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EXTRACTION OF BELT-LIKE ZONES OF RICH-PLANKTON  
WATER FROM SKYLAB S190A MULTISPECTRAL PICTURES

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## ABSTRACT

Two photographic techniques were applied to SKYLAB S190A multispectral pictures for extracting oceanic patterns at the sea surface separately from cloud patterns. One is the image-masking technique and another a stereographic analysis. The extracted oceanic patterns were likely interpreted as areas where the amount, or the concentration of phytoplankton was high by utilizing surface data of water temperature, ocean current by GEK, and microplankton.

## INTRODUCTION

In a sequence of S190A multispectral pictures taken from the SKYLAB on 18 September, 1973, several formats are available for an oceanographic investigation fortunately owing to fairly low cloudiness. However, their black and white images are of complex pattern by combined cloud covers of various thickness and of some oceanographic informations, that is oceanic patterns. Moreover, any oceanic pattern is very weak in tone and very low in contrast against its surrounding sea. Therefore, it is impracticable to interpret any oceanographic condition, or information from it only by the quick-look analysis. Some process or processes are necessary for enhancing the image contrast and extracting oceanic patterns separately from the ones of atmospheric informations.

The extracted patterns at the sea surface, or oceanic patterns are green-colored sea areas in this investigation, which were able

to be likely interpreted as rich-plankton areas by an analysis using surface data of water temperature, ocean current by GEK, and microplankton.

#### USED SKYLAB DATA

Used SKYLAB data in this investigation are SL90A multispectral pictures (black and white) taken on 18 September, 1973. The corresponding locations of each frame are drawn as blocks in Figure 1. Though most part of the SL-3 swath were covered by dense clouds including Tokyo area (left down corner), one of the most interesting sea regions centered approximately at  $39.5^{\circ}\text{N}$ - $145^{\circ}\text{E}$  were fortunately in low cloudiness which corresponding three formats are shown by thick blocks in the figure.

Two typical pictures both of Frame 154 are presented in Figure 2, where the left picture is of the green band (RL-48,  $0.5$ - $0.6 \mu$  in wavelength) and the right the darker red-near infrared band (RL-43,  $0.7$ - $0.8 \mu$ ). In the green band picture (left) a belt-like grey pattern can be faintly seen near the picture center among evident cloud covers. However, it is difficult to interpret by the quick-look analysis whether the pattern is of some oceanic information or thin cloud layer or sea fog. In the darker red-near infrared picture (right) the faintly grey-colored pattern mentioned-above cannot be observed. This difference between the two band pictures depends mostly on the attenuating characteristics of light in the water

column, which is utilized for extracting oceanographic informations in this investigation.

#### EXTRACTION OF OCEANIC PATTERNS BY IMAGE MASKING TECHNIQUE

As the attenuation coefficient of light in water column is large in longer wavelength regions, and very large in the near infrared region, spectra of reflectance from several oceanographic conditions can be understood approximately as three shapes in Figure 3, respectively. And lights scattered from tops of cloud, smog-layer, and reflected sun light at inclined surfaces of sea wave, that is the sunlint, have sufficient components in the near infrared region as shown by the rough sketch of reflectance spectrum concerning to them in the figure. Therefore, these oceanographic conditions are taken in grey color together with clouds, smog layers and areas of sunlint in white or grey color in pictures of RL-48 and RL-47, whereas only these atmospheric informations above the sea surface are clearly taken in RL-43 pictures.

Utilizing the difference between visible regions and the near infrared region, oceanic patterns can be extracted separately from patterns of atmospheric informations by applying a photographic technique of image-masking. Four pictures in Figures 4 and 5 are prints made by the image subtraction process, that is, by overlaying a RL-48 positive transparency with a RL-43 negative transparency in a photographic enlarger. In the left picture of Figure 4, only

distinct cumulus clouds are represented in white, but most of clouds are mixed with oceanic patterns both in grey color, by too weak density of cloud image in RL-43 negative transparency first used. Using a denser negative transparency of RL-43, the right picture in Figure 4 was made, where the separation of clouds and oceanic patterns is nearly complete but the oceanic patterns are in too low contrast owing to their low contrast in RL-48 positive transparency used. By enhancing the images of oceanic patterns in a photographic processing, the left picture in Figure 5 having sufficiently high contrast about oceanic patterns was obtained. However, The separation is again incomplete. Finally, the extraction of the oceanic patterns separately from cloud covers was succeeded having satisfactory image contrast by controlling image densities and contrast in both transparencies.

Figure 6 is a mosaic of three image masking prints from Frame 153, 154 and 155 made by the nega-posit combined printing above explained. The darker pattern likely shows areas of green-colored pattern in the sea because these prints were made with green band pictures (RL-48).

For comparison, another mosaic of image masking pictures from the same frames 153, 154 and 155 is shown in Figure 7, where the yellow-red band pictures (RL-47,  $0.6-0.7 \mu$ ) were used. Here, does not appear any remarkable pattern in the sea. This confirms that the distinct belt-like patterns in the preceding mosaic corresponds the green-colored sea areas.

## EXTRACTION OF OCEANIC PATTERNS BY STEREOSCOPIIC EXAMINATION

In any S190A picture, nearly each half part of the scene is overlapped with its corresponding adjacent pictures as seen in Fig.1. By examining the overlapped scenes in adjoining two pictures with simple stereoscopes (Fig.8), oceanic patterns at the sea surface can be extracted separately from cloud covers at various altitudes above the sea surface. In Fig.9, the rectangular negative picture at the center is of the common scene in adjoining two negative pictures of Frame No. 154 (the left) and of No.155 (the right) by the S190A cameras. The shaded areas in the center picture were recognized as areas of cloud covers in a stereoscopic examination. Then, grey patterns in the remaining areas are oceanic patterns.

The mosaic in Fig.10 was made with successively taken four S190A pictures, where areas of cloud cover are shaded. Through the cloud covers, or shaded areas in the figure, oceanic patterns at the sea surface are shown in darker grey, which mean green-colored water because the S190A pictures used are of the green band (RL-48).

## INTERPRETATION OF THE OCEANIC PATTERNS

The sea of interest is the region where the warmer Kuroshio Current and the cooler Oyashio Current encounter each other showing a complex pattern of warm cores from the Kuroshio Current and of cold cores from the Oyashio Current as seen in Fig.11 (1) and 12 (2), where isotherms ( $^{\circ}\text{C}$ ) at the 100m layer are delineated and ocean

currents by the GEK are plotted with small arrows. Both in July (Fig. 11) and August (Fig. 12), 1973, the Kuroshio Current ran northeastward in the southern part of the sea region of interest, and the cooler water of the Oyashio Current flew southward into the sea region.

It is well-known that the amount, or the concentration of phytoplankton is generally high in the sea region, especially along boundaries between cooler waters from the Oyashio Current and warmer waters from the Kuroshio Current as shown in Fig. 13 (3). In the chart of the sea surface temperature and the amount of microplankton (most of which is of phytoplankton) in July, 1973 (Fig. 14), there can be seen a tendency that the phytoplankton was abundant in southward protruding zones of the cooler Oyashio Current, nearly at  $41.5^{\circ}\text{N}-146^{\circ}\text{E}$  and  $41.5^{\circ}\text{N}-148^{\circ}\text{E}$ (4).

For examining the sea surface temperature in September, 1973, four charts are presented in Figs. 15, 16, 17 and 18 (5), where isotherms ( $^{\circ}\text{C}$ ) in each 5-day period are delineated. The Oyashio water (northwards the high gradient zone of the sea surface temperature) located mostly northwards the  $41^{\circ}\text{N}$  circle in the 1st-5th in September, 1973 (Fig. 15). After an occurrence of striking southeastwards protrusion of the Oyashio water in the 6th-10th period, a sharp pattern of southwards protrusion appeared in the 16th-20th period of September, 1973 (Fig. 18). During the period the SKYLAB SL-3 passed over this sea region.

For assisting the interpretation of the green-colored patterns

extracted from SKYLAB S190A pictures taken on 18 September, 1973, the mosaics in Fig. 6 made by the image-masking technique and in Fig. 10 made by a stereoscopic examination are overlaid on partial charts of the sea surface temperature in 16th-20th period as in Figs. 19 and 20. The belt-like green-colored patterns are seen to coincide nearly to the axis of the sharp protruding pattern of the sea surface temperature. This suggests that the green-colored pattern likely shows areas where the amount of phytoplankton is high, when considering together with patterns in Figs. 13 and 14. It is very interesting in oceanography that the rich plankton water is in belt-like zones not in a flat pattern.

