International Council for the
Exploration of the Sea

C.M. 1963
Plankton Committee
No. 131 /ρ

Primary Production in Icelandic Waters in May - June 1959

by

Thórunn Thórdardóttir

THÜNEN
Digitalization sponsored by Thünen-Institut

Introduction

Since 1958 measurements of primary production by means of the C^{14} technique have been carried out in Icelandic waters mostly in May - June during hydrobiological surveys. The observations in May - June 1959 were more complete than those of any other year as they included, besides zooplankton survey, hydrography and primary production measurements, data on inorganic phosphate and dissolved oxygen. Furthermore, the changes taking place could be assessed with more certainty as the investigations were repeated within short intervals. Therefore, the 1959 observations were chosen as basis for this paper here presented which is intended as a preliminary study of primary production in Icelandic waters.

Material and Method

A total of 131 stations were worked during two cruises from May 23rd - June 1st and June 6-24th (Fig. 1). The method used was the one introduced by Steemann Nielsen in 1952. In order to make the sampling as timesaving as possible samples were taken at standard depths 0, 10, 20 and 30 metres. All samples were illuminated at 8000-9000 lux. The results, which thus may be considered as potential values, are expressed in $mgC/m^3/hour$. At the same standard depths samples were taken for quantitative examination of the phytoplankton species.

By the courtesy of Dr. Unnsteinn Stefánsson and mag. scient. Ingvar Hallgrímsson hydrographical, chemical and zooplankton data were made available.

Hydrographic Conditions

In the offshore area west of Iceland, Atlantic water of uniform salinity (35.10 - 35.20 °/oo) was found in the surface layers during both cruises (Fig. 2). Only in the shallowest part of the coastal region the salinity dropped below 35.0 °/oo. As normally observed Atlantic water extended northwards along the west coast, forming a narrow tongue in the northernmost part of the region. East of Húnaflói another area with salinity above 35.0 °/oo was observed with an intervening region of lower salinity between Kögur and Húnaflói. Off the west coast, between Reykjanes and Látrabjarg, the temperature ranged between 7° and 8°, but 6°-7° off the northwestern peninsula. An area of low temperature (< 6°C) was found during the first survey between Kögur and Húnaflói corresponding to the low salinities, whereas the temperature was more than 6° over most part of the area farther east, where Atlantic influence was more pronounced. However, the observed temperature was somewhat lower in this region during the second survey, especially in the central part, indicating more admixture of arctic water. At the surface the hydrographic conditions showed the same main features as those at 20 meters, except for somewhat lower salinity. Off the northwest coast, between 66° and 67° N, sharp boundaries were observed between the Atlantic water and the polar water. Thus in the section off Látrabjarg, the temperature in the upper layers was about 7°, dropping to less than 0° near the ice border (Fig. 2). Farther to the northeast the temperature and the salinity gradients near the ice border were much less conspicuous. In the oceanic region in the northeasternmost part of the study area, arctic water of low temperature and salinity was found. This cold water was more developed than normally observed (Stefánsson 1961).

During both cruises the stability in the uppermost 100 meters was found to be quite small in the area west of Iceland except for the inshore stations, especially off Reykjanes (Fig. 3) where a very pronounced stratification was observed a few miles off the coast in late May. It is of interest to note that the surface layers were even less stable in June than they were in May because of slightly lower temperatures, except at the first stations of the Reykjanes section. This feature was especially pronounced in the Snæfellsnes section.

Off the northwest and north coasts the stability was in both surveys much greater than off the west coast (Fig. 4). This marked difference is a pronounced feature in the hydrography of these waters and has been found in other years as well. Normally the stability increases significantly from west to east off the north coast, but in late May 1959 the surface layers off Kögur were even more stratified than farther east in the area. Comparing the stability structure during the two cruises off the north coast, a distinct difference was found, viz. that during the first cruise the main stratification was below 25 meters, but in the uppermost 20 meters during the second survey.

The Main Features in the Distribution of Productivity Values

The results of the primary production measurements at the four standard depths mentioned, viz. 0, 10, 20 and 30 meters, are illustrated in Figs. 5-6. It is seen that considerable changes had taken place at the various localities during the period of 2-3 weeks which passed between the two sets of observations. These changes are most pronounced in the Atlantic water west of Iceland. As previously remarked small variations in temperature and salinity were found in the Atlantic water west of Iceland. In spite of this uniformity the picture of productivity values revealed four distinct areas, which seemed to have a phytoplankton development of their own. There was a shift from high to low values and vice versa in each area from one observation to another. At the end of May low values were found next to land, then an area with very high values extended over most part of the shelf region from Reykjanes to Látrabjarg. In the whole region outside, the productivity values were low except in the southwest corner where they were significantly higher. In early June a considerable production was found next to land, whereas that part of the shelf area which during the previous survey was highly productive, now showed low values. Farther to the west, in waters where low production was measured before, vigorous production was observed in June. The zone of maximum production extended northwards along the edge of the shelf. In the southwestern-most part of the study area where considerable production was found before, low values were now found.

In the border area between Polar and Atlantic water off the northwest coast the productivity values were low in late May, although isolated areas of moderate production were found.

Contrary to the almost reverse picture of productivity values which were found in June compared to those in late May west of Iceland, the changes between cruises off the north coast were not conspicuous. In general the western part of this area was more productive than the eastern part during both surveys, especially the coastal area near Kögur and along the western side of Húnaflói. In the central part the values found in both cruises were somewhat higher at the inshore stations than farther offshore. In the tongue of Arctic water farthest to the northeast, however, a considerable production was found in June, especially at 20-30 meters depth.

