Annual Report

Contract No.: 03-5-022-67, T.O.1

Research Unit No.: 151

Reporting Period: 1 April-31 March 1976

Number of Pages: 34

STD Measurements in Possible Dispersal Regions of the Beaufort Sea

Knut Aagaard

Department of Oceanography

University of Washington

Seattle, Washington 98195

24 March 1977

I. Summary

Through a series of CTD sections across the Beaufort Sea shelf we have traced the seasonal hydrographic sequence from fall to spring in one year, and from fall to winter the next.

We have seen that not only are there large seasonal changes in the hydrography, but conditions are also different from one year to the next. The latter point is a caution to us, should we attempt to generalize from too short a time base. Nonetheless, the normal seasonal cycle has now probably been determined at least in outline.

One matter appears to stand out in importance: the Beaufort Sea shelf is certainly not neutral with respect to the Arctic Ocean to the north. Rather there are one or more forms of interaction, in which water and the substances it transports are exchanged between the shelf and the offshore regions. Certainly the salt budget calculations discussed in Section VII can be thus interpreted. It is likely that when the presence of widespread temperature maxima is better understood, it also will point to such an exchange. The most dramatic evidence of exchange is the series of four sections from fall 1976, in which an intense subsurface current core appears to be sweeping up the slope and onto the shelf, flooding at least one section to the innermost station with dense, saline water.

II. Introduction

The general objective of this research unit has been to provide seasonally distributed synoptic temperature-salinity mappings of the Beaufort Sea shelf and slope. In the first year of work the sections were distributed along the entire Alaskan shelf, one each going out from Pitt Point, Narwhal Island, and Humphrey Bay. They were run in the fall (October-November), winter (February), and spring (May). The intent was to provide broad areal coverage. The second year the sections were concentrated in two locations, *viz.* off Lonely and Oliktok. In each region two parallel lines of stations were run in order to more closely examine the east-west hydrographic structure. Because of the similarity in winter and spring conditions during the first year, we felt it sufficient the second year to sample only in the fall and winter.

The general thrust of this work is of course toward understanding the diffusive and advective processes which transport and disperse pollutants and substances of biological and geological importance.

III. Current state of knowledge

Except for the brief ice-free period during summer, hydrographic stations had never been taken in this area prior to the present work. Knowledge was therefore restricted to summer conditions, which briefly appear to be as follows. There are large temperature and salinity ranges (and gradients) on the shelf, with temperatures varying from near-freezing to more than 5°C, and salinities from brackish to greater than 33‰. In summer an eastward intrusion of relatively warm water originating in the Bering and Chukchi seas appears to be a regular feature of the circulation on the outer shelf, being typically located seaward of the 40 m isobath. This water has been identified at least as far east as 143°W. Summer observations have also indicated the likelihood of an intermittent upwelling regime on the eastern part of the shelf. The upwelled water is relatively cold, low in oxygen, and high in nutrients. It has been postulated that the upwelling is a response *to* locally strong easterly winds and that the upwelled water on the shelf moves westward.

The work of the past year-and-a-half has added substantially to this picture, as will be discussed in Section VII of this report.

IV. Study area

The most general area of interest extends eastward from Point Barrow along the entire northern Alaskan coast, *i.e.*, from about 156°30'W to 141°W, a lateral distance of nearly 600 km. The shelf is narrow, with the shelf break typically 80-90 km offshore. The total runoff is relatively small, highly seasonal, and concentrated in a very few rivers of any consequence, the largest of which is the Colville. The area is covered by sea ice, both first- and multi-year, through all but 2-3 months. Even during the height of summer, ice is usually found well onto the shelf.

V. Data collection

The rationale of data collection has been discussed in the annual report of last year and in Section III of this report. In the second sequence of STD sections, run in the fall and winter of the present fiscal year (cruises W25 and W27), the station spacing was decreased somewhat from that of the first year, to about 5 nautical miles. The two parallel lines in each set were located about 15-20 miles apart. The idea was to get as much spatial resolution as possible.

During this second year we made certain changes in equipment and procedure. One was the installation of low-frequency navigation gear aboard the helicopter. This made possible a sizeable improvement in our ability to fix station locations. Another major improvement was to redesign the sensor package into a smaller format. It now fits down through an 8-inch auger hole, thus no longer requiring the laborious task of drilling and chiseling a hole four times the size. A third improvement was installation of a frequency counter along with the data logger, thus enabling constant monitoring of the sensor signals. This has improved the quality of the tapes considerably.

VI. Results

All data from cruises W21-W25 have been submitted to the project data office, properly formatted on magnetic tape. Pictorial representations of all the sections are included in Section VII of this report.

VII. Discussion

Figures 1-9 show the seasonal progression of the hydrography on the Beaufort shelf during 1975-1976. Cruise W21 was in the fall (October-November), W22 in

PITT POINT W21

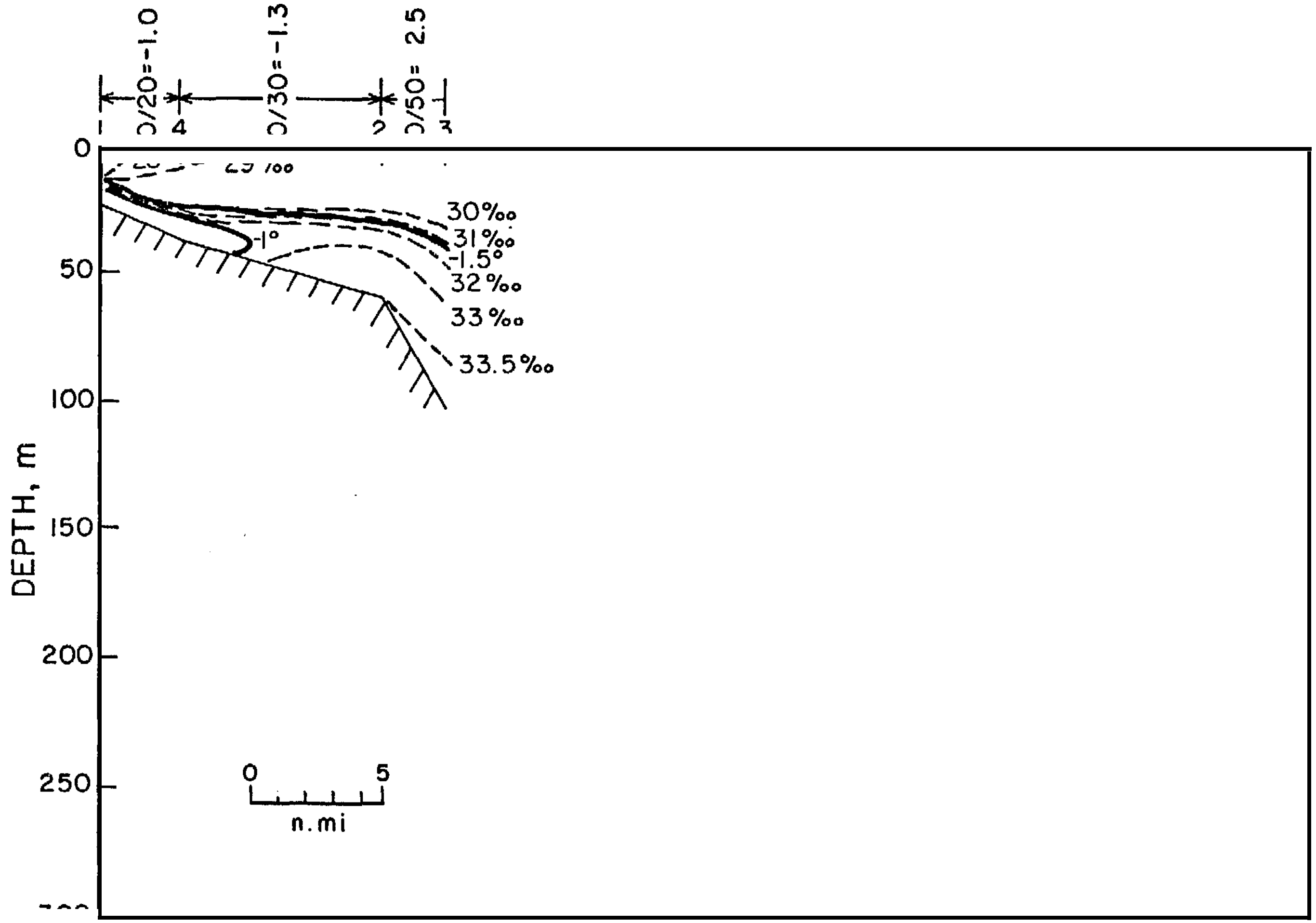


Figure 1

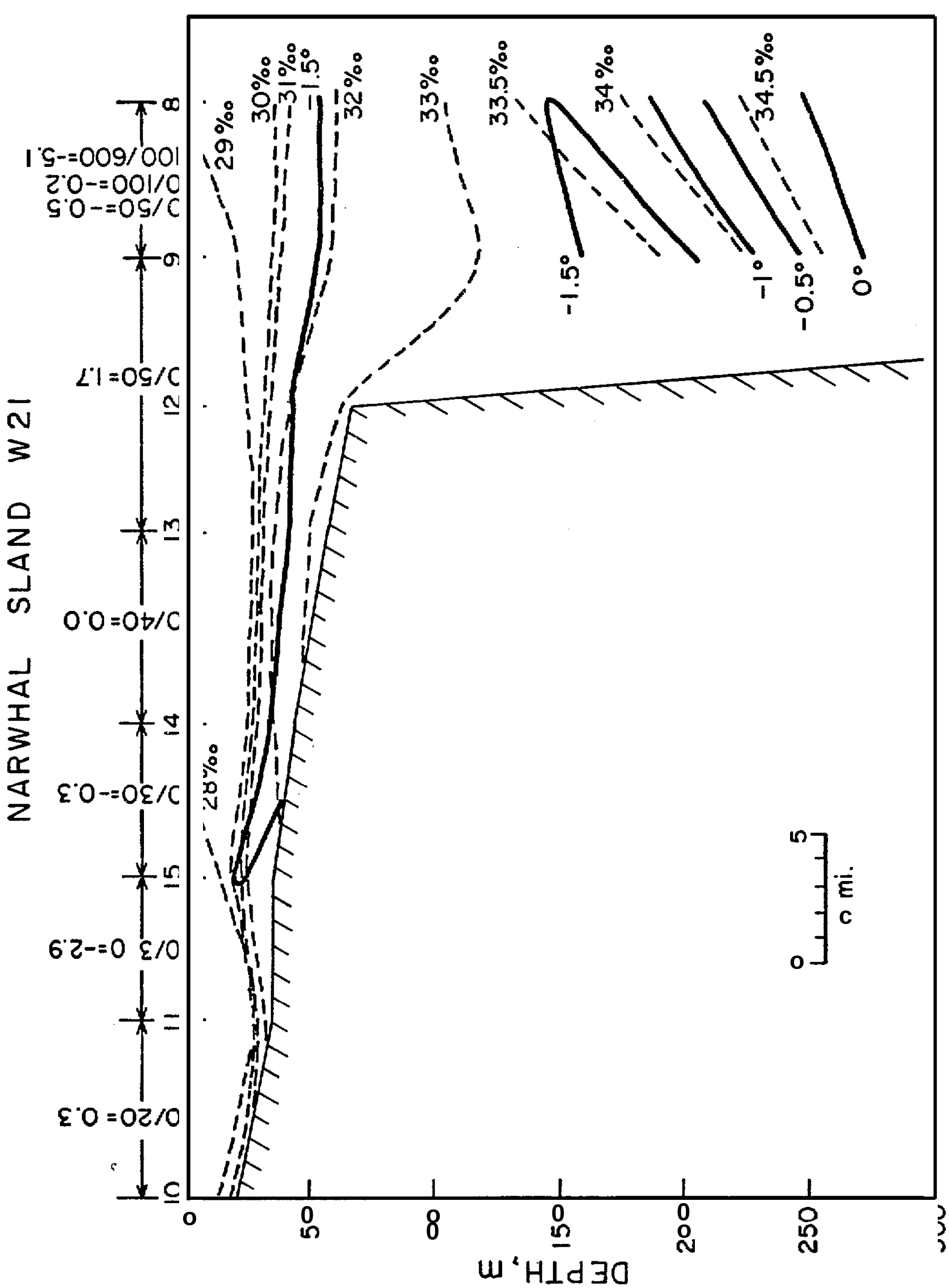

NARWHAL SLAND W21
DEPTH, m
0
50
150
200
250
29‰
30‰
31‰
1.5°
32‰
33‰
33.5‰
34‰
34.5‰
-1.5°
-1°
-0.5°
0°
28‰
mi.

