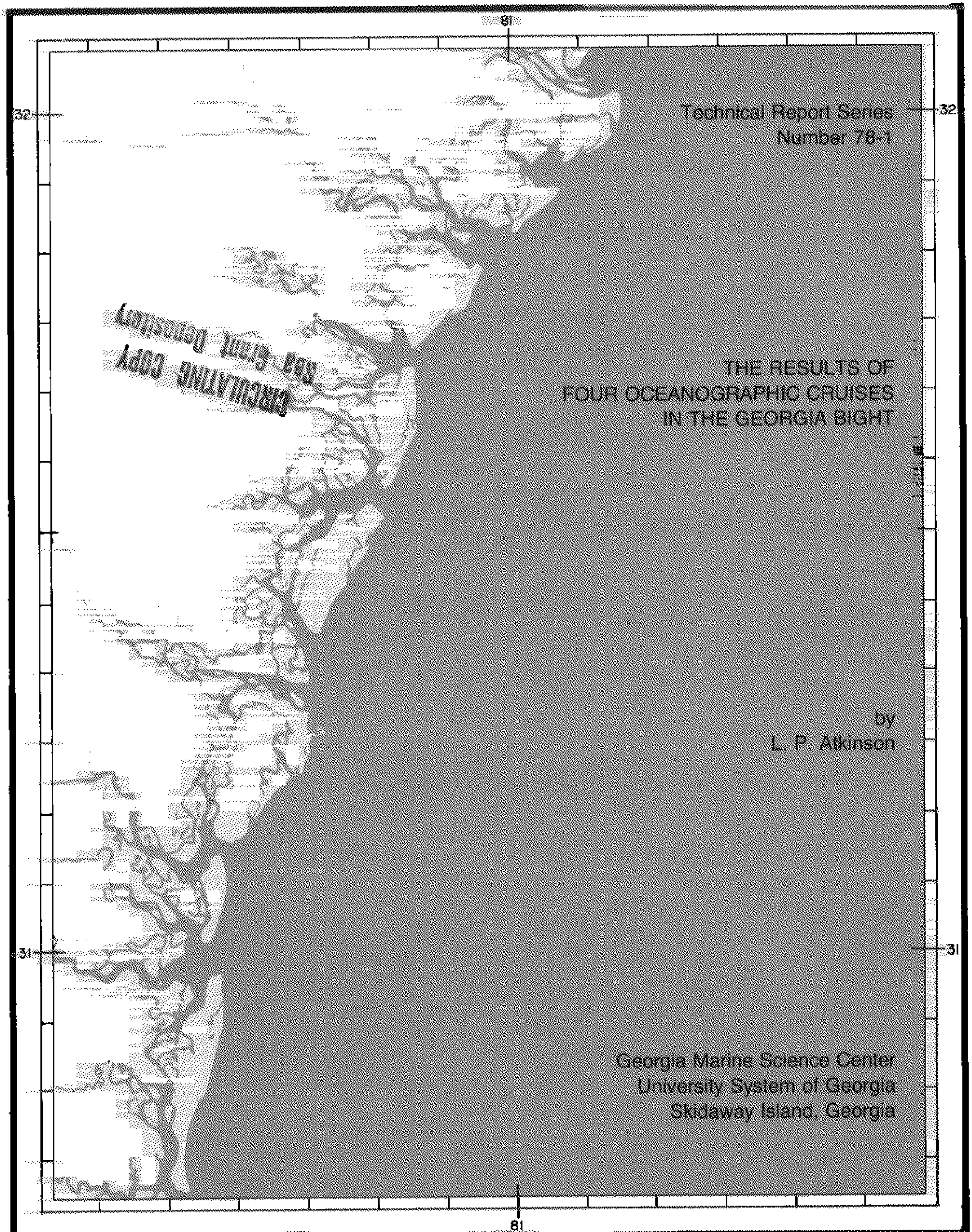

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THE RESULTS OF FOUR OCEANOGRAPHIC CRUISES IN THE GEORGIA BIGHT

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ACKNOWLEDGEMENTS

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INTRODUCTION

During 1973 and 1974 we conducted four oceanographic cruises in the Georgia Bight with the purpose of gaining background seasonal data with which to plan more specific experiments. In this technical report the data are presented in graphical form with interpretation. The data itself was published in two technical reports (Atkinson, 1975 and 1976). Some of the interpretations in this report will be given in more detail in published journal articles.

RESULTS OF FOUR SEASONAL CRUISES

Data

The basic station grid was sampled four times as shown in Figures 1-4. In addition to the onshore/offshore line of stations samples were occasionally taken between sections.

The dates and sampling activities for the four Georgia Bight cruises are summarized in the following table:

Table 1. Sample Inventory

	Dates			
Cruise Name Date (Inclusive)	E-13-73 4-11/IX/73	E-19-73 8-15/XII/73	E-3-74 23-30/IV/74	E-12-74 23-30/VII/74
# Stations	55	62	63	68
# Sample Depths	278	239	215	296
# Salinity Samples	274	233	213	288
# Oxygen Samples	256	135	207	291
# Temperature Observations	278	238	212	295
# Nitrate Samples	276	199	180	244
# Phosphate Samples	276	198	204	291
# Silicate Samples	260	200	208	293
Drift Bottles Released (#/Stations)	60/15	60/15	36/18	36/18

All of the hydrographic data and bathythermograph profiles are stored with the National Oceanographic Data Center and are available under the appropriate cruise name.

The horizontal plots are presented first, followed by the vertical plots. Cruises are referred to by the name (e.g., E-19-73) or the month during which the cruise took place.

Horizontal Distributions

Surface Temperature. Surface temperatures (Figure 5) were observed to range from less than 14°C to greater than 29°C. The higher temperature are always found in the vicinity of the Gulf Stream. During the summer (E-13-73 and E-12-74) solar heating is effective in raising the surface temperature of the Bight uniformly. Thus the horizontal temperature gradients are minimal during the summer. During the winter and spring (E-19-73 and E-3-74) a definite offshore gradient in temperature occurs. On E-19-73 the waters are cooling in response to lower air temperatures. During E-3-74 the shelf waters are generally warmer in response to warmer air temperatures and solar insolation. In the spring (E-3-74) horizontal gradients are minimal except in the vicinity of the Gulf Stream.

Bottom Temperature. The bottom temperature distributions (Figure 6) must be compared to the surface temperature distributions. In three cases (upper and lower left, and lower right) bottom temperatures decrease towards the offshore. This is in contrast to the surface water temperatures that increase in the offshore direction. This occurs because relatively cold, deep, Gulf Stream water is moving onshore along the bottom. This is normally referred to as the intrusion process. This process is very important because it brings new water onto the shelf, replacing what was there. The intrusion process is also evident in the December cruise (upper right) but because the shelf waters are relatively cold (15-20C) the intruding Gulf Stream water appears warm.

Surface Salinity. Surface salinities (Figure 7) range from 31 to greater than 36°/oo. The lower salinities are found near the shore as expected. In general the 35^{o}/oo isohaline follows the 18 m (10 fathom) isobath. However south of the Altamaha River the isohalines begin to intersect the coast. The surface shelf water salinities generally are greater than 36^{o}/oo with a tendency for higher salinities to the south and lower salinities to the north at the same isobath.

During cruise E-13-73 a special situation existed. The low surface salinities on the outer shelf were hypothesized to originate from the Mississippi River during periods of high runoff. See Atkinson and Wallace (1975) for additional discussion.

Surface Density. The surface density plots (Figure 8) show the effect of low salinity water lying along the coast. The central shelf waters are quite often of higher density than inner or outer shelf waters because of the combination of relative high salinities and low temperatures in contrast to higher offshore salinities (and temperatures).

Nearshore geostrophic currents to the south are indicated in all cruises except E-19-73.

Bottom Nutrients. The intrusion of deeper-nutrient rich water onto the shelf is one of the principal sources of phytoplankton nutrients. One way of identifying intruding waters is by looking at the near bottom concentrations of the phytoplankton nutrients and especially nitrate (Figure 9).

As Figure 9 demonstrates nitrate is usually at very low concentrations in the shelf waters, typically being less than 1 μm. However, in the vicinity of an intrusion it is higher, often reaching 10 μm. The figures show a steady increase in the nitrate concentration in the near bottom waters towards the offshore with the only variant being where the increase starts in the cross-shelf direction.

The wave-like structures in these plots are not significant since they could reflect the bias in the time required for sampling. It is significant however that there always appeared to be an intrusion of nitrate-rich water off the St. Johns River.

Vertical Sections

The vertical sections indicate, when combined with the horizontal data, a three dimensional view of the shelf. The data presented are sample location and depth, temperature, salinity, sigma-t (density), oxygen, phosphate, nitrate and silicate.

The legend above the section refer to station numbers. The Roman numerals inset in the section refer to the onshore/offshore sections, I being the most northerly and VI the most southerly. Since station numbers, locations and sections were nearly invariant during the cruises the reader may easily compare various stations and sections. For each cruise the sections proceed from north to south. The stations in a section were either 5, 10, or 15 nautical miles (9.3, 18.5 or 27.8 km) apart.

Cruise E-13-73, 5-10 September 1973. (Figures 10-14) On all sections a strong thermocline extended to varying distances across the shelf. If one compares the vertical temperature profiles with the horizontal distribution of bottom temperatures the cause of the cold bottom waters becomes evident. The steeply sloping isotherms can expose cold water to very shallow depths. For example on Section V (Figure 14) at station 54 18^{o}C water is found at about 220 m, whereas at station 51, which is 25 nautical miles (46 km) to the west, 18^{o}C water is found at 50 m: a rise of 3.7 m per km.

The intense thermocline in the outer shelf waters caused by the invasion of deeper, cold Gulf Stream waters has many important consequences.

The outer shelf is extremely stable because of the extreme vertical density gradients. The cold water contains many dissolved constituents that are lacking in shelf water and thus becomes an important source of these constituents.

Nitrate, phosphate and silicate are quite high on the outer shelf in relation to the lower temperatures because their source is cold, deep water. The onshore movement of nutrient-rich water is especially noticeable in Section V (Figure 14).

An area of maximum salinity is always found at depths of 100-300 meters. In this area salinities often reach $36.5^{o}/oo$ and occasionally $36.7^{o}/oo$. Nearshore salinities progressively decrease. As the near-shore is approached the surface salinity is nearly always less than the bottom salinity. This is expected since fresher water flows out at the surface and salt water flows shoreward to replace that entrained in the surface flow. Silica and phosphate also increase towards the coast with higher concentrations usually found at the surface. This is because the river water carries high concentrations of these nutrients.

The lens of low salinity water that appears in the surface waters near the shelf break, which is especially noticable in sections III, IV, and V (Figures 12-14), represents water that we hypothesized is of Mississippi River origin.

An oxygen minimum is associated with the zone of high salinity. Concentrations often are less than 3.5 ml O_2/l.

Cruise E-19-73, 10-15 December 1973. (Figures 15-20) This cruise was during a period of strong winds and cooling and the data reflect that. Nearly all isolines are vertical which indicate the complete absence of vertical gradients in the shelf waters.

Temperature and salinity progressively decrease towards the coast indicative of atmospheric cooling and the influence of river runoff, respectively. In all sections the colder deep water is poised at the shelf edge and nutrient concentrations are higher in that area. In fact in spite of the intense wind mixing the temperature and nutrient profiles at the shelf break look much like Cruise E-13-73.

Temperature data indicates the Gulf Stream lies nearer to the shelf break in the southern part of the study area relative to the northern sections.

<u>Cruise E-3-74, 24-29 April 1974</u> (Figures 21-26). This cruise was during a time of moderation of the stronger winter winds and seasonal heating. Shelf water temperatures are 18-21^{o}C with little horizontal or vertical structure.The outer shelf waters on section VI (Figure 26) are significantly affected by an intrusion of colder Gulf Stream water. This results in the coldest shelf waters being in the most southerly section.

Salinities in the shelf waters decrease towards the coast and exhibit estuarine type structure with higher salinities near bottom. A salinity maximum usually occurs well east of the shelf break at depths of 100-200 m.

The isotherms in deeper water slope up to the east in section I and II then down (Figures 21-22). At other more southerly sections, they slope down to the east. This implies a counter-current near the shelf break in the northern part of the area: isotherms sloping down to the west indicate the possible presence of a southerly flowing current (flowing counter to the Gulf Stream).

The nutrient concentrations reflect the presence of colder water at the shelf break and are relatively high. Sections I and VI (Figures 21, 26) show an especially active intrusion of deeper Gulf Stream water into the outer shelf waters.

Oxygen concentrations show a consistent minimum at 100-200 m.

Cruise E-12-74, 23-30 July 1974 (Figures 27-32). This cruise was in July during the typical summer season. The area is dominated by southerly winds. In all sections there was a significant intrusion of colder water onto the shelf.

On section I (Figure 27) water of 20°C is present at the shelf break. This cold water was accompanied by nutrient concentrations of .3, 2 and 2 μm for phosphate, nitrate and silicate, respectively. There is an indication of a counter-current at 200- to 300 m in the slope of the isotherms and isopycnals. Low salinity water is present in the nearshore surface waters implying an offshore movement of surface waters. No salinity maxima is observed which implies that the Gulf Stream lies farther to the east as is also implied by the isotherm slopes.

Section II is similar to section I with 20°C water at the shelf break. And again this water is accompanied by high nutrient concentrations. The lack of a well-developed salinity maximum and the isotherm position indicates that the Gulf Stream is well to the east of our stations. Salinities decrease near the coast. There is also an indication of offshore flow of low salinity water at mid-depth in the middle shelf. There are no well-developed oxygen minima.

In Section III (Figure 29) there are indications that the Gulf Stream is near the shelf break. None of the isopycnals or isotherms slope down to the west and the presence of a salinity maximum indicate that the Gulf Stream is closer to the shelf. 20^{o}C water is still at the shelf break and accompanied by high nutrient concentrations.

In Section IV (Figure 30) the position of the isohalines indicates that the Stream is still near the shelf break. Nutrient concentrations are low because of the Gulf Stream position.

In Section V (Figure 31) a current reversal is indicated near the shelf break. The isotherms and isopycnals dip at about 100 m near the shelf break. Nutrient concentrations are higher.

Section VI (Figure 32) represents an eastern movement of the Stream with a current reversal indicated. This could be caused by an eddy like feature. The presence of high salinity water (36.5^{o}/oo) at shallow depths (Stations 58 and 59) confirms this conclusion. High nutrient concentrations also accompany the high salinity water and nutrient concentrations in the shelf waters have been raised. It is concluded that water had intruded into these shelf waters and then was cut off, which is typical for the intrusion process.

DISCUSSION

In the previous sections the data were examined by plotting in horizontal and vertical planes. In this section, we will look at the relationship between the parameters, such as the temperature-salinity relationship. In addition we will calculate new parameters based on the original observations.

Freshwater Volume

The offshore distribution of river runoff (freshwater) is a useful indicator of the potential distribution of a river borne pollutant and of the gross circulation and diffusive characteristics of shelf waters.

Freshwater volume is the amount of freshwater ($S^o/oo = 0$) in m^3 required to reduce the salinity of a water column ($1\ m^2$) at $36^o/oo$ to the observed salinity. The key assumption is that Georgia Bight waters would have a salinity of $36.0^o/oo$ if no runoff waters were present. At any geographic location the amount of required freshwater to affect the observed salinity reduction is:

$$\text{freshwater volume} = \sum_{i=1}^{n-1} \left[\frac{72-(S_i+S_{i+1})}{72}\right]\cdot(Z_i-Z_{i+1})$$

where n = number of depths sampled
72 = twice the base salinity
S_i = observed salinity at depth Z_i
Z_i = depth of sample i

This calculation is made for each oceanographic station yielding a set of values for freshwater volume in m^3/m^2 that can be plotted and contoured as shown in Figure 33.

Drift Bottle Returns

The drift bottle returns (Figure 34) essentially confirm the results of Bumpus (1973). The offshore releases were within 45 km of the coast and not subject to the direct influence of the Gulf Stream which dominates flow at the shelf break. Thus these returns indicate the general direction of circulation of the shelf waters.

The September returns (E-13-73) all indicate a southerly flow with velocities greater than 20 km/day. The very high return rate and consistent southern direction implies a strong coherent flow during this time.

The December 1973 release had no returns although the release pattern was similar to the September release.

The April 1974 returns were also sparse with only two bottles returned. They indicated a weak northerly flow.

The July 1974 returns were high with a strong northerly flow in the northern part of the Georgia Bight and a southerly flow indicated in the inshore part of the southern part of the Bight. The July data may indicate the transition from a predominant northward flow in the winter, spring and early summer to a southerly flow in later summer and fall.

Apparent Oxygen Utilization

In deeper ocean waters the decomposition of plant and animal tissue produces higher concentrations of phosphate, nitrate, and silicate and reduces the amounts of oxygen present: the oxidation process consumes oxygen. The loss of oxygen is measured by subtracting the measured amount (O_2) from that which should be there if no oxidation had occurred. The amount of O_2 that should be in solution is the saturation value (O_2') which is the amount of O_2 that dissolved in seawater if that water is equilibrated with air at the observed temperature and salinity. The apparent oxygen utilization (AOU) is $O_2' - O_2$. Since the oxygen loss (AOU) is dependent on biological oxidative processes it is proportional to the nitrate, phosphate, and silicate produced. The high AOU (low oxygen) water (Figures 35-38) usually inclined with depth as did the isotherms. These values, although low, are not in any way restrictive to biological activity. The initial oxygen concentrations are 5-6 ml O_2/l so even an AOU of 3 ml O_2/l leaves 2-3 ml O_2/l in the water. While the AOU is an interesting parameter the oxygen anomaly is in many ways more useful.

Oxygen Anomaly

The water flowing north in the Gulf Stream has at least two origins. One is the Florida Strait between Florida and Cuba. The second is the Antilles current which flows northward in the area east of the Bahamas. These waters have a common origin in the central north Atlantic Ocean, however, the path for some water is more circuitious than others. The waters that emerge from the Straits of Florida have spent much time in the Caribbean Sea and the Gulf of Mexico and their chemical characteristics have changed. The Gulf Stream water that traveled through the Caribbean and Gulf of Mexico has lower oxygen content than water of an identical temperature that moved in the Antilles current. The amount of this difference is the oxygen anomaly. Thus this tracer is useful to define the two water masses and was originally discussed by Rossby (1936). Since the tracer indicates water of tropical origin it is useful in the interpretation of the shelf flora and fauna which often has tropical components.

During the September cruise (E-13-73) (Figure 39) the zones of high oxygen anomaly coincided with temperatures of ca. 22^{o}C. In Sections I through IV the oxygen anomaly water is not abundant; however, Section V shows large amounts and what appears to be two masses. This correlates with the temperature and density structure which indicates an eddy feature.

During the December cruise (E-19-73) (Figure 40) the oxygen anomaly occurs in large quantities in Section VI which coincides with high nutrient concentrations. Contrasting Section II and VI temperatures and oxygen anomaly the oxygen anomaly occurs when the isotherms tilt up steeply to the continental slope. This condition corresponds to an east position of the Gulf Stream with no eddy structures present.

The E-3-74 data (April) (Figure 41) shows the pattern displayed previously. Where the isotherms indicate an eddy structure we find oxygen anomaly water at the shelf break.

Data from Cruise E-12-74 (July) (Figure 42) shows the most amounts of oxygen anomaly. This correlates with the eddy structure present in many of the sections (I, III, V, and VI).

The distribution of the anomaly is difficult to predict although it does correlate with the presence of eddies (isotherms tilting down to the west) and possibly with Gulf Stream positions. The important observation is the extreme variability of the position and amount of anomalous water. This could be partly due to bias induced by our discrete sampling, however we feel more is indicated. It is indicated that the amounts of various water masses vary with time in the Gulf Stream.

Summarized Horizontal Effect of Runoff and Intrusions.

The offshore extent of runoff and the onshore extent of intrusions were determined from all the data to see if a pattern exists. The composite data (Figures 43-46) for the four cruises are summarized in Table 2. Runoff averages 56 km offshore in the north but less than 3 km in the south. Conversely intrusions extend onshore an average of 20 km but extend much further onshore in the south than the northern part of the area.

The Ranges of Temperature

The annual range in water temperature is important since it will effect animal growth rates or, in extreme cases, the survival rate. While the nearshore waters have an annual range of 12.3°C the offshore surface waters have an average range of 6.4°C and the shelf break bottom waters an annual range of 4.2°C. This results from the influence

TABLE 2

Average offshore extent of runoff			
	Section I	56.5 ± 33.3	n=4
	II	42.3 ± 23.6	n=4
	III	33.8 ± 15.0	n=4
	IV	37.8 ± 23.0	n=4
	V	19.5 ± 1.3	n=4
	VI	2.7 ± 4.6	n=3
Average for all sections		33.4 ± 24.7 km	n=23
Average inshore extent of intrusions			
	Section I	15.5 ± 17.2	n=4
	II	12.8 ± 10.5	n=4
	III	27.3 ± 9.5	n=4
	IV	11.5 ± 1.3	n=4
	V	13.5 ± 13.4	n=4
	VI	40.0 ± 30.8	n=3
Average for all sections		19.2 ± 16.6 km	n=23

of the Gulf Stream. The nearshore waters are subject to extreme cooling and heating causing the large annual range. The offshore surface waters, while also subject to seasonal heating and cooling are moderated by the consistently warm Gulf Stream waters. The deep waters offshore are not subject to atmospheric cooling or heating, but only minor variations caused by Gulf Stream meandering.

These results are important to fisheries since many tropical species cannot tolerate the large temperature ranges observed in the nearshore waters. However they can tolerate the minor temperature ranges in the deeper waters at the shelf break.

T-S Relationship

The relationship of temperature to salinity, a T-S plot, is a standard oceanographic procedure used to analyze data. In the central oceans the TS plot is very characteristic for each ocean and each depth in that ocean (i.e., water of $10^{o}C$ always has a salinity of about $35.0^{o}/oo$). The relationship is very predictable for subsurface waters. However, surface waters can easily change temperature because of atmospheric conditions, and the salinity may change as a result of runoff, rain, or evaporation. Therefore, while the T-S relationship of deeper waters such as the deeper Gulf Stream waters is constant, the T-S relationship of Georgia shelf waters is quite variable depending on the season. Figure 47 shows the T-S plots for the four cruises.

The early winter cruise is a time of minimum temperatures and low runoff, consequently observed temperatures were at a minimum and salinities were relatively high.

During April 1974, which is during the high runoff and warming season, higher temperatures were observed and the lowest salinities of any cruise.

In July 1974, during a period of highest temperatures and decreasing runoff, higher temperatures were observed and lower salinities than in September 1973 when runoff is lower.

The T-S relationship of shelf water closely reflects the runoff and air temperature. That relationship is shown in the following schematic (Figure 48). This diagram was made by taking the minimum observed salinities and temperature for the four cruises, plotting them (heavy dots) and then connecting the dots. This represents the seasonal cycle of salinity and temperature in the nearshore zone for the whole coast. The pattern reflects the combined effect of seasonally varying temperatures and runoff that peaks in the late winter and again in the late summer. Thus from January to April the water continues to warm, but the runoff decreases causing salinity to increase. From July to September the temperatures stabilize while runoff increases, decreasing the salinity. Finally, from October to December the temperature decreases, because of lowering air temperature, while salinity increases because of decreased runoff. This is caused by the subtropical runoff pattern: the runoff pattern in most temperate areas is unimodal.

Nitrate-Phosphate-Silicate-Temperature Relationships

The various relationships between nitrate, phosphate, silicate and temperature are useful to confirm the quality of the data and to elucidate some of the chemical, biological, and physical processes at work.

The ratio between nitrate and phosphate concentrations in deeper water is usually 16:1. This results from the 16:1 ratio of N to P in phytoplankton tissue. The subsequent bacterial mineralization of this tissue in deep water produces the observed 16:1 ratio. All of our nitrate-phosphate data is plotted in Figure 49. The theoretical 16 to 1 line is also shown. Note that at low concentrations there is usually excess phosphate with respect to nitrate. These samples are from shallow areas where nitrate is consumed and not quickly released while phosphate is quickly released.

The plot of nitrate vs AOU (apparent oxygen utilization; Figure 50) demonstrates that nitrate is produced at the expense of oxygen: an oxidation/reduction reaction.

Since all nutrient concentrations generally increase with depth and temperature decreases one may expect a relationship between these parameters. Figure 51 shows a nitrate-temperature plot of all of our data. At lower temperatures the relationship is very consistent and essentially allows one to predict nitrate given the water temperature.

CONCLUSIONS

The preceding data presentation and discussions make many points. It should be apparent that many things about the Georgia Bight are predictable. Temperature-salinity relationships and patterns are consistent and reasonably predictable as are the nutrient relationships. Knowledge of the processes that control these is where we fall short. Intrusions, although easily recognized, are not understood. We do not know to what extent they occur or how often. The distribution of freshwater in the offshore waters is also easily detected but we do not understand the forces that disperse the waters and produce the distribution we observe.

The understanding of these processes is more important in many cases than knowing the distribution of some compound resulting from the process. We must know the process if we are to make reasonable judgments concerning the effects of man's activities on the ocean system.