#### CONCLUSTONS

In any space photographs oceanic conditions or oceanographic informations are very faintly taken and their contrast against surrounding sea is very low. Furthermore, images of thin cloud layers, smog layers, sea fog, and areas of sunlint appear in many cases grey in color nearly alike oceanographic informations. Therefore, it is necessary to extract oceanographic informations separately from informations above the sea surface. By applying the image masking technique and the stereoscopic examination to SKYLAB S190A multispectral pictures, green-colored patterns at the sea surface were extracted. Then, they were likely interpreted as rich plankton areas by the availability of using surface data.

## ACKNOWLEDGEMENTS

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## REFERENCES

- 1) The Ten-day Marine Report (in Japanese). Japan Meteorological Agency, Nos. 967 and 968, 1973
- 2) The Ten-day Marine Report (in Japanese). Japan Meteorological Agency, Nos. 970 and 971, 1973
- 3) Kawarada, Y., M. Kitou, K. Furuhashi and A. Sano, 1968;  
Distribution of Plankton in the Waters neighboring Japan in 1966 (CSK). Oceanogr. Magaz., 20, (2), 187-212
- 4) Hakodate Marine Observatory (1973): Oceanographic Observation Report of The Hakodate Marine Observatory (in Japanese).  
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- 5) Tohoku Regional Fisheries Research Laboratory, 1973: Summary of Oceanographic Conditions in the North Eastern Offshore of Japan, Sept., 1973 (in Japanese).

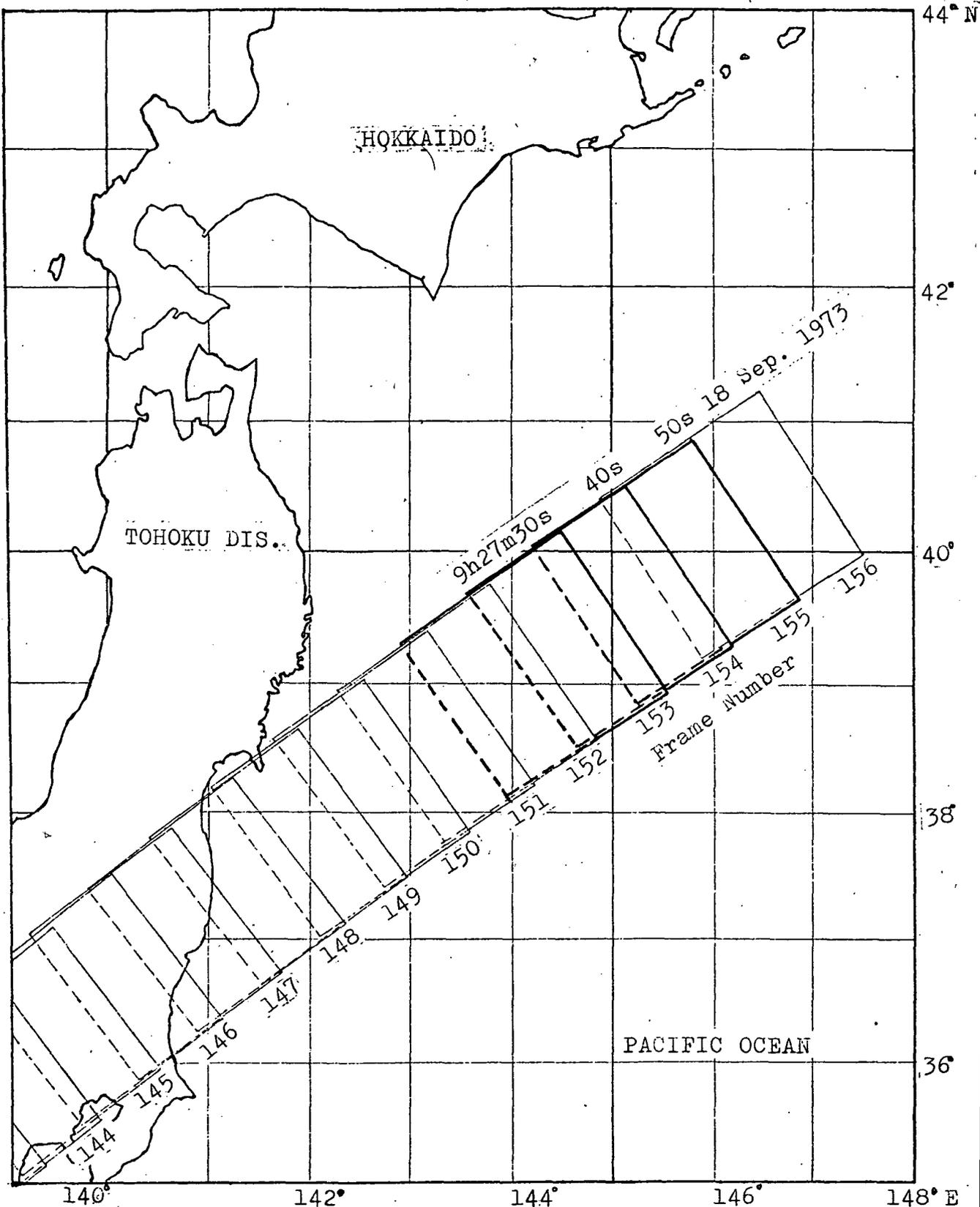
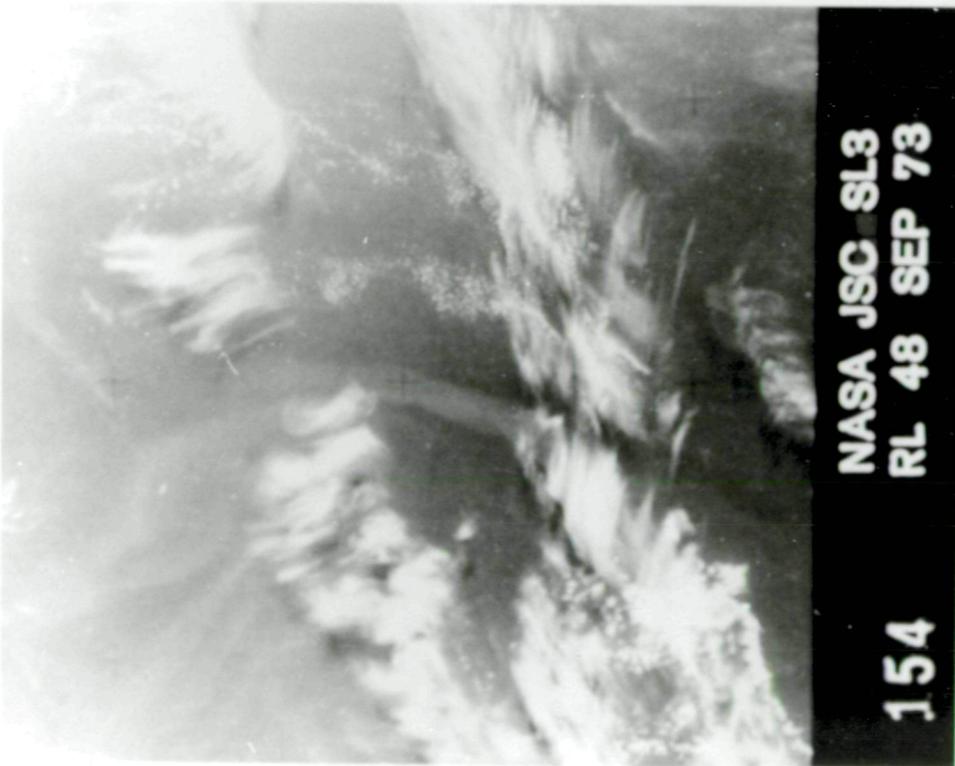


Figure 1 Locations of S190A multispectral pictures used in this investigation, taken from the SKYLAB SL-3, 18 Sept., 1973.