Figure 2

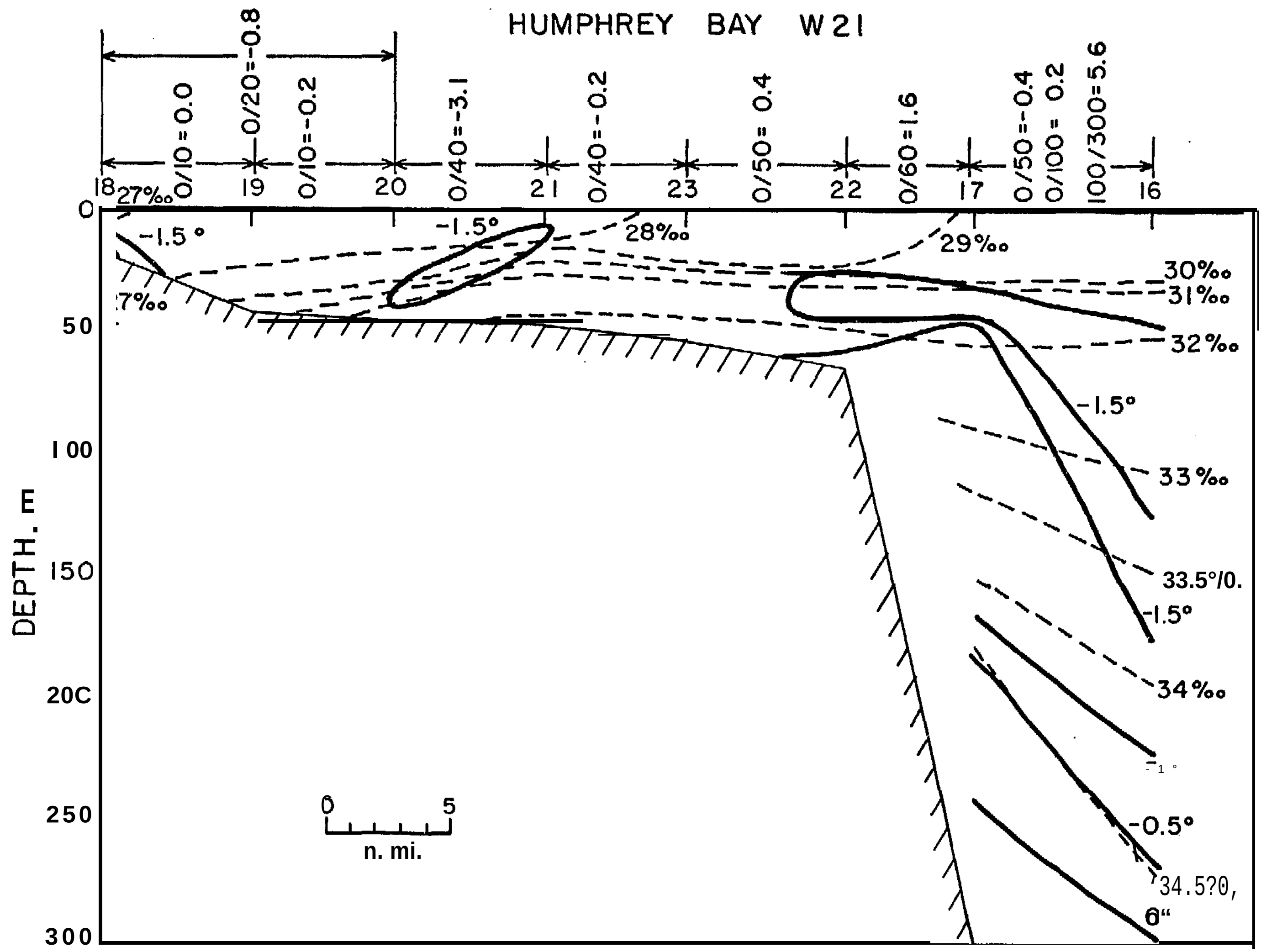

HUMPHREY BAY W21
0/10=0.0
0/20=-0.8
0/10=-0.2
0/40=-3.1
0/40=-0.2
0/50= 0.4
0/60=1.6
0/50=-0.4
0/100= 0.2
100/300=5.6
18
19
20
21
23
22
17
16
27‰
-1.5°
-1.5°
28‰
29‰
30‰
31‰
32‰
7‰
-1.5°
33‰
33.5°/0.
-1.5°
34‰
-0.5°
34.5?0,
DEPTH. E
0
50
100
150
20C
250
300
0
5
n. mi.

Figure 3

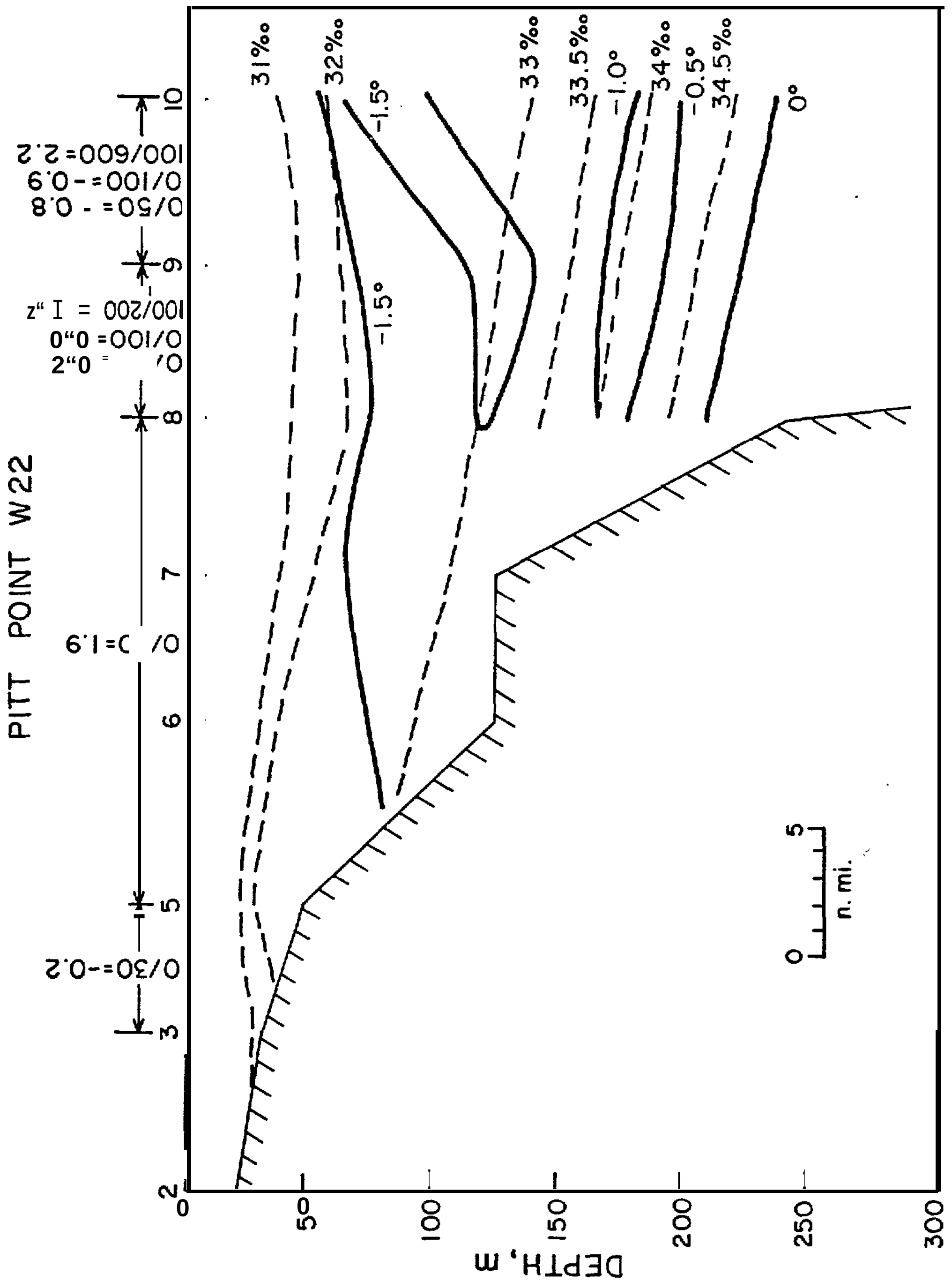

PITT POINT W22
DEPTH, m
0
50
100
150
200
250
300
2
3
5
6
7
8
9
10
31‰
32‰
33‰
33.5‰
34‰
34.5‰
-1.5°
-1.0°
-0.5°
0°
0
5
n. mi.

Figure 4

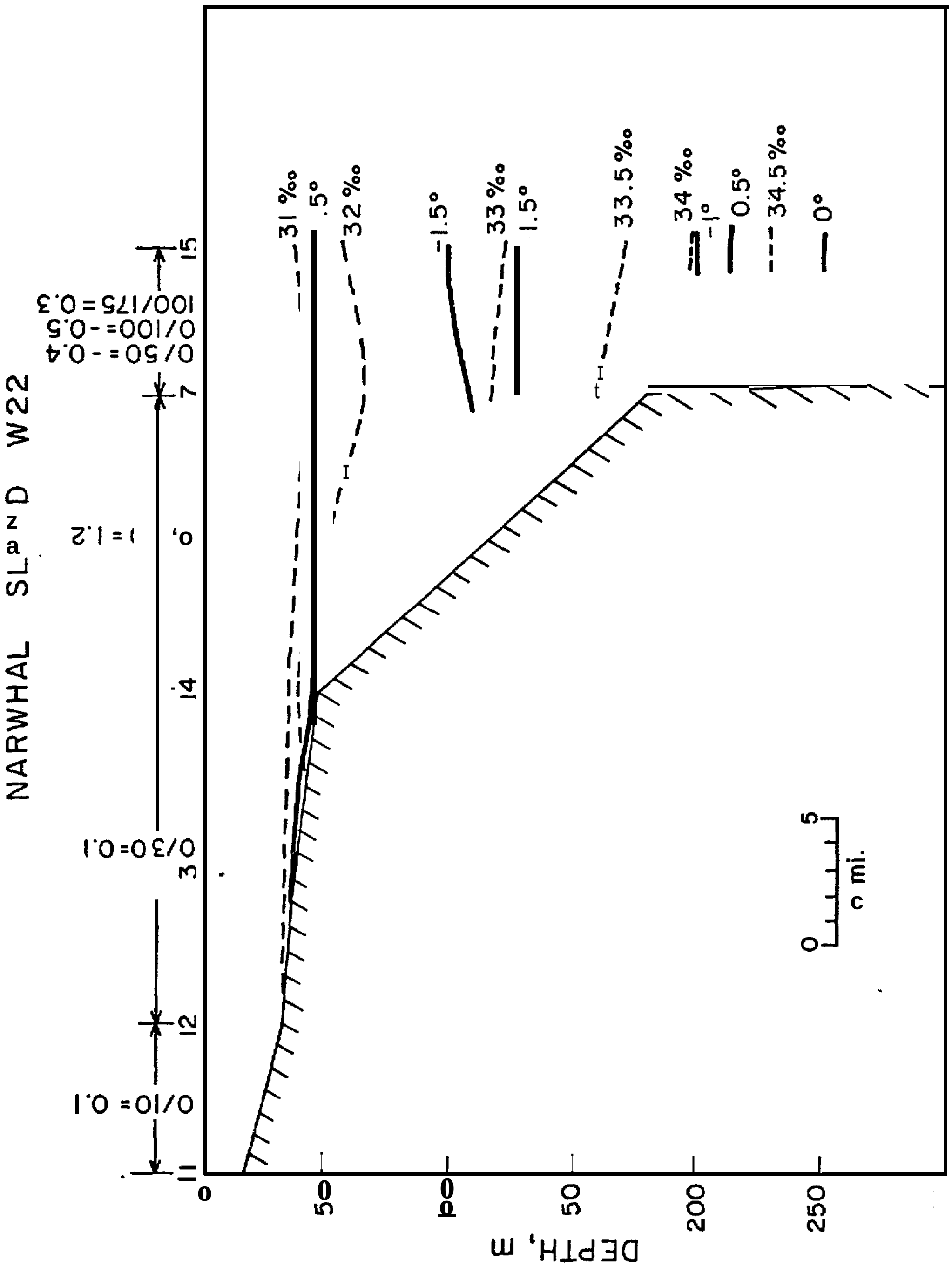

NARWHAL SLAND W22
0/10 = 0.1
0/30=0.1
0/50= -0.4
0/100= -0.5
100/175=0.3
31 ‰
.5°
32 ‰
-1.5°
33 ‰
1.5°
33.5 ‰
34 ‰
-1°
0.5°
34.5 ‰
0°
c mi.
DEPTH, m
0
50
200
250
11
12
3
14
7
15

Figure 5

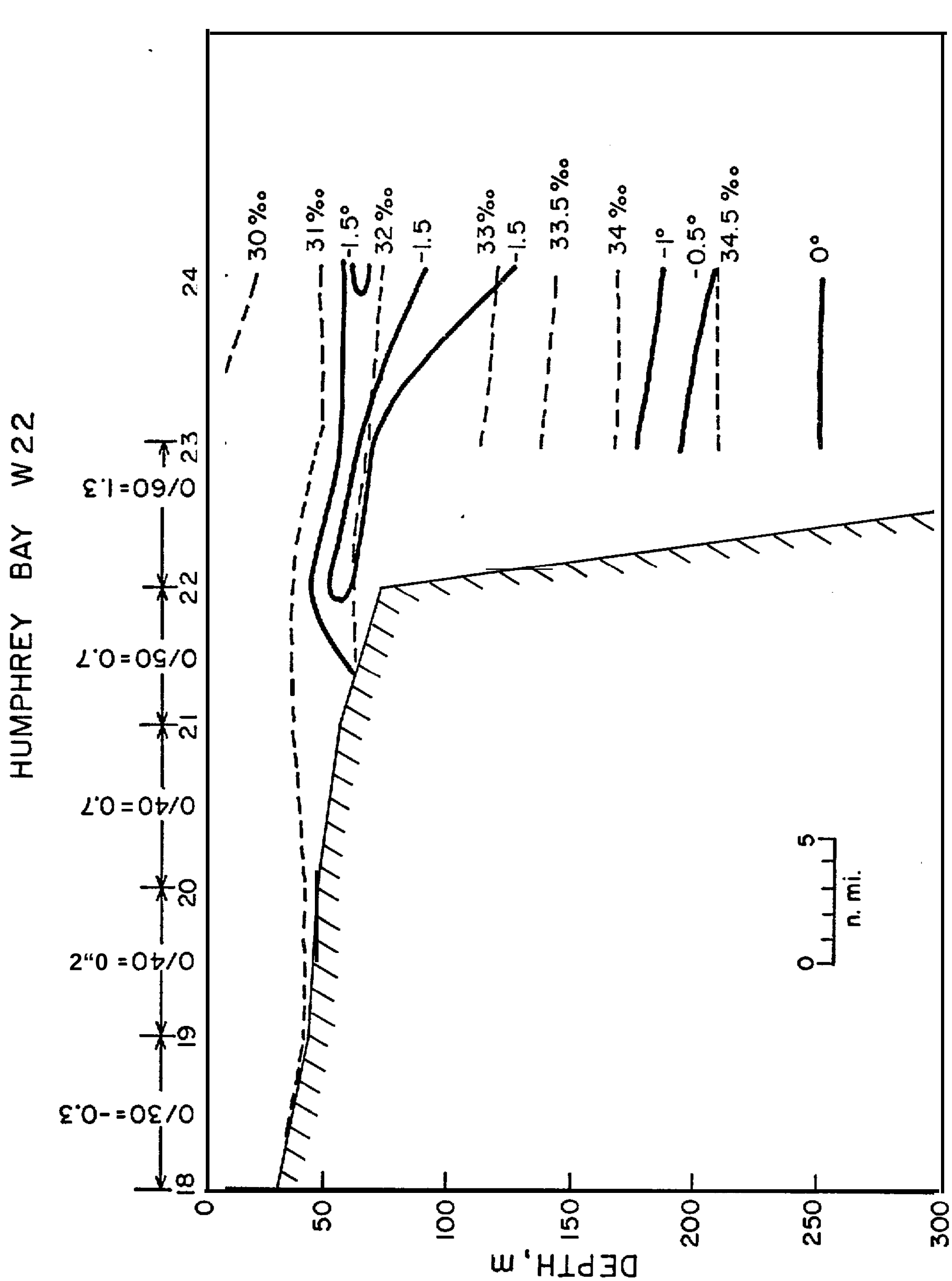

HUMPHREY BAY W22
18
19
20
21
22
23
24
0/30=-0.3
0/40=0.7
0/50=0.7
0/60=1.3
30‰
31‰
-1.5°
32‰
-1.5
33‰
-1.5
33.5‰
34‰
-1°
-0.5°
34.5‰
0°
DEPTH, m
0
50
100
150
200
250
300
0
5
n. mi.

