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Report of Larval Herring Surveys in the Gulf of Maine and on Georges Bank During December 1973 and February 1974 Conducted by R/V *Albatross IV*

by

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Introduction

R/V Albatross IV conducted surveys of larval herring (*Clupea harengus*) distributions on Georges Bank and environs during December 4-21, 1973, and February 11-18, 1974. The December survey was the scheduled ICNAF Larval Herring Survey, an annual, cooperative ICNAF study since 1971. Time did not permit sampling the Scotian Shelf during December; the February sampling was primarily on Georges Bank. The cruise tracks (Figures 1, 2) show the ICNAF stations occupied .

Methods

Larval herring were sampled during each cruise with a single pair of 61 cm Bongo nets at each station. Tows were single oblique and to a maximum depth of 100 m. Rate of net deployment was 50 m/min. while haulback rate was 10 m/min., continuous to the surface. Ship speed was 3.5 knots. Both .505 and .333 mm mesh nets were used. All plankton samples were preserved in 5% formalin. Herring larvae were initially sorted at sea for preliminary enumeration; they were later recounted and measured in the laboratory ashore.

Additional samples with the above Bongo nets were taken on selected stations during each cruise for studies of vertical distribution of the larvae. These included sampling the depth intervals 0-15, 15-40, and 40-80 m by repeated oblique hauls at 10 m/min. (December cruise), horizontal tows at 10, 20, and 50 m depth (February cruise), and 10-minute surface tows (both cruises). Ten-minute Neuston tows using a net with a 1x2 m mouth and .947 mm mesh were also made on most of the December stations. Results from these additional samples will not be discussed in this report.

XBT temperature profiles were taken at all stations, along with surface salinity samples during each cruise. Salinity-temperature-depth profiles were obtained on selected stations during December, using the STD instrument.

Results and Observations

A. Environmental

Except for the Nantucket Shoals area and the northeastern portion of Georges Bank, almost all areas on Georges Bank were warmer in December 1973 as compared with December 1972 (Figure 3). The tongue of cooler water normally seen over the southeastern edge of the Bank, and representing the influence of the Scotian Current as well as flow from Northeast Channel, had been deflected seaward and beyond the 100 m isobath. Farther westward the temperature gradients normally along the periphery of the Bank had a strong northerly component as they necessarily curled around the cool tongue. This appeared related to the presence of greater than 11° waters over shoal areas of the Bank farther to the west. In previous years the 11° isotherm appeared only in the vicinity of the 100 m isobath. Related to this development was a tongue of warmer water that extended northward over western Georges Bank. These features suggest a stronger development in 1973 of the clockwise gyre over eastern Georges Bank, resulting in greater advection of central Bank waters to the southeastern periphery of the Bank; the resulting southerly displacement of the cool tongue of less than 9° C water appeared to be responsible for generating a northerly component to the normally peripheral flow pattern along the southern edge, which component may have been related to the warm tongue pushing northward over western Georges Bank.

The temperature gradients along the shelf edge south of Nantucket Shoals were sharply convoluted, as they were in December 1972. This may be a normal feature, perhaps related to the change in curvature of the shelf edge in this area. Shelf water appeared to have been carried far beyond the shelf edge in two areas: south of South Channel and south of Cape Cod.

The surface salinity pattern in December 1973 (Figure 4) reflected the conditions suggested by the temperature field. The lobe of less than 32.5‰ water normally extending eastward onto Georges Bank from the Nantucket Shoals area was largely dissipated over Georges Bank, again suggesting a greater than normal, northerly component to the peripheral flow pattern along the shelf edge. Less than 33.5‰ shelf-type water was seen extending southward farther than the 1000 m isobath in the two areas mentioned above. Surface densities (Sigma-t) reflect more the salinity rather than the temperature distributions, particularly along the shelf edge. They are shown in Figure 5.

The outwelling of shelf waters into the Slope Water zone is not merely a surface feature. The two areas of extension of shelf waters beyond the shelf edge, south of South Channel and south of Cape Cod, that appeared as convolutions in the surface temperature field, are seen more clearly in the temperature distributions at 30 and 100 m (Figures 6, 7. Bottom temperatures are shown for depths less than 100 m on the 100 m chart). There they appear as buds of water in the process of breaking off into the Slope water. This is probably an important mode of transport of Shelf waters into the transition region of the Slope zone. Satellite infrared images of this region show that the Shelf-Slope front is a ragged edge suggestive of eddy exchanges and interactions with large Gulf Stream warm-eddies. Clearly the frontal effects along the shelf edge have important effects on Shelf Water processes.

The February 1974 surface temperatures appear more normal with respect to our notions of circulation on Georges Bank, i.e. with a peripheral flow around the Bank (Figure 8). The lobe of greater than 6° water extending northward over western Georges Bank may be related to the similar feature seen in December. Temperatures over Georges Bank were about 4° cooler than in December while they averaged 5° cooler south of Nantucket Shoals. Along the southeastern edge of the Bank temperatures rose about 3° due to warmer Slope waters lying in closer proximity to the Shelf edge.

February temperatures at 30 and 100 m (Figures 9, 10), and salinities and densities (Figures 11, 12) all show the strong gradients overlying the Shelf edge where the Shelf waters meet the Slope waters. The 33 and 33.5 o/oo salinity isopleths, marking the approximate seaward boundary of Shelf Water, followed a more regular pattern along the Shelf edge than in December. Surface densities had increased due to surface cooling since December.

B. Biological

The December 1973 distributions of herring larvae, in numbers per 10 m^2, are given in Figures 12 to 17 showing larvae of all lengths combined and larvae by 5 mm length intervals. All larvae are from the .505 mm net.

Herring larvae were much more abundant in December, 1973 as compared with December, 1972. In 1972 only five stations over the Nantucket Shoals-Georges Bank area yielded catches greater than 100 larvae/10 m^2, whereas in 1973 most stations shoaler than 60 m over Georges Bank and between 60 and 80 m south of Nantucket Shoals yielded more than that number (Figure 13). A large region in the western Gulf of Maine to the northwest of Georges Bank had concentrations of 1-10 larvae/10 m^2, perhaps representing continuous offshore dispersal of larvae from Stellwagen Bank, Jeffreys Ledge, and northwestern Georges Bank. Seaward transport of larvae in the form of localized lobes extending over deep water occurred off the eastern tip of the Bank and to the south of Cape Cod and south of the western portion of Georges Bank, i.e. south of South Channel. In the latter two areas lobes or pockets of greater than 10 larvae/10 m^2 were in the same locations of Shelf water outwelling as indicated by the temperature and salinity distributions. The Nantucket Shoals area appeared to have few larvae, in contrast to the indications from December, 1972. However, sampling there was too sparse for definite conclusions on this matter.

Larvae less than 10 mm in length in 1973 were abundant over all shoal areas of Georges Bank (Figure 14) in sharp contrast to the situation of December, 1972, at which time only 3 stations yielded larvae of this size. These larvae were sparse in the Nantucket Shoals area. The strong concentrations (50-100/10m^2) just to the east of South Channel on the western end of Georges Bank should probably not be considered Nantucket Shoals larvae. Some of these larvae seemed in the process of being carried toward the shelf edge. Others had already been transported beyond the edge, particularly in the area south of Cape Cod. The 10-14 mm larvae were more widespread over Georges Bank (Figure 15) relative to the less than 10 mm larvae, and the 15-19 mm larvae, as in 1972, were the most widespread of all size categories (Figure 16).

The distribution of both these groups extended beyond the shelf edge north of South Channel into the Gulf and south of Cape Cod. Denser concentrations of herring larvae south of Nantucket Shoals first appeared in the 10-14 mm grouping. However, these larvae did not seem related to the larvae that had been carried off the shelf south of Cape Cod. Rather, those larvae seemed to have been transported from the east by the peripheral flow along the southern edge of Georges Bank. Concentrations of larvae greater than 100/10m^2 over eastern Georges Bank appeared in the 15-19 mm grouping, suggesting older larvae that were largely contained in the vicinity of their egg beds. Some of these larvae, however, seemed to be contributing to the lobe of larvae being carried northwestward, perhaps by the same currents responsible for the northward tongue of warm water in the same area.

The 20-24 mm larvae were restricted largely within the 100 m contour, except for some localized lobes of low concentrations extending into the Gulf of Maine. None of these larvae were over deep water south of Cape Cod (Figure 17).

The largest larvae, greater than 25 mm in length, were found well on the Bank, largely just south of the shoal axis between 40 and 60 m of water (Figure 18). A few of these larvae remained over deep water off the eastern tip of Georges Bank. It seems likely that larvae carried beyond the 100 m isobath have little likelihood of being carried back onto the shelf. However, they may survive longer within the Gulf than in the Slope waters. The distributions of all size groupings of herring larvae are summarized in Figures 19 and 20.

The February, 1974 larval herring distributions show a different pattern from that of the previous December (Figures 21, 22, 23, 24). Whereas the distributions in December showed a progressive localization onto shoal areas of Georges Bank from the 15-19 mm to the greater than 25 mm groups, in February the trend was just the opposite. The greater than 25 mm group was the most widespread, covering most of Georges Bank and even extending beyond the 100 m isobath in places. Perhaps a change in behavior is involved with the maturing larvae and the approach of spring.

The more condensed distribution of larvae less than 19 mm long (Fig. 22) was to be expected since recruitment to the population had been declining since December. The next two larger size categories (Figs. 23, 24) are interesting in that they show the development of widespread, sparse concentrations over the northern half of Georges Bank. These distributions are summarized in Figures 25 and 26.

The length frequencies of larvae from these areas, Nantucket Shoals (stations 1-30), Georges Bank (stations 50-64, 70-85, 88-99) and a transition zone north of Georges Bank (stations 31-33, 47-49, 65-69, 86-87, 100-101, 104) are compared between December, 1972, December 1973, and February, 1974 (Figure 27). The most notable feature revealed is the broadening of the left hand limb of the histograms of December 1973 indicating a more extended, more slowly declining spawning activity as the season progressed. On Georges Bank there were very few newly hatched larvae seen in December, 1972, but their numbers were substantial in December and some were captured as late as February during the 1973 season. Larvae at 20 mm length were a more important component of the larval stock in 1973 than they were in 1972 indicating that growth and/or survival was better in 1973.

Summary and Discussion

The 1973 December larval herring survey shows distributions interestingly different from that of the previous two seasons. Temperatures were warmer and flow patterns seemed altered. Herring larvae were more abundant and more widespread than in December, 1972, particularly over Georges Bank. Spawning was extended into February and likely spread more evenly throughout the season. Larvae carried beyond the 100 m isobath were also more extensively distributed. In the region south of Cape Cod, at least, seaward transport of larvae beyond the shelf edge was correlated with temperature and salinity distributions that suggest medium scale, eddy diffusion processes. Larvae that are carried to the southern periphery of the Bank are probably eventually lost to the slope waters by these processes if they do not perish earlier. The increased localization of catches of larger sized larvae over the shoal areas of Georges Bank suggest that survival is poor for larvae transported to deeper waters. However, in February the larger larvae were the more extensively distributed, perhaps reflecting a behavioral change in the maturing larvae. The bulk of the larvae are always contained inside the 100 m isobath and processes that determine year class success may largely occur there.

REFERENCES

Schnack, D., and W. T. Stobo, 1973. ICNAF joint larval herring survey in Georges Bank-Gulf of Maine areas in 1972 - Preliminary summary. ICNAF Res. Doc. 73/115.

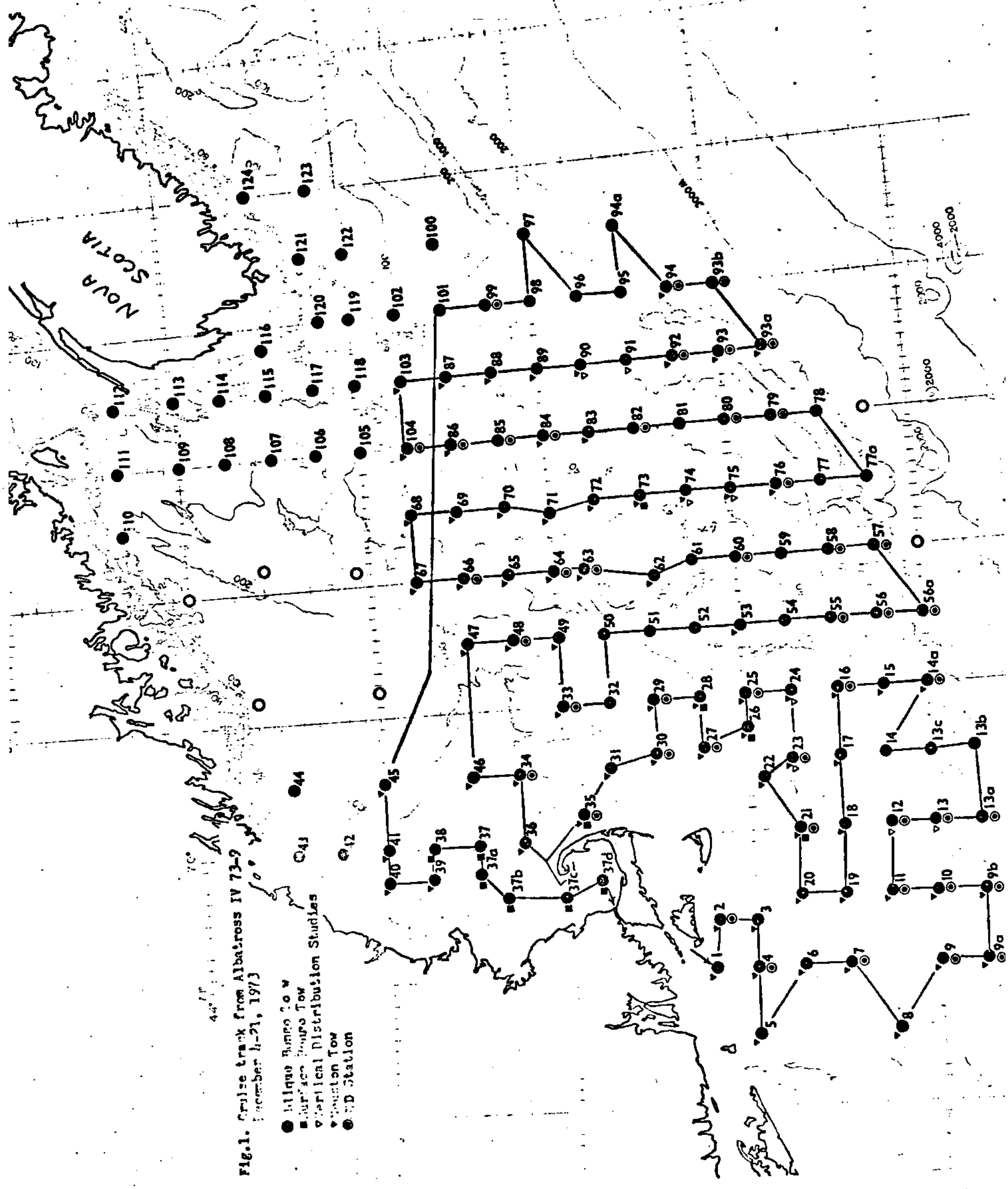


Fig.1. Cruise track from Albatross IV 73-9 December 4-21, 1973

- ● Oblique Bongo Tow
- ■ Surface Bongo Tow
- ▽ Vertical Distribution Studies
- ▼ Neuston Tow
- ◉ STD Station