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FIGURES

Figure 1. Station locations, Cruise E-13-73

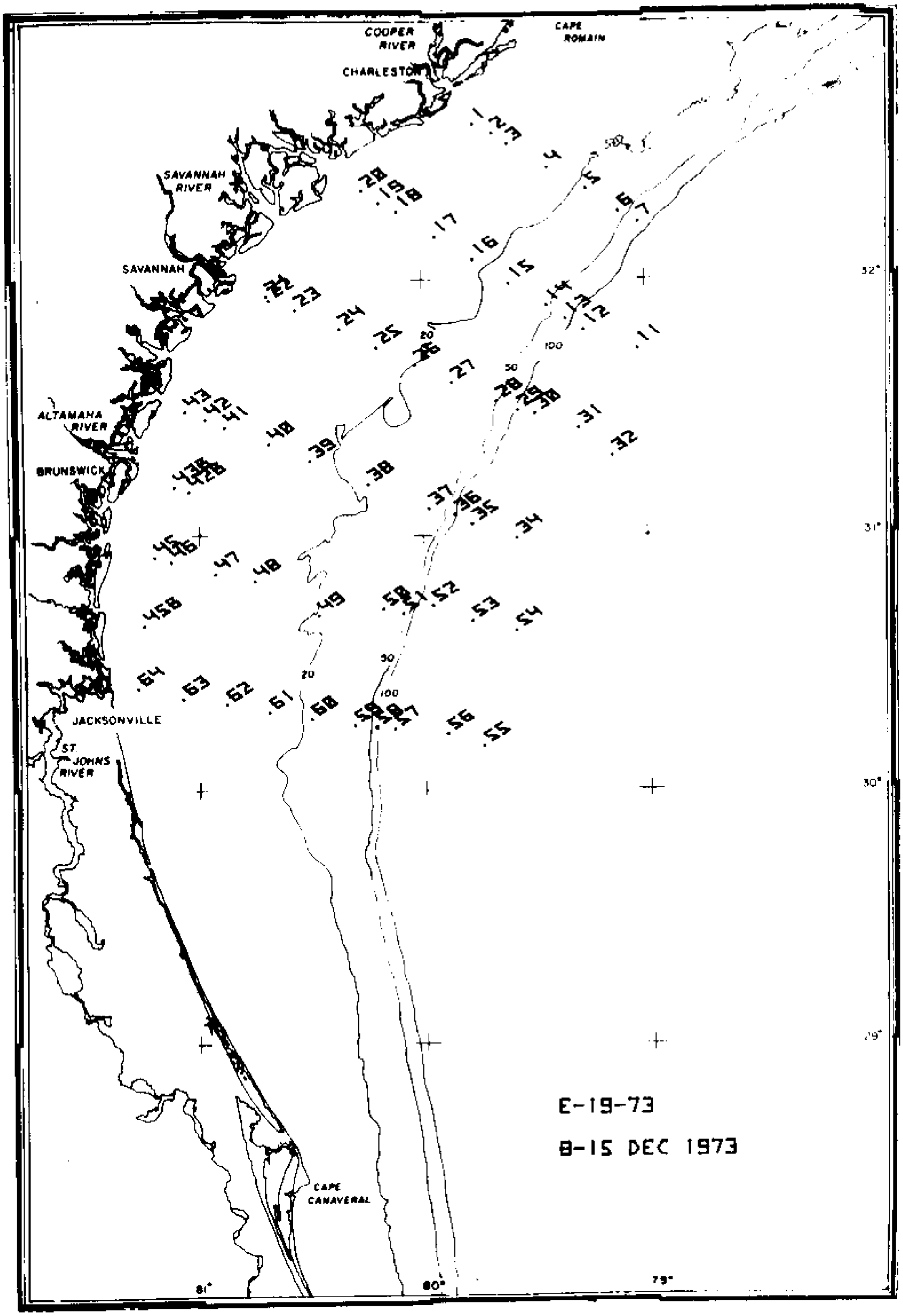

Figure 2. Station Locations, Cruise E-19-73

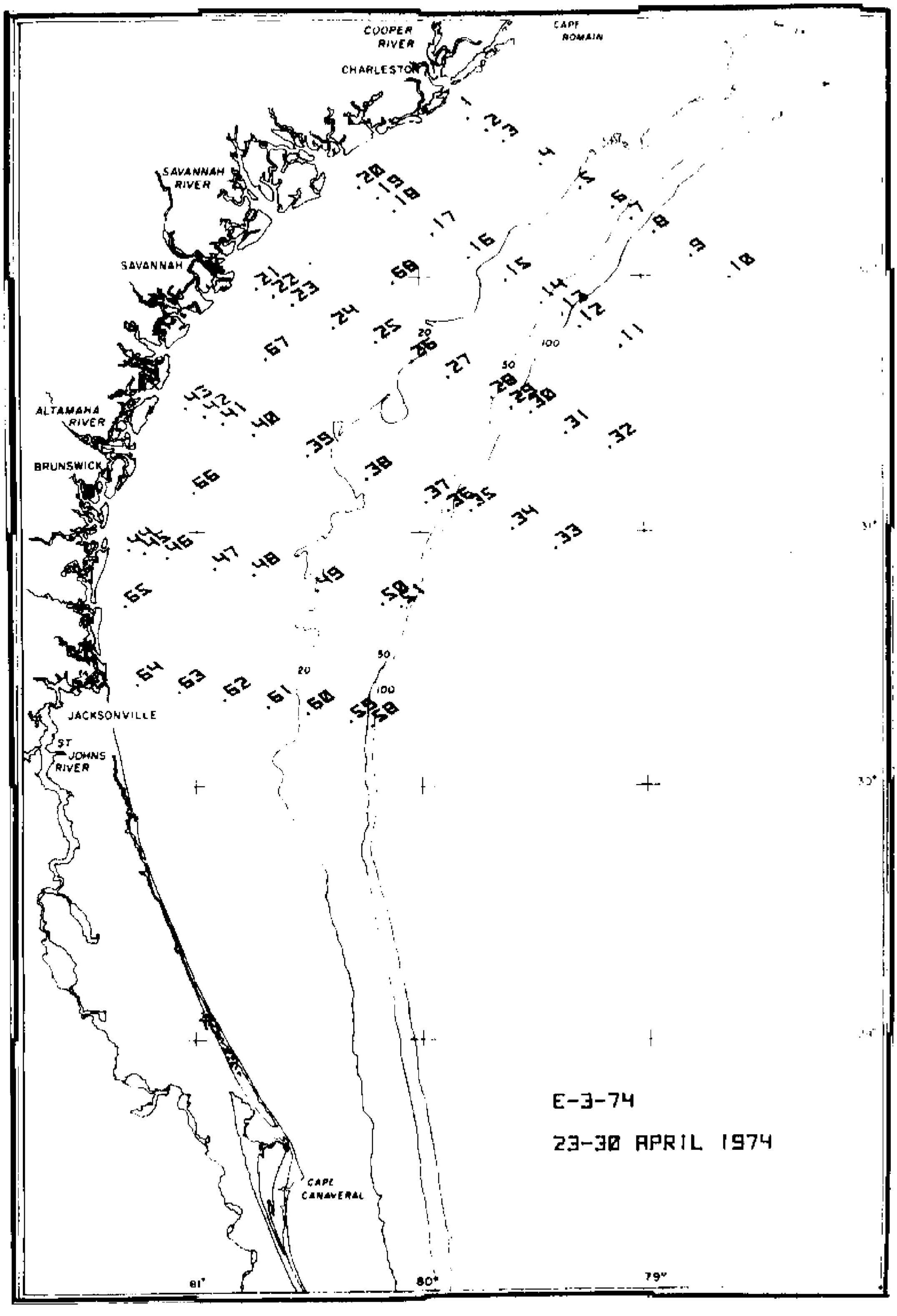

Figure 3. Station Locations, Cruise E-3-74

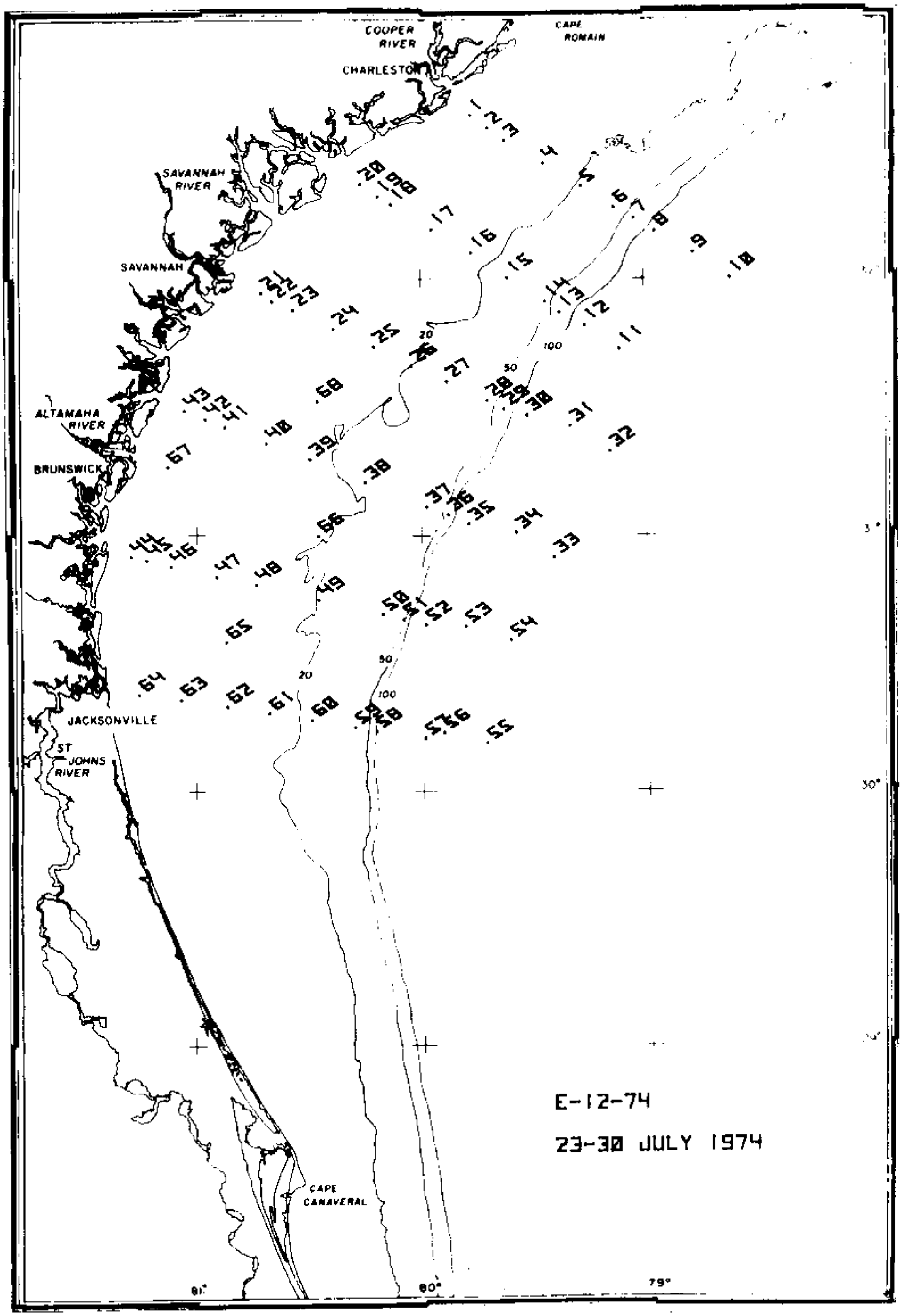

Figure 4. Station Locations, Cruise E-12-74

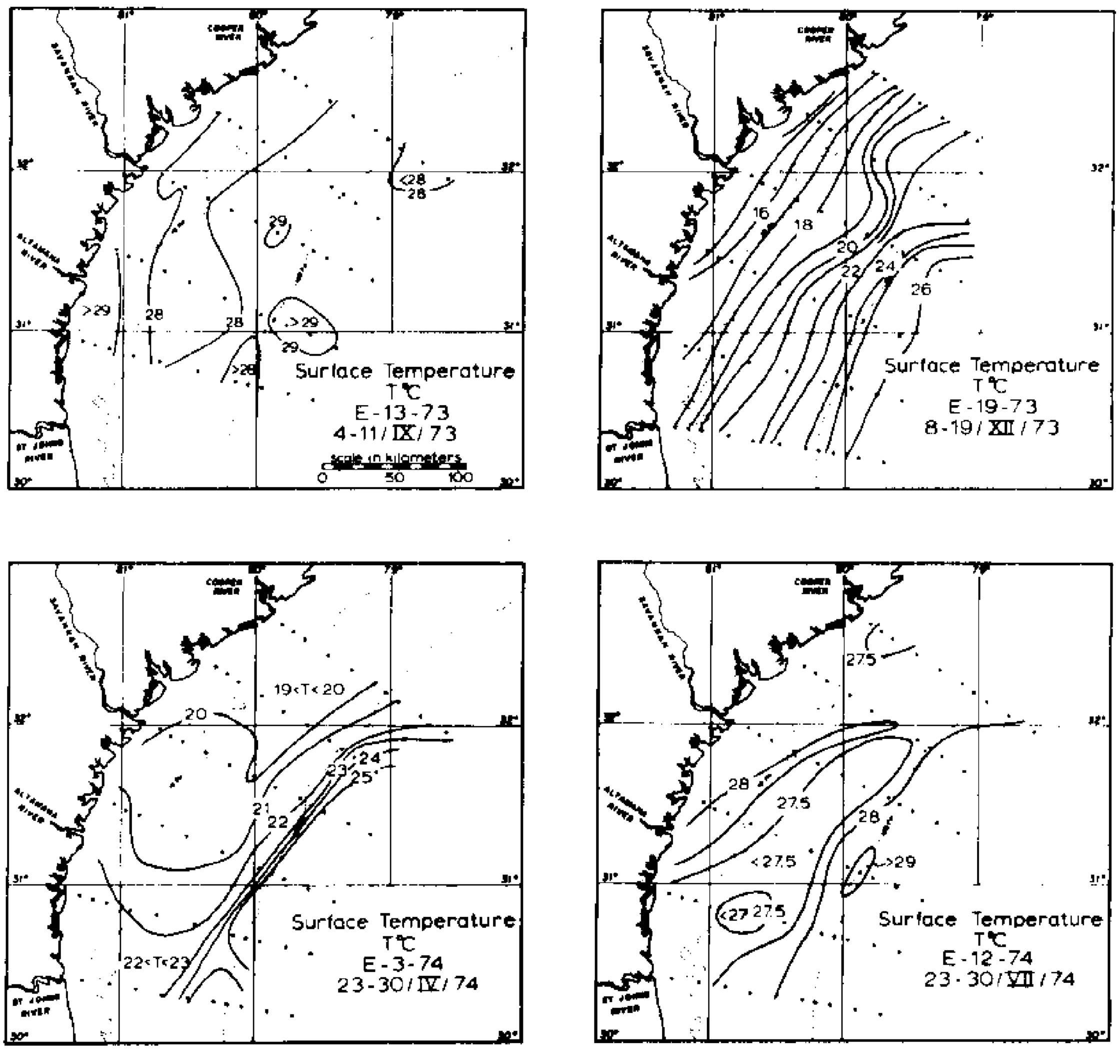

Figure 5. Surface Temperature

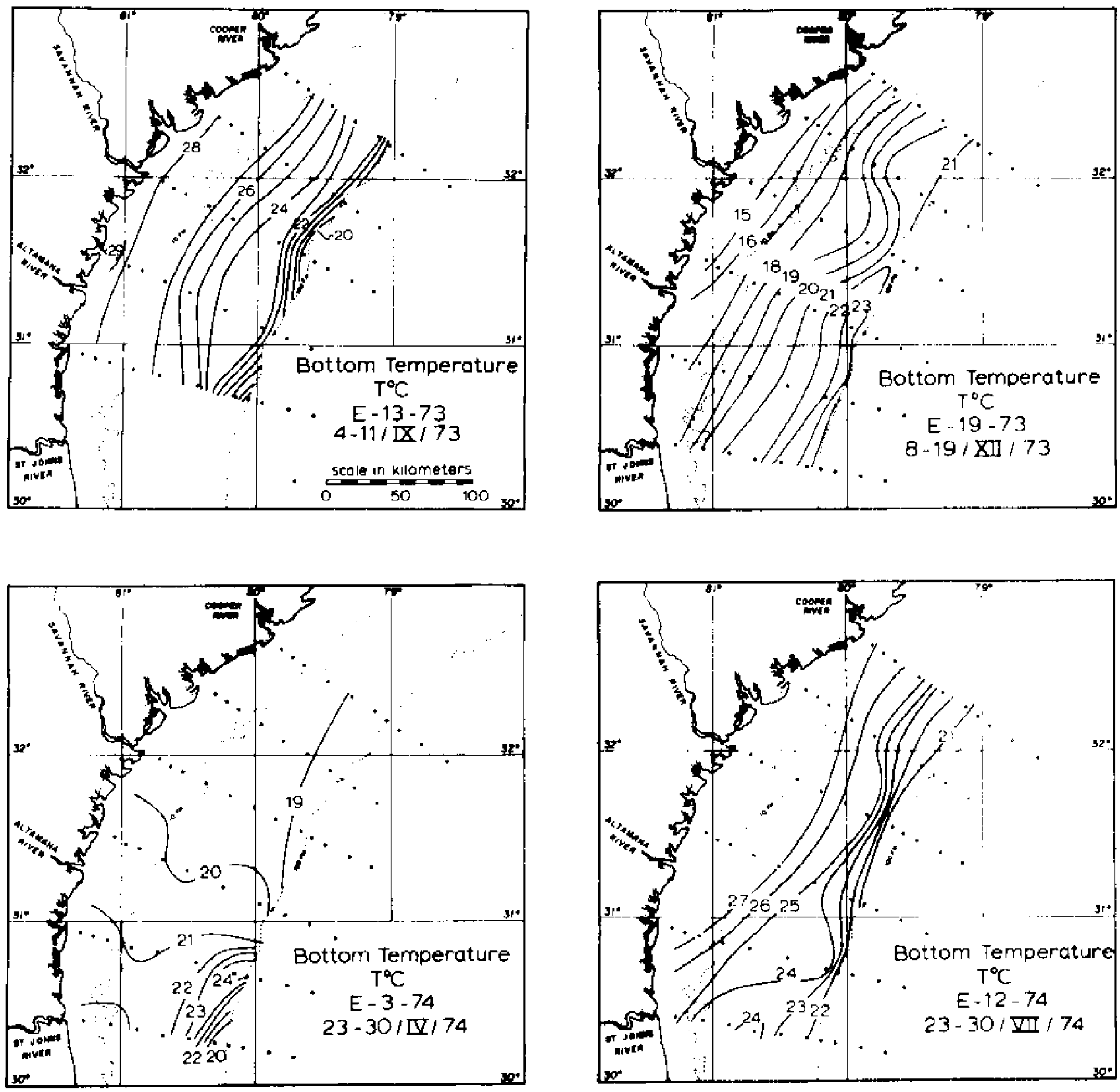

Figure 6. Bottom Temperature

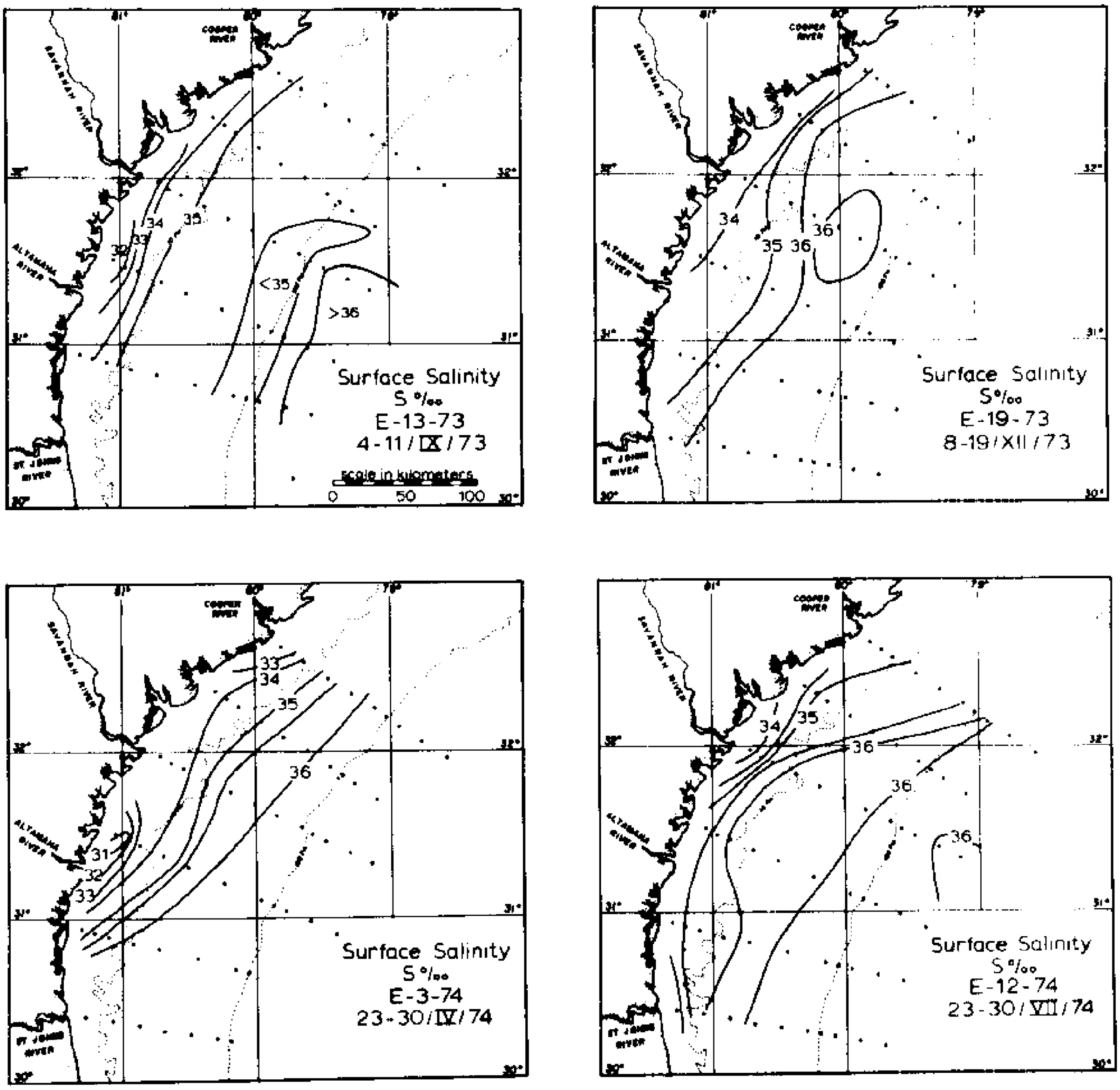

Figure 7. Surface Salinity

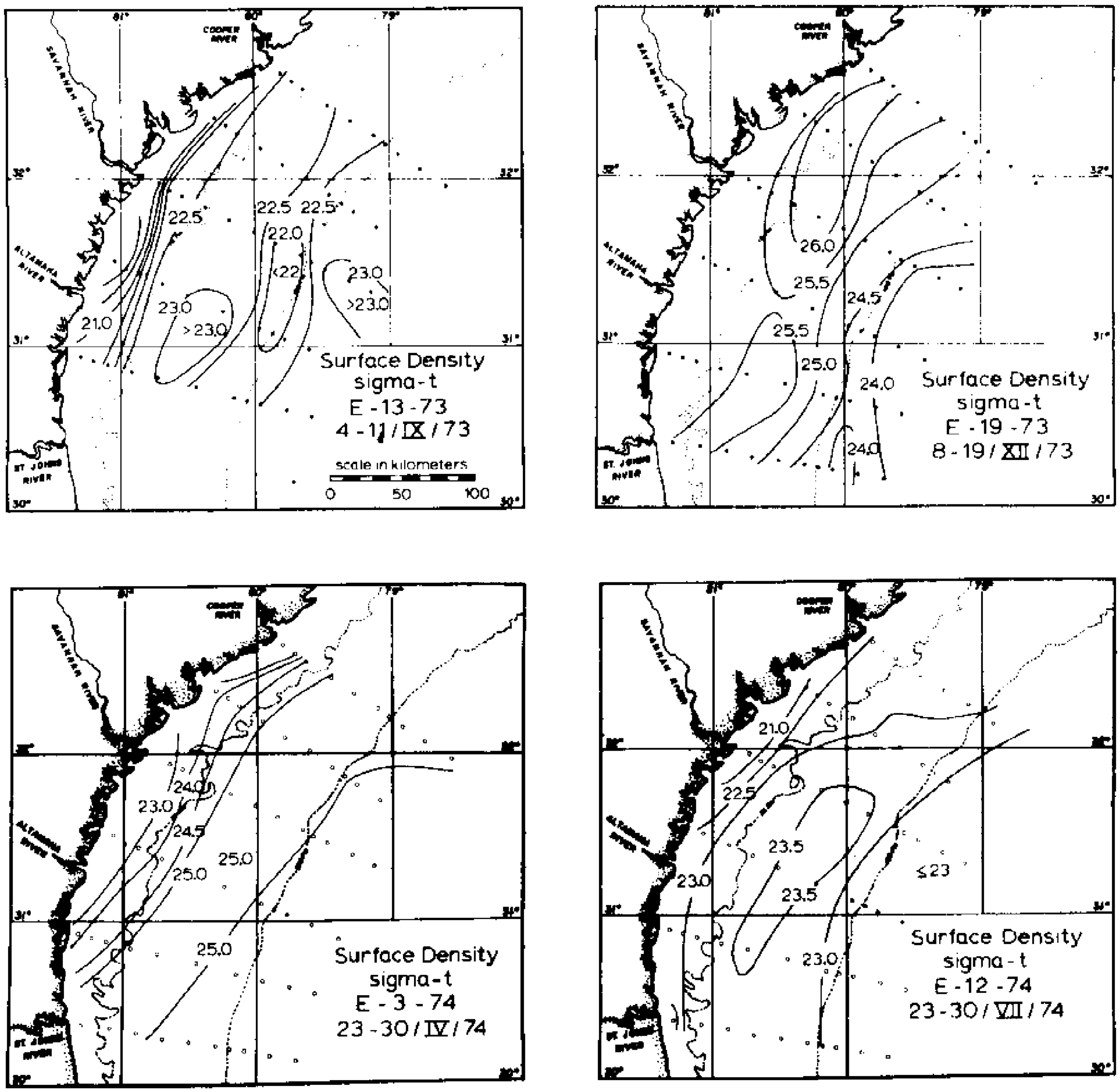

Figure 8. Surface Density

