GRADIENTS IN SURFACE PHYTOPLANKTON BIOMASS ON AND AROUND GEORGES BANK

by

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1. Introduction

1.1 Brief historical summary

Georges Bank, Browns Bank and the Northeast Channel are important bathymetric features that affect circulation, hydrography and productivity in the Gulf of Maine, Georges Bank and Browns Bank areas of the northwest Atlantic continental shelf. In this report we present an extensive set of contour maps depicting the distribution of surface pigments (an index of the abundance of the primary producers) and phytoplankton community size composition.

1.2 Principal objectives of present studies

Our objective was to determine if there are discernible and characteristic differences in phytoplankton abundance and community size composition between Georges Bank and the water adjacent to it.

2. Methods

2.1 Data set on which study is based

Water samples for pigment analysis were collected on 54 cruises from October 1977 through March 1982 as part of an extensive ongoing monitoring and assessment program to characterize the ecosystem over the northwest Atlantic continental shelf from Cape Hatteras to Nova Scotia.

2.2 Brief description of methodology in data analysis

Pigment estimates were made from samples processed on shipboard according to methods of Evans and O'Reilly (in press). Surface chlorophyll a mg m^{-3} and surface phaeophytin a mg m^{-3} were added to give an estimate of total pigments present in surface waters. Additionally, the percentage of community chlorophyll a (percentage nannoplankton) contributed by the nannoplankton size fraction (<20 μm) was calculated. Pigment data collected for surface waters east of 71°00' latitude from 18 cruises between 1980-1982 were examined to determine if characteristic gradients in phytoplankton abundance and community size composition were present between Georges Bank and surrounding water.

Distributional maps for total pigments and percentage nannoplankton were generated using SYMAP program, version 5, Harvard Center for Environmental Design Studies, Laboratory for Computer Graphics and Spatial Analysis. In order to determine the frequency and intensity of gradients in these phytoplankton parameters, the outer portion of Georges Bank, as defined by the 200 m isobath, was divided into seven sections based on latitude and longitude (Figure 1). Distribution of the total pigments and percentage nannoplankton for each section of the bank were individually examined, cruise-by-cruise.

3. Results

A total of 18 cruises was analyzed between February 1980 and March 1982. Contoured depictions of total pigments and percentage nannoplankton for each of these surveys are presented in Figures 2 and 3. Based on these depictions, Figure 4 summarizes the apparent existence of gradients in seven areas around the bank. We define gradients as progressive changes in phytoplankton distribution (pigments or percentage nannoplankton) that occur over relatively short distances and separate two areas of biomass different from each other. The presence of gradients in pigment data between the surface water on Georges Bank and in surrounding surface water is considered here as evidence of a transition zone or ecotone with concentrations of phytoplankton different on each side of the gradient.

The number of sections or areas of the bank examined from each survey varied from 3-7. This resulted in a total of 180 observations (90 total pigment, 90 percentage nannoplankton). In Figure 4, each section of the bank for which data are available from a particular cruise is represented by a box. The upper triangular portion indicates the presence or absence of a gradient in the percentage nannoplankton data. The lower portion represents the presence or absence of gradients in total pigment data. In general, there are more data from the western portion of the bank, sections 1, 2, 6 and 7 (Figures 1 and 4).

Gradients present on the northern portion of the bank occur around the 200 m isobath with pigment concentrations to the north in the Gulf of Maine much lower than those in the adjacent area of the bank. Gradients present on the southern portion of Georges Bank are associated with water between 60-100 m, and pigment concentrations on the Georges Bank side of the gradient are higher than those in waters seaward of the 100 m isobath.

In general, the trends in percentage nannoplankton data followed the total pigment data, with higher concentration of netplankton found on Georges Bank than in surrounding water. The fact that high biomass concentrations are found on Georges Bank and that netplankton generally is found in greater quantities than nannoplankton, makes Georges Bank a more highly productive area where energy can be transferred efficiently through the system.

A major argument advanced by Ryther (1969) and Parsona and LeBrasseur (1973) outlines the importance of the size of the phytoplankter as well as the quantity of phytoplankton being produced and available to higher links in the marine food chain. In this scheme, the smaller nannoplankton are grazed by microplankton, the microzooplankton are grazed by macro-zooplankton and fish graze the macrozooplankton, whereas the carbon and energy of the relatively larger netphytoplankton is consumed directly by macrozooplankton which in turn are direct prey for fish. The consequence of this scheme is that netphytoplankton-dominated algal communities may lead to greater energy and matter inputs to higher (fish) trophic levels since the netplankton grazing scheme has fewer trophic transfers (and associated energy losses) than nannoplankton-based food chains.

In a paper entitled "The structure of plankton communities", Steele and Frost (1976) state "...the primary conclusion is that size structure is as important and probably more significant than total biomass in determining modes of transfer between trophic levels." From the foregoing, the shallow <60 m area on Georges Bank, in addition to being a highly productive area (470 g C m^{-2} y^{-1}), is also an area where the potential "usable" particulate carbon production is high.

Evidence of gradients on and around Georges Bank was present in total pigments and percentage nannoplankton data during most surveys. In the EVRIKE 80-01 survey, there was no evidence of gradients in either data sets but only the western half of the bank was sampled. The distribution of surface biomass was peculiar relative to anything observed previously and more data would have been necessary to determine the presence or absence of gradients. There was some ambiguity in the presence of gradients in pigment and nannoplankton data on ALBATROSS 80-07, DELAWARE 80-09 and ALBATROSS 82-01 surveys. This was due to inadequate sampling that resulted in insufficient data to determine the presence or absence of gradients. As a result, these four cruises were not considered in the following discussion.

The evidence concerning the presence or absence of gradients between Georges Bank and surrounding areas varied with surveys and seasons of the year. The presence of gradients was most obvious during late winter (February-March) during all three years surveyed. During these sampling times, gradients in total pigment data were marked in all sections of the bank sampled. There was some variation in the percentage nannoplankton distribution but, in general, it was similar to the pigment distribution in most of the sections sampled. During these months we consistently observed gradients in both the pigment and percent nannoplankton data as well as strong occurrence between these two phytoplankton parameters.