The Productivity Values in Relation to Environmental Factors

a. The Atlantic water west of Iceland

The area nearest to land off the west coast is represented by two stations close to the peninsulas Reykjanes and Snæfellsnes. The production was low at both stations at the end of May. Phosphate and oxygen (Fig. 7) were available from the station off Reykjanes. The low phosphate values (0.4 µg-at/L at 10 m) and relatively low oxygen saturation (108% in 10 m) for this phosphate uptake indicate that production had taken place in these very stratified waters prior to our visit. It seems likely that the same stage of growth development was met with at the shallow station off Snæfellsnes where the depth was only 40 m. Only 10-14 days later when these localities were visited again, the production had increased considerably. Both stations were situated at localities where there are strong tidal currents, and the hydrographic feature at such localities may offer quite other conditions for the growth of phytoplankton than within the bays, from which we have no data at this time. Besides ample possibilities for renewal of the surface layers the phenomenon of sequence might be more frequent.

As mentioned before very high production was measured during the last days of May over the outer part of the shelf area from Reykjanes to Látrabjarg. On the shoreside of the production maximum very high oxygen saturation and low phosphate values were observed (O_2 = 127%, P = 0,37 µg-at/L at 10 m) at the second

station of the Snæfellsnes section and (O_2 = 114.7, P = 0.37 µg-at/L at 20 m) at the second station off Reykjanes. This might indicate that the production had already culminated there at the time of the observation and it might also indicate that the spring maximum does not necessarily occur at the same time over this shelf area, but rather that it starts successively from the coast to the region where the extremely close isolines are indicated i.e. between stations A 59/19 and A 59/20 in Snæfellsnes section and stations A 59/4 and A 59/5 in Reykjanes section (Fig.5). About 10-14 days later the main production was apparently over in this area, as the values were now quite low.

In the low-production area west of the production maximum observed in late May high phosphates (0.9 - 1.0 µg-at/L) and low oxygen saturation (96 - 100%) were found in the surface layers (Fig. 7). This shows that the spring maximum had not yet occurred in this wide area. At the same time considerable production was found over the deep water in southwesternmost part of the study area, where highest values were found at the last station in the Reykjanes section (8 mg C/m^3/hour). The very high phosphate values and relatively low oxygen saturation (Fig. 7) in this area indicate that at this time we encountered the very beginning of the phytoplankton production. When the measurements were repeated about the middle of June most of the oceanic area which in May was unproductive, was now highly productive, in spite of even lower degree of stability. The production reached maximum on the edge of the shelf in the Látrabjarg section where values as high as 36 mg C/m^3/hour were found at 0 and 10 m at St. B59/40. This productive water widens over the banks off the northwestern peninsula and its northern limits are in the Kögur area. In accordance with the increased production the phosphate values were reduced, although they were still rather high in the oceanic part of the area (about 0.6 µg-at/L at 10 m). The vertical distribution showed that the utilization had extended below 50 m (Fig. 7). In the very productive water of the shelf area the phosphate values were much lower in the near surface layers than in the oceanic region. The higher values of productivity found in the waters above the shelf in June might be attributed to more favourable growth conditions there. In the area farthest to the west, where the production had just started at the end of May, the values were very low in June. It seems as if the height of the growth had occurred during the period

between the surveys. However, the phosphate values were rather high (0.6-0.7 µg-at/L) and the vertical distribution down to 100 m was similar to what it was in the productive area, whereas values were lower. If the assumption is correct that the spring increase was over, then it seems likely that the production was kept at a low level for other reasons than lack of nutrients. In this connection it may be pointed out that higher concentrations of zooplankton (Fig. 12) were found in this region than elsewhere in June except isolated maximum close to Reykjanes. This suggests that grazing might have played an important part in limiting the standing stock of phytoplankton.

Comparing the vertical distribution of density in May with the production areas, we find higher degree of stability within the area near land where the most vigorous production was found. However, the marked differences within short distances that appeared on the productivity charts, do not correspond to similar differences in the stability distribution. As regards the area in the southwestern part of the study area it seems difficult from the stability alone as it appears in Fig. 3 to explain the earlier start in spring growth, as the vertical density gradients are very similar to those found in the unproductive area, except perhaps at the deepest station of the Reykjanes section.

However, it is of interest to note that during the second survey the maximum production coincides with the water of greatest density (Fig. 8). This density maximum over the slope appears to be a general feature (cf. Stefánsson 1962, p. 61).

b. The Border Area off the Northwest Coast

The phosphate values in the surface layers in the iceborder area at the end of May were rather high (Fig. 9). Yet some utilization of phosphates had taken place, especially in the waters where the stratification was most pronounced. Moderate production was found in very limited areas. The low productivity values generally found along the iceborder together with low oxygen saturation indicate a low growth rate in these waters. This was unexpected since the surface layers were very stable at some of the stations (Fig. 9). In view of the rather high zooplankton concentrations found here, it might be possible that grazing had kept the production at a low level

in this area. The low values might also be due to lack of supply of initial population which can thrive in this narrow boundary area.

c. The Northern Area

In the coastal region north of Kögur considerable production was found in late May. In agreement with this the phosphates were reduced to rather low values (Fig. 10). In June the productive tongue from the western area reached the Kögur section, the maximum values were found within 10-40 miles off the coast. In the near surface layers of the main production area the phosphates were reduced to very low values and extremely high oxygen saturations were found.

In spite of rather stable water masses and apparently sufficient nutrient supply (P = 0.7 - 0.8 µg-at/L at 10 m) in the central part off the north coast, very low productivity values were found in May. However, the utilization of the phosphates in surface layers showed that production had been going on.

As compared to the observations in late May the phosphate reduction in June was relatively small in the surface layers of the offshore area, but the decrease in phosphates was considerable between 30 and 100 meters depth in spite of the pronounced stratification in the surface layers. The productivity values were still very low, yet there was an increase in oxygen saturation within the area. In the inshore area where a little increase in production was found the consumption of phosphates had gone farther than offshore. The very low productivity rate in most part of the central area where growth conditions seem to be favourable might be explained by the grazing of zooplankton as supported by the high concentrations of zooplankton during both surveys (Figs. 11-12). Other factors impeding the production might also be important.

Somewhat greater production and lower phosphates were found in the cold Arctic water farthest to the northeast. Here the greatest production was not found at the surface but at 20 and 30 meters. Plankton samples taken by means of high speed sampler showed significantly higher values at the surface than at 15 meters, which again might indicate grazing.

