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Ecological Conditions of Silver Hake Concentration on the Scotian Shelf Area

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Abstract

Silver hake (*Merluccius bilinearis* (Mitchill)) distribution and density in the Scotian Shelf area was researched in relation to some environmental conditions, including near bottom water temperature, salinity, circulation, wet biomass of net zooplankton, density of small and large zooplankton. Complex observations were carried out by means of successive surveys in the investigation area at 61°W, covering shallow waters and the outer shelf edge. Hydrological observations at the stations were fulfilled with probe of STD type. To present the mesoscale circulation field, the diagnosis model of three-dimension circulation was used, based on the barogradient ratios, taking into consideration only its horizontal part. Water temperature, salinity, density and atmospheric pressure were taken as initial data to the model. Zooplankton sampling was carried out with the egg-net of 80 cm opening diameter, or with the large BONGO plankton sampler, fixed on the upper rope of the trawl. Research hauls were carried out by the bottom trawl "Silver Hake-4M", used by AtlantNIRO as a standard fishing gear in trawl surveys to assess demersal fishes abundance. The towing period was 30 min at each station. The fields of the above characteristics distribution obtained in six surveys of the investigation area, were compared to each other, to catch-per-effort value and silver hake distribution. The factors which had the major impact on the silver hake distribution were revealed. The results of this research are useful to conduct future inventory trawl surveys and to monitor the conditions affecting the silver hake distribution.

Key words: Distribution, environment, silver hake, zooplankton, Scotian Shelf

Introduction

The work presented is the final part of the research program carried out during 1988 and 1990, within the framework of a Soviet-Canadian agreement on fishery in the Scotian Shelf area. The program was aimed at considering the impact of environmental conditions on the silver hake (*Merluccius bilinearis*) distribution in their breeding and prespawning periods. Materials were collected in two cruises of Soviet research vessels; a middle-tonnage trawler "*Strelnya*" (June–August, 1988) and a large-tonnage trawler "*Evrika*" (May–July 1990), based on previous ecological surveys of the Scotian Shelf and multiple surveys of small shelf areas. The entire silver hake distribution pattern in relation to the ecological conditions (near-bottom temperature field, salinity, oxygen, phosphates content, geostrophic circulation and forage zooplankton) was presented to the Scientific Council of NAFO according to the results of surveys in 1988 (Sigaev, MS 1990), and with the results of surveys and statistically treated data on catches and environmental conditions, according to the shelf slope surveys in 1990 (Sigaev, MS 1994). In this report only observations in the investigation area in 1990 are considered. This was dictated by the fact that observations in the investigation area carried out in 1988 were incomplete. In the 1988 survey, 3 attempts were made "to fix" in on the prespawning silver hake aggregations, however, due to various reasons including those of a technical nature, the surveys in each area could not be repeated more than 3 times.

Unlike the surveys in 1988, in 1990 only one shelf area was selected. In 1990, six surveys were carried out, including measurements of water temperature, salinity, phosphates, sampling of forage zooplankton and exploration catches of silver hake at each station. As compared to the survey in 1988, the oxygen content measurements were excluded from the observations, as that factor was not a limiting one in the silver hake ecology. The other observations in the investigation area were similar in 1990 and 1988. The major purpose of successive surveys in the investigation area was to monitor the variability of environmental conditions and to reveal the factors affecting the silver hake distribution and density.

Materials and Methods

The results of observations at 12 stations, repeated 6 times during 26 June–12 July 1990, in the shelf area between 60°30' and 62°30'W were used. At each station, half-hour hauls were carried out with the trawl, adopted in AtlantNIRO to fulfil inventory trawling surveys of demersal fishes from large vessels and to fish silver hake. It therefore permitted a comparison of the survey catches with the commercial catches. Hydrological observations and water sampling were carried out with a STD type hydrological probe. Zooplankton was sampled with a large Bongo Plankton Sampler or taped net of 80 cm in diameter, attached to the upper rope of a trawl and equipped with flowmeters. Unlike the surveys in 1988, when zooplankton was sampled by the step-oblique towing of entire water layer, sampling in 1990 was done directly in the layer at which towing was conducted and simultaneously with a towing. Wet biomass of zooplankton in each sample was weighed aboard the vessel, while the dominant species density and species composition of zooplankton were determined in the AtlantNIRO laboratory. The complex data obtained on the environmental conditions and silver hake catches were used to create and analyze the distribution fields of hydrological features, zooplankton and silver hake catches.

To describe the water flow fields in more detail as compared to the geostrophic circulation, a non-linear quasi-geostrophic model for three-dimensional circulation assessment (D-2) developed by Sarkisyan, was used (Sarkisyan, 1977, 1986; Stepanov and Sarkisyan, 1977). The latter was based on the known equations of hydrodynamics. General practical application of the model is shown in works by Tjuriakov and Kuznetsova in the Leningrad Hydrometeorlogical Institute (LGMI), Sedykh (AtlantNIRO) etc. (Tjuriakov and Kuznetsova, 1972, 1976; Kuznetsova and Tjuriakov, 1978, 1982; Tjuriakov *et al*., 1978; Sedykh, 1975). The assessment of three-dimensional circulation by the model for our investigation area was carried out also in LGMI. The results were presented in a paper by Kuznetsova *et al*. (1993). Water temperature and salinity fields at stations of the investigation area for standard levels, interpolated from the station points to the knots of the uniform grid of the fields estimated, were used as the initial data to determine water flows. The atmospheric pressure fields observed at stations were also interpolated to the knots of the grid, and were used together with the data on the bottom relief. It should be mentioned, that the model allows to estimate the horizontal movement velocity and direction at selected levels, three components of the vertical movement (drift, gradient and barocline) and the total vertical velocity. In our research the horizontal circulation fields are of most interest, since we study the distribution of the near-bottom species. In this case it was desirable to obtain the near-bottom circulation fields of the investigation area. The model was found to provide the calculation of water flow velocity and direction at standard levels for the investigation area grid knots. In consideration of the shelf bottom slope, the following approach was used to determine the near-bottom water flow field. For each estimated field at the standard level velocity, values were selected only from the points located nearest to the bottom, starting from the field at the 30 m level, followed by 50 m, 75 m, 100 m and 150 m levels. Fields of vectors and horizontal flow modules for each of 6 surveys, created in above way, was considered as near-bottom structures of the horizontal circulation. Further, an attempt was made to reveal the circulation heterogeneity in the form of mesoscale gyres by vectors. For this purpose continuous lines were drawn medial to the estimated points towards the vectors within each field.

Results and Discussions

Silver hake catches distribution. The distribution of silver hake catches in the investigation area during 26 June–12 July is shown in the Fig. 1. The survey-to-survey catch distribution shows that silver hake was actually absent in the depth range from 100 to 50 m, and its major concentration occurred on the slope at depths of 120–150 m and below. Besides, the most efficient hauls appeared at the stations of the extreme northern row. Catches at the stations of the northern slope row were, as a rule, one or two orders of magnitude lower than southern ones. Catch in the slope area varied from 0 to 1 770 kg per half hour, which was influenced by different environmental conditions. As to the shallow area (the area of major silver hake spawning), it should be noted, that at the early stage of work in these investigations, prespawning silver hake occurred only in insignificant amounts (14–18 kg per half an hour) as compared to the slope area. It shows the lack of spawning in that time. However, by the end of the period (9–12 July) large aggregations of spawning silver hake were observed in the area, and the catch amounted to 10 to 500 kg per half an hour. It was evident that the major spawning in the shallow area off Sable Island occurred in the first ten days of July. To follow the silver hake catch variations in the slope area, the catch values were averaged for each survey. Values obtained are presented in the Table 1. The table shows that the lowest average catch values on the slope were obtained during the second and fifth surveys, the highest during the third one, and intermediate values associated to the first, fourth and sixth surveys. Below we try to explain these variations assuming the environmental conditions impact on the latter.