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NASA JSC SL3  
RL 48 SEP 73

154



NASA JSC SL3  
RL 43 SEP 73

154

Figure 2 Visible RL-48 ( 0.5-0.6  $\mu$  band ) picture ( left ) and near infrared RL-43 ( 0.7-0.8  $\mu$  ) picture ( right ), both centered nearly at 49.5°N -145°E, 18 Sept., 1973.

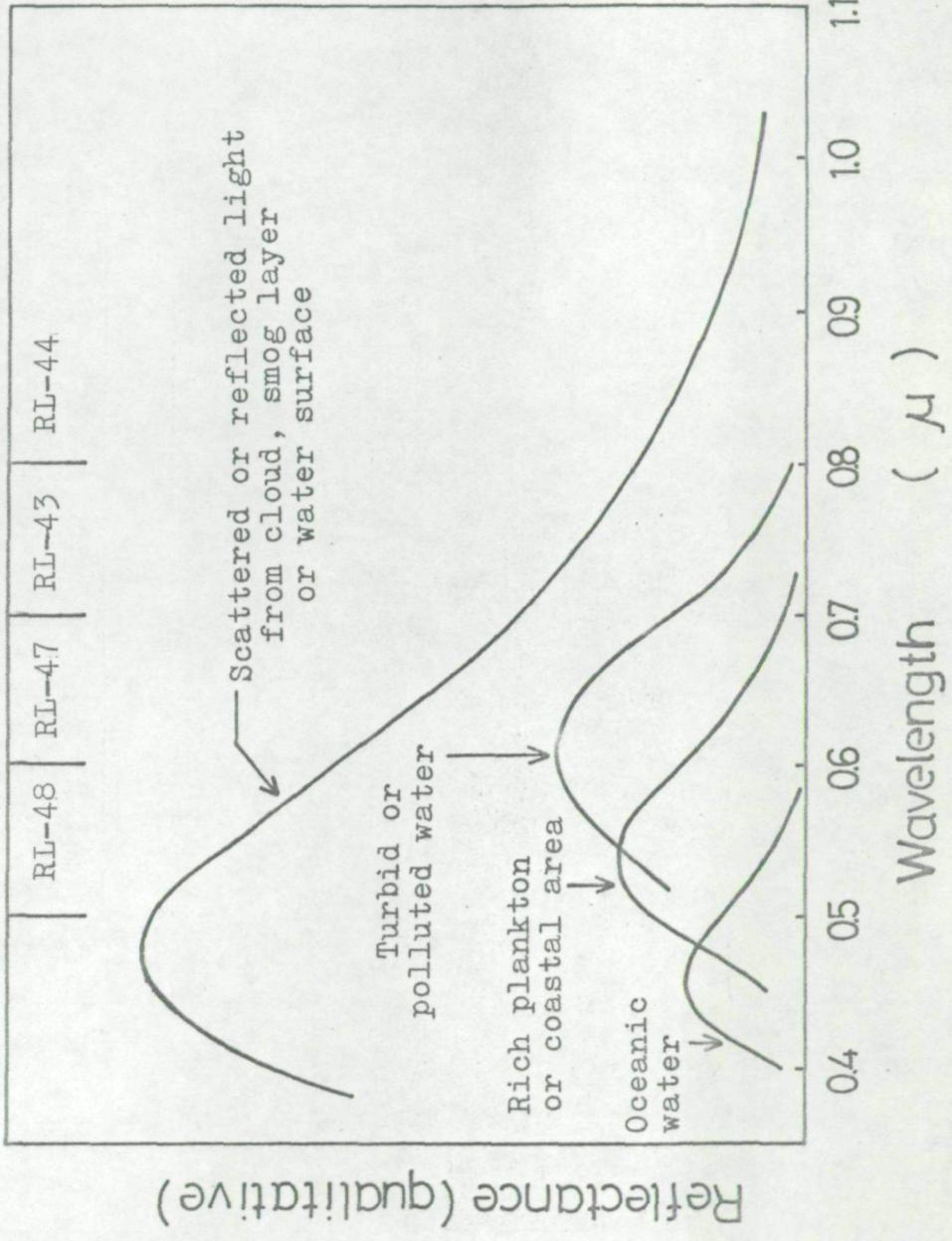


Figure 3 Rough sketch of reflectance spectra for several oceanic conditions beneath the surface and for cloud, smog layer, and sunglitter, all above the sea surface.

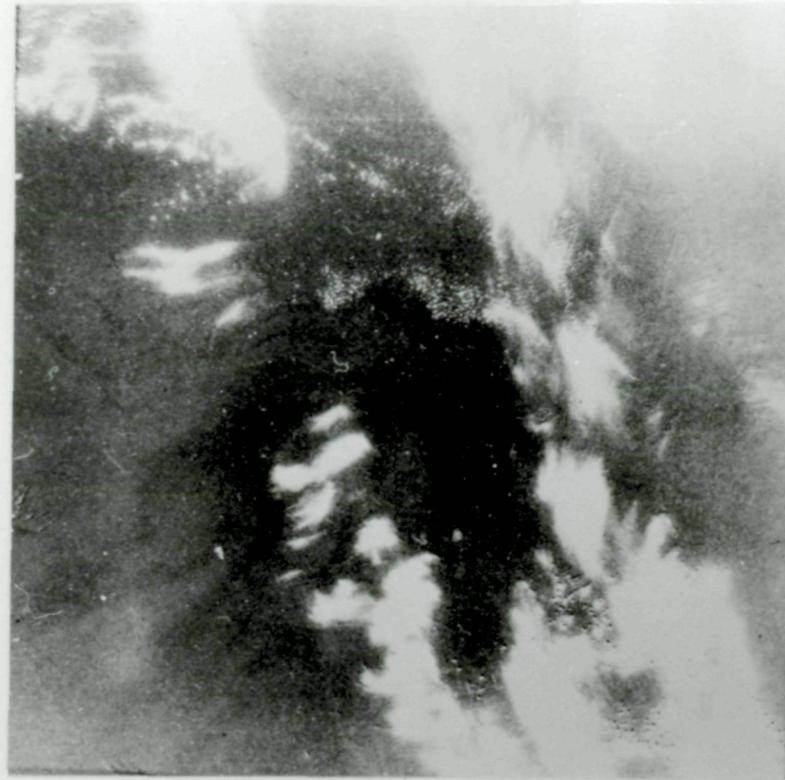
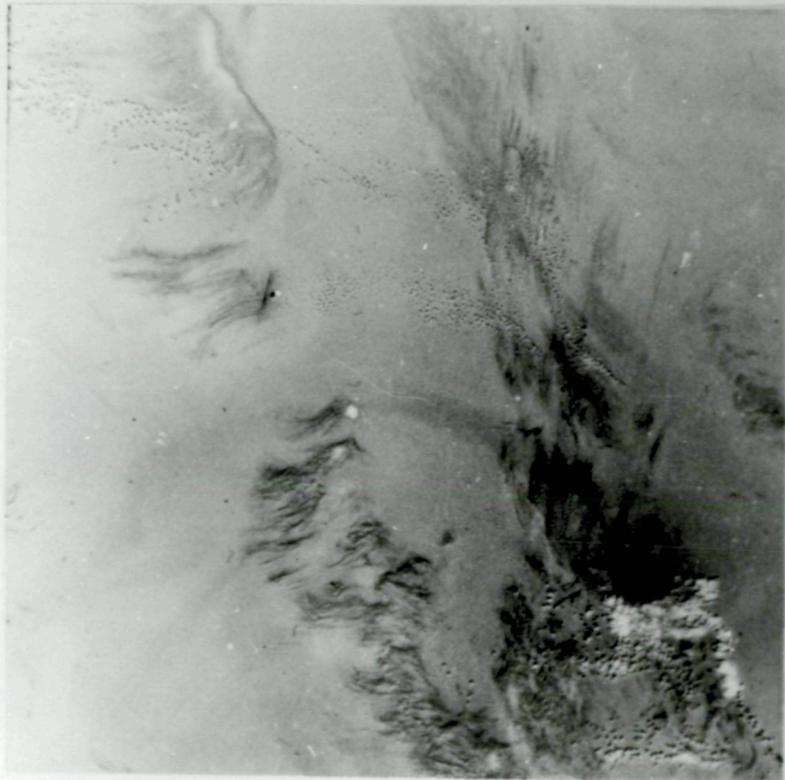


Figure 4 Trial of photographic image masking for extracting colored oceanic pattern in green separately from cloud covers.  
a) The separation is not succeeded. b) The separation is nearly completely made. However, the oceanic pattern is in too low contrast against its surrounding sea.