During spring there was reduced correlation between these two parameters. From late March through June, gradients in the nannoplankton data were more obvious (marked) and were found in nearly all sections sampled. During these months, gradients in pigment data were seen less frequently and were not as strong as those in nannoplankton data. Out of 22 sections examined, 21 had gradients (14 marked, 7 ambiguous) in the nannoplankton data. Fifteen sections had gradients (9 marked, 6 ambiguous) in the pigment data.

During summer months of July, August and September, gradients were present almost exclusively in the pigment data. Marked gradients were observed 11 times in pigment data while only once in nannoplankton data. Gradients were observed ambiguously three times in both pigment and nannoplankton data during this time period. During fall and early winter, from October through December, evidence of gradients was found in all sections sampled but strength of the gradients was not consistent among sections. Evidence for the presence of gradients was strong on both the north and south portions of the bank, being slightly stronger on the northern portion.

Comments concerning the presence of gradients on the easternmost section of the bank cannot be made as this portion of the bank was sampled too infrequently.

We possess insufficient data on the Scotian Shelf to permit generalizations concerning the distribution in phytoplankton abundance and size composition.

4. Summary

Surface pigment data east of 71°00' latitude was examined from 18 cruises from February 1980 through March 1982 for the presence of gradients. Gradients were interpreted as an indication of transition areas between two different biomass regimes. The presence of gradients was observed between Georges Bank and surrounding waters during most sampling times.

In general, surface data on Georges Bank are highly representative of phytoplankton concentrations throughout the euphotic layer (O'Reilly and Evans, 1981). Consequently, the data presented in this report suggest that standing stocks and productivity of phytoplankton are generally greater on Georges Bank than in surrounding water.

5. Conclusion

The finding of recurrent gradients in the phytoplankton parameters between Georges Bank and surrounding waters indicates that the bathymetry and resulting hydrography are important factors which govern the distribution, abundance and production of phytoplankton.

6. References

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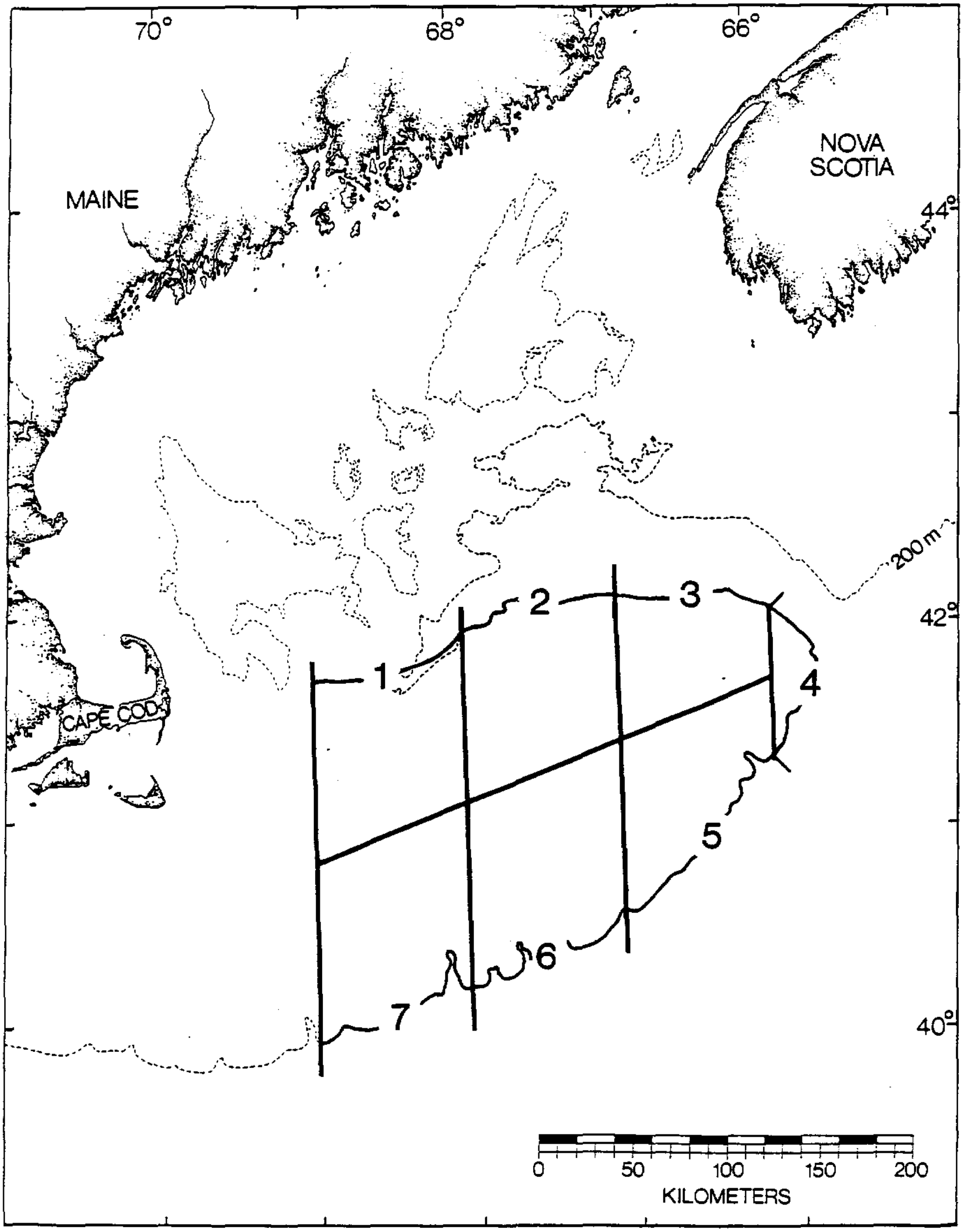
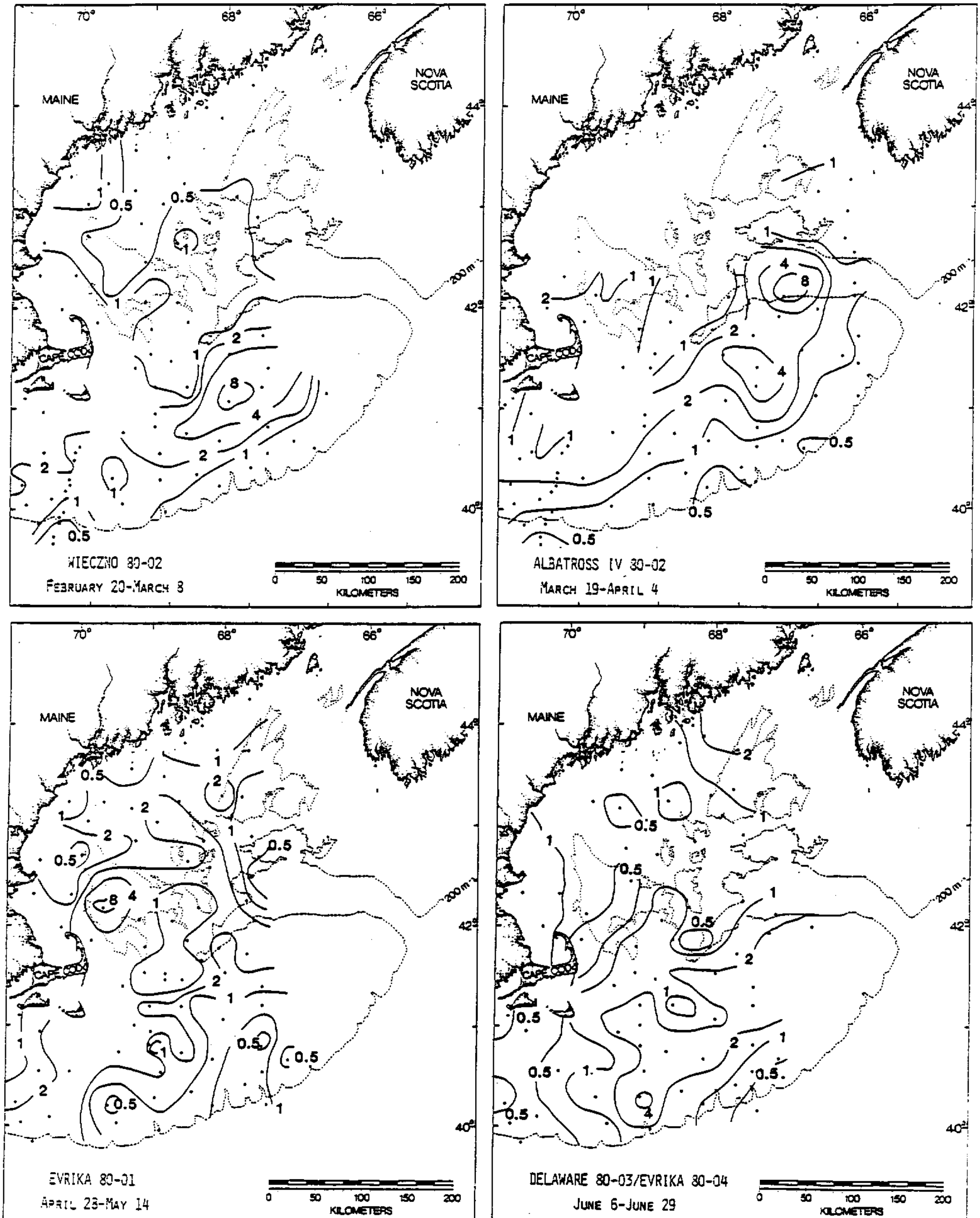