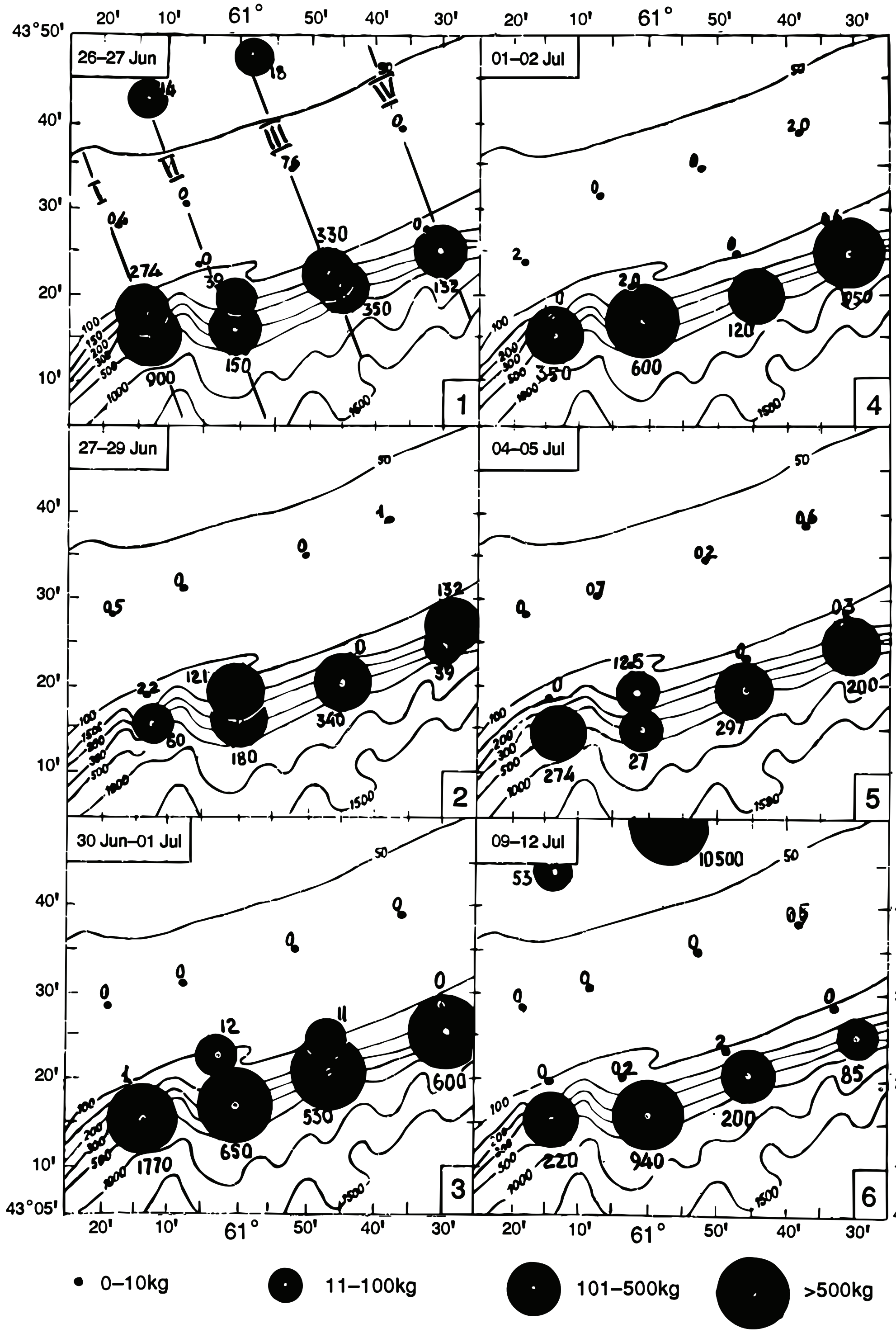

Fig. 1. Distribution of cathces (kg) in the investigation area during 26 June–12 July 1990.

Near-bottom temperature and catches. As is seen from Fig. 2, the near-bottom temperature fields varied from survey to survey, however, during the entire period silver hake were distributed within a temperature range of 7.5–10.5°C. This factor affects the silver hake occurrence on the slope at depths not less than 100–120 m, since the layer of 100–50 m is characterized by the Cold Intermediate Layer of water which is avoided by silver hake. The near-bottom layer temperature varied within 0.7–5.0°C

TABLE 1. Distribution of average silver hake catches, wet biomass of zooplankton and plankton species predominated in samples. (E = Euphausiidae; C = Calanoida; Th = Themisto)

Survey No.	1	2	3	4	5	6
Date	26–27 Jun	27–29 Jun	30 Jun–01 Jul	01–02 Jul	04–05 Jul	09–12 Jul
Average catch kg/0.5 hour	272	109	447	253	101	181
Average zooplankton biomass (g/catch)	170	233	221	136	164	660
Predominant plankton species	E/C	C	E	C/E	C	Th

in the investigation area and all exploratory hauls within this temperature range resulted in zero silver hake catches. As was noted before (Sigaev, MS 1990, MS 1994), the temperature gradient at the shelf-slope front is another important environmental feature for silver hake. This feature within the investigation area varied during the surveys. The lowest temperature gradient near the bottom was observed during the second and fifth surveys (Fig. 2.2 and 2.5). During the second survey the gradient lowered, apparently due to the cold water advection decrease over entire investigation area, while during the fifth survey the gradient reduced due to the warm water advection in the area between 60°50' and 61°15'W.

It was noted that during these second and fifth surveys, the average silver hake catch at the slope were the lowest values, while in other surveys the temperature gradient near the bottom remained high. In general during the observation period, starting from the third survey, the temperature field in the investigation area was characterized by temperature decreases at intermediate depths due to increased advection of cold waters. As is seen from Fig. 2, the near-bottom temperature minimum decreased as follows 2.7, 2.6, 2.2, 1.8, 1.6°C with simultaneous extension of cold water area. The above process provided retention of high gradients at the shelf-slope front. Thus, we may conclude that water temperature at the depths of silver hake distribution and temperature gradient should be considered as the major environmental factors controlling the silver hake distribution in the Scotian Shelf area. The above information also allows to recommend that inventory trawl surveys for adult silver hake avoid trawl stations on the shelf within the depth layers of 100–50 m, as the catches these were always around zero. Since areas of the above-mentioned depths constitute a considerable part of the shelf, the restriction will save time and expenses of inventory surveys.

Near-bottom salinity and catches. The distribution of salinity and silver hake catches was similar to that of temperature, i.e. all considerable catches were obtained within the maximum salinity gradient zone at the slope (Fig. 3). The decrease in the gradients was also observed during the second and fifth surveys. If the salinity fields are presented according to the three-layer structure of the shelf water masses, it may be stated that the silver hake aggregations associate with the warm slope water mass, characterized by salinity of 33.50–35.50‰ (Briantsev, 1964; 1967). As Fig. 3 shows, all significant catches were obtained within the above salinity range. Thus, the factor of salinity may become a reliable indication of breeding and prespawning aggregations on the shelf.

It should be noted, that in major spawning grounds of silver hake, salinity does not seem to be one of the major factors, since its values in the surface water mass of spawning grounds are considerably lower than on the slope (32.05–32.20‰). In this case temperature conditions remain to be the major factor, or in other words, sufficiently warm water in the spawning grounds provides optimal conditions for egg and larval development and survival. Besides, water circulation in the shallow area off the Sable Island, which is the quasi-stationary anticyclonic eddy (Sigaev, 1978), restricts eggs and larvae transport outside the shallow area at the early stage of development, and is likely to be an important factor.

Water circulation in the investigation area. Two circulation models were used to present water flow fields in the investigation area. The first model is truly geostrophic one, taking into consideration water density redistribution and the Coriolis force. The second model is based on hydrodynamic equations, taking into account a gradient, barotropic and drift components, bottom relief and boundary conditions. The results of the geostrophic circulation estimation are shown in the Fig. 4. In this figure, the water flow fields are rather uniform and reveal the general westward transport, and the lack of any significant heterogeneity within the restricted investigation area. Thus the reliable interpretation of catch distribution in the geostrophic circulation field is impossible.

