GREAT LAKES FISHERY COMMISSION
Research Completion Report[1]

Development of a detailed digital bathymetric map of the St. Marys River for sea lamprey larval sampling and analysis with Survey Designer

by

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October 31, 1994

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Development of a detailed digital bathymetric map of the St.Marys River for sea lamprey larval sampling and analysis with Survey Designer

by

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SUMMARY

PROJECT TITLE:

Development of a detailed digital bathymetric map of the St.Marys River for sea lamprey larval sampling and analysis with Survey Designer

PROJECT DATES: July 1, 1994 to August 31, 1994

PROBLEM STATEMENT AND OBJECTIVES:

The project is an extension of the previous project entitled "Mapping of larval distribution on the St.Marys River on the basis of sampling with supplementary environmental information and sampling design using multidimensional spatial modeling". Bathymetry is the most detailed supplementary information known. Therefore it is one of the most important environmental variables for multidimensional spatial modeling and adaptive larval sampling. The detailed bathymetric map for continuous representation of depth is a necessary component of *Survey Designer*. The map for St.Marys River is based on NOAA data, sounding surveys by Marquette Biological Station and sea lamprey survey data. Problems of verification, correction , and merging data of the three sources are solved to combine them.

RATIONALE AND RELEVANCE TO COMMISSION OBJECTIVES:

The St.Marys River Control Task Group identified mapping of the distribution and population density of sea lamprey larvae in the river as critical information needed to plan and to predict the effectiveness of either TFM treatments or spot treatments with granular Bayer-73. Detection of a 10% change is the goal of larval surveys that is a more rigorous criterion than they usually apply in fisheries.

PROCEDURES:

The data set is extended on compare with the original proposal with 1994 survey data because of importance of the area off St. Marys Falls and Locks. Three bathymetric data arrays are merged for the digital map development. They are NOAA data (60,701 points), field sounding data (59,243 points) and survey data (4,167 points). A base map is digitized using the NOAA 14883 and 14884 charts. The data were verified with spatial spline technique. Fifty points were detected and deleted as wrong measurements. Field sounding data for two areas were recalculated with inverted moving smoothing filter. The detailed fragment of the 14884 chart was used to improve accuracy of the shoreline. It is an extension of the original proposal as well. The developed map consists of 7 areas and 204 fragments with automatical adjustment by *Survey Designer*. Therefore the fragmentation is hidden from an end user. The new 32-bit version of *Survey Designer* is optimized for greater number of data segments to speed up computation.

DELIVERABLES:

1. Report with 11 color maps.
2. Files of the digital bathymetric map for the St.Marys River (3.3Mbytes on 3 floppy disks).
3. 32 bit version of *Survey Designer* is optimized for greater number of data segments.

1. BACKGROUND

Integration of biological and environmental information provides an opportunity to explain part of spatial variability of larval density. Bathymetric information is the most detailed information among environmental variables that are available before a survey. Therefore it can be used for adaptive sampling before other data are collected. It is one of the most important environmental variables for analysis of larval distribution as well. Application of a spatial model with supplementary environmental information has been made with the 1993 survey data for North Channel and the northern part of Lake Nicolet. Results were presented in the report entitled "Mapping of larval distribution on the St.Marys River on the basis of sampling design using multidimensional spatial modeling", Great Lakes Fishery Commission, 1993 by D.A.Stolyarenko. Now the area of interest is extended over the whole basin of St.Marys River.

2. PROBLEM STATEMENT AND OBJECTIVES

The major objective is to improve accuracy of stock assessment. The supplementary information can compensate deficiency of direct measurements of larval density and assist adaptive sampling. The detailed bathymetric map for continuous representation of depth is a necessary component of *Survey Designer*. The map for St.Marys River is based on NOAA data, sounding surveys by Marquette Biological Station and sea lamprey survey data. Somewhere they are in contradiction. Problems of verification, correction, and merging data of the three sources are solved to combine them. A digital map for *Spline Designer* is a 3-dimensional object that provides an opportunity to draw an arbitrary depth contour, 16.404 ft for instance (that is 5m).

3. MATERIAL AND METHODS

Three bathymetric data arrays are merged for the digital map development. They are NOAA data (60,701 points), field sounding data (59,243 points) and survey data (4,167 points), the total is 124,111 points. A base map is digitized using the NOAA 14883 and 14884 charts. The detailed fragment of the 14884 chart was used to improve accuracy of the shoreline of the western area.

Because the number of points is great the data are divided on 207 rectangular segments. Optimal fragmentation on run time was made that is important for real time applications of *Survey Designer*. The fragments are matched for continuous representation of bathymetric information automatically. Therefore a user cannot recognize the division of the map by fragments. The digital map was constructed for seven areas (Tables 1 and 2). Bathymetric maps for the areas are represented on Fig. 1-7.

The data were transformed to a stereographic projection (a spherical model with the tangent point with coordinates of 46 degrees N and 84 degrees W).

The data were verified and three types of problems were found.
1. Soundings include errors in depth measurements and positioning.
2. Wrong soundings happened sometimes from the start of the survey.
3. Data of near opposite transects were moved to the opposite directions.

Survey Designer Software System was used for data verification and correction. The first problem was solved with a technique of smoothing splines (Fig.8). Fifty points were detected and deleted as wrong measurements to solve the second problem. The reason of the third problem was supposed to be in hardware implementation of moving average for noise suppression. But it caused the delay in sounding measurements (Fig.9). To decrease the effect the inverted moving filter was used.

4. RESULTS

Results are represented on Fig. 1-7 and Tables 1 and 2. The digital map (three 1.44M floppy disks) is activated with *Survey Designer*. The 32-bit version of *Survey Designer* is optimized for greater number of data segments to speed up computation.

Application of the map to two 1994 survey data sets of the first stage for the western area off St.Marys Falls and the western area of Little Lake George area is shown in Fig.10 and 11. Fig.10 shows a standard approach to processing large data sets with the number of stations greater than 1000 that is a technical limitation of *Survey Designer*. A filter was applied to the data set to produce a subset of 980 stations. A window for map was chosen of less size. Thus, a filter was used with overlapping, point at a white background allows us to adjust fragments. Of course, the same approach was applied to the second fragment as well.