Figure 1. Sectional division of the peripheral area of Georges Bank for determination of the presence or absence of gradients.

Figure 2. Contoured distribution of total surface pigments for eighteen cruises from February 1980 thru March 1982.



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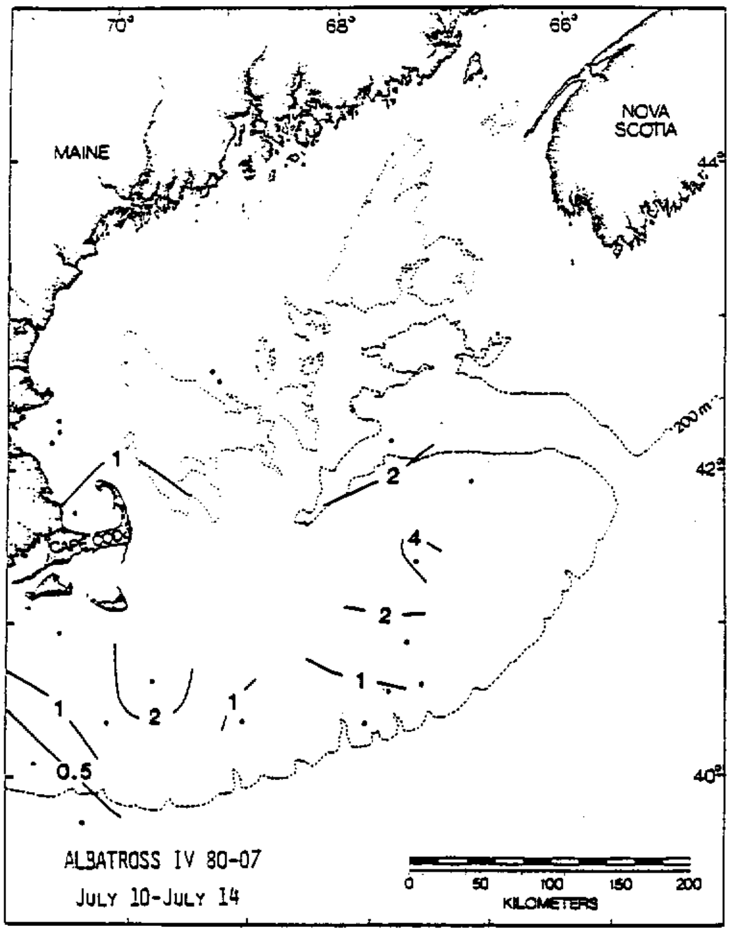
WIECZNO 80-02
FEBRUARY 20-MARCH 8
ALBATROSS IV 80-02
MARCH 19-APRIL 4
