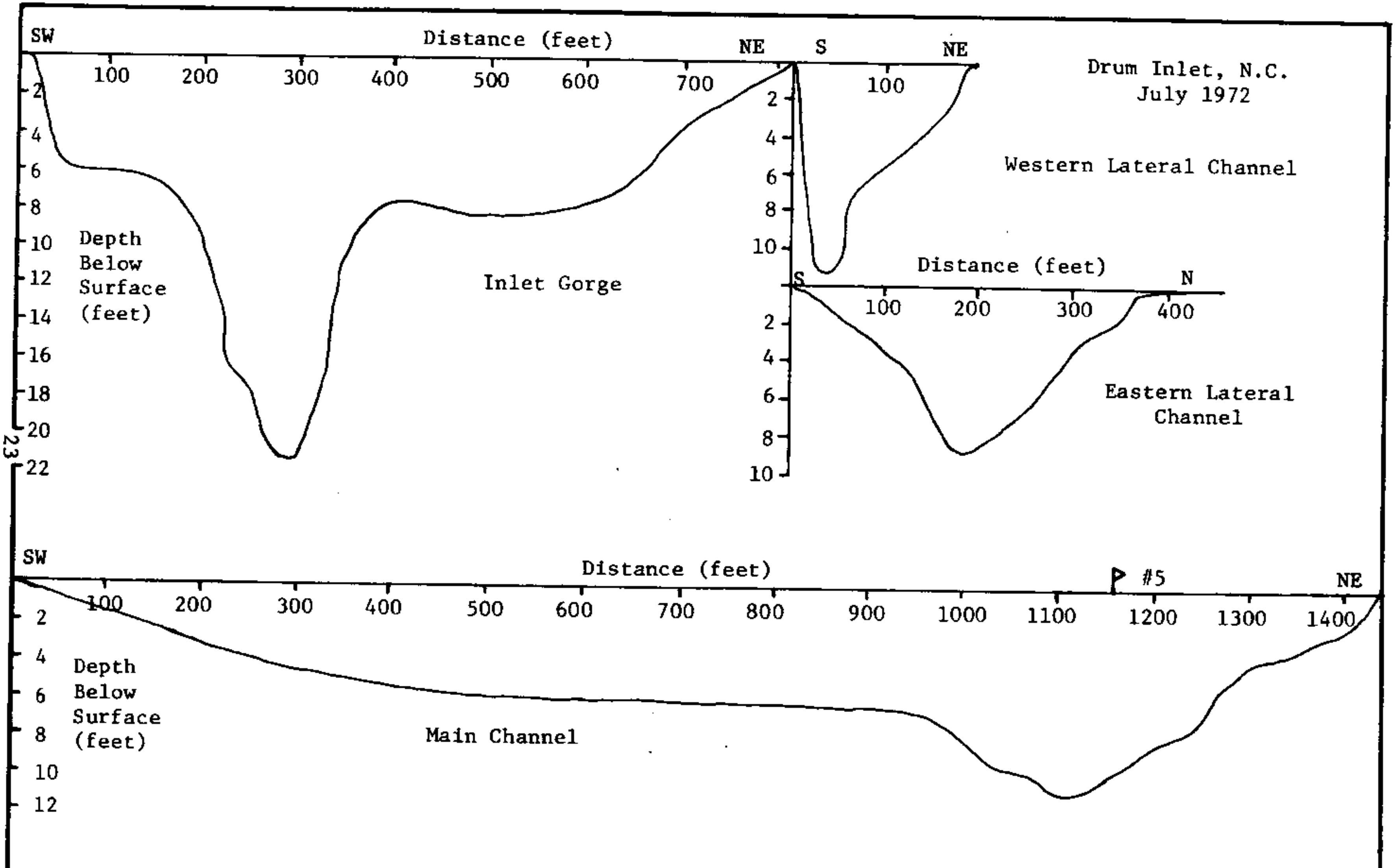

Figure 4.4 CROSS SECTIONS OF INLET GORGE, MAIN CHANNEL AND TWO LATERAL CHANNELS.

ebbed through the main channel at maximum flow. The total flow through the three channels was then 25,490 ft^3/sec, which is very close to that calculated for the inlet.

Two methods for calculating the tidal prism have been described by O'Brien (1969). The first is a standard method using the tidal area at high water shown on U.S.C.& G.S. charts multiplied by the semi-diurnal range at the inlet. The second method involves a graph of flow area versus tidal prism (Figure 4.5). This second method, which is dependent on the inlet cross-section, indicates the restriction that the inlet itself imposes on the volume of flow through it. Conversely, the first method does not depend on inlet size but rather the size of the basin into which the inlet opens. The graphic (second) method yielded a value for the tidal prism of 3.0×10^8 ft^3. This represents a tidal radius of 5000 feet or some 6,800 feet less than the distance from Drum Inlet to Atlantic, strongly suggesting that the water from the inlet did not reach Atlantic at the time of this study, although the tidal head at the inlet was undoubtedly the driving mechanism of the small tide at Atlantic. These values do not take into account the greater distance that the water would travel due to channeling through the flood tidal delta.

4.1.4 Hydrodynamic Data in Drum Inlet

Figures 7.1 through 7.14 (located in the appendix) give the isohalines of the surface waters for July 17 and

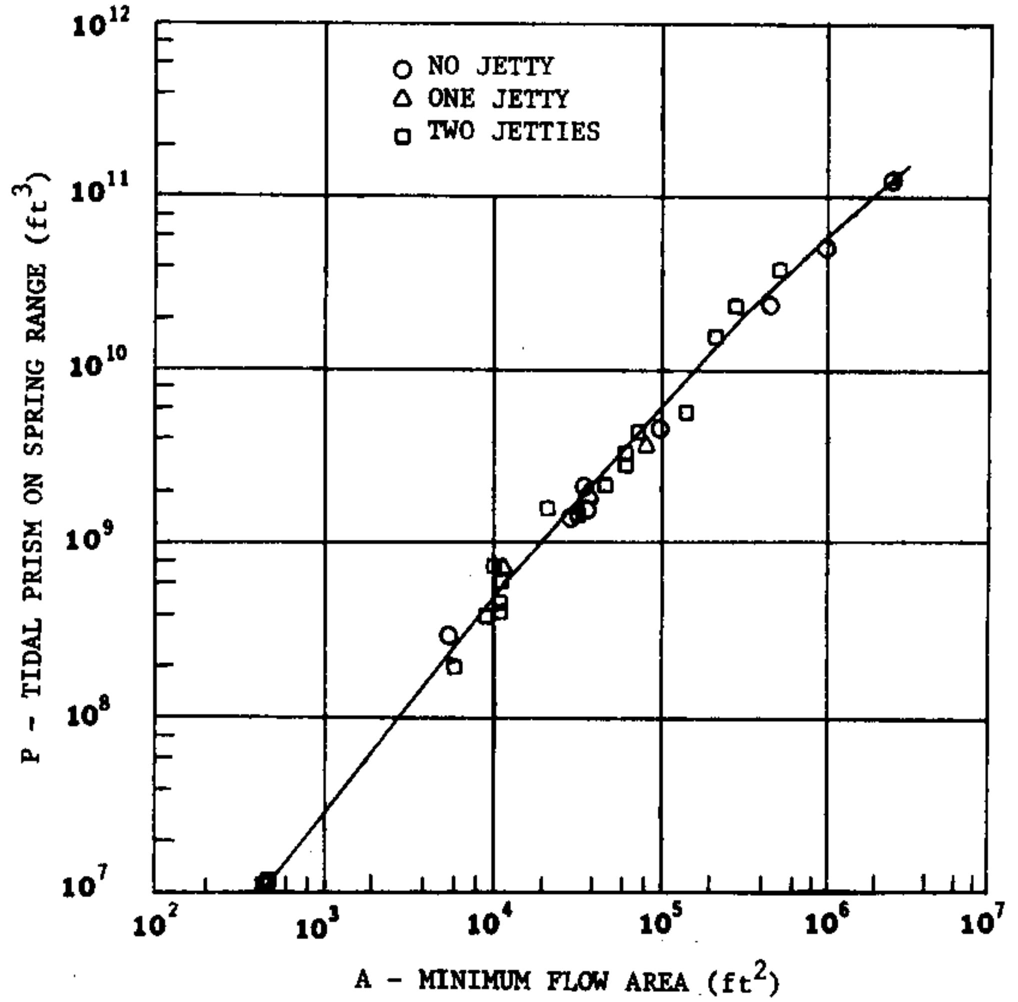

Figure 4.5 TIDAL PRISM VERSUS FLOW AREA (FROM O'BRIEN, 1969, FIGURE 2, PAGE 685).

July 19, during the period from 0800 to 2000 in two hour increments. On July 17 the series of figures begin during an ebb tide and show a reversal of the tide to flood at 1200. A maximum salinity of 35.24 $^{0}/oo$ was observed at station # 5 at 1730 near slack tide. At 1800 the ebb had just begun and by 2000 the flow had definitely reversed.

During ebb between the hours of 0800 and 1000, the progressive movement of lower salinity water down the main channel toward the inlet and that of the higher salinity water down the western lateral channel is shown in Figures 7.1 and 7.2. During flood, beginning sometime between 1000 and 1200, it appears at 1200 that the higher salinity ocean water moves up the main channel hugging the spoil area to the east, but moving also into the western and eastern lateral channels. Near 1400 the maximum salinity waters appear to be centered more in the channel. At high tide (near 1600) the spoil areas were covered with water up to a depth of three feet and the flooding waters moved out over these areas toward the sound.

The ebb at 1800 and 2000 appears to be quite different from that at 0800, nearly one tidal period earlier. The lower salinity water is in the western lateral channel and the west side of the main channel.

The sequence of figures for July 19 shows a somewhat

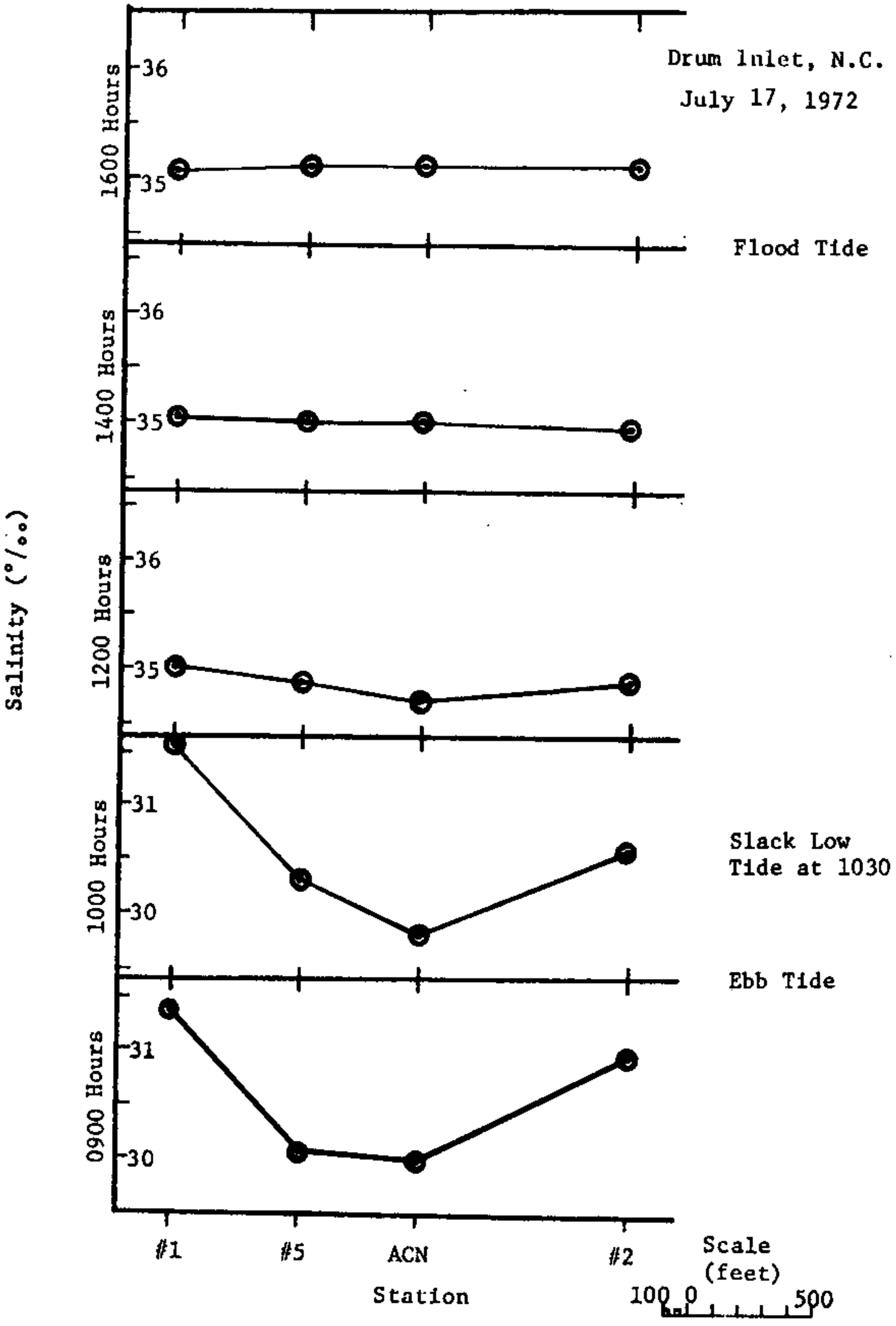

Figure 4.6 SURFACE SALINITY PROFILES BETWEEN STATIONS #1 AND #2.