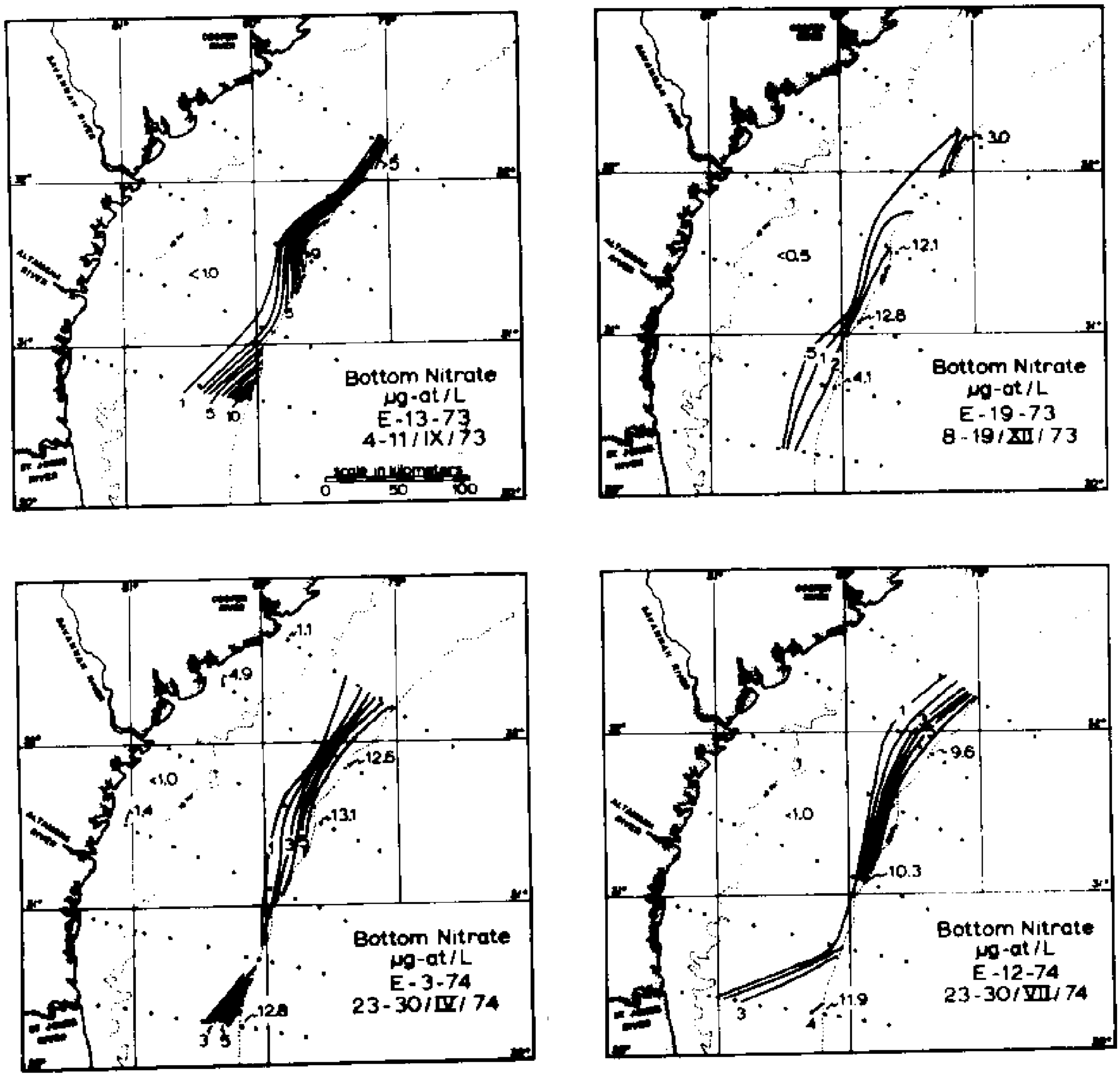

Figure 9. Bottom Nitrate

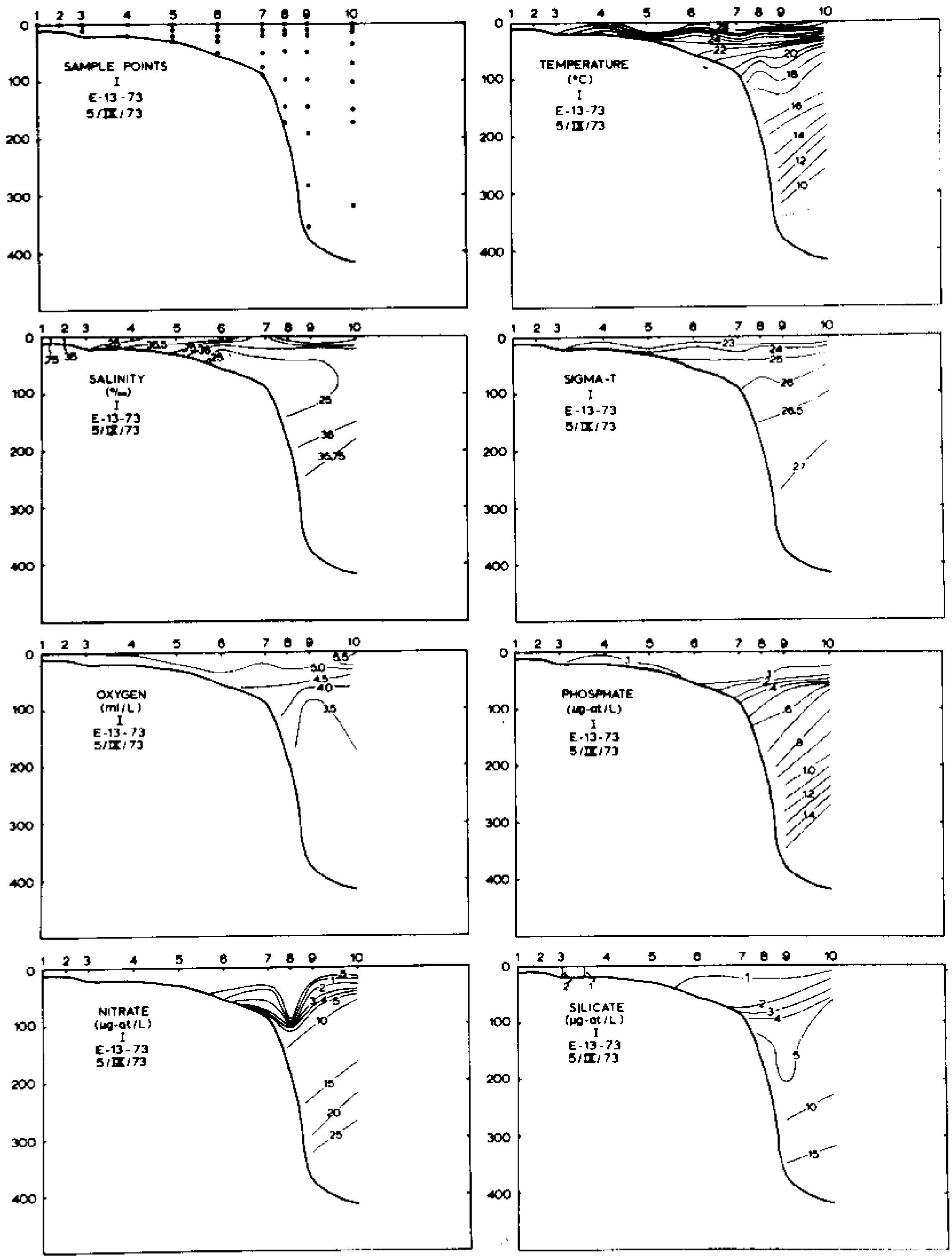

Figure 10. Vertical Section, Cruise E-13-73, Section I

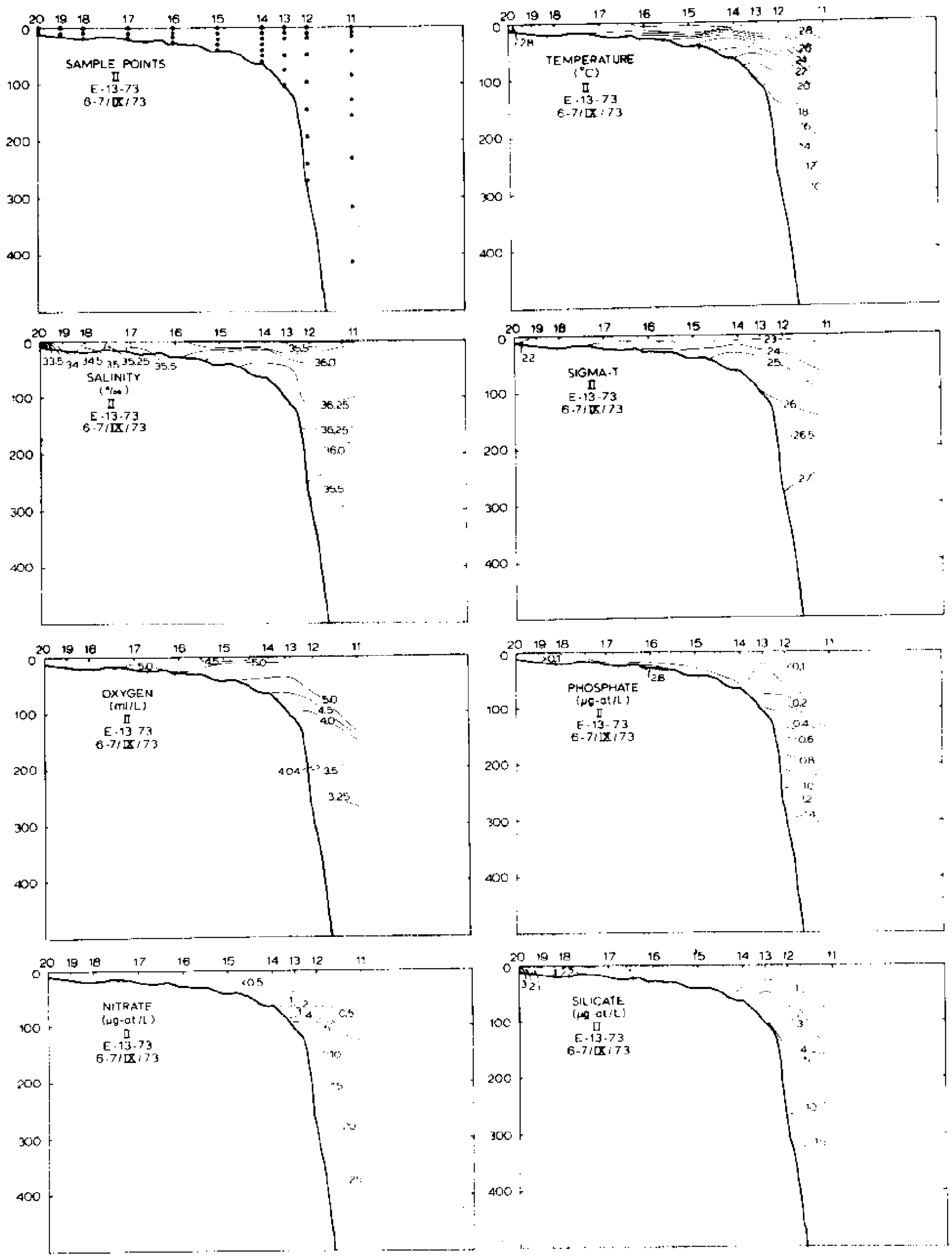

Figure 11. Vertical Section, Cruise E-13-73, Section II

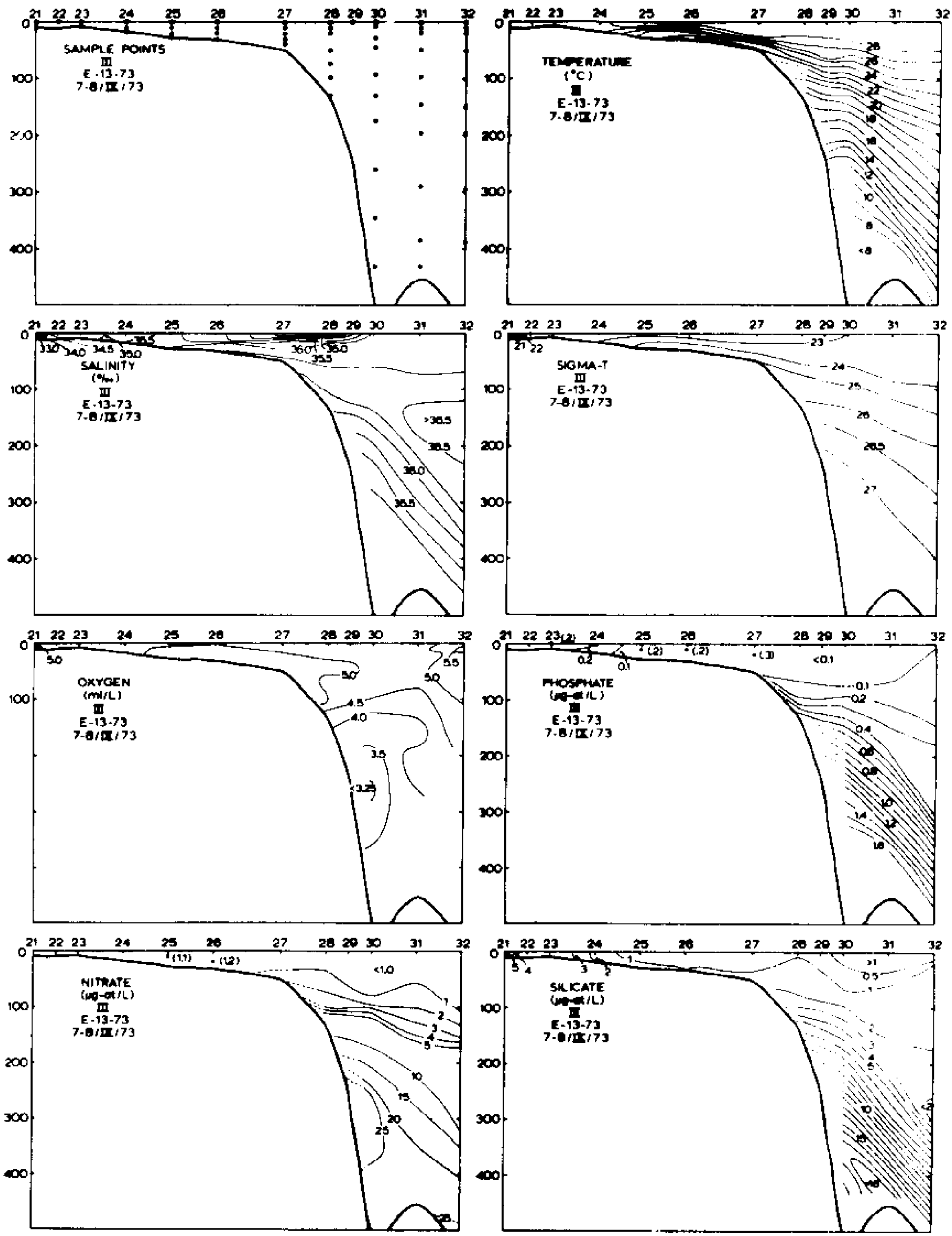

Figure 12. Vertical Section, Cruise E-13-73, Section III

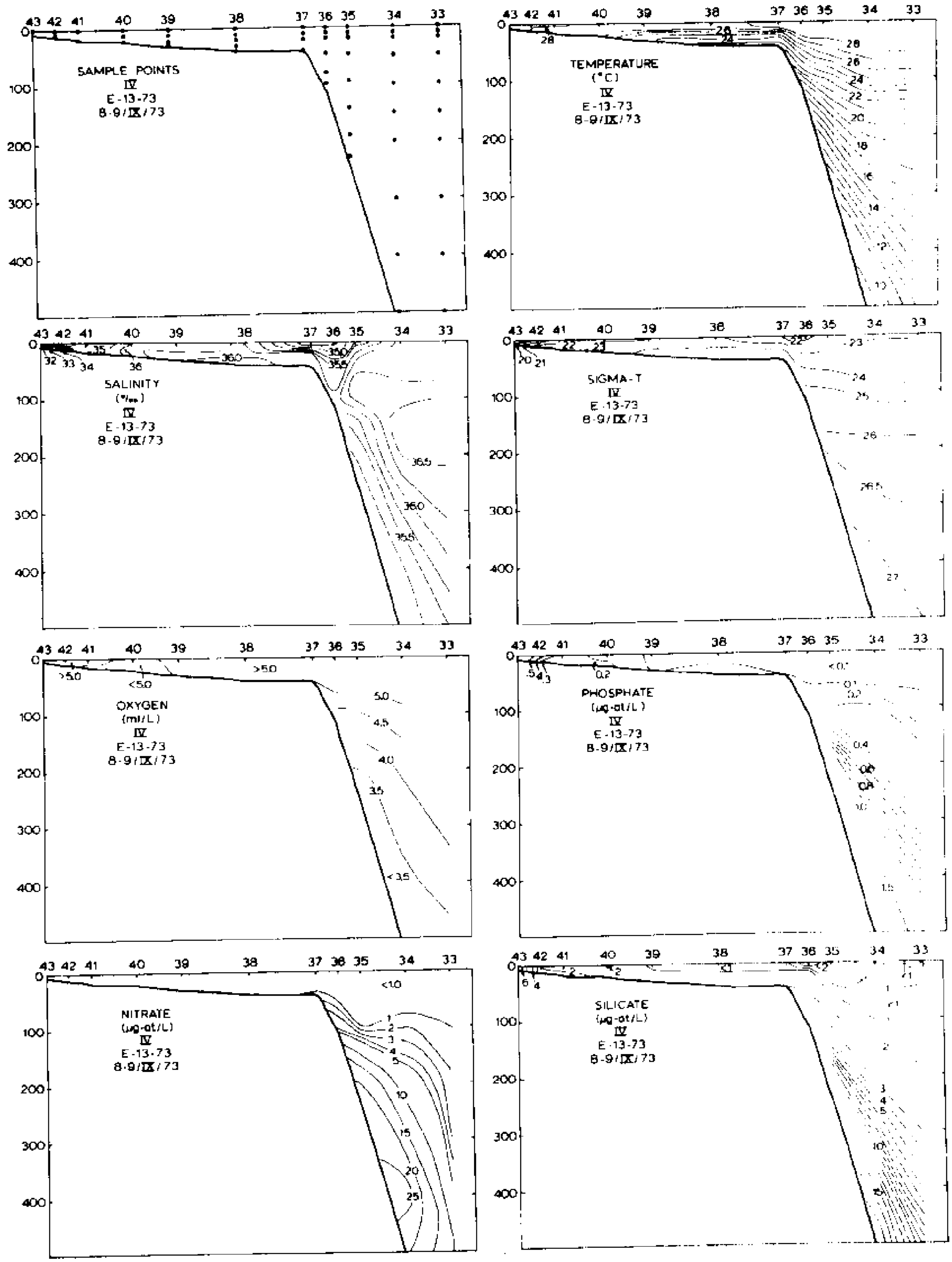

Figure 13. Vertical Section, Cruise E-13-73, Section IV

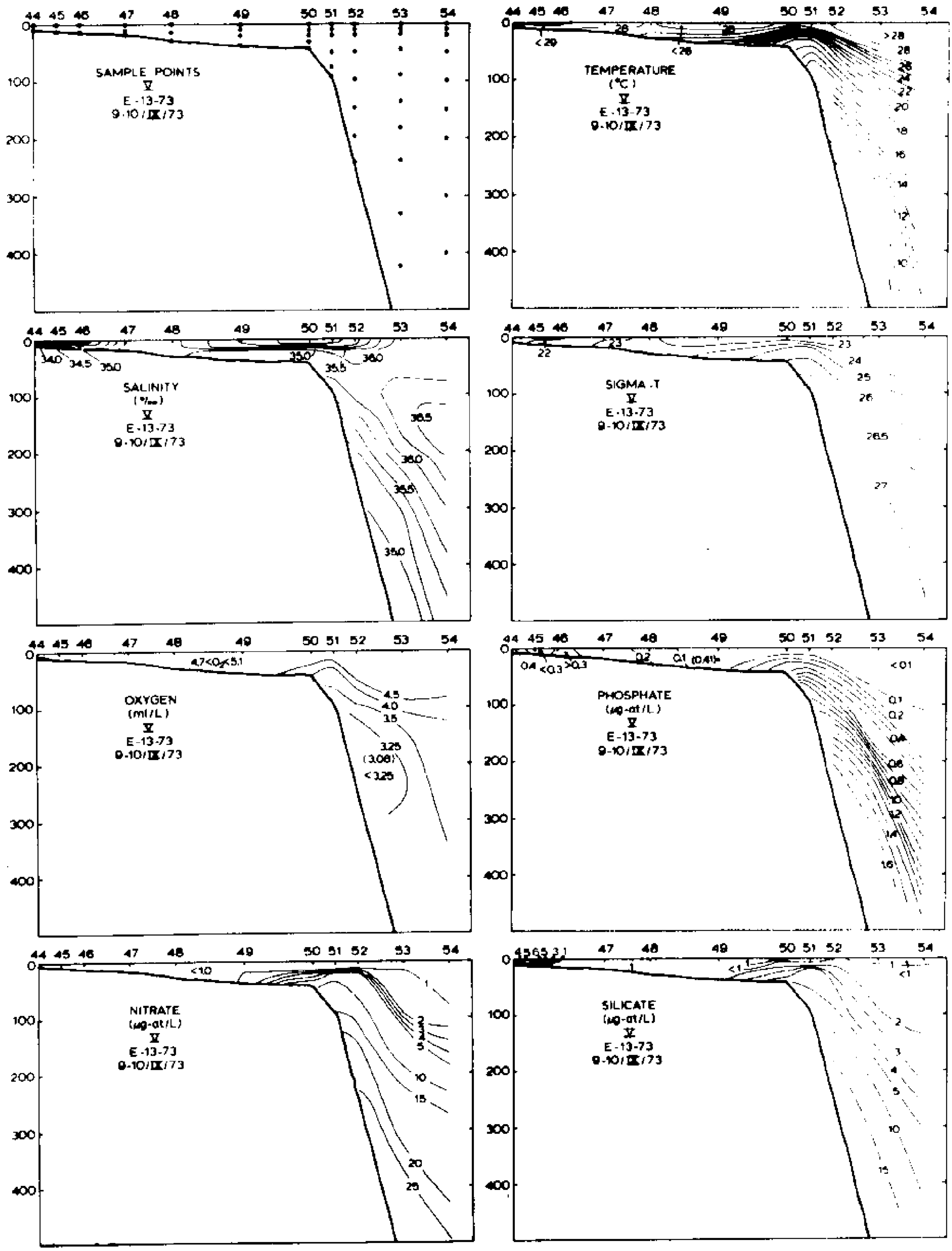

Figure 14. Vertical Section, Cruise E-13-73, Section V

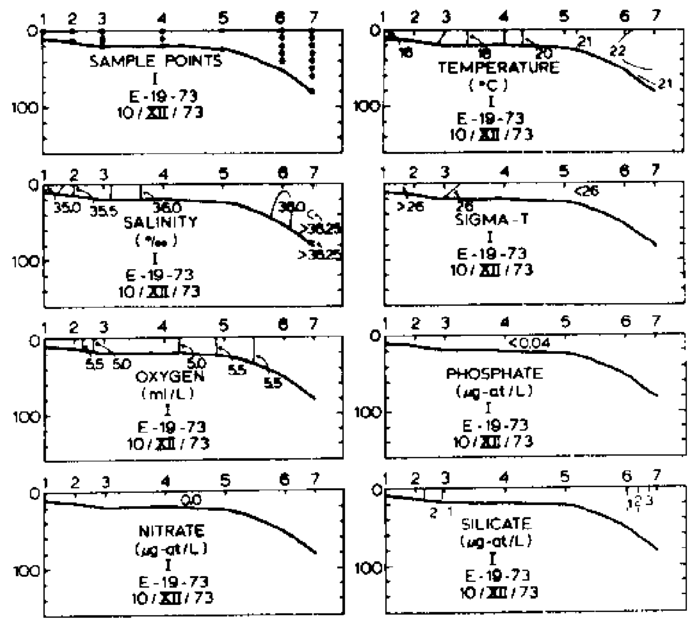

Figure 15. Vertical Section, Cruise E-19-73, Section I