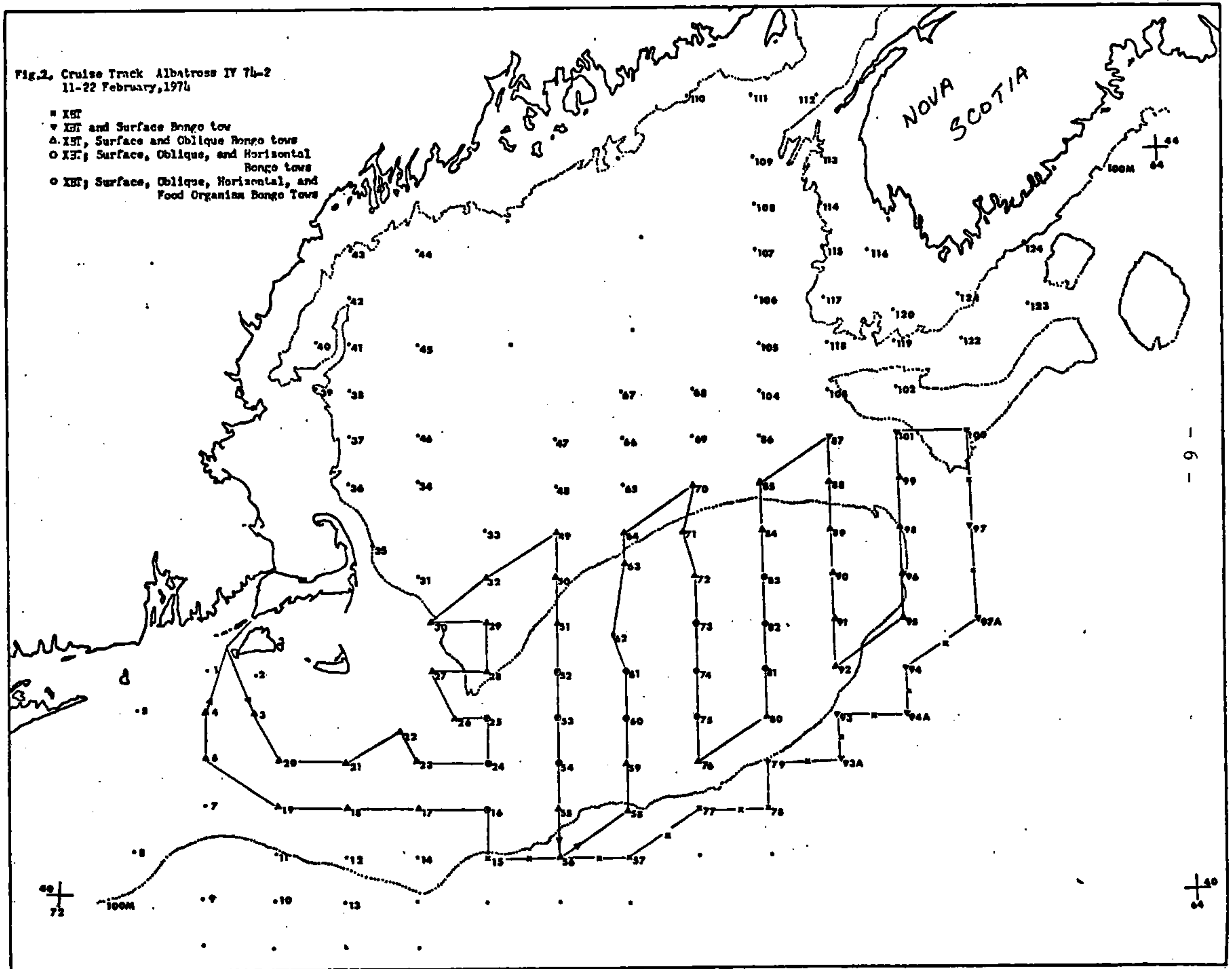


Fig.2. Cruise Track Albatross IV 74-2
11-22 February, 1974

- ▪ XBT
- ▾ XBT and Surface Bongo tow
- △ XBT, Surface and Oblique Bongo tows
- ○ XBT; Surface, Oblique, and Horizontal Bongo tows
- ● XBT; Surface, Oblique, Horizontal, and Food Organism Bongo Tows

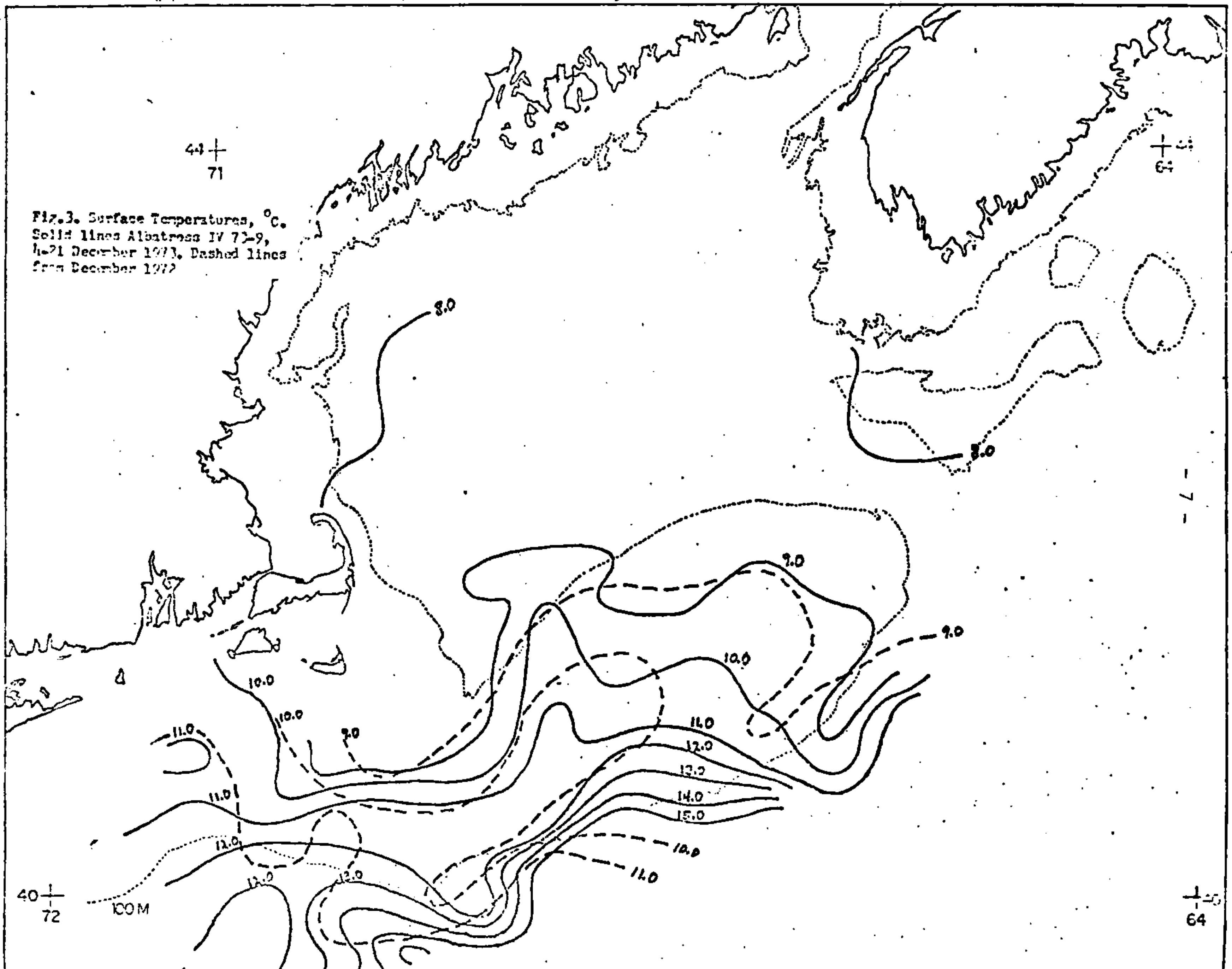


Fig.3. Surface Temperatures, °C. Solid lines Albatross IV 73-9, 4-21 December 1973. Dashed lines from December 1972

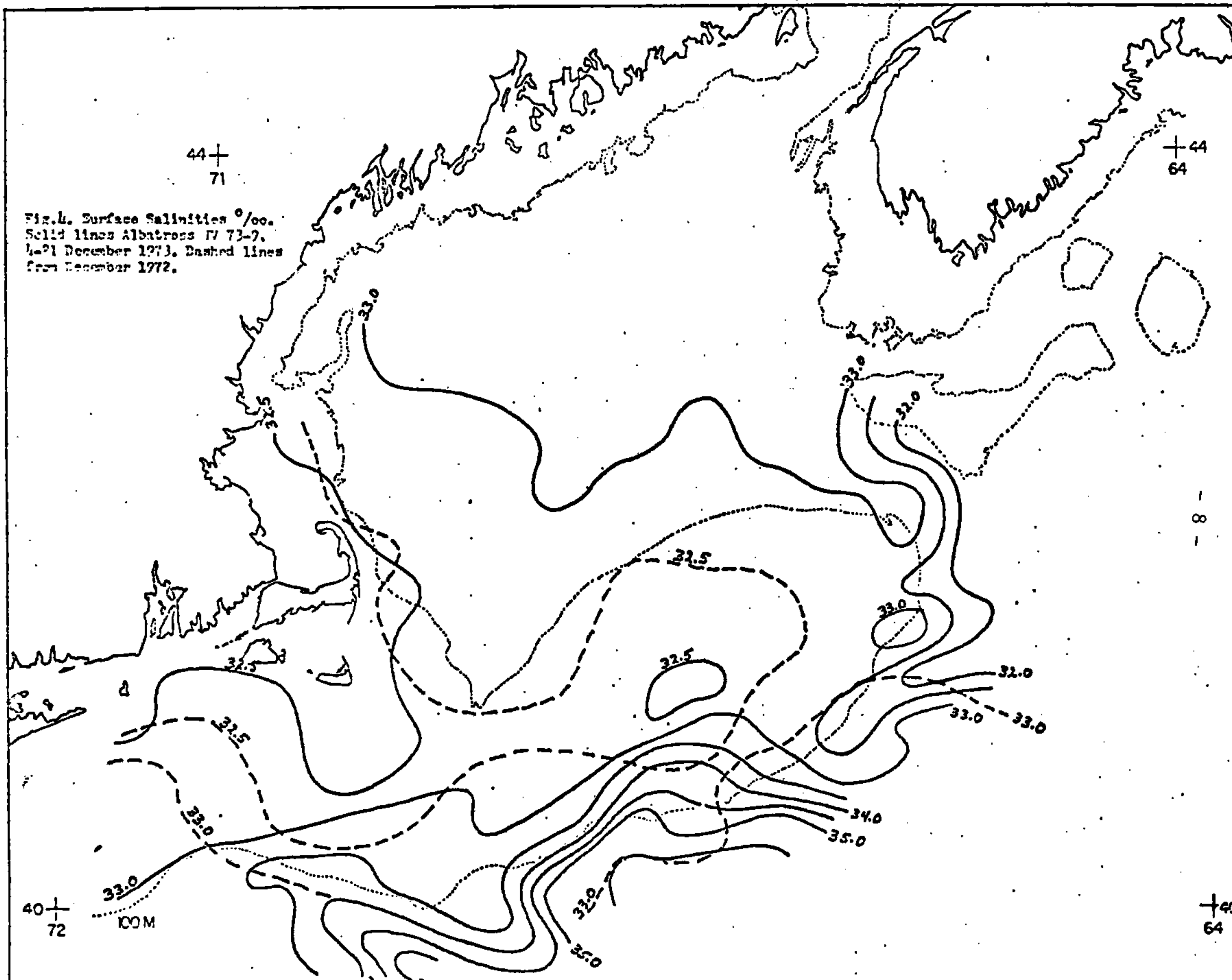


Fig.4. Surface Salinities °/oo. Solid lines Albatross IV 73-7, 4-21 December 1973. Dashed lines from December 1972.