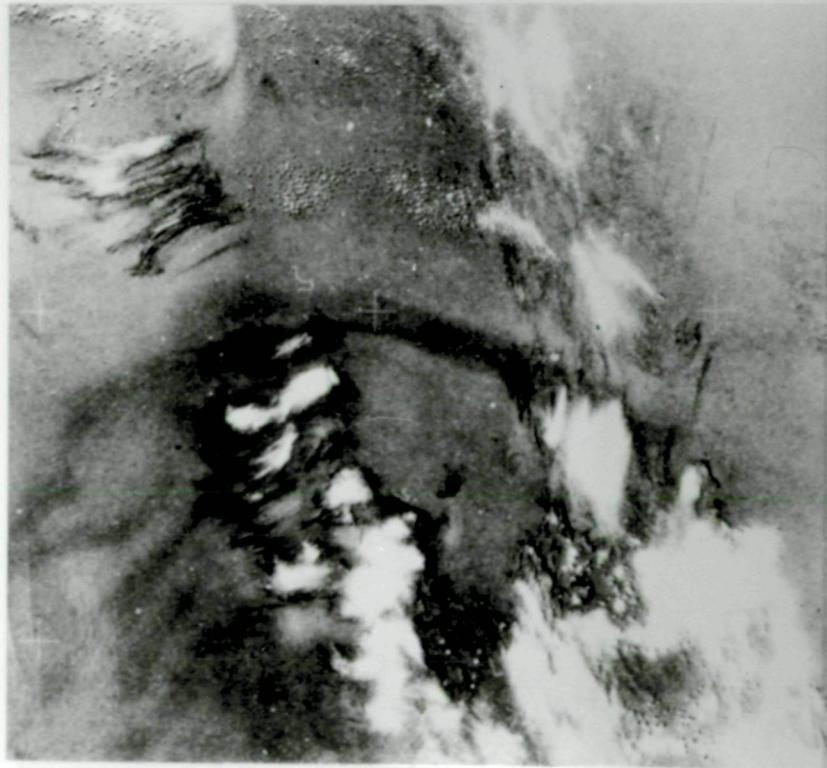


Figure 5 Trials of photographic image masking ( continued ).  
c) The oceanic pattern has sufficiently high contrast, but the separation of cloud covers from the oceanic pattern is again incomplete. d) The extraction of the oceanic pattern separately from cloud covers is succeeded having satisfactory image contrast.



Figure 6 Mosaic of image masking pictures from RL-48 ( green band ) with RL-43 ( near infrared ). The darker pattern likely shows areas of green-clored sea and the white pattern represents cloud covers.



Figure 7 Mosaic of image masking pictures from RL-47 ( 0.6  
-0.7  $\mu$  , yellow-red band ) with RL-43. Here does not  
appear any remarkable pattern in the sea. This confirms  
that the darker pattern in the preceding mosaic corresponds  
to green-colored sea areas.



Fig. 8 Examining scene of a pair of adjoining S190A pictures  
with simple stereoscopes

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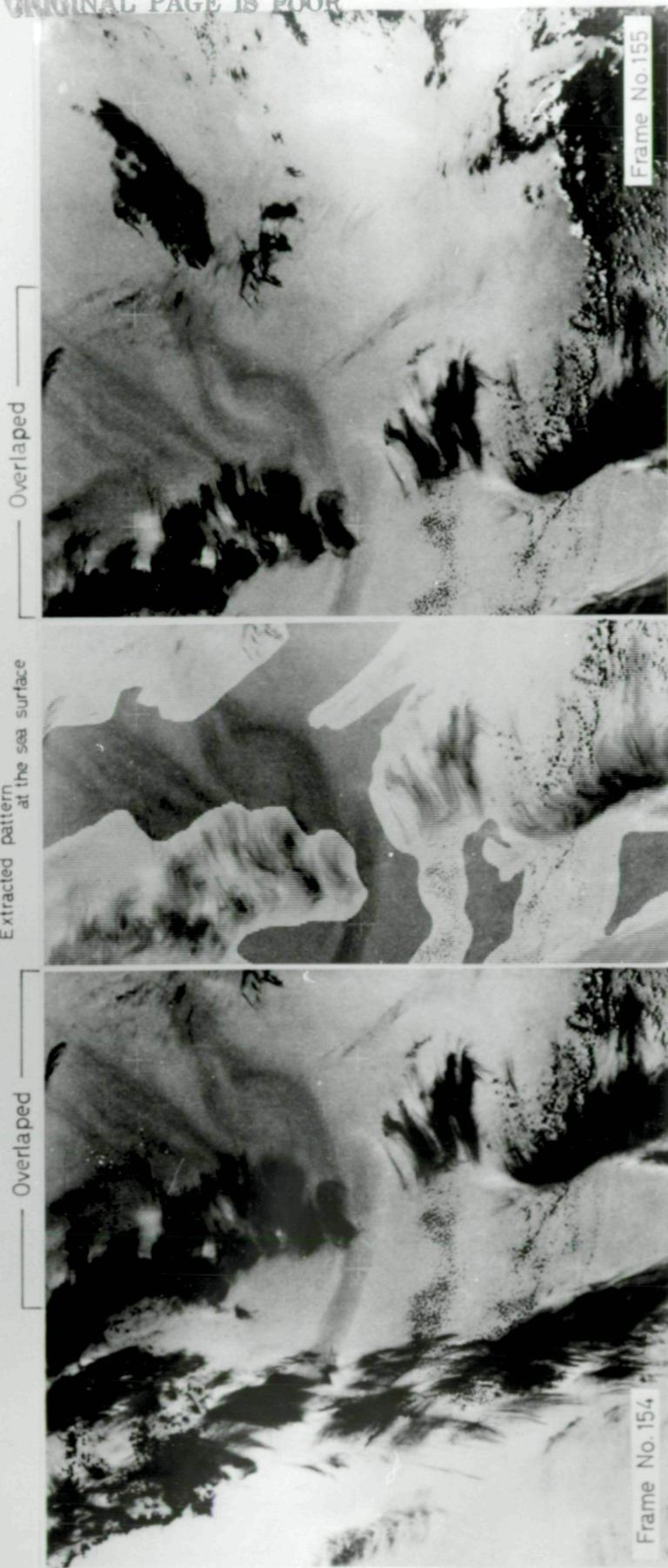


Fig. 9 Overlapped scene in a pair of adjoining SL90A pictures in RL-48 (left and right), and extracted oceanic patterns and cloud patterns (shaded)

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Fig. 10 Mosaic of stereoscopic-examined pictures (Frame Nos. 152, 153, 154 and 156). Shaded patterns are areas covered by Cirrus, Cirrostratus and Cumulus clouds. Belt-like darker grey patterns in the remaining areas are green-colored waters