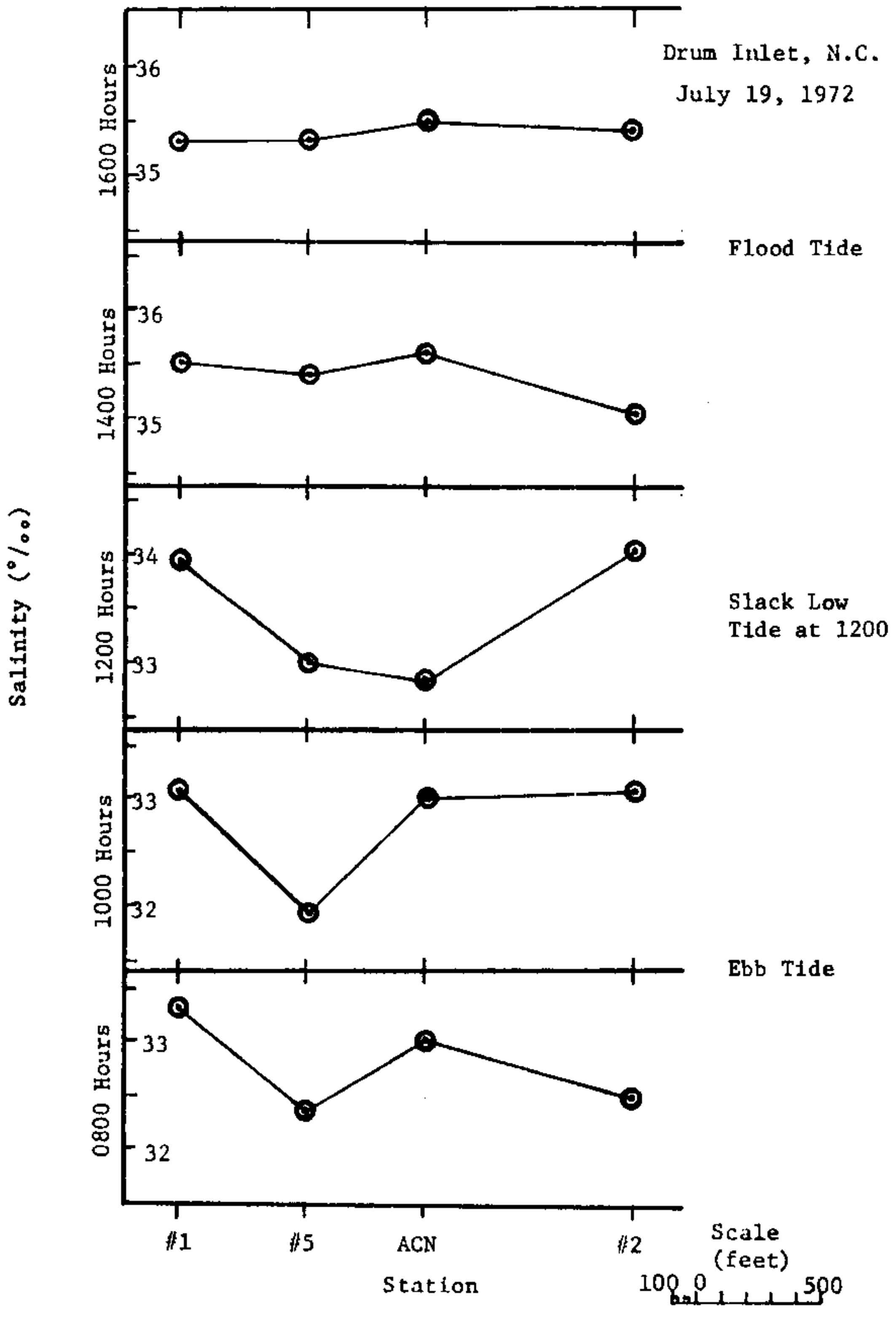

Figure 4.7 SURFACE SALINITY PROFILES BETWEEN STATIONS #1 AND #2.

similar picture in the main channel. Here the ebb is well along at 0800 with velocities of nearly two knots and a flow in the main channel similar to that at 2000, but the flow in the western lateral channel is similar to 0800 and 1000 on July 17. The flood appears to be much like that of July 17 also.

In Figures 4.6 and 4.7 the salinity of the surface water for a line connecting stations # 1, # 5, ACN and #2 is given with the relative distance between the stations to scale. The approximate low tide for July 17 was 1030 at the inlet. A notable feature here was the salinity minimum at station # 5 and station ACN preceeding and at slack low water. This same basic pattern was shown again on July 19 when the low water was approximately at 1200 at the inlet. An explanation for this pattern during ebb and its absence during flood is that during flood the more dense ocean water followed the channels while the lighter sound water spread out over the shoal area adjacent to the channels.

4.1.5 Hydrodynamic Data in Core Sound

Figures 4.8 and 4.9 represent the flow in Core Sound for July 20 and 21 respectively. The buoys (circled numbers) mark the locations of stations taken in September 1972. The bold arrows represent surface velocities, while the small arrows are bottom velocities.

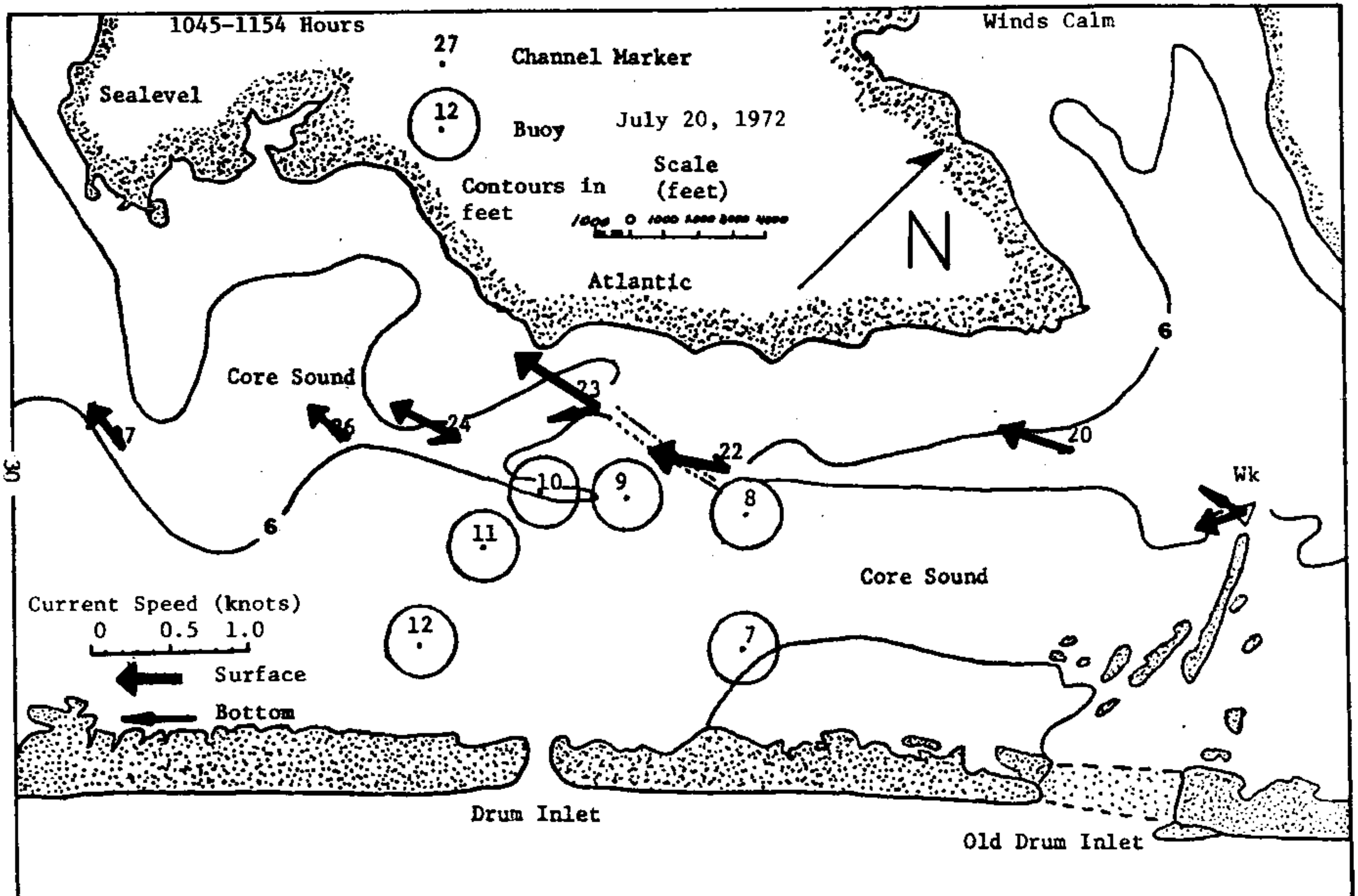

Figure 4.8 FLOW VECTORS IN CORE SOUND, JULY 20, 1972.