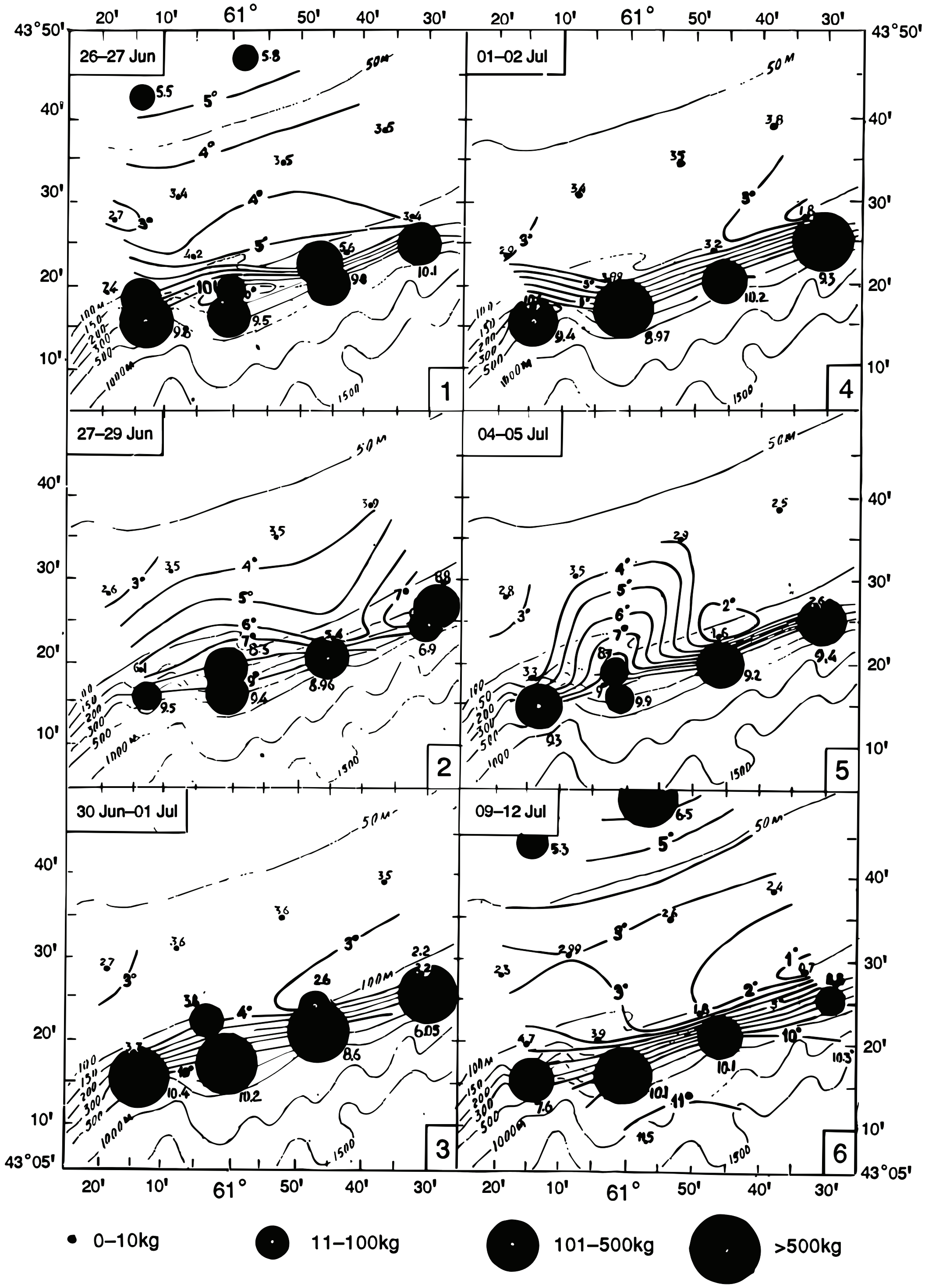

Fig. 2. Distribution of near-bottom temperature (°C) and silver hake catches in the investigation area during 26 June–12 July 1990.

The horizontal part of circulation, estimated with the hydrodynamic model for a near-bottom surface is shown in Fig. 5. In the speed of the water flow (knots) assessment grid, arrows show the direction and numbers indicate velocity in cm/sec. Dotted lines point the gyre contours. These fields fundamentally differ from the previous ones, as they have heterogeneities in the form of mesoscale eddies, comparable to the investigation area. Following the survey-to-survey water flow pattern, some peculiarities

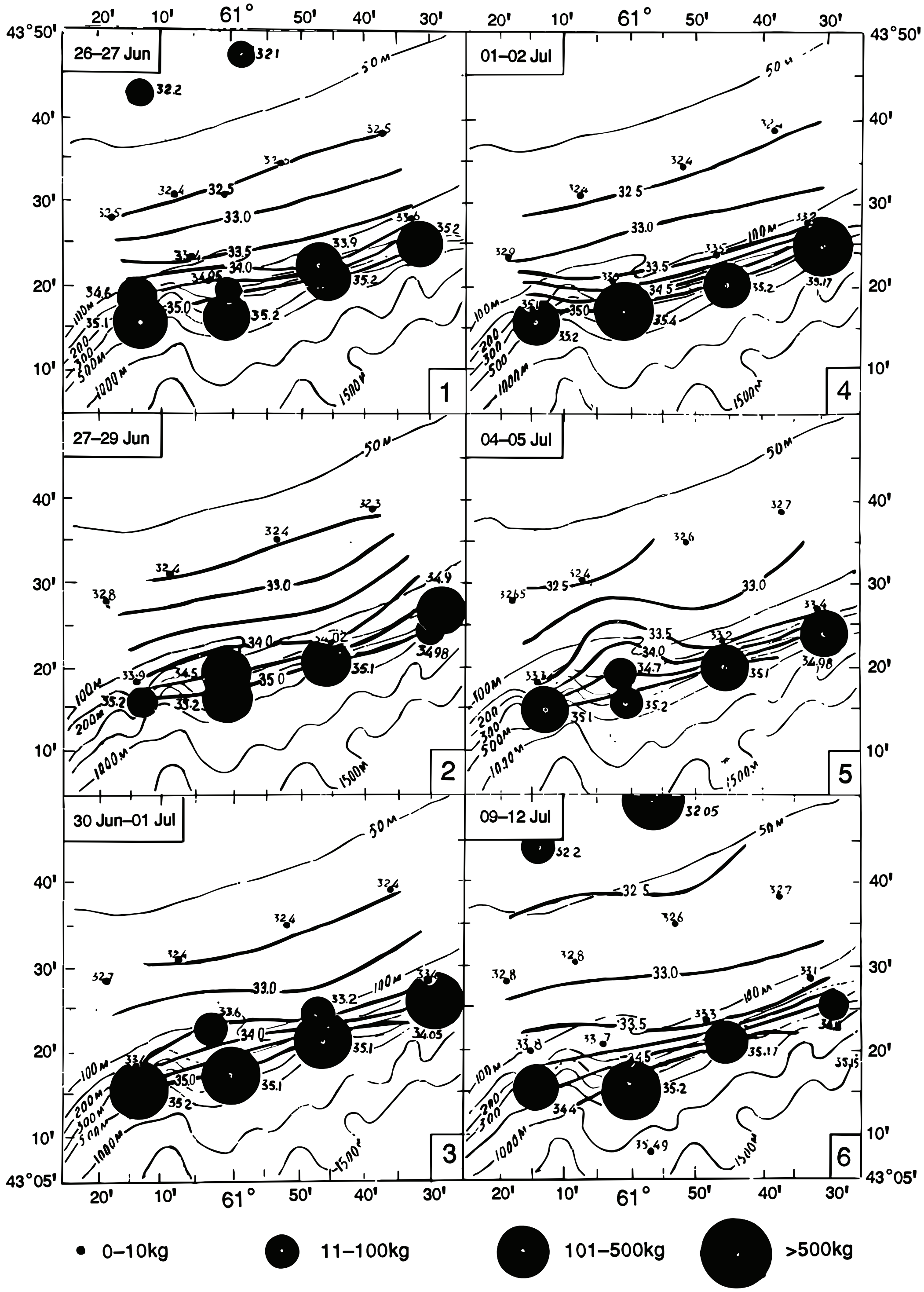

Fig. 3. Distribution of near-bottom salinity (°/₀₀) and silver hake catches in the investigation area during 26 June–12 July 1990.

