# BIOLOGICAL, PHYSICAL, AND CHEMICAL DYNAMICS ALONG A NEW YORK BIGHT TRANSECT OFF LONG BRANCH, NEW JERSEY MAY TO OCTOBER 1983

by

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In the temperate continental shelf water of the Middle Atlantic Bight, two extremes occur in the physical and biological regimes. During winter months, when strong winds and tides frequently mix the water column, biomass (chlorophyll a mg/$m^3$) and nutrients are generally distributed uniformly throughout the water column (to approximately 100 m). During the less windy summer months over the shelf, the water becomes thermally stratified; there is a relationship between the thermal structure and vertical distribution of chlorophyll a and nutrients in the water column. In nearshore waters, there is an additional relationship between nutrient-rich freshwater input from land runoff (freshettes) and increases in chlorophyll a concentration. Based on extensive 5-year study of the shelf, from Cape Hatteras to Nova Scotia, the highest concentrations of chlorophyll a are found in shallow, inshore waters, where hypoxia is experienced during summer months (Evans-Zetlin and O'Reilly, 1983; O'Reilly, et al., in press; Draxler, this report). Over the 5-year study period, relatively few stations were sampled inshore. To better understand the relationship of phytoplankton to the dynamics of oxygen depletion in an inshore coastal area, a series of weekly cruises to examine biological, chemical, and physical properties of the water column was initiated in May 1983 during the onset of stratification along a transect off Long Branch, New Jersey. Data collected between May and September 1983 will be discussed. Sampling locations are presented in Figure 1. The following discussion describes data found in Figure 2.

## Phytoplankton Biomass Distribution

During the period of water column stratification in relatively stable offshore areas, the vertical distribution of chlorophyll a within the water column is determined by the position of the thermocline with light and/or nutrients limiting. Generally in surface waters above the thermocline, light is sufficient for productivity but nutrients are limiting and available mostly through _in situ_ recycling. In waters below the thermocline, nutrients are generally abundant but light is limiting. In both of the above areas of the water column, chlorophyll _a_ concentrations are relatively low. The highest chlorophyll _a_ concentrations are generally found in the thermocline/pycnocline, where light from above and nutrients diffusing into the thermocline/pycnocline from below, are sufficent for significant growth to occur. This layer of high chlorophyll _a_ concentration, at times, can be related to oxygen depletion. If the compensation depth falls above the chlorophyll maximum, the phytoplankton community will be in a respiring mode, take up oxygen, and contribute to the decrease of oxygen content in the water. The position of the thermocline and subsurface chlorophyll _a_ maximum deepens as the season progresses. The concentration of chlorophyll _a_ found in the subsurface maximum can be 7-10 times that found in waters above and below (O'Reilly, et. al. in press). This generalized pattern of relatively low chlorophyll _a_ concentrations above and below the thermocline, with chlorophyll _a_ concentrations significantly higher in the thermocline, persists throughout the stratified season until fall overturn when the system again becomes mixed.

The above distributional pattern was observed in the relatively shallow waters over the Long Branch transect, but not consistently throughout the warm season. However, when compared with deeper, offshore water, the water over the transect was relatively unstable with regard to the physical, biological, and chemical structures. At any one time, estuarine and coastal runoff, wind-mixing, nutrient regeneration in bottom waters, upwelling or downwelling might act upon the system causing it to vary from the generalized vertical pattern described above. Because of the shallow nature and proximity to land and the Hudson-Raritan estuary, the water over the transect frequently was affected by events that introduced freshwater and made nutrients more available to the system. Nutrient "inputs", such as those found in freshettes in May and June (Draxler et al., this report), can increase productivity and change the patterns of chlorophyll a distribution.

Waters of reduced salinity, with accompanying elevated nutrient concentrations, were seen inshore as a wedge (May 18) and as a reduced salinity layer over part of or the entire transect (June and August 8). When this occurred, highest chlorophyll a concentrations were generally associated with reduced salinities, and decreased with depth as salinities increased to reach a minimum in bottom waters.

When nutrient concentrations were elevated in bottom water and light was sufficient, the highest chlorophyll a concentrations were found in bottom waters, and chlorophyll a concentrations generally increased with depth, the lowest concentrations found at the surface (July 11 and 18, mid-transect). If the compensation depth was significantly above bottom, the phytoplankton in the chlorophyll a maximum could contribute to oxygen depletion. Relatively high concentrations of chlorophyll a were found in bottom waters just below the 1% light depth at station 3 on July 5 and stations 4 and 5 on July 11. These high concentrations coincided with decreasing oxygen concentrations and could have contributed to the oxygen depletion.

In both of the above cases, chlorophyll a concentrations around the thermocline were intermediate in the range of concentrations observed. When nutrients were abundant in both surface and bottom waters, chlorophyll a concentrations were generally highest in surface water, intermediate in bottom waters, and lowest in the mid-water column (June 1 and 13, mid-transect).

In all of the above cases, chlorophyll a concentrations around the thermocline/pycnocline, which under static conditions, would constitute a peak in chlorophyll a for the water column, are found to be low or intermediate in the range of values observed.

## Pycnocline

The pycnocline was well established in June and generally found between 5-10 m, although it was sometimes deeper at seaward stations. It remained in the same relative position until August when the system was thoroughly mixed following a major downwelling event. When it was reestablished, it was lower in the water column (between 10-20 m) and remained at this depth until September when the pycnocline began to break down.

In the beginning of the stratified season, salinity played a major role in determining the pycnocline structure and steepness, while temperature played a minor role. As the season progressed, the effect of salinity decreased and that of temperature increased, until at the end of the season, temperature played the major role in determining pycnocline structure and location. When the mixing event between August 8 and 15 passed, the effect of salinity was negligible.

## Salinity

The lowest salinities were observed in spring. In May and June there was a definite freshwater influence on the transect, probably from the Hudson/Raritan estuary outflow. Reduced salinity waters were observed: 1) inshore with salinities increasing seaward (May), and 2) as a layer of low salinity water over either part of or the entire transect with salinity increasing with depth (June and August).

In June the freshwater layer was most noticeable in the upper 5 m of the water column and the halocline was generally found between 5-10 m. As the months progressed and the layer became more saline, the range of salinities observed in the water column was reduced and the halocline weakened.

The halocline was broken up during the downwelling event between August 8-15, and, when reestablished, was much weaker; by September it was nonexistent.

Periodically throughout the season, freshwater inputs were observed with their accompanying increases in nutrient and chlorophyll _a_ concentrations. Highest chlorophyll _a_ concentrations were associated with these inputs and were generally found in the upper 5 m of the water column.

### May

In May, stratification was seen in chlorophyll _a_, nutrient, and salinity concentrations seaward of the 23 m isobath. A weak pycnocline was present with a chlorophyll _a_ maximum directly above it. Shoreward of the 23 m isobath the vertical stratification was absent, although gradients in nutrients, chlorophyll _a_, and salinity were present extending from shore seaward to the 23 m isobath.

Inshore of the 23 m isobath, chlorophyll _a_ and nutrient concentrations paralleled freshwater input. They decreased seaward as salinities increased.

### June

In June, lower salinity water was not isolated inshore as in May but was found over the entire transect in the upper 10 m of the water column. In this low salinity layer in early June, nutrient and chlorophyll _a_ concentrations decreased with depth while salinities increased. Salinities ranged from ~22-27 ppt, nitrate ($NO_3$) from ~1-10 μM, ammonium ($NH_4$) from ~2-5 μM, and chlorophyll a from ~8-15 mg/$m^3$. The nitrocline, halocline and pycnocline occurred around 10 m. The chlorocline varied around 10 m and was present at the bottom of and just below the pycnocline. Below 10 m salinities were relatively uniform; chlorophyll a and nutrient concentrations were relatively low except along the bottom where patches of elevated concentrations were found. Chlorophyll a and nutrient concentrations in these patches never reached concentrations found in the freshwater layer.

The freshwater layer became more saline as June progressed; by the end of the month it became less pronounced covering only part rather than the entire transect as it had during the beginning and middle of the month. By the end of the month salinities in the layers ranged from ~28-30 ppt. Although changes in the range of salinities (ppt) occurred during June, the overall distributional pattern remained constant throughout the month. The range of chlorophyll a and nitrate concentrations decreased from the beginning to the middle of the month, then remained the same to the end of the month. The range of $NH_4$ remained the same throughout June.

The distributional pattern of nitrate in mid-June was similar to the pattern observed in early June, but the range of observed values was narrower and decreased from ~1.0 μM at surface to ~0.1 μM in the middle of the water column. Again, elevated patches of $NO_3$ were found along the bottom; lowest values were found in the mid-water column. By the end of June, the distributional trend reversed and nitrate concentrations increased with depth, the lowest $NO_3$ concentrations located in the upper waters and the highest in bottom waters.