EVRIKA 80-01
APRIL 23-MAY 14
DELAWARE 80-03/EVRIKA 80-04
JUNE 6-JUNE 29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JULY 10-JULY 14
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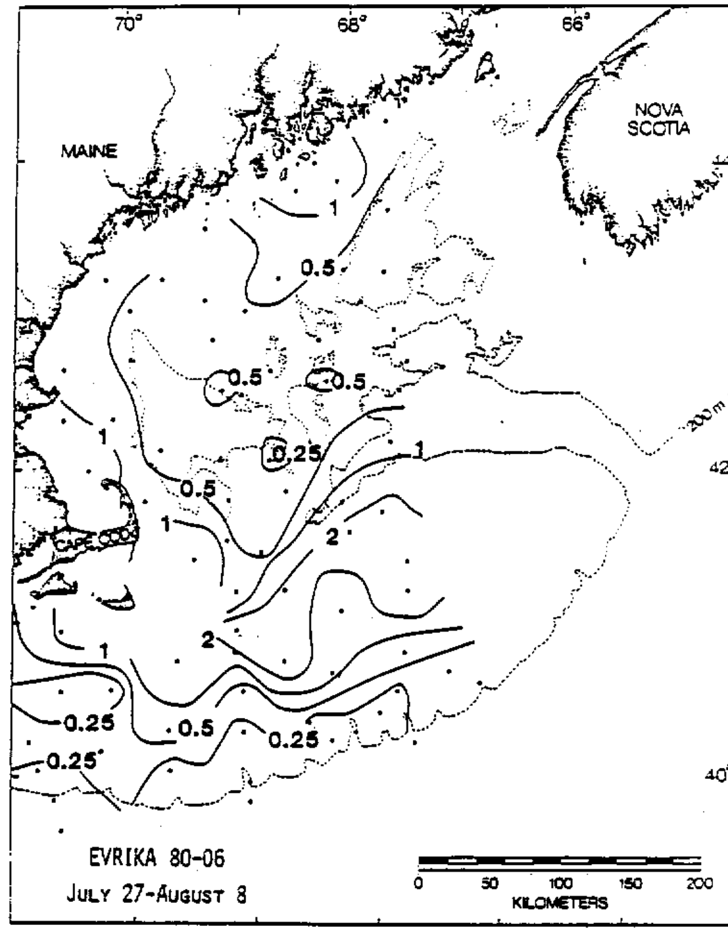
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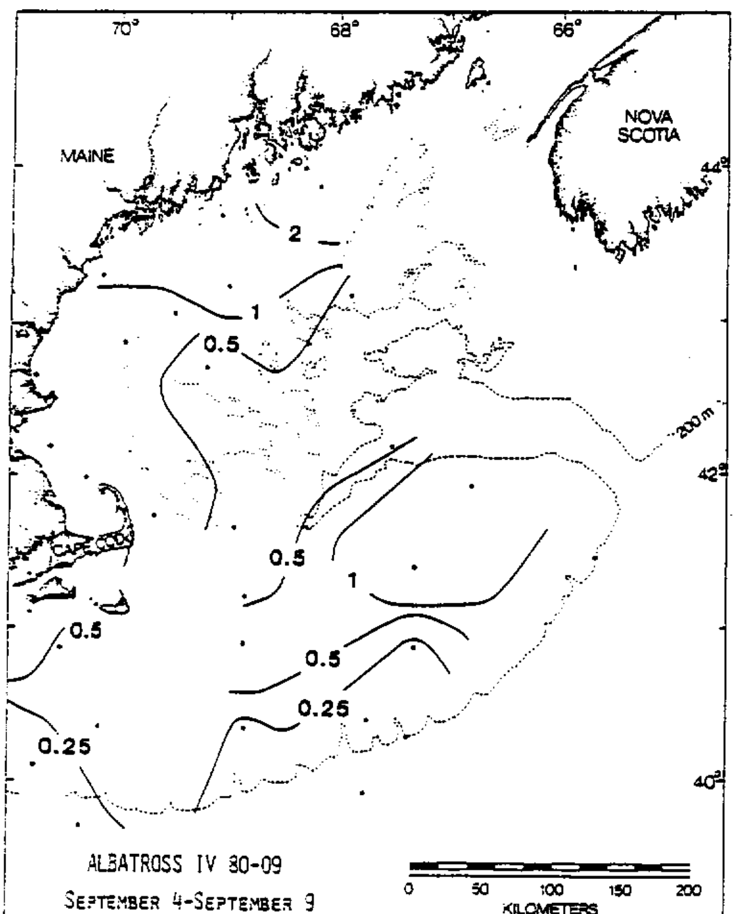
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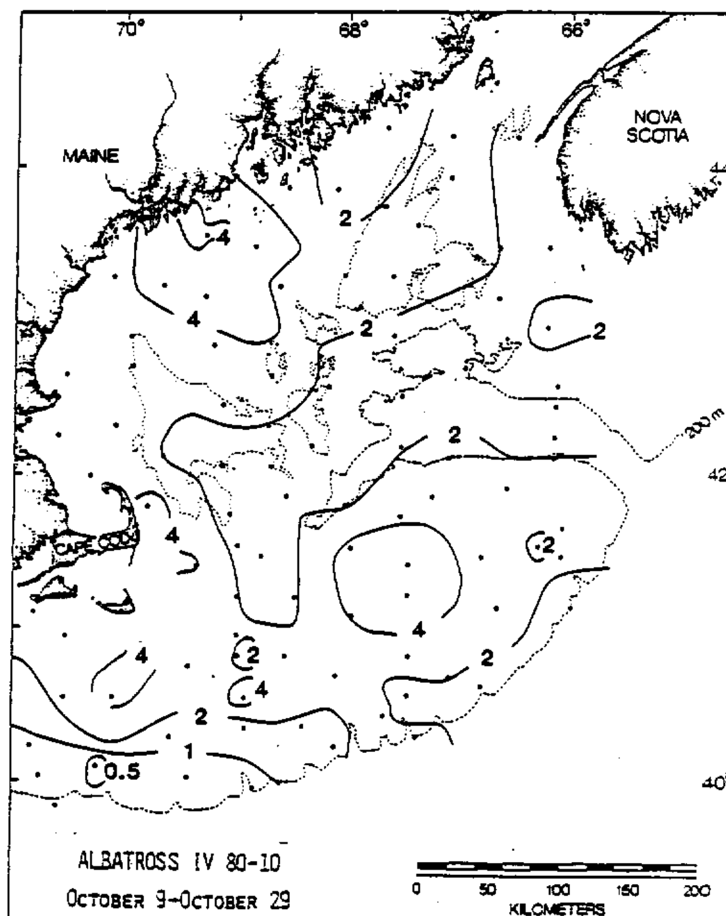