Concluding Remarks

The observations here described indicated a more active primary production in the area west of Iceland than off the north coast in May-June 1959. It should be pointed out that in the waters west of Iceland the investigations took place during the period when spring maximum occurred, and it was found that within a period of only two weeks the distribution of productivity values changed radically. It is demonstrated that in this area the production may be quite vigorous in spite of low stability. The suggestion was made that in certain regions here investigated the primary production may be kept at low levels because of zooplankton grazing, especially in the central area north of Iceland. This suggestion is supported by the distribution of zooplankton.

Literature: Steemann Nielsen, E., 1952. The Use of Radio-active Carbon for Measuring Organic Production in the Sea. Journ. du Conseil, 18 (2).

Stefánsson, U., 1961. Hydrographic Conditions in Icelandic Waters in May-June 1959. Ann. Biol. Vol. XVI (1959).

Stefánsson, U., 1962. North Icelandic Waters. Rit Fiskideildar Vol. III.

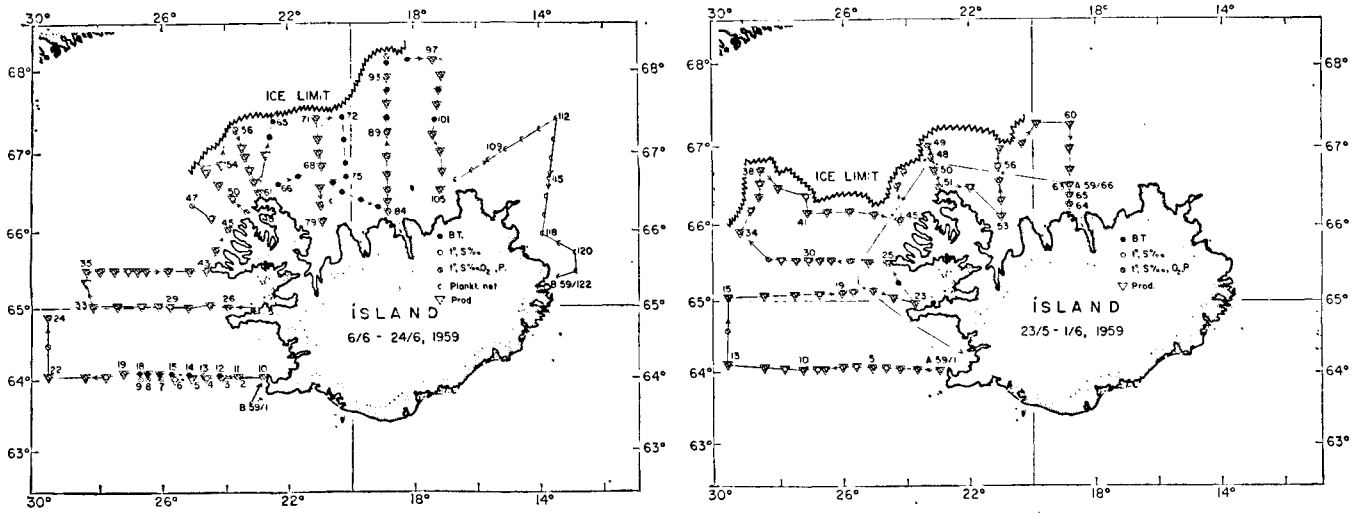

FIG. 1. Locations of stations, A59 stations, 23/5—1/6, B59 stations, 6/6—24/6 1959.