Figure 6

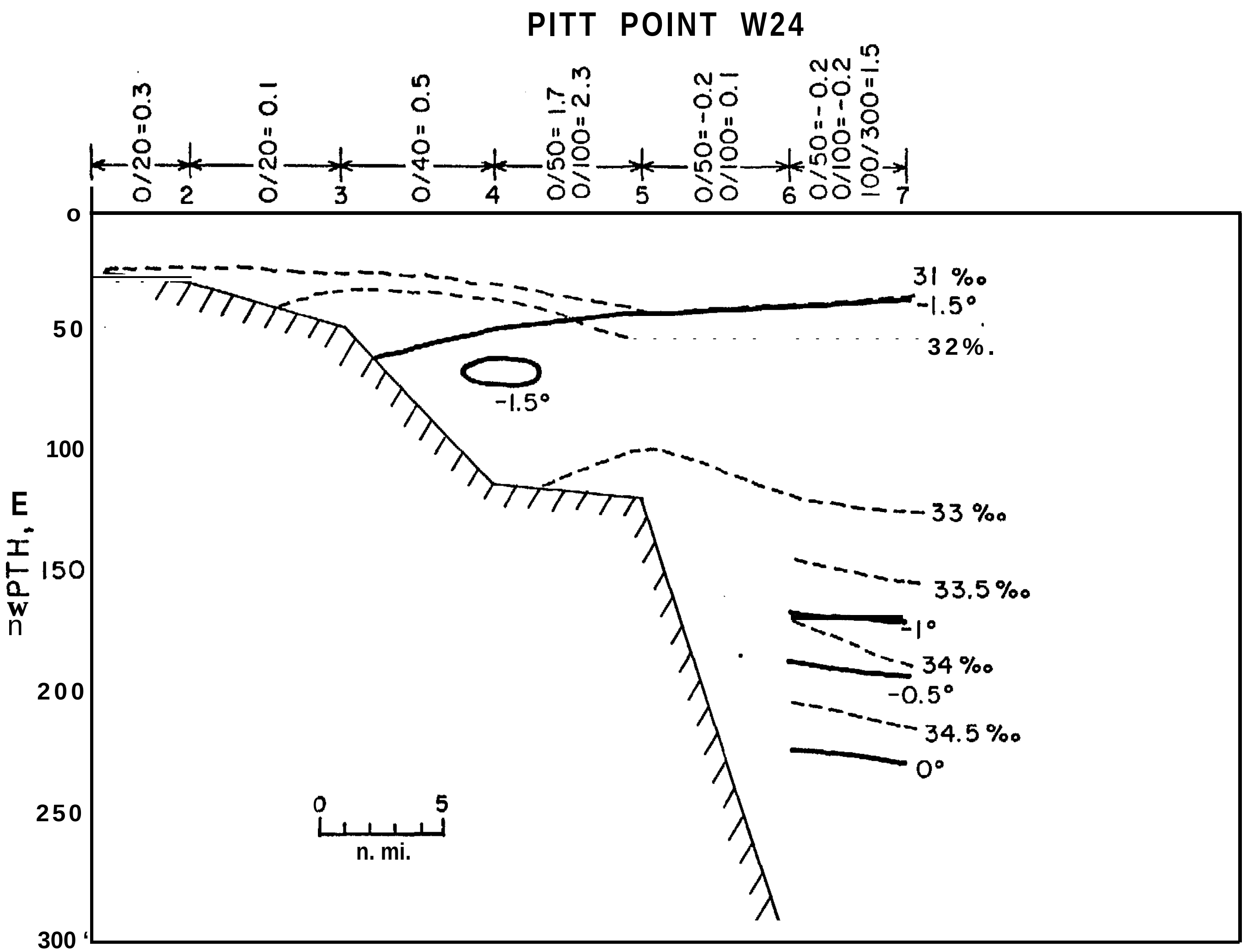

PITT POINT W24
0/20=0.3
0/20= 0.1
0/40= 0.5
0/50= 1.7
0/100= 2.3
0/50= -0.2
0/100= 0.1
0/50= -0.2
0/100= -0.2
100/300=1.5
2
3
4
5
6
7
0
50
100
150
200
250
300
31 ‰
-1.5°
32%.
-1.5°
33 ‰
33.5 ‰
-1°
34 ‰
-0.5°
34.5 ‰
0°
0
5
n. mi.

Figure 7

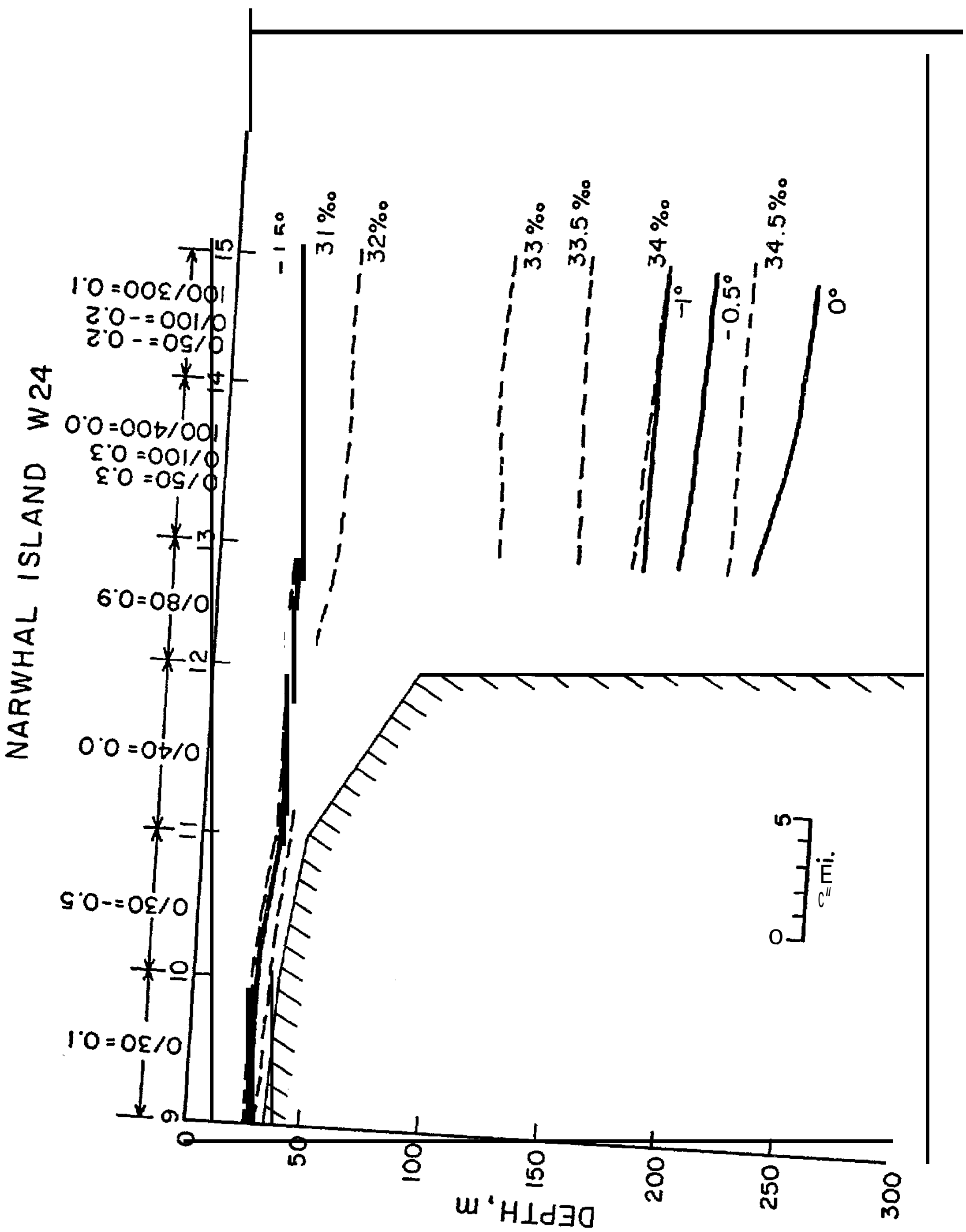

NARWHAL ISLAND W24
0/30=0.1
0/30=-0.5
0/40=0.0
0/80=0.9
0/50=0.3
0/100=0.3
100/400=0.0
0/50=-0.2
0/100=-0.2
100/300=0.1
9
10
11
12
13
14
15
31‰
32‰
33‰
33.5‰
34‰
34.5‰
-1°
-0.5°
0°
0
5
mi.
DEPTH, m
0
50
100
150
200
250
300

Figure 8

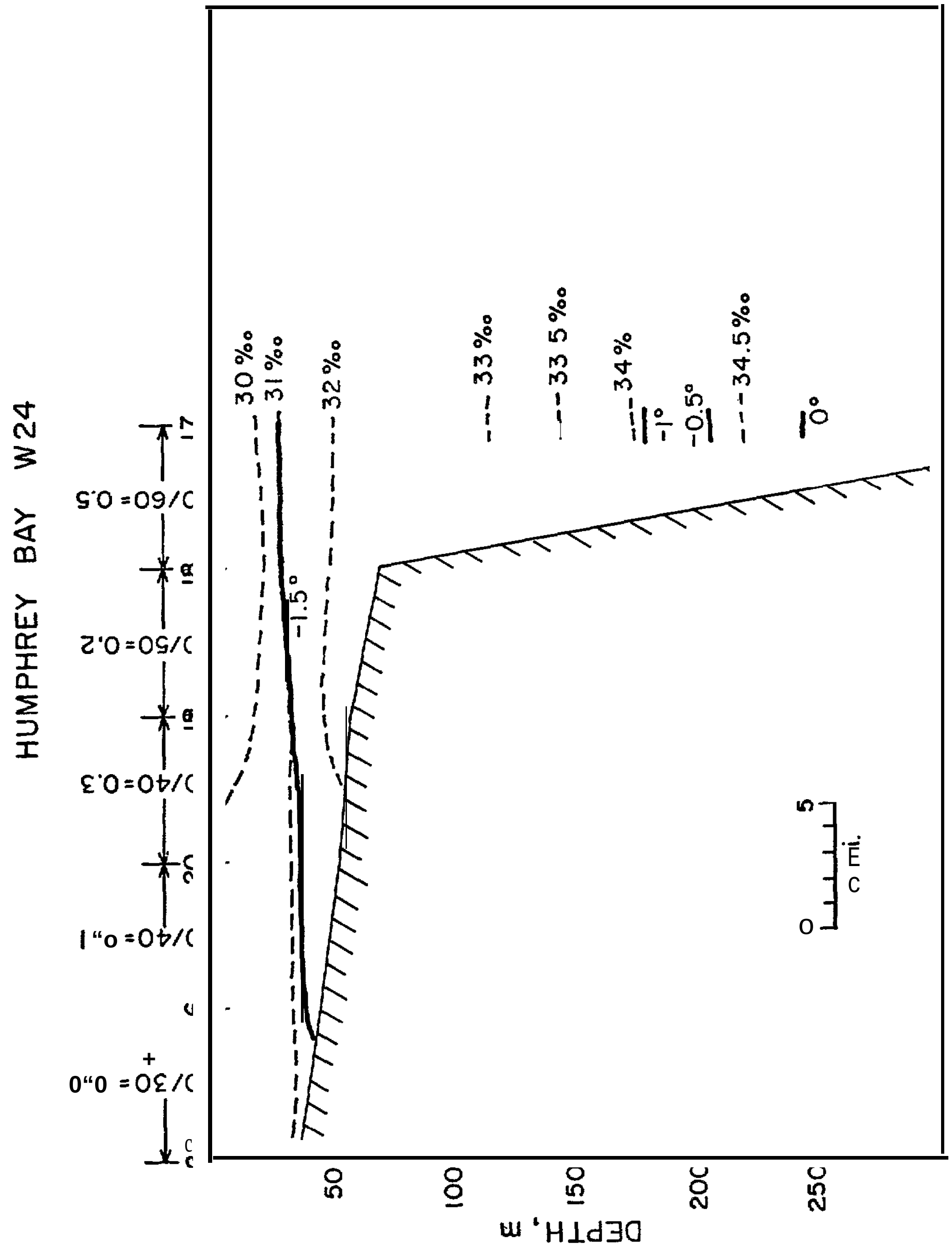

HUMPHREY BAY W24
DEPTH, m
50
100
150
200
250
30‰
31‰
32‰
33‰
33 5‰
34‰
-1°
-0.5°
34.5‰
0°
-1.5°
0
5
mi.

Figure 9

the winter (February), and W24 in spring (May). The Pitt Point, Narwhal Island, and Humphrey Bay sections transect the western, central, and eastern shelf, respectively, and are assumed to have been representative of those regions.

In the fall (Figs. 1-3) the entire shelf was markedly stratified, with a strong salinity (and hence density) gradient below 20-30 m. Above the pycnocline the upper layer was of relatively low salinity (everywhere less than 30‰, and at station 18 less than 27‰) and nearly homogeneous in both temperature and salinity. An example is given in Figure 10, showing conditions at station 22 on the Humphrey Bay section. The temperatures in the upper isothermal layer were generally very close to the freezing point, with some tendency toward a slight supercooling (relative to the freezing point at one atmosphere). This upper homogeneous layer is the result of thermohalic convection driven by freezing. The process will continue throughout the winter, reducing the over-all shelf stratification. The fall sections also show a gradual seaward increase in upper-layer salinity, about 1-2°/00 across the width of the shelf. Along with the salinity stratification, this represents a remnant of the previous summer hydrography, which is strongly influenced by runoff and ice melt. Finally, a number of the stations show a pronounced temperature maximum somewhere below the mixed layer. The presence of this maximum at the Pitt Point section is clearly seen in Figure 1, where it represents water of Bering Sea origin. We shall come back to this problem later in the discussion.

In the winter (Figs. 4-6) the overall stratification on the shelf was markedly less than in the fall, and the upper mixed layer extended deeper, typically below 30 In. At the same time the upper-layer salinity was also higher, being above 31‰ everywhere on the shelf. These features are apparent by contrasting Figure 10 with Figure 11, which shows conditions at station 22 on the Humphrey Bay winter section. [The two stations, W21-22 (Fig. 10) and W22-22 (Fig. 11), were, taken at the same location.]