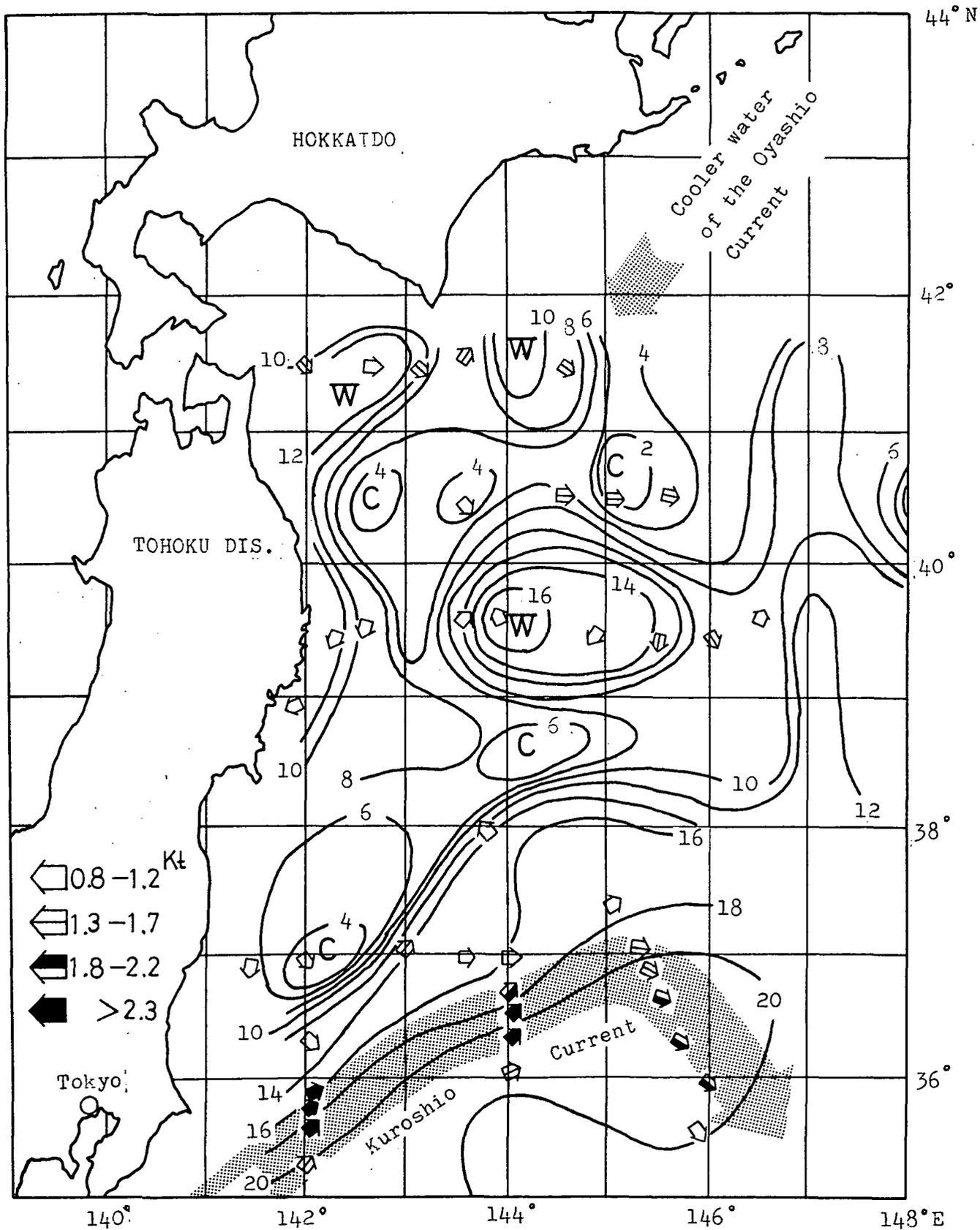


Fig. 11 Water temperature (°C) at the 100m layer and ocean current by GEK, July, 1973

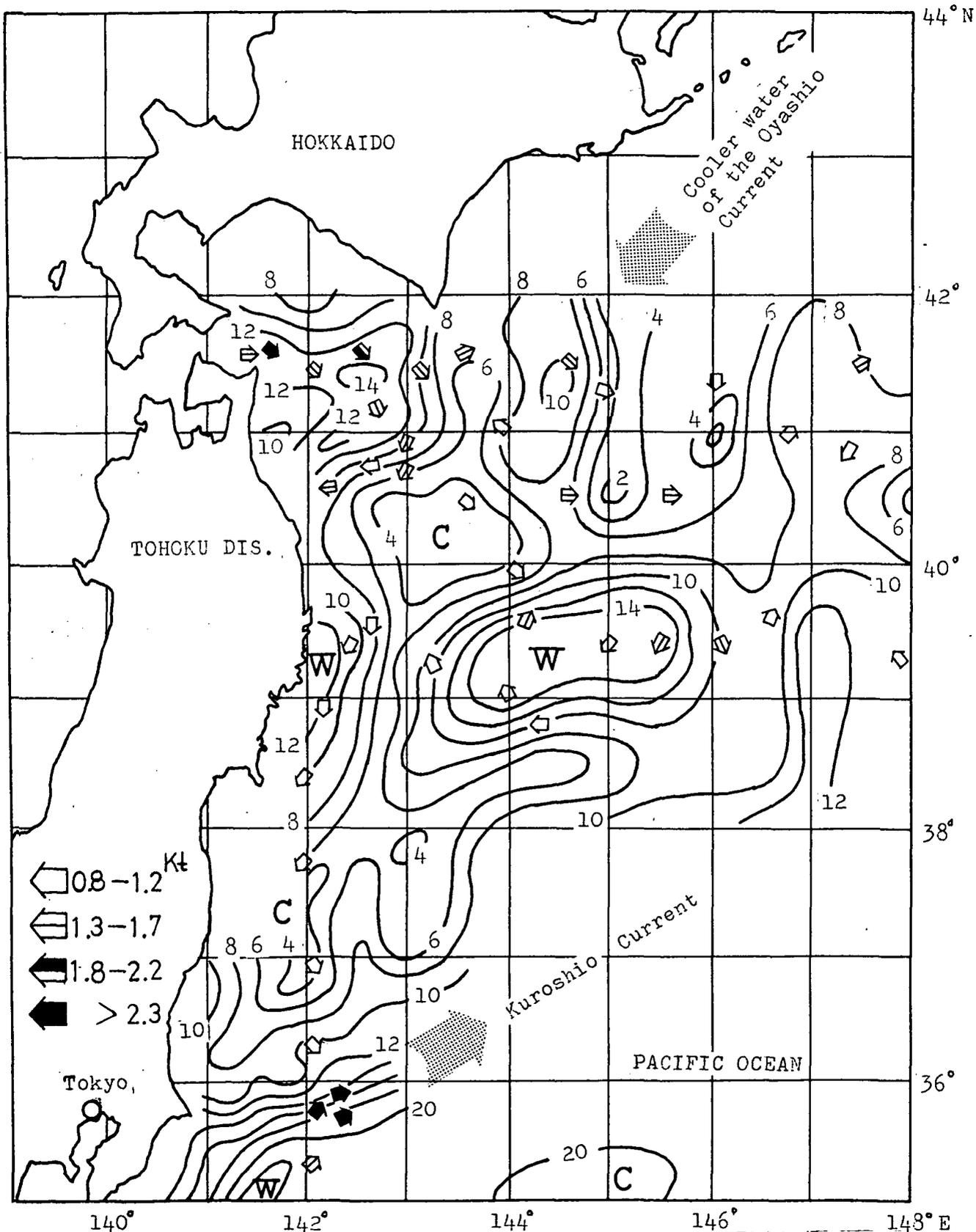


Fig. 12 Water temperature ( $^{\circ}$ C) at the 100m layer and ocean current by GEK, Aug., 1973