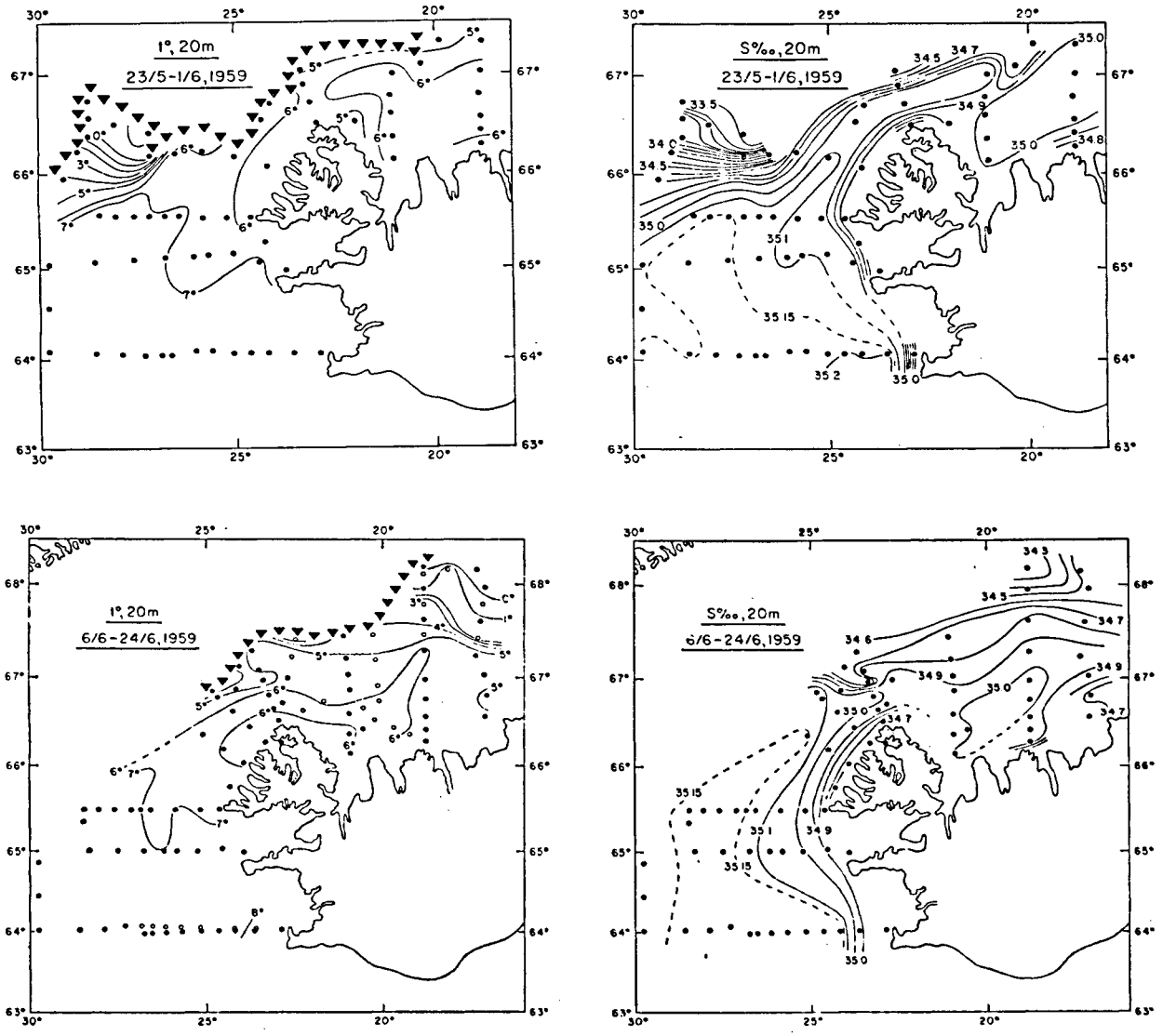

FIG. 2. Salinity and temperature distribution at 20 m, 23/5—1/6 and 6/6—24/6 (after Stefánsson, 1961).

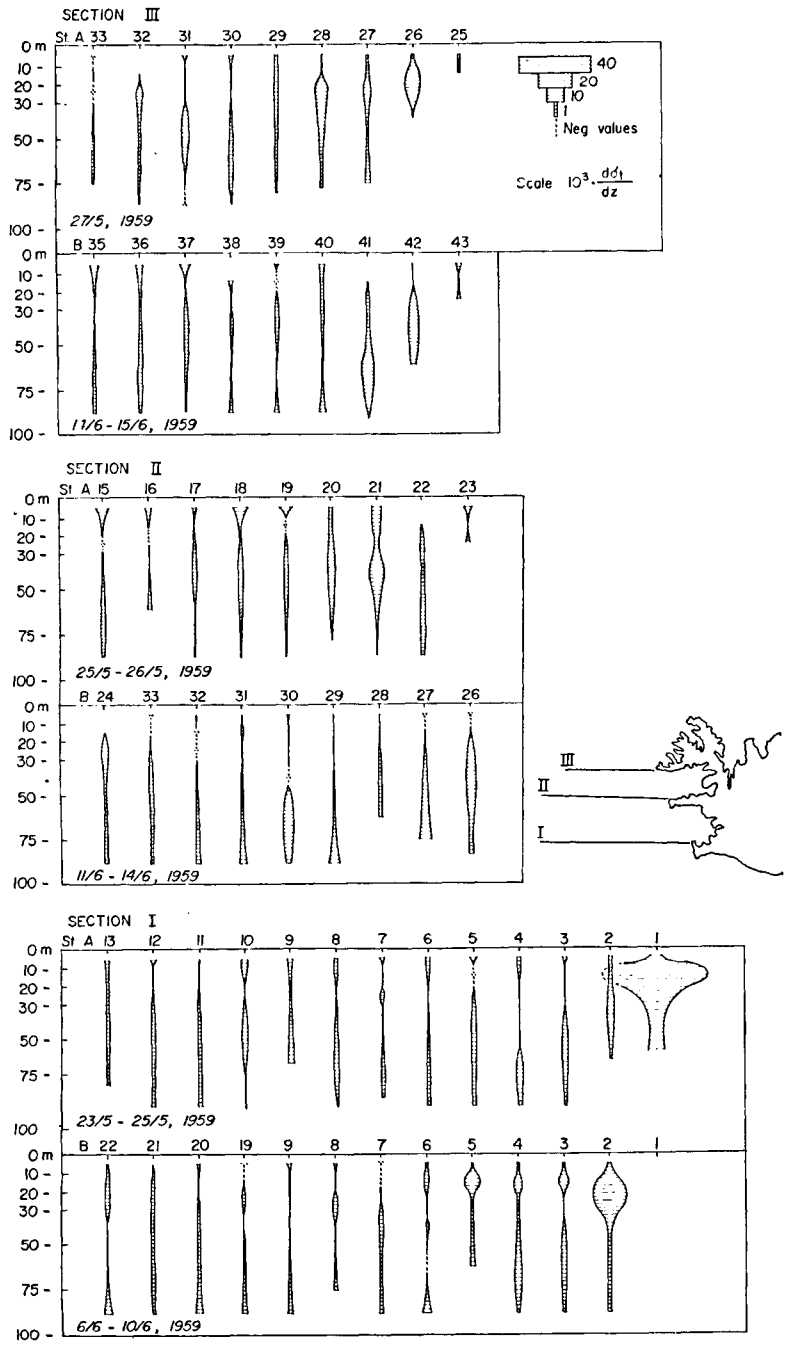

FIG. 3. Stability diagrams for 3 sections west of Iceland. A stations — first survey, B stations — second survey.