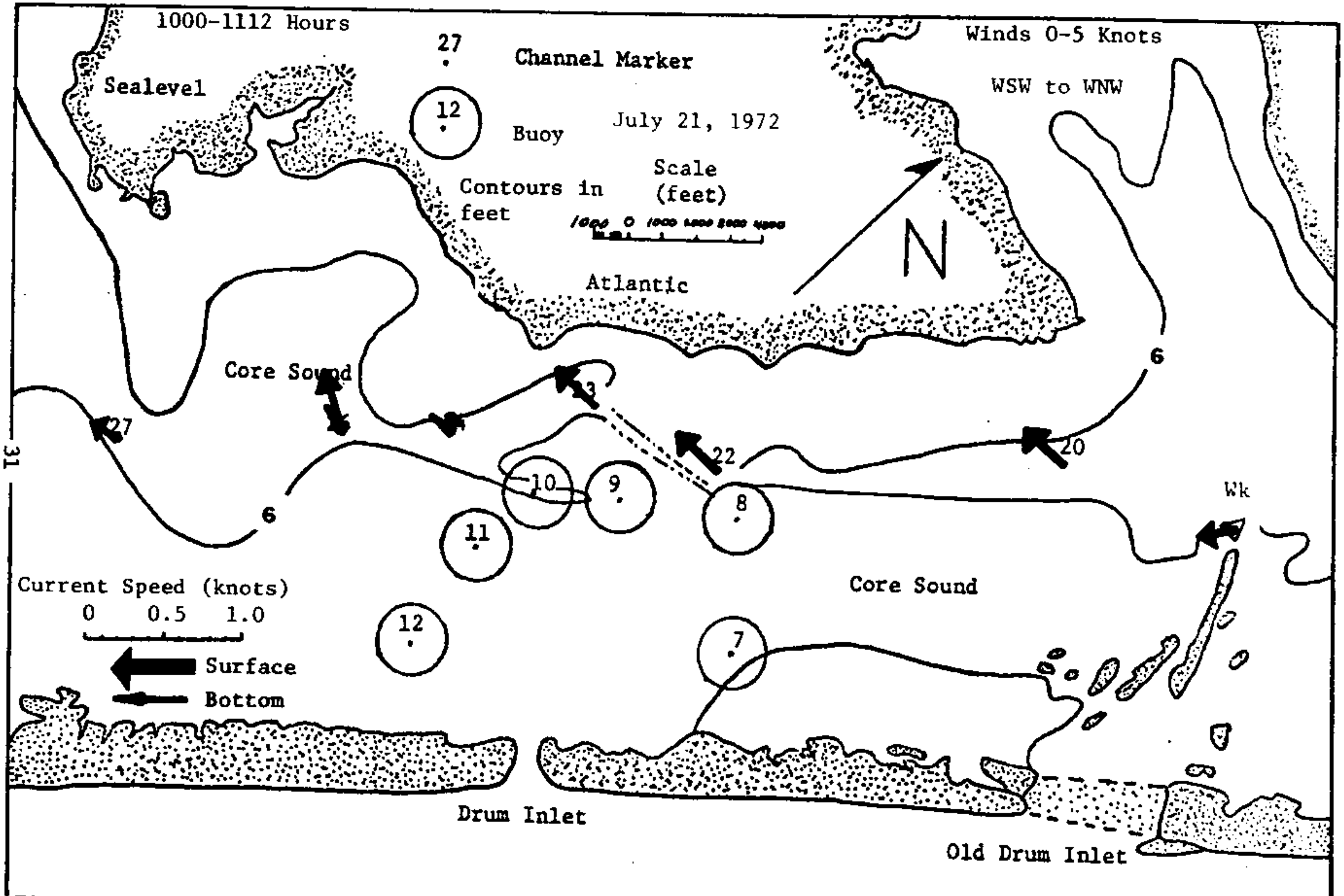

Figure 4.9 FLOW VECTORS IN CORE SOUND, JULY 21, 1972.

A resultant flow is shown to the southwest in Core Sound away from Pamlico Sound; note that the current direction follows the channel for the most part. During the two days represented on these figures the tide was ebbing at Drum Inlet. It appears that the inlet, in July 1972, did not exert an influence over the entire width of Core Sound. It apparently could not alter the southwestward flow of water in the sound significantly, which agrees with the conclusion concerning the extent of tidal influence drawn earlier from tidal prism calculations.

The wind was calm on July 20. On July 21 the winds were WSW to WNW at 0 to 5 knots. The flow shifted slightly toward the mainland in apparent response to this gentle wind. Salinities in the sound at all the channel marker stations were fairly constant with a range at the surface of 29.8 ^{o}/oo to 33.0 ^{o}/oo and 31.3 ^{o}/oo to 33.4 ^{o}/oo at the bottom on July 20. The higher salinities were observed at the stations adjacent to the inlet, decreasing, except for station Wk, to lower values at the stations farther from the inlet. July 21 showed similar results. Station # 23 had a vertical gradient of over 2.5 ^{o}/oo (Figure 4.10). Being in the waterway this may represent the more dense flood water trapped in the channel. The lowest salinity values for the surface and the bottom for both days were at station #27, the southernmost of those sampled. The higher salinity at

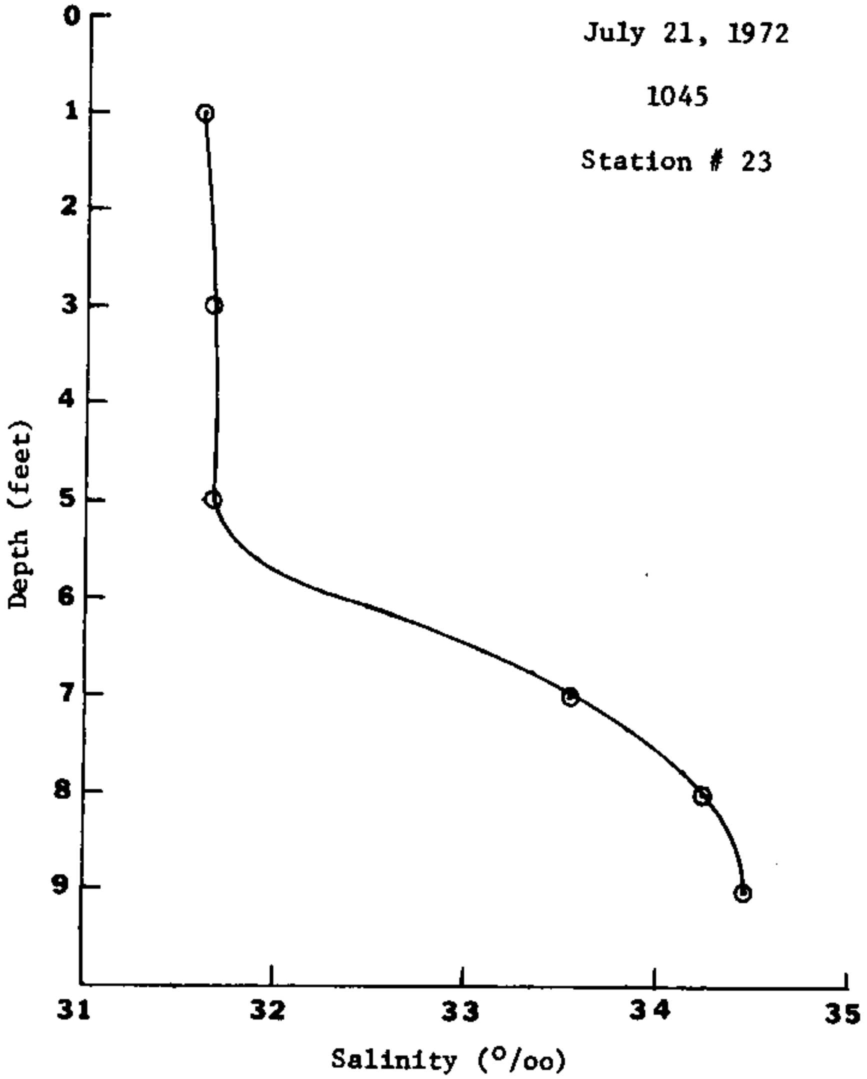

Figure 4.10 VERTICAL SALINITY PROFILE AT STATION # 23.

station # 20 may suggest either that water from Ocracoke Inlet may be moving southward along the sound's channel, or that there may be an additional channel somewhere between station #7 and # 8 where ocean water from Drum Inlet may enter the deeper part of the sound. Results from the September trip seem to suggest the later, as will be discussed in the next section.

4.2 September Research Trip

In September of 1972 a second trip was made to Drum Inlet to collect data in the inlet gorge and at seven stations (Figures 4.11 and 4.12) at an average radius of about 7,500 feet on the sound side from the inlet; the nearest being 5,300 feet, the farthest 10,200 feet. The purpose of sampling at this distance from the inlet was to try to pick-up the way in which the flood water from Drum Inlet entered the sound by detecting the salinity variations between stations. This average distance of 7,500 feet represented the extent to which the flood tidal delta penetrated into the sound as observed on aerial photography.

The stations at the inlet consisted of three buoys along the axis of the channel. One was located in the center of the inlet, a second 500 feet away just on the sound side of the inlet and a third about 500 feet down the main channel from the second. Wind and rainfall data are presented in Figures 4.1 and 4.2.

The data, presented in Figures 4.11 and 4.12, were taken for an eight hour period. The velocity vectors and salinity contours were for the surface water. Initially, the flow was ebbing at all stations except # 7. Here the flow, though small, was away from the inlet. At 1000 flow was basically the same as at 0900 with some reversal showing up at station # 8. The salinity structure was the same. Slack tide, at 1300, showed up at most of the stations at 1200 as low velocities and random flow directions. The salinity contour was again unchanged. At 1400 the effects of the high salinity ocean water were detected as well as the flooding current direction. The anomalous velocity vector at station # 10 probably represented erroneous data. At 1600 and 1700 the water was entering the inlet and was progressively turning northwards along the stations from # 12 to #8.

The winds on the sixteenth and seventeenth had been blowing from the south to southeast at 0 to 8 knots, and as a result, water was pushed toward Pamlico Sound. This lower sound level and the proximity of these six stations to the inlet allowed the inflow of water through the inlet to have a marked effect on the salinity range. Over this sampling period, station # 10 had the greatest salinity range with 5.0 $^{o}/oo$.

5. Conclusion

Drum Inlet, during the time of this study, was a

Drum Inlet, N.C.

September 17, 1972

▬ ▬ ▬ Isohaline

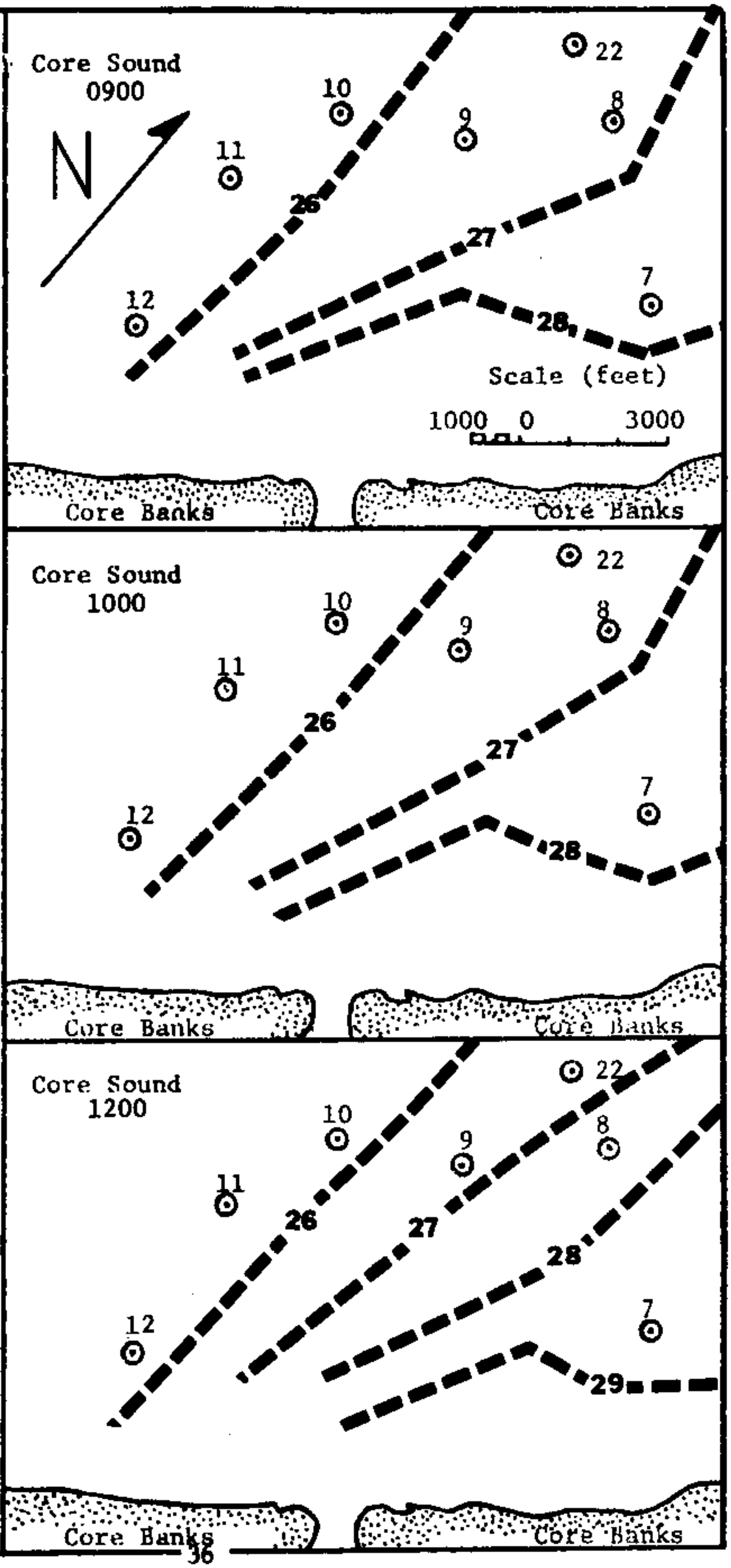

Figure 4.11 SURFACE SALINITY CONTOURS, 0900 TO 1200.