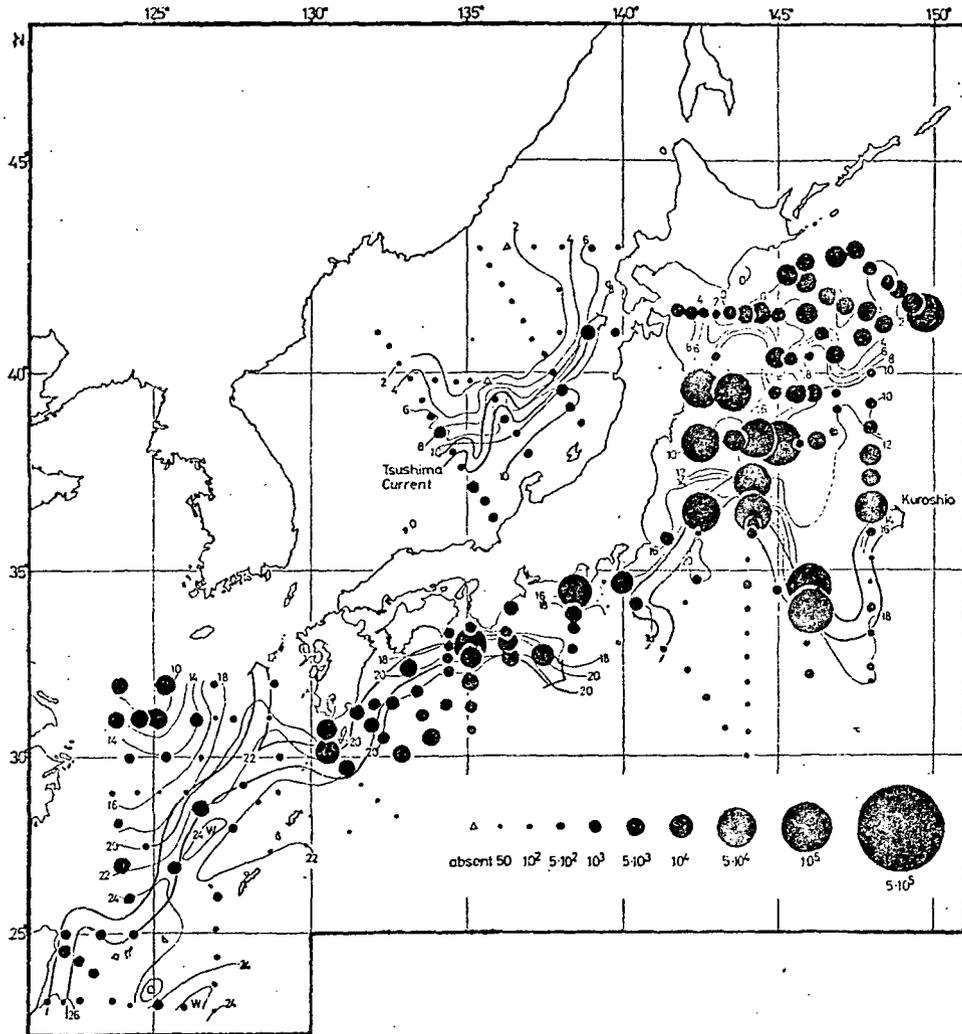


Figure 13 Distribution of diatom standing crops ( cells/l ) and the temperature ( °C ) at the surface neighboring Japan from January to March, 1966. ( after Y.Kawarada et al, 1968 ) .