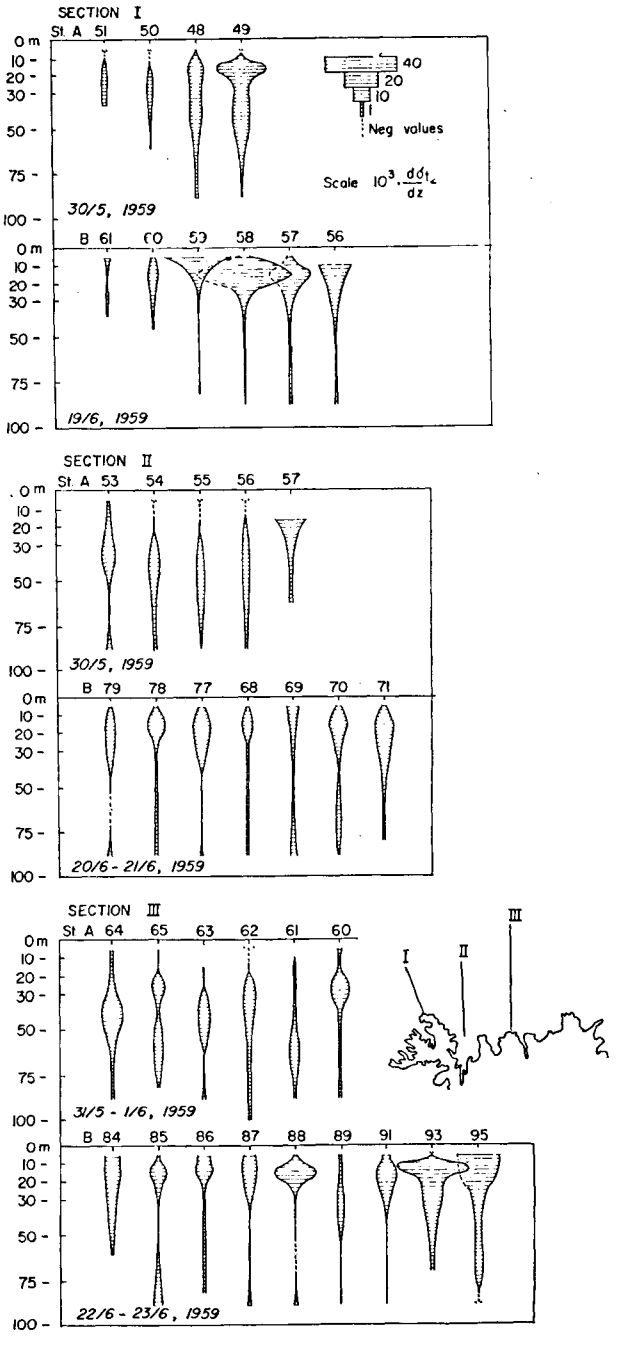

FIG. 4. Stability diagrams for 3 sections north of Iceland. A stations — first survey, B stations — second survey.

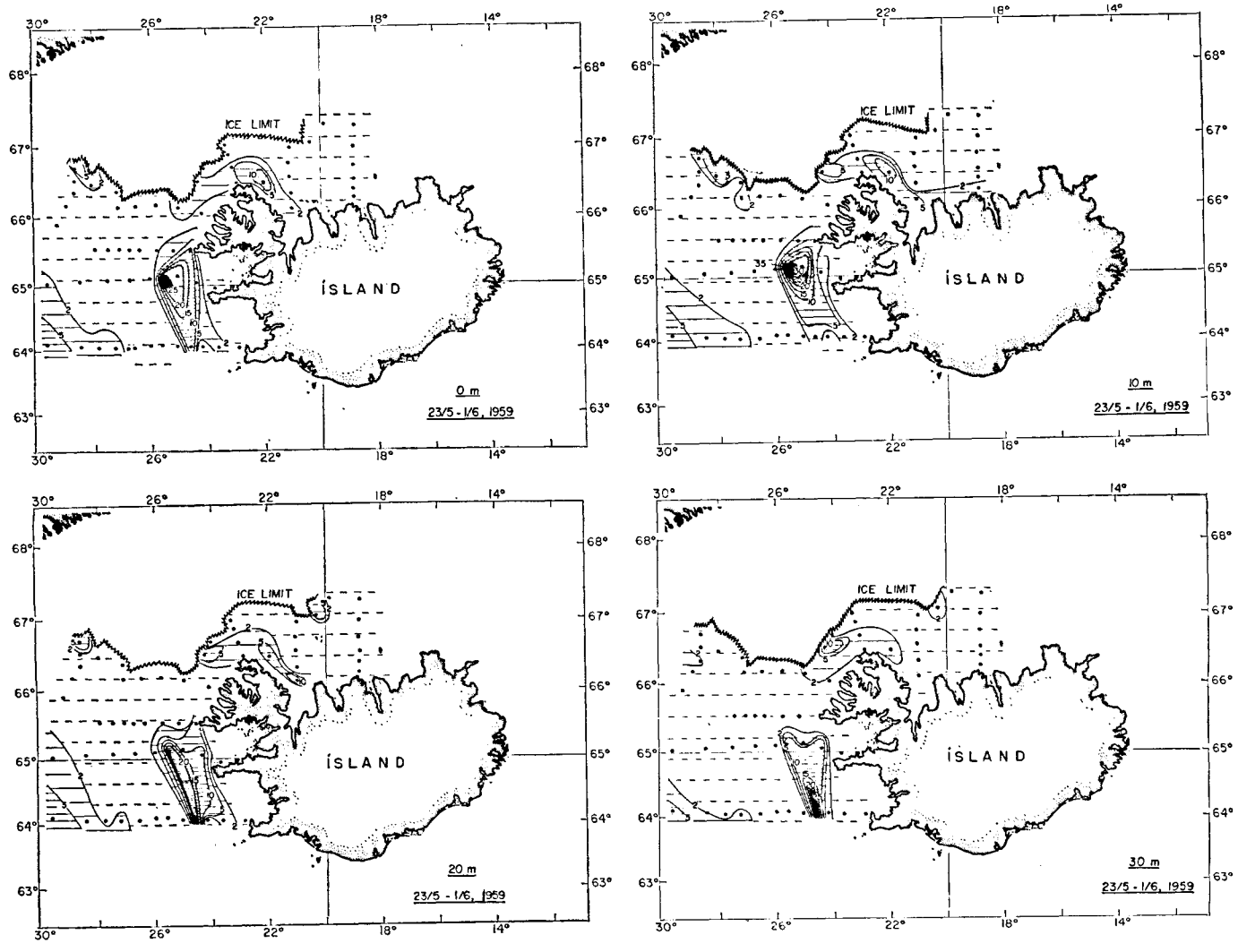

FIG. 5. Distribution of productivity values, mg C/m³/hour, at 0, 10, 20 and 30 m, 23/5—1/6.