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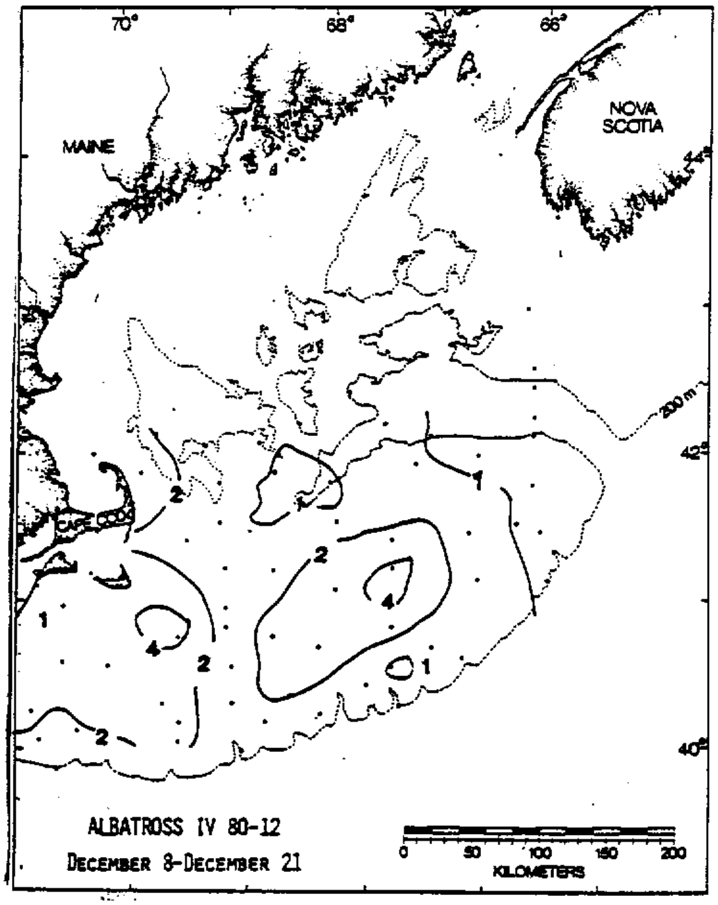
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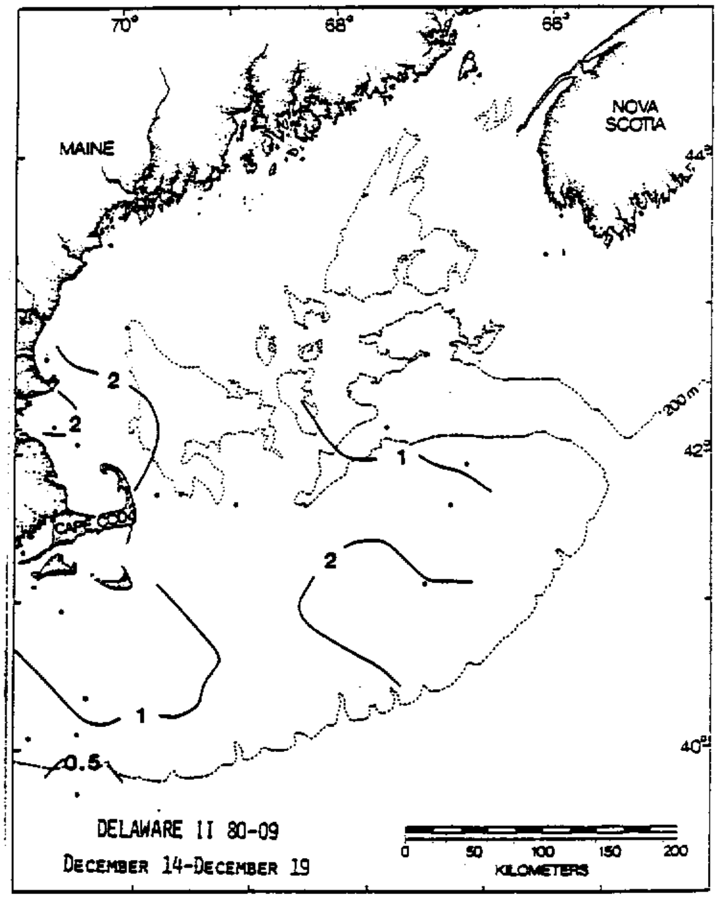
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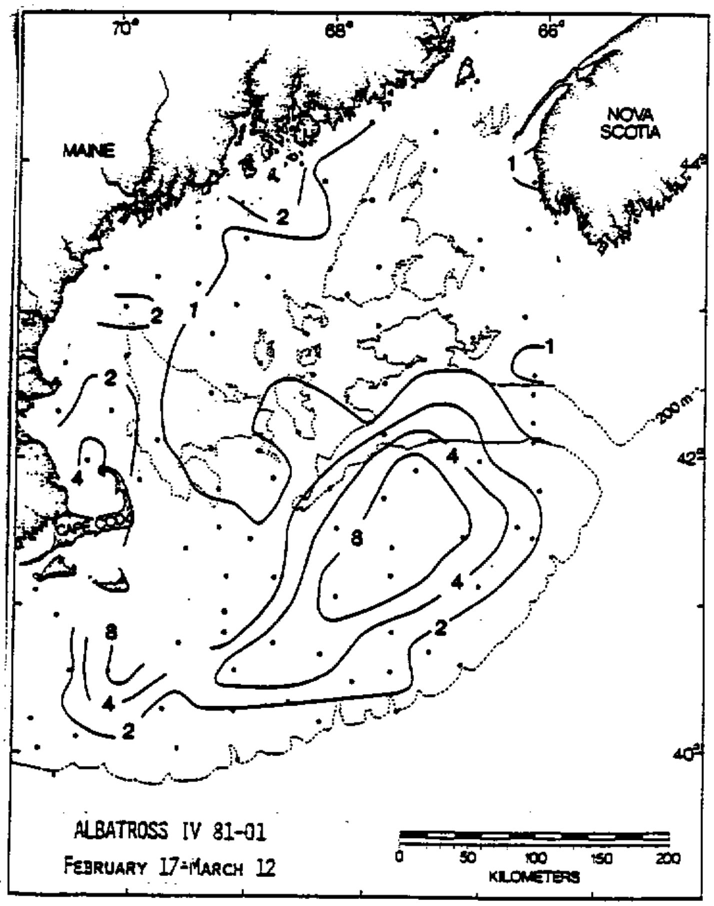
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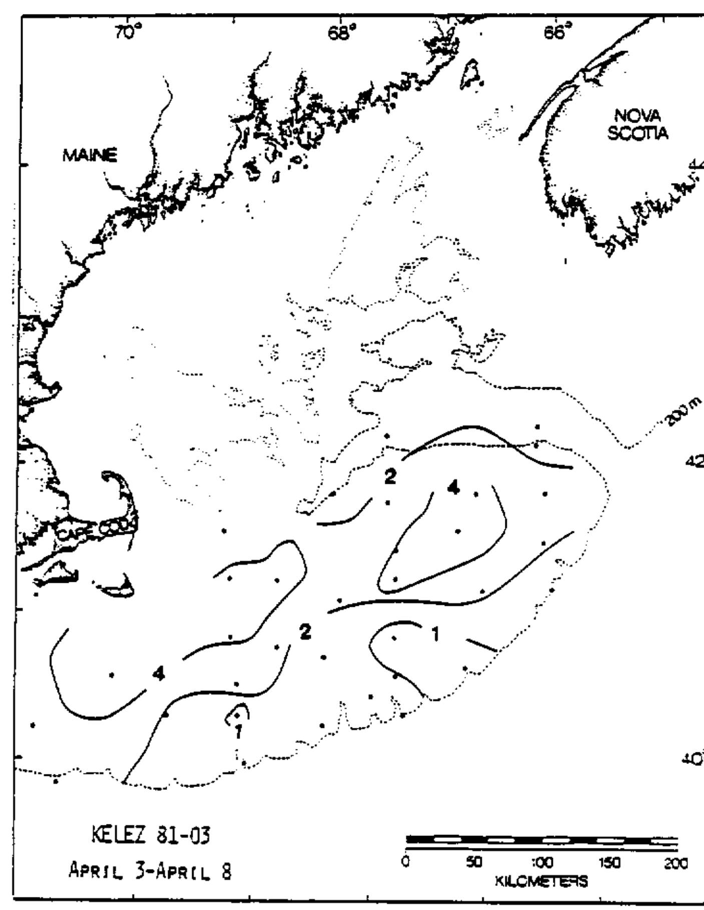