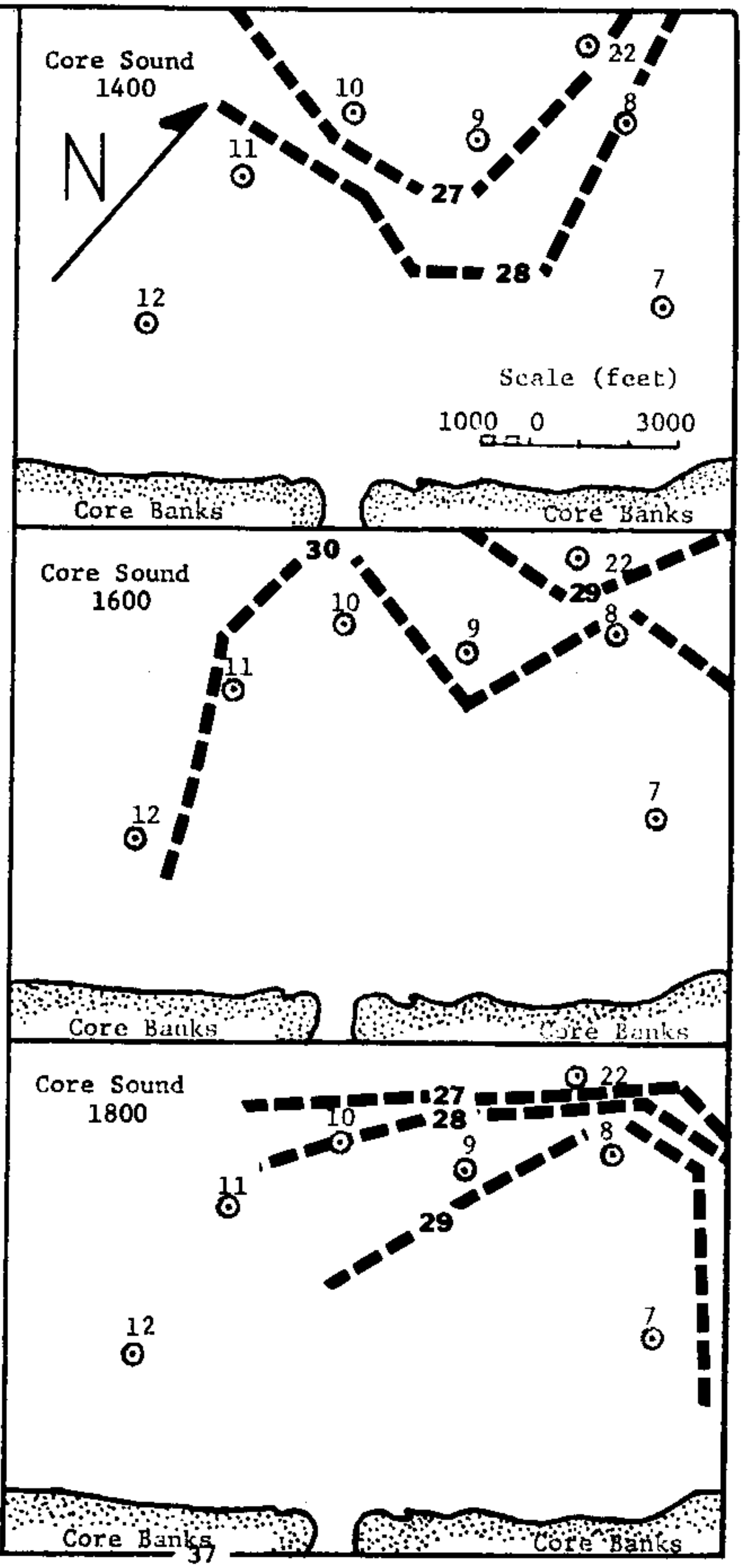

Figure 4.12 SURFACE SALINITY CONTOURS, 1400 TO 1800.

young inlet in a transition stage. It had neither established an equilibrium width nor a complete network of channels inside the inlet. Subsequent maintenance dredging was required to straighten the main channel into Core Sound to facilitate the flushing capability of the inlet. The rate of inlet widening should decrease as the inlet reaches a state of equilibrium.

The sound water in the vicinity of Drum Inlet was as deep as any in Core Sound so the inlet may be expected to remain open for a period of time on the order of several years as did Old Drum Inlet. History has shown that inlets along Core Banks are subject to closing due to shoaling. It is thus reasonable to expect the same fate for Drum Inlet when the inlet is no longer able to flush itself (except during storms when inlets generally free themselves of much of the sediment clogging them). If a channel is to be maintained by dredging, it should be dredged straight into the sound since this would offer the least resistance to the flow and thus the greatest flushing potential.

A stated purpose for the opening of the inlet was to provide a salinity source for the shellfish of Core Sound to flourish in. This introduction of salt water was accomplished and will be enhanced as greater flows are realized through a wider inlet. Higher salinity water was detected in the sound at a distance of three miles from the inlet. Measurements were not made beyond this point but it is expected that this water extends considerably further up and down the sound. For oysters and crabs reproduction is enhanced by a range of salinity from 20 ^{o}/oo to 28 ^{o}/oo (O. Kinne, 1971, pp. 950-951). Areas with this range were available thus allowing the possibility for development of these shellfish.

The more dense, high salinity water seems to remain in the deeper areas of the sound even during ebb tide. This is evidenced by the occasionally high vertical salinity gradient in mid-sound (Figure 4.10). Thus, the inlet does act as a salinity source for the central portion of Core Sound.

By far the most interesting result of this study was the movement of the tides in Drum Inlet and Core Sound. To provide an explanation for the lag in the tide at Atlantic, more detailed information of the tides in the ocean, at the inlet and throughout the sound needs to be collected. This is a potentially rich topic with which to be concerned, since other areas along the North Carolina coast may have similar conditions.

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7. APPENDIX

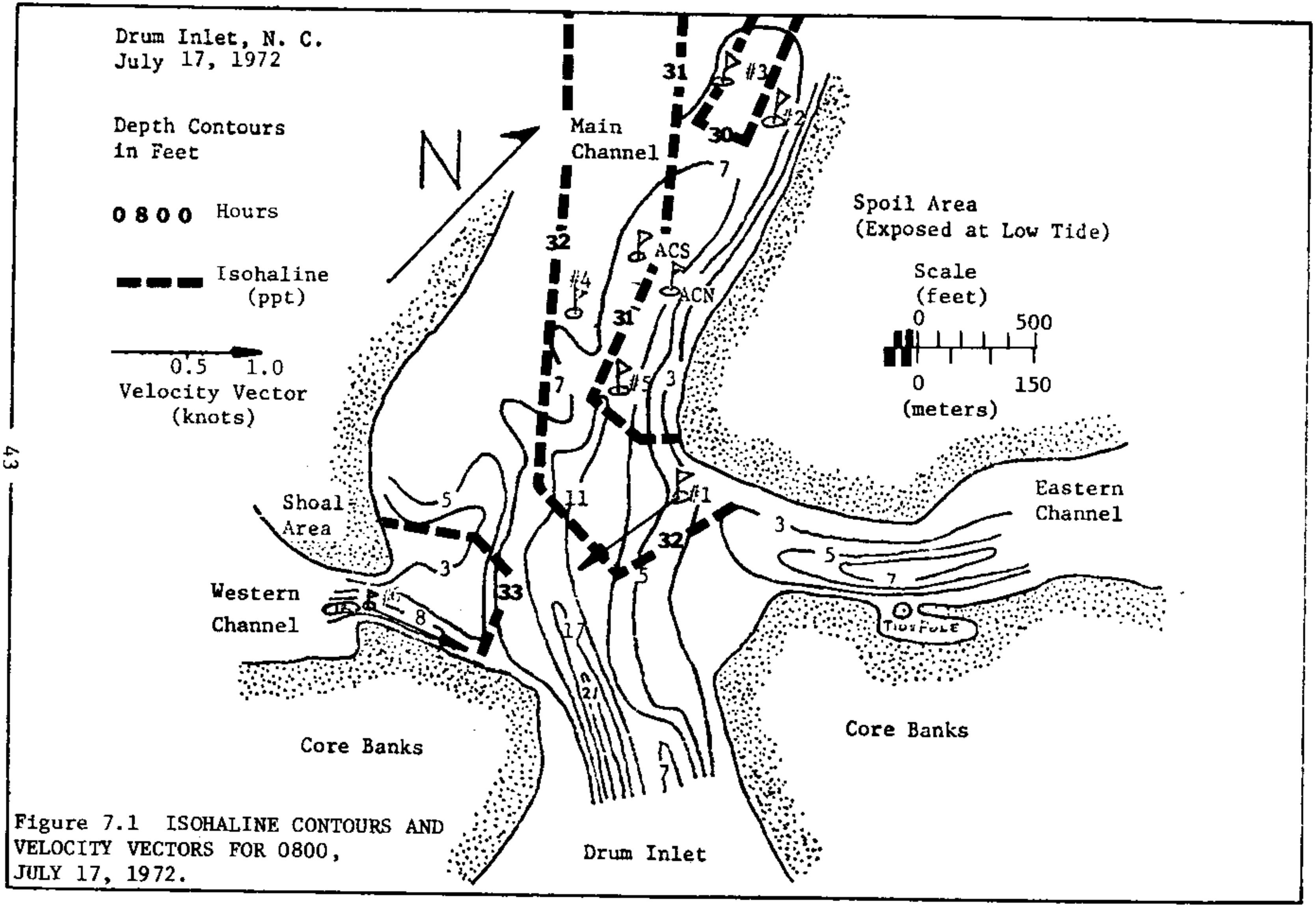

Figure 7.1 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 0800, JULY 17, 1972.