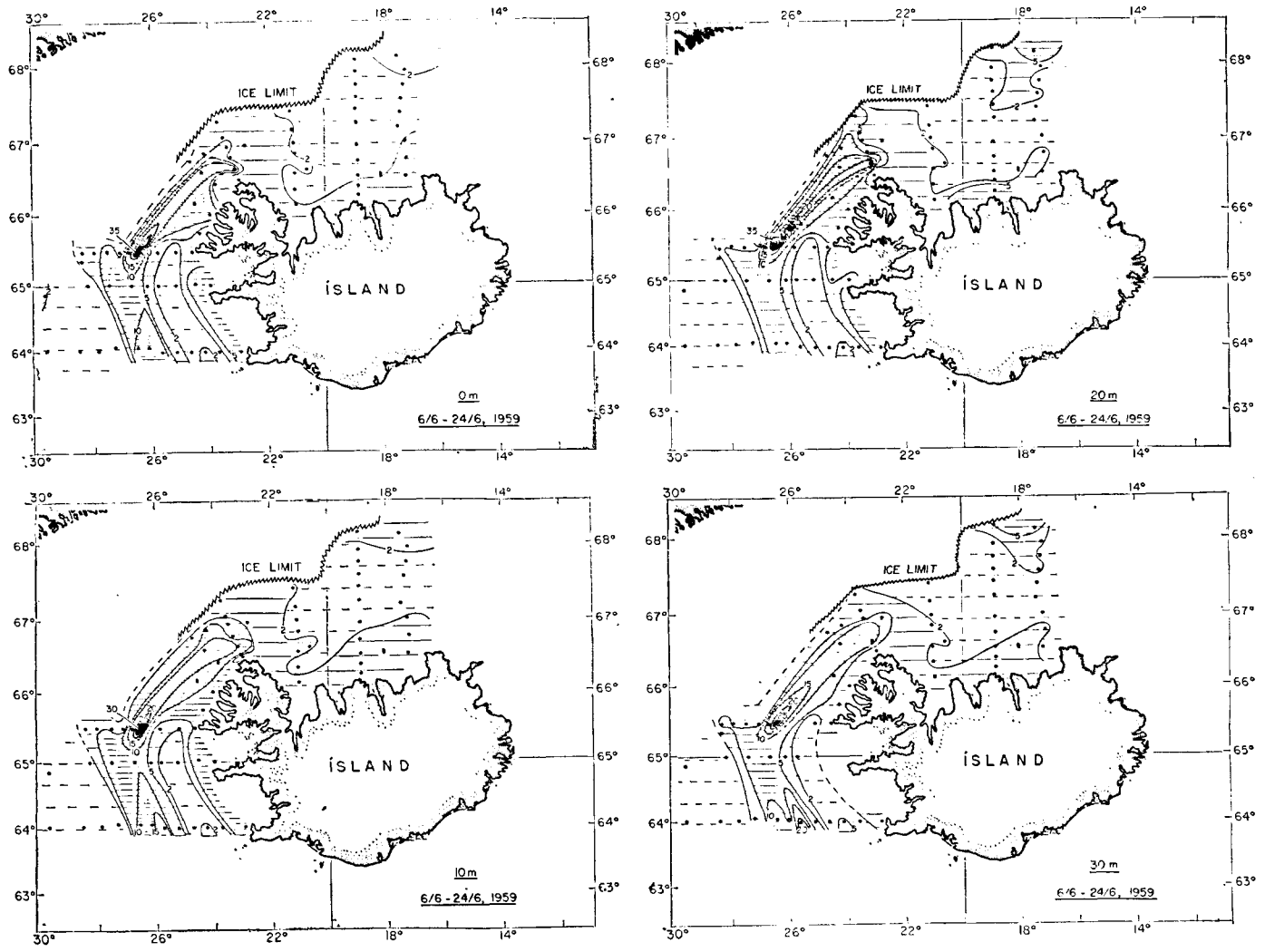

FIG. 6. Distribution of productivity values, mg C/m³/hour, at 0, 10, 20 and 30 m, 6/6—24/6.