The estimated number of larvae for the first area of 7.66 sq.km is 700 thou. For the second area of 6.56 sq.km the estimated number is 106 thou. Comparison of the numbers shows the following recommended distribution of research effort. The number of samples for the second stage of the survey should be divided with the ratio 7 to 1 between the areas. The same approach is applicable to areas of small scale as well.

Figure 12 shows three dimensional representation of the bathymetric map. It is specific feature of the digital map developed. Because of representation by a continuous surface it allows to draw arbitrary depth contours as sections of the surface. The number of the contours can be arbitrary as well.

Table 1. Areas of the digital map

N	Area	Name
1	St. Marys Falls to Frechette Point (Western Area)	WESTERN
2	Black Point to Partridge Point (North Channel)	NORTHCH
3	Partridge Point to Churchville Point (Little Lake George)	LGEORGE
4	Frechette Point to Six Mile Point (Northern Part of Lake Nicolet)	NORNICO
5	Six Mile Point to Neebish Island (Lake Nicolet)	LNICOLE
6	Channels of Neebish Island	NEEBISH
7	Munuscong Lake	MUNUSCG

Table 2. Files of the digital map

Directory	Number of files	Total, bytes
WESTERN_	44	700,038
NORTHCH_	11	175,112
LGEORGE_	41	652,108
NORNICO_	10	159,036
LNICOLE_	45	714,296
NEEBISH_	42	668,158
MUNUSCG_	15	239,200
Total	207	3,307,948