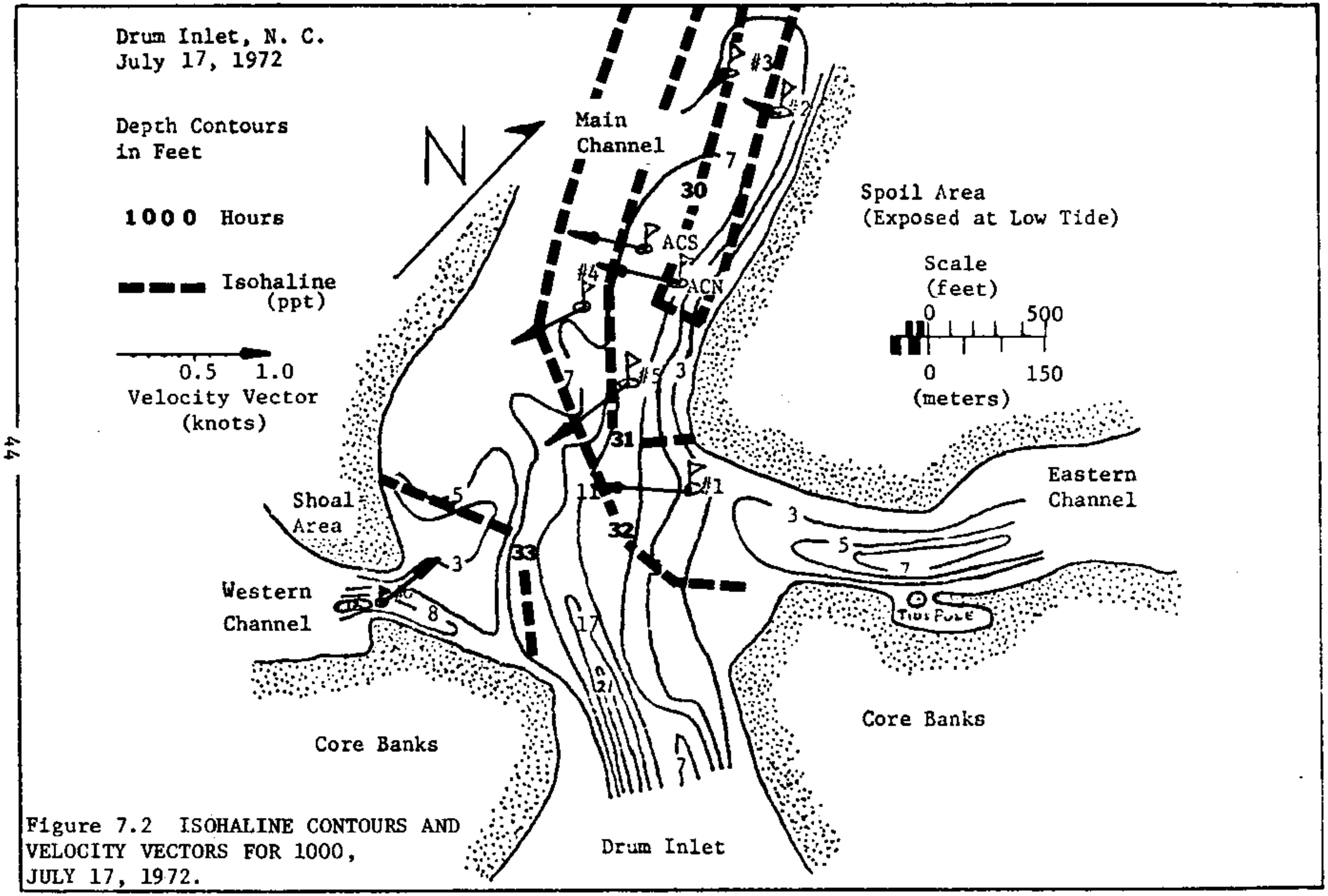

Figure 7.2 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1000, JULY 17, 1972.

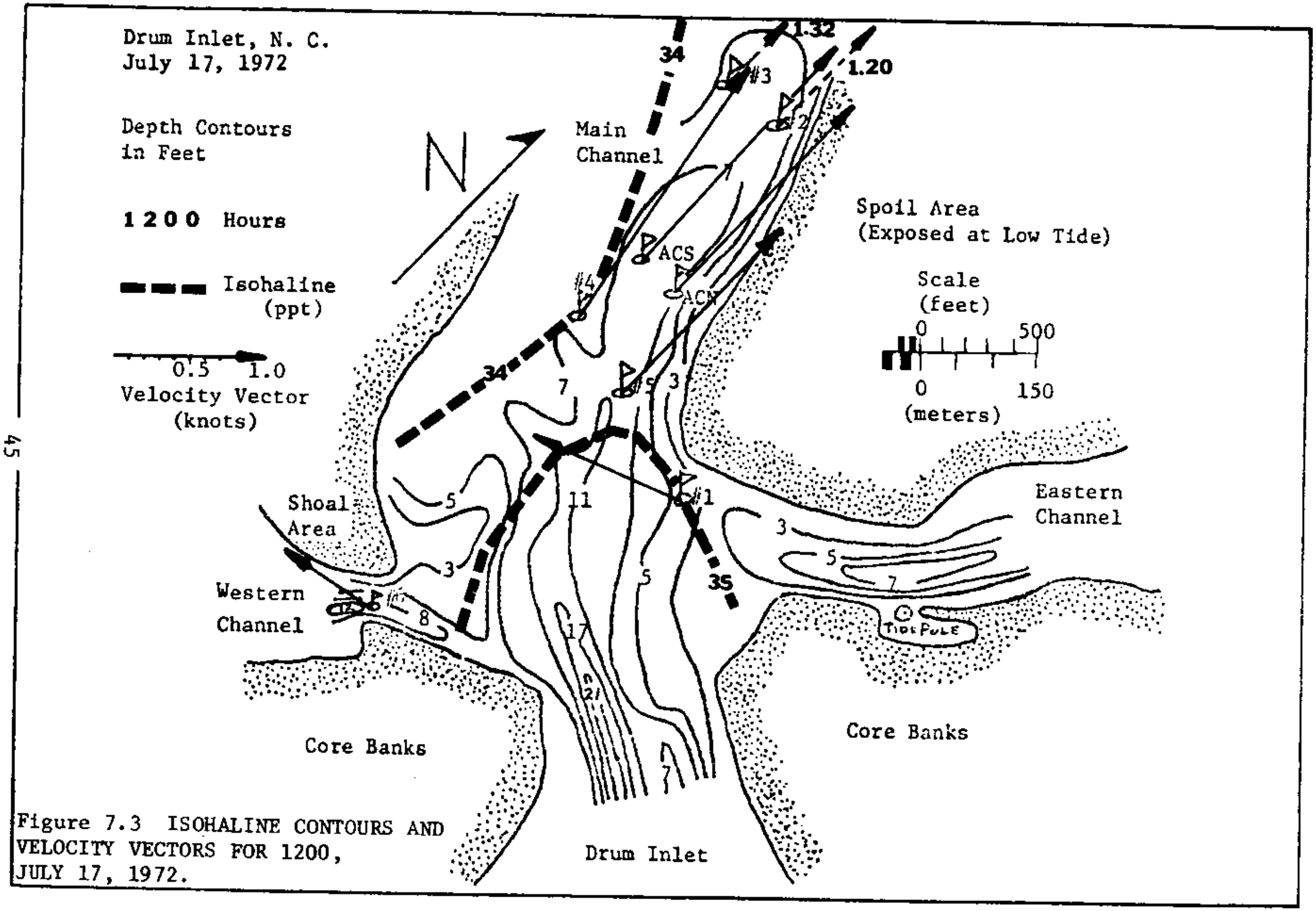

Figure 7.3 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1200, JULY 17, 1972.

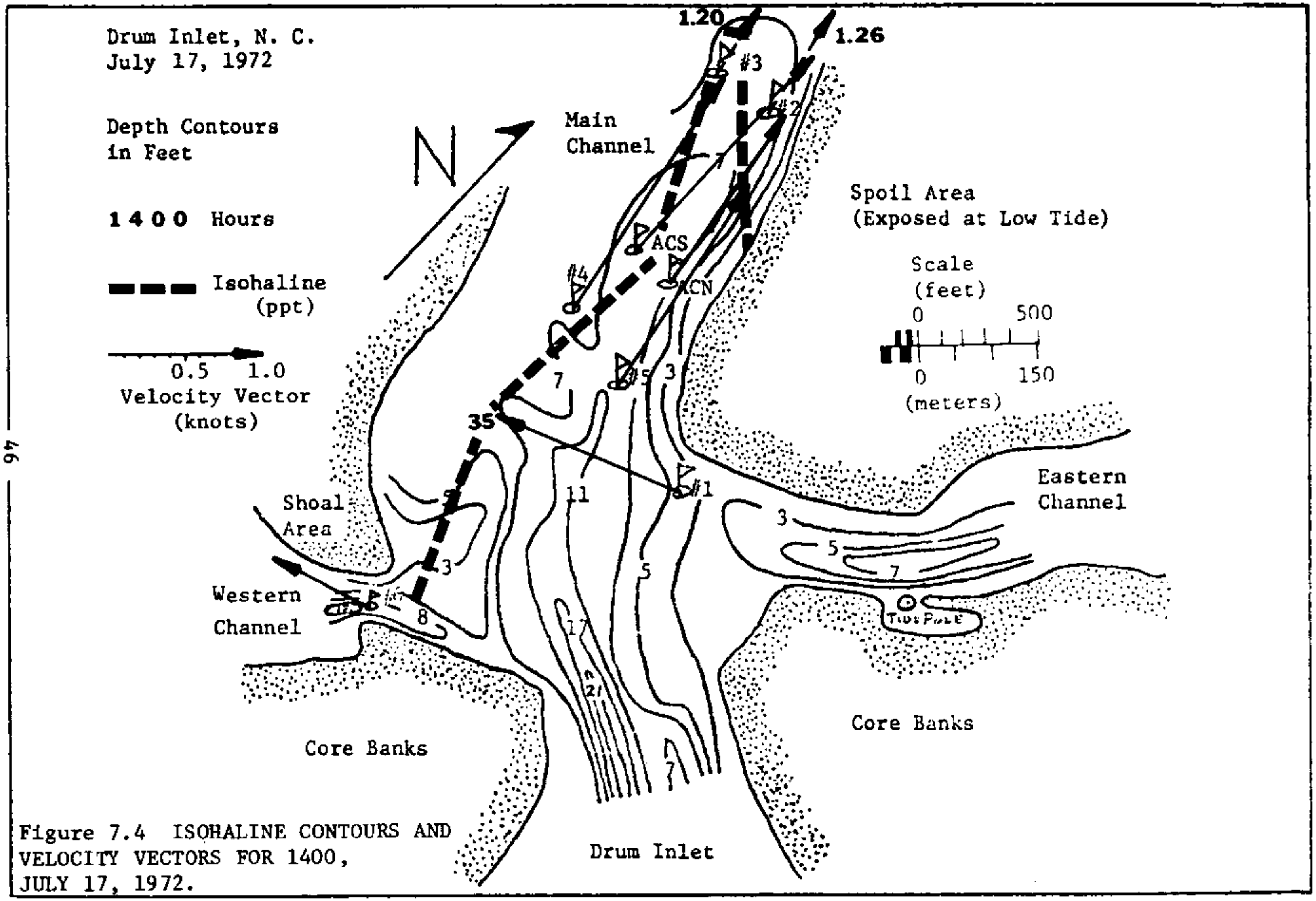

Figure 7.4 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1400, JULY 17, 1972.

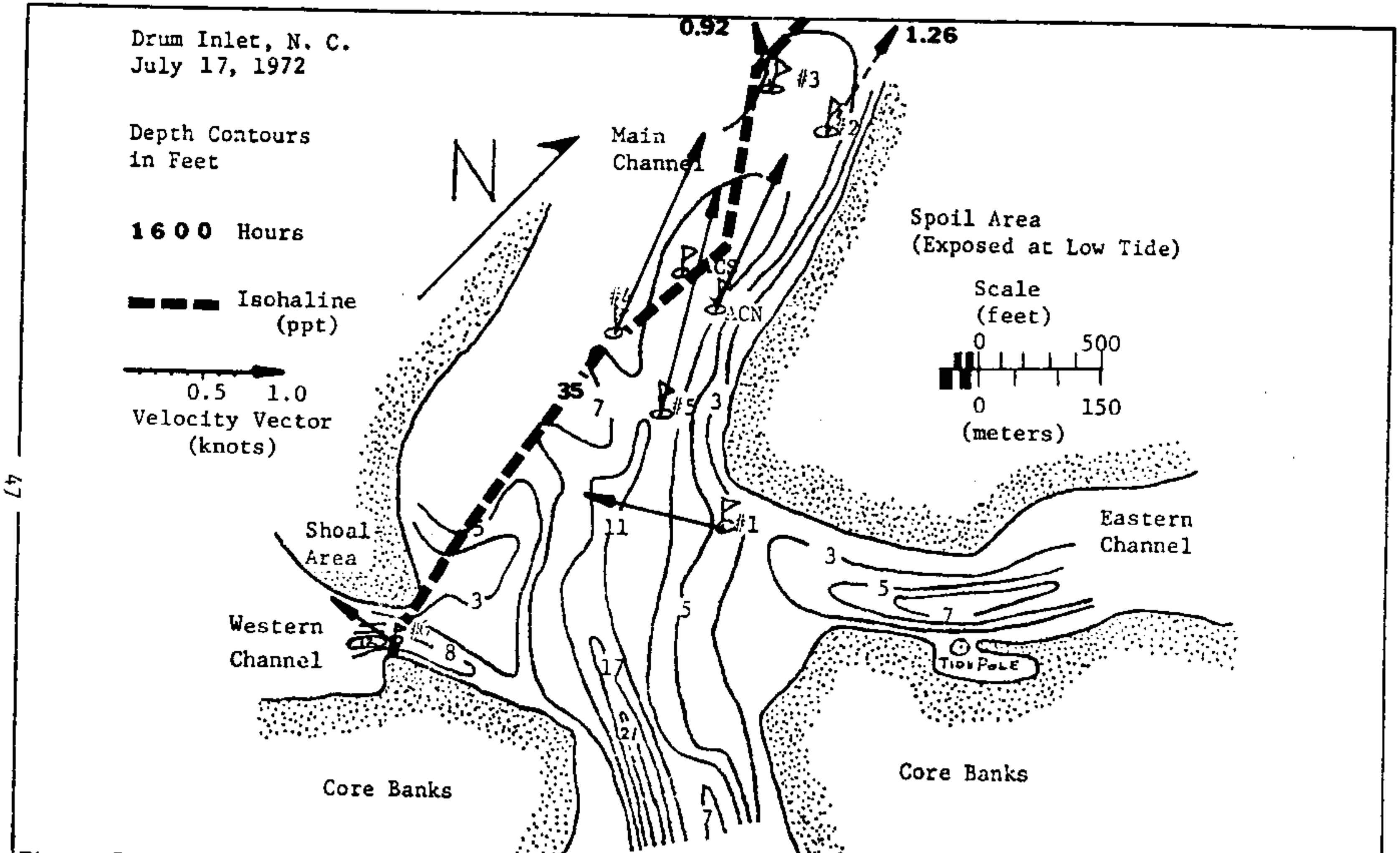

Figure 7.5 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1600, JULY 17, 1972.