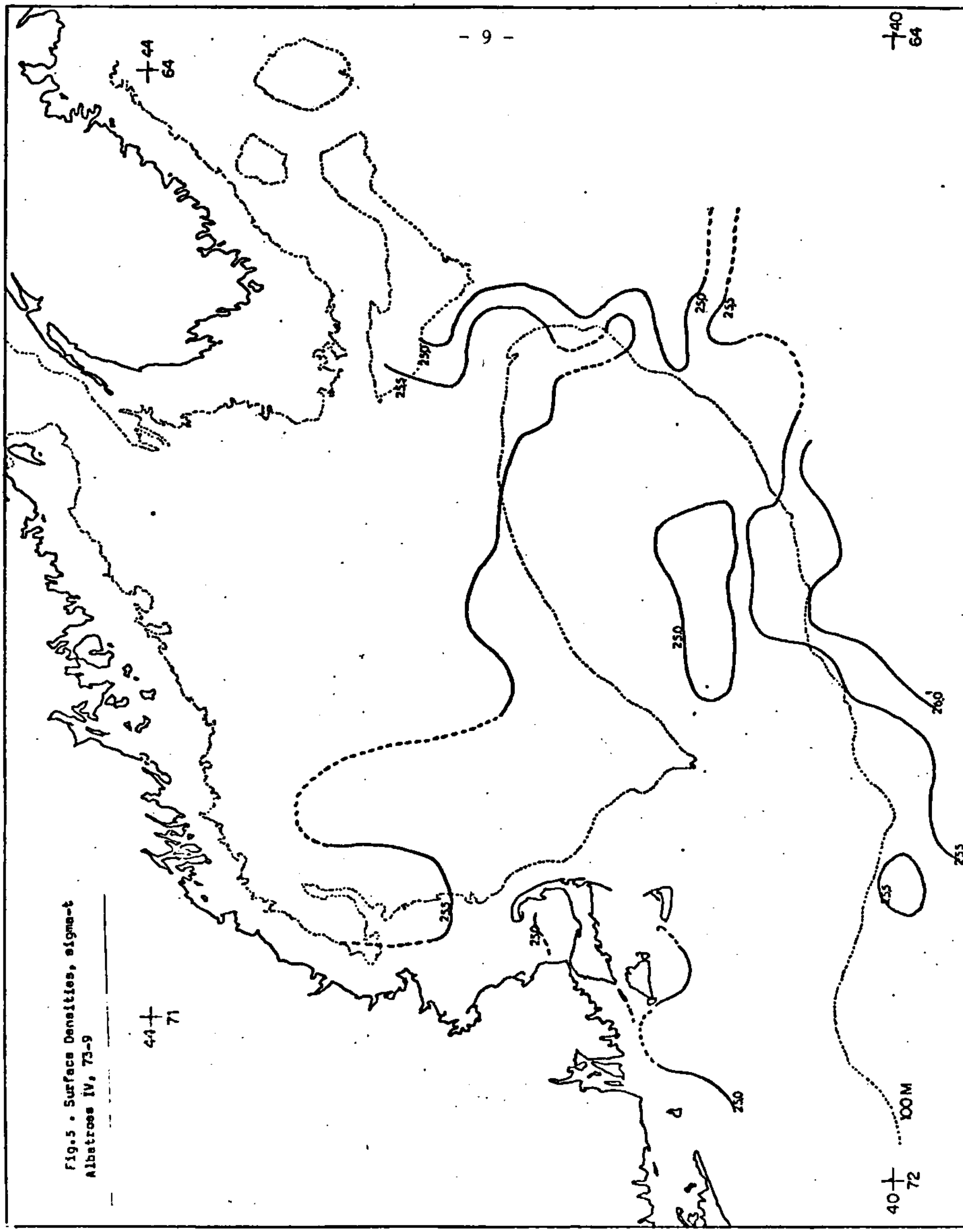


Fig.5 . Surface Densities, sigma-t
Albatross IV, 73-9

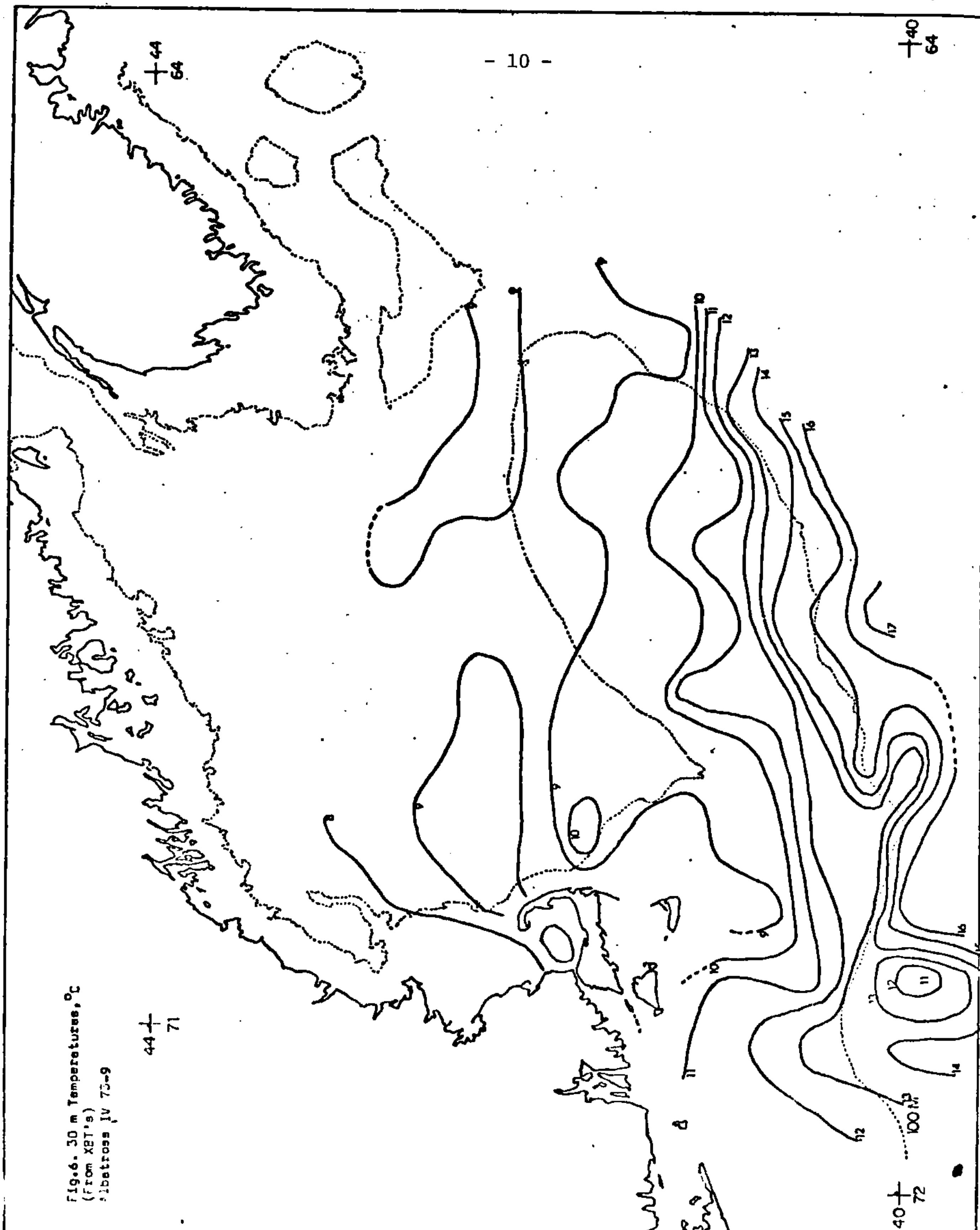


Fig.6. 30 m Temperatures, °C
(From XBT's)
Albatross IV 73-9

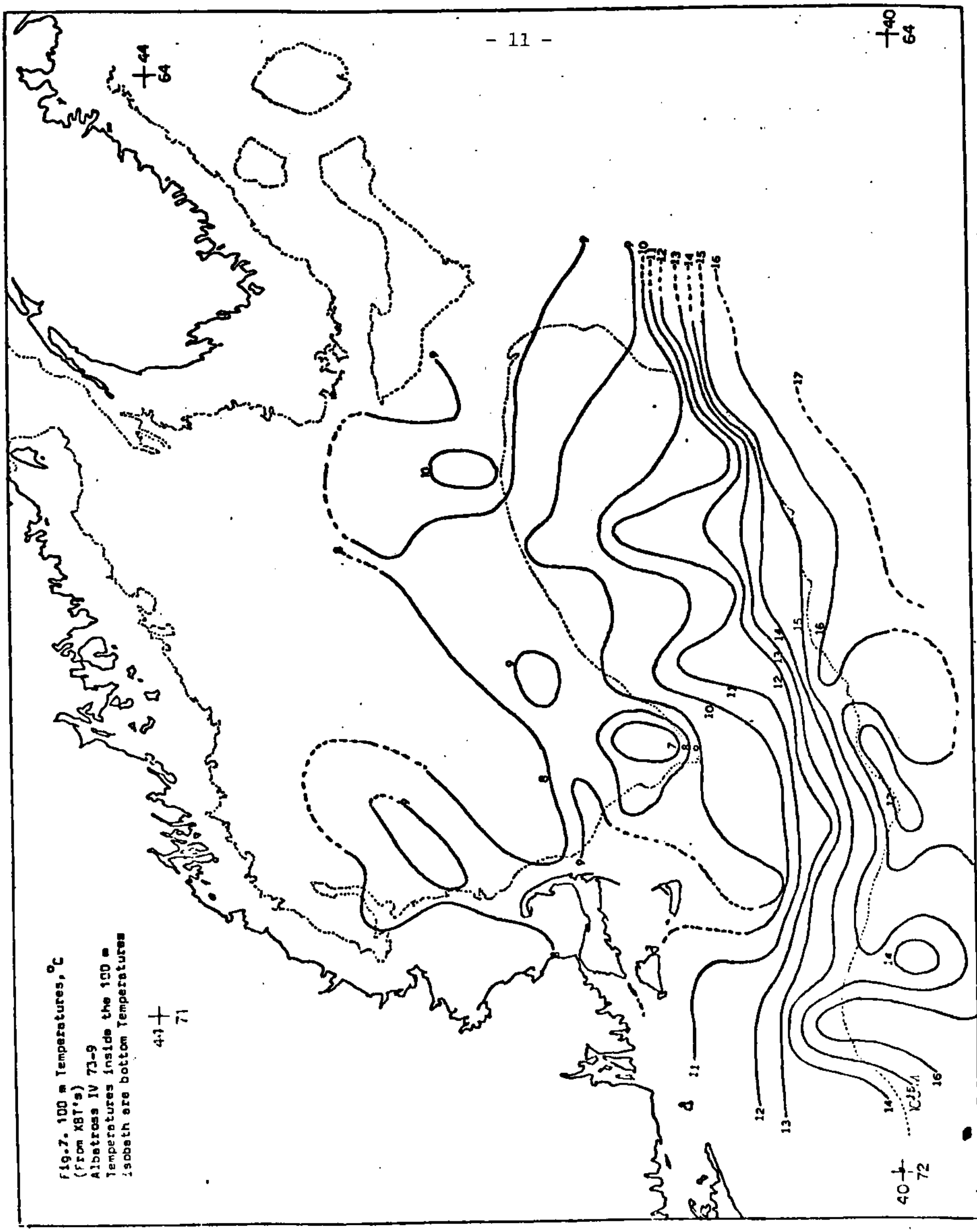


Fig.7. 100 m Temperatures, °C
(From XBT's)
Albatross IV 73-9
Temperatures inside the 100 m
isobath are bottom Temperatures