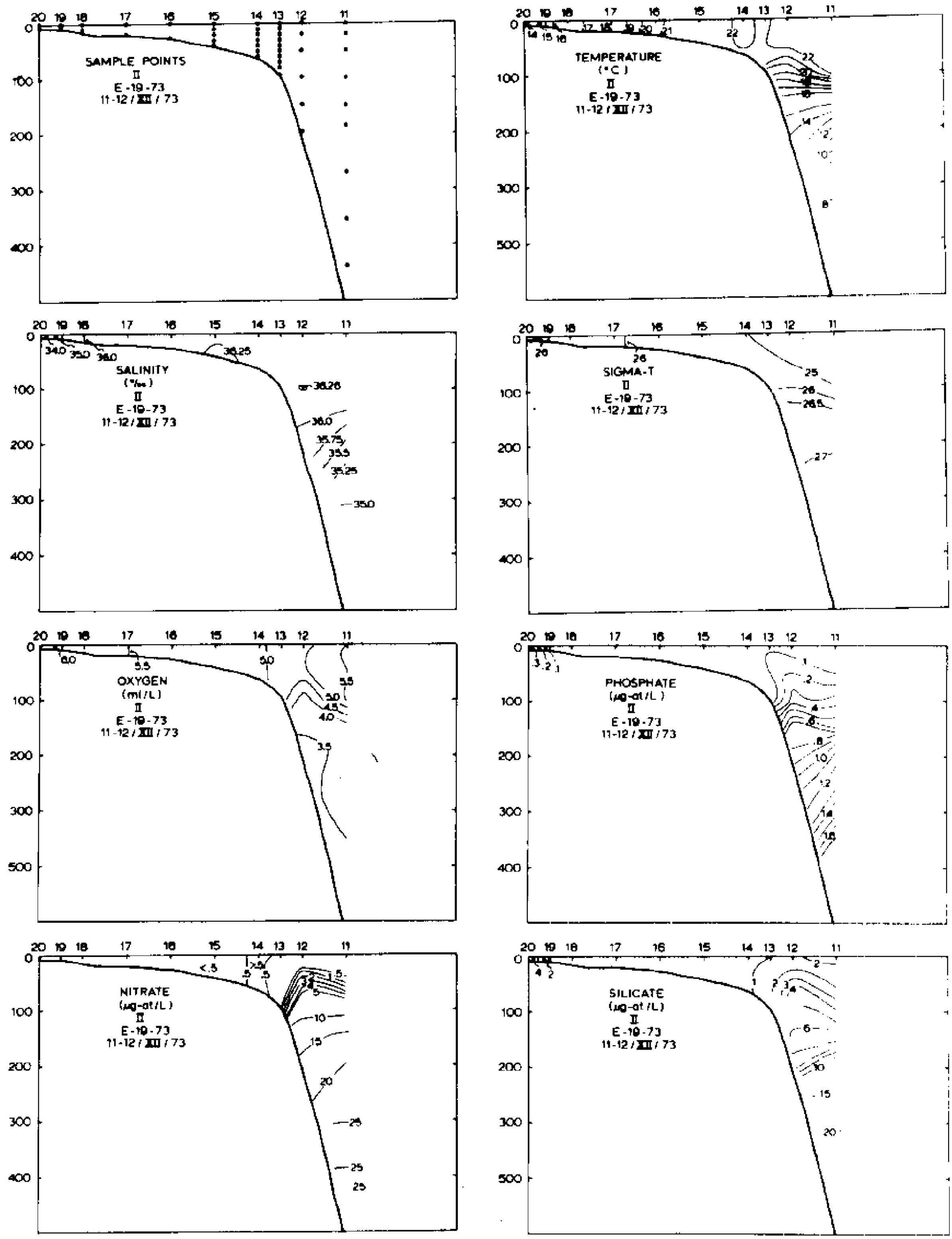

Figure 16. Vertical Section, Cruise E-19-73, Section II

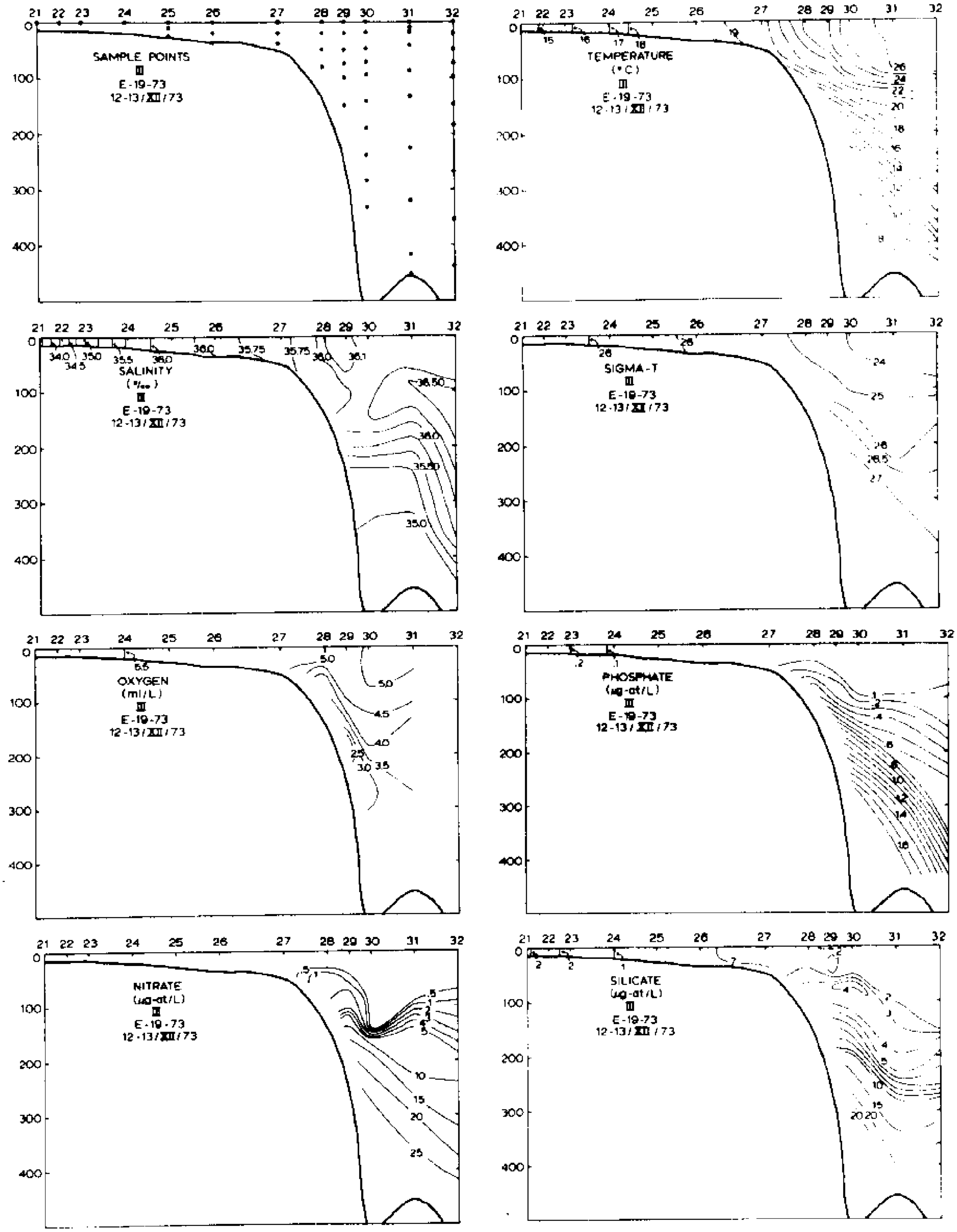

Figure 17. Vertical Section, Cruise E-19-73, Section III

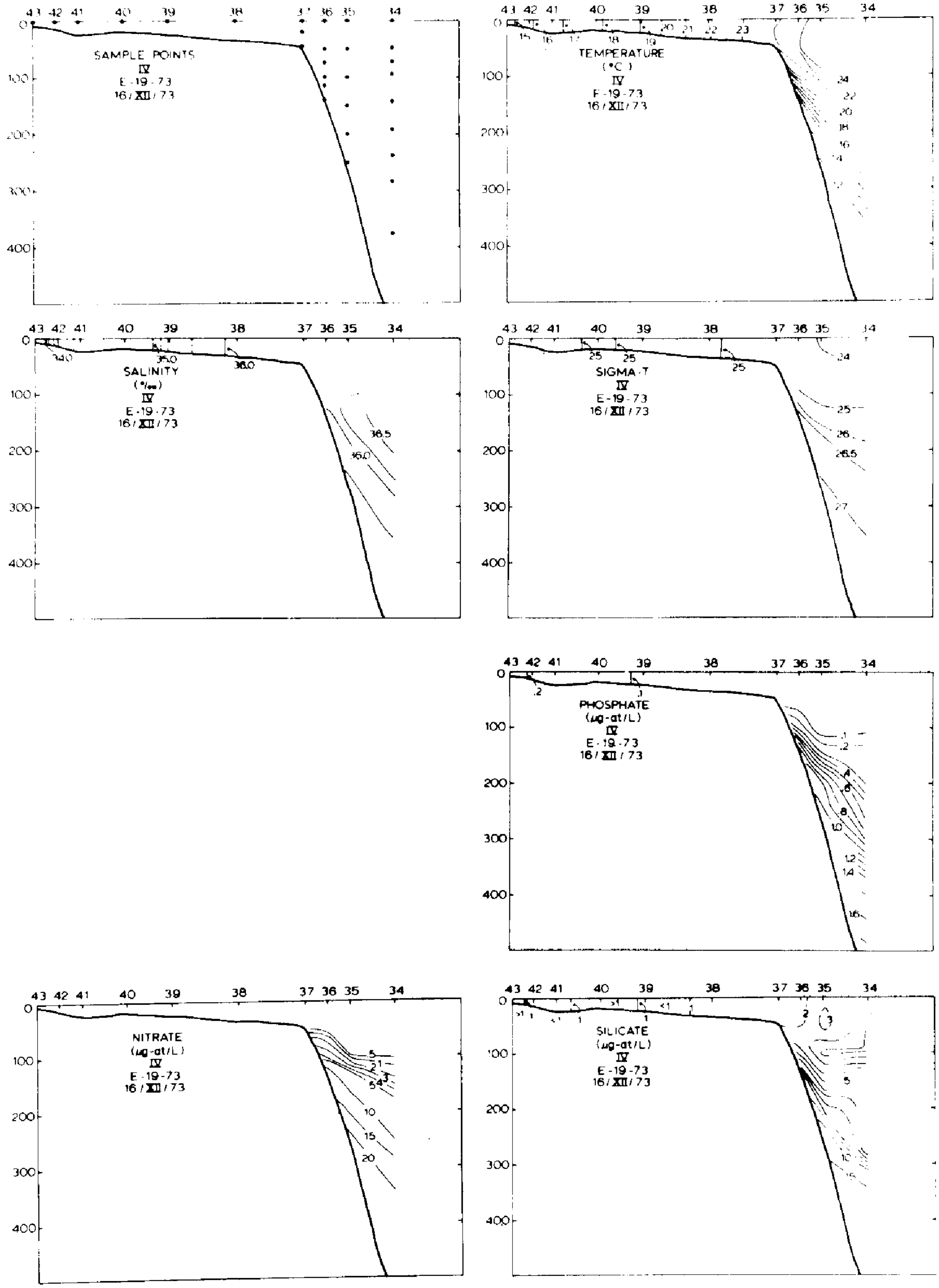

Figure 18. Vertical Section, Cruise E-19-73, Section IV

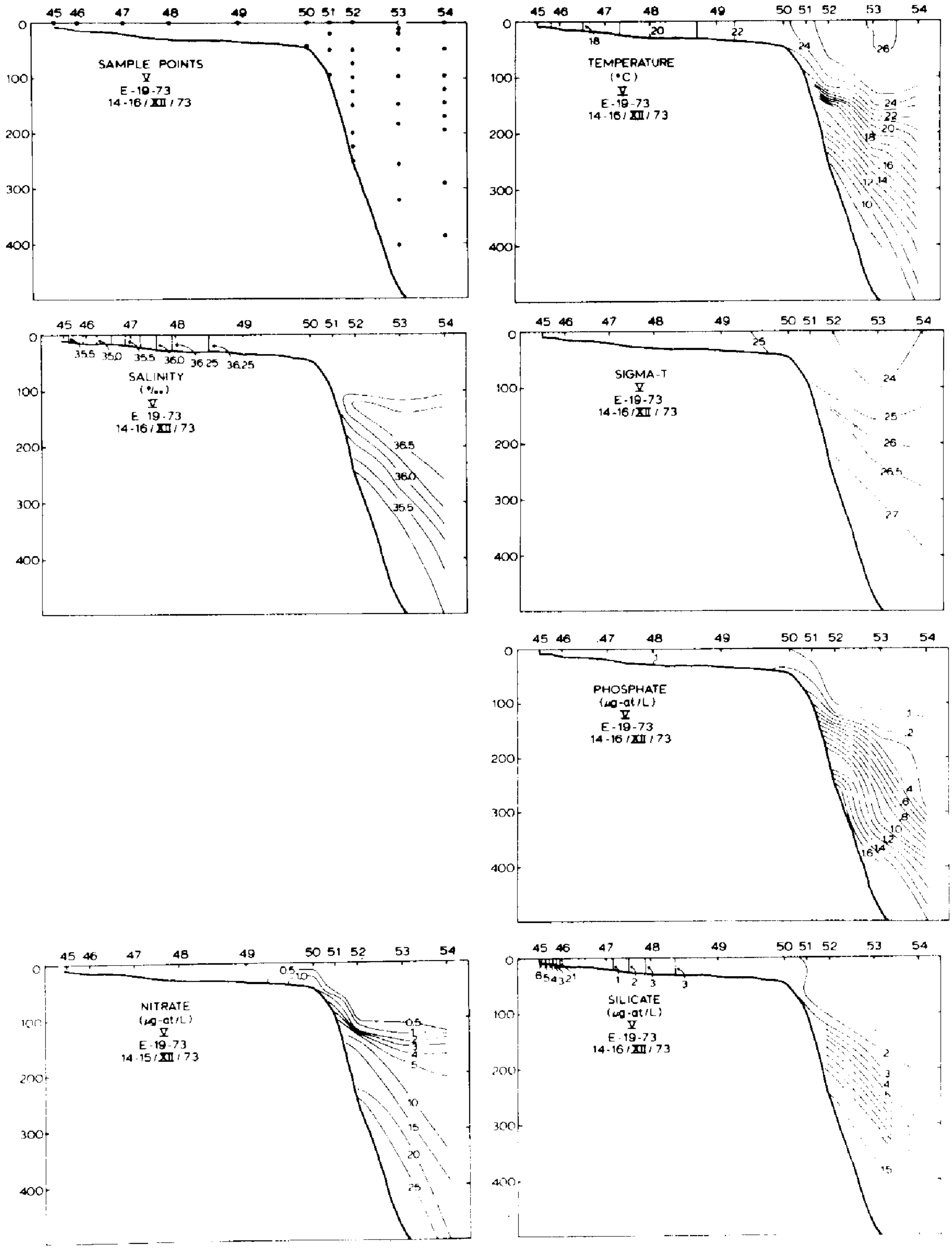

Figure 19. Vertical Section, Cruise E-19-73, Section V

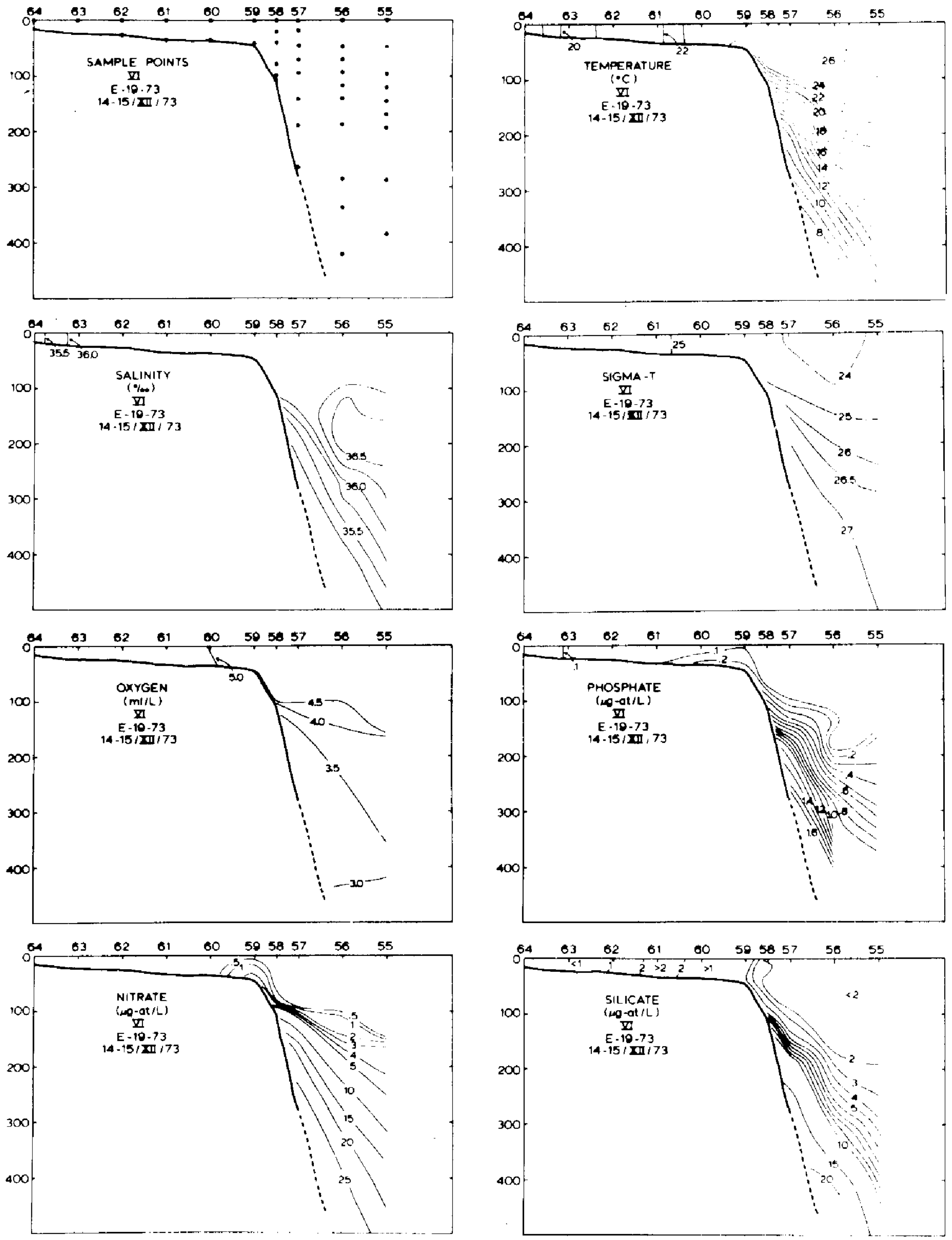

Figure 20. Vertical Section, Cruise E-19-73, Section VI

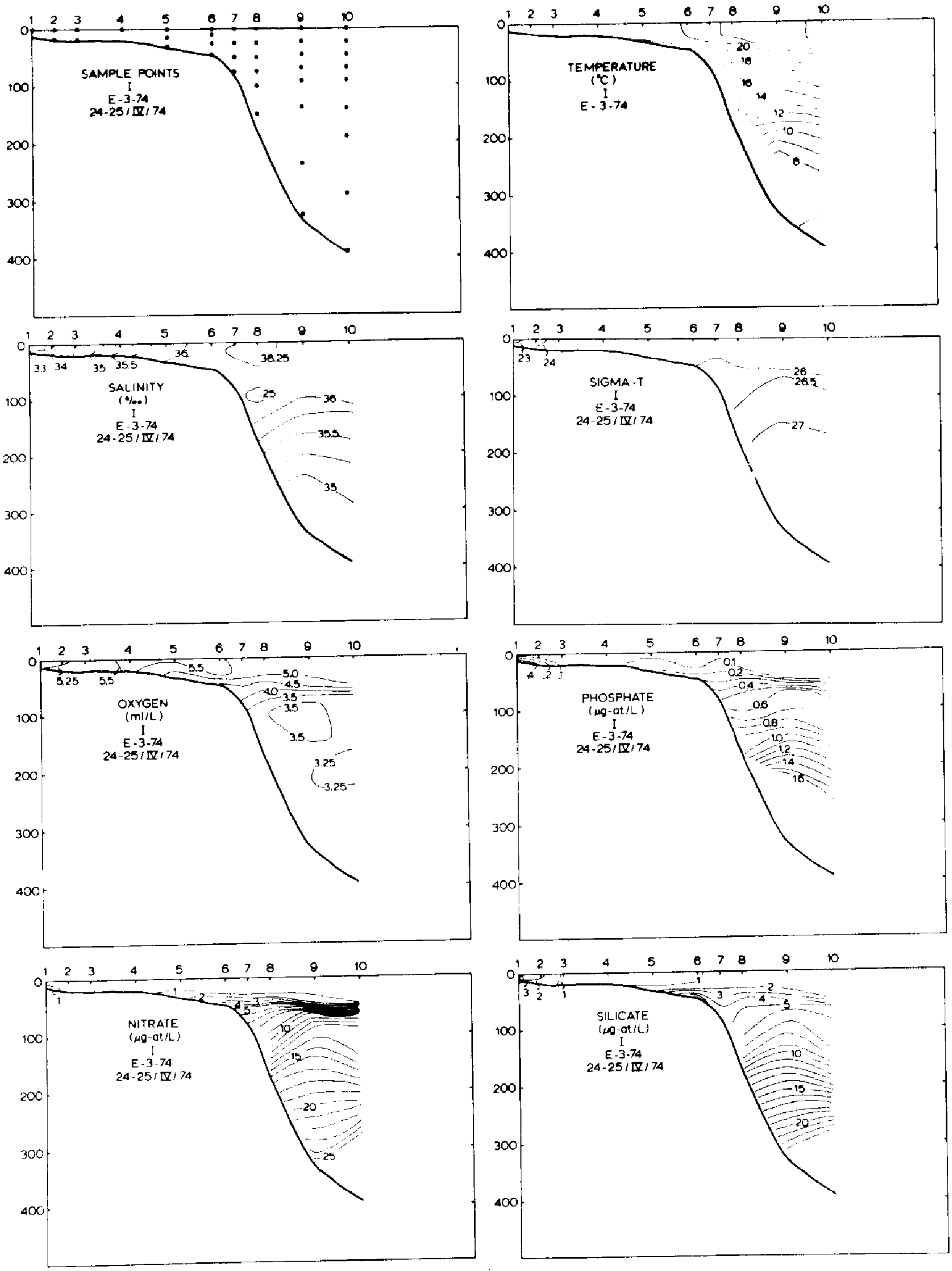

Figure 21. Vertical Section, Cruise E-3-74, Section I

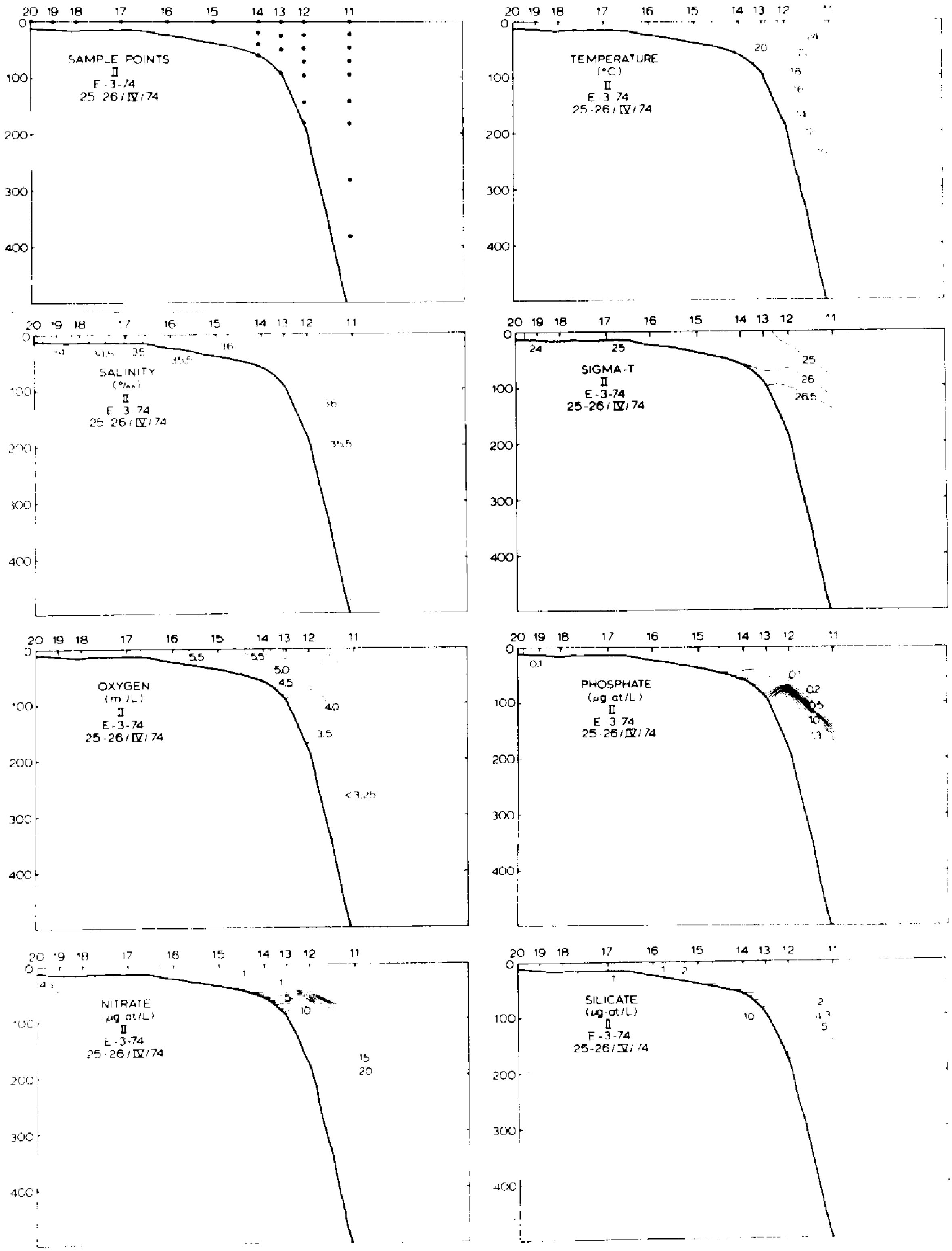