While both a reduced stratification and an increase in salinity are to be expected as winter progresses, due to the separation of salt by freezing, the salinity increase from station W21-22 to W22-22 is larger than reasonably can be explained by this process. Over 2 m ice would have to be formed from November to February for the salinity increase. That this result is not just a local one at this one station is shown by the total salt budget for both the Narwhal Island and Humphrey Bay sections. The mean salinity increase above 50 m over the shelf for the Narwhal Island section, between November and February, was 1.310/0., requiring the formation of about 270 cm ice. Similarly the increase for the Humphrey Baysection shoreward of station 22 was 1.51°/00, which corresponds to forming about 370 cm ice. These calculated amounts of ice formation are almost certainly high by a factor of 2-3. On the other hand, changes in the salinity after February can readily be explained by freezing, or as being within the resolution of the methods. For example, from February (W22) to May (W24) the mean salinity in the Narwhal Island section increased by only 0.25‰, corresponding to 55 cm of ice formation; and the mean salinity in the Humphrey Bay section decreased -0.050/0., which is undoubtedly below the noise level. The conclusion must therefore be that during fall and early winter, there is a net advective flux of salt onto the Beaufort Sea shelf. Such a flux does not necessarily involve large volume transports. For example, if the new saltier water coming onto the shelf is 1‰ more saline than the water it replaces, then the flow rate of saline water onto the entire shelf region between the Narwhal Island and Humphrey Bay sections need not exceed 0.06 Sv in order to maintain the salt budget. The source of

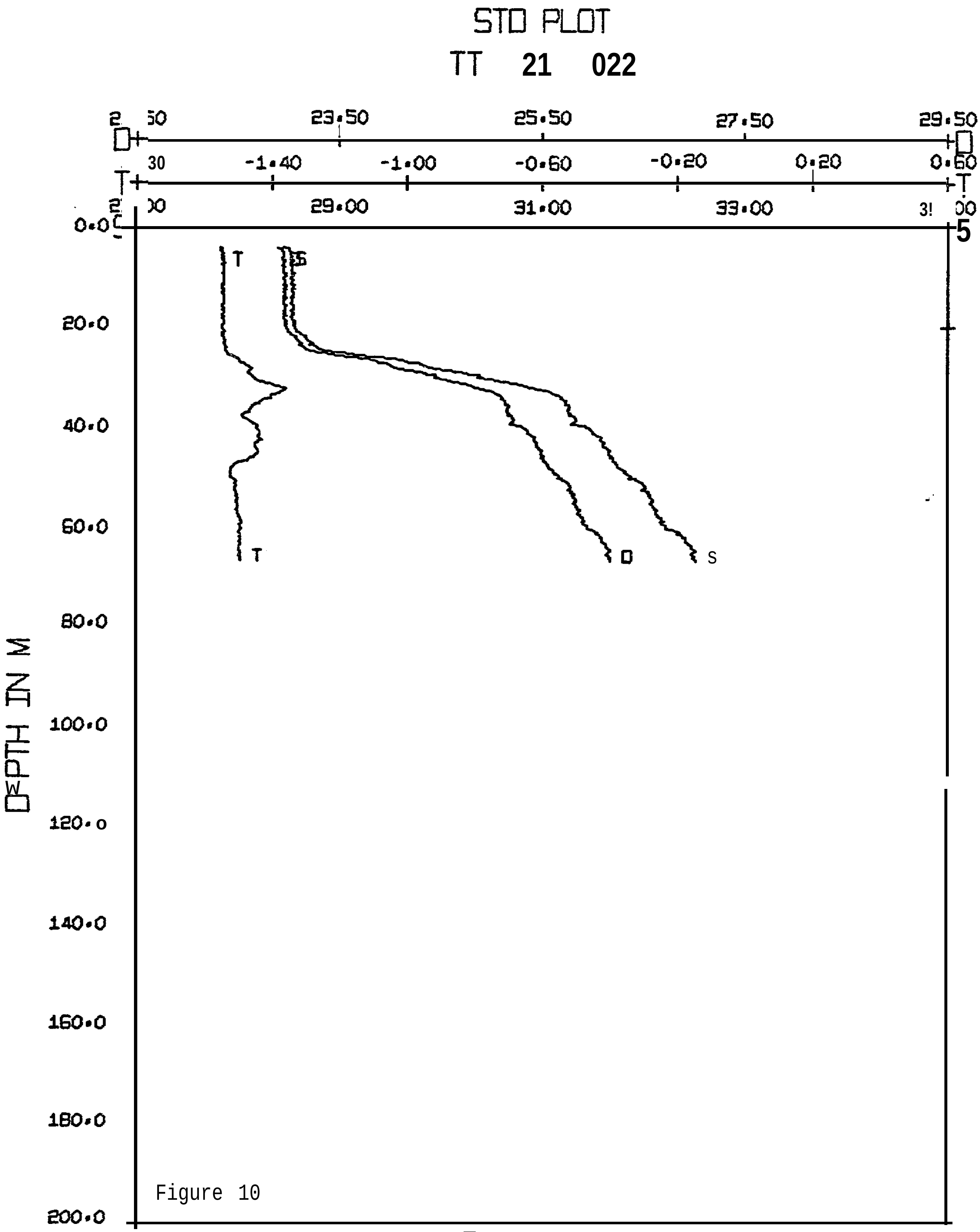


Figure 10

T = **TEMPERATURE - C**
S = SALINITY - 0/00
D = SIGMA-T

LATITUDE 70-29.7N
LONGITUDE 141-53.0W

DATE 10 NOV. 1975
BEGIN 2018

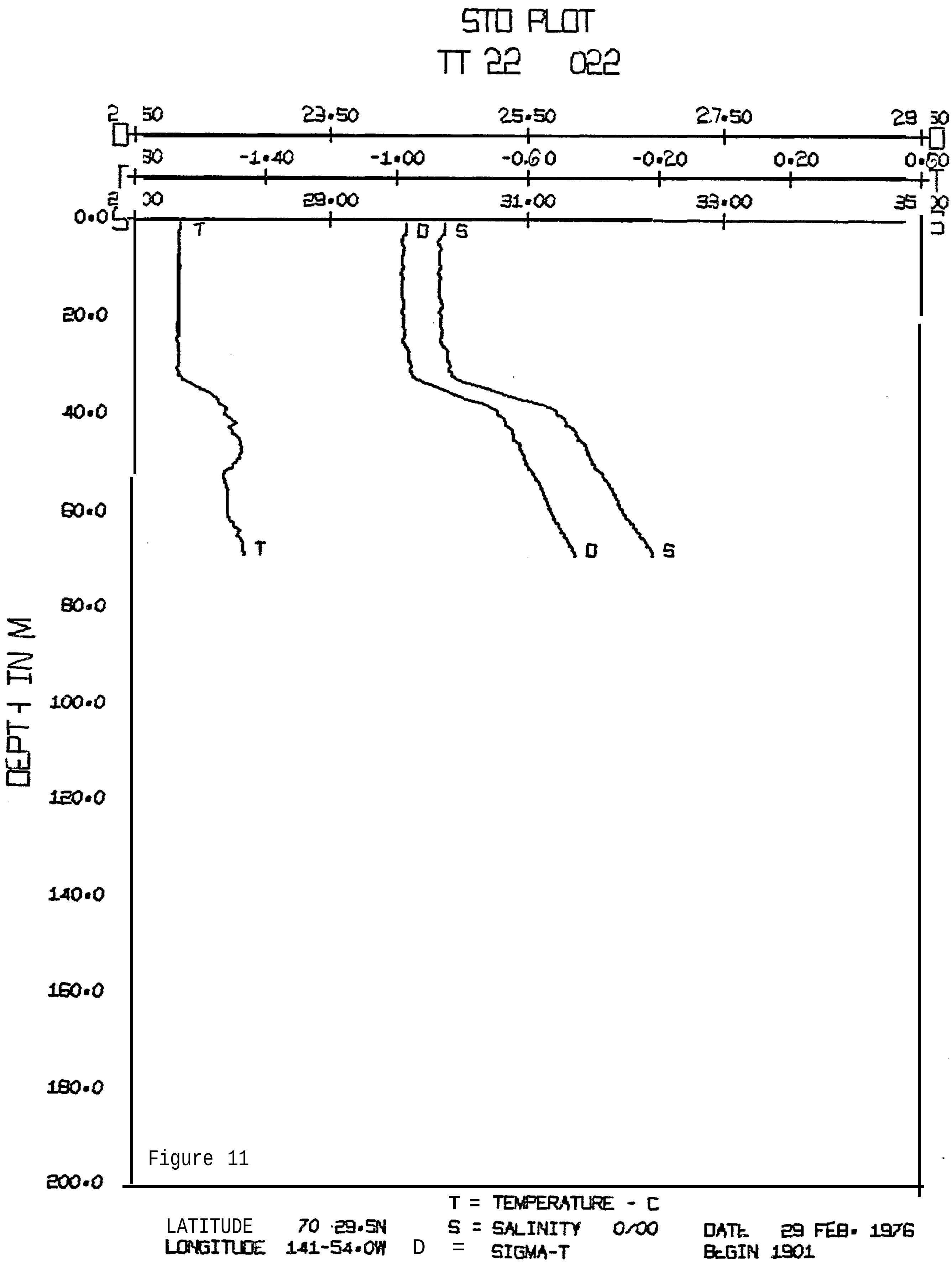

STD PLOT
TT 22 022
23.50
25.50
27.50
-1.40
-1.00
-0.60
-0.20
0.20
0.60
29.00
31.00
33.00
35
T
D
S
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
DEPTH IN M
T = TEMPERATURE - C
S = SALINITY 0/00
D = SIGMA-T
LATITUDE 70 29.5N
LONGITUDE 141-54.0W
DATE 29 FEB. 1976
BEGIN 1901

Figure 11

saline water must for the present be considered unknown. Conceivably it could lie in the Chukchi Sea, or alternatively it may be in the form of water upwelled from deeper levels in the Arctic Ocean.

Another feature of the winter salinity distributions is that except off Pitt Point the upper-layer salinity decreased seaward. At the Narwhal Island section the total decrease was 0.5‰ and at the Humphrey Bay section 0.8‰. In the spring sections (Figs. 7-9) there is a similar trend, this time at the Pitt Point section also. Several possible mechanisms suggest themselves. One is that relatively dense water sinking from the upper layer above the shelf moves into the Arctic Ocean at mid-depth and is replaced by less saline water moving inshore in the upper layer. Such a transverse circulation is in the cyclonic sense (looking westward along the shelf) and would be driven by a shallow salt source on the shelf. Freezing is of course an obvious example of such a salt source, its relatively greater intensity inshore conceivably being due either to the volume of water underlying a given surface area being less there, or to the amount of ice actually formed on the shelf being greater than offshore. Alternatively, relatively saline water being advected onto the shelf from the Chukchi Sea and later sinking from the shelf could also drive such a transverse circulation. Regardless of the details, a cyclonic circulation involves some form of free gravitational convection, being driven by a source of dense water at a relatively high elevation. The second possible mechanism responsible for the observed salinity distribution is upward movement of saline water onto the shelf from deeper levels in the Arctic Ocean. This water would have to flow in along the bottom of the shelf and then be subjected to a relatively effective vertical mixing on the inner or middle shelf. Such a transverse circulation is in the anticyclonic sense (looking westward) and would in effect be driven by a deep salt source seaward of the shelf. It thus represents a forced convection. A third possible mechanism is of course that the horizontal salinity gradient represents a baroclinic adjustment to a more-or-less steady geostrophic westward flow.

The temperatures in the winter sections were typically about 0.1° colder than in the fall, and in the upper layer the water showed a slight (on the average about 0.03°C) but definite supercooling. As in the fall, one or more subsurface temperature maxima were common.

The spring sections (Figs. 7-9) are very similar to those from winter. The salinity and density structure is about the same, but there are some slight differences in the temperature of the upper layer: it is not quite as cold, but is instead beginning to show a slight spring warming. Only four stations had near-surface temperatures below the freezing point. The temperature of the remaining stations varied from just above the freezing point to an extreme of about 0.16°C above at station 17. At the latter station, the upper 200 m of which are shown in Figure 12, the warming is restricted to a 5-m thick layer and is accompanied by a salinity that is slightly lower than that of the underlying water. As in the fall and winter, there generally were temperature maxima below the upper mixed layer.

The dynamic height differences between adjacent stations are also shown in Figures 1-9. For example, in Figure 1 the notation 0/20 = -1 between stations 1 and 4 means that the dynamic height at the surface relative to 20 db at station 1 was 1 dynamic centimeter higher than at station 4. Geostrophic motion at the surface relative to that at about 20 m would therefore be eastward. Had the sign been positive, it would have been westward. For a station separation of 5 nautical