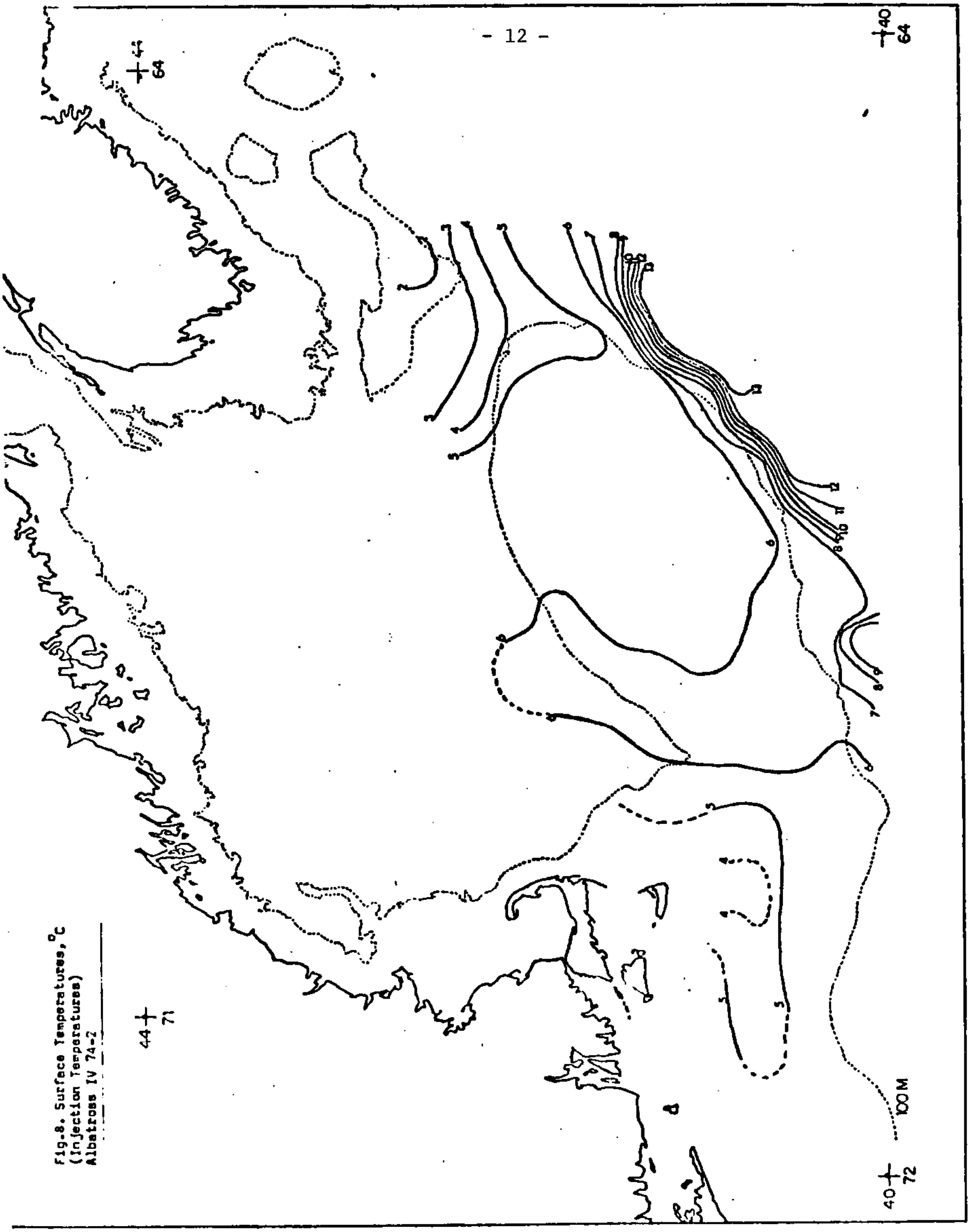


Fig-8. Surface Temperatures, °C
(Injection Temperatures)
Albatross IV 74-2

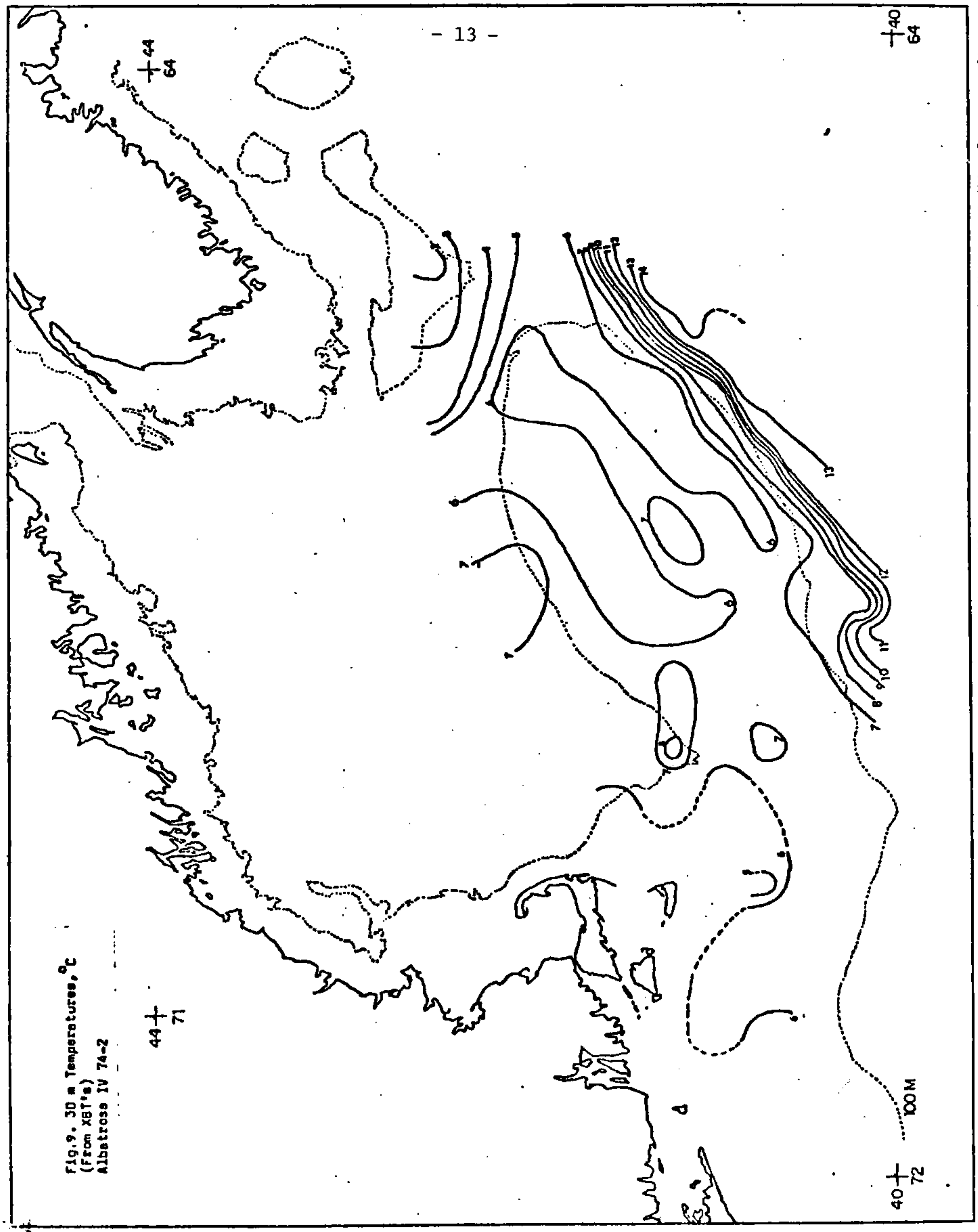


Fig.9. 30 m Temperatures, °C
(From XBT's)
Albatross IV 74-2

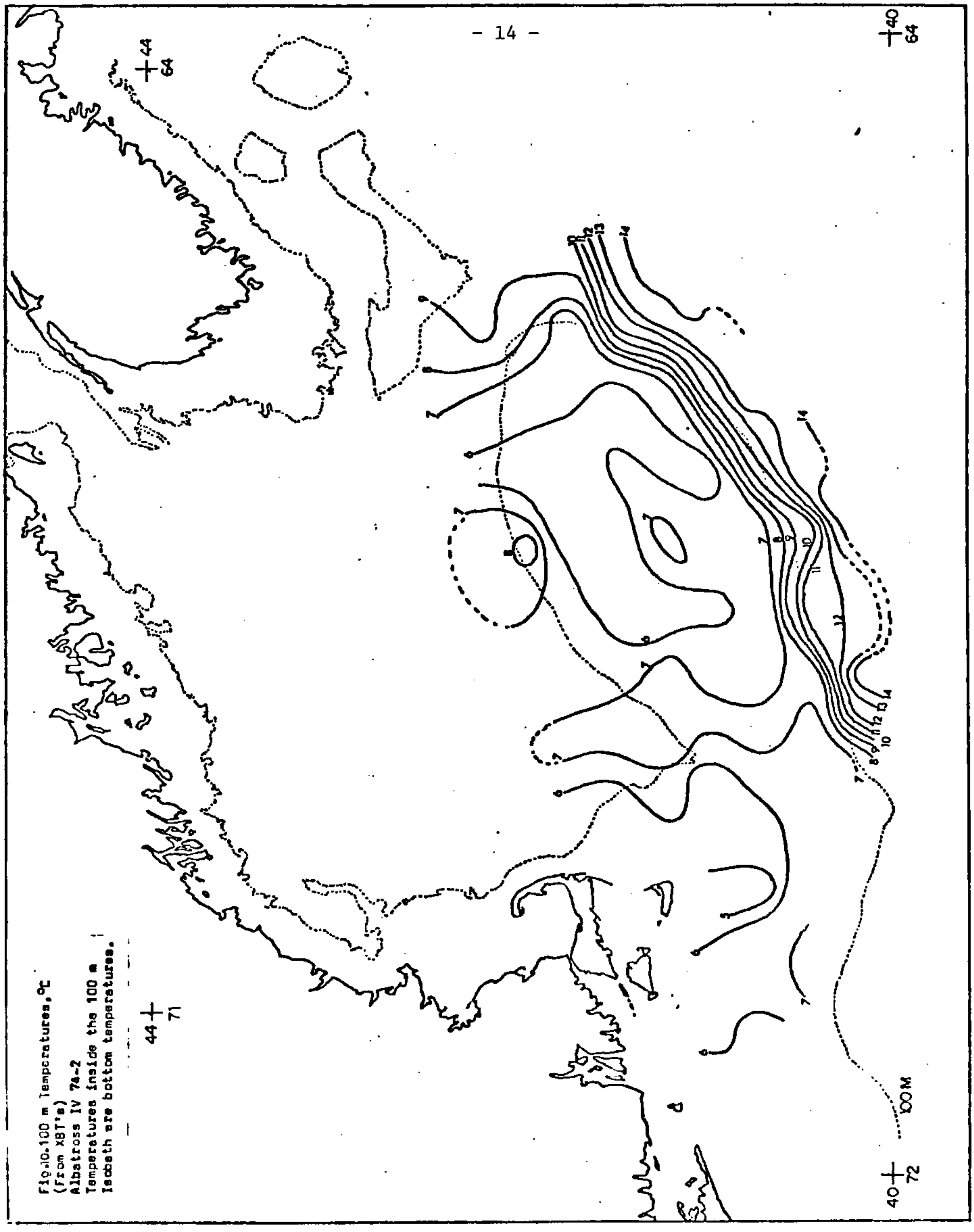


Fig.10. 100 m Temperatures, °C
(From XBT's)
Albatross IV 74-2
Temperatures inside the 100 m
Isobath are bottom temperatures.