The range of ammonium concentrations found during all sampling in June was between 1-5 μM but the distributional pattern varied. In early June the distributional pattern was similar to that of $NO_3$ and chlorophyll - relatively high values in surface and bottom waters, lowest in the midwater column. By mid-June the pattern had changed; $NH_4$ concentrations generally increased with depth except mid-transect where the pattern similar to that observed in early June persisted. By the end of June ammonium concentrations increased with depth over the entire transect. This generalized distributional pattern was observed through the beginning of August.

The distribution of chlorophyll a in mid-June varied over the transect. Inshore of the 17 m isobath, chlorophyll a concentrations peaked directly above the 1% light level in the middle of the pycnocline. In the middle of the transect, chlorophyll a concentrations were low in mid-water and slightly higher in surface and bottom waters. Chlorophyll a concentrations alternated between high and low values in waters on the seaward side of the transect. Low concentrations in the mid-water column in the middle of the transect were in the same range as the beginning of the month. By the end of June chlorophyll a distribution was the reverse of nutrients. Concentrations decreased with increasing depth; elevated chlorophyll a concentrations on the surface, and low concentrations in bottom waters except inshore where highest concentrations were found along the bottom.

July-September

From July to the beginning of August, the pycnocline was still well established and was generally steepest between 5-10 m, and defined by temperature rather than salinity. The water overlying the transect became more saline as time progressed. Stratification was present but no steep halocline was observed. Both $NO_3$ and $NH_4$ concentrations were lowest in surface waters and increased with depth, reaching the highest concentrations on the bottom. The range of values observed in $NO_3$ was similar to that in June but higher concentrations of $NH_4$ (~10 μM/l) were observed in bottom waters where concentrations averaging ~5 μM/l were seen in June. Concentrations greater than ~10 μM/l were generally below the 1% light level.

Chlorophyll *a* concentrations were generally highest in the mid-water column and lower in surface and bottom waters. The highest concentrations were usually above the 1% light depth and between either the middle and bottom or just below the bottom of the pycnocline.

Exceptions to this pattern occurred when high chlorophyll *a* concentrations were found at the bottom of the water column. When this occurred, chlorophyll *a* concentrations generally increased with depth.

A strong pycnocline persisted through August 8. Between August 8 and 15 the system was mixed by a downwelling event; the strong thermocline and halocline broke up. A weak halocline was reestablished and persisted through September 5, after which salinities in the water column generally ranged between ~30.5 and ~31.5 ppt and were fairly uniform over the transect. After the mixing, the pycnocline was reestablished but lower in the water column, generally between 10-20 m. It was well defined from August 22 through September 13 when it began to breakdown inshore.

From August 8 through September 19, chlorophyll *a* concentrations were generally stratified in the inner one- or two-thirds of the transect, with the exception of August 22 when the entire transect was stratified. The distributional pattern varied over the transect and among sampling times. As in May and June, chlorophyll *a* concentrations were elevated when relatively low salinity water was introduced to the system (August 8, 22, and 29) either forming a gradient from land seaward as in May or decreasing with depth as in June. Correlations between low salinity water and increased chlorophyll *a* concentrations were isolated to nearshore waters. Elevated patches of chlorophyll _a_ were seen in bottom waters on August 22 and 29 and September 13. In general, chlorophyll _a_ concentrations on the seaward side of the transect were relatively low and somewhat homogeneously distributed within the water column. By September 19 chlorophyll _a_ concentrations were low over the entire transect except in bottom and mid-transect water where they were slightly elevated.

## Summary

The distributional pattern of chlorophyll _a_ is variable in shallow, unstable inshore waters. As bottom depth and distance from shore increase, the water column becomes more stable and the distribution pattern of chlorophyll _a_ is more consistent over time. Generally, the highest concentrations of chlorophyll _a_ are found where light and nutrients are sufficient for growth. The highest concentrations can be found at the surface, or bottom of the water column generally in or around the bottom of the thermocline/pycnocline. The compensation depth, at times, is above the thermocline/pycnocline. During these times, the phytoplankton community is respiring, depleting oxygen from the water column, thus can contribute to hypoxic conditions.

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Evans-Zetlin, C., and J. O'Reilly. 1983. Phytoplankton and community size composition. In: 106-mile site characterization update. J. Pearce, D. Miller, and C. Berman (eds.). NOAA Technical Memorandum NMFS-F/NEC-26.

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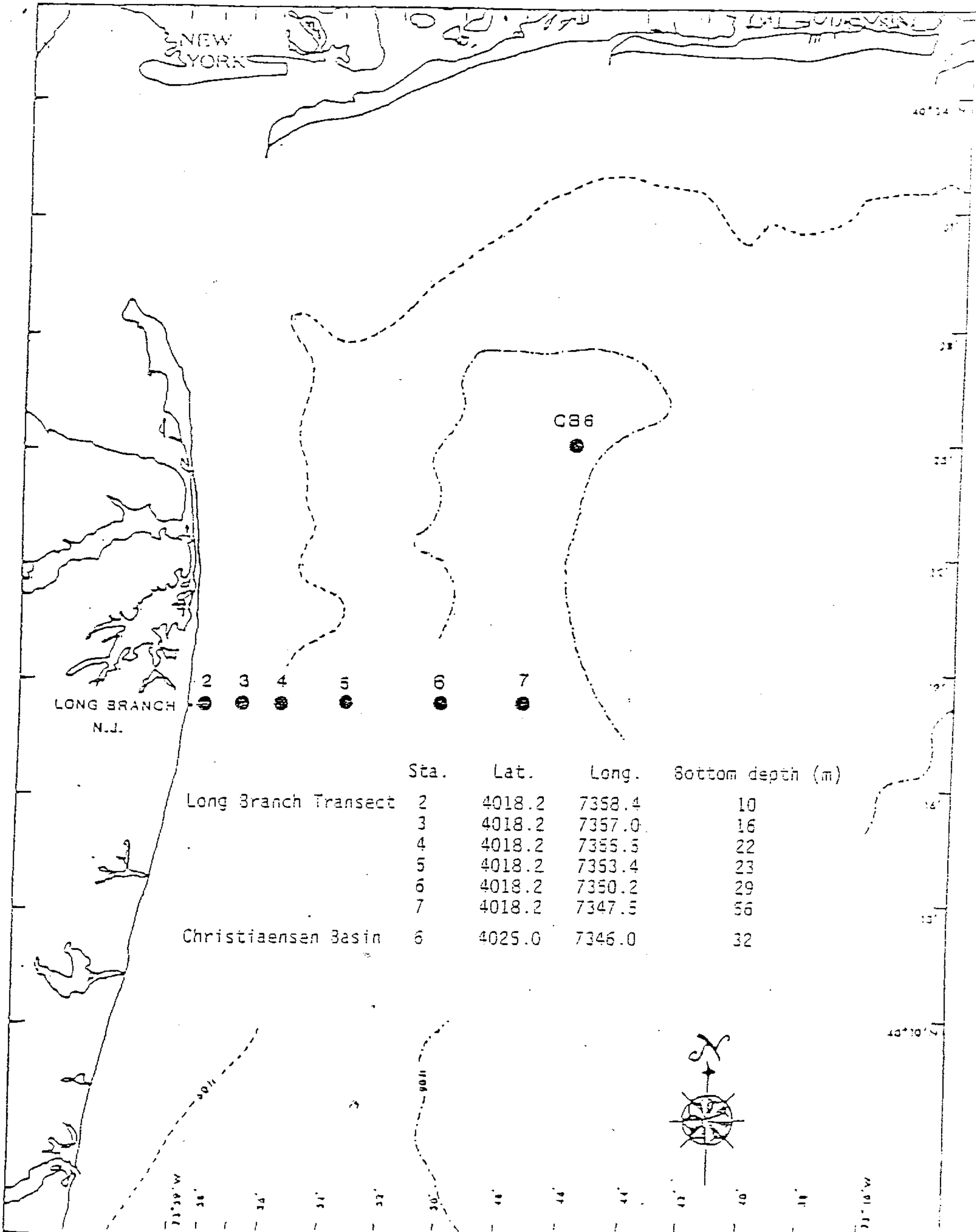



| | Sta. | Lat. | Long. | Bottom depth (m) |
|---|---|---|---|---|
| Long Branch Transect | 2 | 4018.2 | 7358.4 | 10 |
| | 3 | 4018.2 | 7357.0 | 16 |
| | 4 | 4018.2 | 7355.5 | 22 |
| | 5 | 4018.2 | 7353.4 | 23 |
| | 6 | 4018.2 | 7350.2 | 29 |
| | 7 | 4018.2 | 7347.5 | 36 |
| Christiaensen Basin | 6 | 4025.0 | 7346.0 | 32 |