may be outlined. The first survey shows the anticyclonic eddy formation in the center of the investigation area near the bottom, which develops and extends over the entire area during the second survey. During the third survey some smaller eddies of the opposite rotation are found. During the fourth survey, the entire area was occupied by one cyclonic eddy, and during the fifth survey two eddies

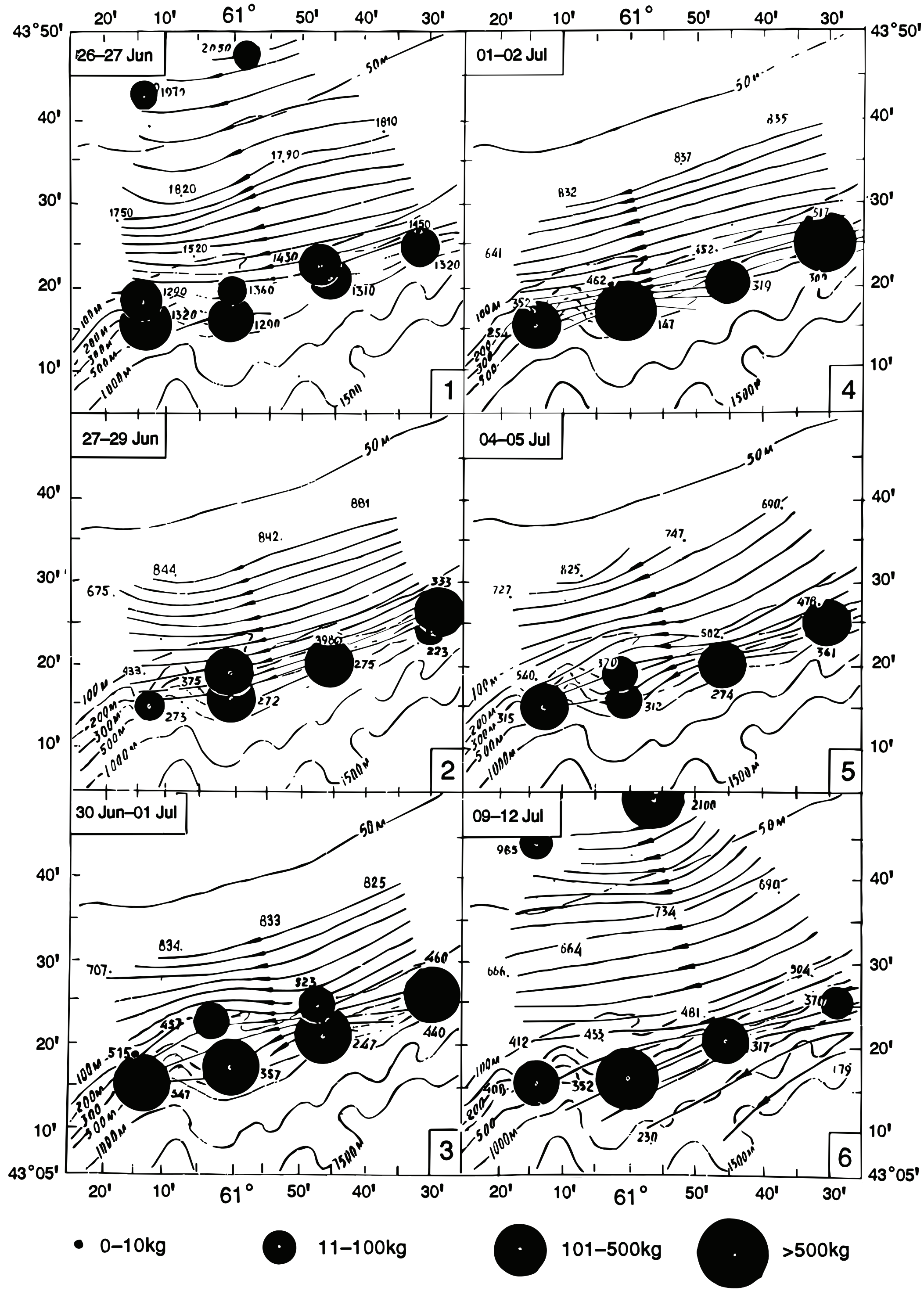

Fig. 4. Fields of geostrophic circulation and silver hake catches in the investigation area during 26 June–12 July 1990.

of opposite rotation were observed. Finally, during the last survey, one anticyclonic eddy was formed over the investigation area near the bottom. The estimated near-bottom flow velocities seem comparable to the actual ones of the shelf. A more detailed consideration of variations in the near-bottom flow patterns suggest that the replacement of eddies is directed westwards in accordance to the geostrophic transport.