Figure 22. Vertical Section, Cruise E-3-74, Section II

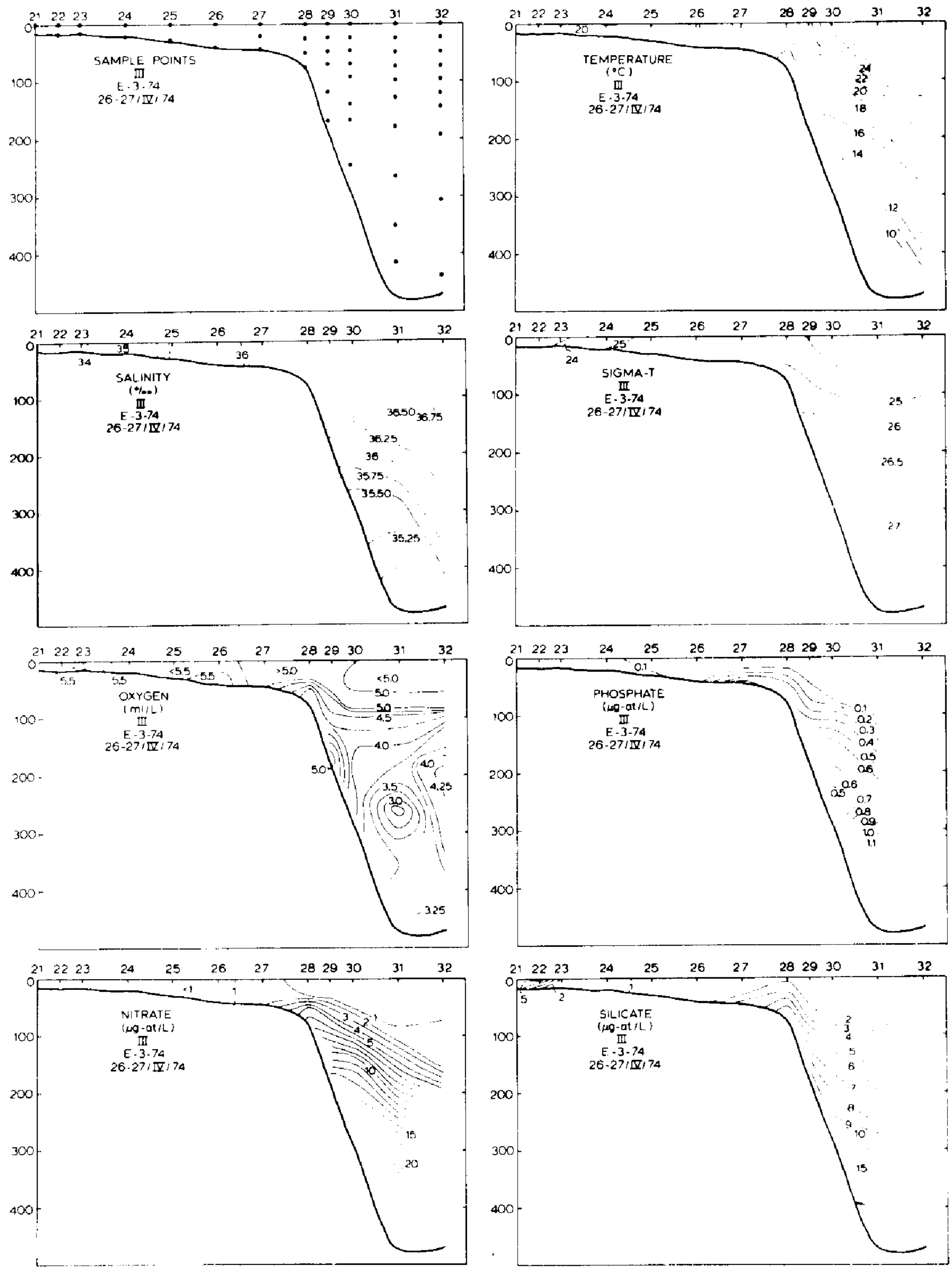

Figure 23. Vertical Section, Cruise E-3-74, Section III

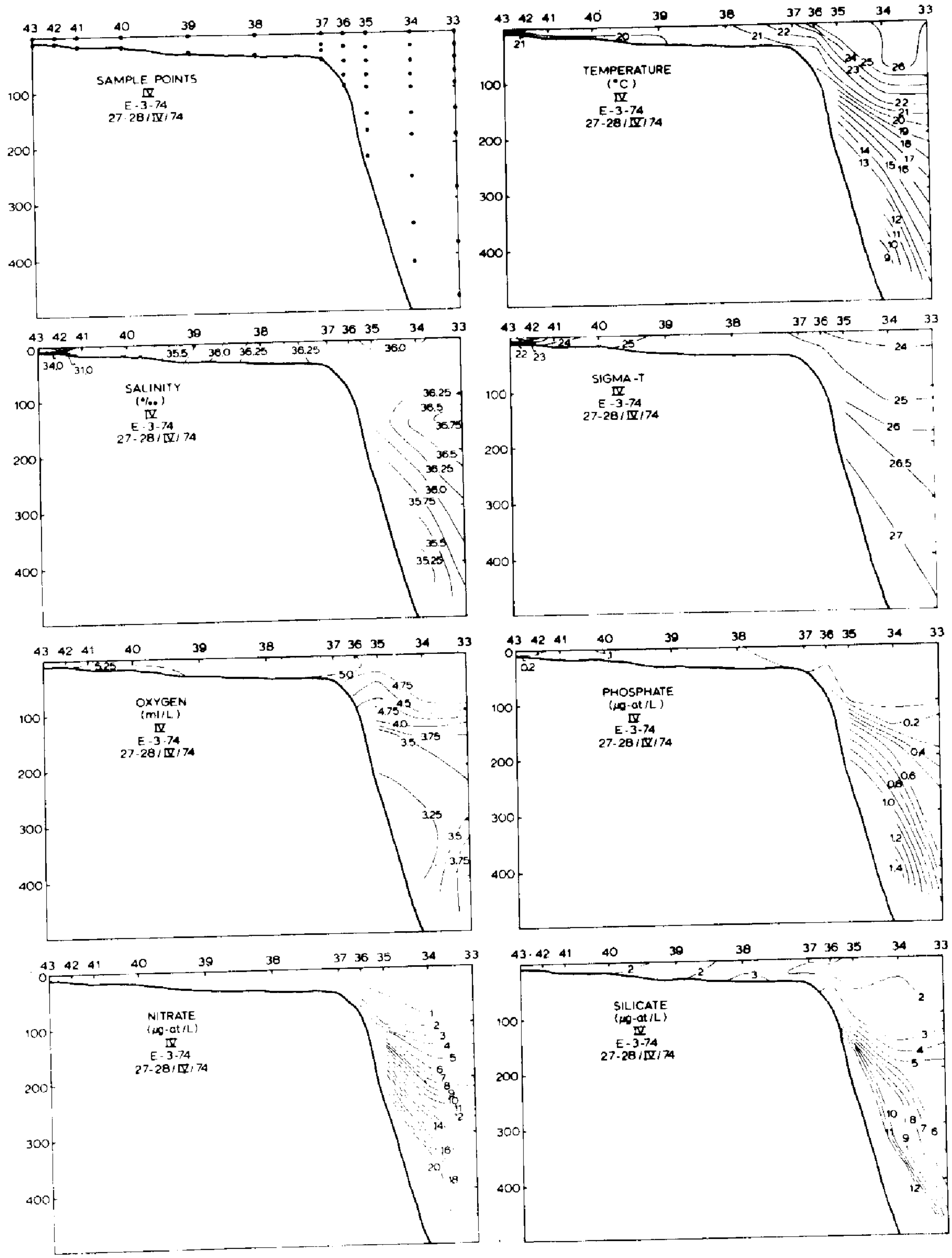

Figure 24. Vertical Section, Cruise E-3-74, Section IV

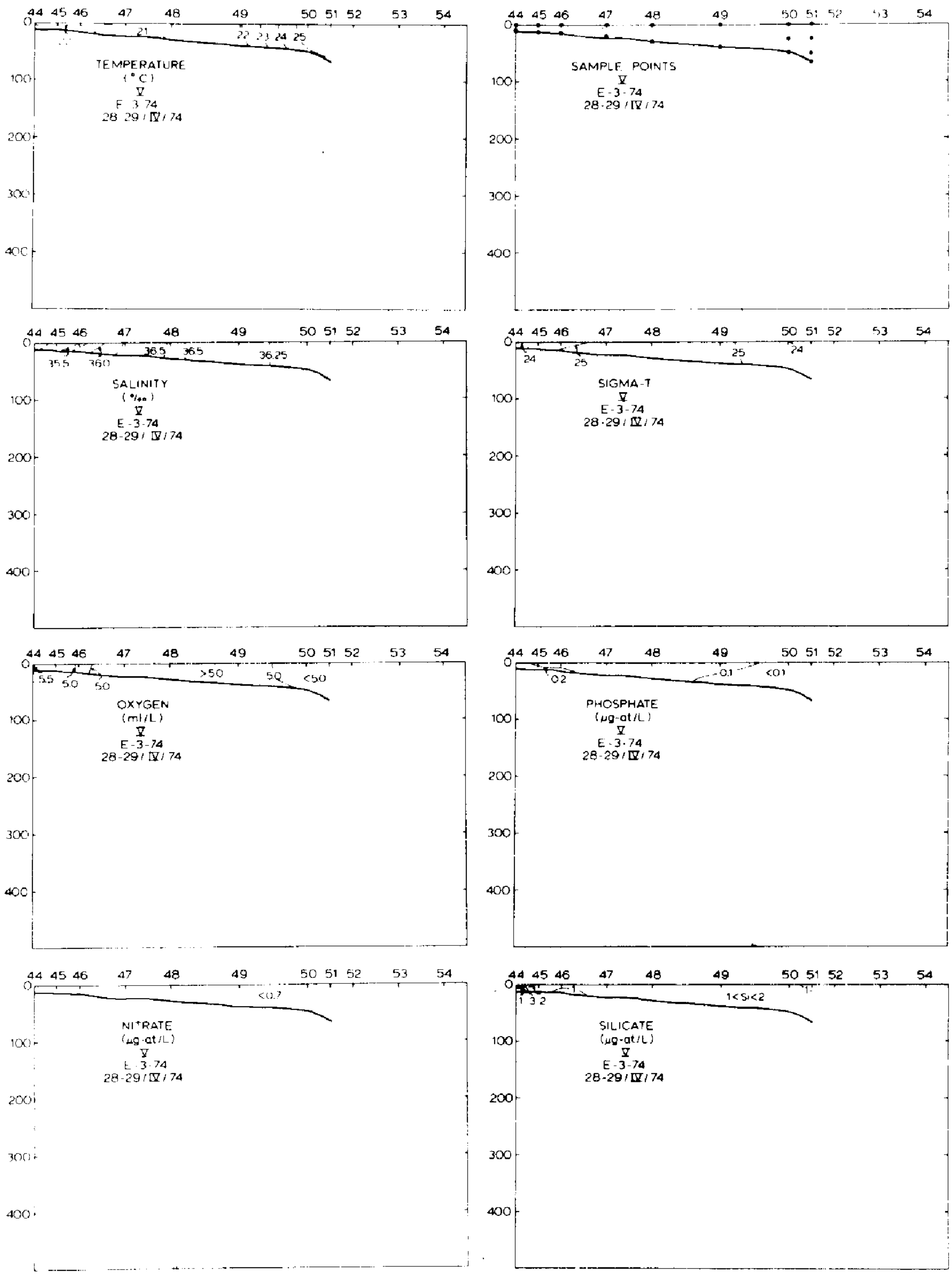

Figure 25. Vertical Section, Cruise E-3-74, Section V

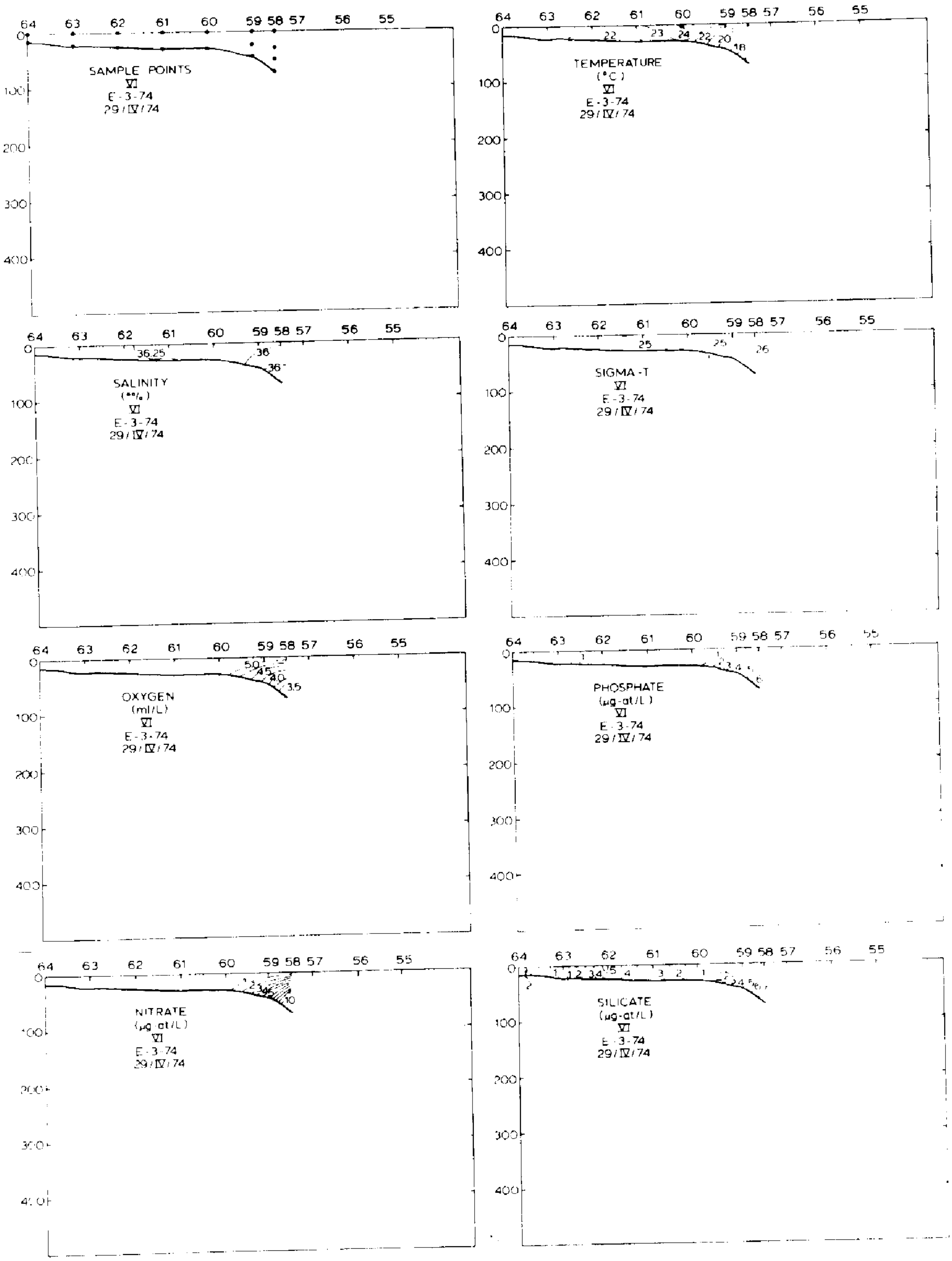

Figure 26. Vertical Section, Cruise E-3-74, Section VI

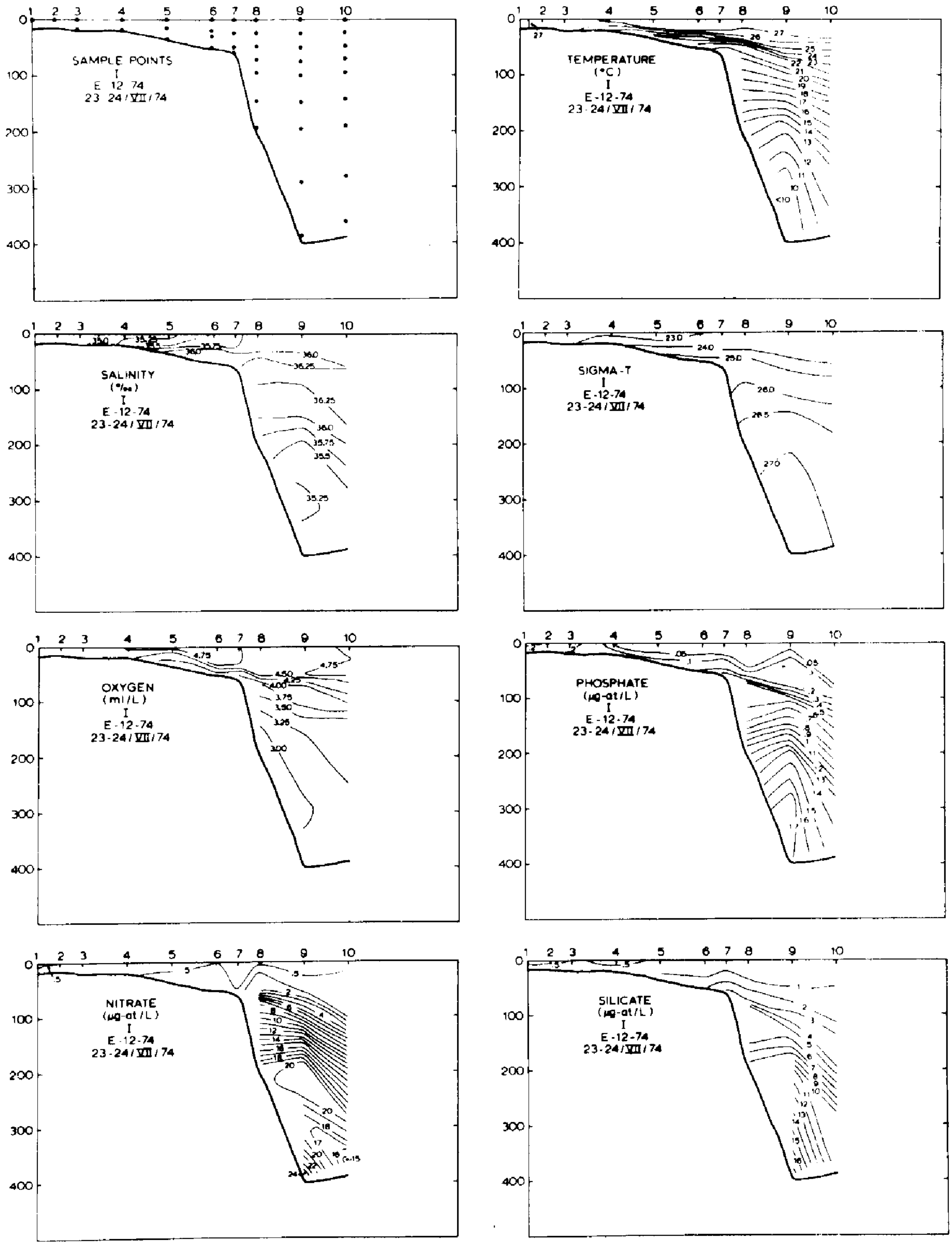

Figure 27. Vertical Section, Cruise E-12-74, Section I

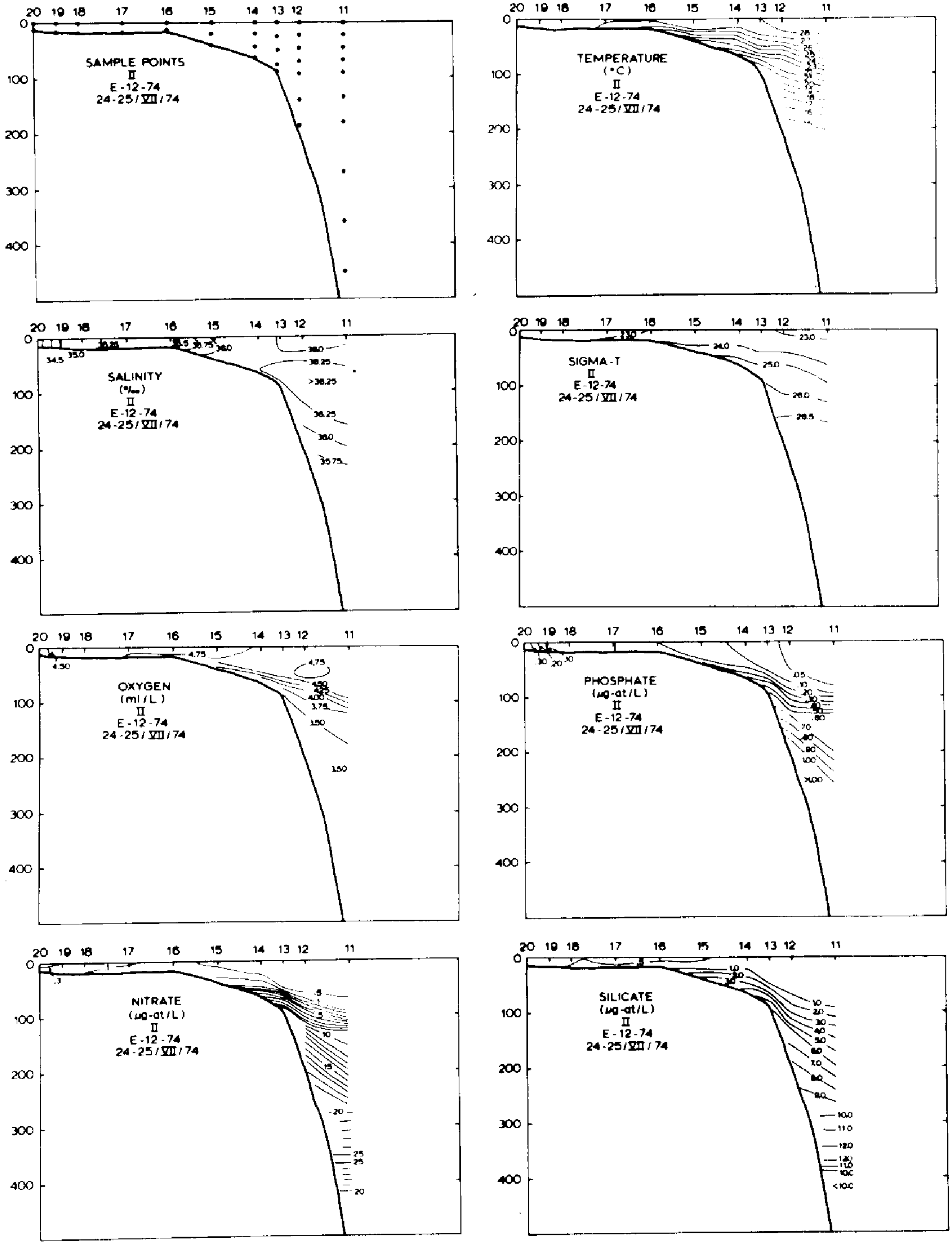

Figure 28. Vertical Section, Cruise E-12-74, Section II

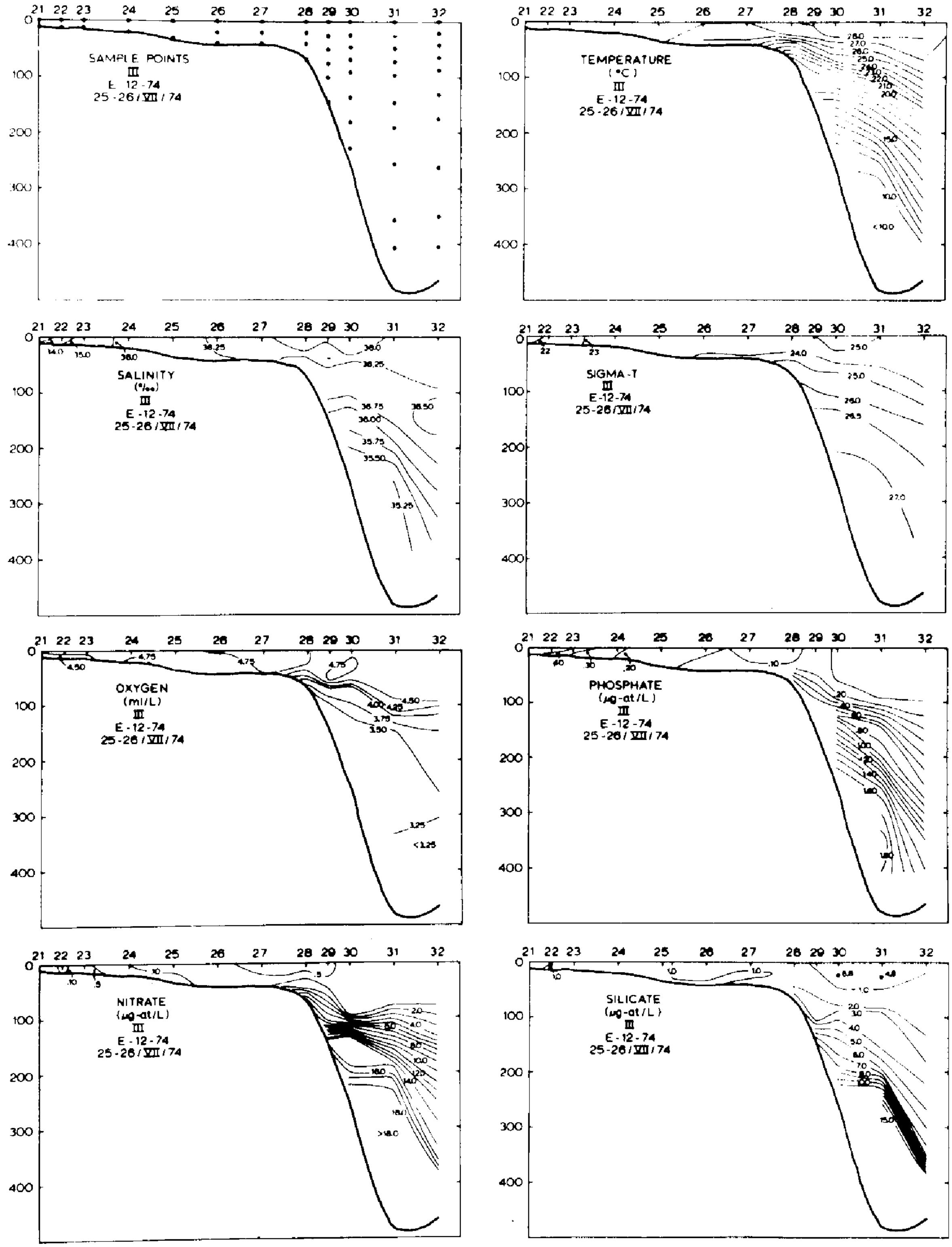