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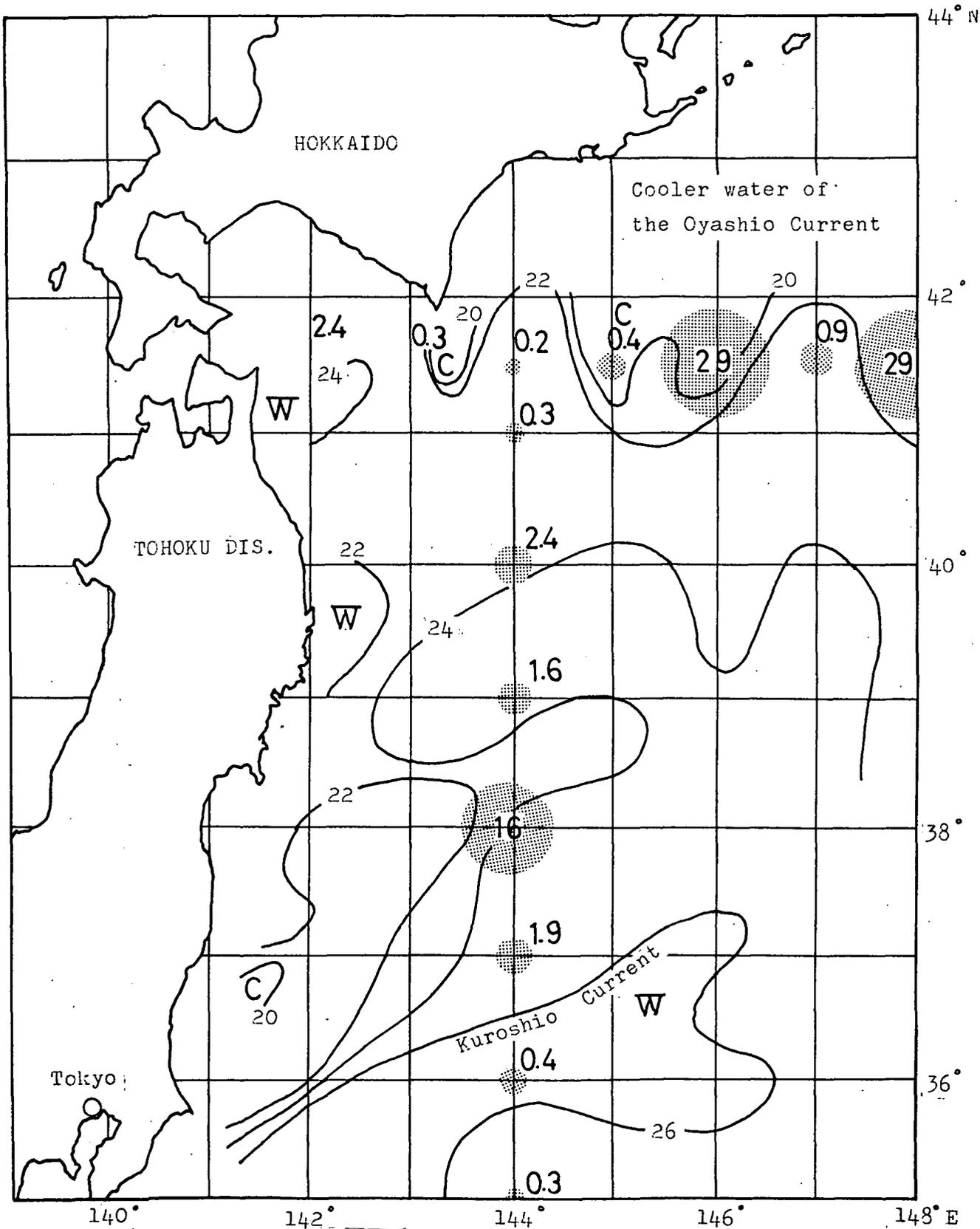
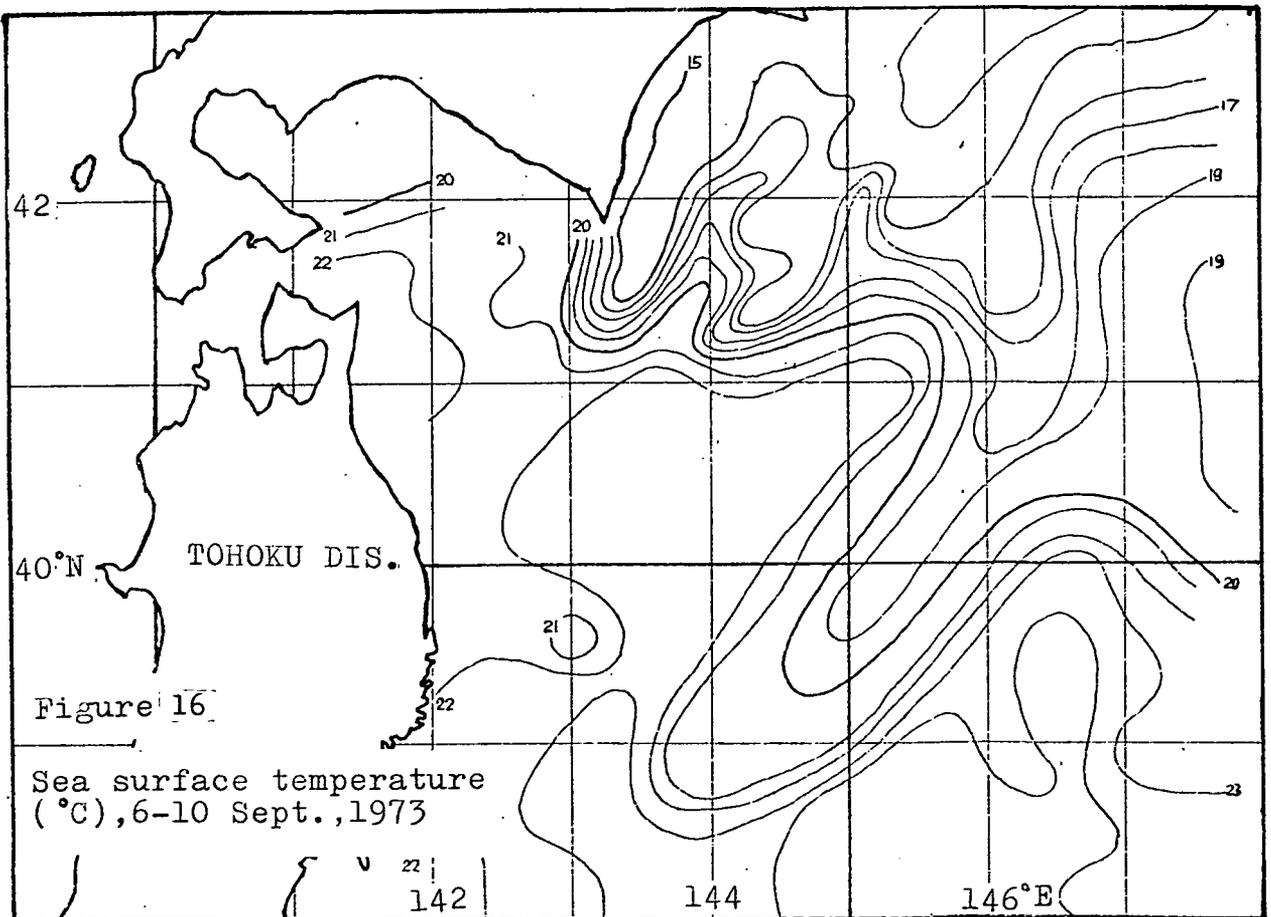
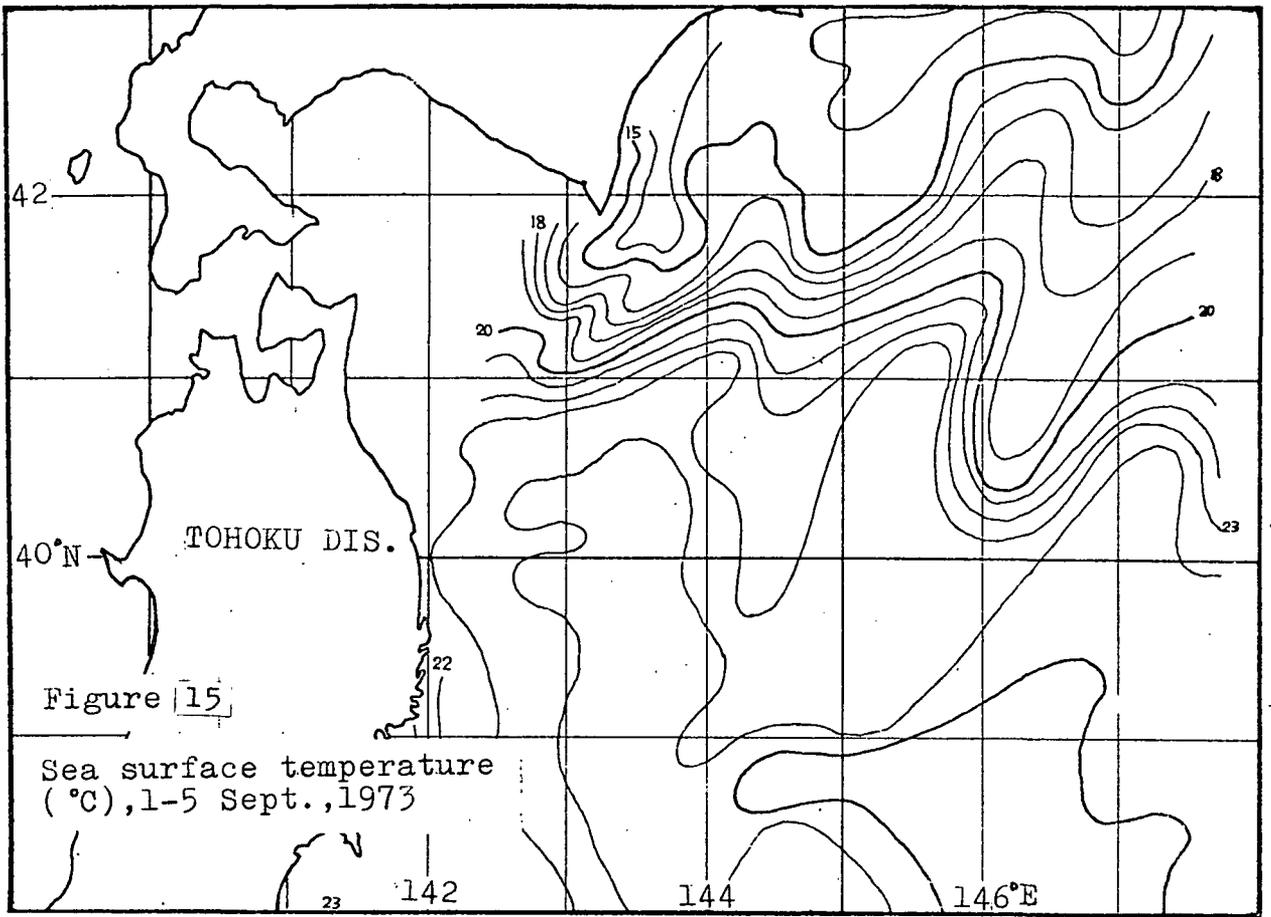