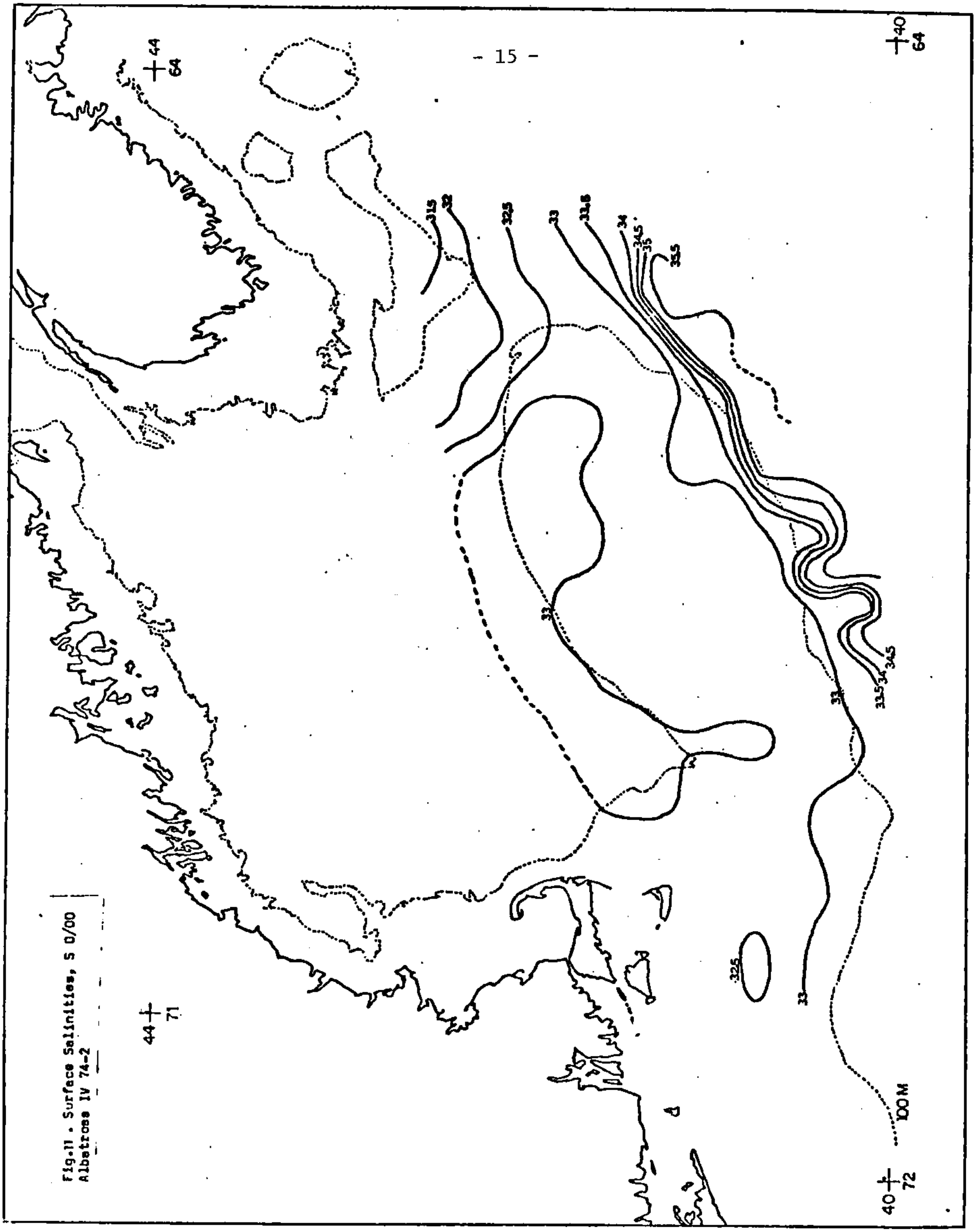


Fig.11. Surface Salinities, S 0/00
Albatross IV 74-2

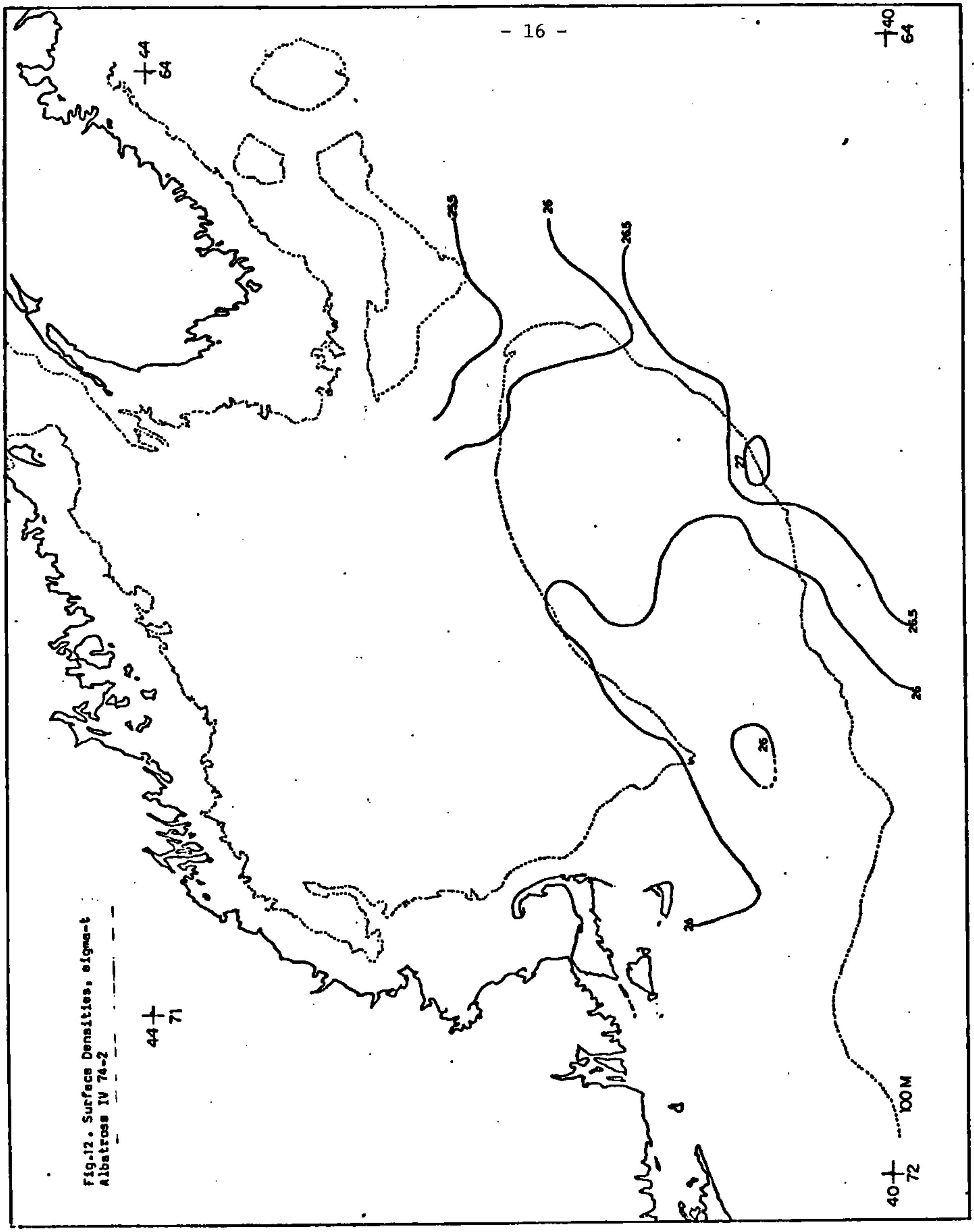


Fig.12. Surface Densities, sigma-t
Albatross IV 74-2

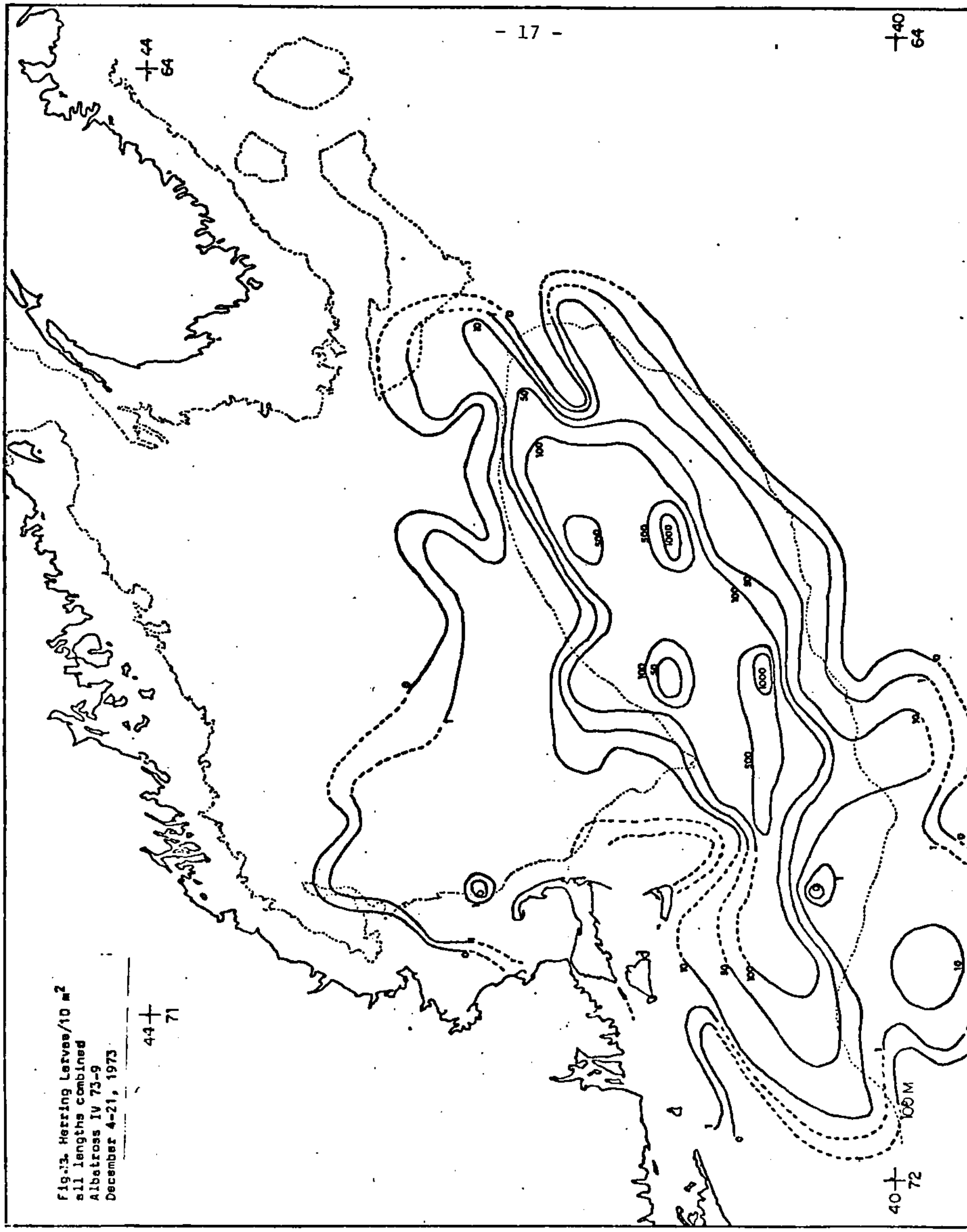


Fig. 13. Herring Larvae/10 m^2
all lengths combined
Albatross IV 73-9
December 4-21, 1973