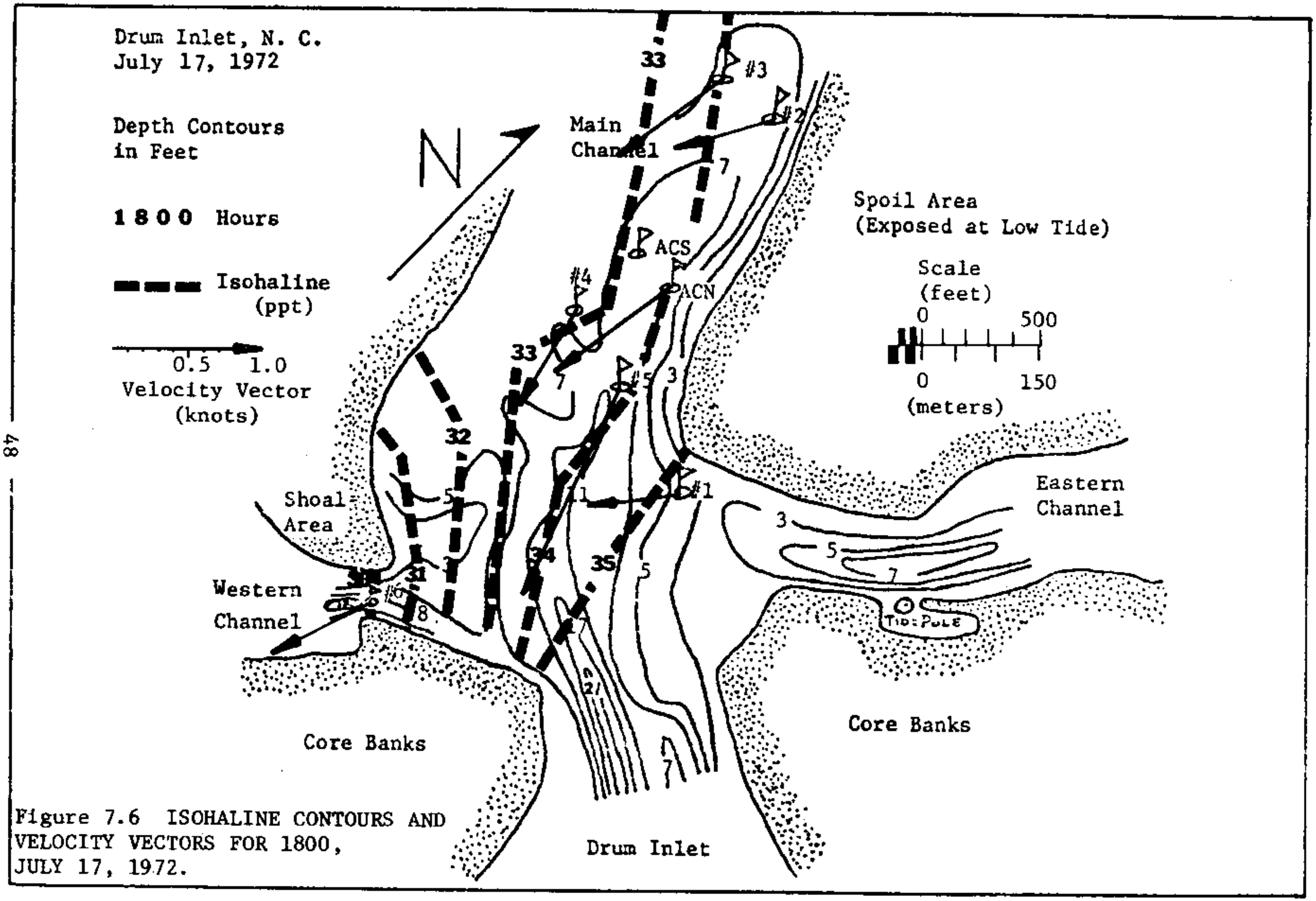

Figure 7.6 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1800, JULY 17, 1972.

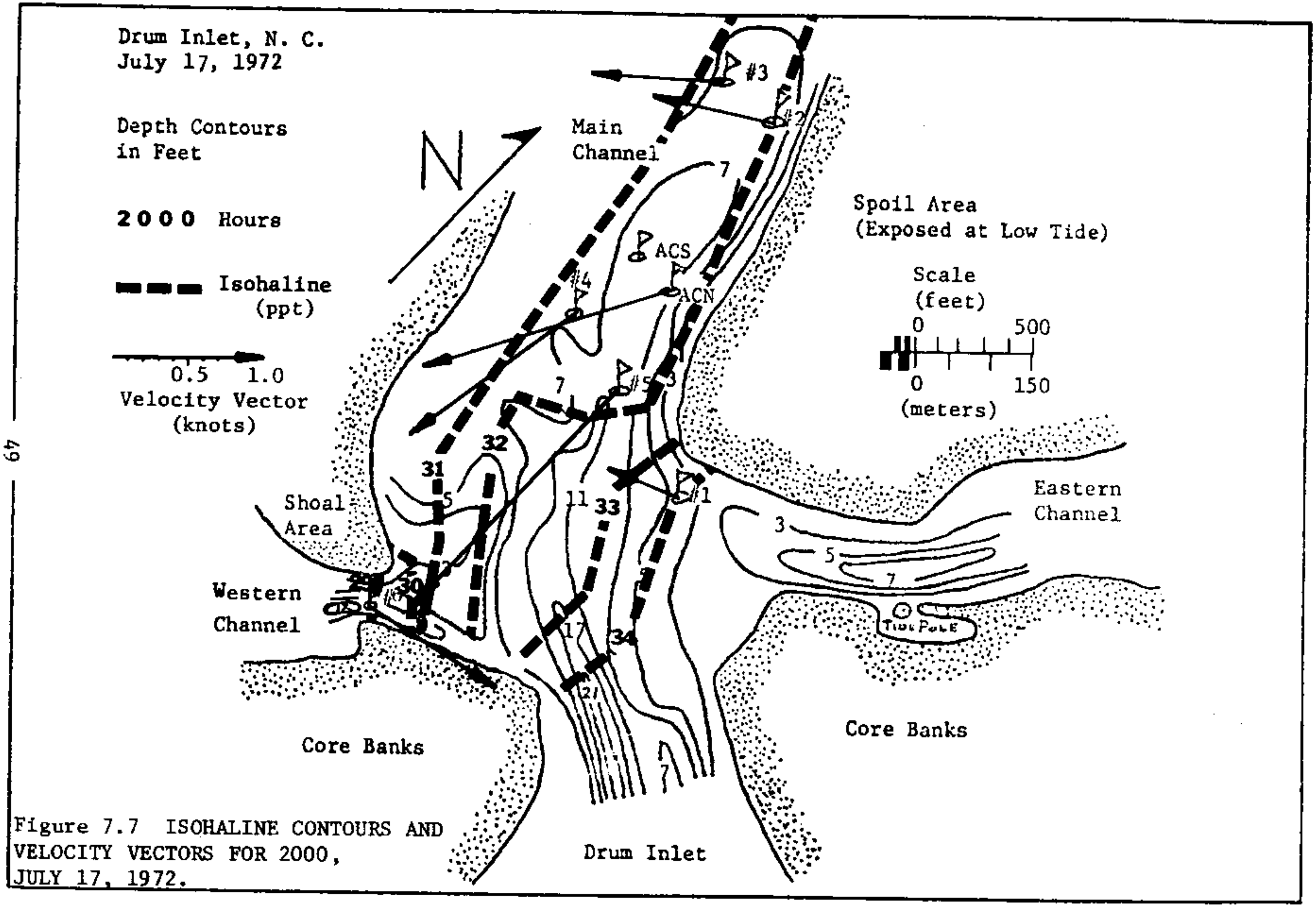

Figure 7.7 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 2000, JULY 17, 1972.

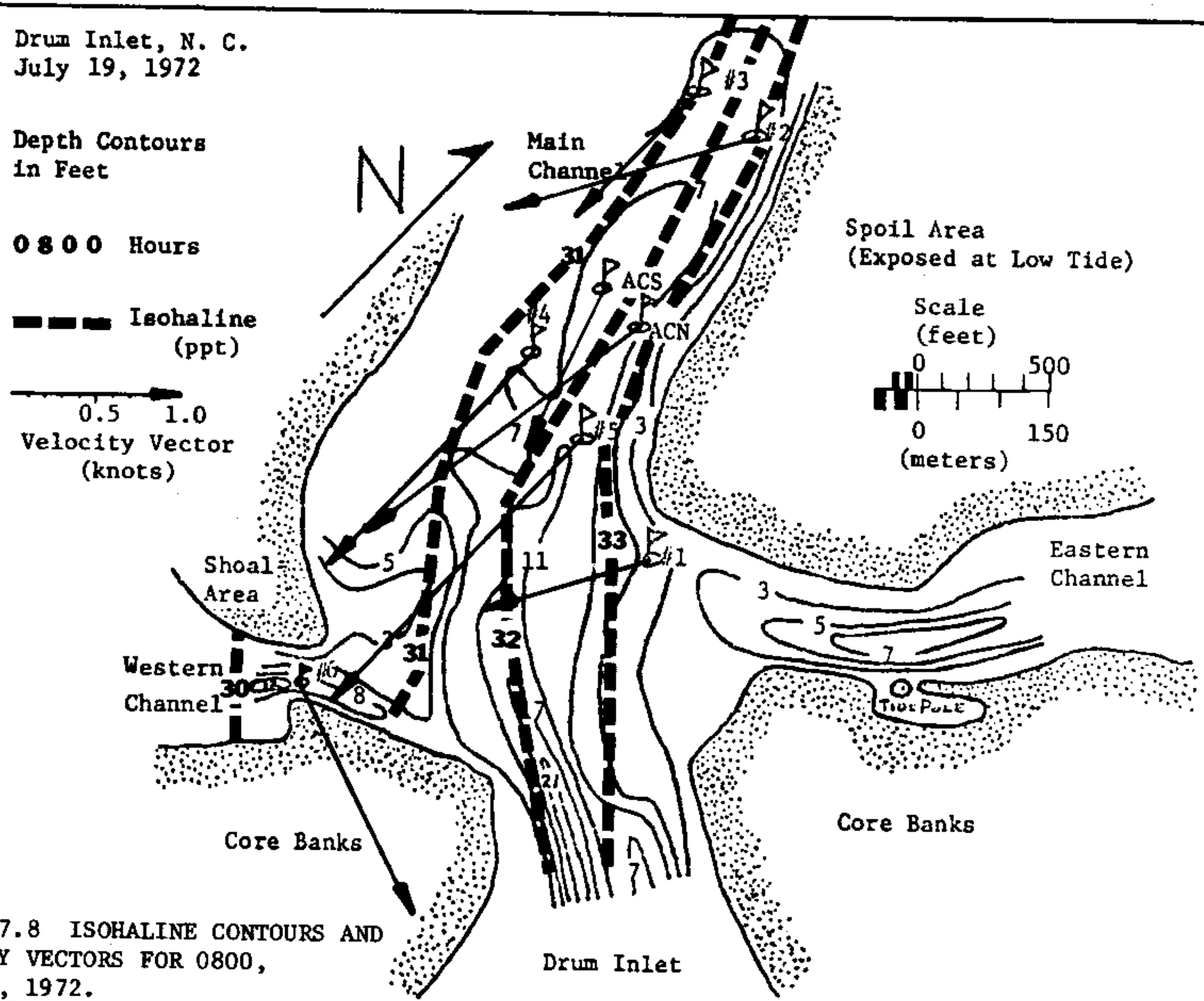

Figure 7.8 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 0800, JULY 19, 1972.