FIGURE 1

LOCATION OF STATIONS ALONG STUDY TRANSECT

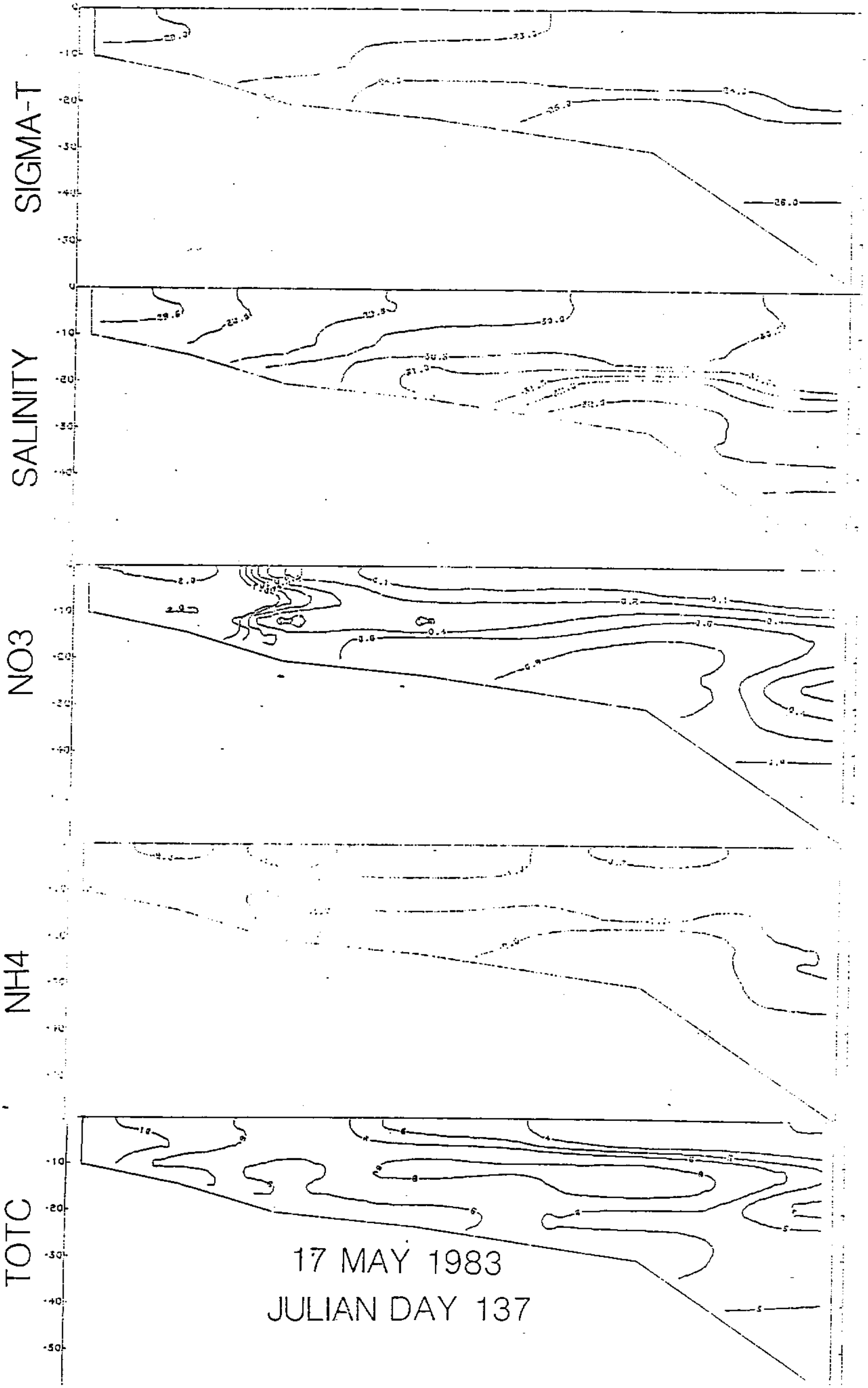
FIGURE 2

CROSS SECTION OF LONG BRANCH TRANSECT

sigma T, salinity, nitrate,
ammonium and total chlorophyll _a_

May 17 - September 19, 1983

# TRANSECT MONITORING



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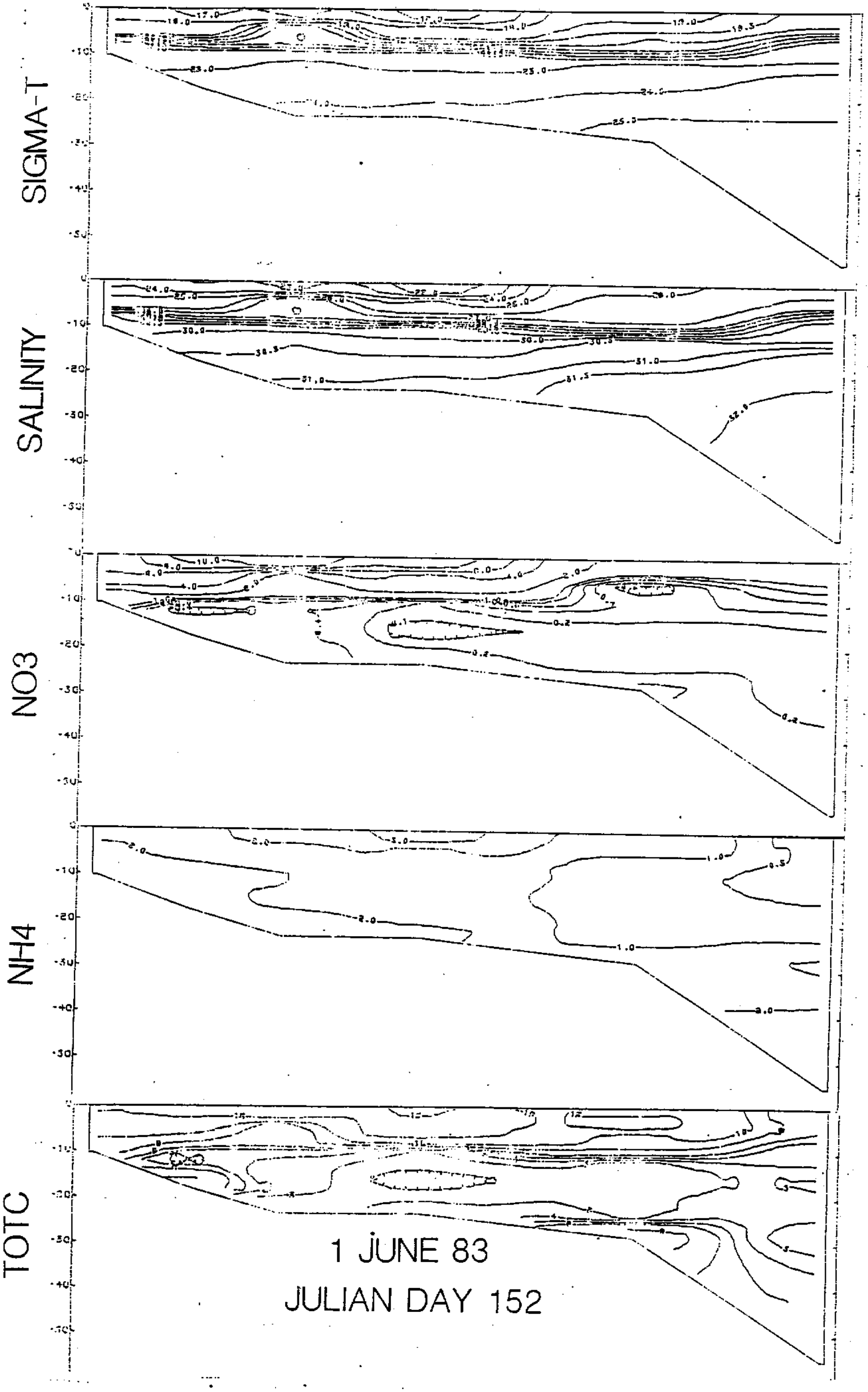