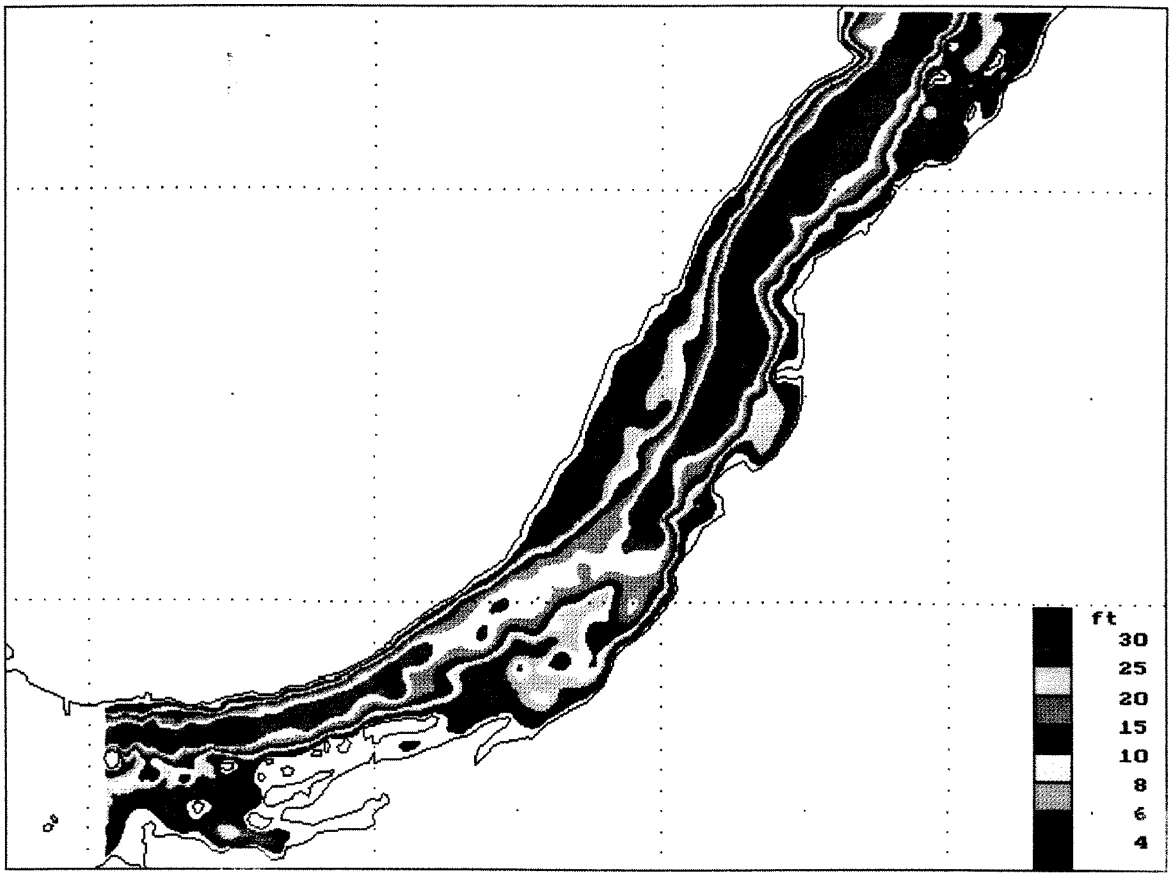

Fig. 1. Bathymetric map of North Channel from Black Point to Partridge Point

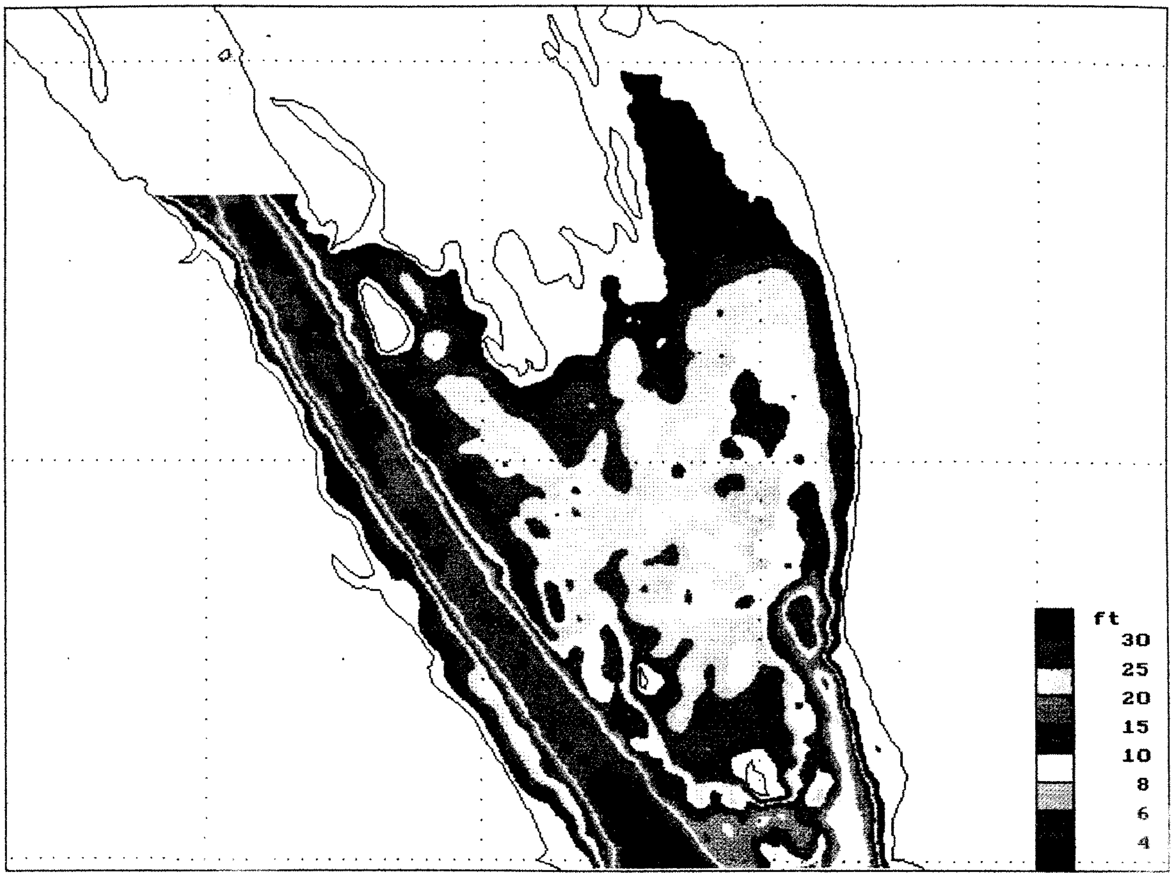

Fig. 2. Bathymetric map of the northern part of Lake Nicolet from Frechette Point to Six Mile Point

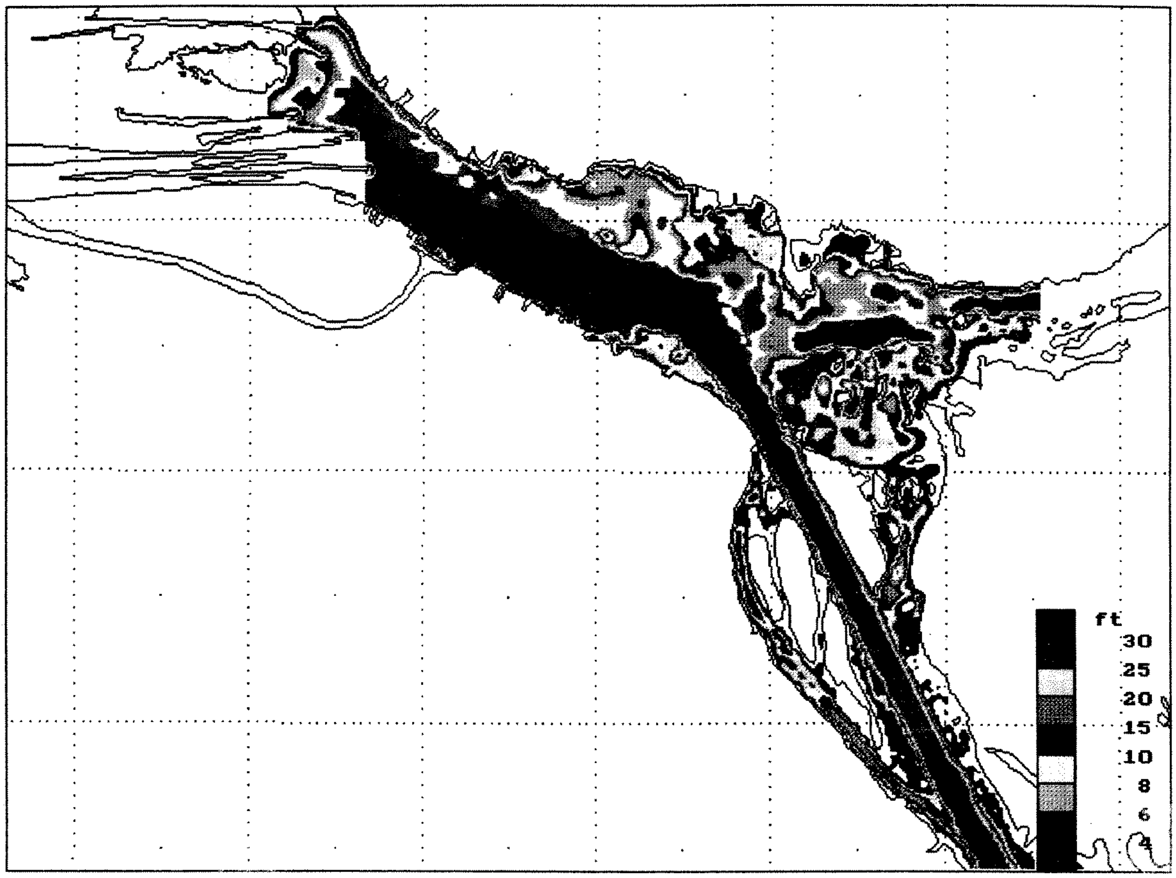

Fig.3. Bathymetric map of the western area from St.Marys Falls to Frechette Point