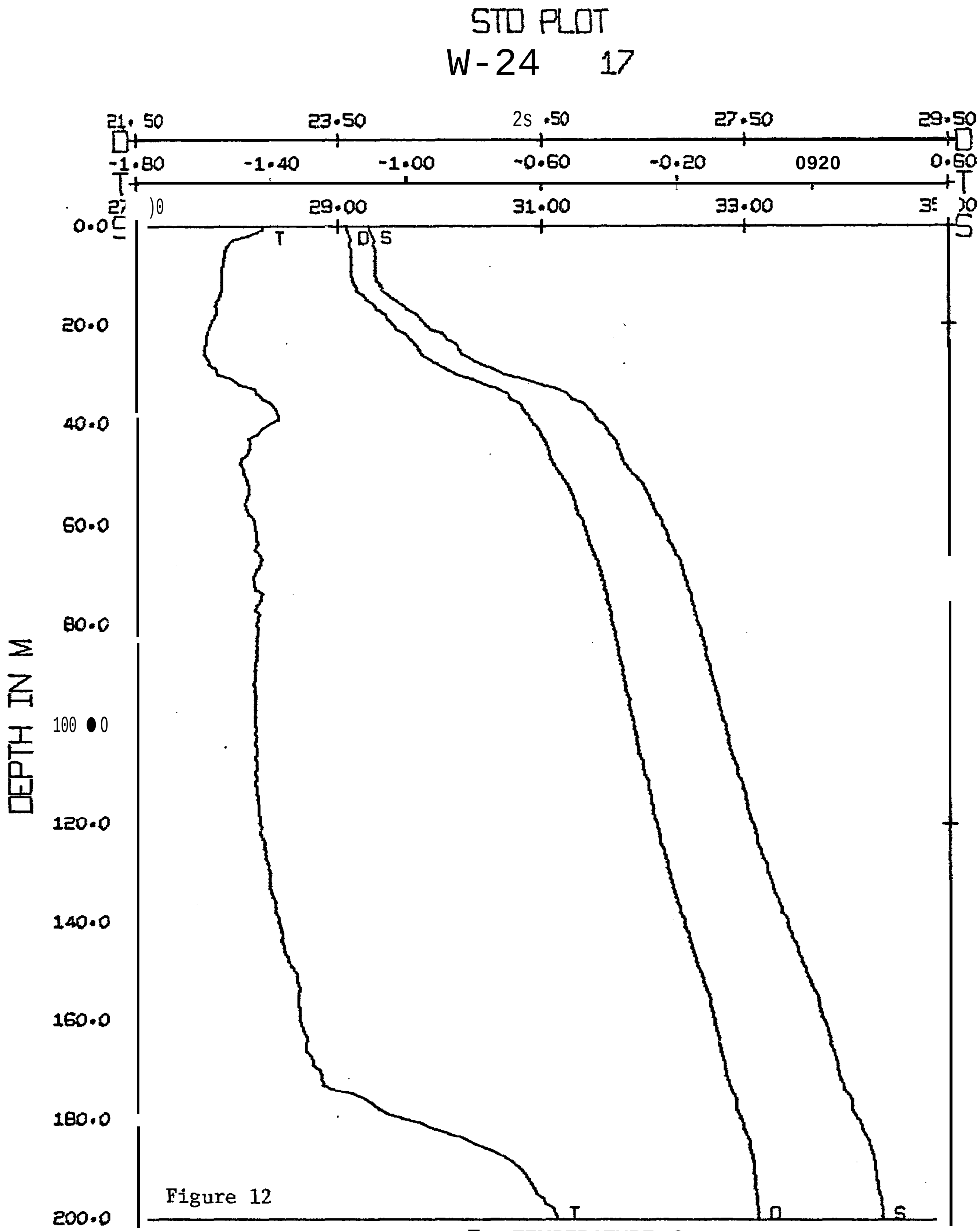


Figure 12

LATITUDE 70-33.8N
LONGITUDE 141-44.0W

T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T

DATE 28 MAY 1976
BEGIN 2258

miles, a dynamic height difference of 1 dynamic centimeter corresponds to "a relative geostrophic speed of just under 8 cm see-l. While there is of course no guarantee that dynamic height calculations for *a* shallow shelf regime have much significance in specifying the flow field, one might perhaps expect that any more-or-less persistent features in the dynamic topography at least indicate the mean flow directions. With this caveat the indicated flow in the fall was easterly on the inner and middle shelf and westerly on the outer shelf and slope. In the winter the only easterly flow was on the inner shelf, with westerly flow indicated on the middle and outer shelf. In the spring the flowwas westerly over almost the entire shelf. The general westerly flow indicated along the slope in most of the sections is of course the intensified southern part of the Beaufort gyre. These speeds range from less than 1 cm see-l to 30 cm sec^{-1}.

There is an interesting dynamic topographic feature which appears on at least five of the sections, *viz.* a change in the sign of the calculated geostrophic shear at the outermost stations over the slope. The feature is, for example, clearly seen between stations 9 and 10 in Figure 4. The sign change occurs at about 1.00 m depth. Without knowing the absolute topography of some reference surface, the simplest interpretation is that there is a maximum in the westerly flow at the depth of the sign change, *i.e.*, a sub-surface current core. We shall return to this matter in discussing the observation from fall 1976.

Figures 13 and 14 show the sections taken during fall 1976 (31 October-4 November). The two Lonely sections are located about 15 miles apart, as are the two Oliktok sections. In certain respects the observed conditions are more like those encountered the previous winter, rather than like those of the fall. For example, very low salinities are missing in the w25 sections, water less saline than 29‰ being observed at only one station. In contrast, the upper water salinities in the W21 sections were less than 29°/₀₀ at all but four stations. Similarly, the over-all stratification in the W25 sections is closer to that in W22 and W24 than to that in W21. Another point of contrast is that in fall 1976 the salinity generally decreased seaward whereas in 1975 it had increased. The easterly flow over the inner and middle shelf indicated in the W21 sections is also missing in W25; instead westerly flow prevails. The winter temperature structure is not fully developed in the W25 sections, however. For example, one-fifth of the stations still show the surface layer to have been slightly above the freezing point, although admittedly within 0.01-0.02°C of freezing. About a third of the stations showed supercooling in excess of 0.01°C.

By far the most remarkable feature of the W25 sections is the steeply inclined isopleths above the outer shelf and slope. In each case, Atlantic water which is normally found well below 200 m over the slope can be seen on the shelf. In the Oliktok East section (Fig. 14), water warmer than 0°C and more saline than 34.5°/00 was observed at 91 m. To my knowledge, Atlantic water has previously been found this shallow only in the St. Anna Canyon, which indents the northern Kara Sea. In the Lonely West section (Figure 13) the effect of the onshore flow of relatively warm and saline water can be seen even at the innermost station, where the bottom 10 m were warmer than -l°C and above 34°/00 in salinity. 'Whether such flushing of the shelf by dense water upwelling from off the slope is a rare phenomenon, is unknown. Six of the nine sections shown in Figures 1-9 do in fact portray the 33‰ isohaline climbing onto the shelf, three of them to above 50 m depth. Such a mechanism would of course provide the salt source needed to satisfy the salt budget calculations discussed earlier. It is appropriate to point out that neither during nor within at least 10 days prior to the section occupation

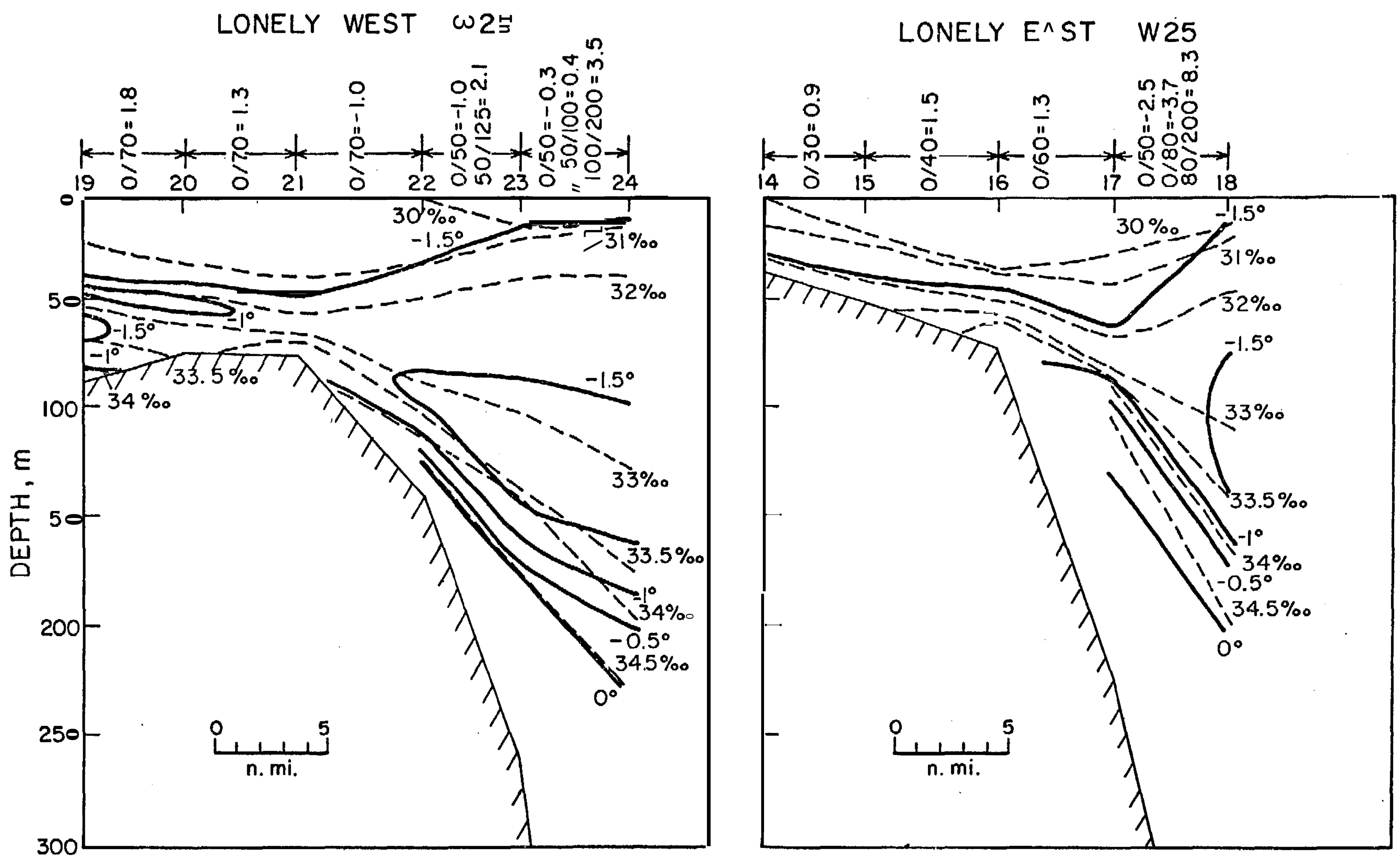
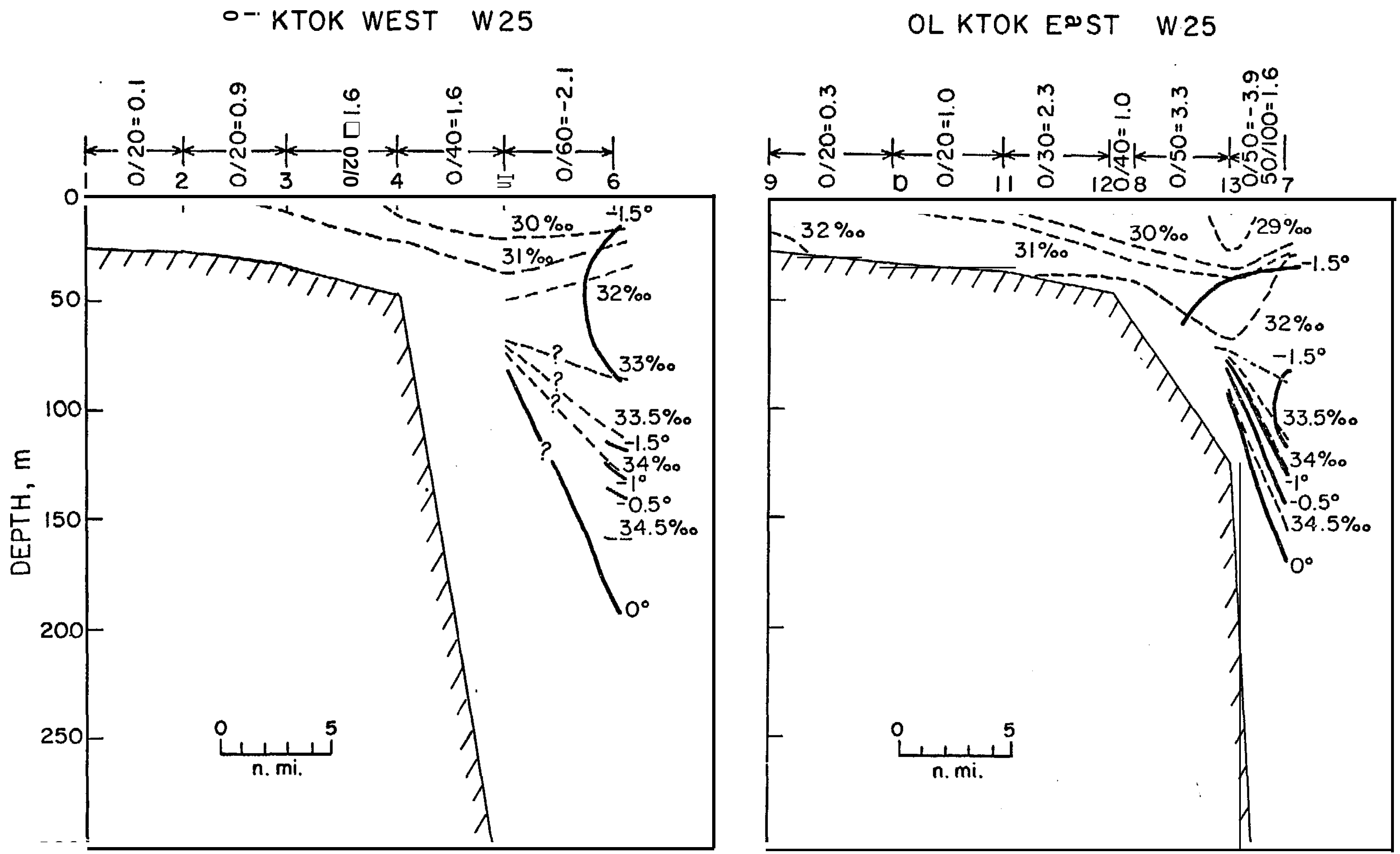

LONELY WEST
0/70=1.8
0/70=1.3
0/70=-1.0
0/50=-1.0
50/125=2.1
0/50=-0.3
50/100=0.4
100/200=3.5
19
20
21
22
23
24
DEPTH, m
0
50
100
150
200
250
300
30‰
-1.5°
31‰
32‰
-1°
-1.5°
33.5‰
34‰
33‰
33.5‰
-1°
34‰
-0.5°
34.5‰
0°
0
5
n. mi.
LONELY EAST
W25
0/30=0.9
0/40=1.5
0/60=1.3
0/50=-2.5
0/80=-3.7
80/200=8.3
14
15
16
17
18
30‰
-1.5°
31‰
32‰
-1.5°
33‰
33.5‰
-1°
34‰
-0.5°
34.5‰
0°
0
5
n. mi.

Figure 13



o– KTOK WEST W25
OL KTOK EaST W25
0/20=0.1
0/20=0.9
0/20 □ 1.6
0/40=1.6
0/60=-2.1
0/20=0.3
0/20=1.0
0/30=2.3
0/40=1.0
0/50=3.3
0/50=-3.9
50/100=1.6
DEPTH, m
30‰
31‰
32‰
33‰
33.5‰
34‰
34.5‰
29‰
-1.5°
-1°
-0.5°
0°
n. mi.

Figure 14

were there strong easterly winds, such as have been proposed to drive summer upwelling.

Another notable feature of the W25 sections is the change in sign of the geostrophic shear at the outermost stations. This generally occurred between 50 and 80 m. A similar feature has been pointed out earlier for a number of the W21-W24 sections. Again the simplest interpretation is a high-speed core of westerly moving water at mid-depth. In the case of the Lonely East section, the geostrophic speed at 80 m relative to that 200 m is about 65 cm see-l, *i.e.*, well over 1 knot. Below 200 m the shear appears relatively small. It is important to note that the flow indicated by the dynamic topography is not aligned with the bottom topography, but has an onshore component. For example, between stations 23 and 17 this component at 80 m relative to 200 m was about 8 cm see-l.