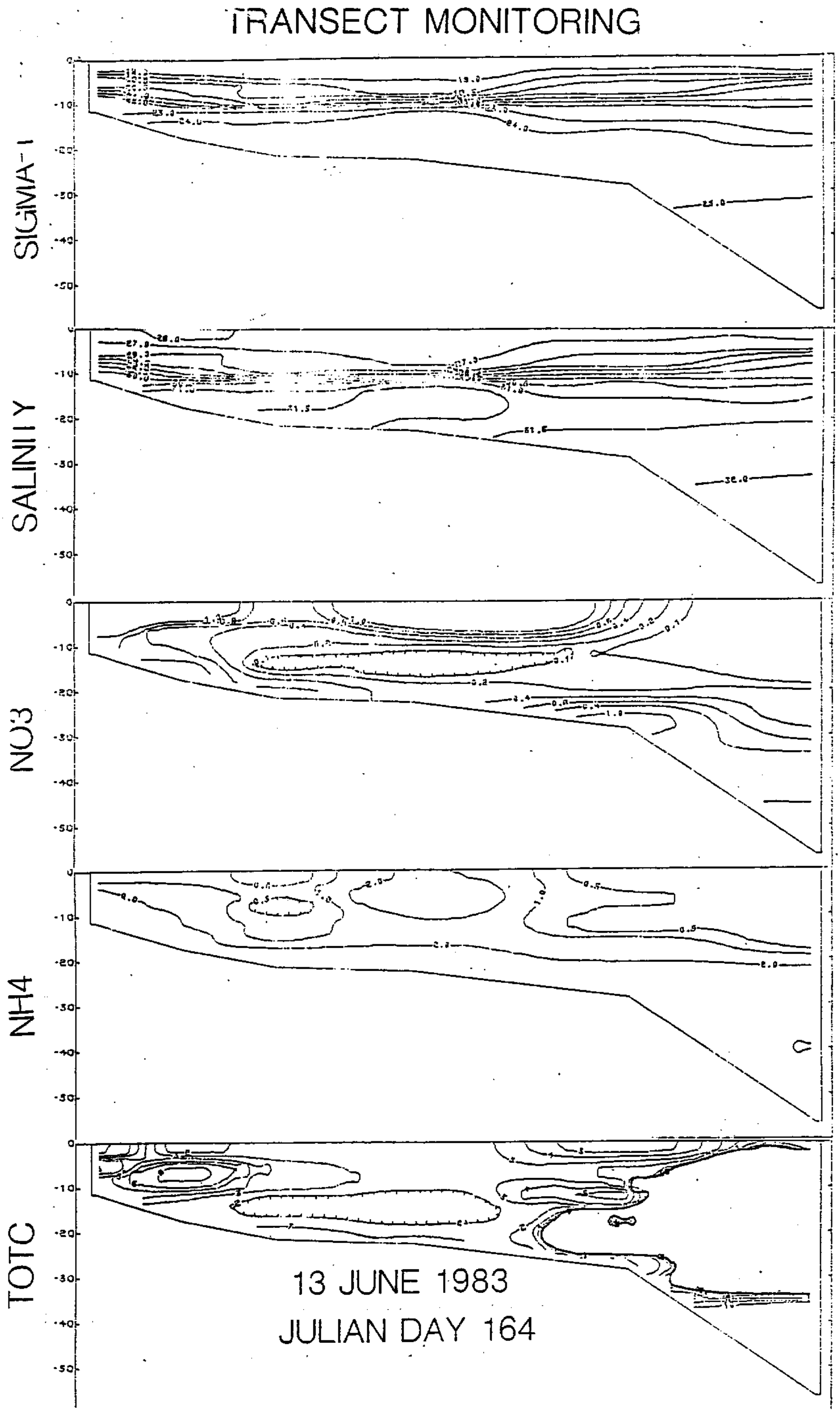

TRANSECT MONITORING
SIGMA-T
SALINITY
NO3
NH4
TOTC
13 JUNE 1983
JULIAN DAY 164

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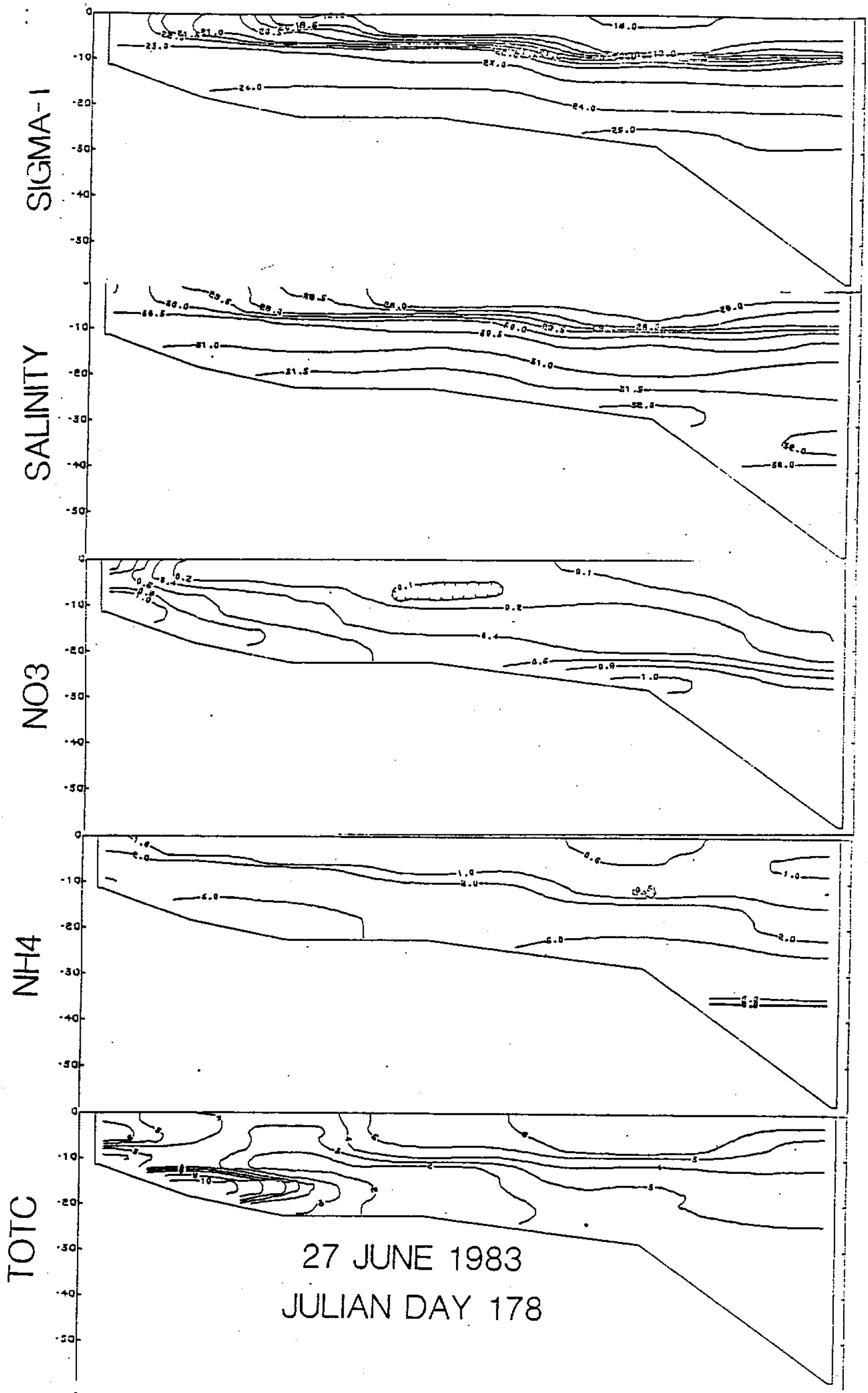

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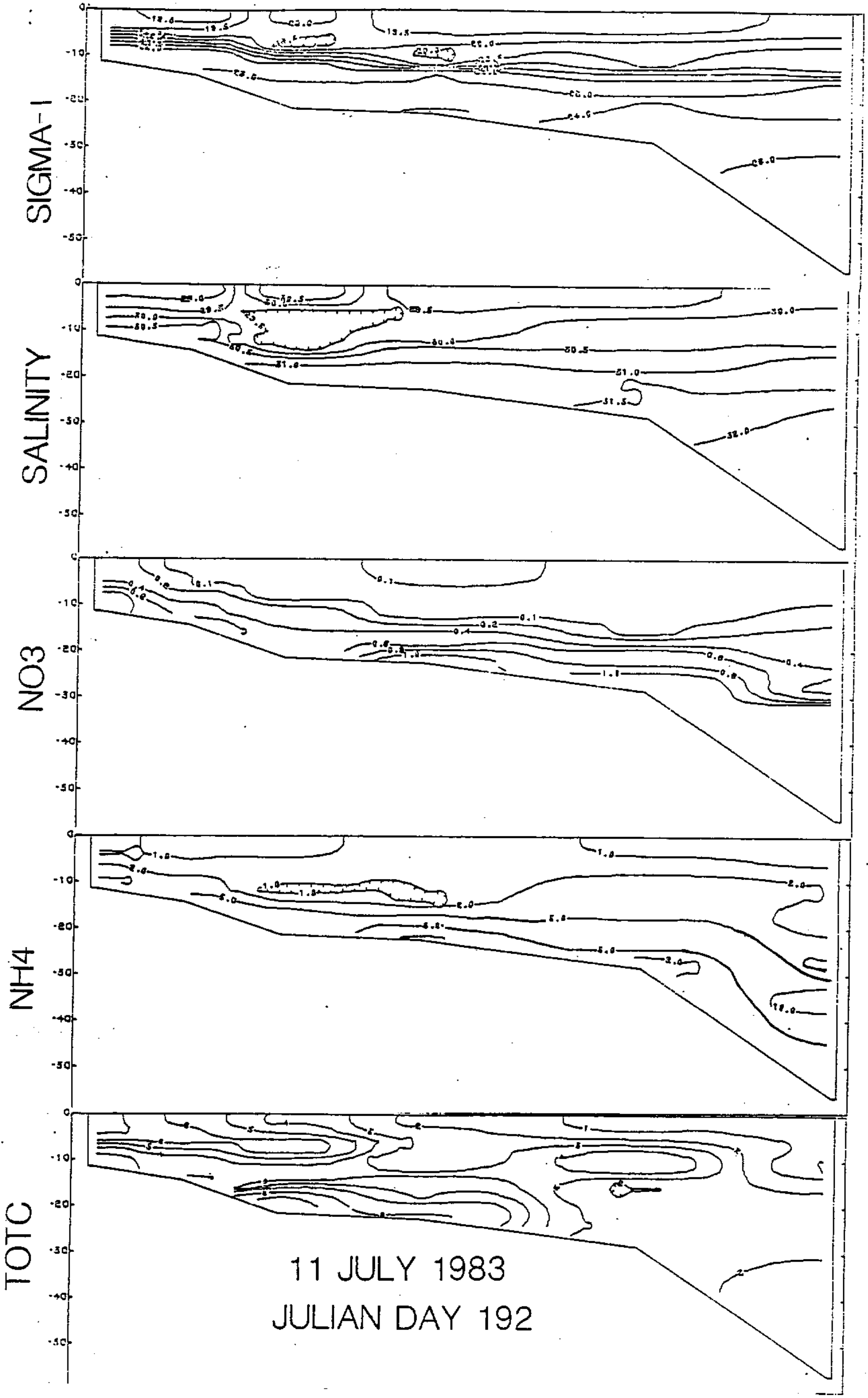