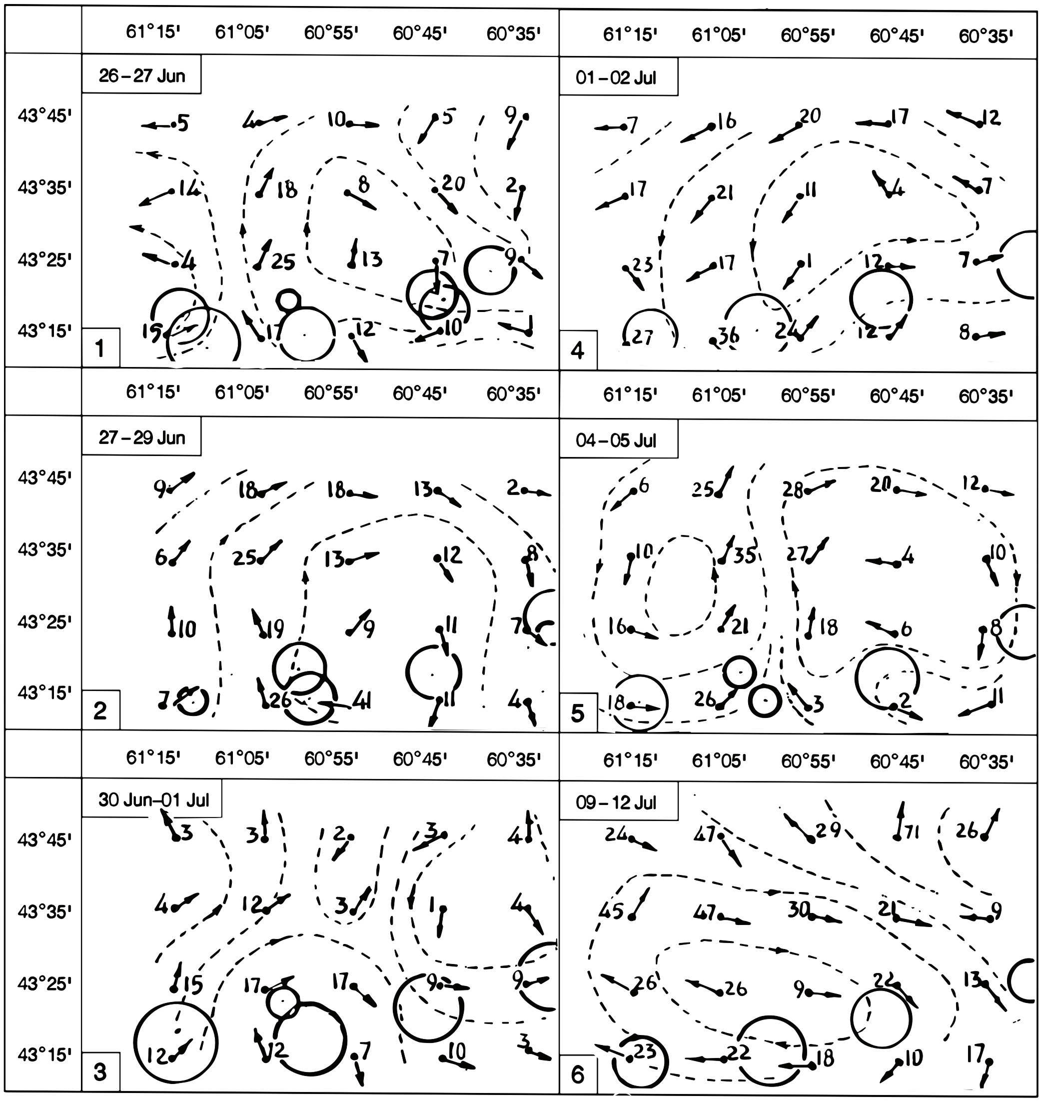

Fig. 5. Fields of near-bottom horizontal circulation, estimated by the Sarkisyan's model D-2, and distribution of silver hake catches.

Simultaneous consideration of water flow fields on Fig. 5 and silver hake catch distribution reveals the following peculiarities. During the second survey when the average catch was low, stations were located on the slope in the center of the anticyclonic eddy. During the fifth survey, when the average catch was also low, stations were at the southern edge of two opposite directed eddies. Besides, low catches during this survey occurred in the northward water flow between the above eddies. Catches of average size were obtained at stations located at the periphery of dominating eddies. (Surveys 1, 4, 5). The largest average catches at the slope, associated with the first, fourth and fifth surveys were observed when a definite pattern had not been developed yet in the investigation area. The above-mentioned mesoscale circulation features in the investigation area, certainly did not directly affect the silver hake aggregation distribution and development. This effect may be expected rather through development and distribution of forage zooplankton patches, as discussed below.

Phosphates distribution. The near-bottom distribution of phosphates was similar to those of water temperature, salinity and geostrophic circulation (Fig. 6). Along the slope, the gradients develop due to the rapid increase of phosphates content with depth. This common picture is intensified by the upwelling events, related to the intrusion of warm slope water onto the shelf. The upwelling of water with increased nutrient contents results in development of phytoplankton, followed by zooplankton in the area, as well as in all other ocean areas. Thus, along the shelf slope, the bioproductive zone oc-

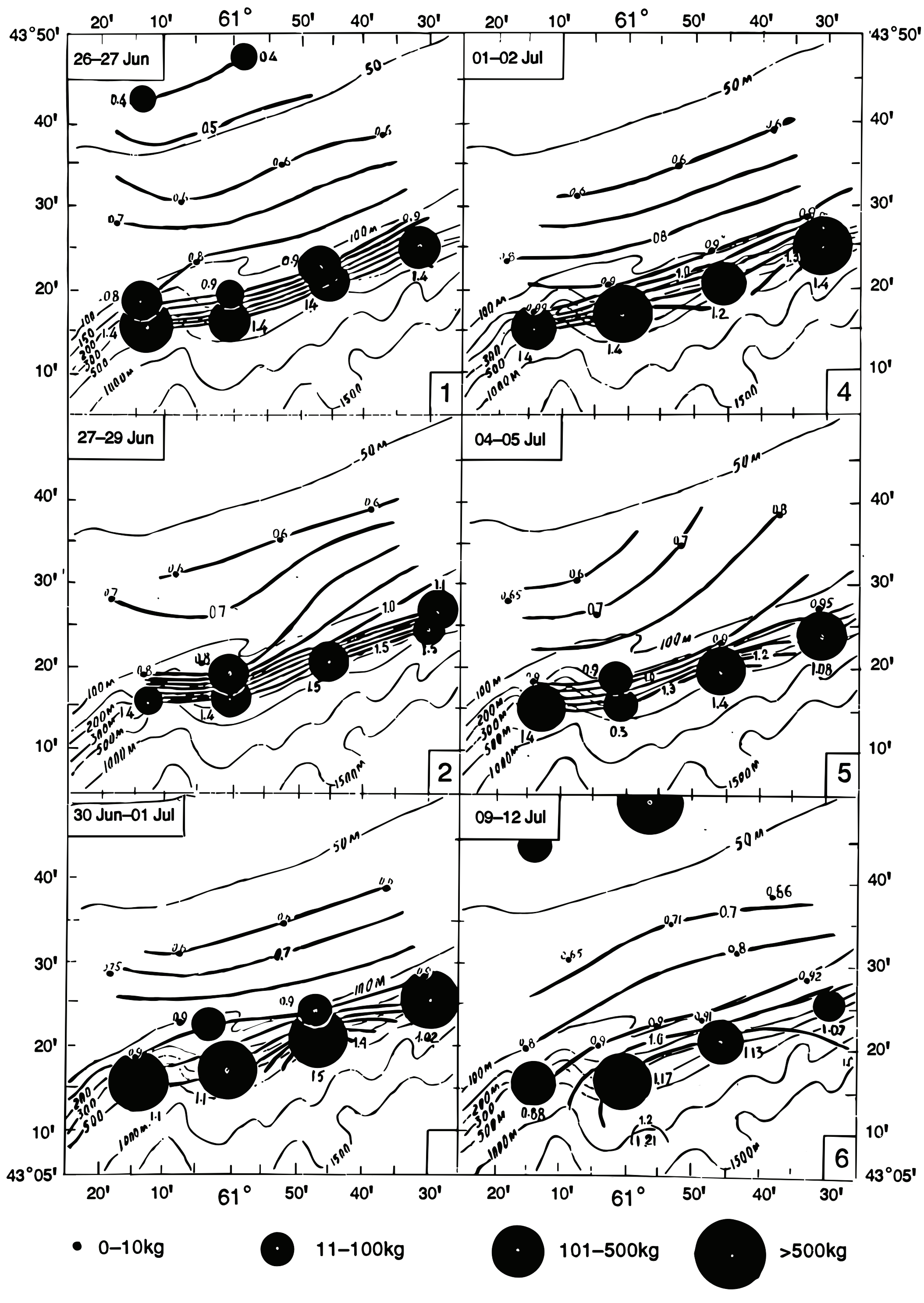

Fig. 6. Phosphates (PO) distribution near-bottom in the investigation area during 26 June–12 July 1990.

curs continuously providing the base for zooplankton development and the forage for silver hake. Examples of high nutrient content at the water upwelling areas are shown in Fig. 7.

Forage zooplankton and catches. The data on wet biomass and on plankton forms dominating in samples were used to compare zooplankton distribution and silver hake catches. Both biomass values and silver hake catches were averaged only in samples from the slope (Table 1). As the table shows the silver hake catch value did not correspond to the average wet biomass of zooplankton. At this point, the comparison of catches and forage zooplankton species dominating in each survey, although the latter are divided into small and large forms, reveals apparent correspondence to each other (Fig. 8). Low silver hake catches at the slope were associated with small forms (Calanoida) dominating in the second and fifth surveys; and moderate catches were associated with approximately equal number of large and small zooplankton (Euphausiidae and Calanoida) at the slope in the first and fourth surveys. The highest average catches were associated with large forms (Euphausiidae) dominating at the slope in third survey.

The following provides a description of the survey-to-survey qualitative and quantitative variations in the distribution of major forms.