The indications are thus of a rapid westerly flow of dense water along the slope arid outer shelf, with the core of the current between 50 and 100 m. The flow is so inclined to the shelf edge as to flood portions of the shelf with saline water. In one observed instance (Fig. 13) the saline water extended at least 15-20 miles inshore from the shelf edge.

Finally, the general matter of subsurface temperature maxima merits a brief discussion. Apart from the Atlantic Water influence, such features can be seen at one or more stations on each of the W25 sections, as is also the case for each of the earlier cruises. For W25 the maxima are particularly prevalent at the two Lonely sections. Determining the source and mixing history of these features proves to be a very difficult problem, however. They vary greatly with respect to extent, temperature, density, and fine-scale structure. An example is given in Figure 15 and 16, showing conditions at station W25-6 from the Oliktok West - section and at station W25-19 from the Lonely West section. At station 6 the two relatively small temperature maxima have associated salinities of 31.73 and 32.55°/00 and densities of 25.53 and 26.20 in σ_t. At station 19 there were also two maxima, but they were very large and had associated salinities of 32.09 and 33.34″/00 and densities of 25.82 and 26.85 in σ_t. In the case of station 19 it is probably safe to say that the upper maximum represents Bering Sea water that has flowed into the Beaufort past Point Barrow, while the lower maximum is the result of warm, saline water flowing up the slope as discussed earlier. However the origin and mixing history of the temperature structure at station 6 is certainly not clear. Even within a single closely spaced synoptic section, the T-S structure in the vicinity of the temperature maxima varies enormously. A case in point is the Lonely East section, stations W25-14 through W25-18, illustrated in Figures 17-21. Only at the two innermost stations is the hydrography strikingly similar.

VIII. Conclusions

We have seen that not only are there large seasonal changes in the hydrography, but conditions are also different from one year to the next. The latter point is a caution to us, should we attempt to generalize from too short a time base. Nonetheless, the normal seasonal cycle has now probably been determined at least in outline.

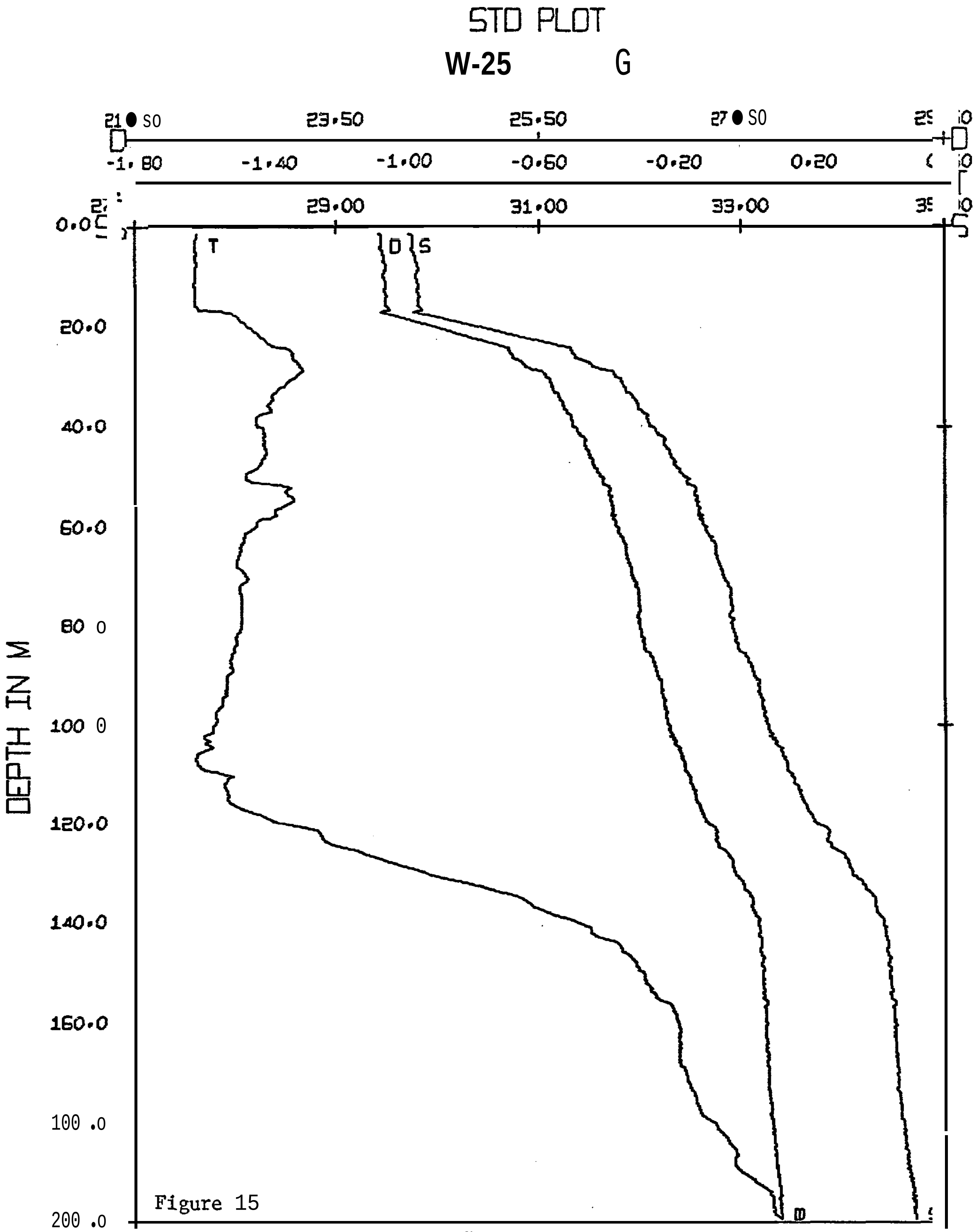


Figure 15

T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T

LATITUDE 71-19.0N
LONGITUDE 149-57.4W

DATE 31 OCT. 1976
BEGIN 2220

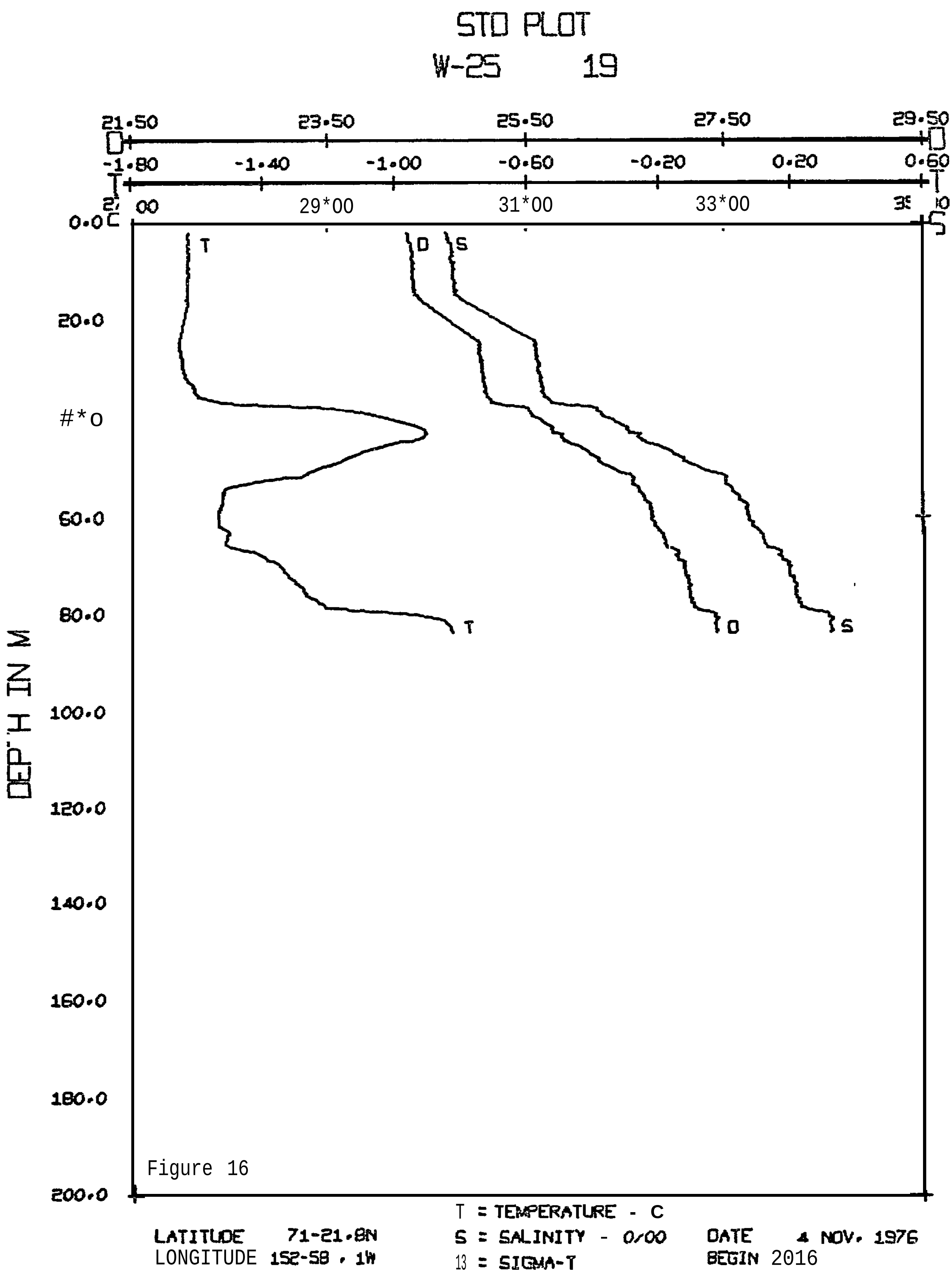

STD PLOT
W-25 19
21.50
23.50
25.50
27.50
29.50
-1.80
-1.40
-1.00
-0.60
-0.20
0.20
0.60
29*00
31*00
33*00
0.0
20.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
DEPTH IN M
T
D
S
T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T
LATITUDE 71-21.8N
LONGITUDE 152-58 . 1W
DATE 4 NOV. 1976
BEGIN 2016