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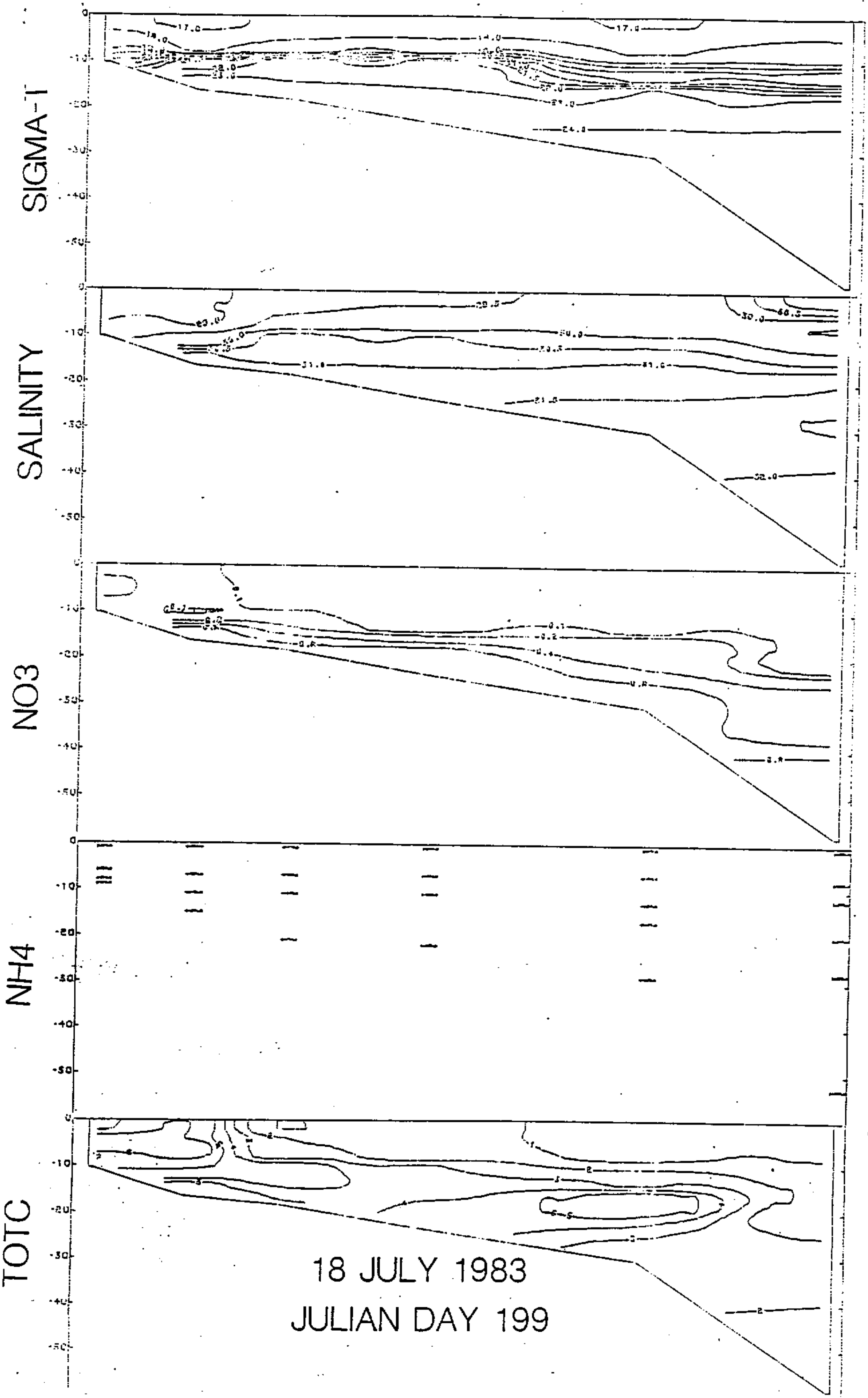

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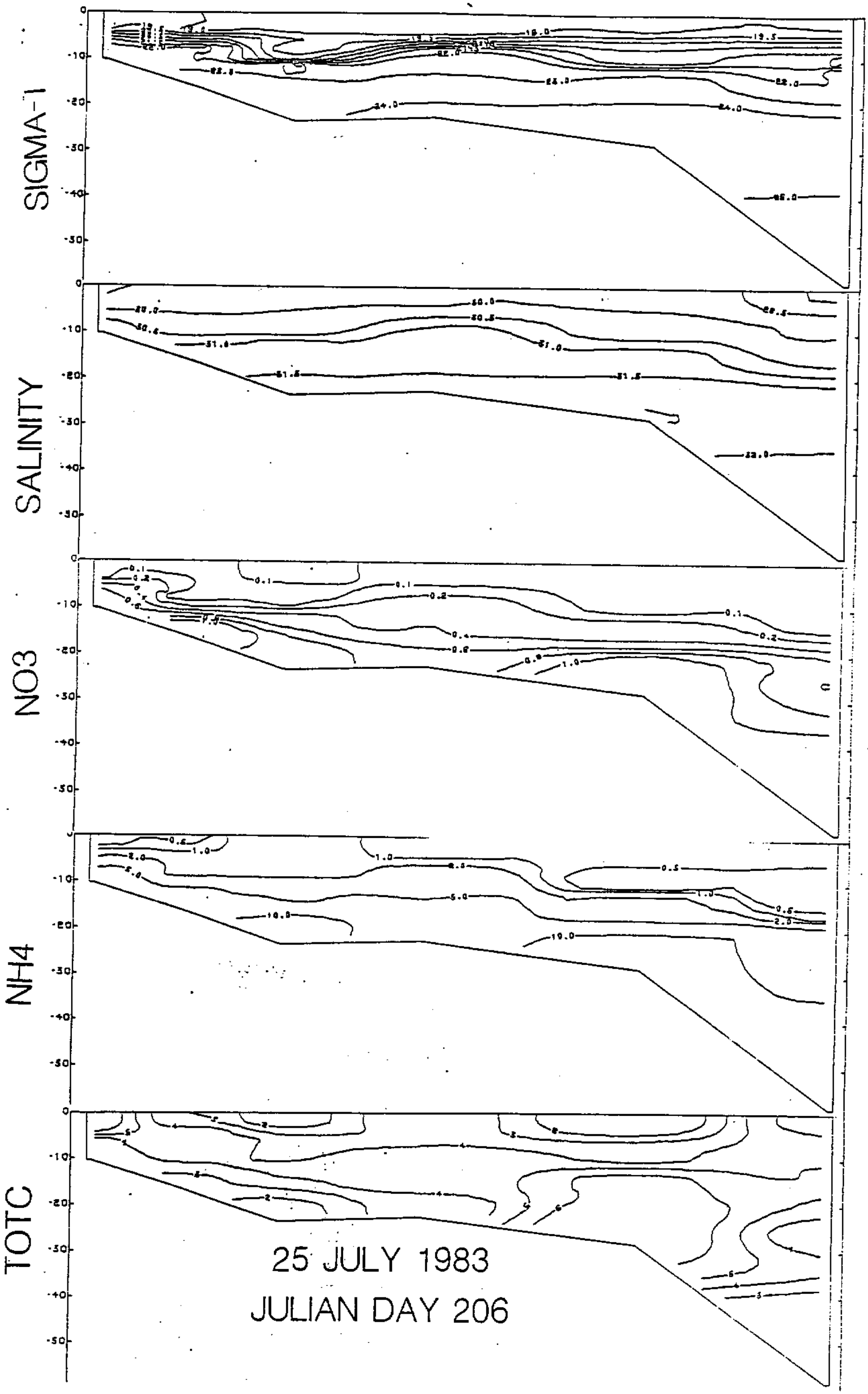