Figure 29. Vertical Section, Cruise E-12-74, Section III

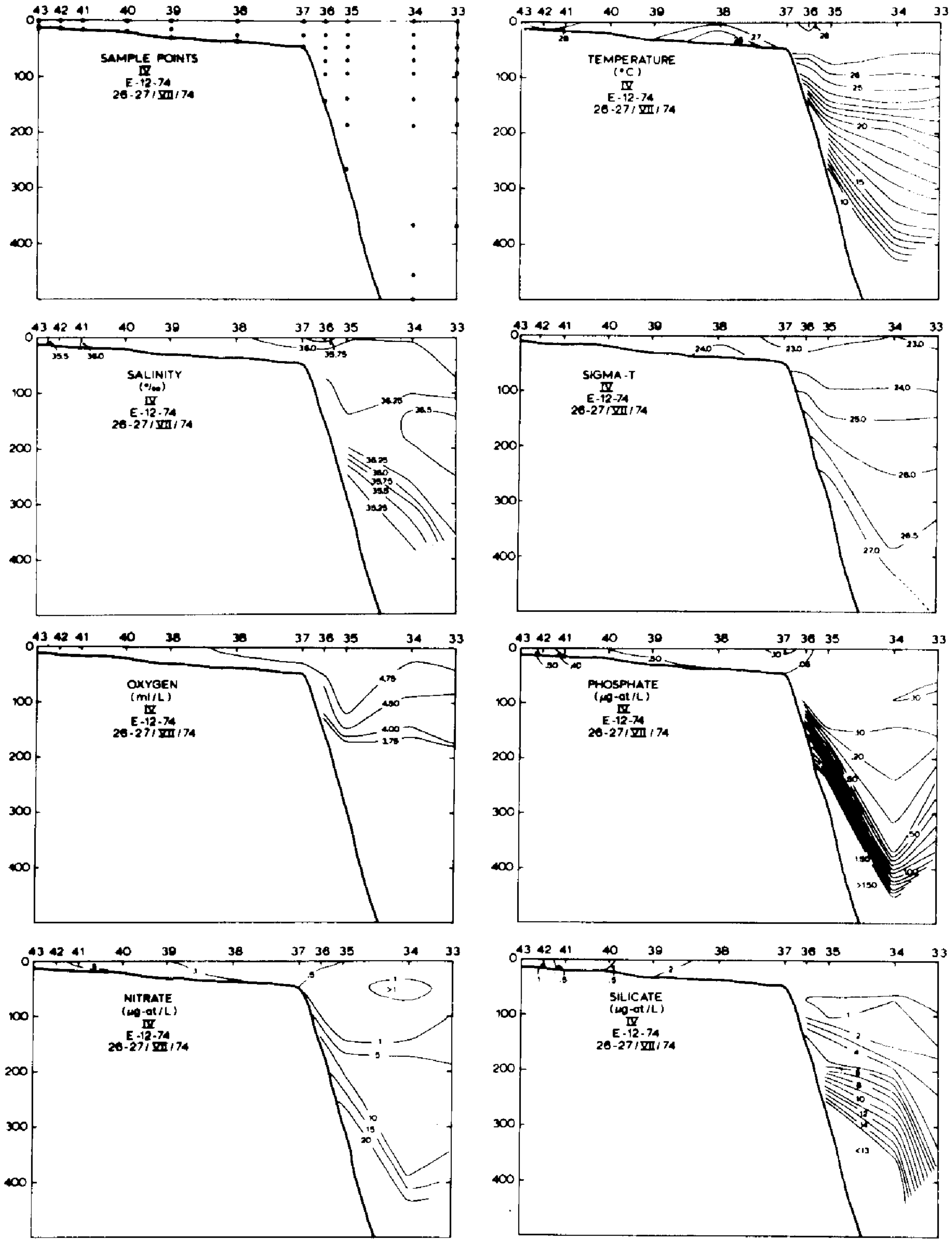

Figure 30. Vertical Section, Cruise E-12-74, Section IV

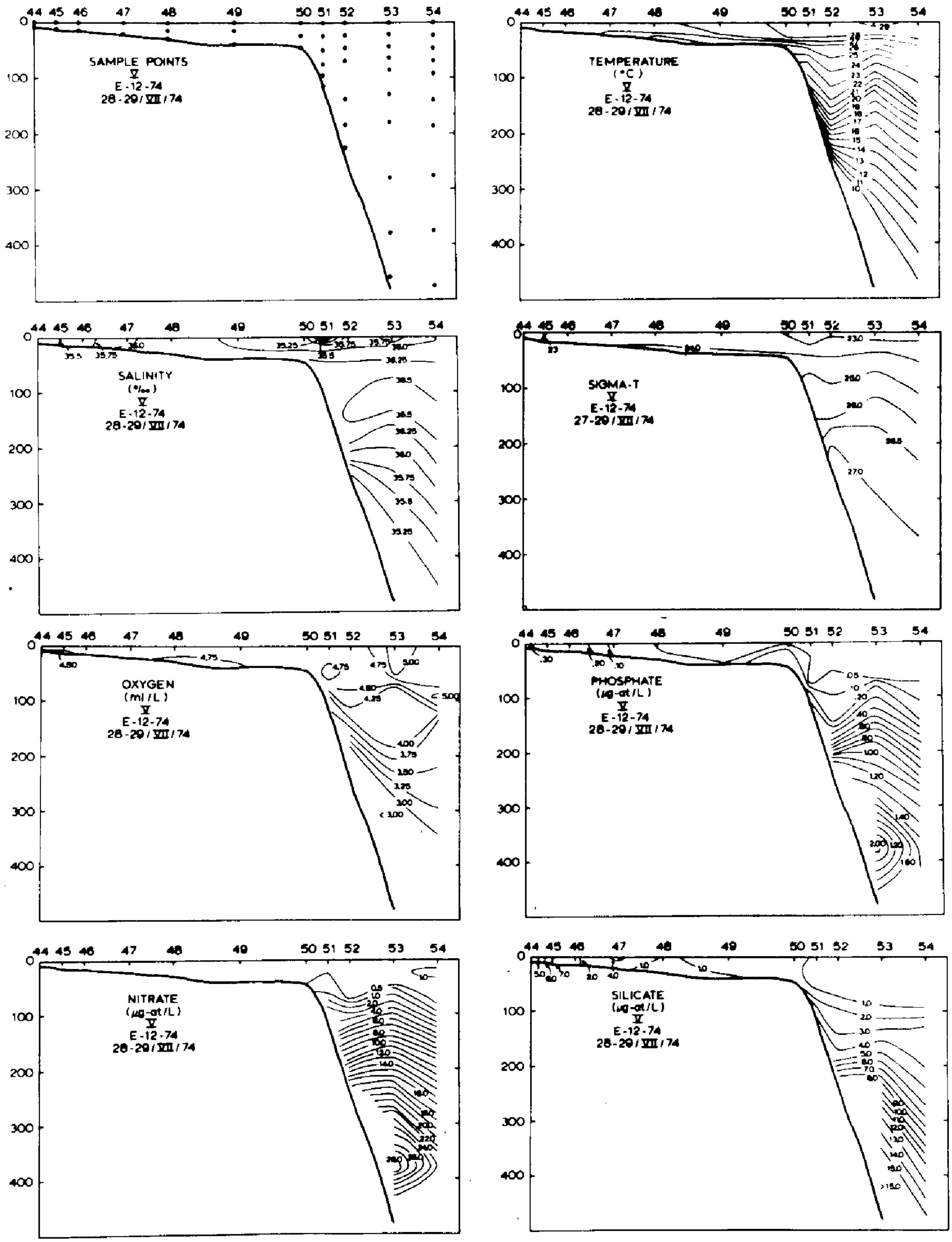

Figure 31. Vertical Section, Cruise E-12-74, Section V

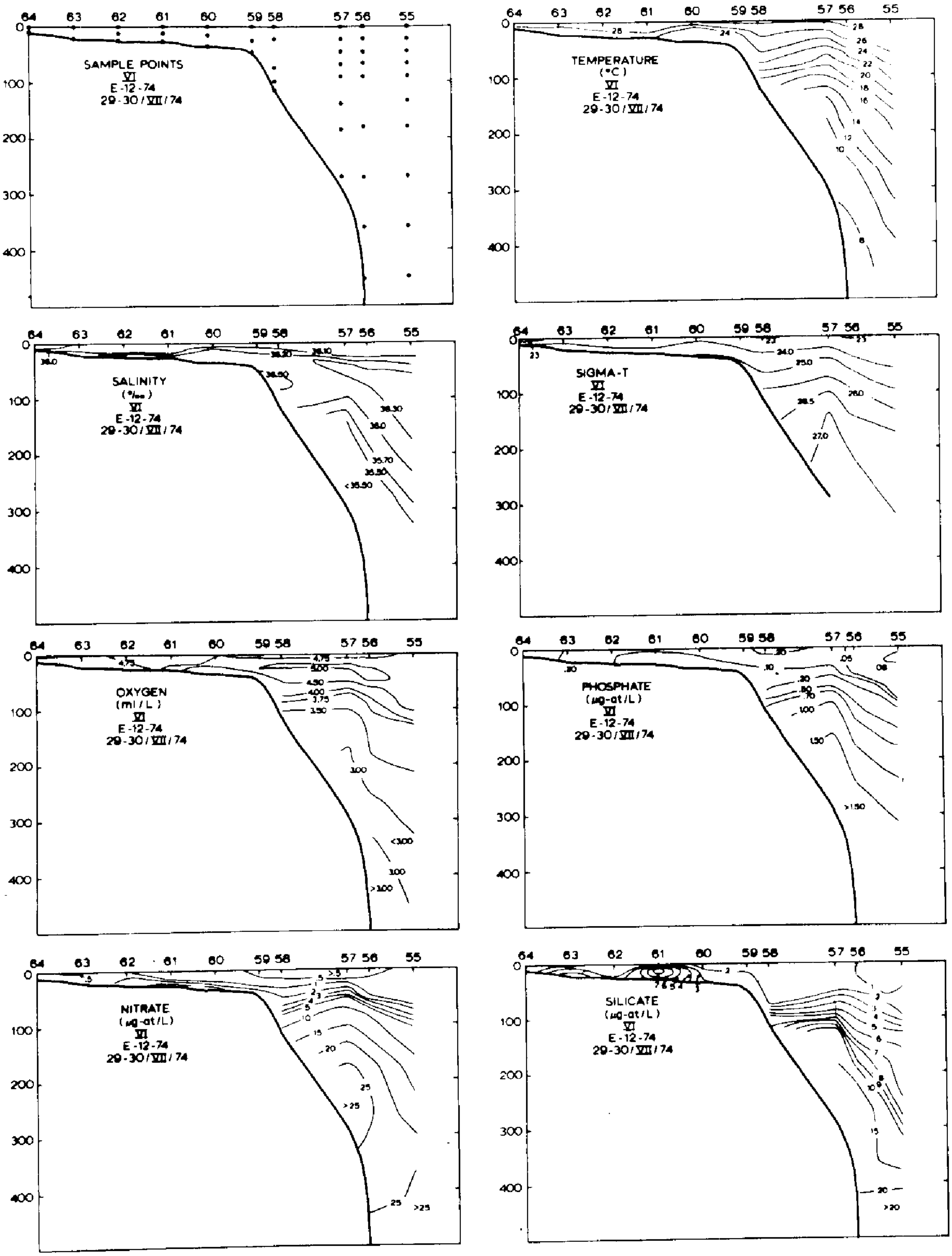

Figure 32. Vertical Section, Cruise E-12-74, Section VI

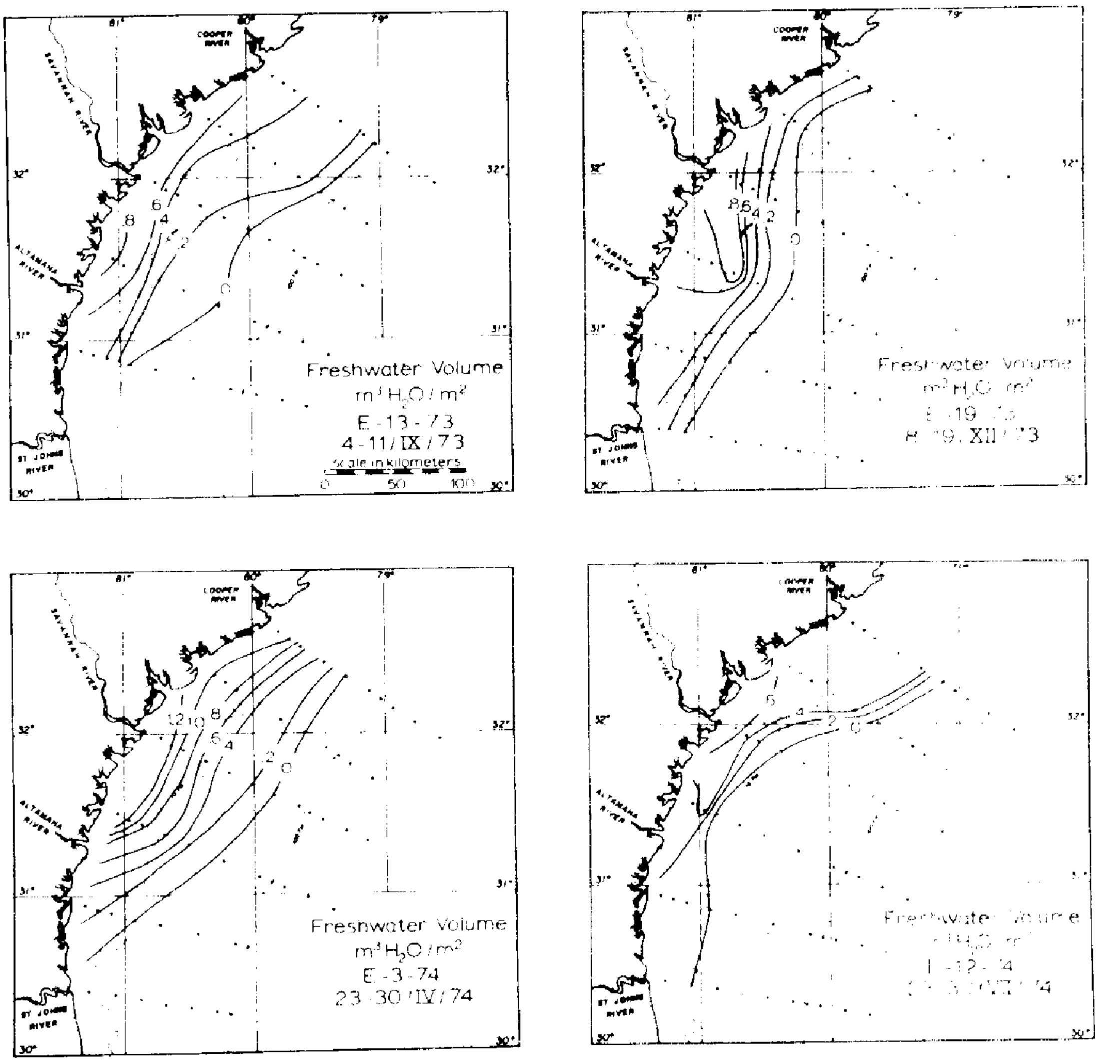

Figure 33. Distribution of Freshwater

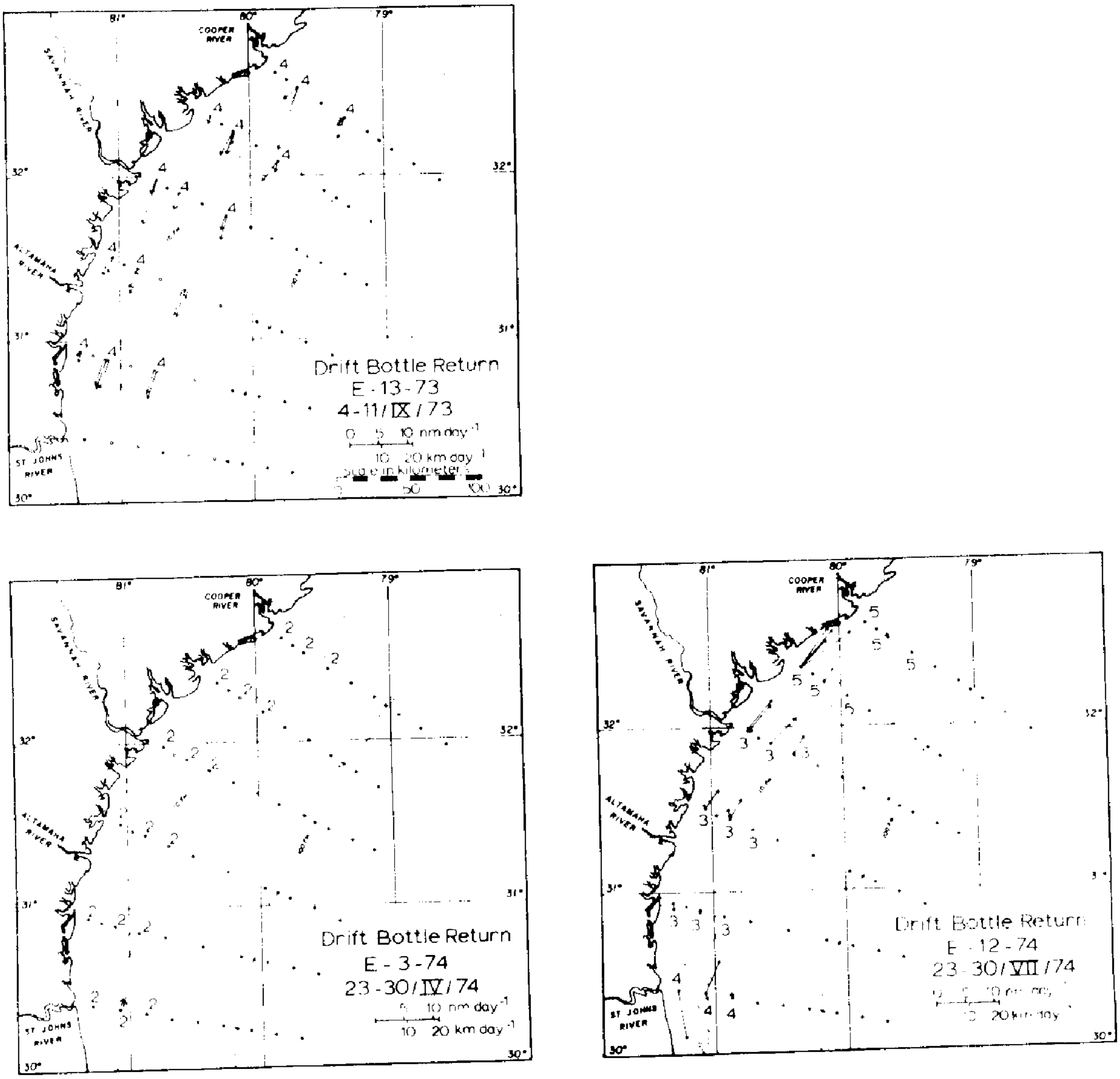

Figure 34. Drift Bottle Trajectories

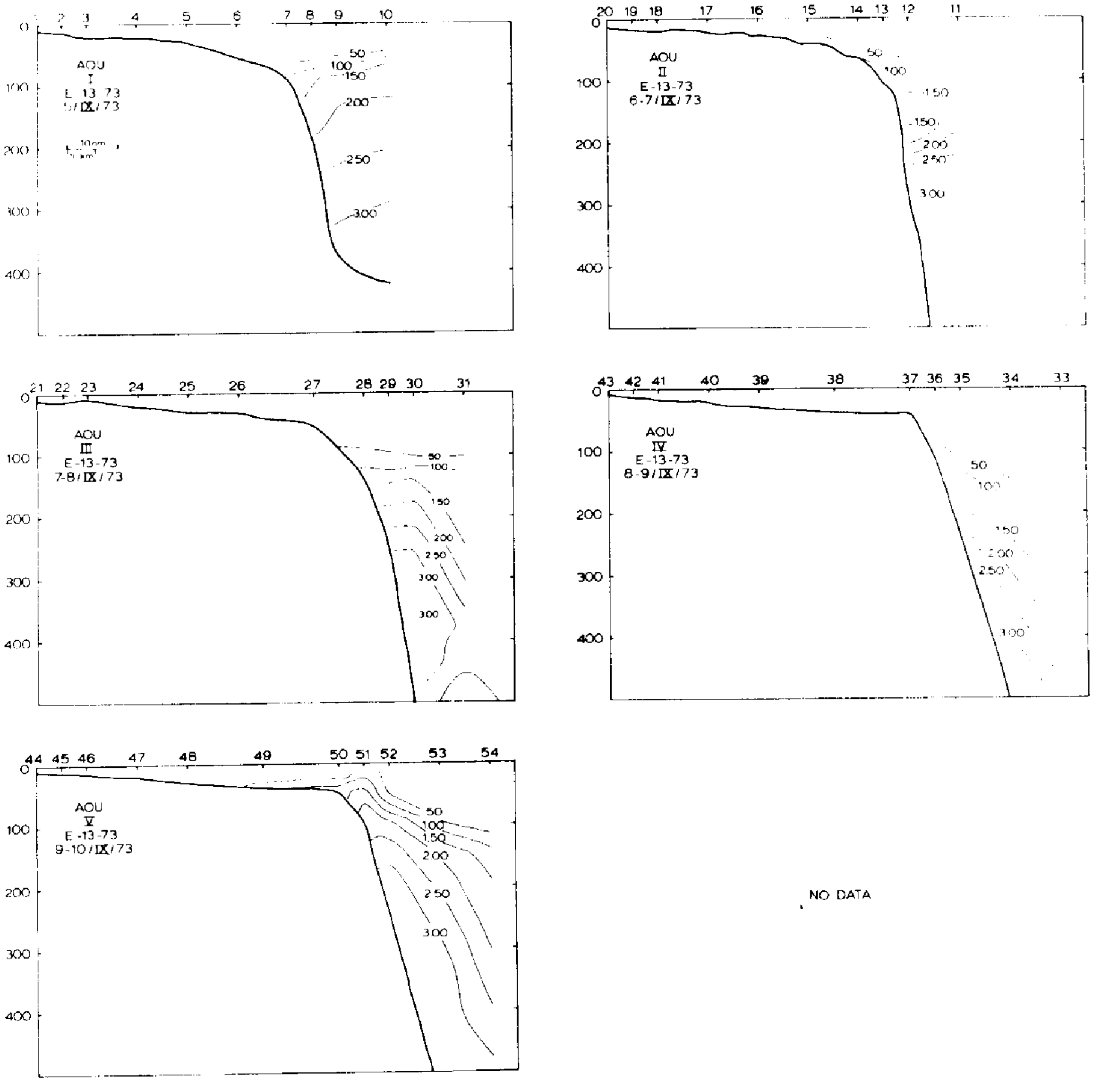

Figure 35. Apparent Oxygen Utilization, Cruise E-13-73

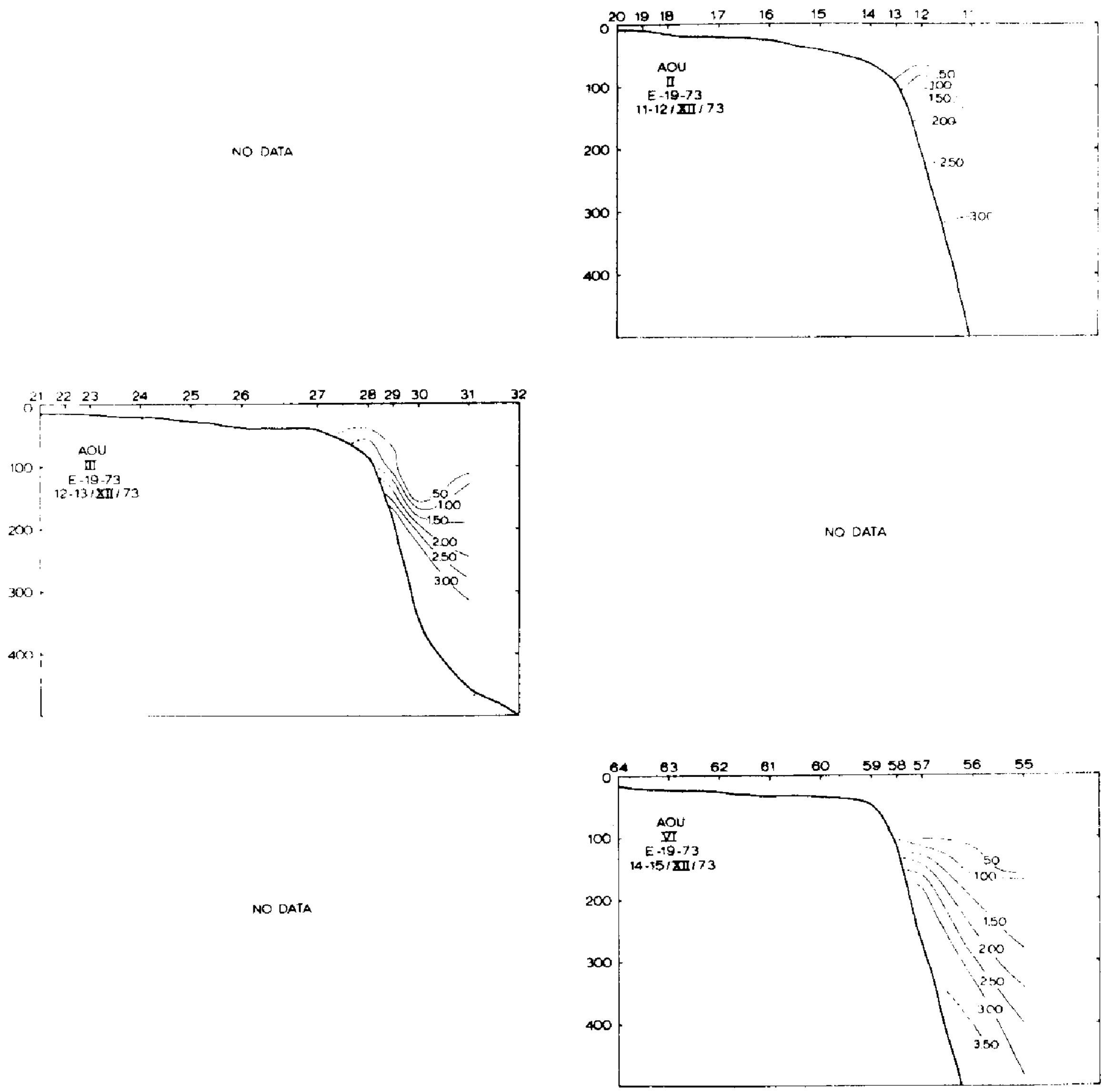