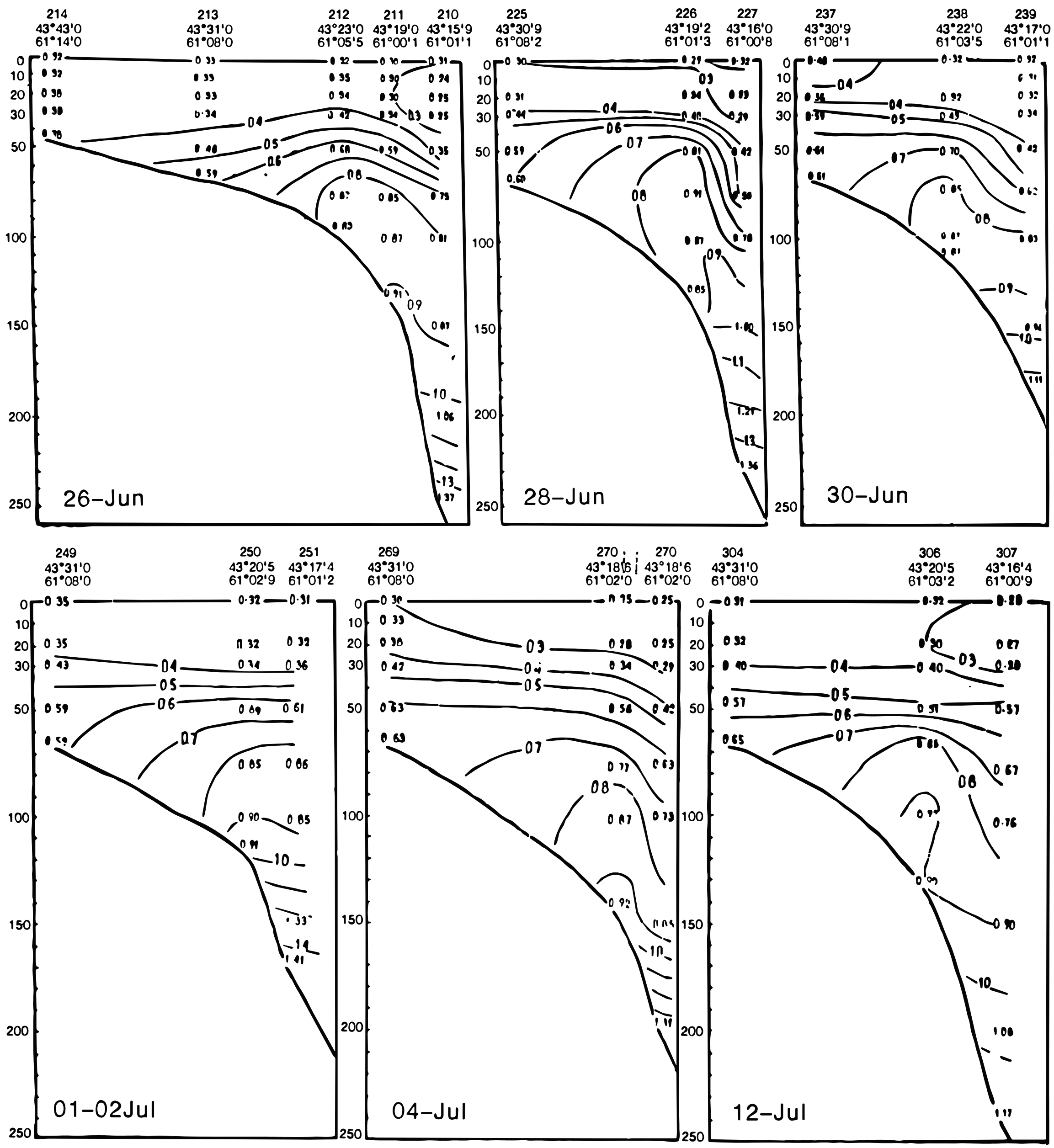

Fig. 7. Vertical distribution of phosphates at Section 2 of the investigation area during 26 June–12 July 1990.

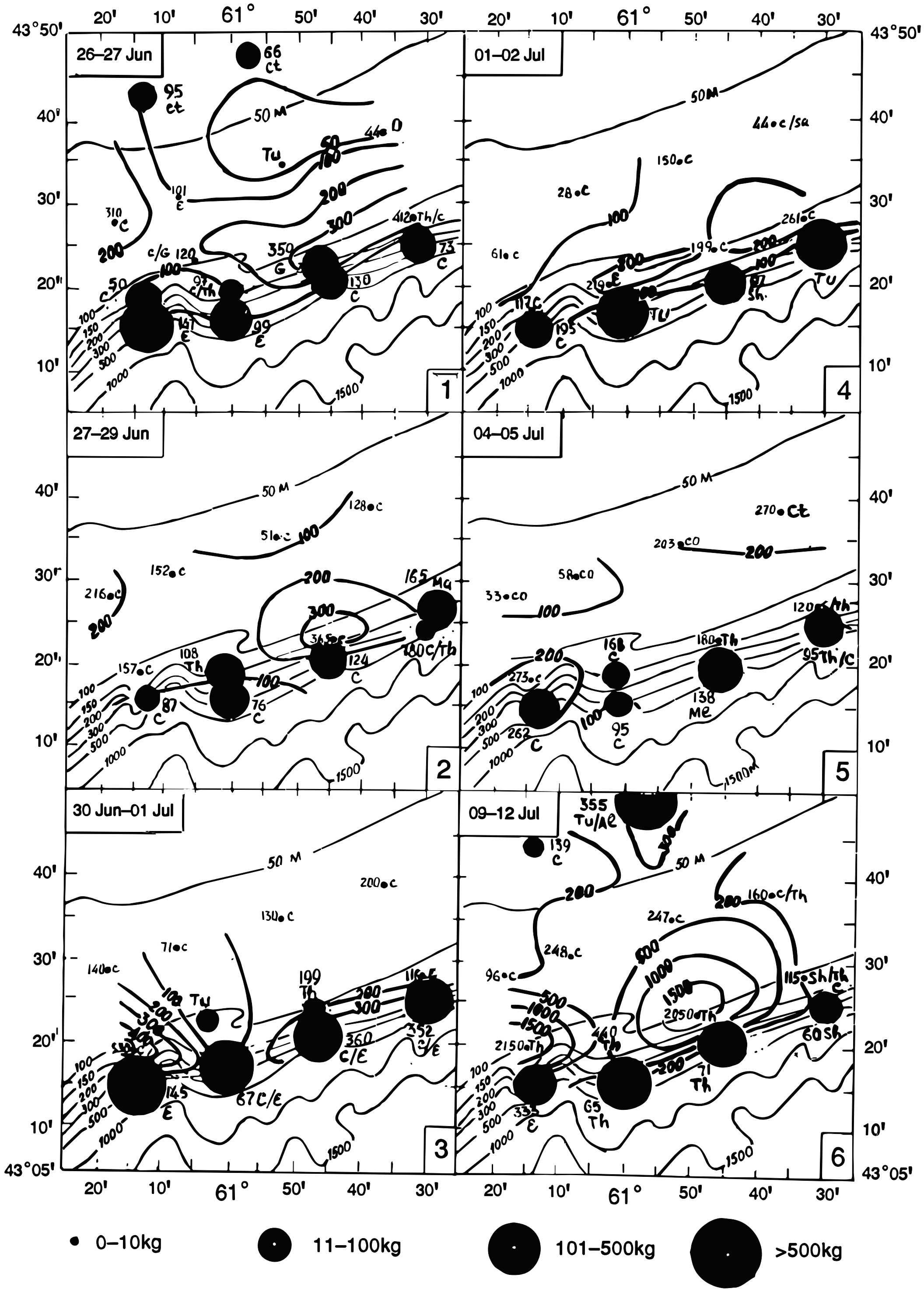

Fig. 8. Distribution of wet biomass (g/catch) of zooplankton which predominated in samples and silver hake catches. Isolines shows equal wet biomass of zooplankton in g per catch. The following symbols illustrate the dominating forms in samples:

Sh	–	Shrimp	C	–	Calanoida
E	–	Euphausiidae	Co	–	Copepoda
Th	–	Themisto	Sa	–	Saggita
Ma	–	Magatyphanae	Tu	–	Tunicata
Me	–	Meganichtyphanes norvegica	O	–	Ovapisces
G	–	Gammariidae	Al	–	Alga
Ct	–	Ctenophora			

During the first survey, the small zooplankton dominated at the eastern slope and formed a patch of biomass over 300 g per catch in the center (Fig. 8). Westwards, the large zooplankton of lower biomass values dominated, however, the silver hake catch in the area was higher than in the eastern part. This provides evidences of the selectivity of the food items by the silver hake. Note, that the catch at the slope corresponded to the average during the period of the study in the investigation area.