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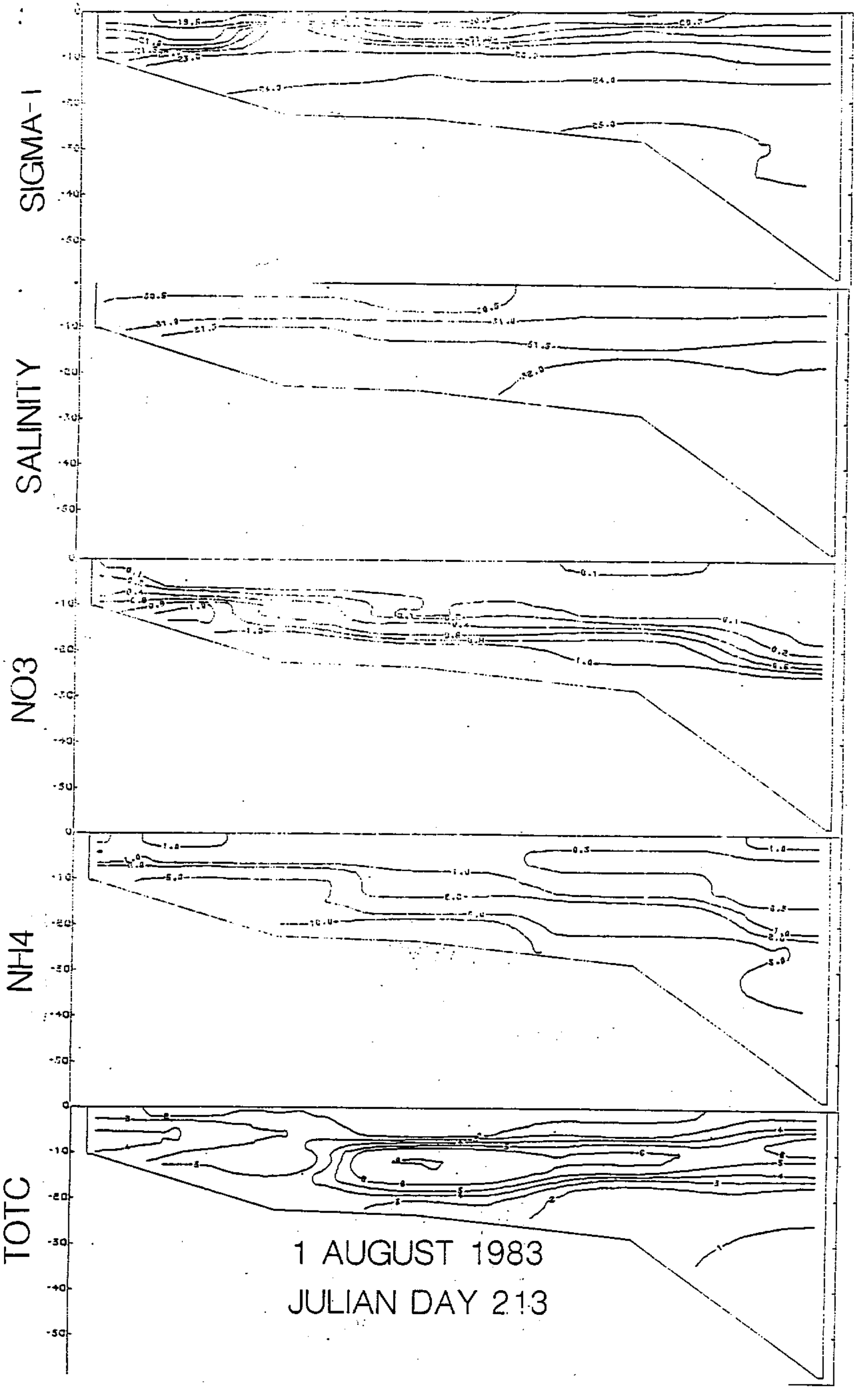

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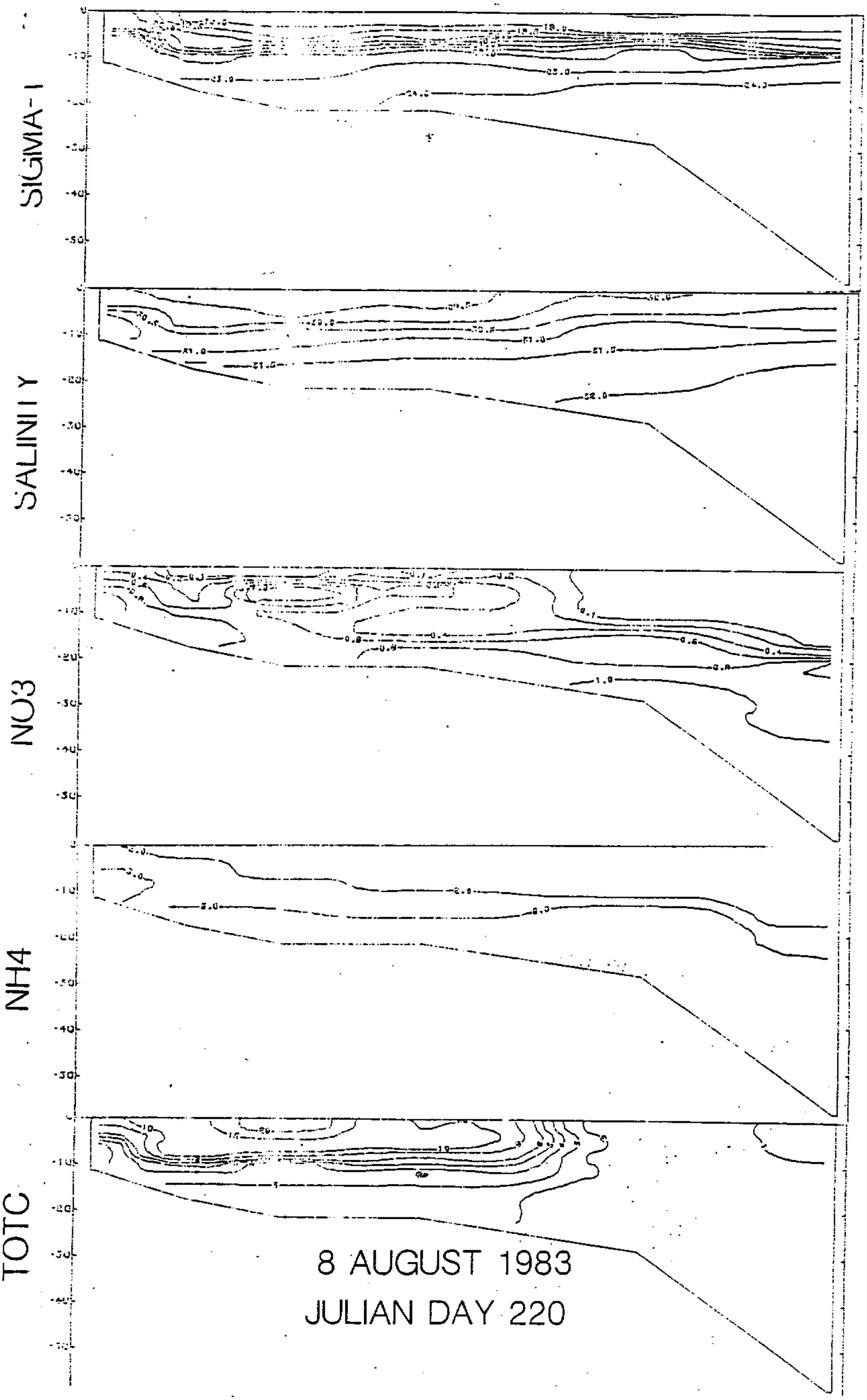