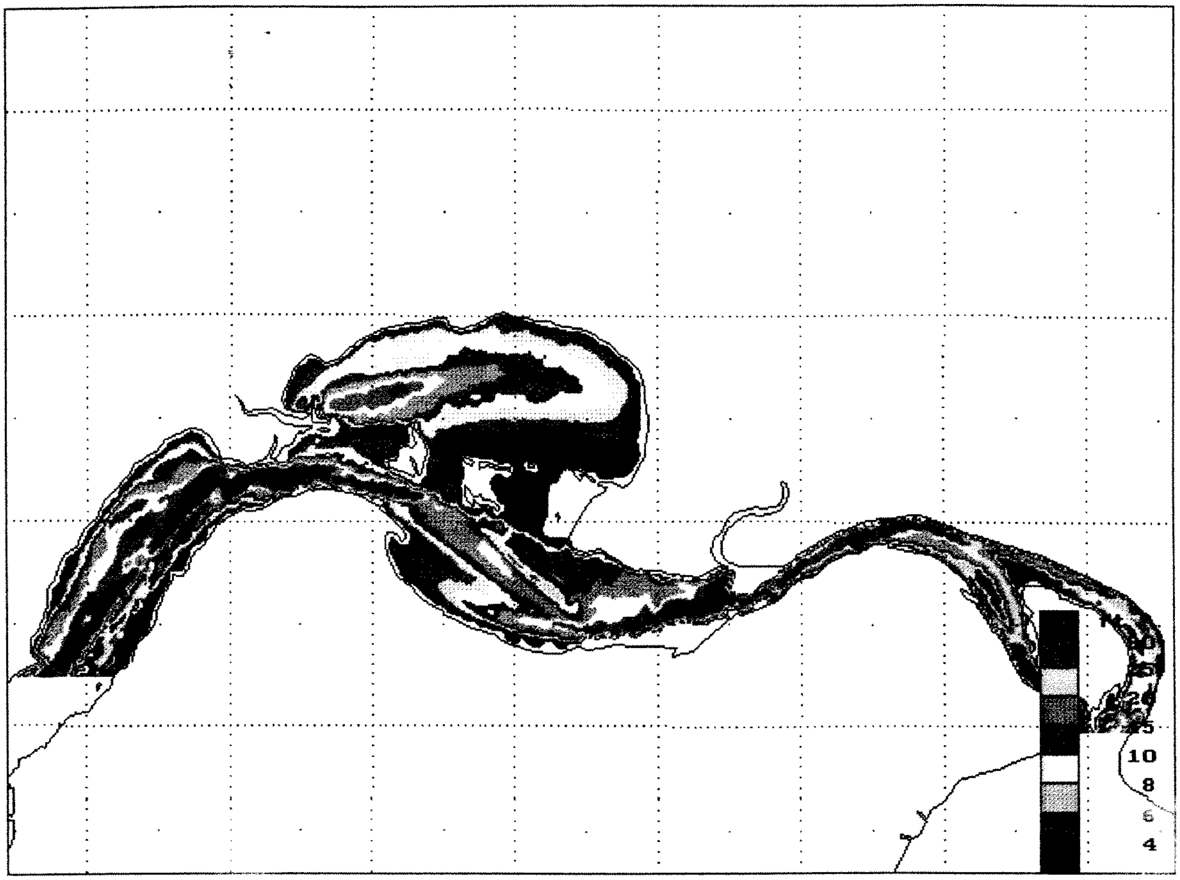

Fig. 4. Bathymetric map of the eastern area from Partridge Point to Churchville Point including Little Lake George