Figure 16

STD PLOT
W-25 014

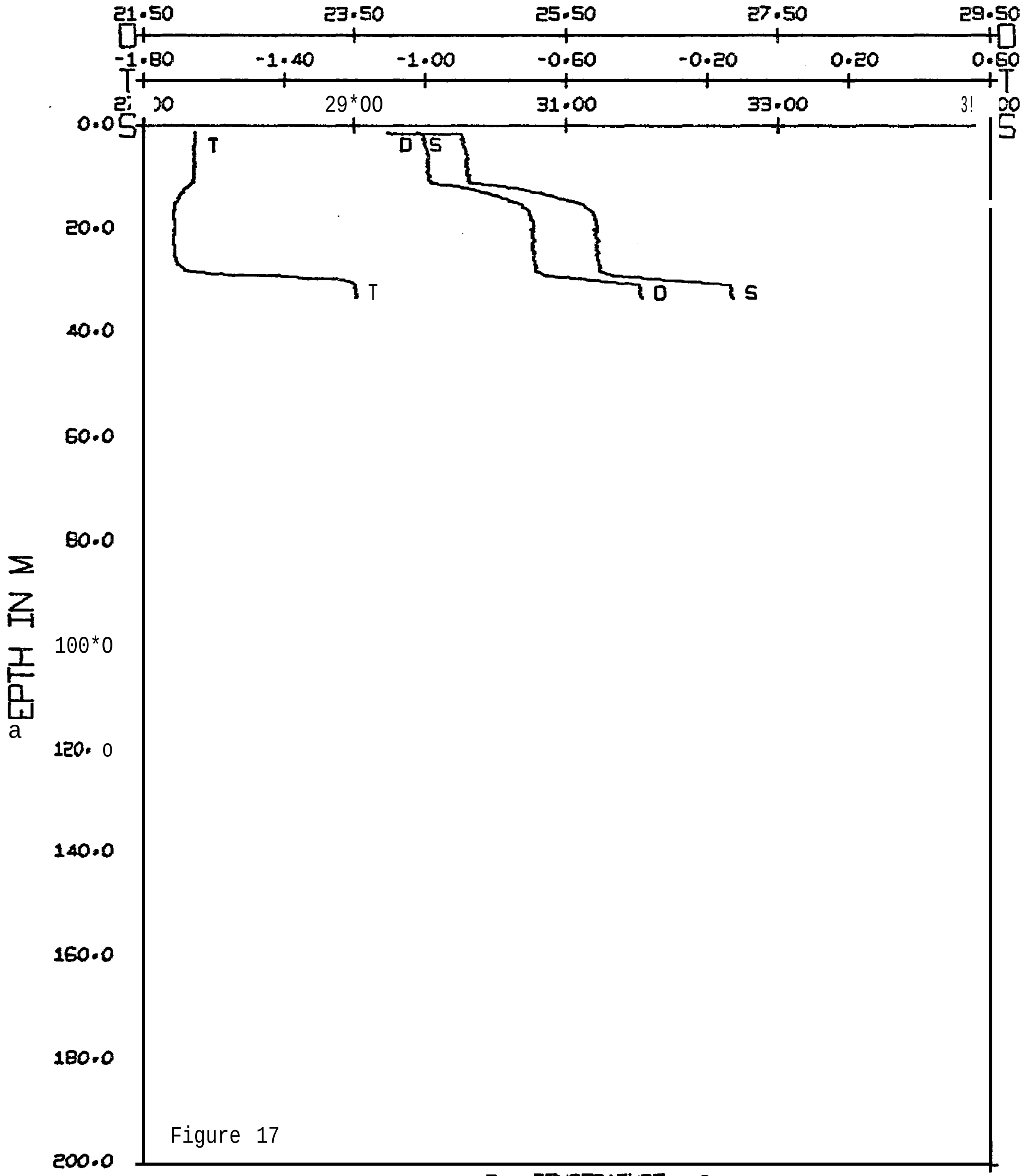


Figure 17

T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T

LATITUDE 71-12.7N
LONGITUDE 152-18.9W

DATE 3 NOV. 1976
BEGIN 2123

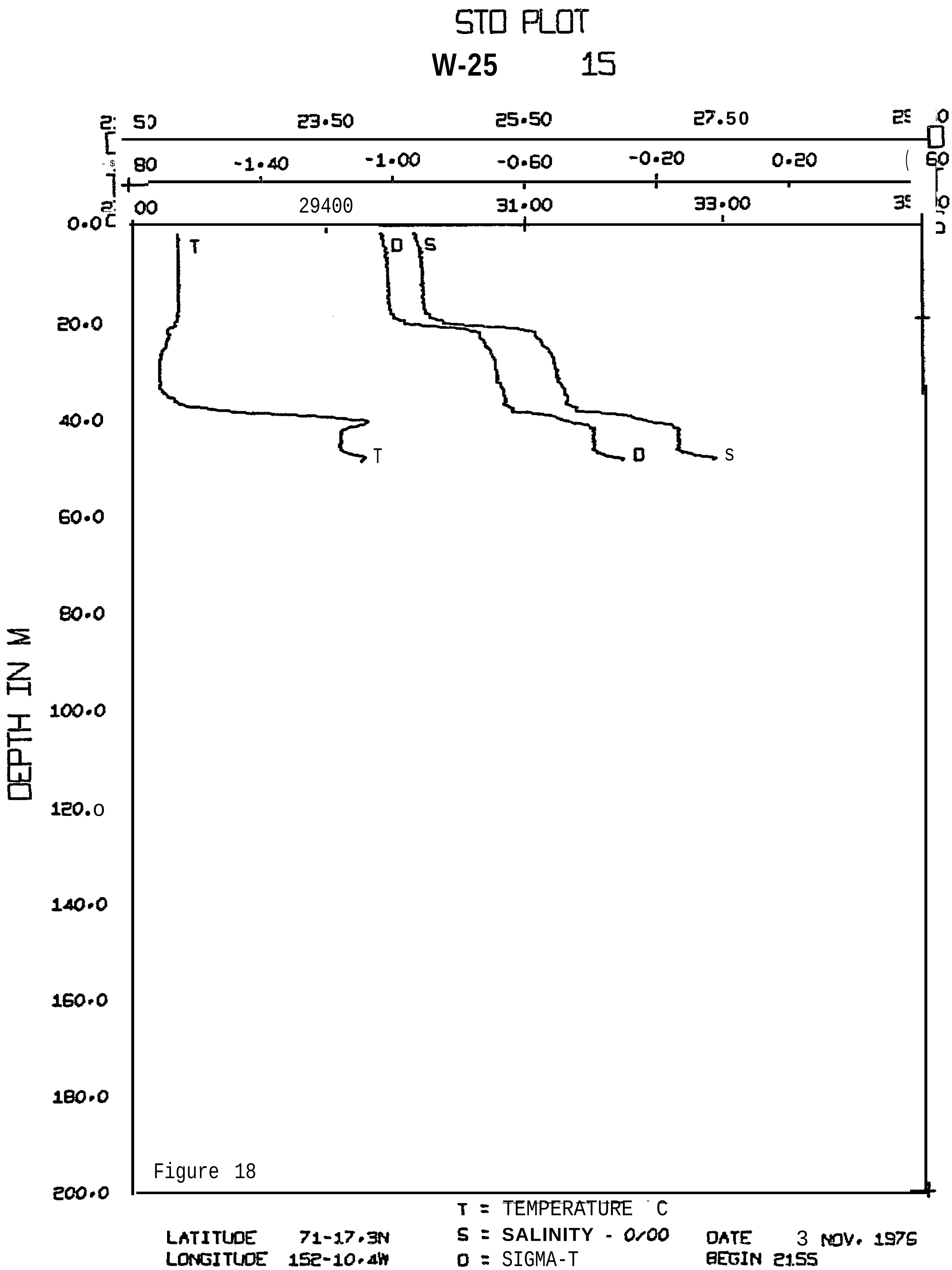

STD PLOT
W-25 15
23.50
25.50
27.50
-1.40
-1.00
-0.60
-0.20
0.20
29400
31.00
33.00
DEPTH IN M
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
T
D
S
T = TEMPERATURE C
S = SALINITY - 0/00
D = SIGMA-T
LATITUDE 71-17.3N
LONGITUDE 152-10.4W
DATE 3 NOV. 1976
BEGIN 2155

Figure 18

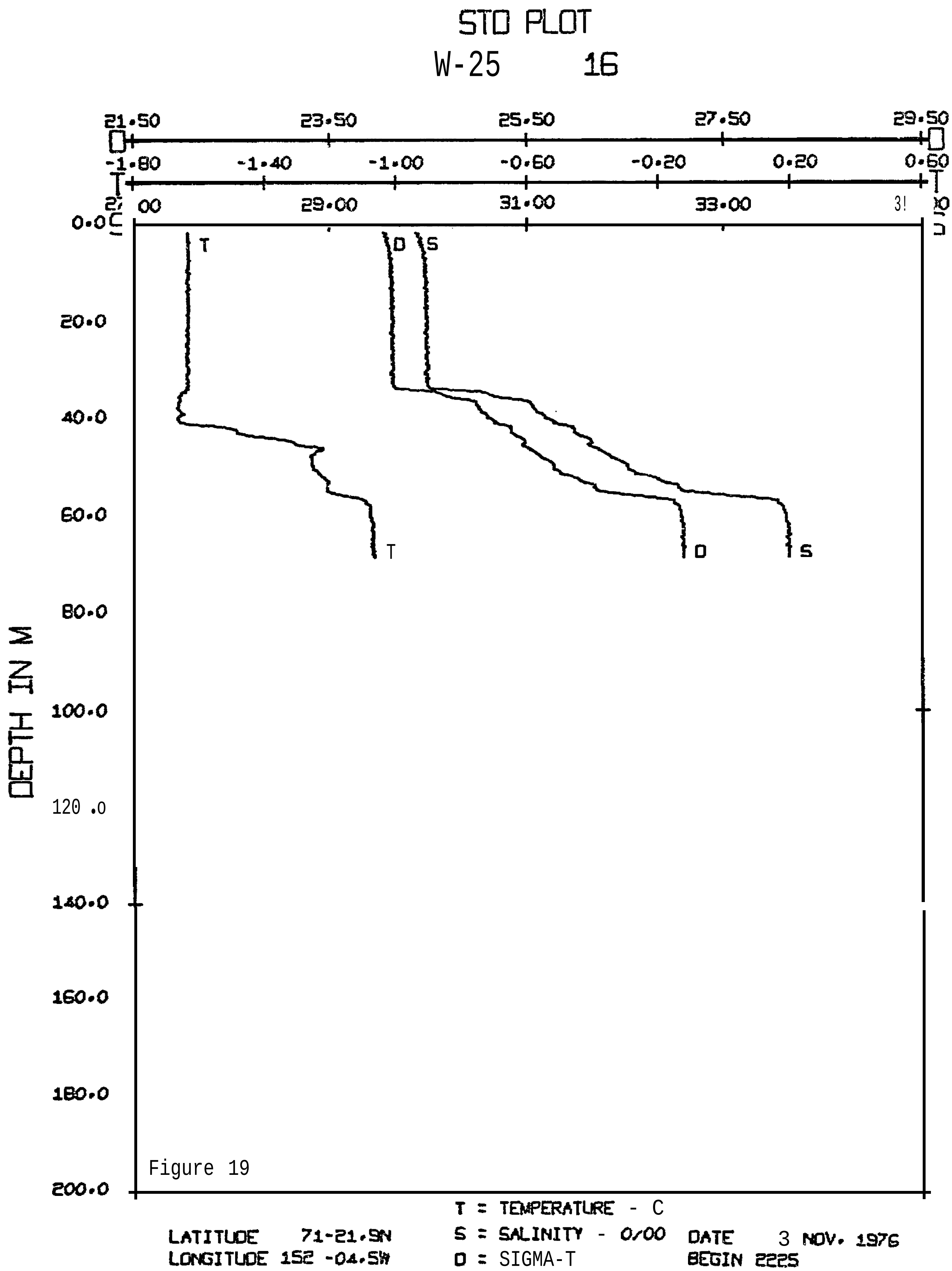

STD PLOT
W-25 16
21.50
23.50
25.50
27.50
29.50
-1.80
-1.40
-1.00
-0.60
-0.20
0.20
0.60
29.00
31.00
33.00
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
DEPTH IN M
T
D
S
T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T
LATITUDE 71-21.9N
LONGITUDE 152 -04.5W
DATE 3 NOV. 1976
BEGIN 2225

Figure 19

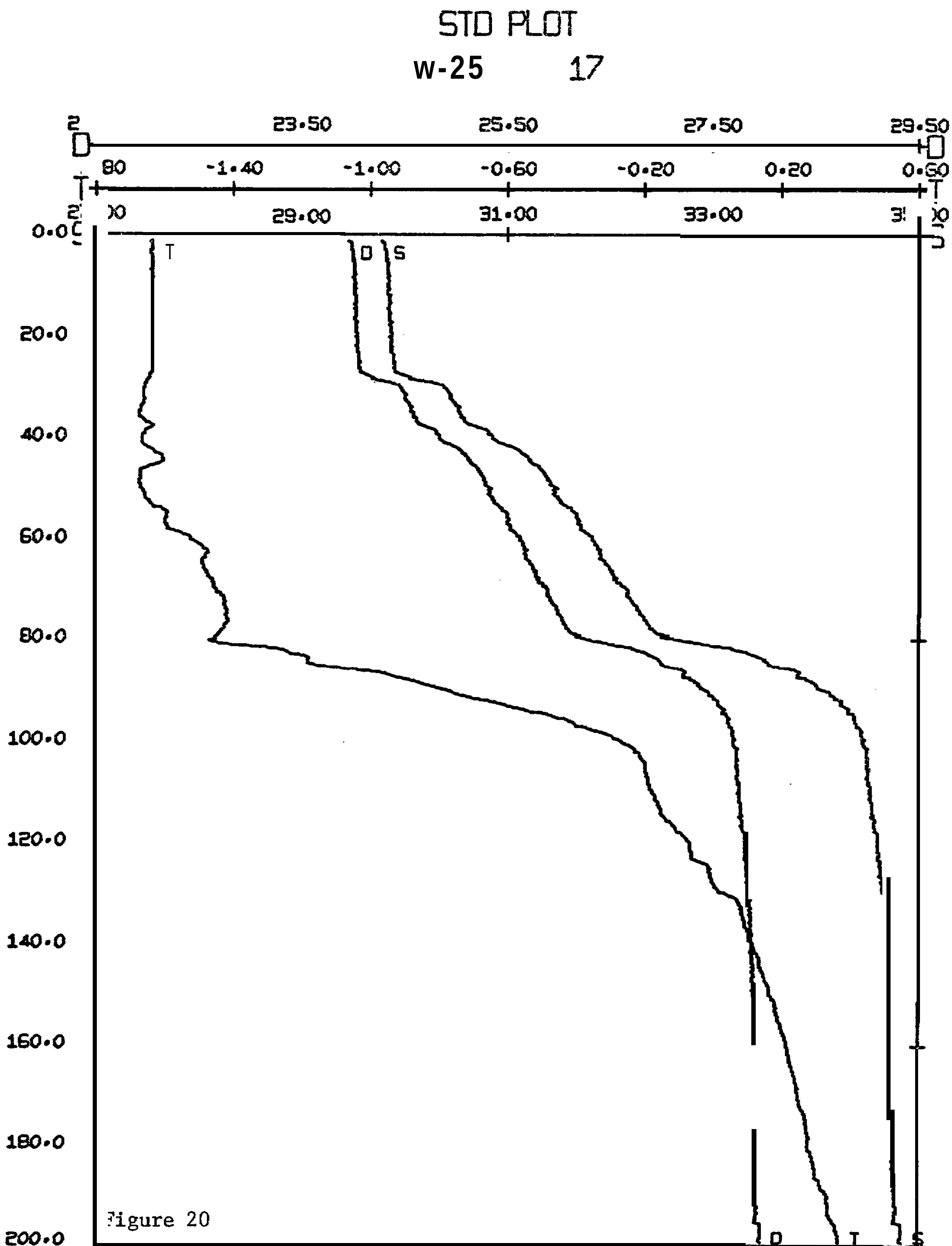


Figure 20

T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T

LATITUDE 71-26.7N
LONGITUDE 151-58.0W

DATE 3 NOV. 1976
BEGIN 2258

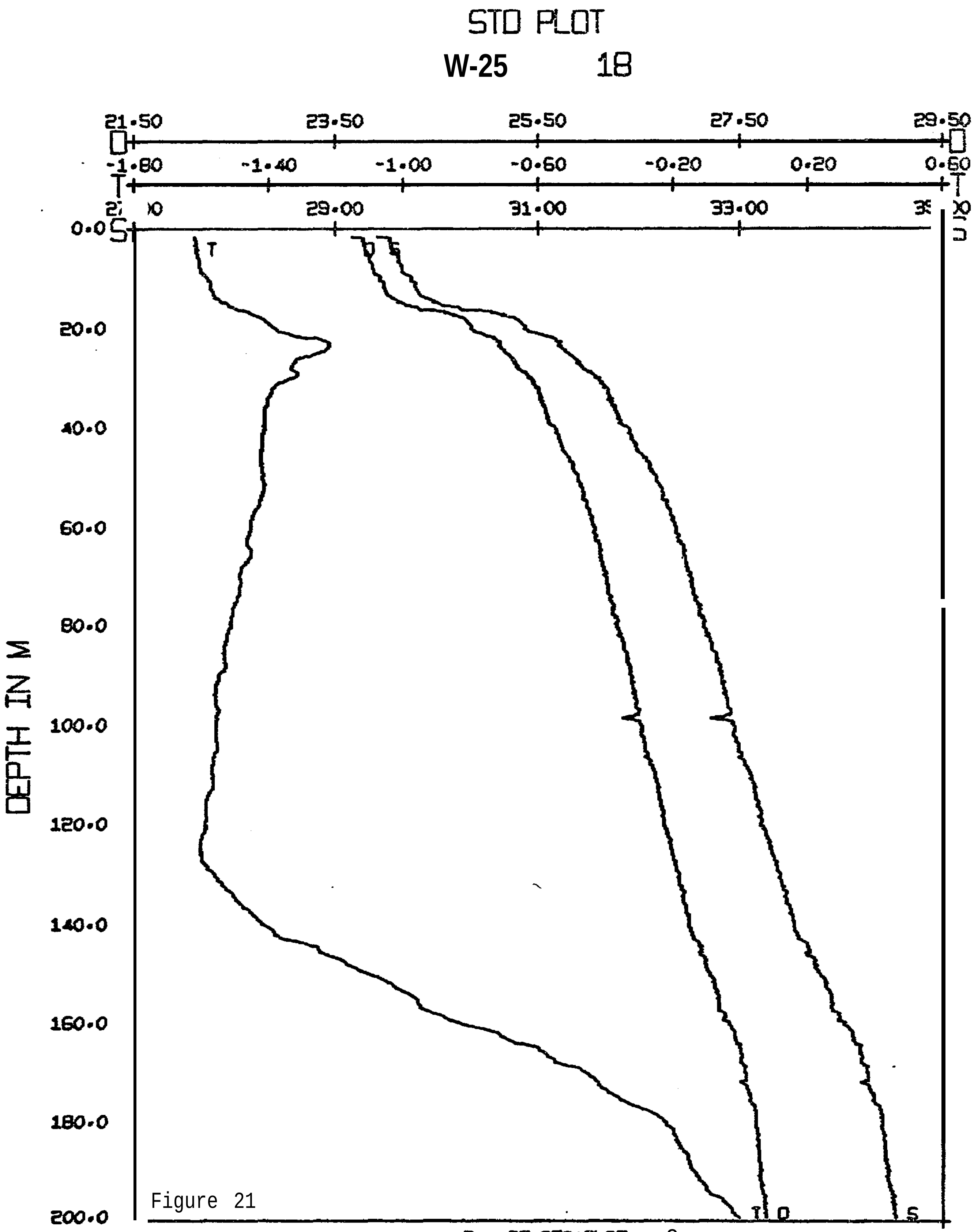


Figure 21

T = TEMPERATURE - C
S = SALINITY - 0/00
D = SIGMA-T

LATITUDE 71-31.2N
LONGITUDE 151-50.7W

DATE 3 NOV. 1976
BEGIN 2338

One matter appears to stand out in importance: the Beaufort Sea shelf is certainly not neutral with respect to the Arctic Ocean to the north. Rather there are one or more forms of interaction, in which water and the substances it transports are exchanged between the shelf and the offshore regions. Certainly the salt budget calculations discussed in Section VII can be thus interpreted. It is likely that when the presence of widespread temperature maxima is better understood, it also will point to such an exchange. The most dramatic evidence of exchange is the series of four sections from fall 1976, in which an intense subsurface current core appears to be sweeping up the slope and onto the shelf, flooding at least one section to the innermost station with dense, saline water.