Figure 36. Apparent Oxygen Utilization, Cruise E-19-73

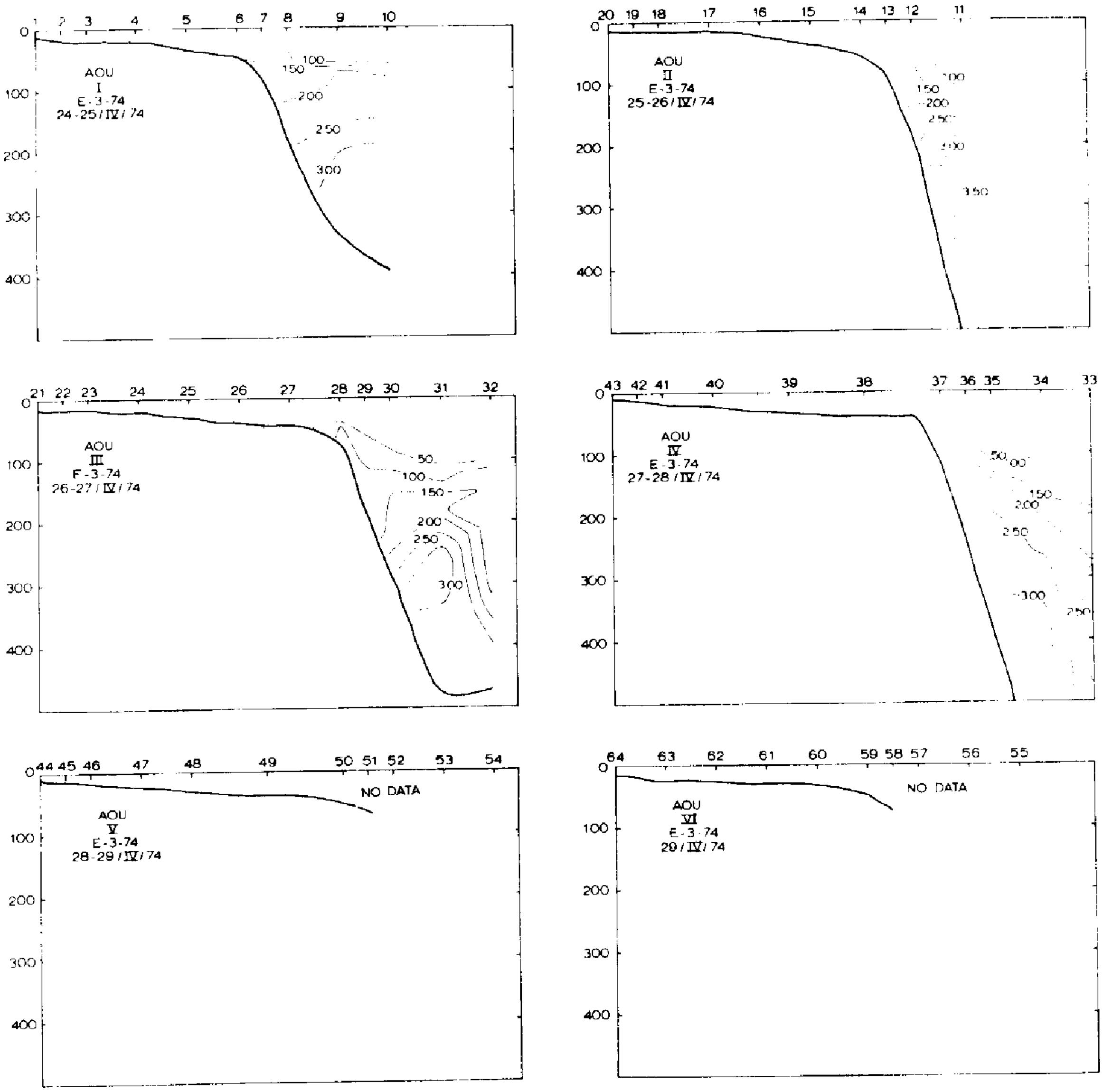

Figure 37. Apparent Oxygen Utilization, Cruise E-3-74

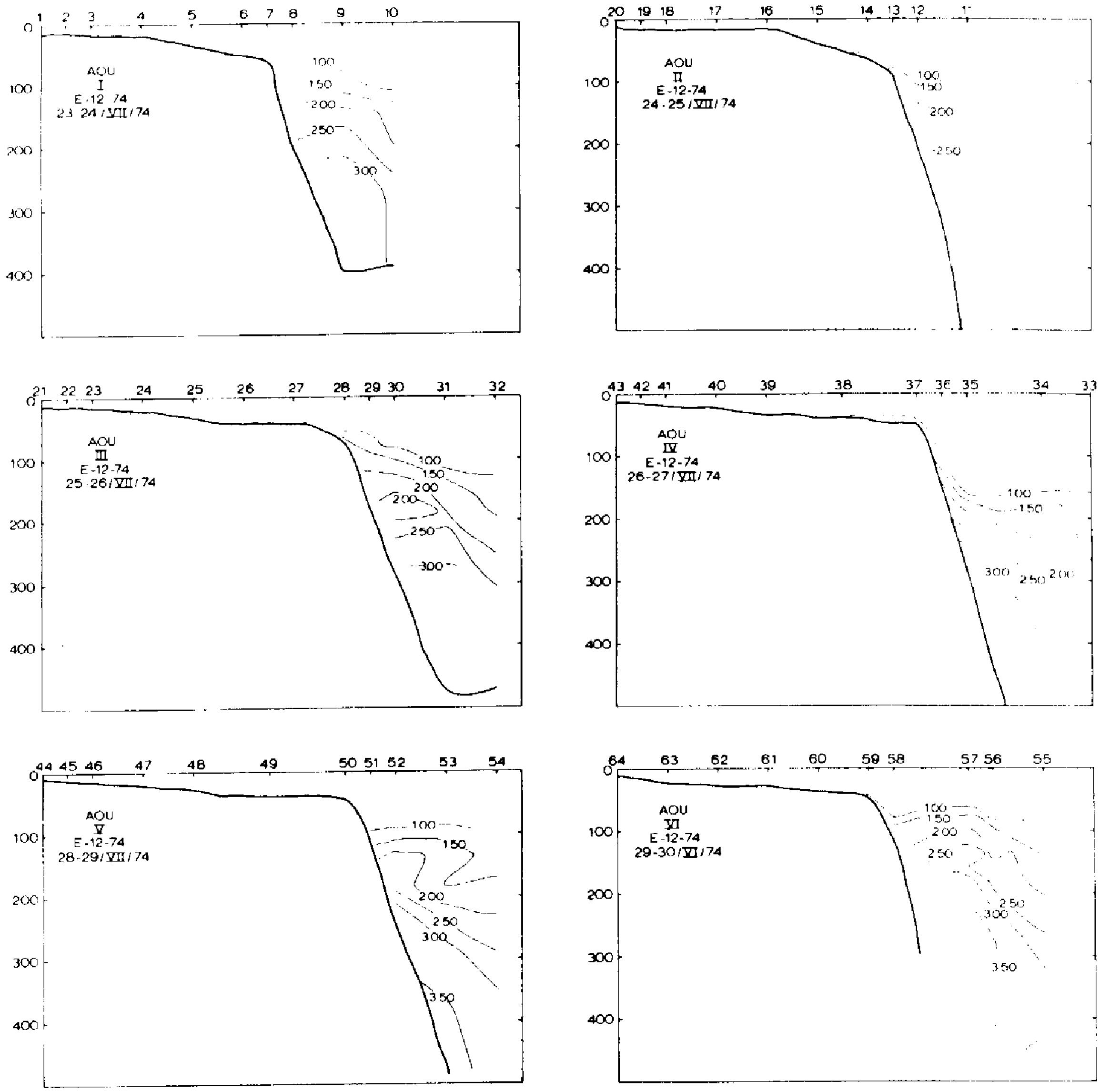

Figure 38. Apparent Oxygen Utilization, Cruise E-12-74

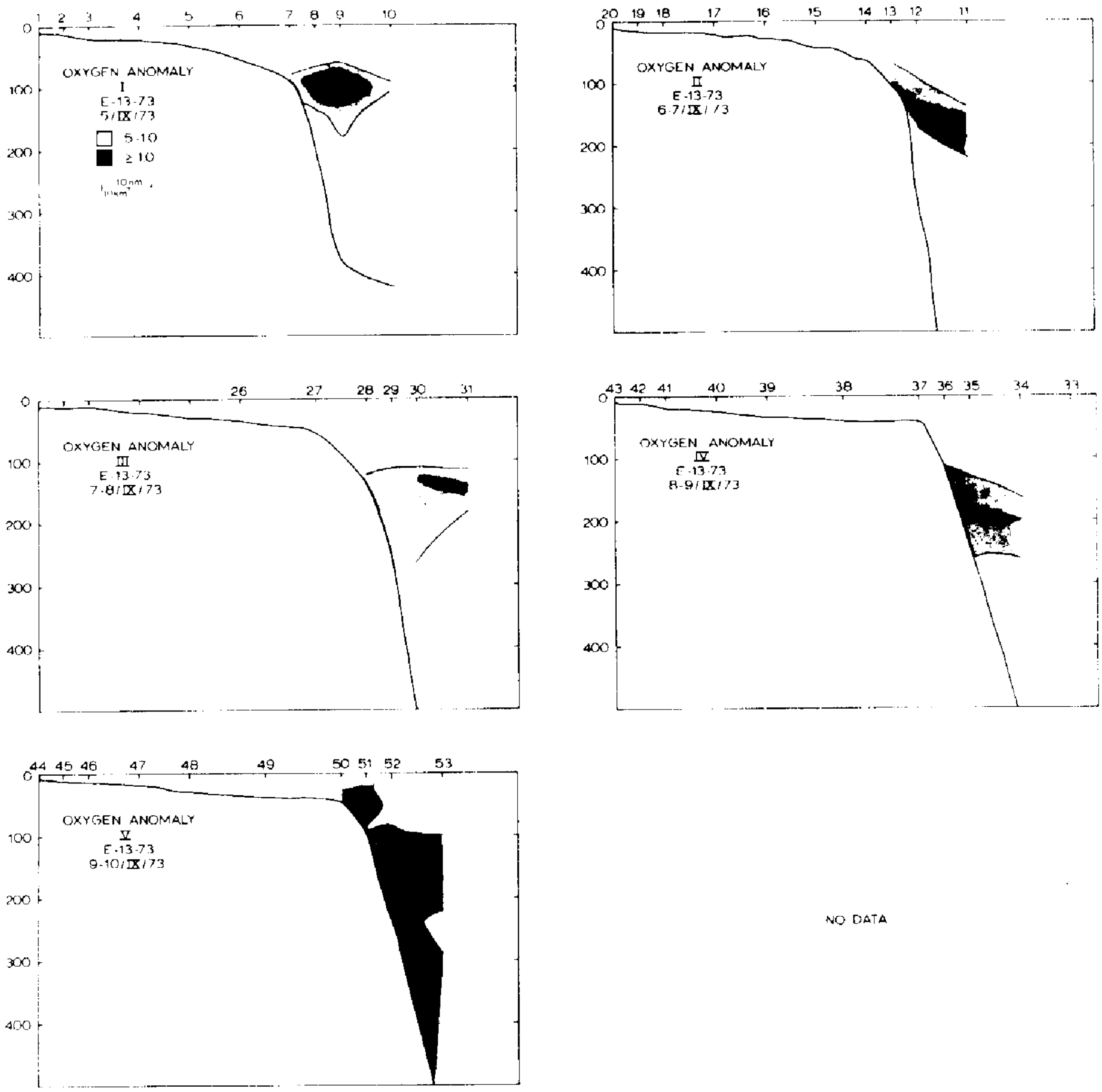

Figure 39. Oxygen Anomaly (ml O_2/L), Cruise E-13-73.

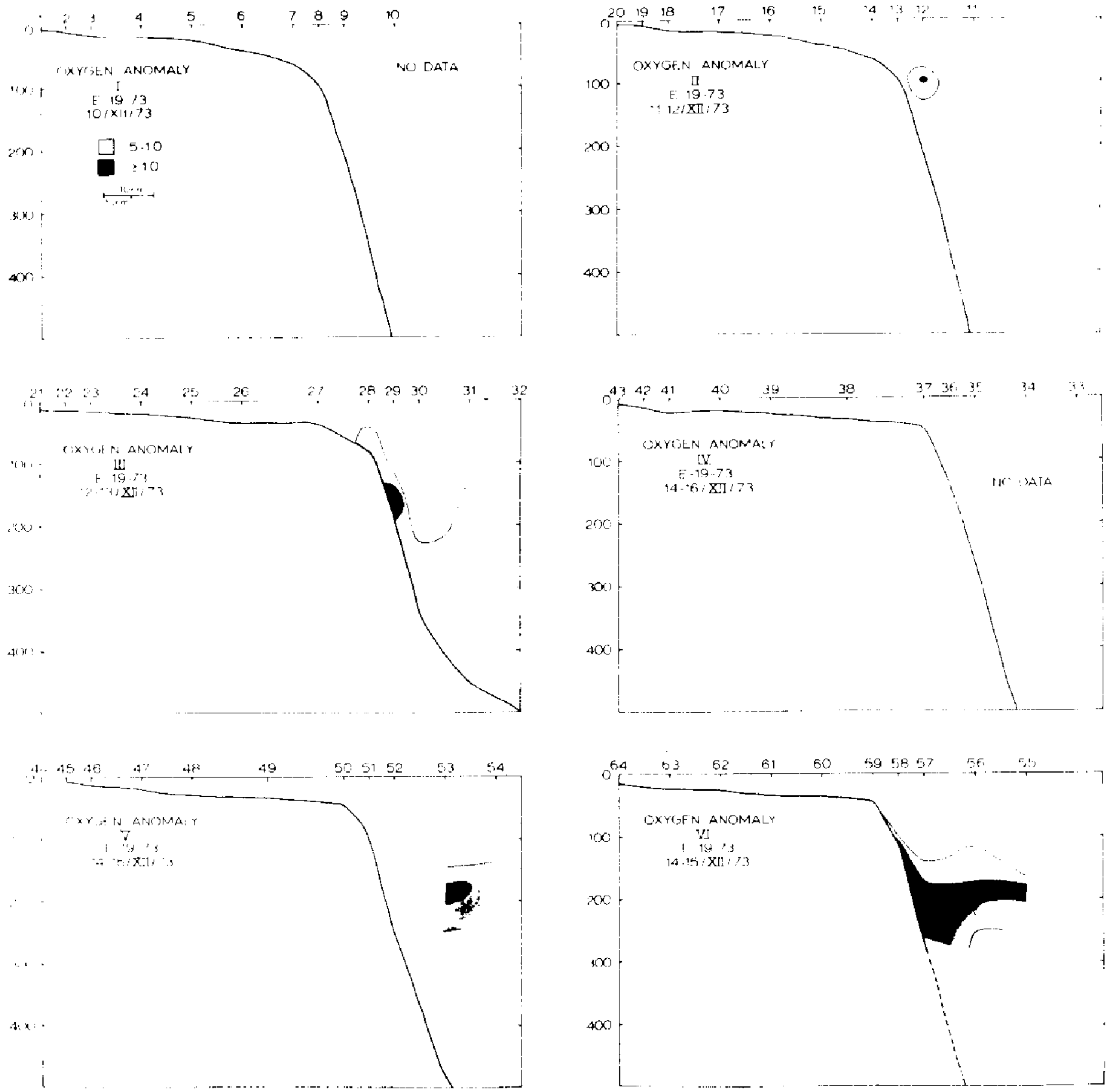

Figure 40. Oxygen Anomaly (ml O_2/L), Cruise E-19-73.

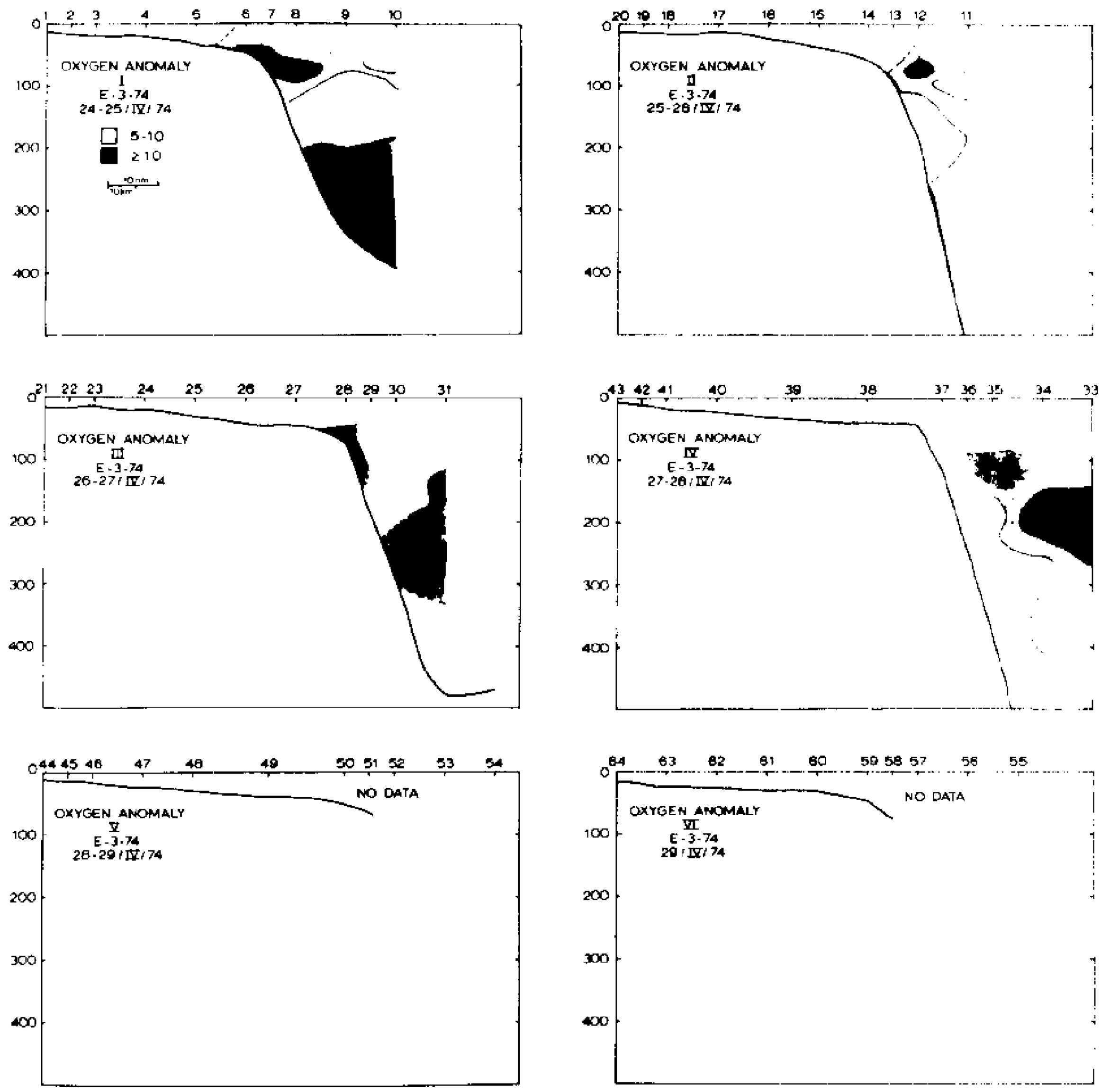

Figure 41. Oxygen Anomaly (ml O_2/L), Cruise E- 3-74.

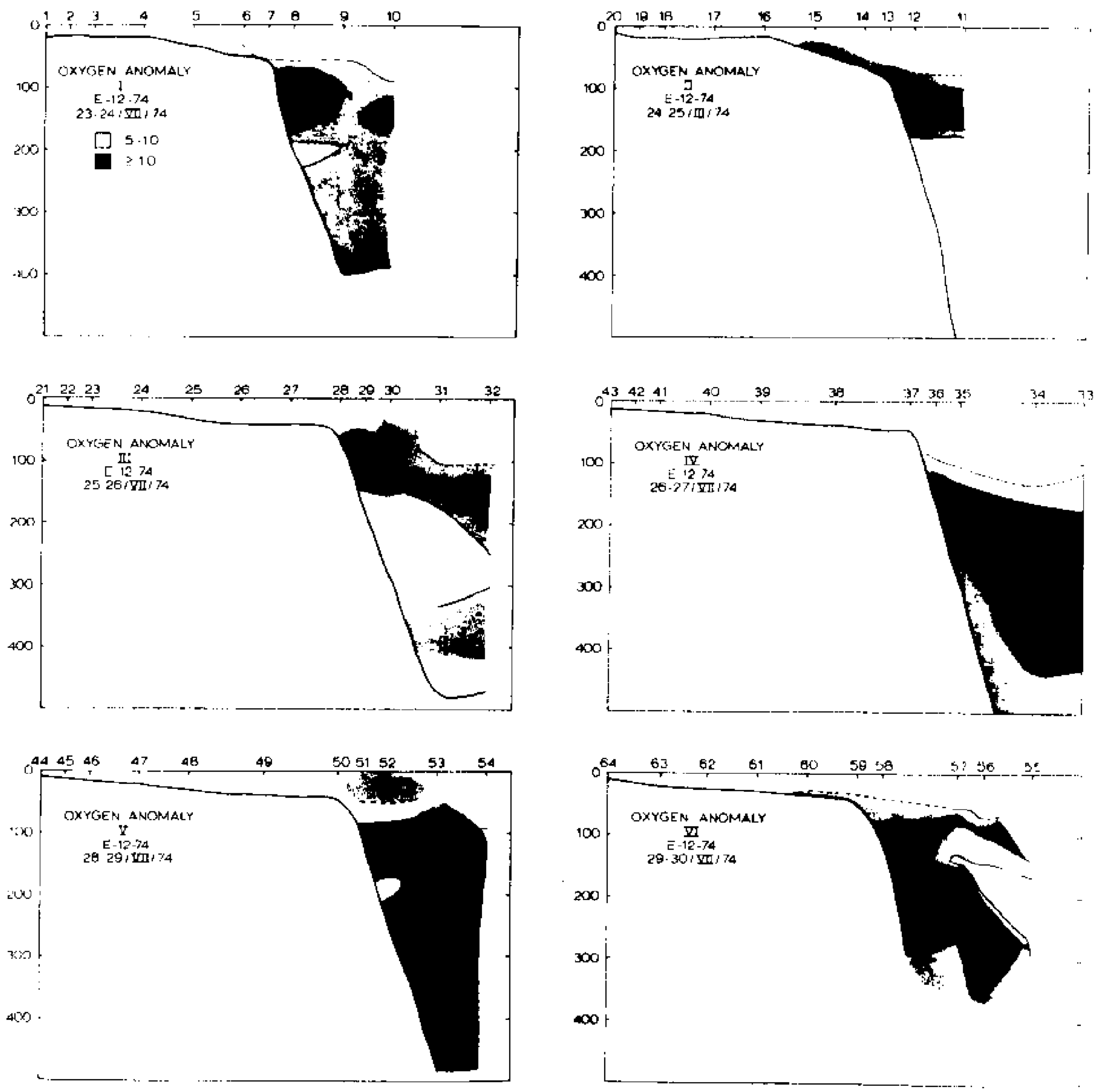

Figure 42. Oxygen Anomaly (ml O_2/L), Cruise E-12-74.