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CAPE COD
KELEZ 81-03
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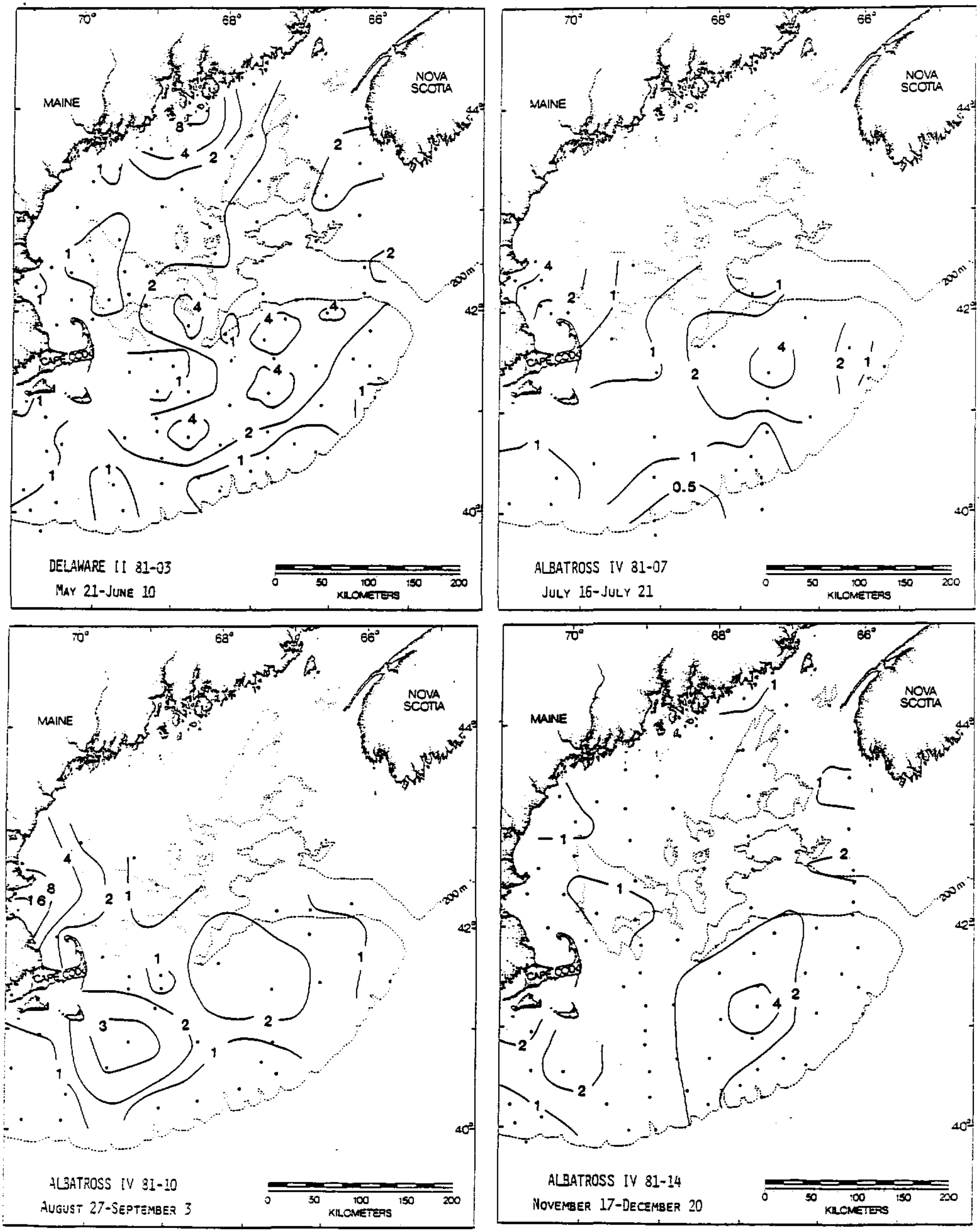
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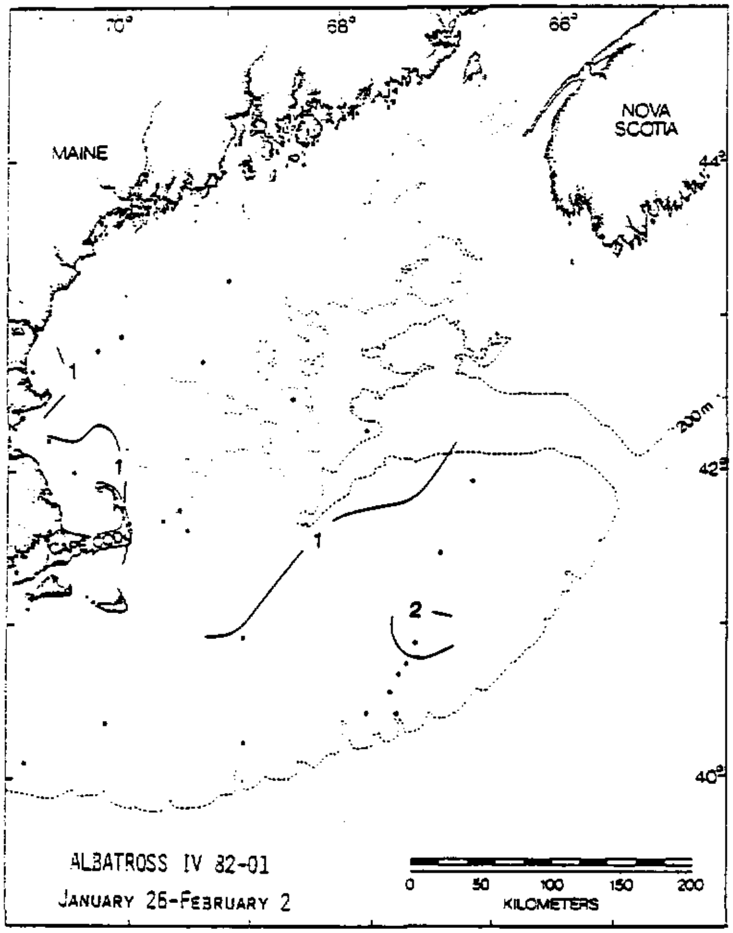
July 16-July 21
ALBATROSS IV 81-10
August 27-September 3
ALBATROSS IV 81-14
November 17-December 20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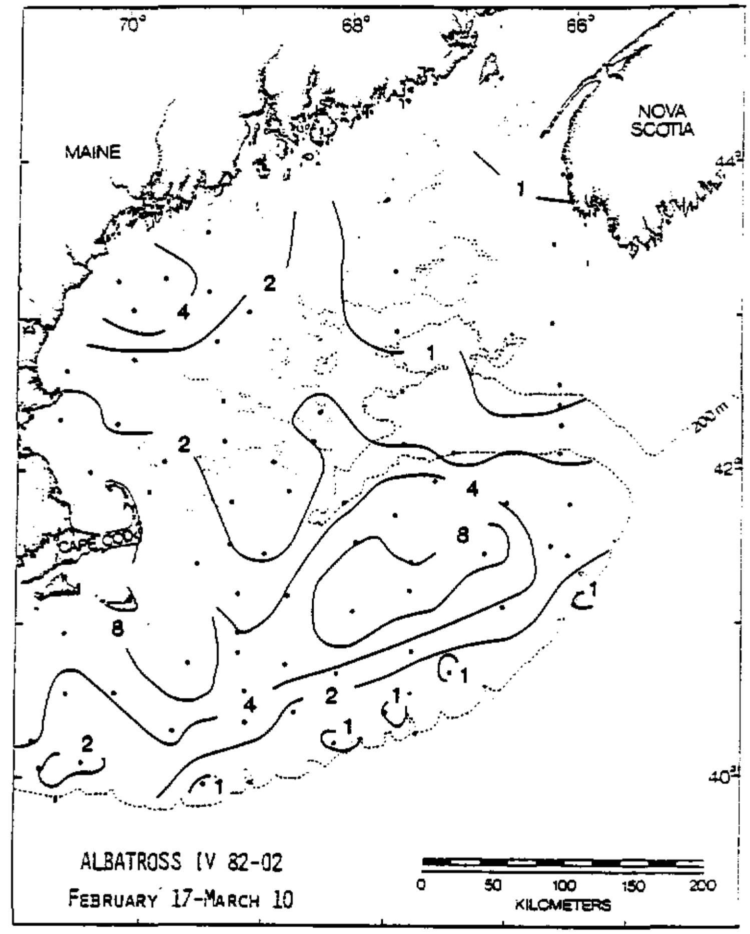