IX. Needs for further study

The remainder of the contract year will be spent processing and analyzing the four sections from winter 1977. Additionally we will continue work on the earlier data. The question of exchange across the shelf, discussed briefly in Section VIII, will be the focus of much of this effort. Among the goals is achieving some understanding of the nature and significance of the temperature extrema.

X. Summary of 4th quarter operations

A. Field operations

The winter field work is described in the preliminary report on survey W27 (Ref.: M77-29), a copy of which is appended hereto.

B. Problems

The normal range of problems was encountered; there are no recommended changes.

C. Estimate of funds expended to 28 February 1977

	Total allocation (5/16/75-9/30/77):		$142,627
A.	Salaries - faculty and staff	$12,317	
B.	Benefits	1,446	
C.	Expendable supplies and equipment	3,811	
D.	Permanent equipment:	23,281	
	Counter/timer $790		
	Calculator $750		
E.	Travel	4,640	
F.	Computer	2,924	
G.	Other direct costs	22,537	
H.	Indirect costs	5,986	
	Total expenditures		77,395
	Remaining balance		65,232

University of Washington

Department of Oceanography

Seattle, Washington 98195

Preliminary Report

University of Washington Participation in NOAA UH-IH Helicopter CTD Survey W27

STD Measurements in Possible Dispersal Regions of the Beaufort Sea

4-11 March 1977

by

Richard B. Tripp

NOAA Contract 03-5-022-67, TA 1

Research Unit No. 151

Approved by:

Knut Aagaard, Research Associate Professor
Principal Investigator

Francis A. Richards, Professor
Associate Chairman for Research

REF: M77-29

STD MEASUREMENTS IN BEAUFORT SEA

1. *Objectives*

To examine by means of STD measurements the possible sinking and spreading into the Canadian Basin of waters modified on the Beaufort Shelf. Cruise W27 is the second survey during this contract year in the examination of this possibly very important dispersal mechanism.

2. *Narrative*

Two sets of CTD stations, each consisting of two parallel lines normal to the coast, were occupied across the shelf. One set was off Lonely and the other off Oliktok. Station spacing was approximately five miles and parallel line spacing was fifteen miles. Pertinent CTD station information is listed in Appendix A.

The scenario of events is as follows:

March 4, 1977 Weather: cloudy, temperature -28°C, winds 015/10.
0903 AST - Tripp and Swift departed Barrow in helicopter N56RF (Barnhill and Winter) for the Lonely West section. There was some difficulty finding suitable ice. Most of the ice was rafted and > 6 ft.
1230 - After accomplishing two stations we departed for Lonely to refuel.
1450- Departed Lonely for Station 3.
1850 - Landed at last site in this line. However, it was nearing total darkness and we had to abort the station.
2030 - Return to Barrow. A total of 5.6 hours of flight time were logged.

March 5, 1977 Weather: cloudy, light snow, temperature -28°C, winds 035/15.
0916 AST - Darnall and Swift departed Barrow in helicopter N56RF (Barnhill and Winter) for the Lonely East section.
1410- Returned to Lonely to refuel after occupying Station 9. The fuel pump at the Husky camp was down and refueling was delayed for four hours.
2030 - Departed Lonely for Barrow. Severe icing conditions.
2110 - Returned to Lonely. A total of 3.7 hours of flight time were logged.

March 6, 1977 Bad weather: no flying was attempted.

March 7, 1977 Weather: clear; temperature -30°C, winds 090/16.
1145 AST - Darnall and Swift departed Lonely in helicopter N56RF (Barnhill and Winter) for Station 10 on the Lonely East section. After finishing the station, the heaters on the helicopter quit working. The radios became inoperative because of the cold.
1416 - Returned to Barrow. A total of 2.1 hours of flight time were logged.

March 8, 1977 No flying. Helicopter down for maintenance.

March 9, 1977 Weather: cloudy, temperature -27°C, winds calm.
0900 AST - Tripp and Darnall departed Barrow in helicopter N57RF (Feld and Winter) for Lonely.
1035 - Departed Lonely, after refueling, for the Oliktok West section.

March 9, 1977, cont'd.
1730 - Returned to Lonely for fuel after occupying Station 15.
1845 - Departed Lonely.
1935 - Returned to Barrow. A total of 5.7 hours of flight time were logged.

March 10, 1977 Weather: cloudy, temperature -28°C, winds 360/05.
0923 AST - Tripp and Darnall departed Barrow in helicopter N57RF (Feld and Winter) for Lonely.
1053- Departed Lonely, after refueling, for the Oliktok East section.
1748 - Returned to Lonely for fuel after occupying Station 22.
1820 - Departed Lonely.
1920 - Returned to Barrow. A total of 6.1 hours of flight time were logged.

March 11, 1977 Weather: clear, temperature -32°C, wind 035/3.
0934 AST - Tripp, Darnall, and Lt. L. Ashim (U.S. Naval Postgraduate School) departed Barrow in helicopter N57RF (Feld and Winter) to complete the Lonely East section.
1350 - Returned *to* Lonely for fuel after occupying Station 25.

1450- Departed Lonely.
1556- Returned to Barrow. A total of 4.0 hours of flight time were logged.

During this time period, the ice was compact, quite broken and rafted. The winds were light and prevailed from the northeast. A few narrow leads were observed at the edge of the shelf. The refrozen leads were ∿ 3 ft thick and the rest of the ice > 5 ft thick. There were some pieces of multi-year ice throughout the area.

3. *Methods*

CTD casts were taken on each station utilizing a Plessy Model 9400 profiling system with a redesigned sensor package capable of permitting its deployment through an eight-inch auger hole. 110V power was supplied by a 2½ KW Onan portable generator. This operation worked quite satisfactorily out of the UH-IH helicopter. The data were stored on 7-track magnetic tape for reduction ashore. In order to determine field correction factors for the conductivity and temperature sensors, a water sample and temperature measurement were obtained from a Nansen bottle one meter above the sensors.

Salinity samples were analyzed at Barrow utilizing a Hytech Model 6220 portable salinometer S/N 4917.

4. *Personnel*

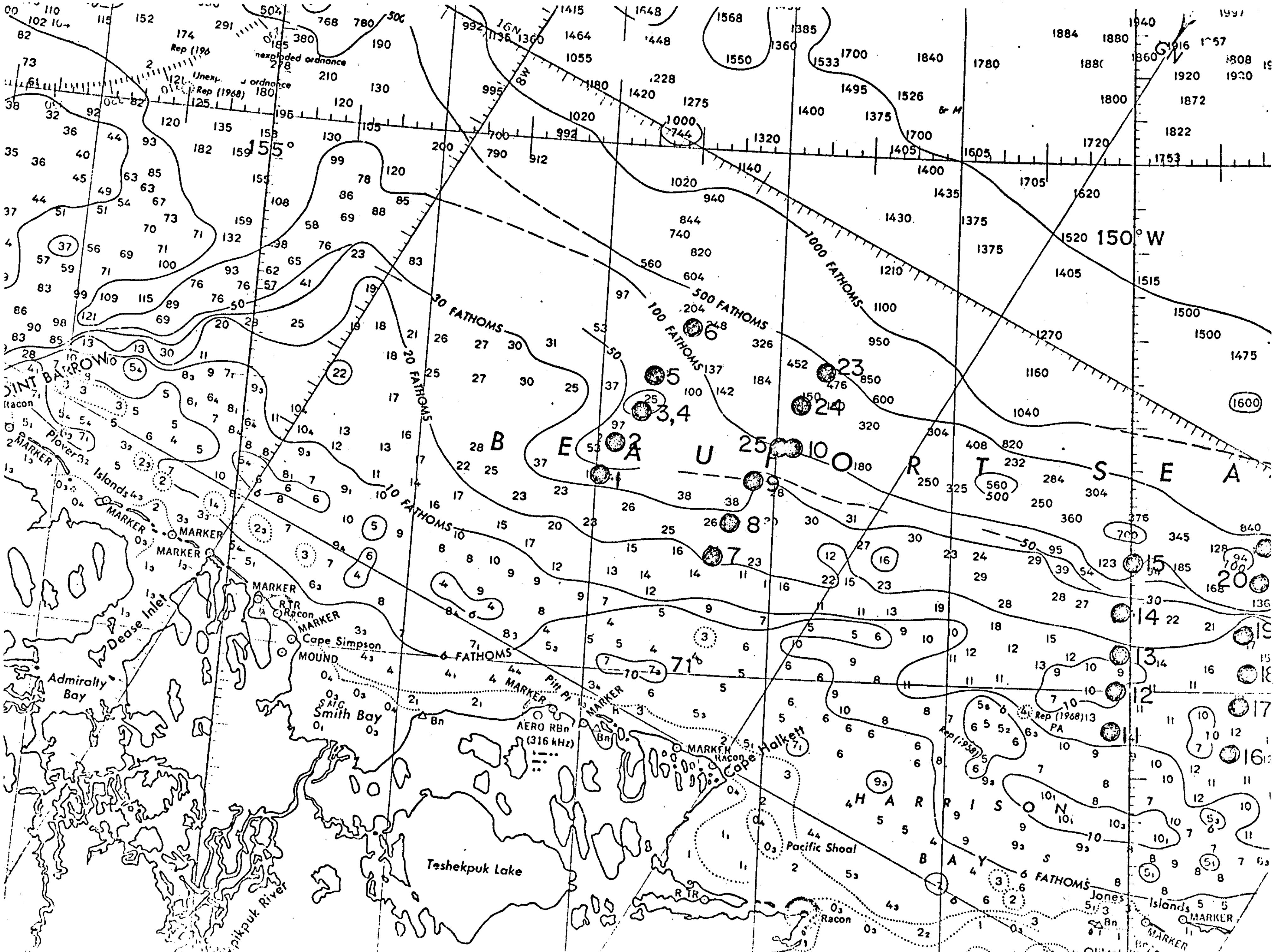
R. B. Tripp	Principal Oceanographer	University of Washington
C. H. Darnall	Oceanographer	University of Washington
J. Swift	Graduate Student	University of Washington
Lt. Mike Barnhill	Pilot N56RF	NOAA
R. DeHart	Mechanic N56RF	NOAA
Lt. Don Winter	Pilot N57RF	NOAA
G. Feld	Mechanic N57RF	NOAA

5. *Acknowledgments*

The NOAA personnel participated in every aspect of the operation. Lt. Barnhill, Mr. Feld and Mr. DeHart's "can-do" approach was greatly appreciated, and certainly helped in accomplishing the mission.

APPENDIX A

Consec. No.	Date/Time GMT March 1977	Latitude N	Longitude W	STD Depth M	Water Depth M
1	4-2158	71-22.0	152-57.6 -	83	84
2	2305	71-26.0	152-52.9	78	79
3	5-0154	71-30.1	152-43.3	6	74
4	0157	71-30.1	152-43.3	73	74
5	0247	71-34.4	152-38.0	126	127
6	0358	71-39.9	152-30.3	366	367
7	2059	71-13.1	152-17.0	26	27
8	2251	71-17.5	152-11.6	48	4 9
9	2341	71-22.5	152-06.1	83	84
10	7-2234	71-25.8	151.54.2	220	221
11	9-2347	70-55.4	150-07.3	25	26
12	10-0023	70-59.9	150-05.4	27	28
13	0102	71-04.0	150-03.6	39	40
14	0 1 4 1	71-08.6	150-01.7	56	57
15	0253	71-14.4	149-59.3	540	>541
16	2208	70-52.3	149-24.5	28	29
17	2244	70-58.0	149-21.9	3 1	32
18	2328	71-01.8	149-19.5	37	3 8
19	11-0021	71-06.9	149-20.7	42	43
20	0104	71-12.5	149-14.8	81	324
21	0127	71-12.5	149-14.8	323	324
22	0210	71-16.7	149-12.2	529	>530
23	2112	71-35.8	151-44.7	547	>548
24	2212	71-31.5	151-53.0	547	>548
25	. 2308	71-26.0	151-59.1	198	199


BEAUFORT SEA
HARRISON BAY
150° W
155°
1000 FATHOMS
500 FATHOMS
100 FATHOMS
30 FATHOMS
20 FATHOMS
10 FATHOMS
6 FATHOMS
POINT BARROW
Plover Islands
Dease Inlet
Admiralty Bay
Cape Simpson
Smith Bay
Pitt Pt
AERO RBn (316 kHz)
Cape Halkett
Pacific Shoal
Teshekpuk Lake
Jones Islands
Oliktok Pt
Unexploded ordnance
MARKER
Racon
Figure 1