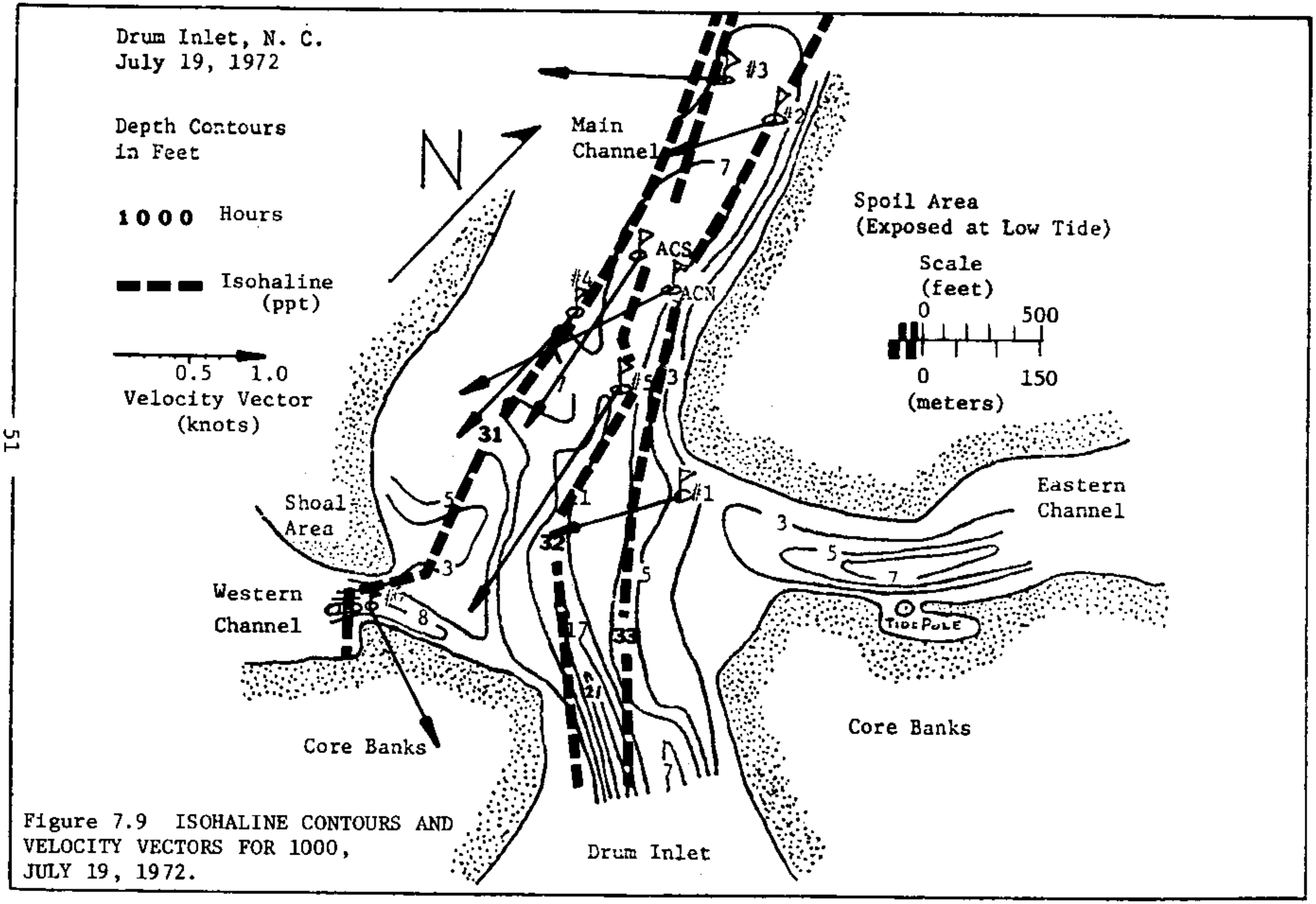

Figure 7.9 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1000, JULY 19, 1972.

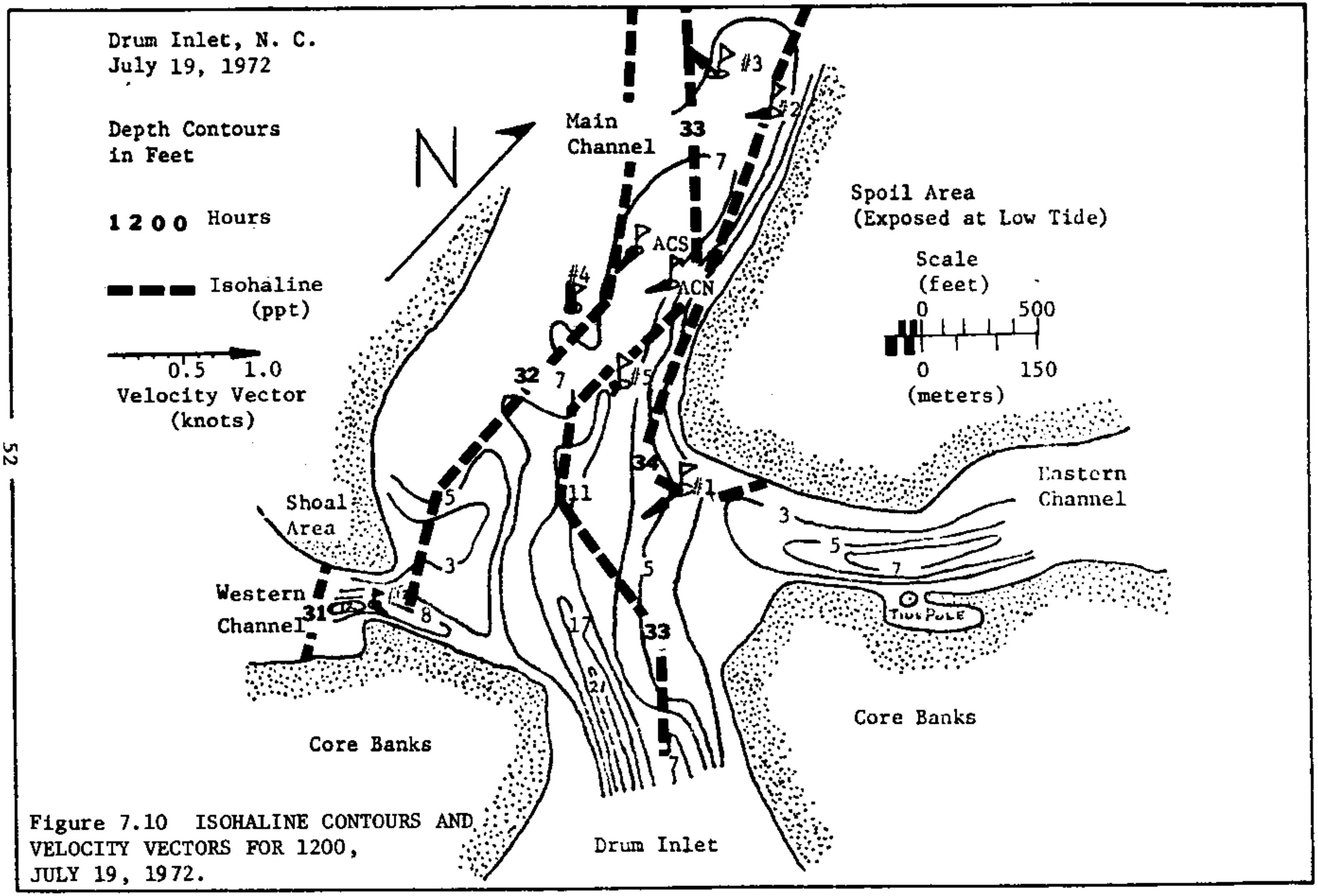

Figure 7.10 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1200, JULY 19, 1972.

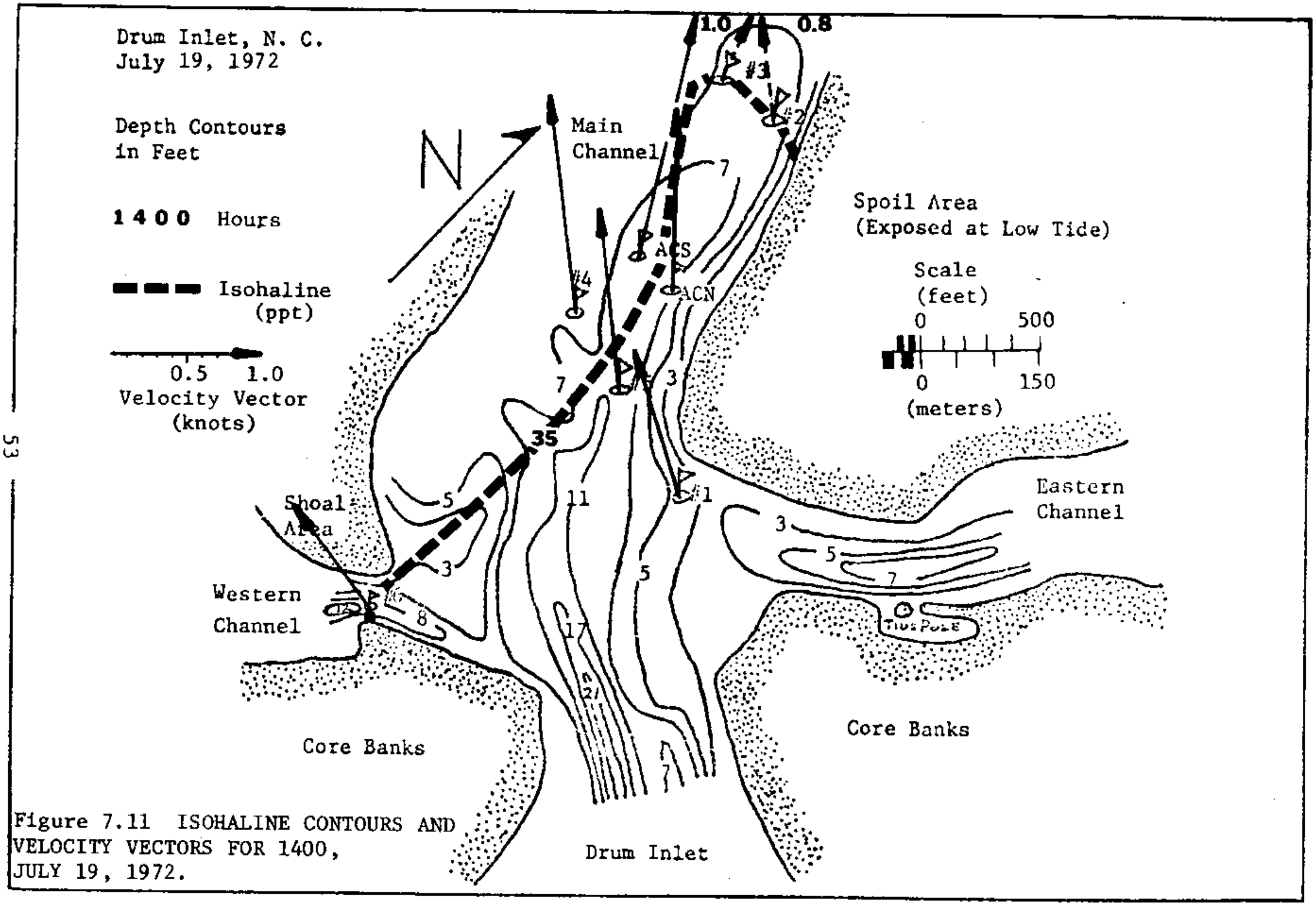

Figure 7.11 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1400, JULY 19, 1972.