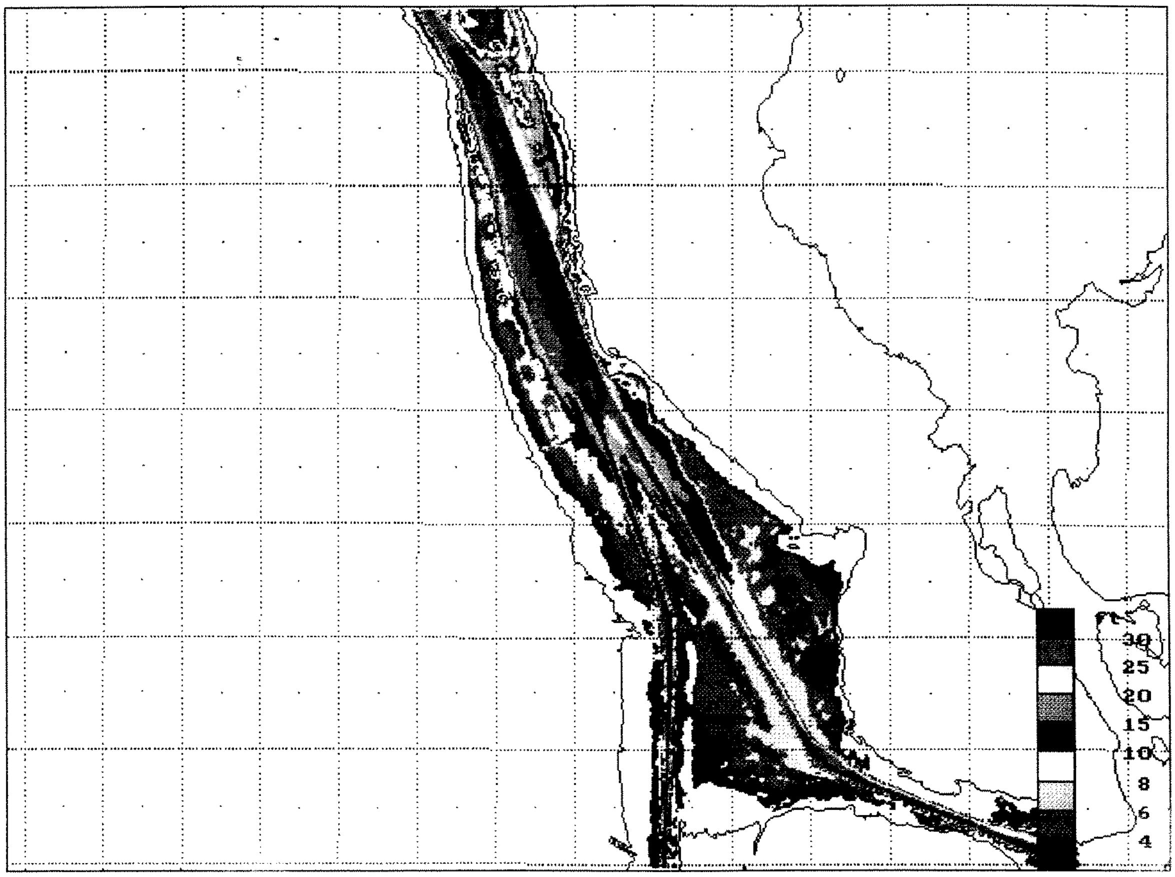

Fig.5. Bathymetric map of Lake Nicolet from Six Mile Point to Neebish Island

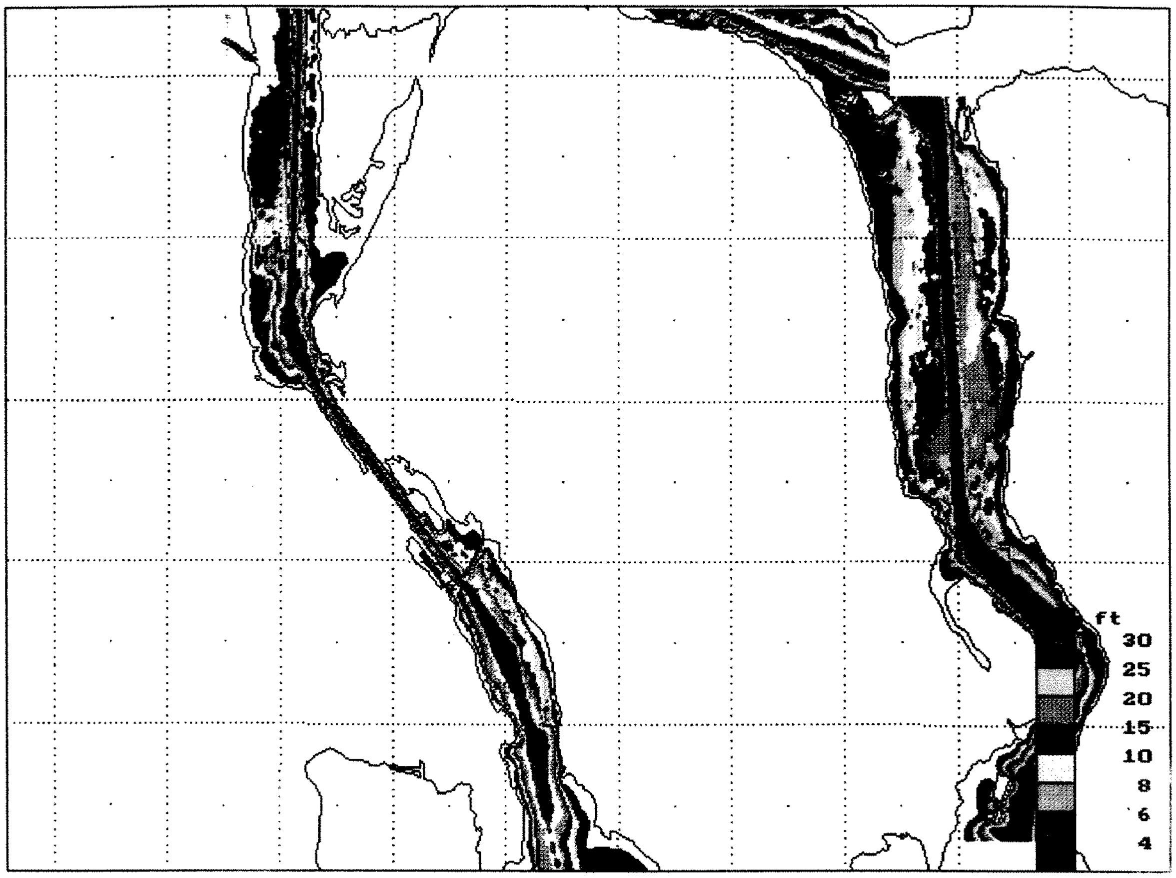

Fig.6. Bathymetric map of channels off Neebish Island

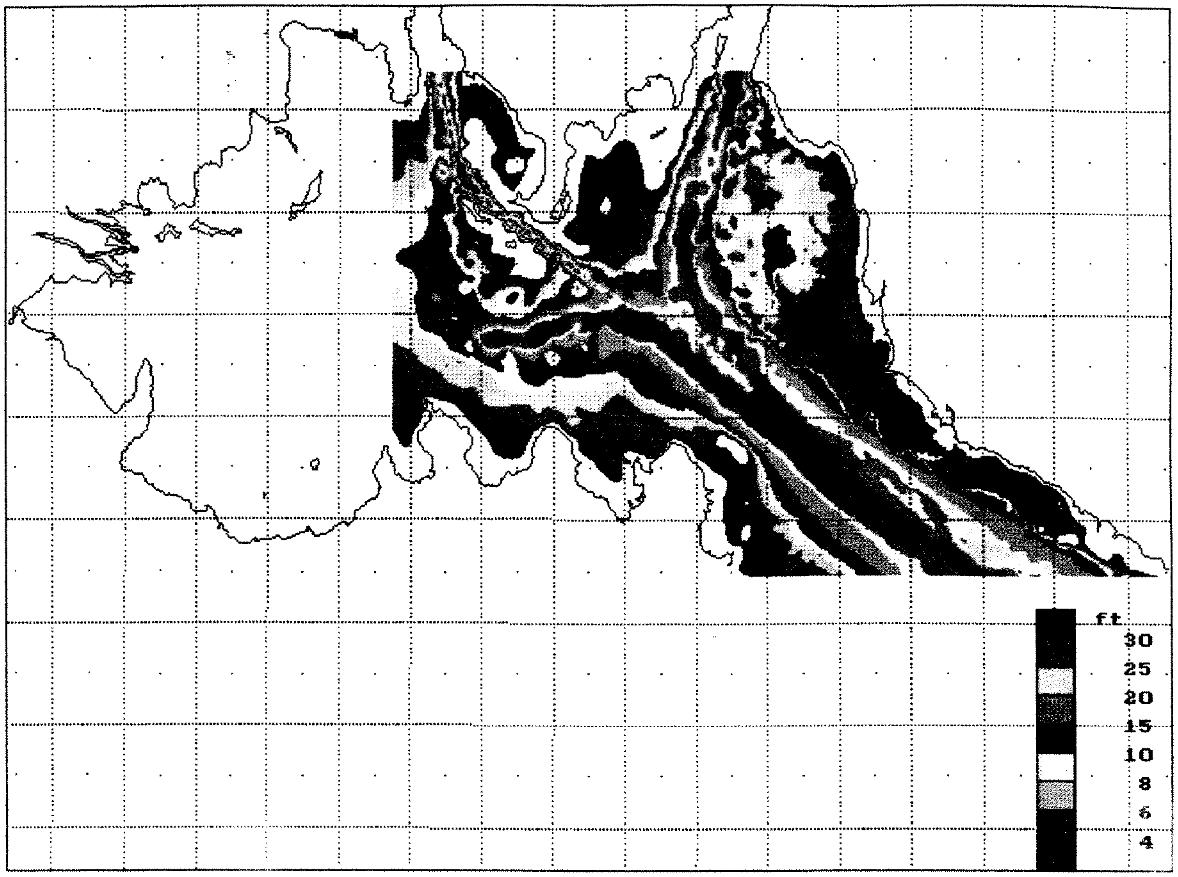

Fig.7. Bathymetric map of Munuscong Lake

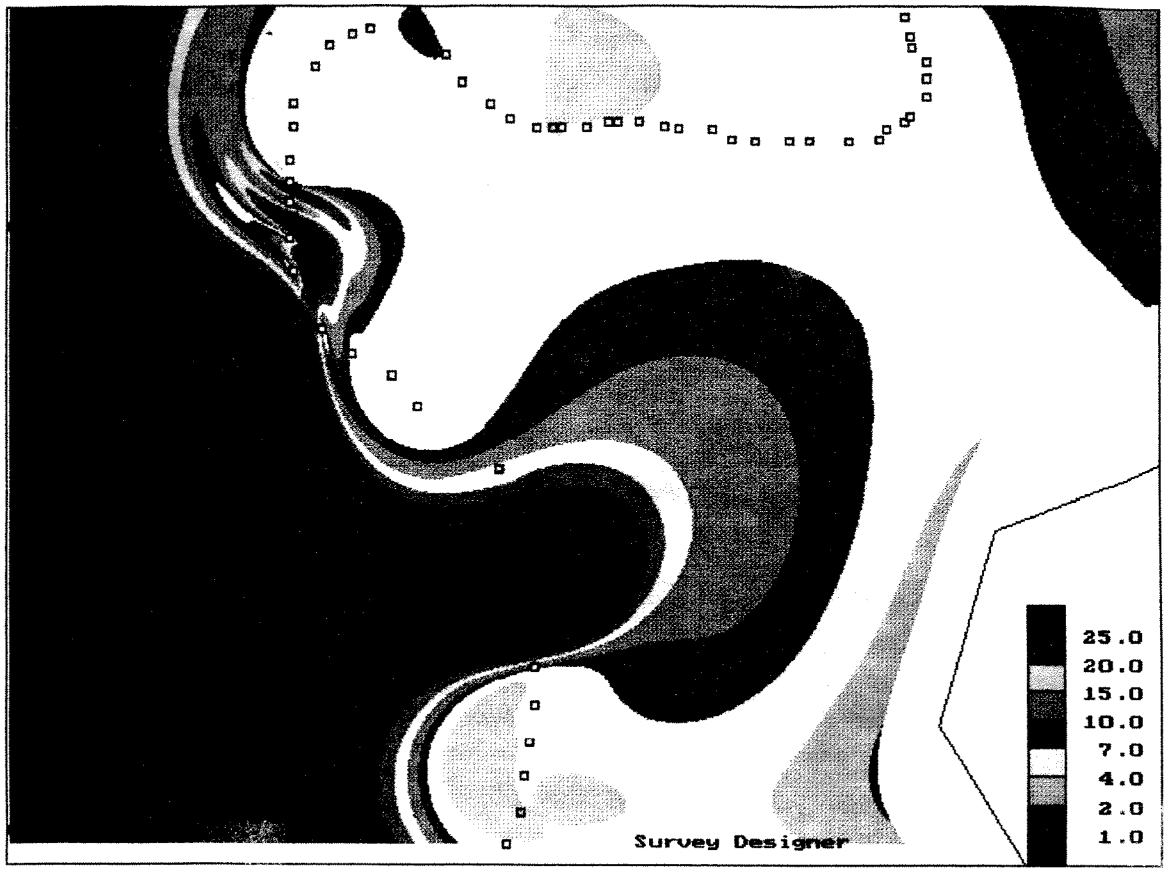

Fig.8. Sounding data should be smoothed because of random errors in depth measurements and positioning. The figure shows two transects marked with red points (30m) and blue points (4m) which cross each other, they were made at different time. The hypothetical map is represented under assumption that the data are precise.