Fig. 14 Sea surface temperature ( $^{\circ}\text{C}$ ) and amounts of microplankton, July, 1973



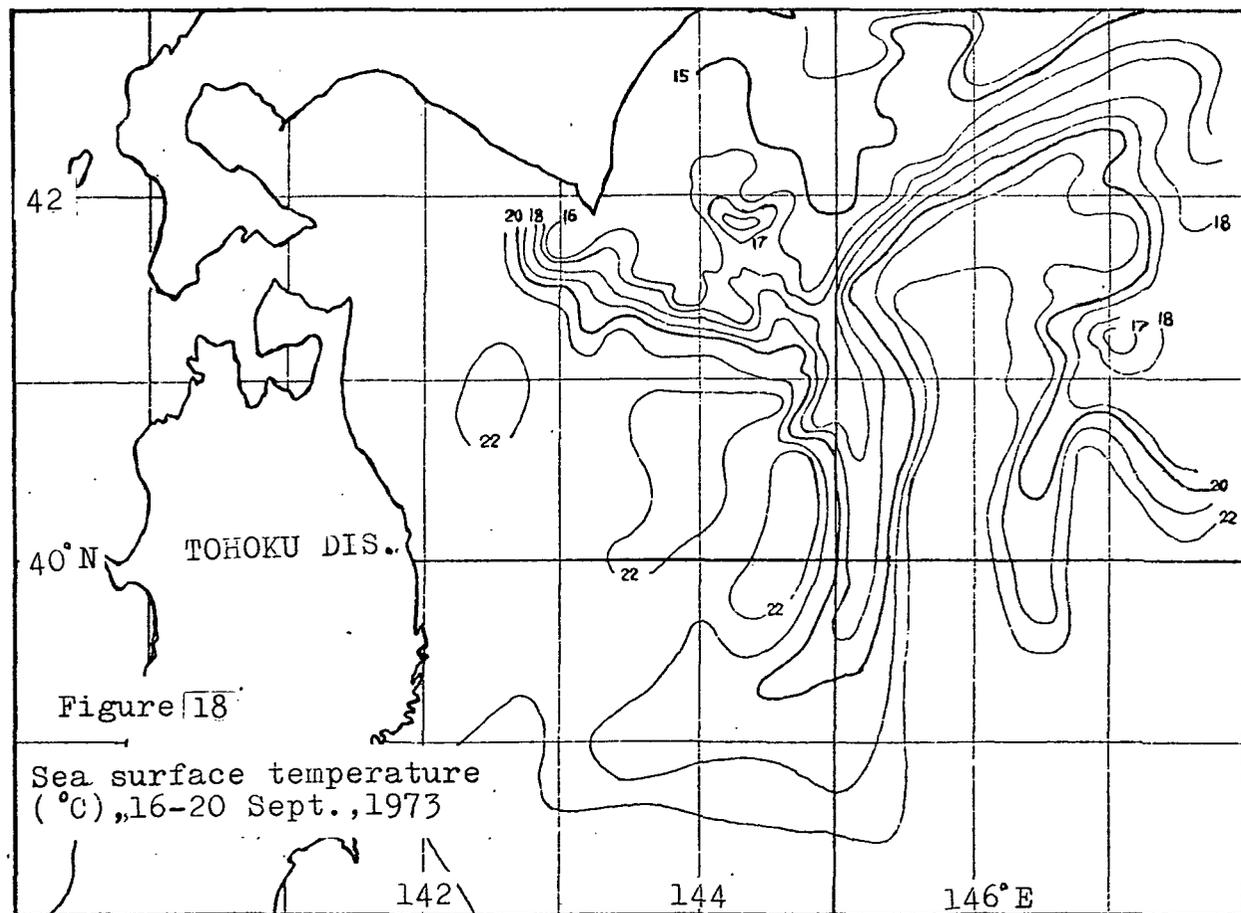
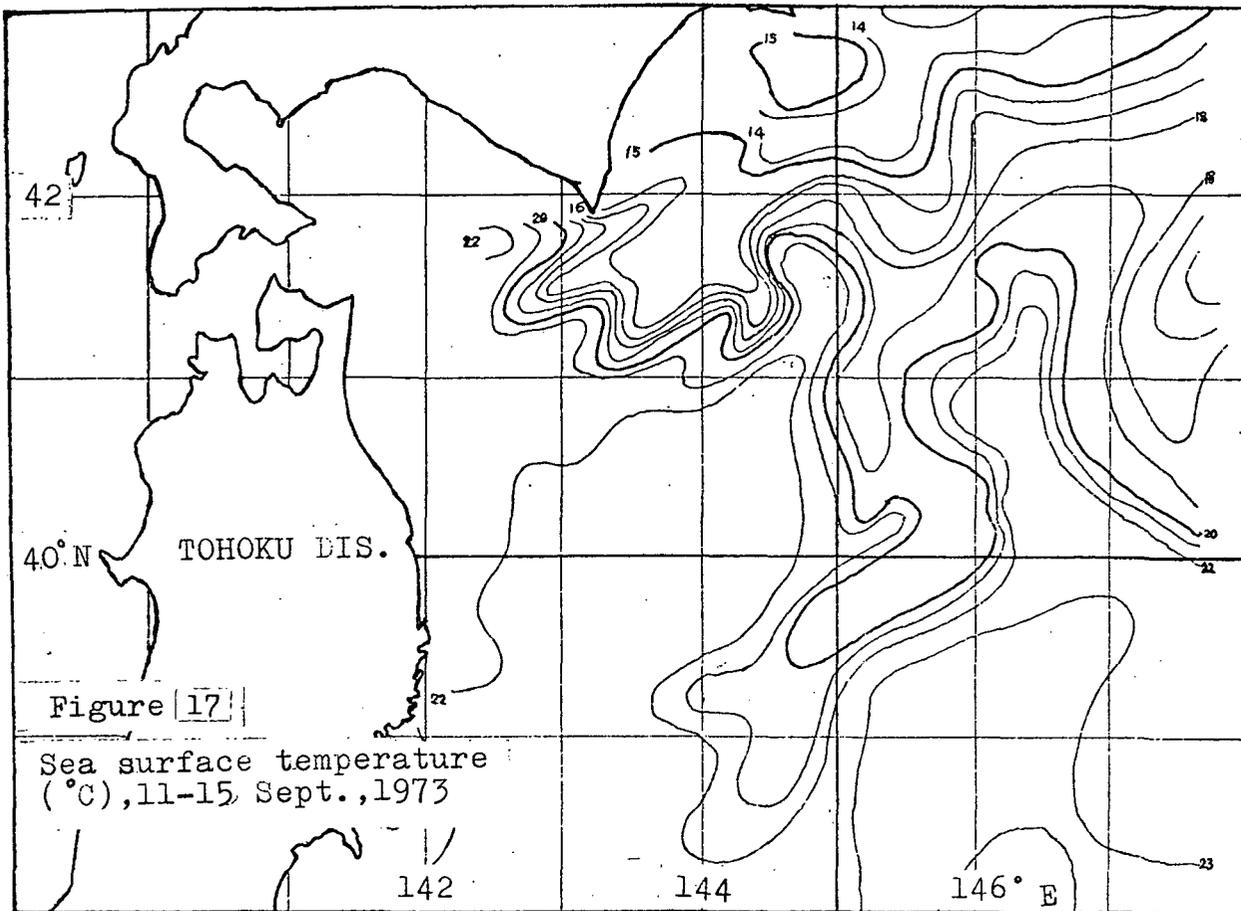




Figure 19 Pattern of green-colored sea extracted from SKYLAB S190A ( MSC ) pictures, 18 Sept., 1973 overlaid with isotherms of the sea surface temperature ( °C ) by surface in 16-20 Sept., 1973.

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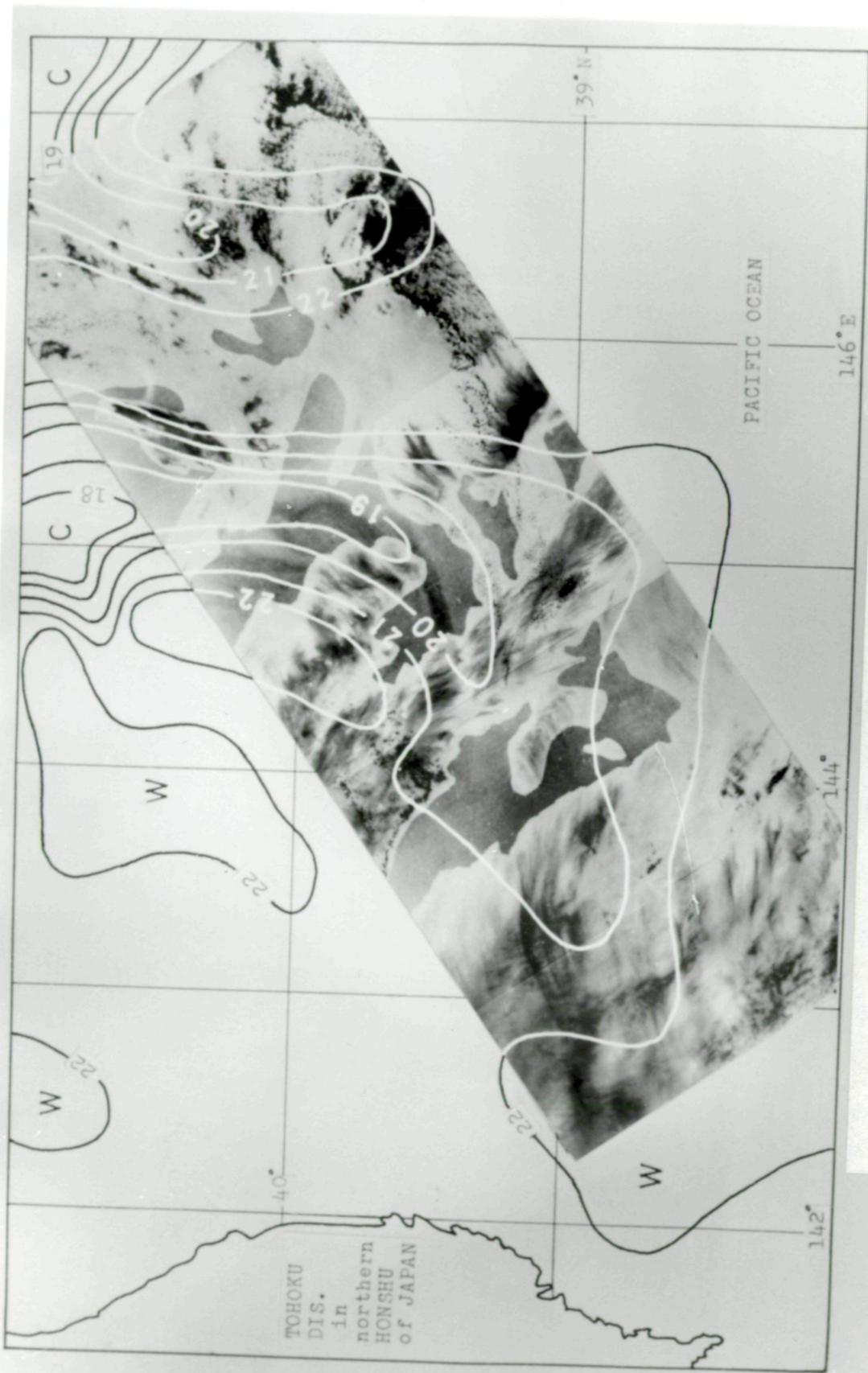


Fig. 20 Pattern of green-colored waters (18 Sept. 1973) extracted by a stereoscopic examination, and superimposed isotherms ( $^{\circ}\text{C}$ ) at the sea surface (16-20 Sept., 1973)