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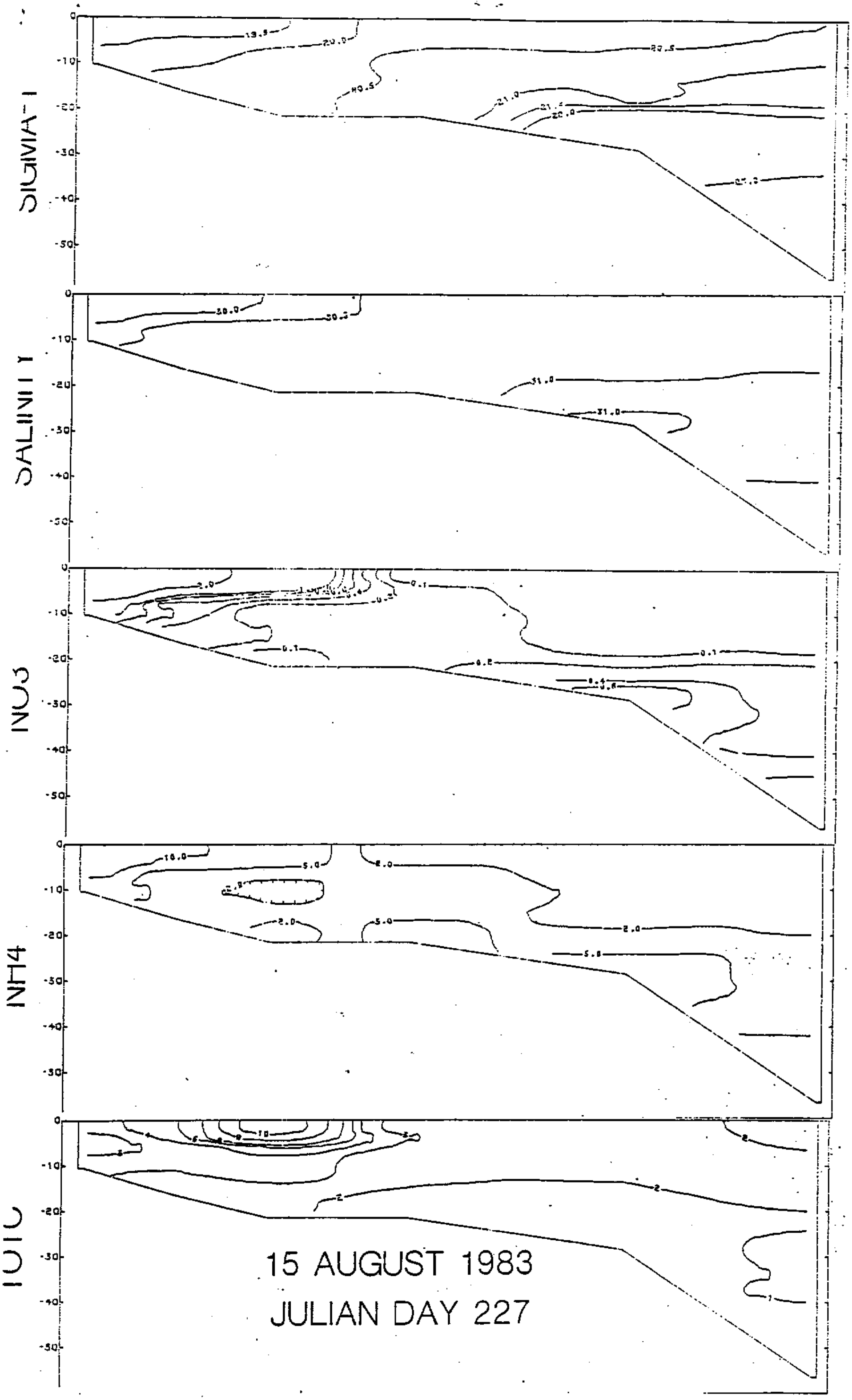

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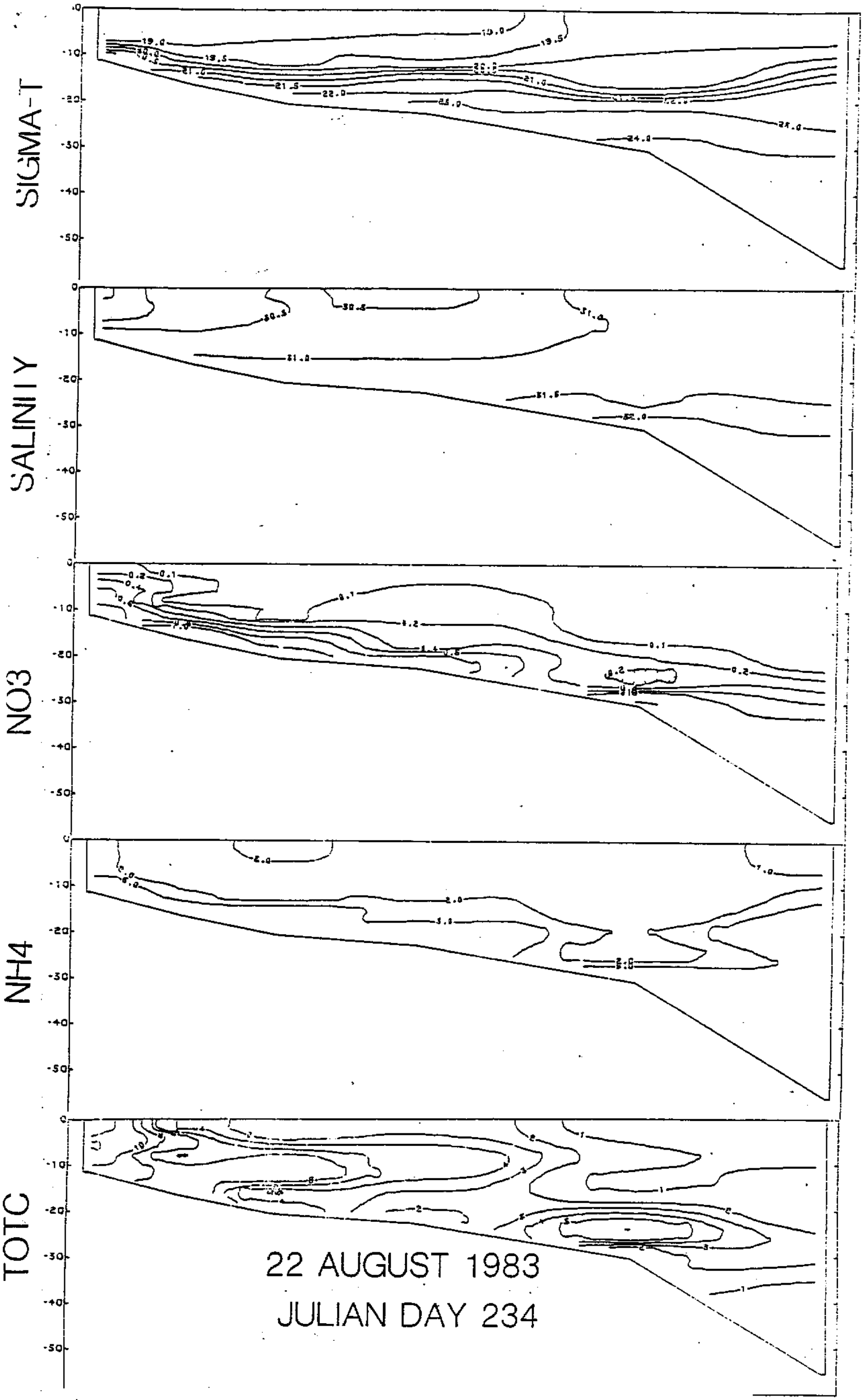

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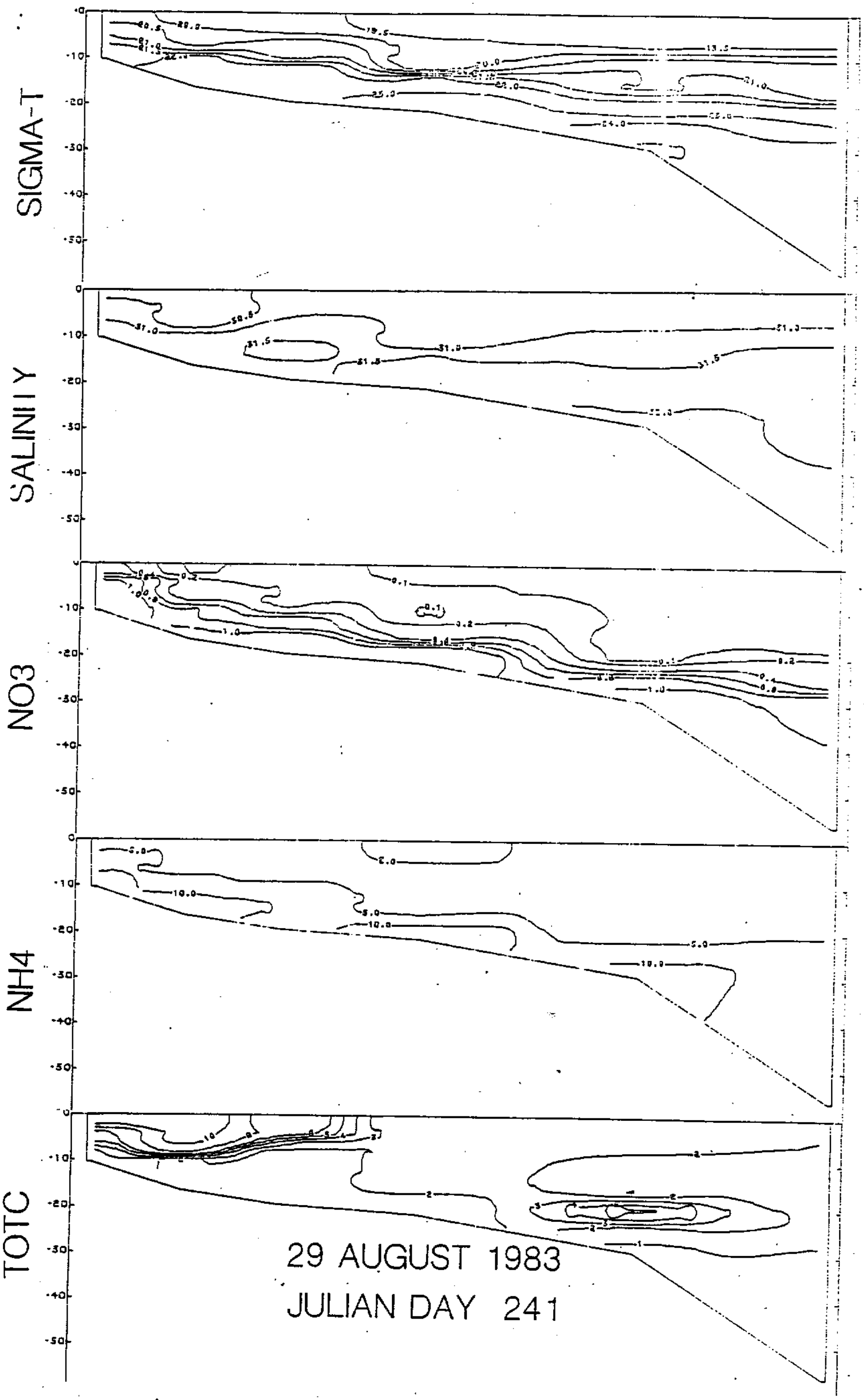