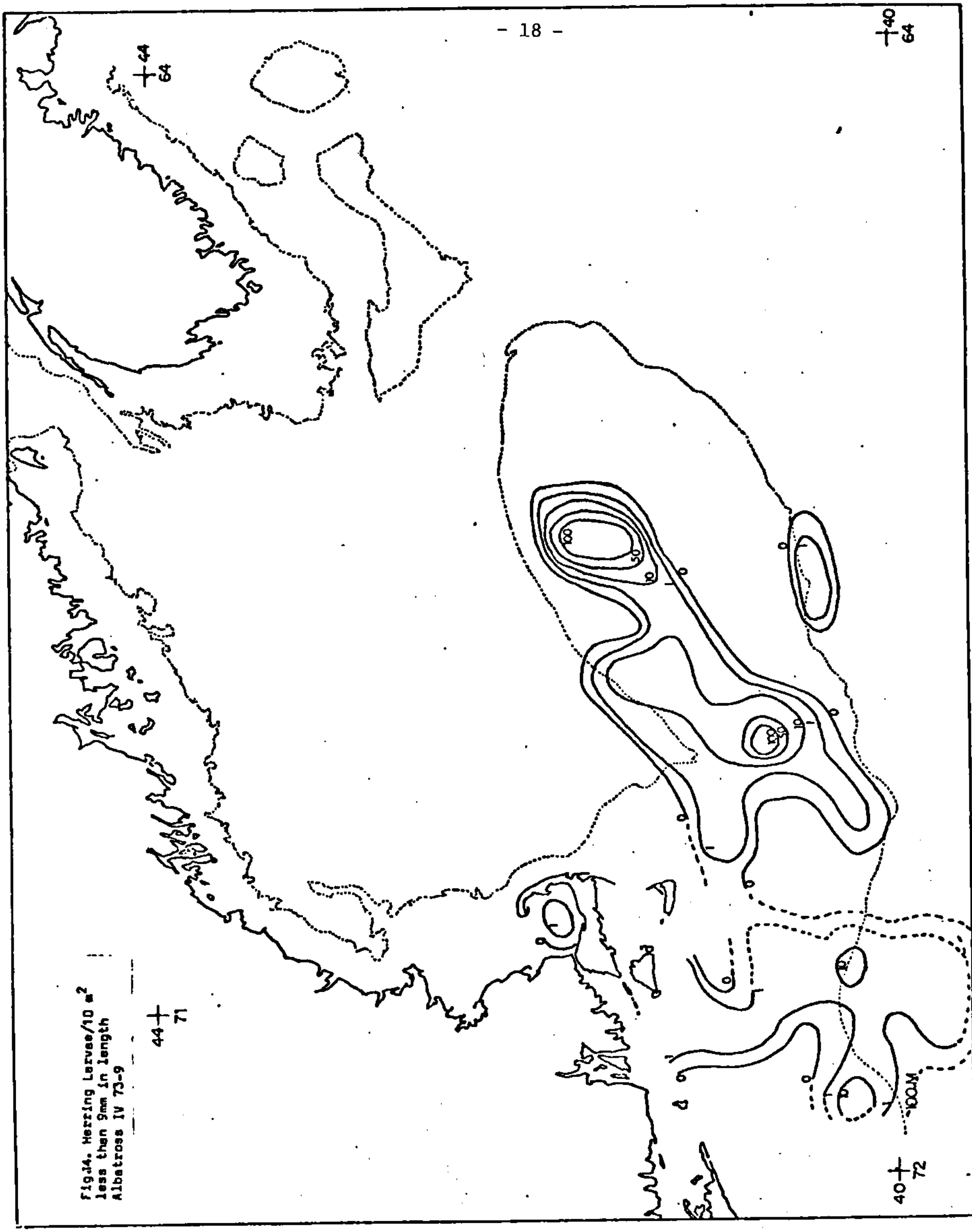


Fig.14. Herring Larvae/10 m²
less than 9mm in length
Albatross IV 73-9

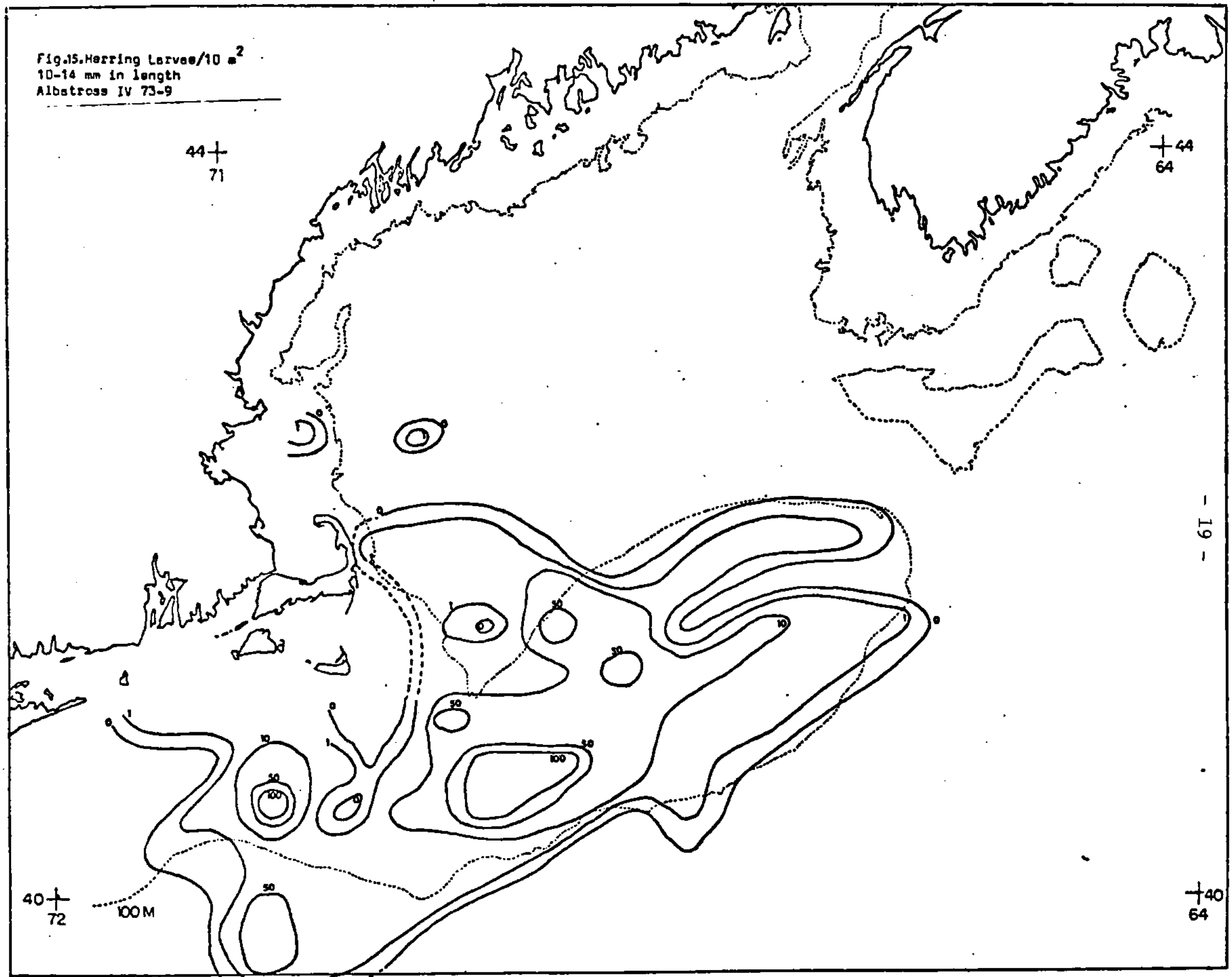


Fig.15.Herring Larvae/10 m^2
10-14 mm in length
Albatross IV 73-9

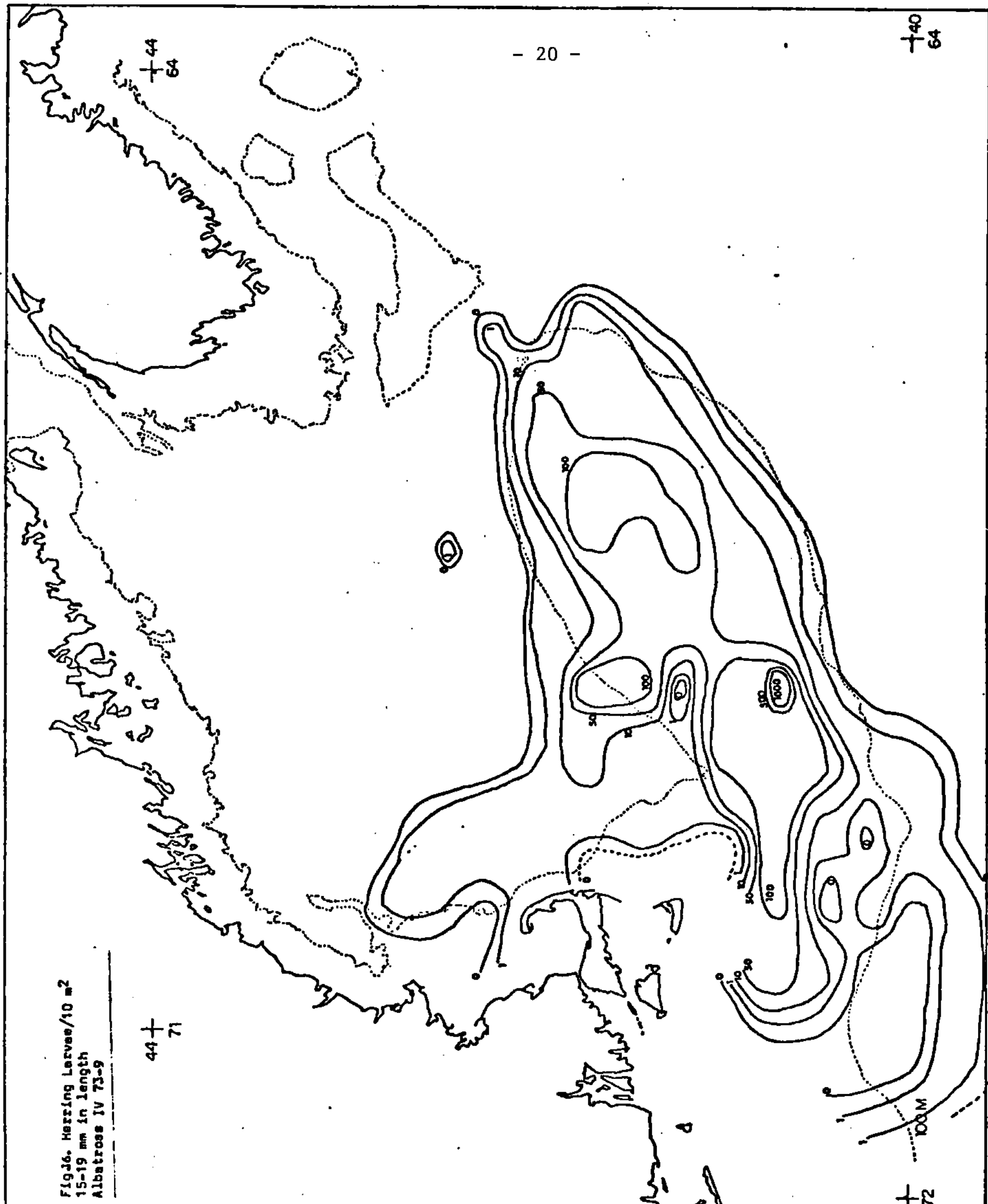


Fig16. Herring Larvae/10 m^2
15-19 mm in length
Albatross IV 73-9

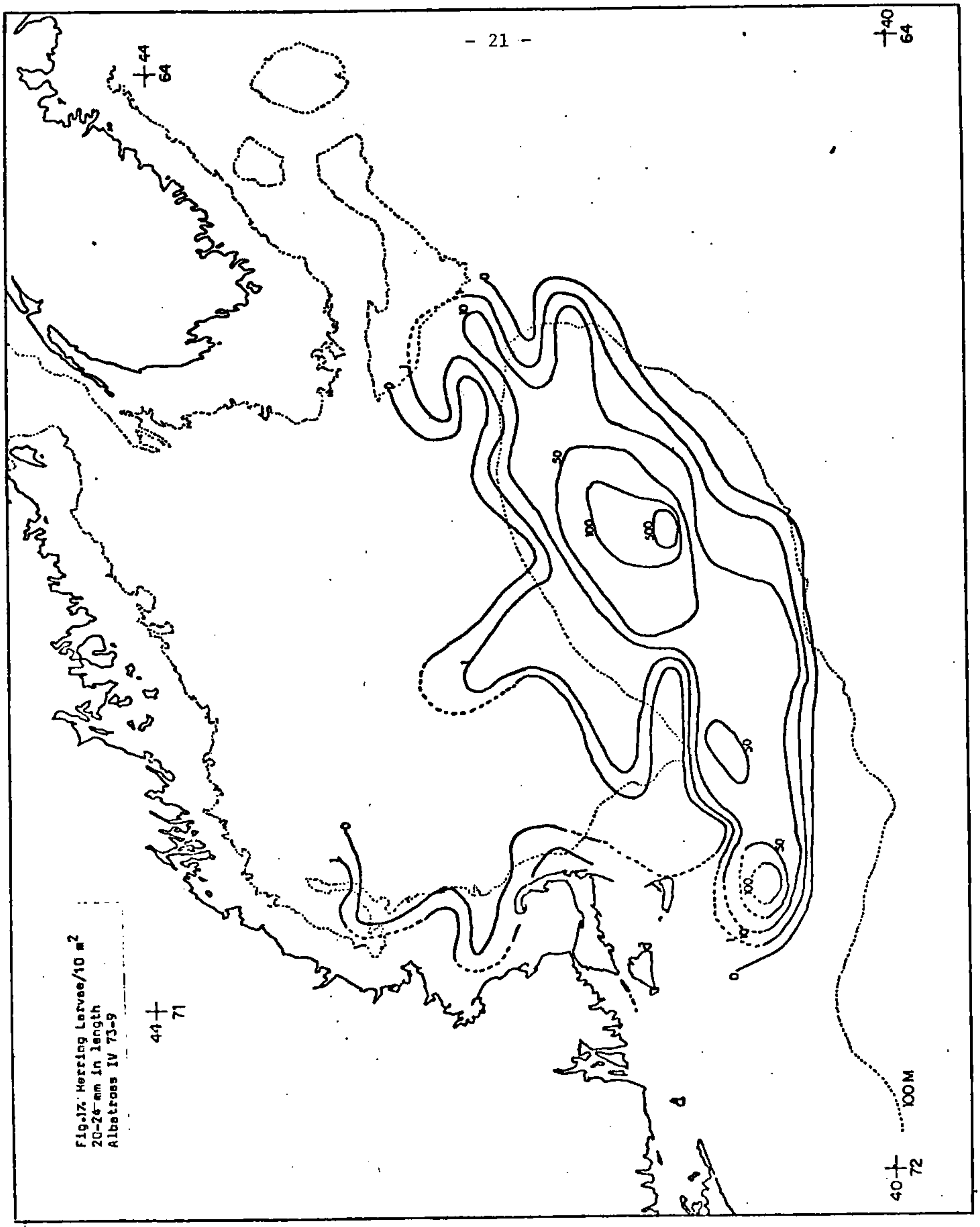


Fig.17 Herring Larvae/10 m²
20-24 mm in length
Albatross IV 73-9

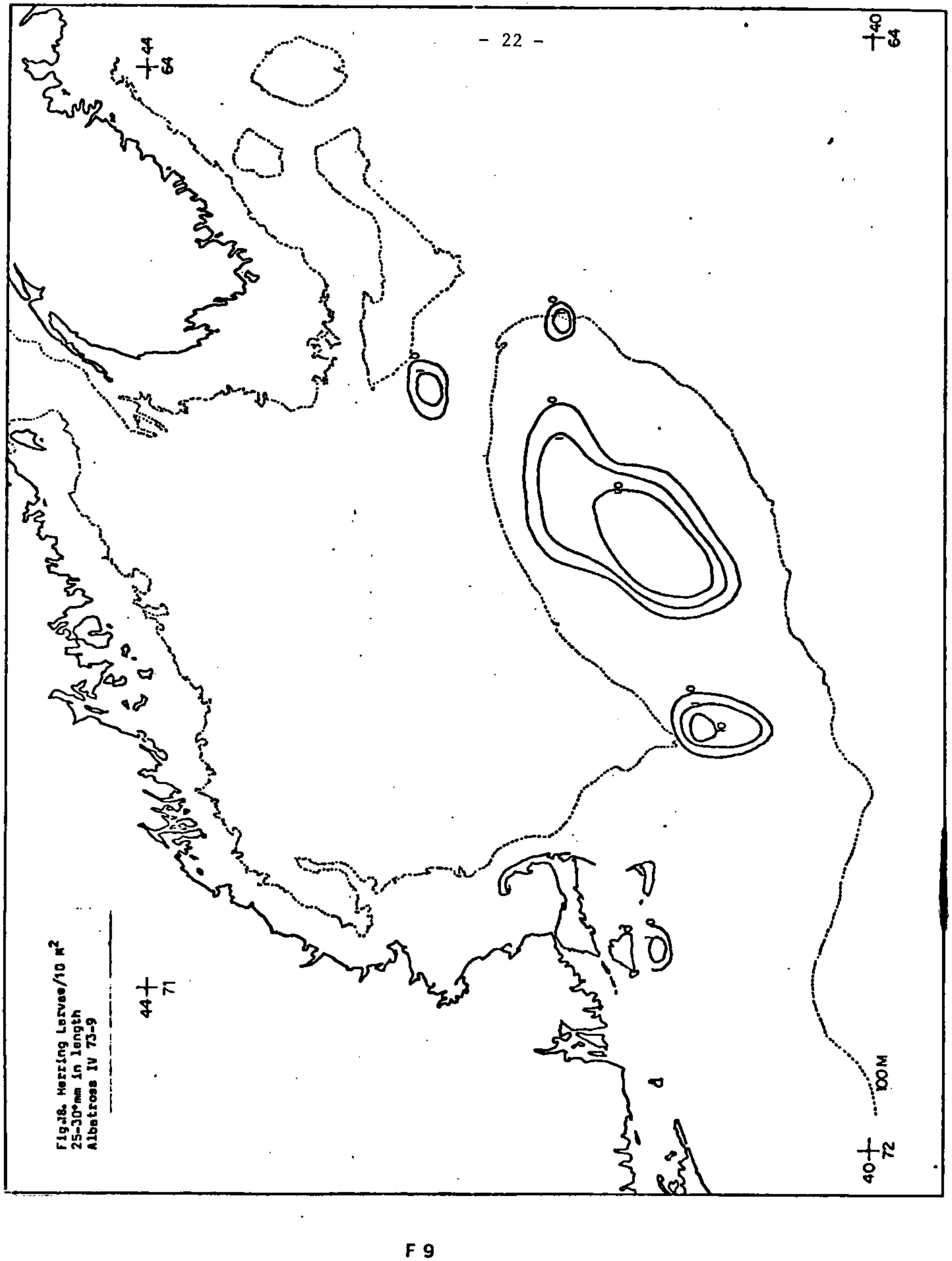


Fig.18. Herring Larvae/10 m²
25-30*mm in length
Albatross IV 73-9

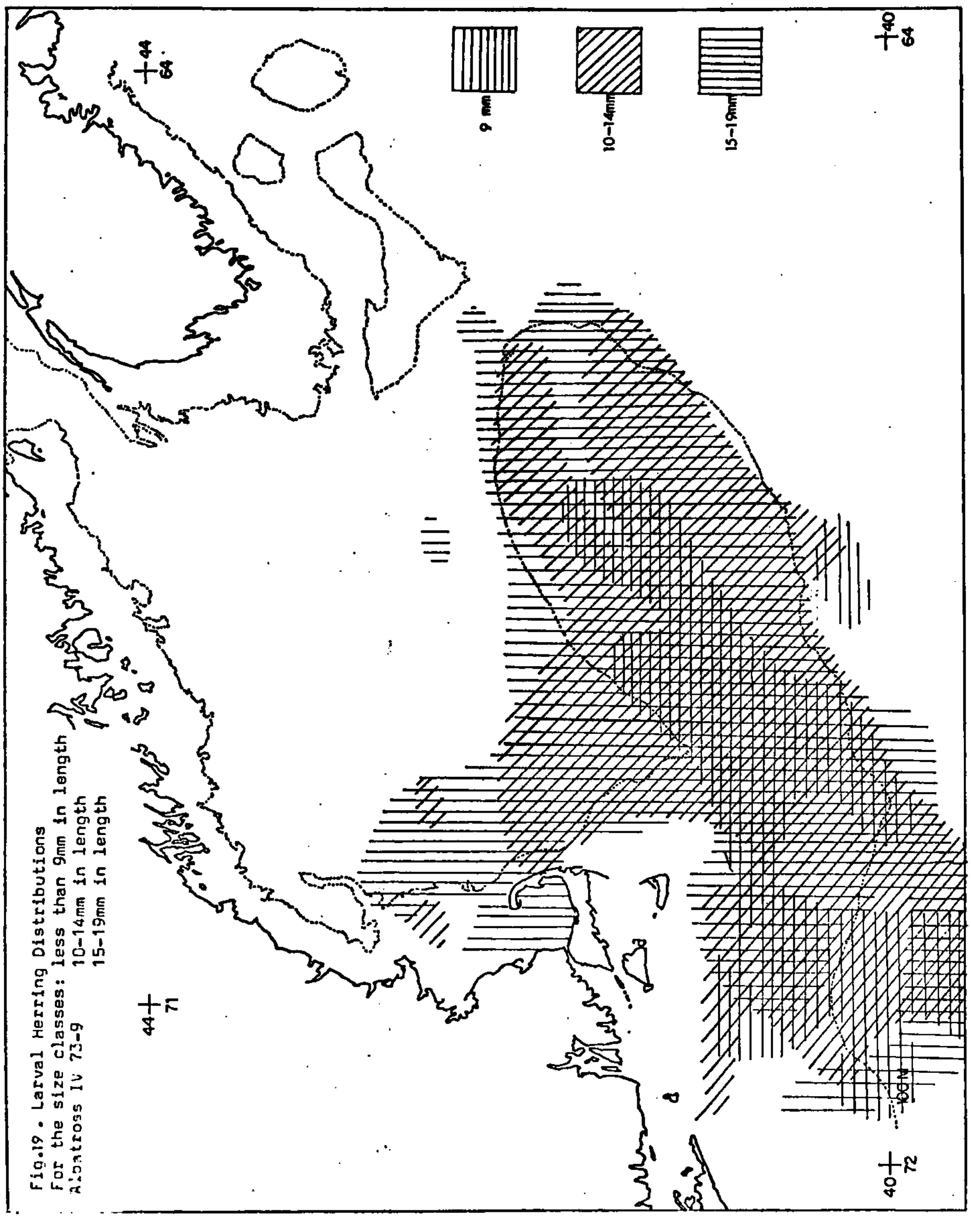


Fig.19 . Larval Herring Distributions
For the size classes: less than 9mm in length
Albatross IV 73-9 10-14mm in length
15-19mm in length

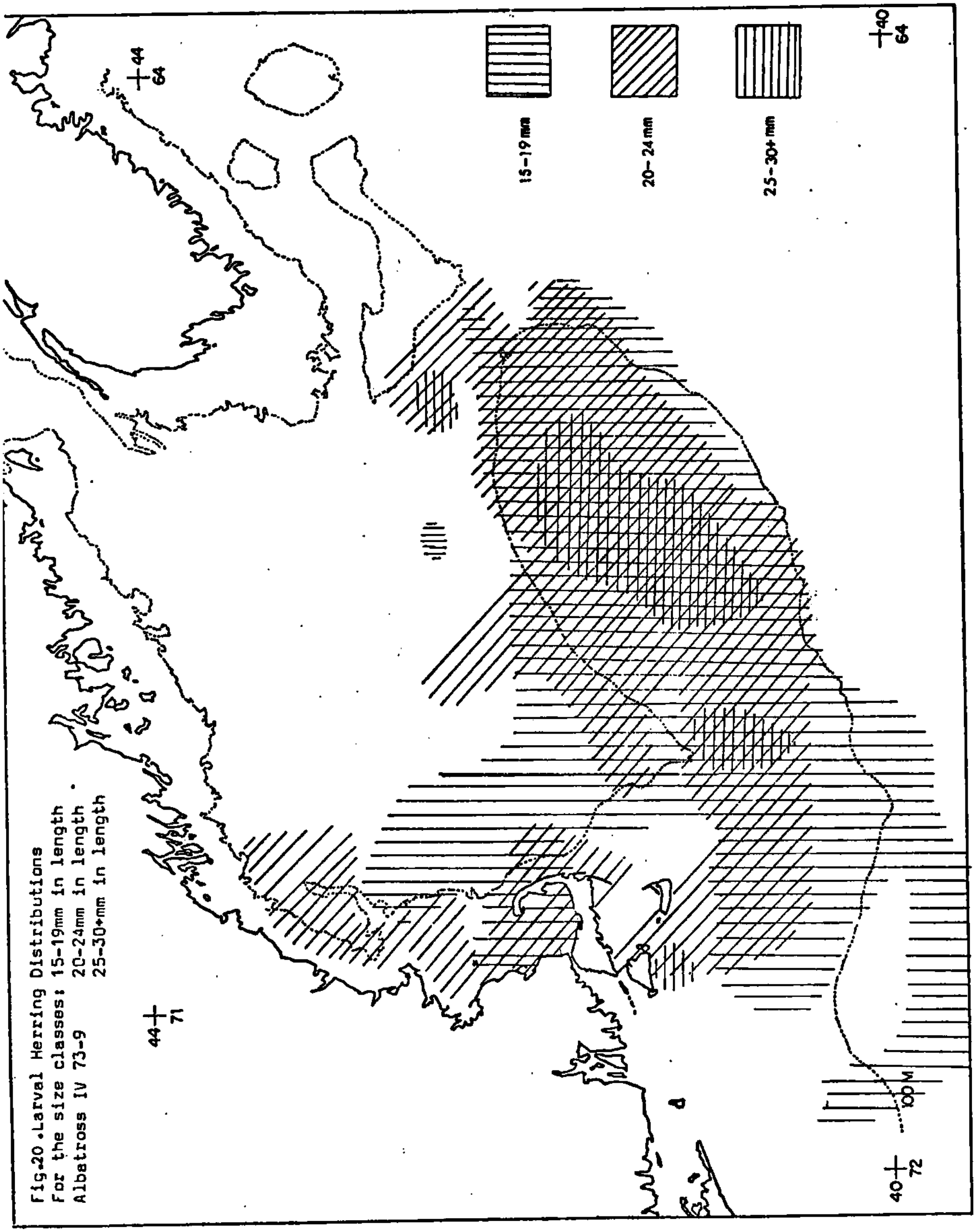


Fig.20.Larval Herring Distributions
For the size classes: 15-19mm in length
20-24mm in length
25-30+mm in length
Albatross IV 73-9