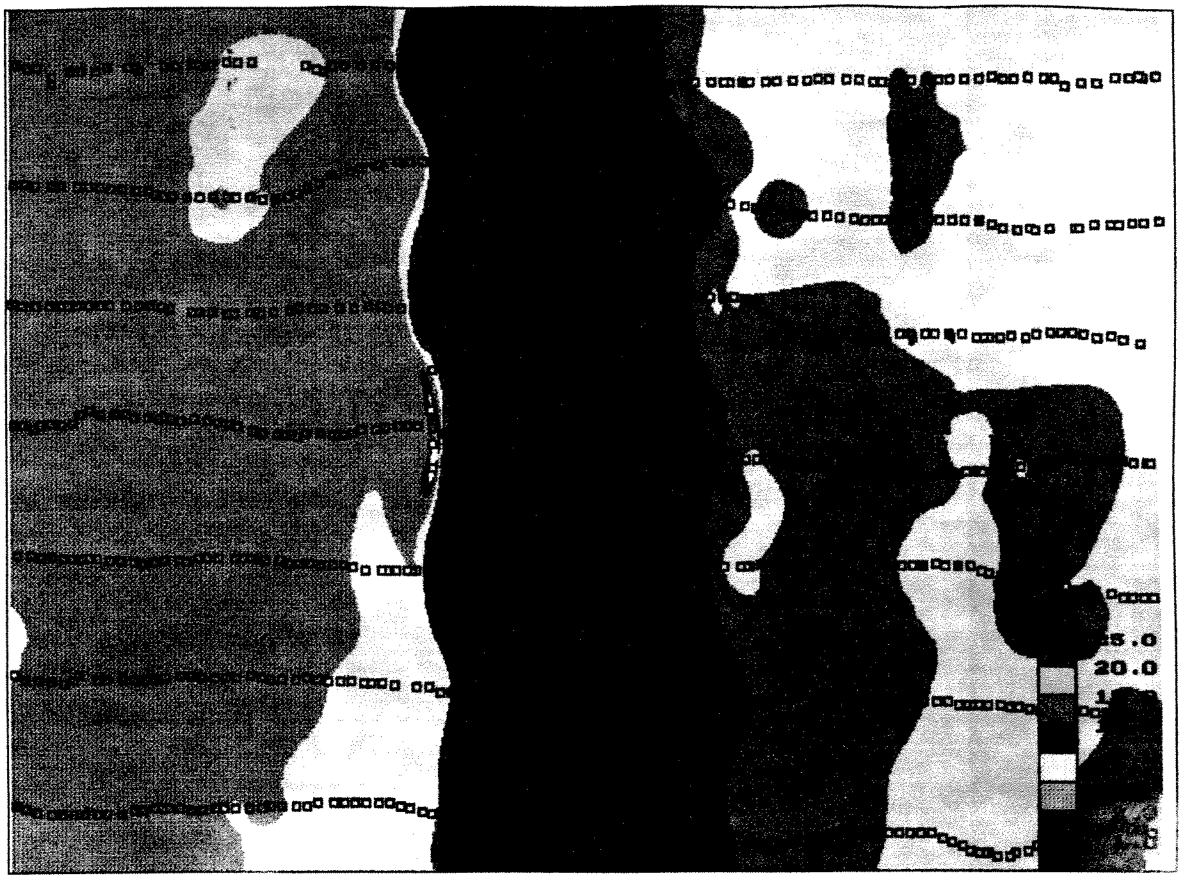

Fig.9. Problems of data verification. This is an example of errors in sounding data: four blue and light green points of 7 m at the center of the figure were deleted as wrong soundings of the start of a transect. The hypothetical map is represented under assumption that all soundings are precise. The waved red strip of deep water shows another problem that is inherent in the sounding data gathered. Data of opposite transects are moved to the opposite directions.

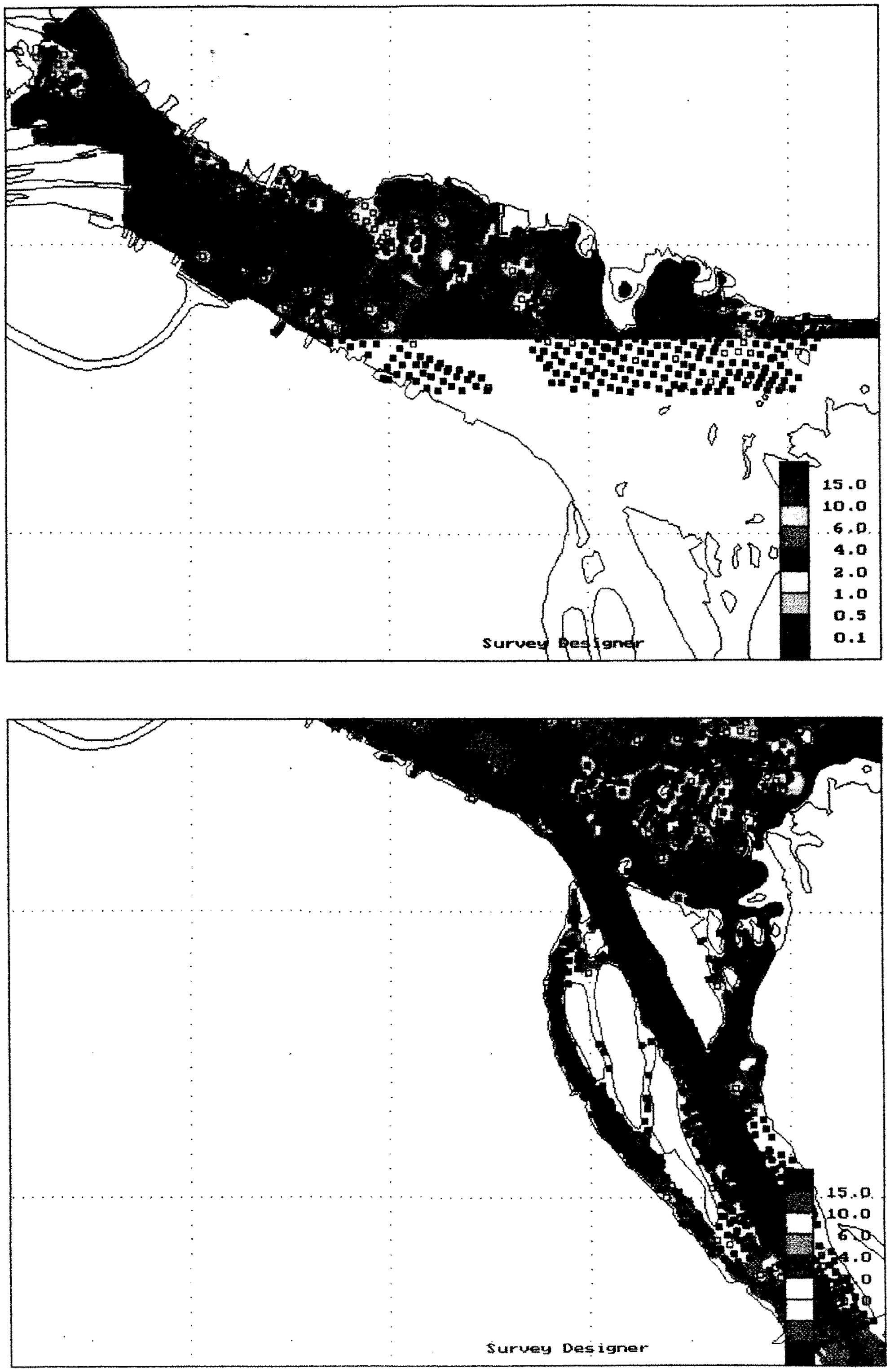

Fig.10. Larval density for the western area that is represented by two fragments. The figure shows a standard approach to processing large data sets with the number of stations greater than 1000.