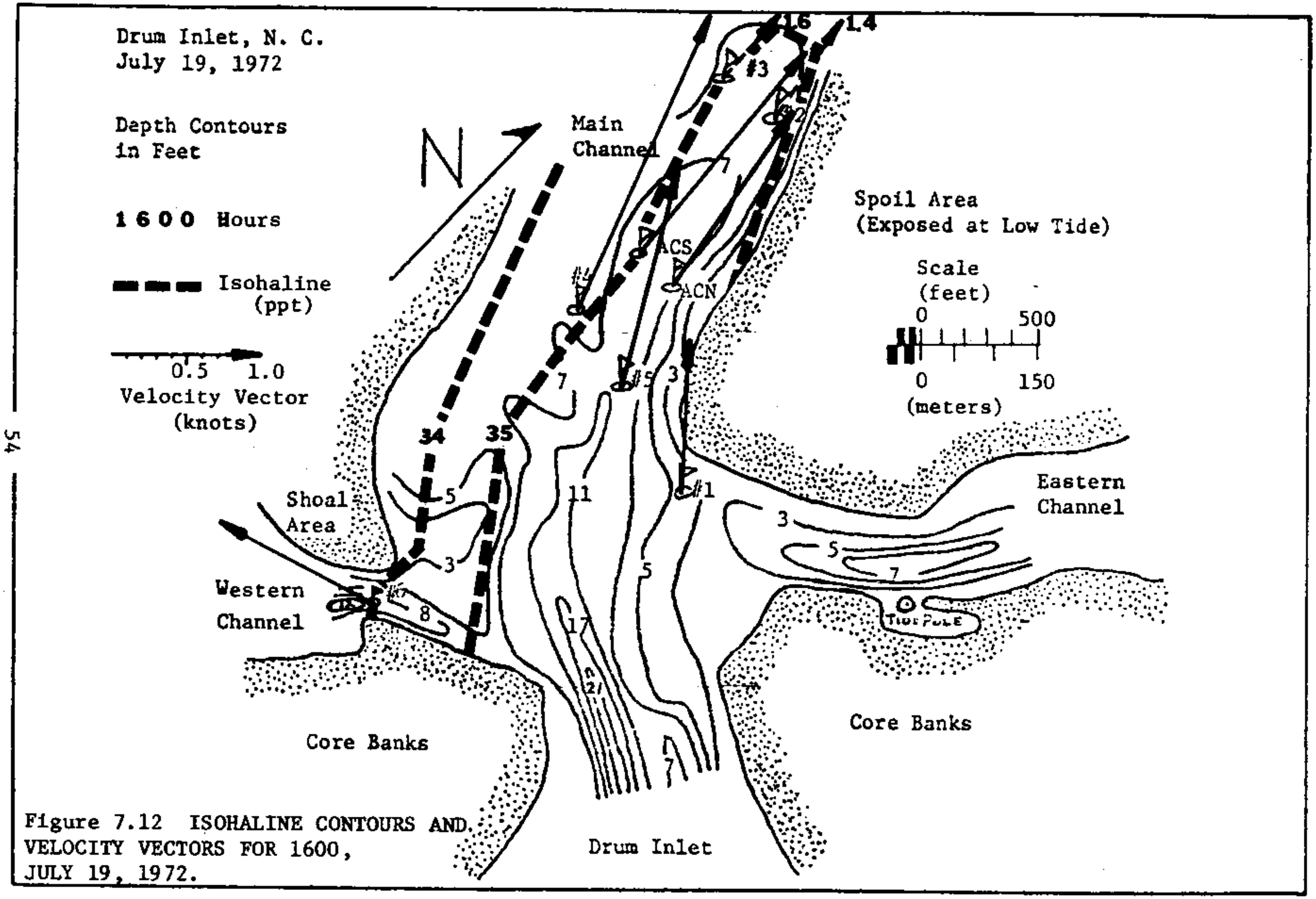

Figure 7.12 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1600, JULY 19, 1972.

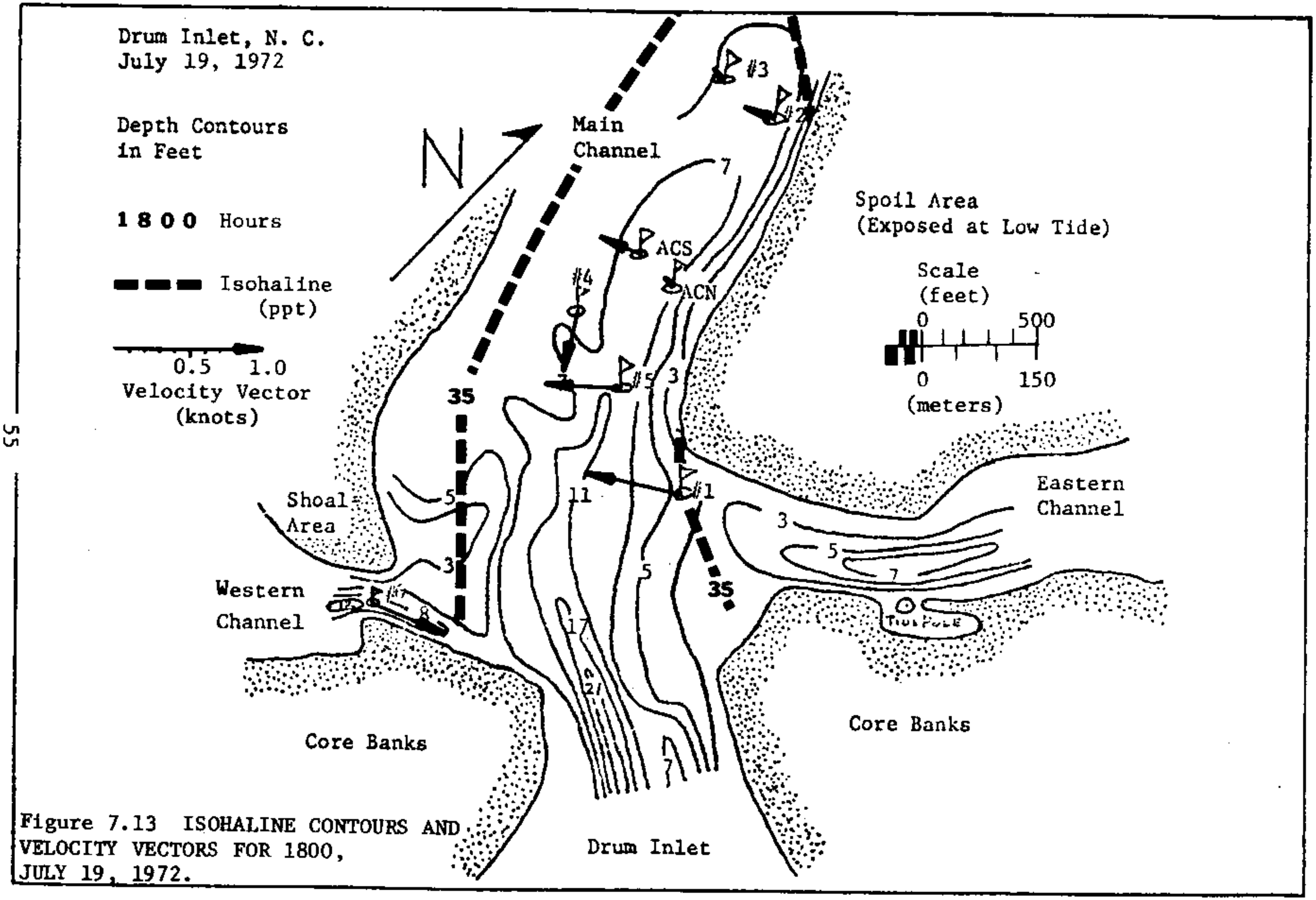

Figure 7.13 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 1800, JULY 19, 1972.

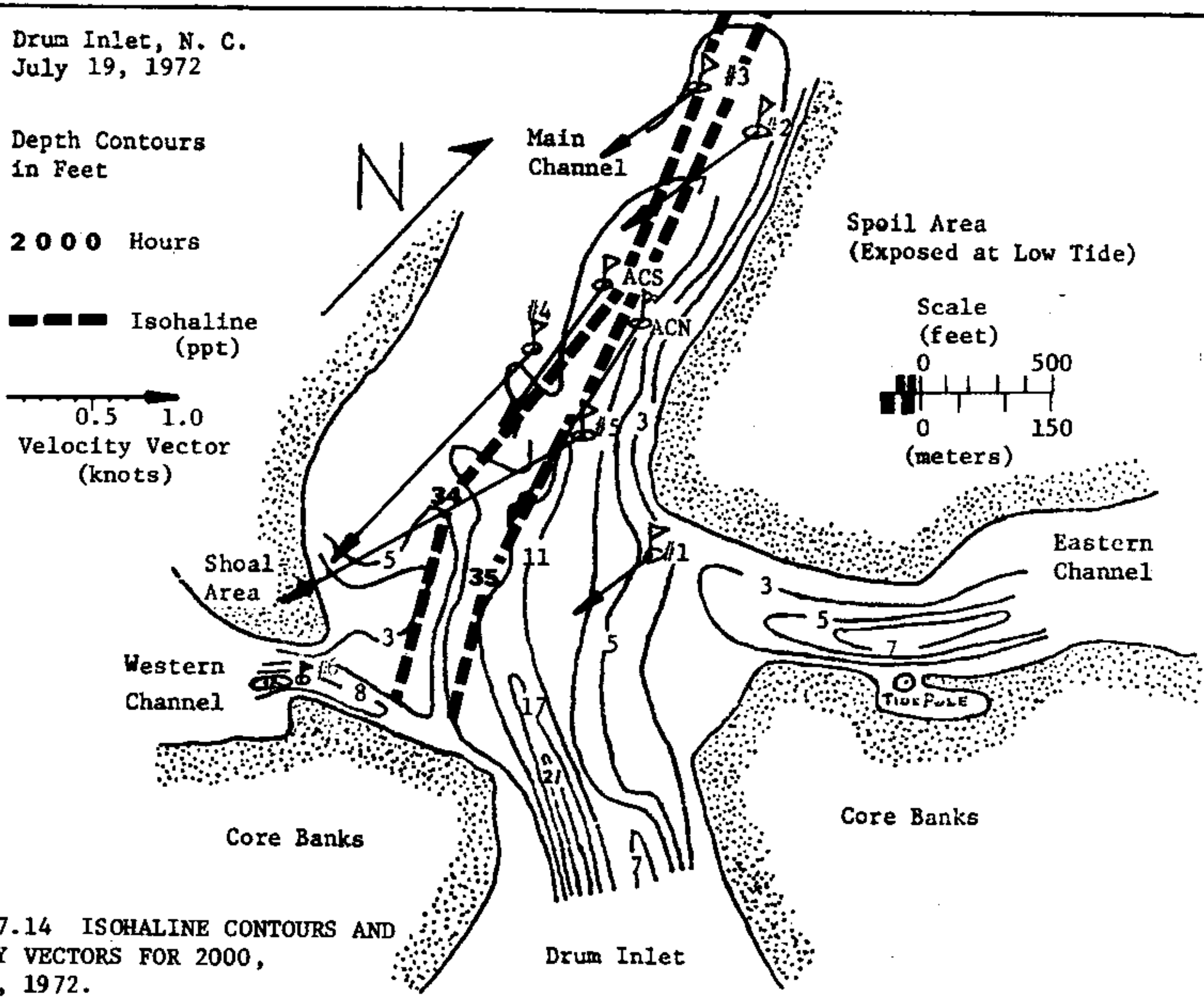

Figure 7.14 ISOHALINE CONTOURS AND VELOCITY VECTORS FOR 2000, JULY 19, 1972.