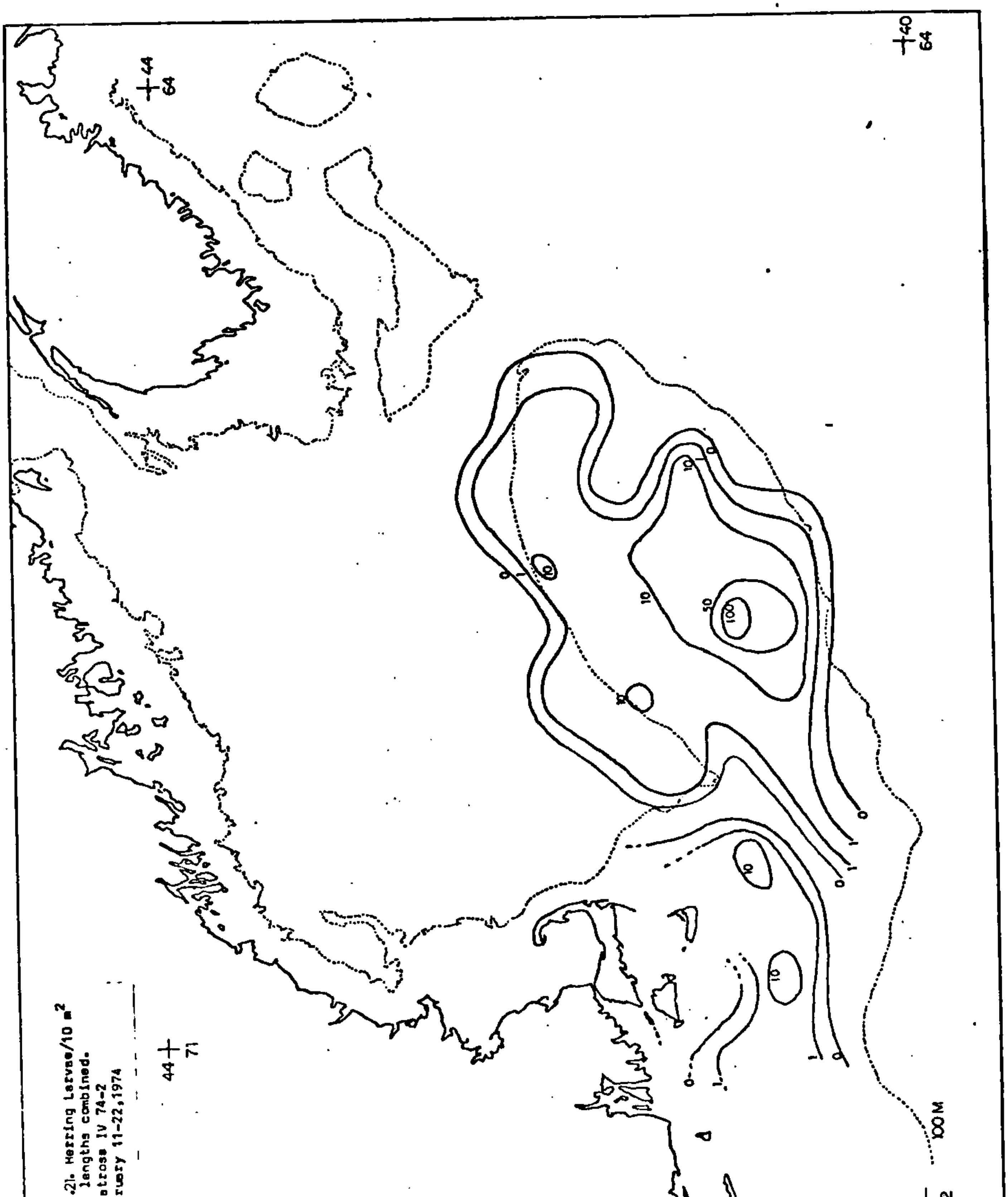


Fig.21. Herring Larvae/10 m²
All lengths combined.
Albatross IV 74-2
February 11-22,1974

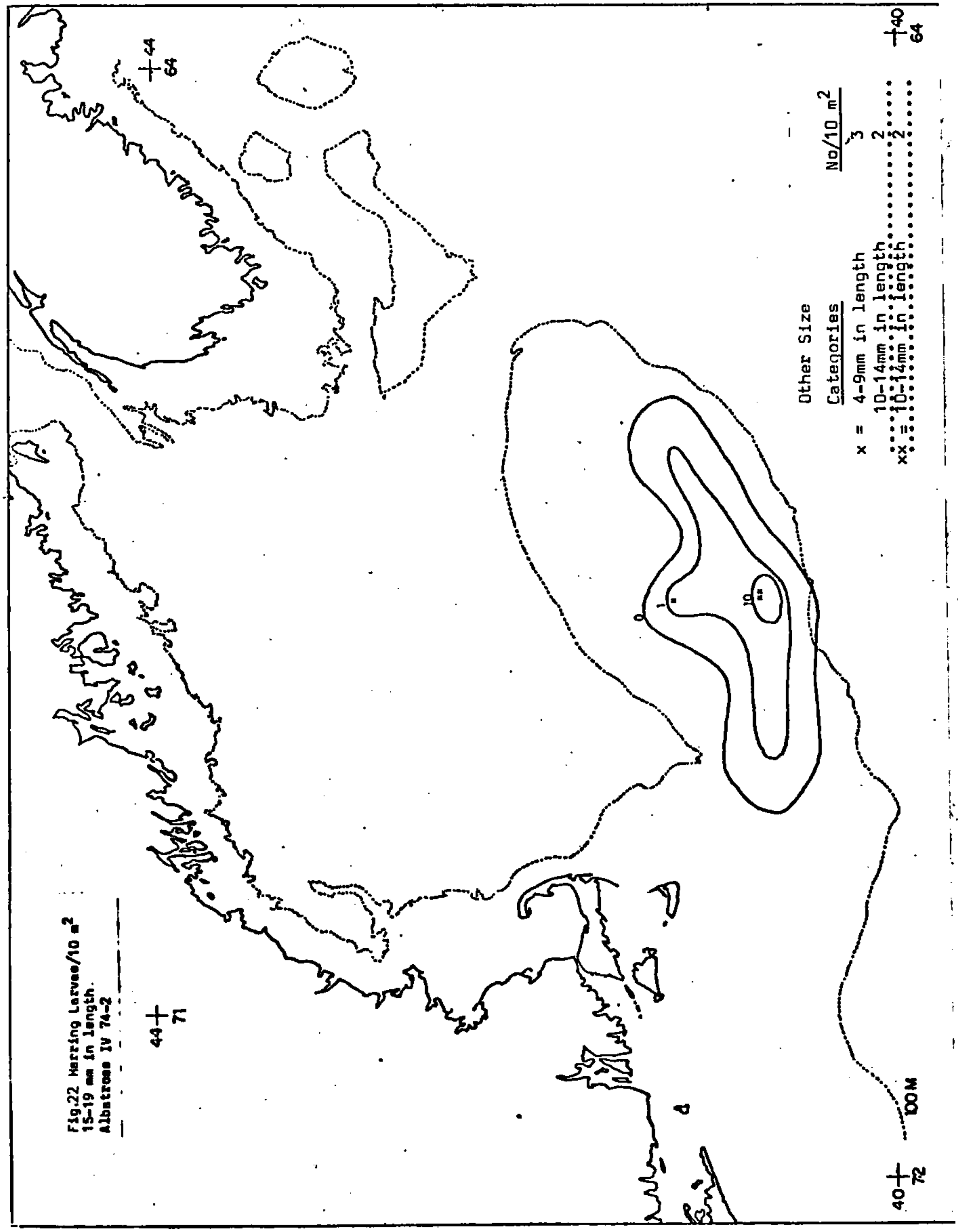


Fig.22 Herring Larvae/10 m²
15-19 mm in length.
Albatross IV 74-2
44 64
40 64
44 71
40 72
100M
0
1
10
Other Size
Categories
x = 4-9mm in length
10-14mm in length
xx = 10-14mm in length
No/10 m²
3
2
2