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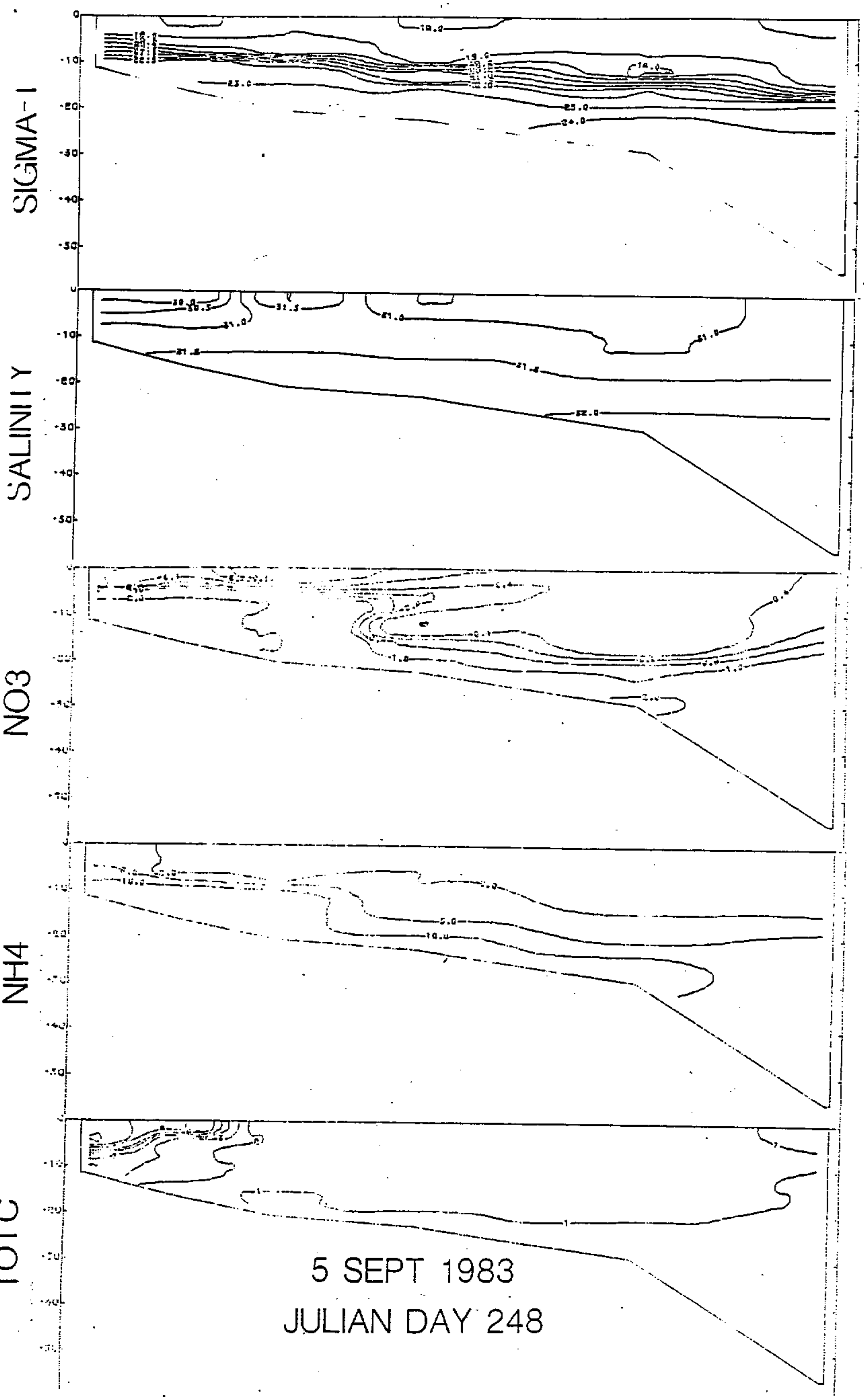

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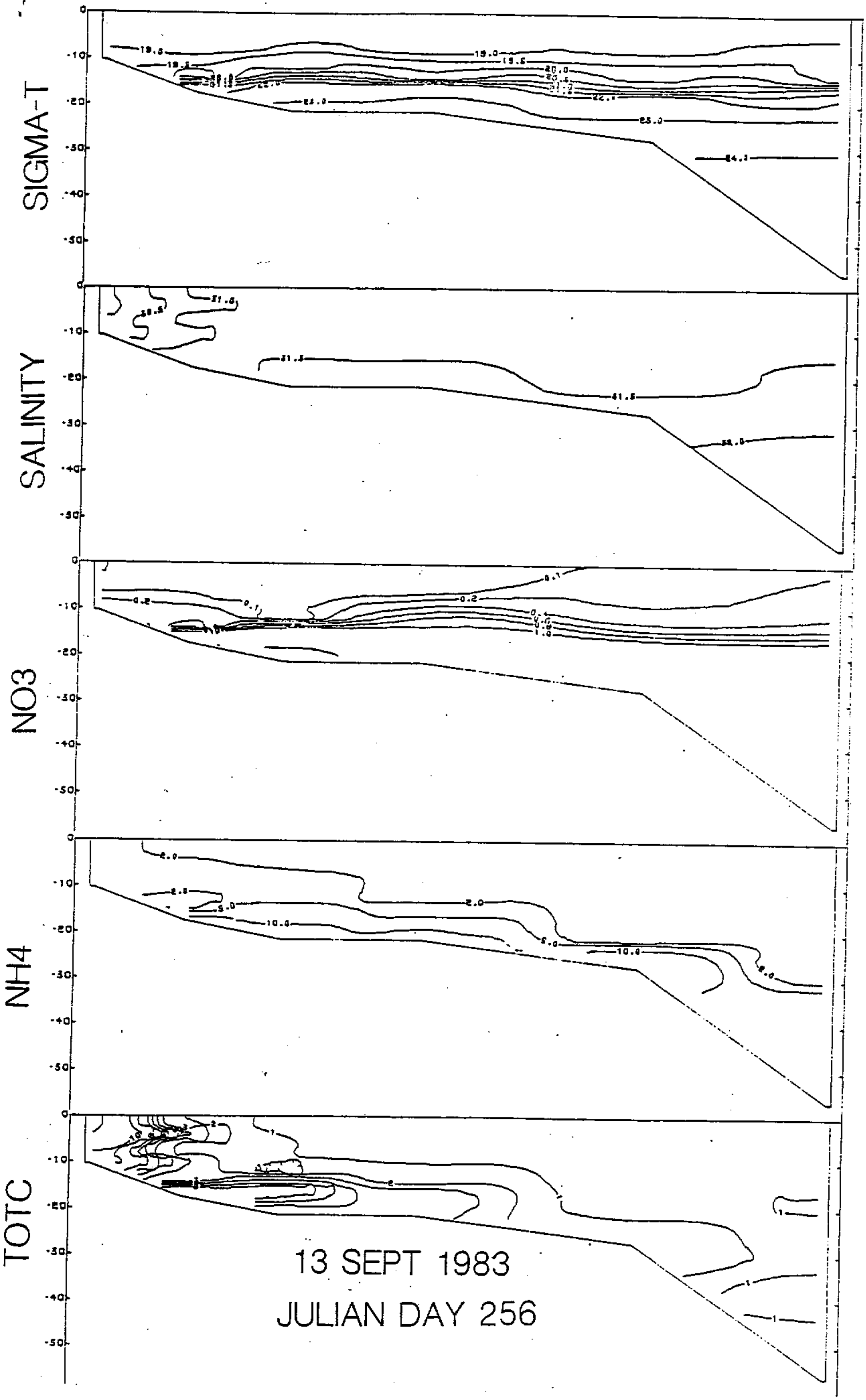

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