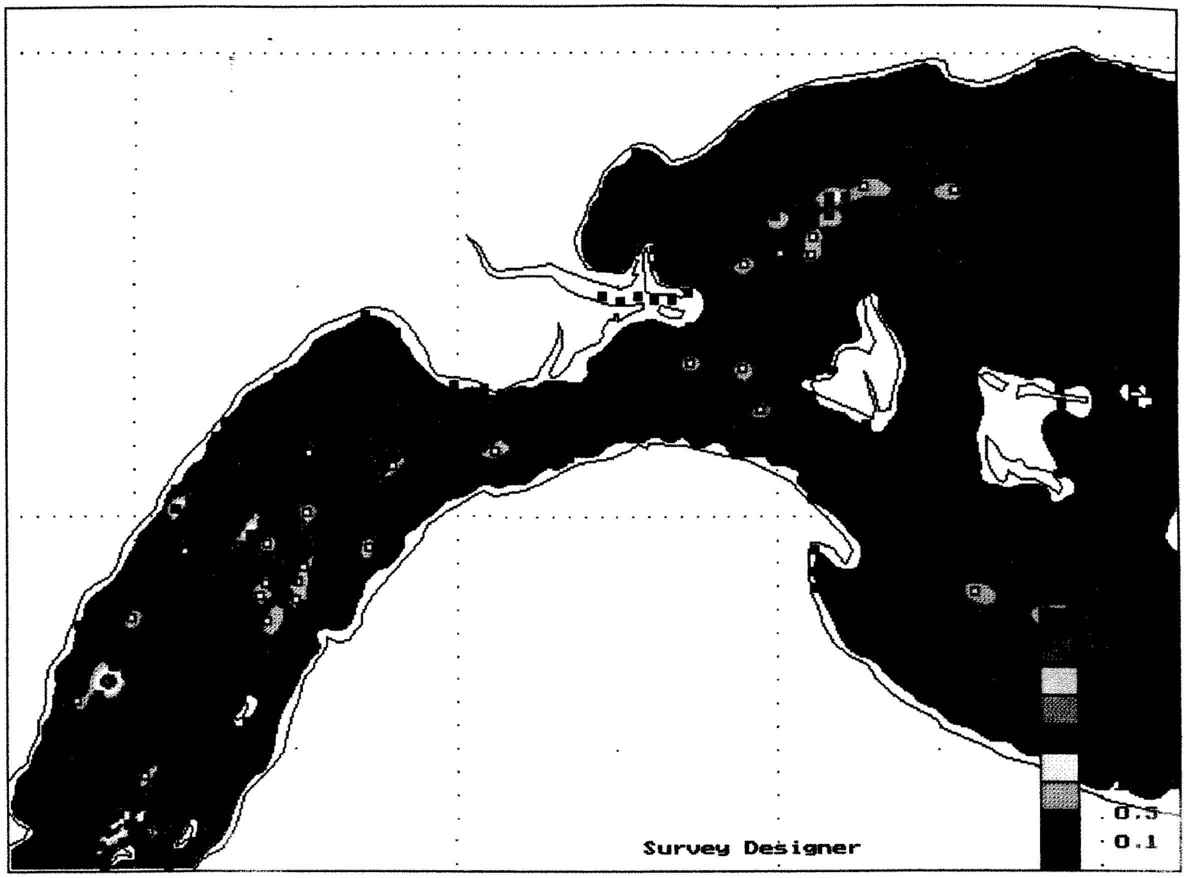

Fig.11. Larval density for Little Lake George area on the basis of survey data of the first stage sampling.

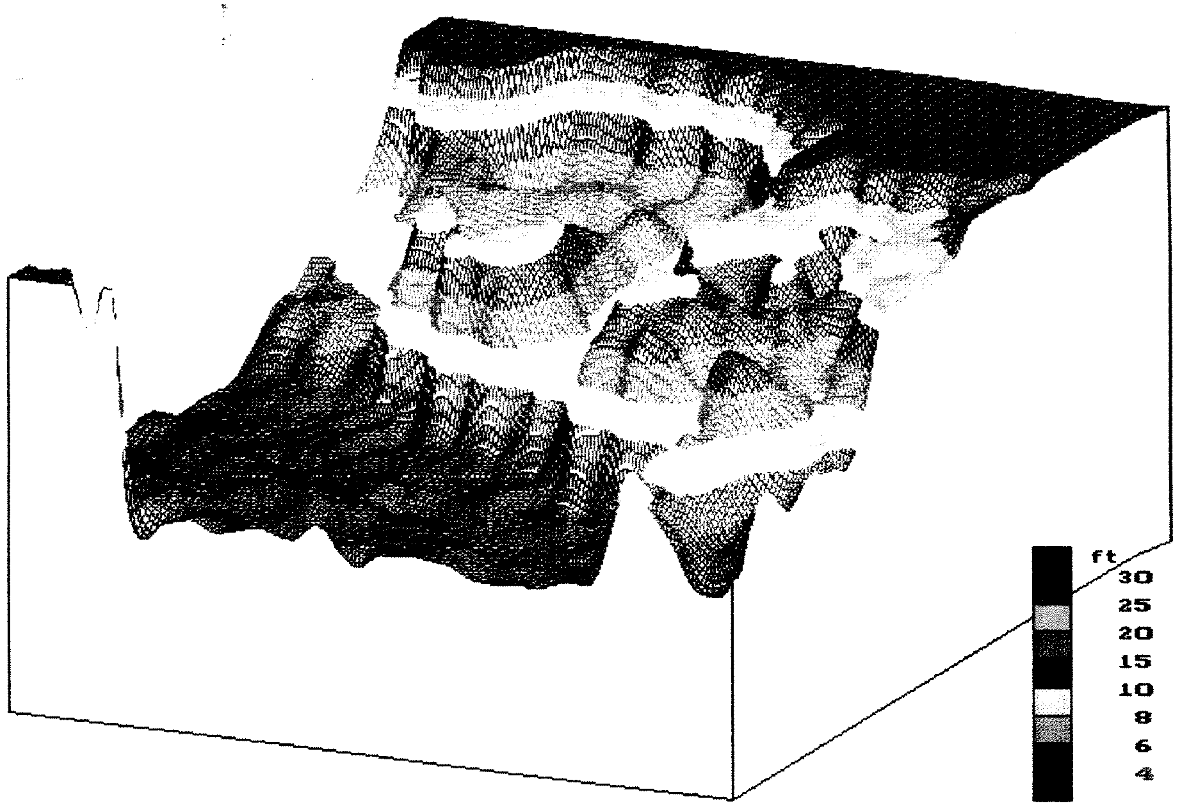

Fig.12. Continuous representation of bathymetry by the digital map allows to draw arbitrary depth contours as sections of the surface.