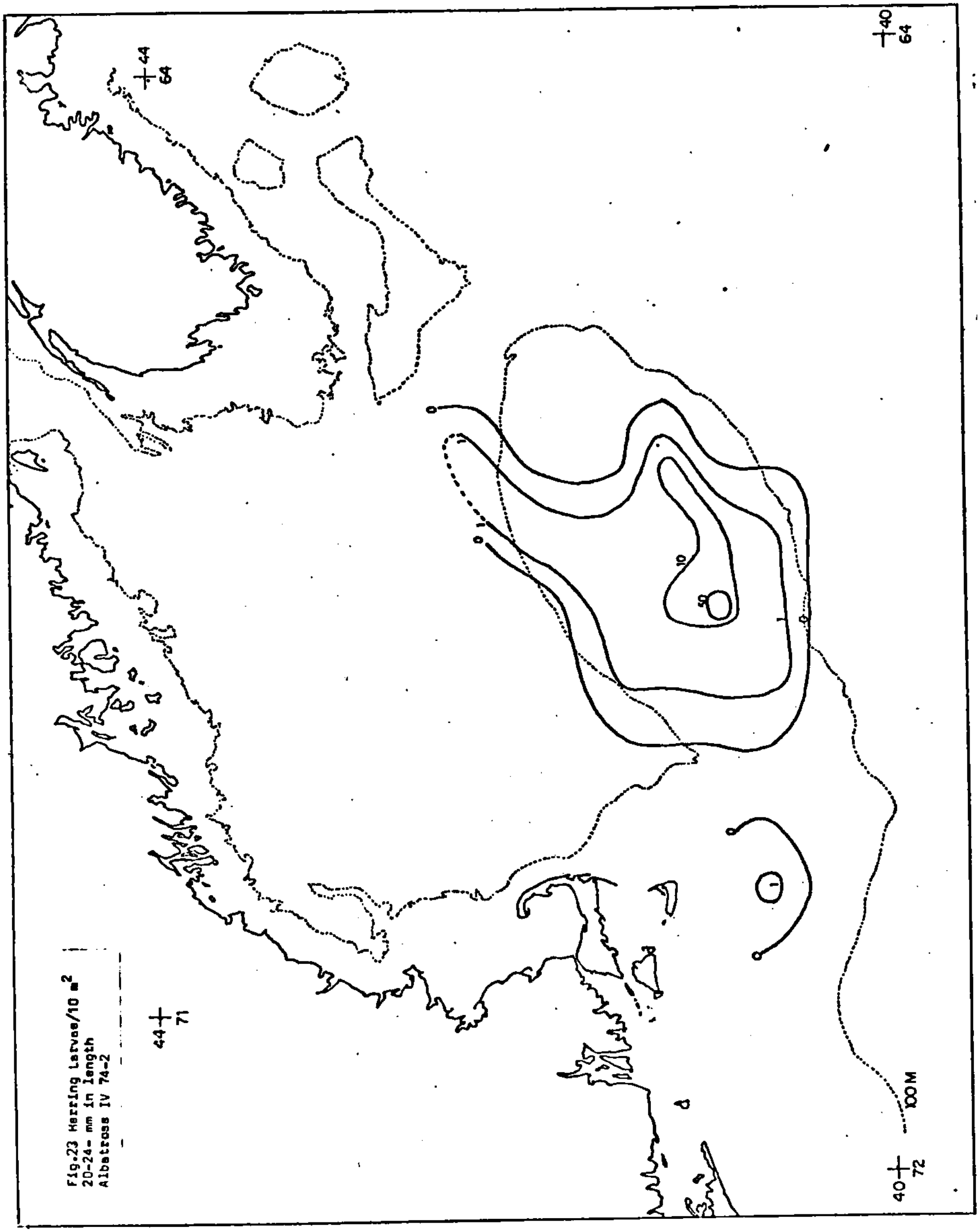


Fig.23 Herring Larvae/10 m^2
20-24- mm in length
Albatross IV 74-2

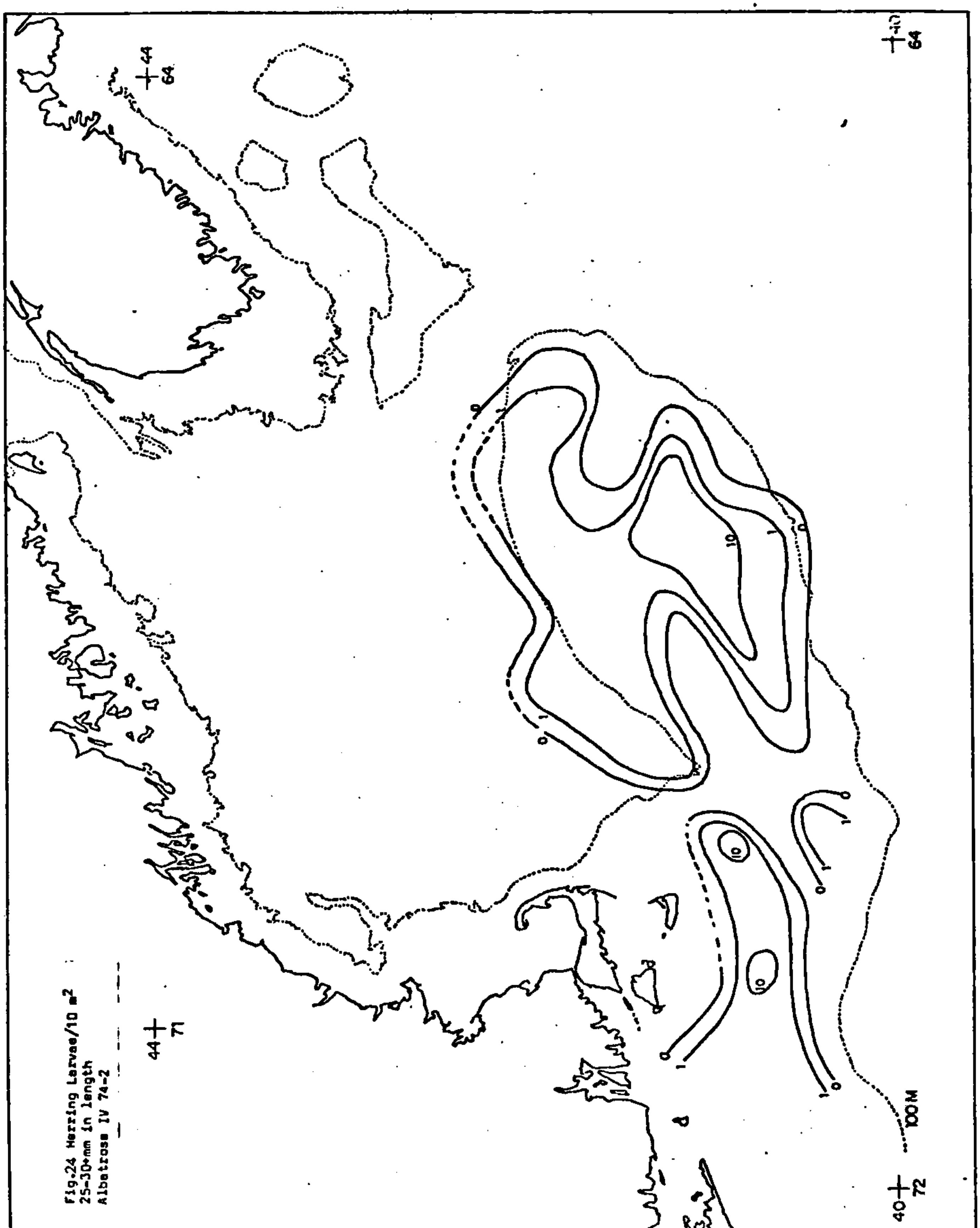
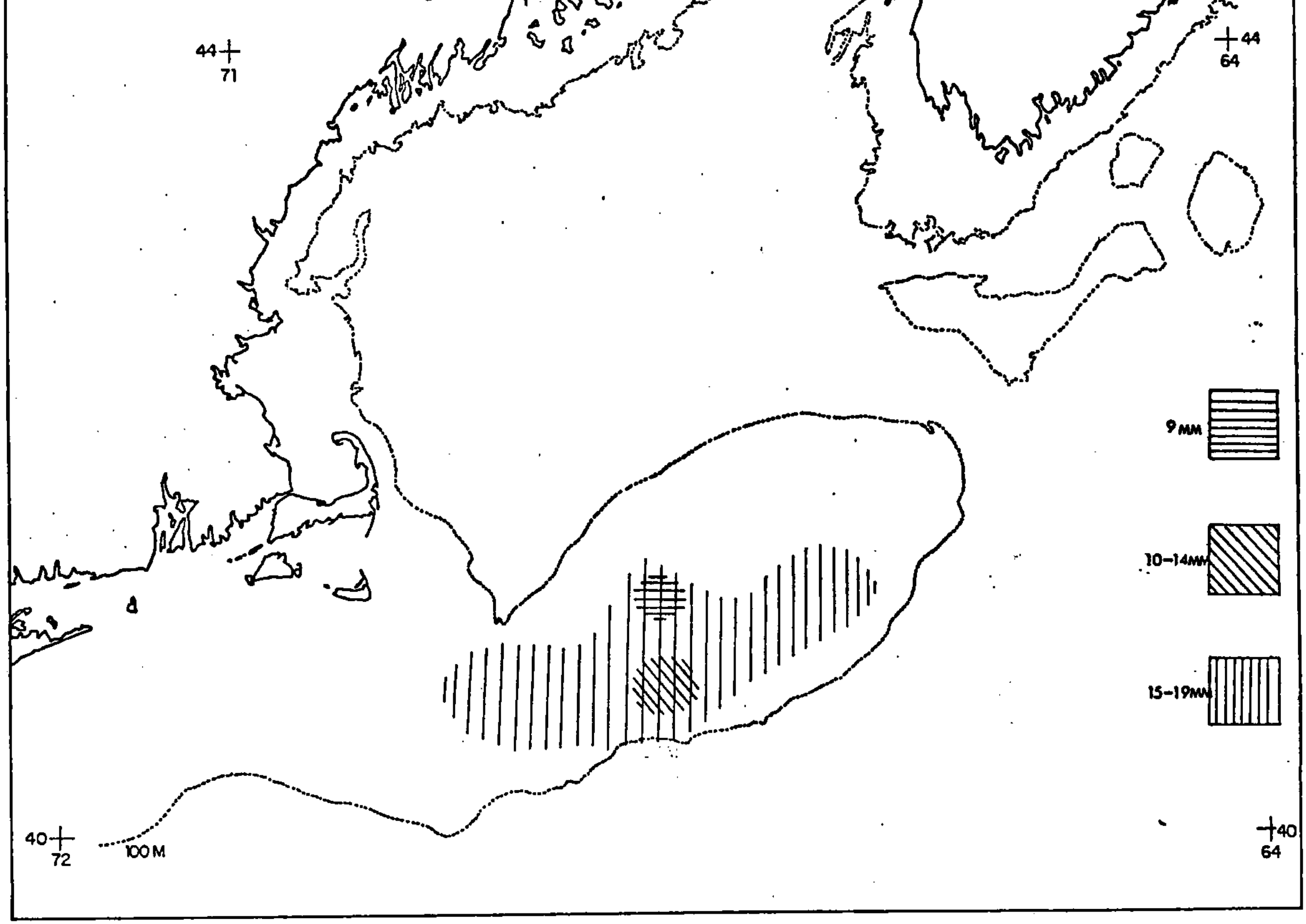


Fig.24 Herring Larvae/10 m^2
25-30+mm in length
Albatross IV 74-2

Fig.25.Larval Herring Distributions
For the size classes: less than 9mm in length
Albatross IV 74-2 10-14mm in length
15-19mm in length



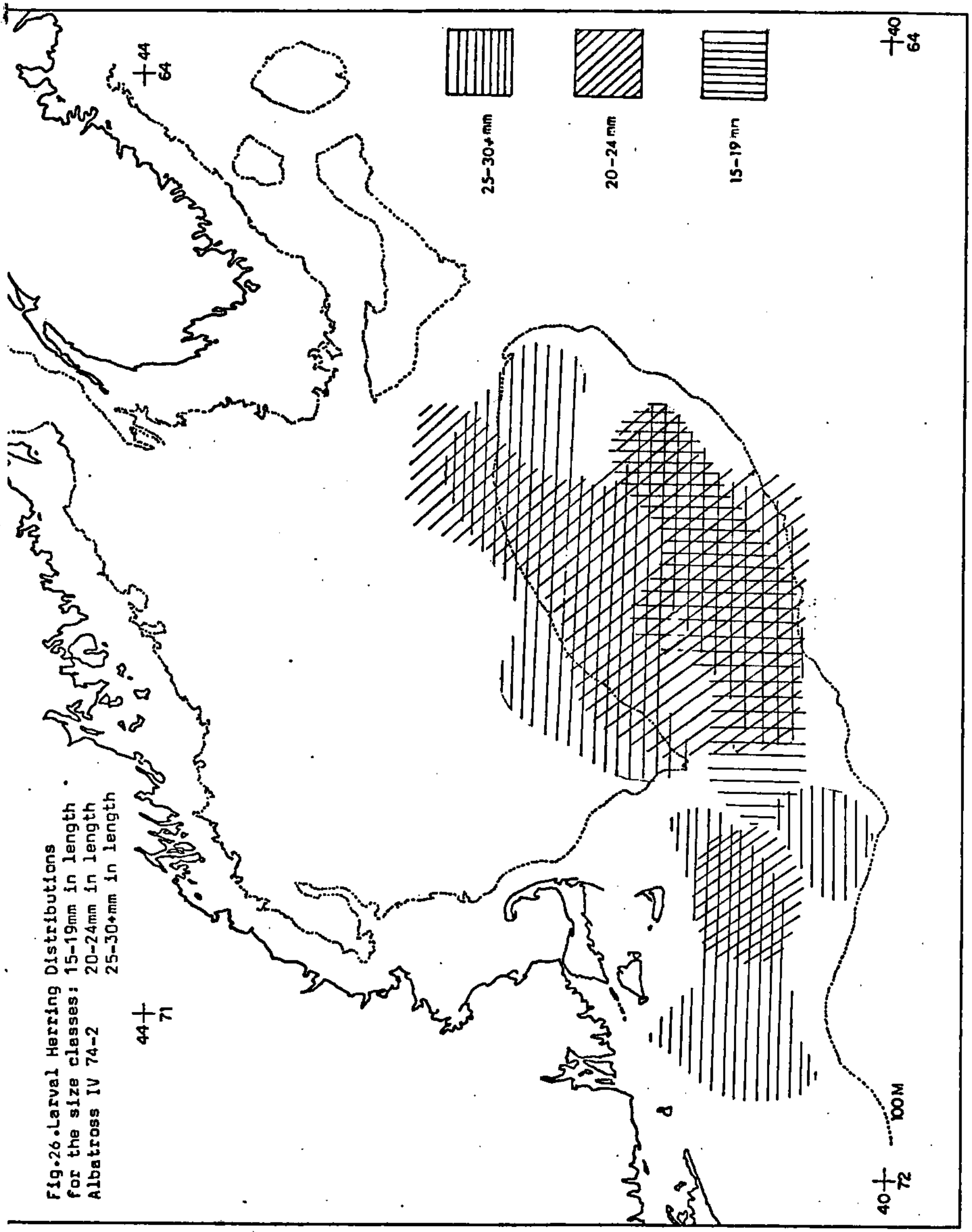


Fig.26.Larval Herring Distributions for the size classes: 15-19mm in length
20-24mm in length
25-30+mm in length
Albatross IV 74-2

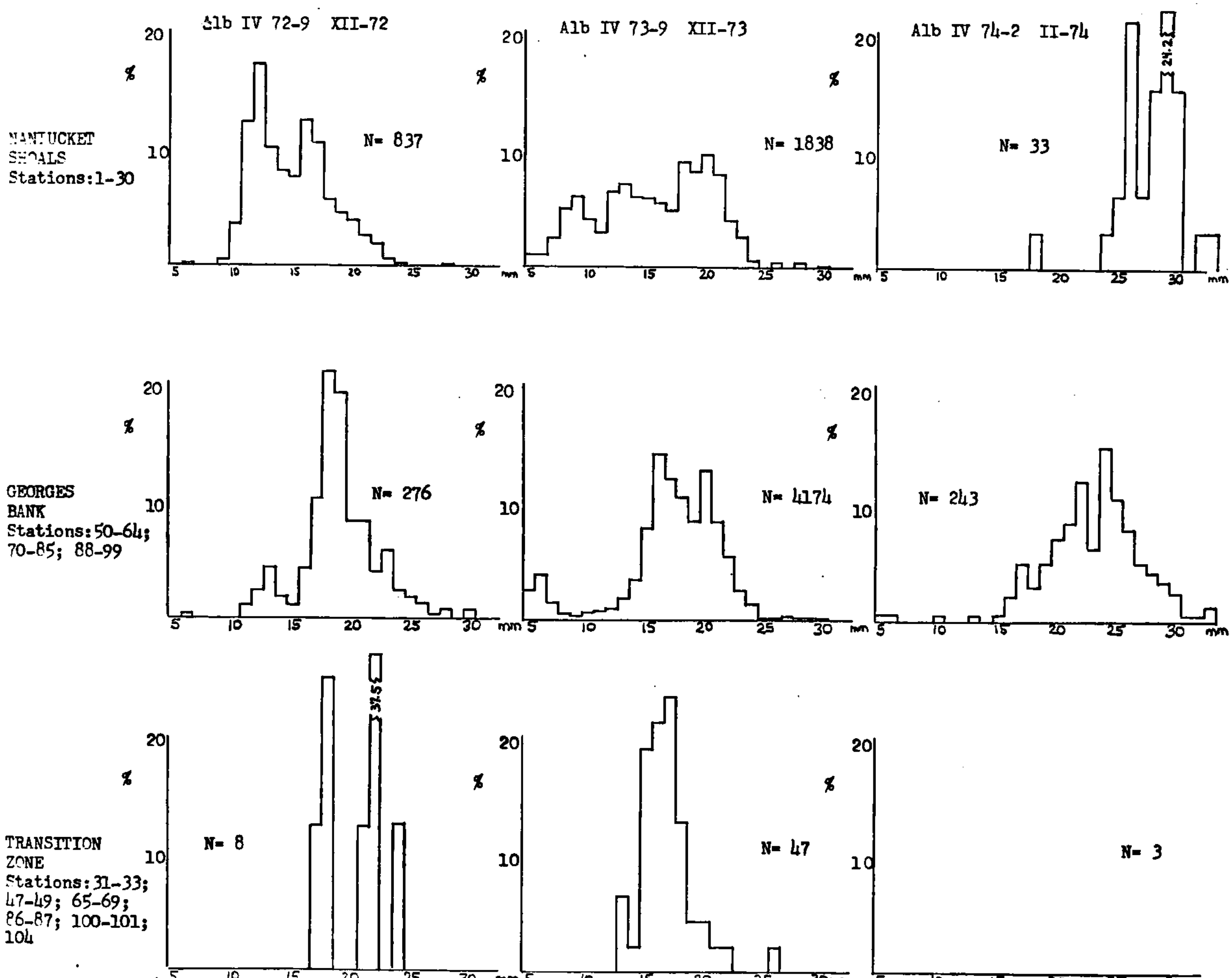


Fig. 27. % Length frequency of herring larvae by areas.