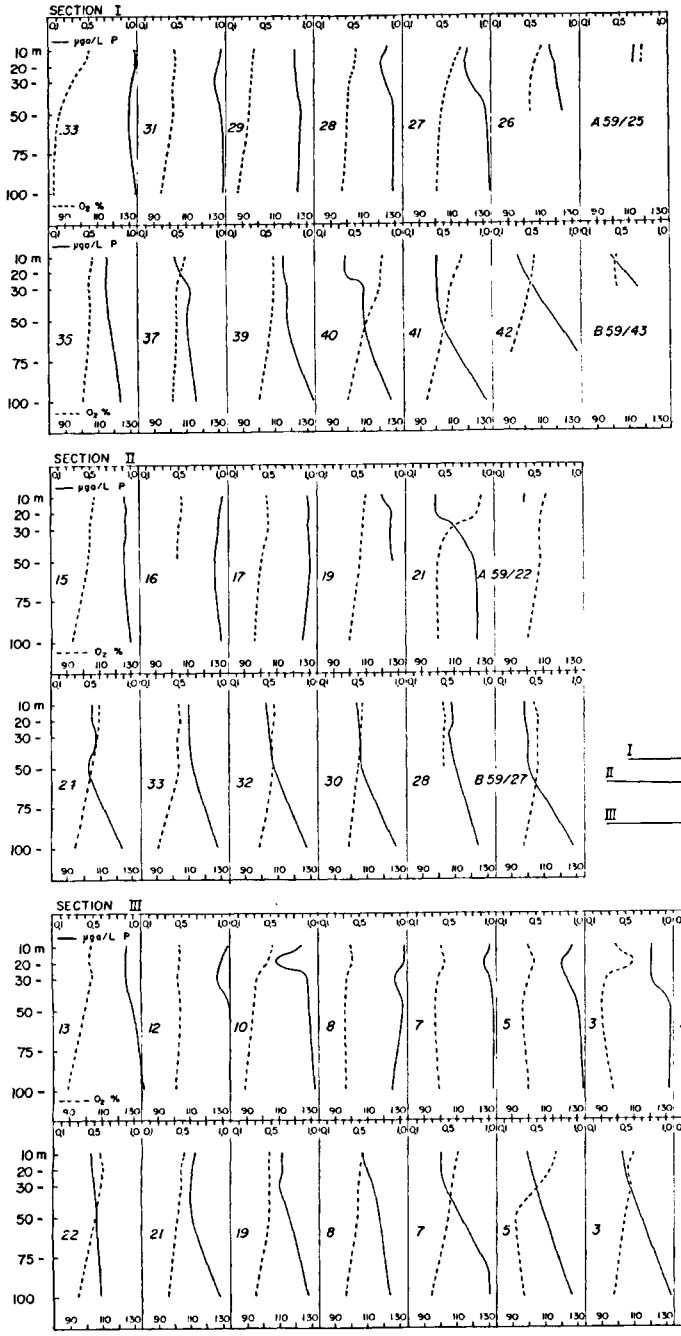

FIG. 7. Vertical distribution of oxygen saturation and phosphate (10—100 m) in 3 sections west of Iceland. A stations — first survey, B stations — second survey.

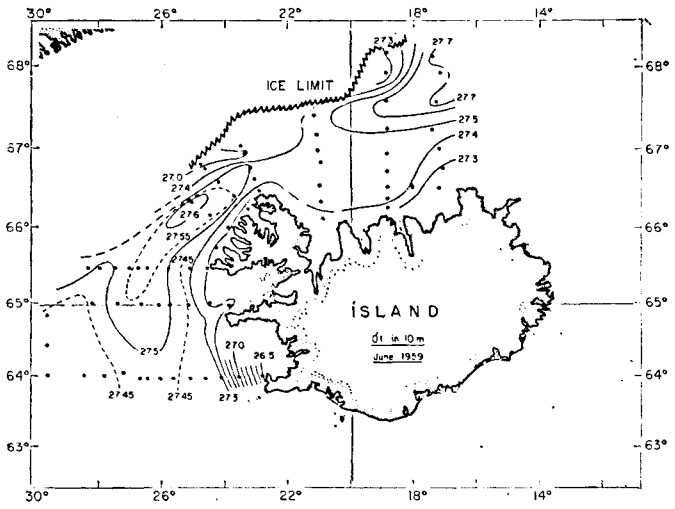

FIG. 8. Distribution of density at 10 m depth.

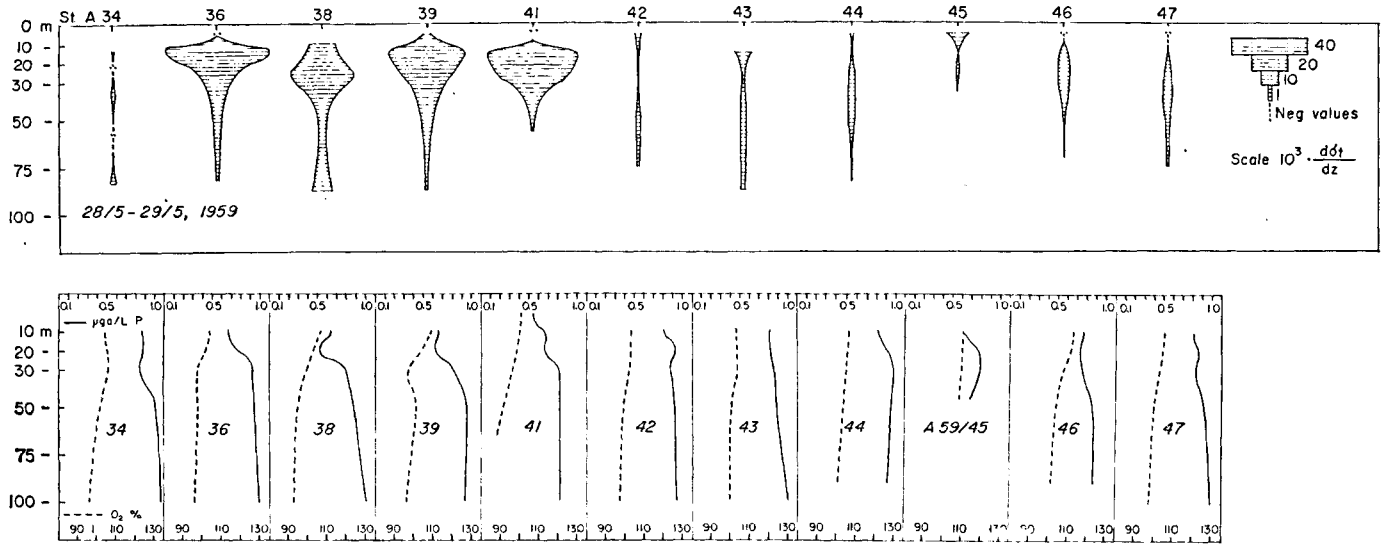

FIG. 9. Stability diagrams and vertical distribution of oxygen saturation and phosphate (10—100 m) at stations near the ice limit northwest of Iceland in the first cruise.