In the second survey, the small forms dominated, which dominated in the same patches eastward, where biomass was over 300 g per catch. The patch size considerably decreased as compared to the first survey. Note, that the average silver hake catch at the slope was relatively low in that time.

During the third survey, significant variations were observed related to apparent domination of large zooplankton in the areas where silver hake were found at the slope. Two patches were distinguished. In the eastern patch the large forms dominated. Its biomass exceeded 300 g per catch. The western patch of the biomass with over 500 g per catch consisted mainly of Calanus, and the silver hake catch was zero. Further southwards along the slope, the Euphausiidae domination was noted (145 g per catch). Exactly in that area of the slope, the silver hake catch was at a maximum for entire period of observation in the investigation area (1 700 kg), as well as the average value of the silver hake catch. It seems, that in this case as well, the ability of the silver hake to select larger food appeared.

During the fourth survey, both small and large zooplankton forms dominated in samples from the slope, however, the highest silver hake catches were obtained at stations where the large forms dominated (Fig. 8). The zooplankton distribution was more uniform than in the previous surveys, when the density was slightly higher at the slope (200 g per catch). As was mentioned above, the silver hake catch at the slope averaged by stations, was compatible to the intermediate value.

During the fifth survey, zooplankton density decreased and amounted to mainly below 200 g per catch. A small patch with a biomass of over 200 g per catch was found at the western boundary of the investigation area. Small and moderate size forms dominated in the catches. It was noted the average silver hake catch at the slope was compatible to the lowest value during the survey period.

During the last survey, two strong patches of zooplankton (with the biomass over 2 000 g per catch) again appeared in the investigation area. In this period, moderate size zooplankton (Themisto) dominated at the slope though Euphausiidae and shrimps dominated by weight at separate stations. As a result, the average silver hake catch at the slope increased.

Following the zooplankton distribution over the entire investigation area over all 6 surveys, it was noted that Calanus was the main dominating species in the depth range of 100–50 m near bottom. Calanus is known to occur in the Cold Intermediate Layer. In conclusion, it should be noted that the zooplankton density variability appears to have a lesser impact on the silver hake density and distribution, than the size of the zooplankton. Thus, food selectivity is judged to be the second major factor affecting distribution of this species.

Circulation and zooplankton distribution. It may be supposed that the near-bottom circulation fields, estimated based on the model D-2, and near-bottom forage zooplankton distribution should be comparable. However, the comparison of Fig. 5 and 8 shows that the zooplankton distribution features may not be explained by the water flow pattern in all surveys. Let us discuss these in the order zooplankton patch distributions were observed in surveys and relate them to the location of mesoscale eddies found. In the first survey a zooplankton patch of Calanus domination occurred in the eastern periphery of the anticyclonic eddy where the near-bottom water flow was directed south-south-eastward, i.e. from the shallow areas to the slope, and turned westward at the slope. It seems to promote Calanus transport from shallower depths to deeper waters, and into a zone of high gradient, and then transported further westward along the shelf-slope front, which was indicated by the patch extension from the east to the west. It is likely the case that when the hydrological front 'shelf-slope' acts as 'the liquid wall', there is restricted plankton uptake outside the shelf. At the western slope, the current vectors had an opposite direction from the south to the north, along the boundary belt between the anticyclonic eddy and the adjacent cyclonic one. This may promote Euphausiid aggregation in the area.

In the second survey, the patch of Calanus occurred in the eastern periphery of the same, but destroyed the anticyclonic eddy, where the vectors were also directed from the north to the south. To the west, the water flow had a northward direction, however, Calanus dominated there. This may also be the result of aggregation due to its transport from the eastern patch along the slope.

In the third survey, the vector directions were similar to the previous one; predominance of the transport from the north to the south in the eastern part, and from the south to the north in the western part. Besides, zooplankton patches were associated with the periphery of the oppositely directed eddies.

The fourth survey was characterized by a relatively uniform zooplankton distribution on the slope, where the southern periphery of the destroyed cyclonic eddy was located with predominant eastward vectors. The fifth survey revealed, as was noted above, two eddies of different direction with the southern periphery at the slope. The opposite direction of water flow vectors seem unlikely to promote apparent zooplankton patch formations. To the east, at the southern periphery of the anticyclonic eddy, the middle-size zooplankton predominated, and to the west, at the southern periphery of the cyclonic eddy and Calanus was the dominating species.

In the sixth survey, the eastern patch of zooplankton occurred at the eastern periphery of the large cyclonic eddy, where middle-size zooplankton predominated. The western patch, with middle and large forms predominating, was affected by the western periphery of the eddy where the water flow was directed west-north-westward.

Thus, generally we may conclude that the forage zooplankton patch distribution and composition are compatible with the near-bottom eddy locations and the vector flow direction. It may be noted also that eddies occurred at the boundary between two water masses, directly determining the density distribution of zooplankton species, and these in turn are often consumed by the silver hake. In any case, the near-bottom flows revealed, as evidenced by the likely northward transport of Calanus, the distribution of Calanus was in the Cold Intermediate Layer and its aggregations were in some areas of the hydrological front as well as being transported in the opposite direction. Similarly, the large zooplankton from the warm slope water may concentrate in the front area, and its patches may shift northwards of the front. The above-mentioned mechanisms allows us to suppose that the most favourable feeding conditions for the silver hake occur in the area when water flow was predominantly along the slope and where there was a lack of cross flows, i.e. in the front stability conditions. The more detailed pattern of zooplankton distribution was obtained based on the results of the samples sorted at the AtlantNIRO laboratory. Figures 9 and 10 show the density distribution of some relatively large (Euphausiidae, Gammariidae, Giperiidae) and small (Calanoida) forms of zooplankton in the investigation area, which more precisely reflects the dynamics of the large and small zooplankton patches and the relation of the latter to the average silver hake catch dynamics at the slope.

The analysis of silver hake stomach contents from samples, obtained at the investigation area stations and in the slope surveys shows that the bulk of the silver hake (modal length of 28–33 cm) consumed mainly Euphausiidae, and rarely Gammariidae, Giperiidae, shrimps, anchovy and very rarely, Calanus. Even in those cases when Calanus predominated in zooplankton samples, the silver hake stomach content consisted mainly of Euphausiidae. Thus, it may be concluded that feeding and prespawning silver hake aggregations are mainly formed in the large zooplankton patches.

Finally, the ecological conditions of silver hake aggregations on the Scotian Shelf area may be summarized as follows:

1. Surveys in the investigation area confirmed that feeding and prespawning silver hake aggregations develop at the warm side of the hydrological front 'shelf-slope' at temperatures of 7.5–10.5°C. In the cold water of the intermediate layer at the depth of 50–120 m, no aggregations of silver hake develop and they only occur as few individuals. This conclusion may be utilized in the design of future inventory surveys.

2. The front, at the boundary between two water masses, is the necessary environmental condition for the silver hake, providing both optimal physical conditions and forage base, as it is the major instrument of the latter development and distribution.

3. Euphausiids which aggregate in patches also at the warm side of the front 'shelf-slope', constitutes the feeding base of the silver hake in the size range observed in the study.

4. The analysis of the near-bottom circulation shows that the lack of cross flows, destructing a 'liquid wall' which restricts the major food transport northwards to the more suitable temperature conditions, are in fact unfavourable to silver hake. However, carrying small zooplankton unsuitable for silver hake feeding from the north to the front, appears the most favourable condition of devel-opment and maintenance of forage zooplankton patches at the front.