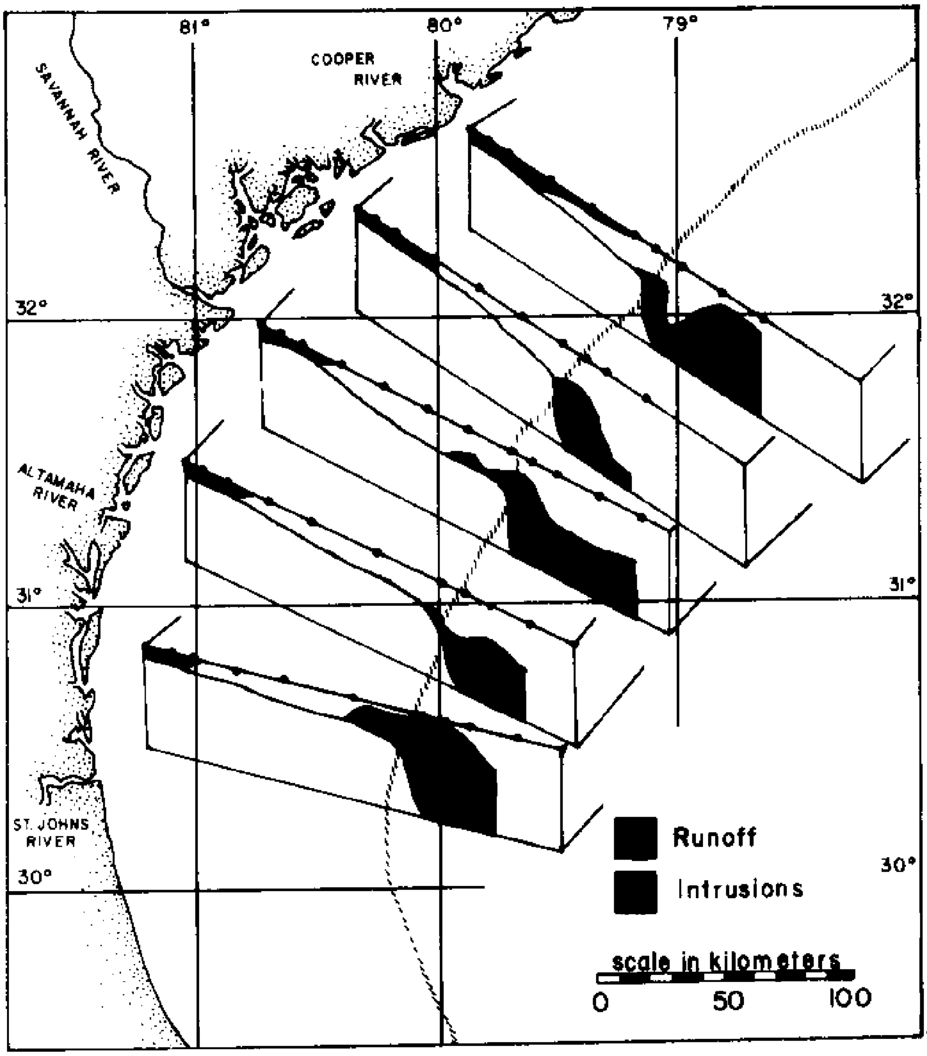

Figure 43. Summarized Horizontal Extent of Runoff and Intrusions E-13-73

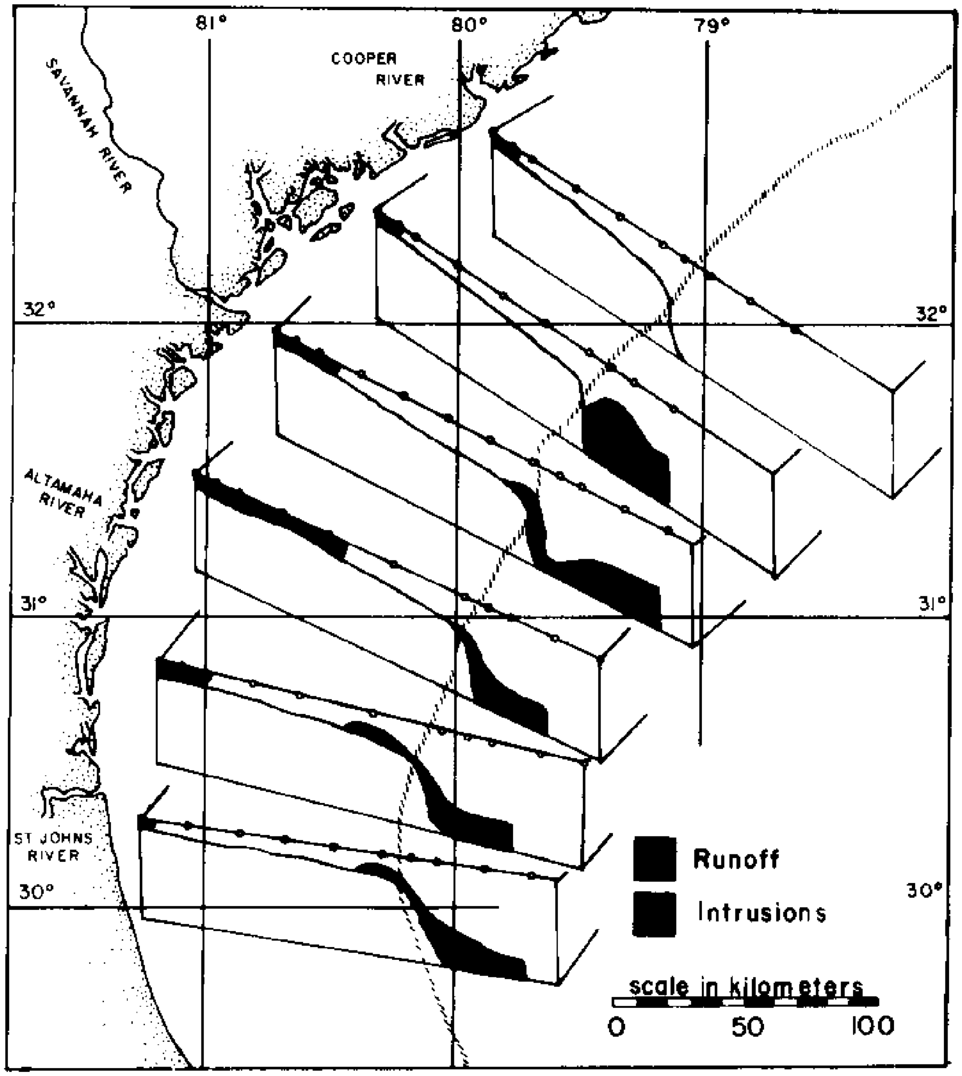

Figure 44. Summarized Horizontal Extent of Runoff and Intrusions E-19-73

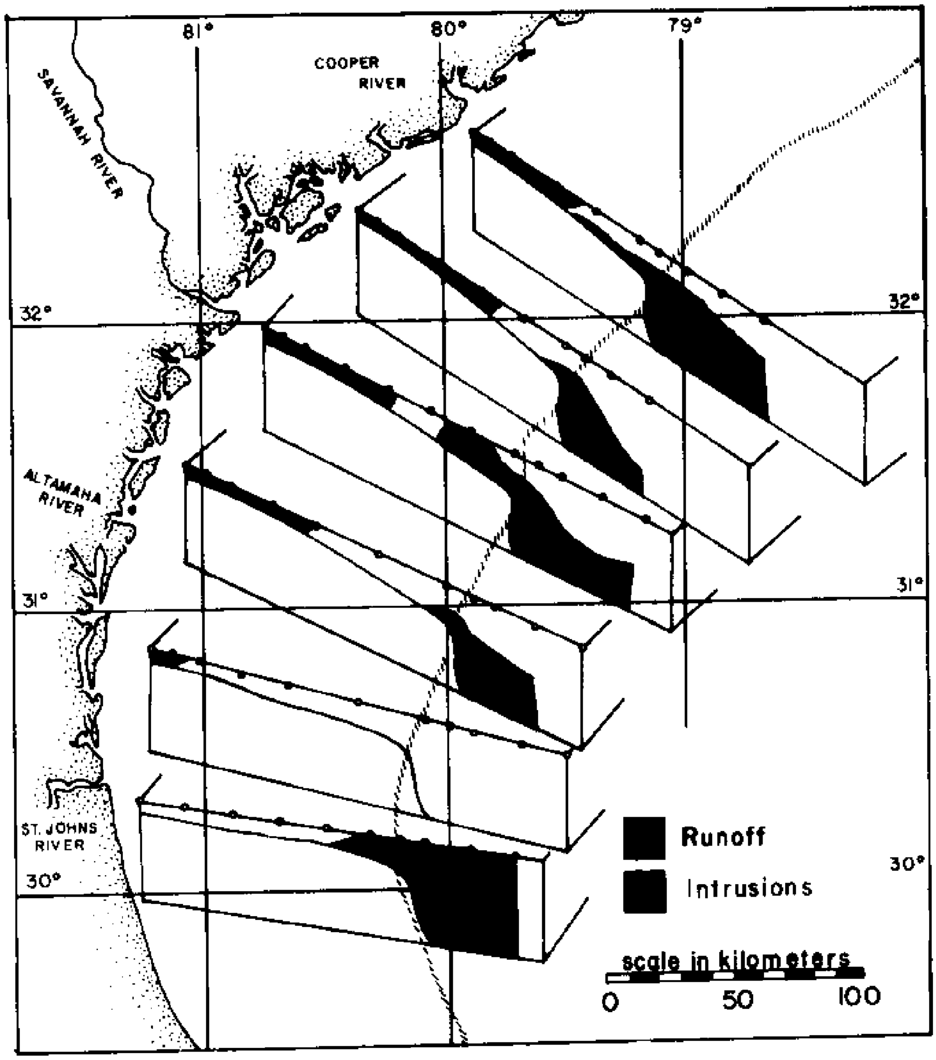

Figure 45. Summarized Horizontal Extent of Runoff and Intrusions E-3-74

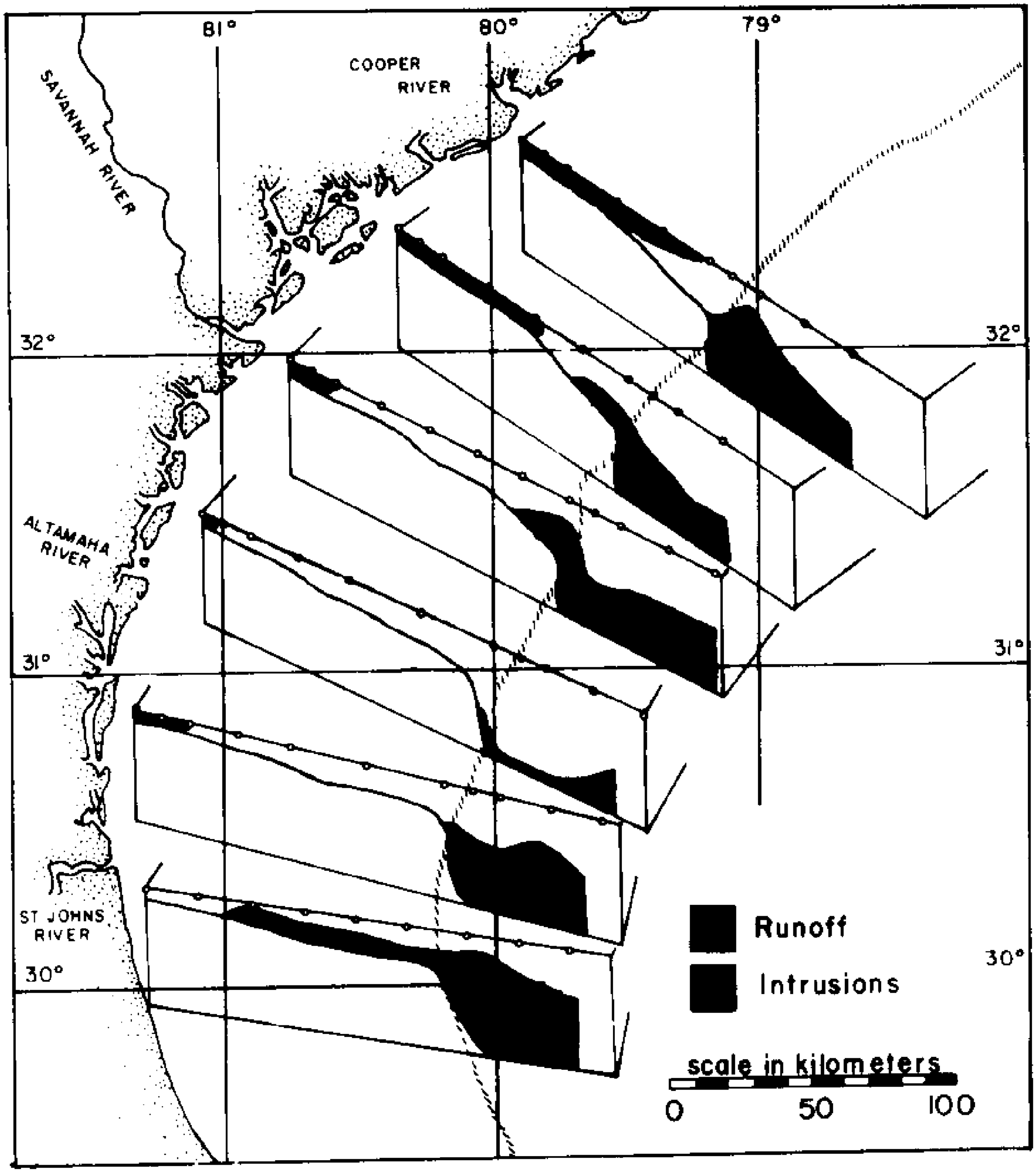

Figure 46. Summarized Horizontal Extent of Runoff and Intrusions E-12-74

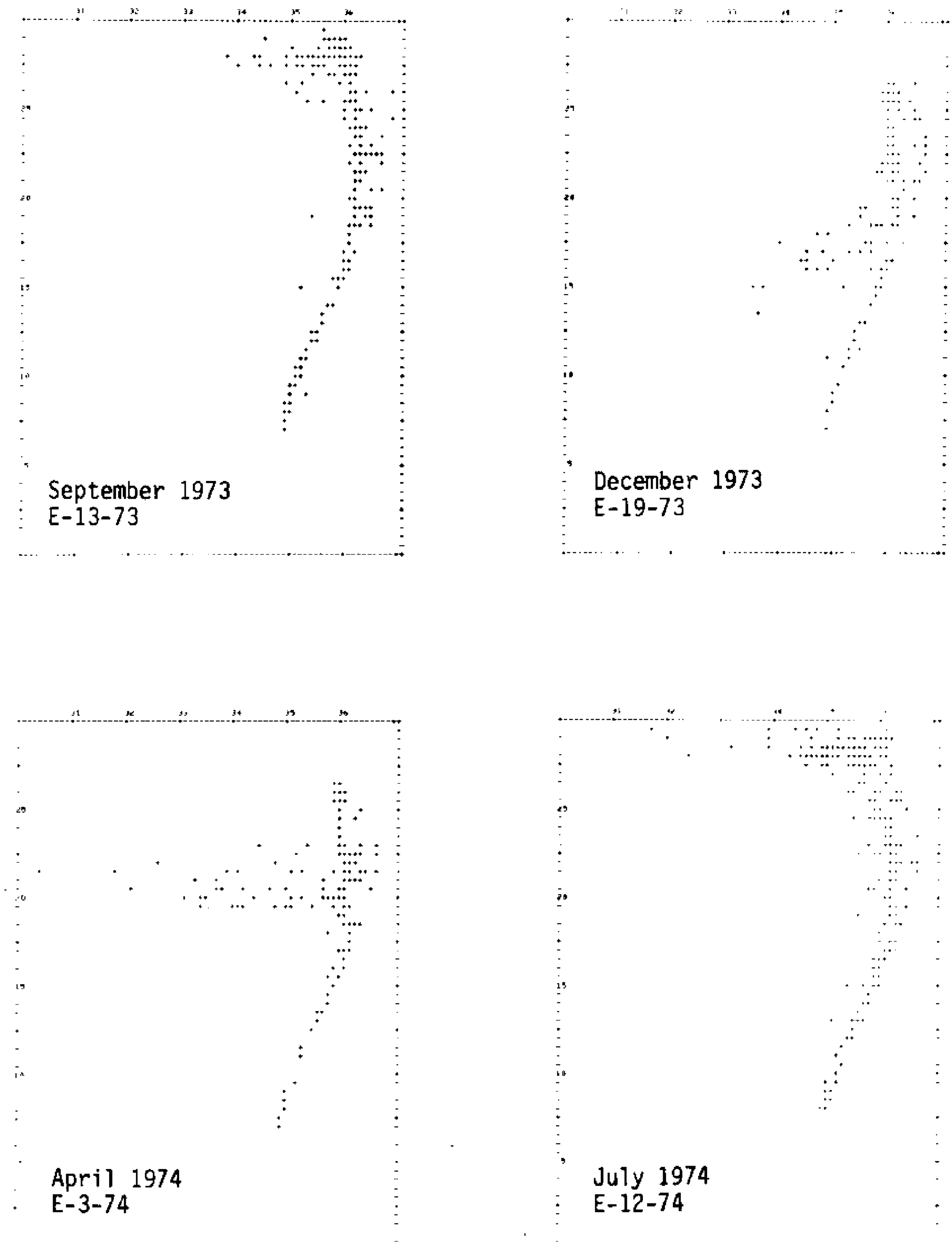

Figure 47. Temperature-Salinity Plot

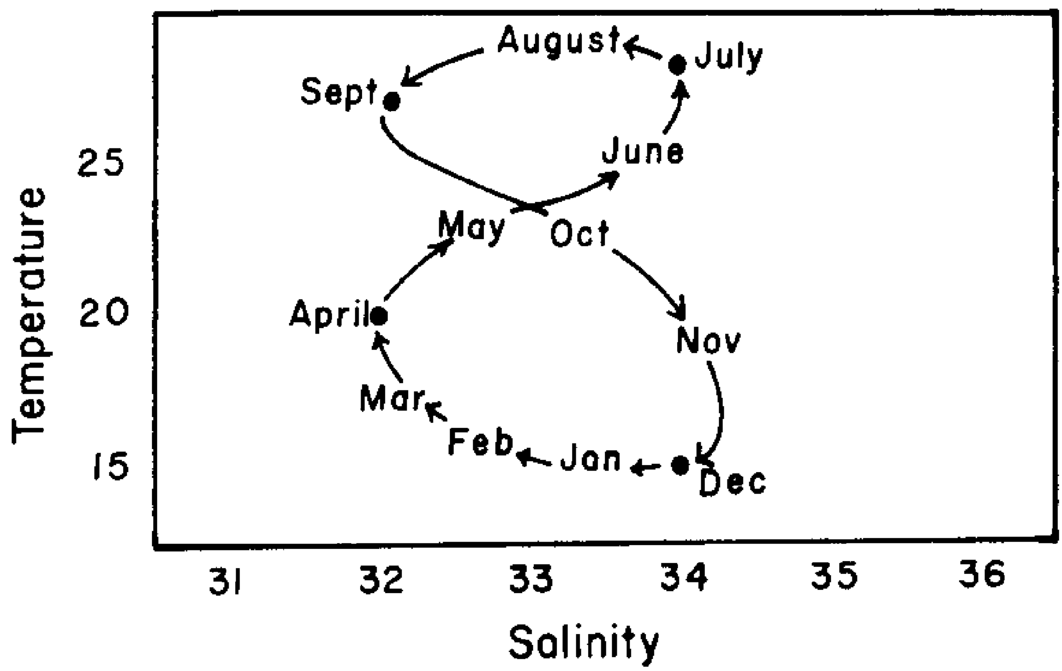

Figure 48. Schematic Seasonal T-S Plot

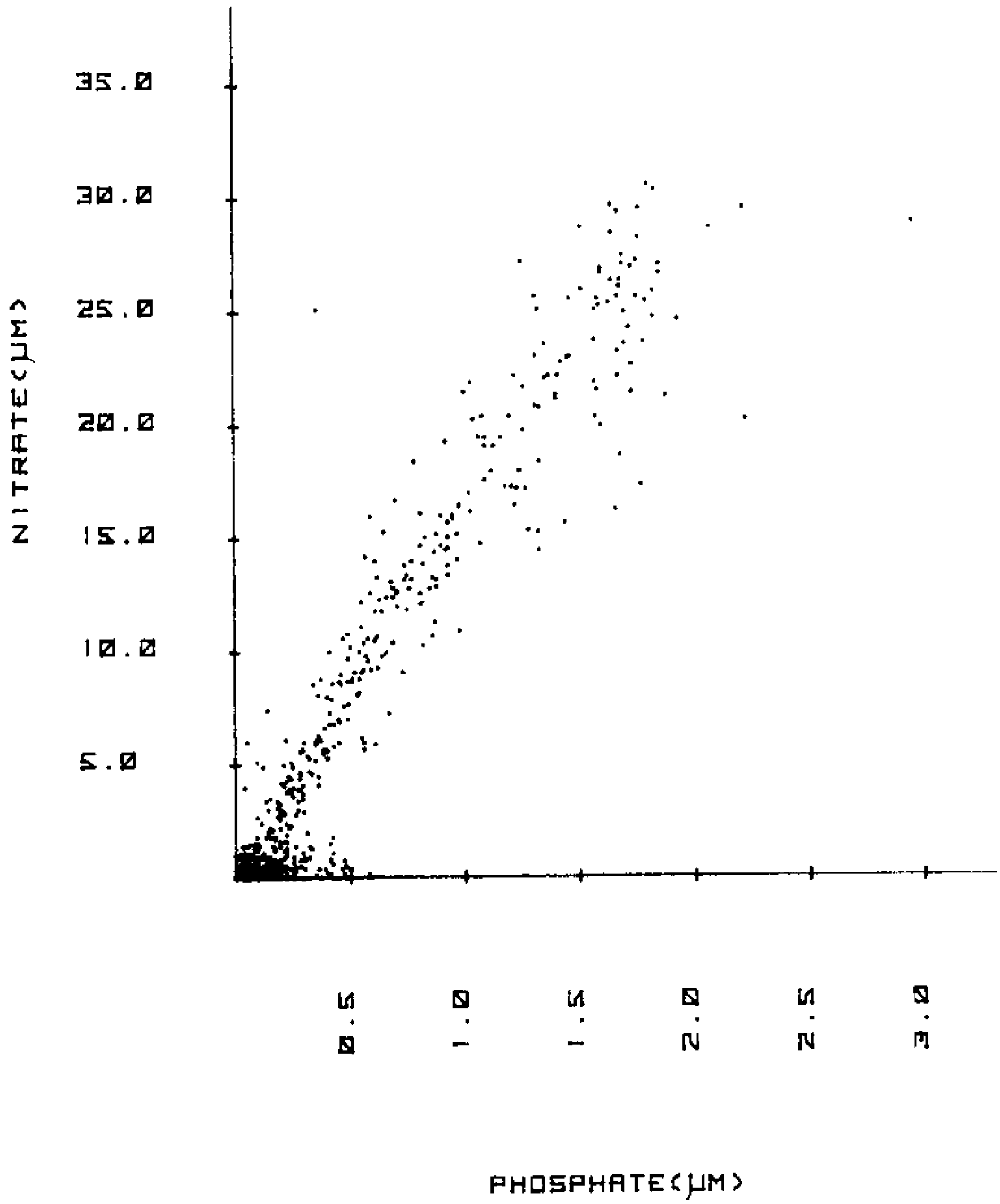

Figure 49. Phosphate-Nitrate Plot

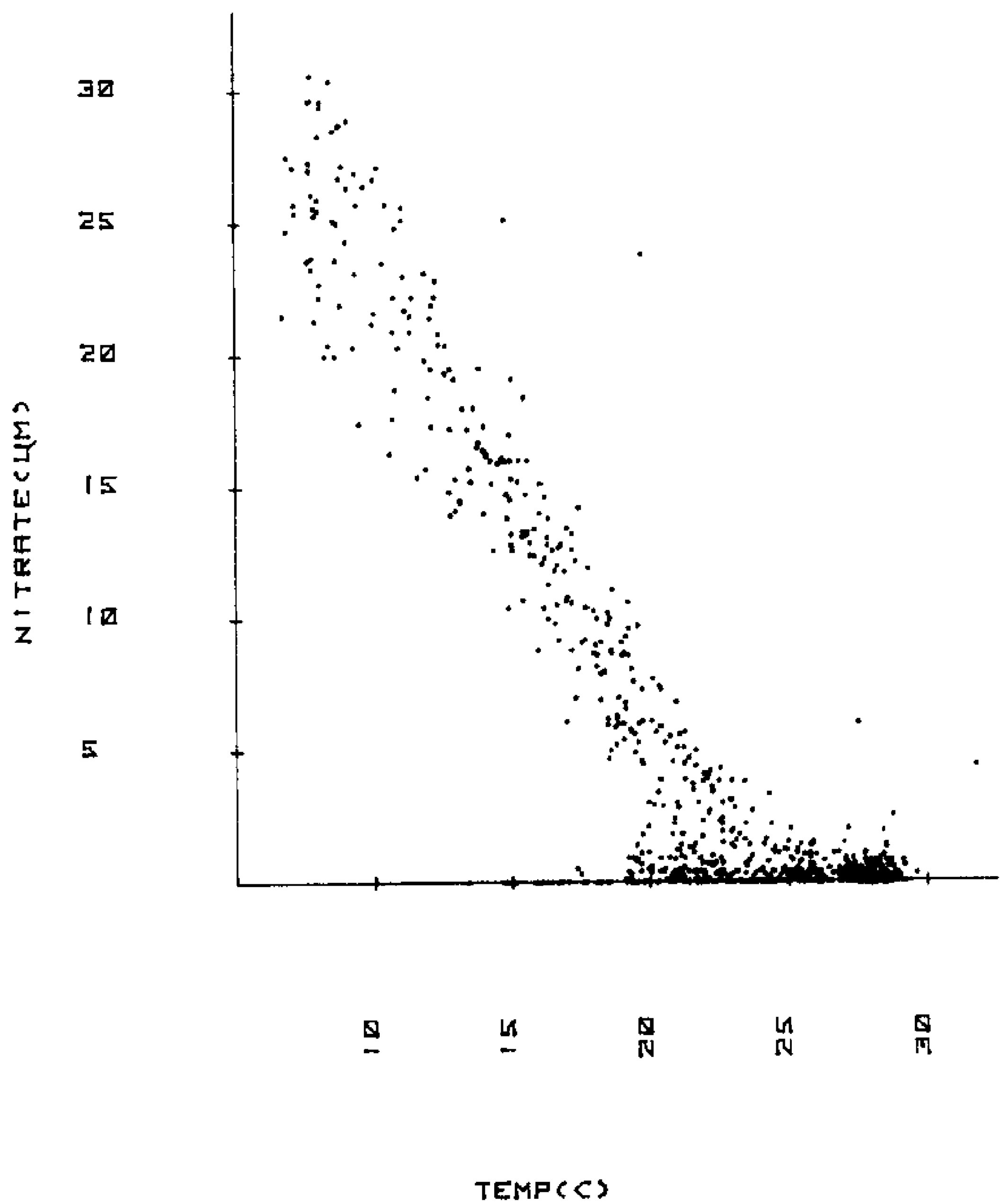

Figure 51. Nitrate-Temperature Plot