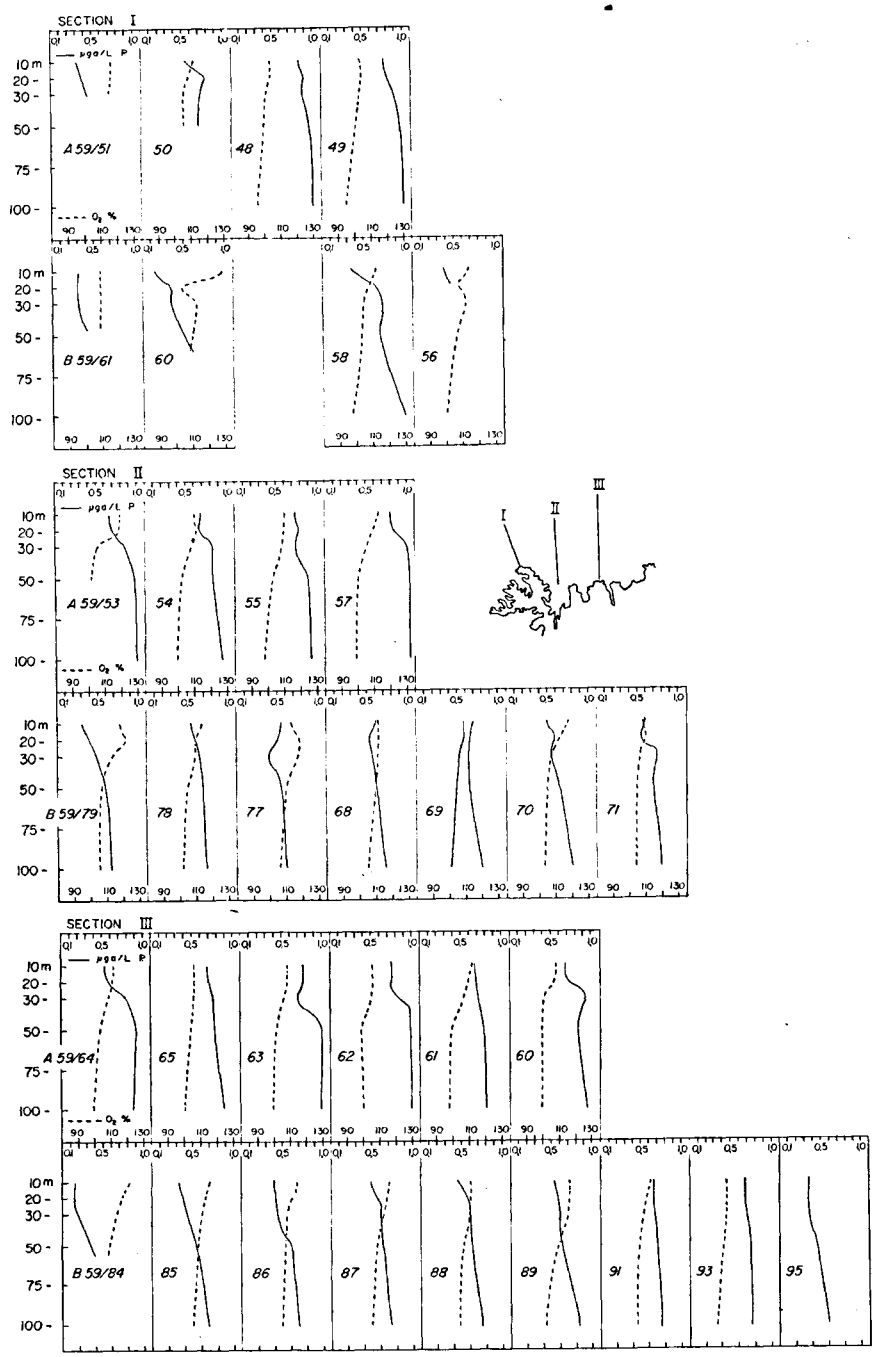

FIG. 10. Vertical distribution of oxygen saturation and phosphate (10—100 m) in 3 sections north of Iceland.

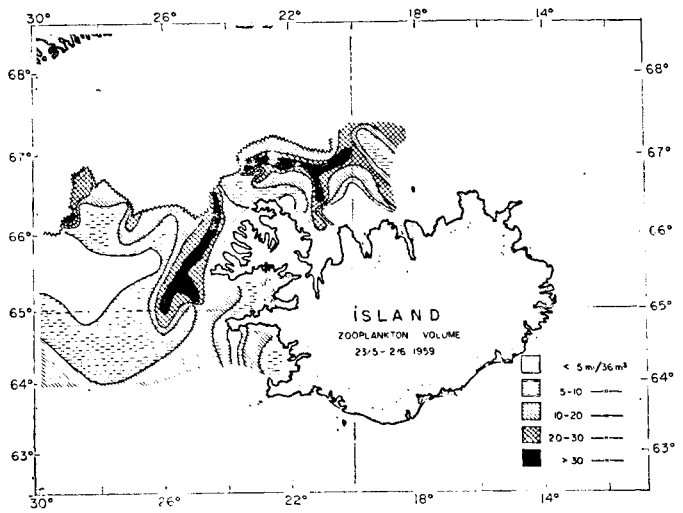

FIG. 11. Icelandic High Speed Sampler. Horizontal towing at 2 m depth.

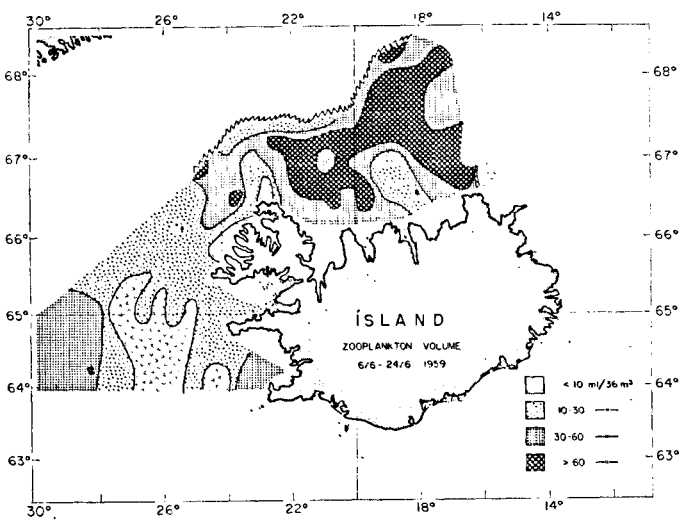

FIG. 12. Icelandic High Speed Sampler. Horizontal towing at 2 and 15 m depth. Mean value.