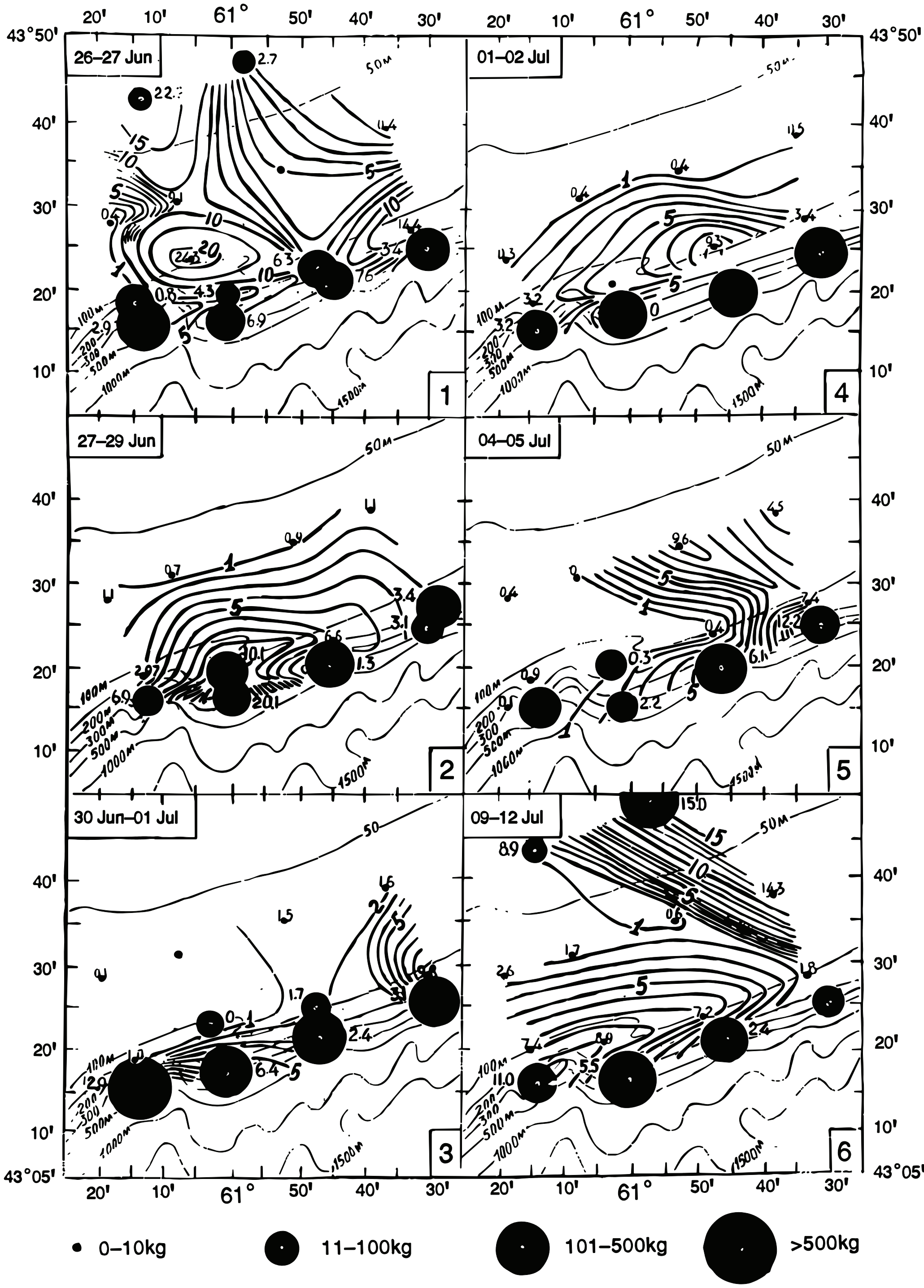

Fig. 9. Distribution of large zooplankton (Euphausiidae, Gammariidae, Giperiidae, shrimps) in mg/m^3 in the investigation area during 26 June–12 July 1990, and silver hake catches.

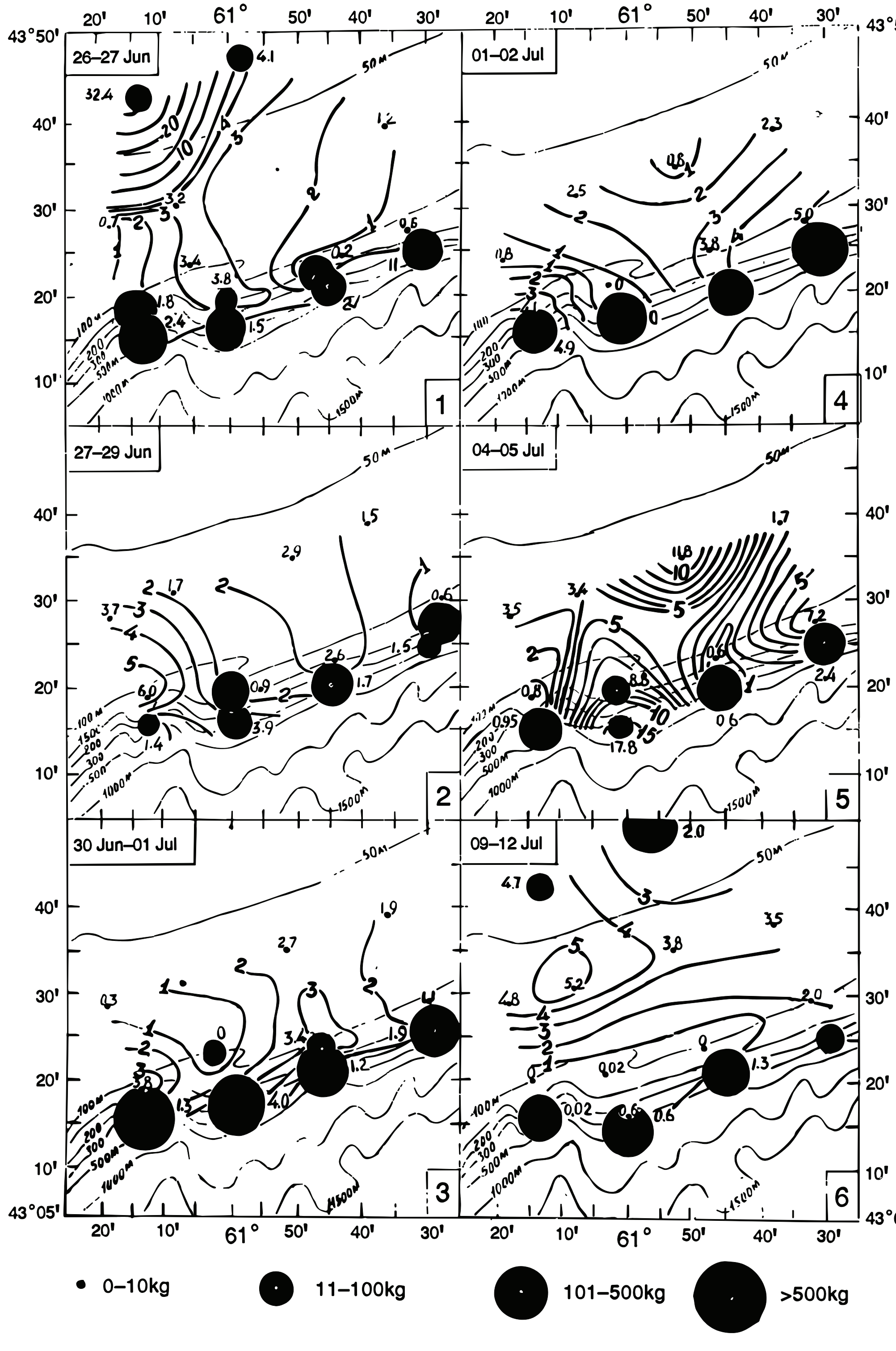

Fig. 10. Distribution of small zooplankton (Calanus) in mg/m^3 during 26 June–12 July 1990, and silver hake catches.

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