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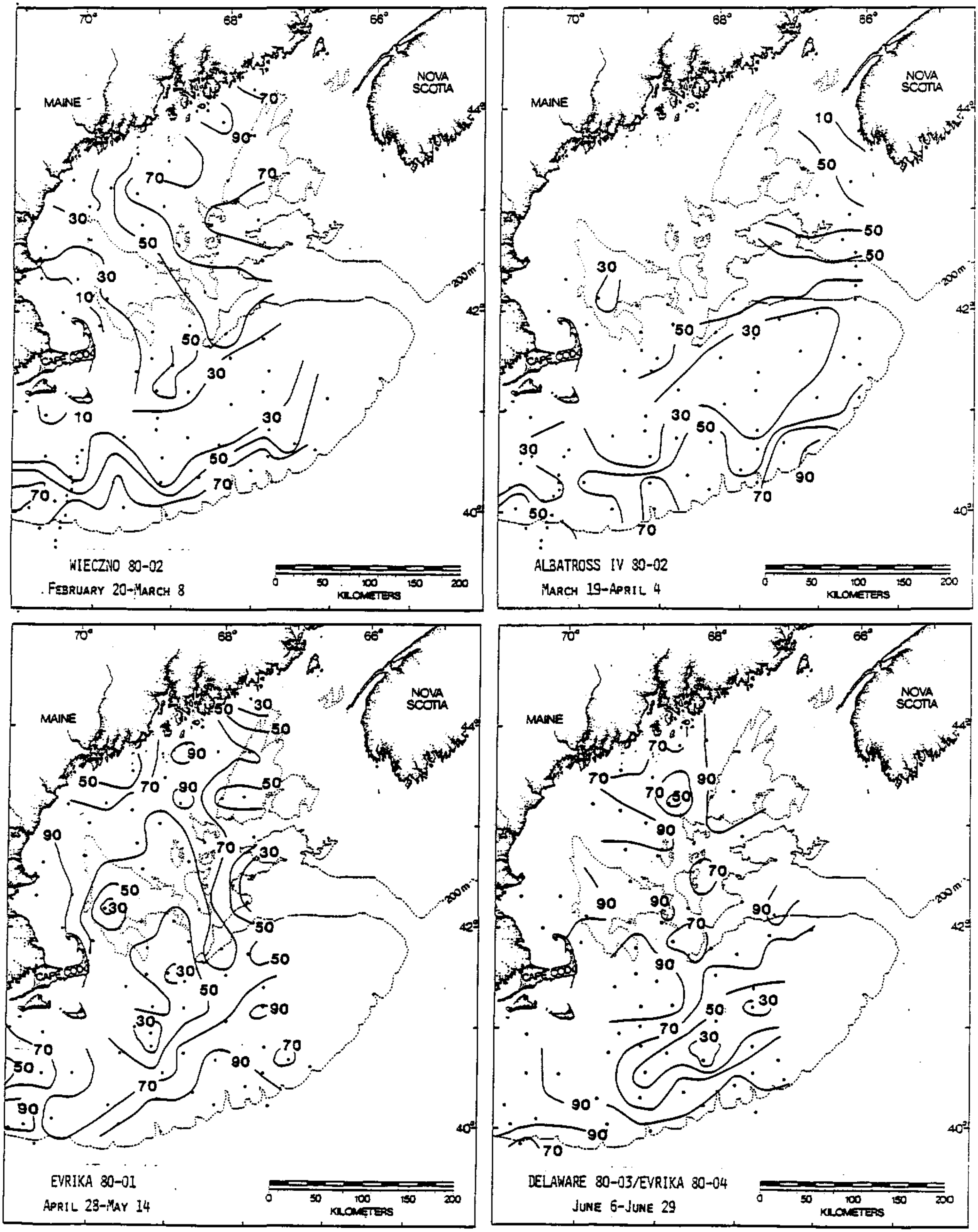
Figure 3. Contoured surface distribution of percentage nannoplankton for eighteen cruises from February 1980 thru March 1982.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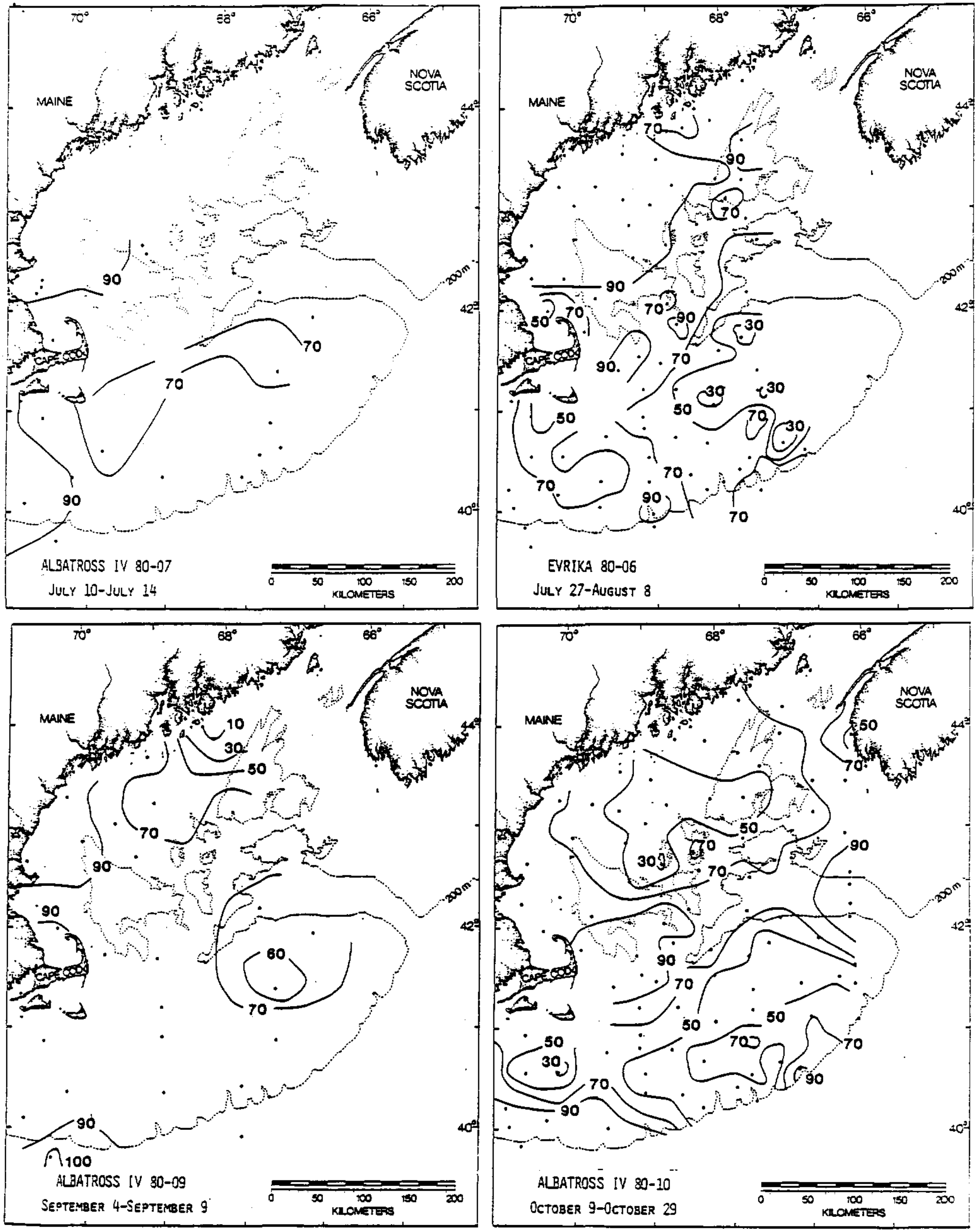
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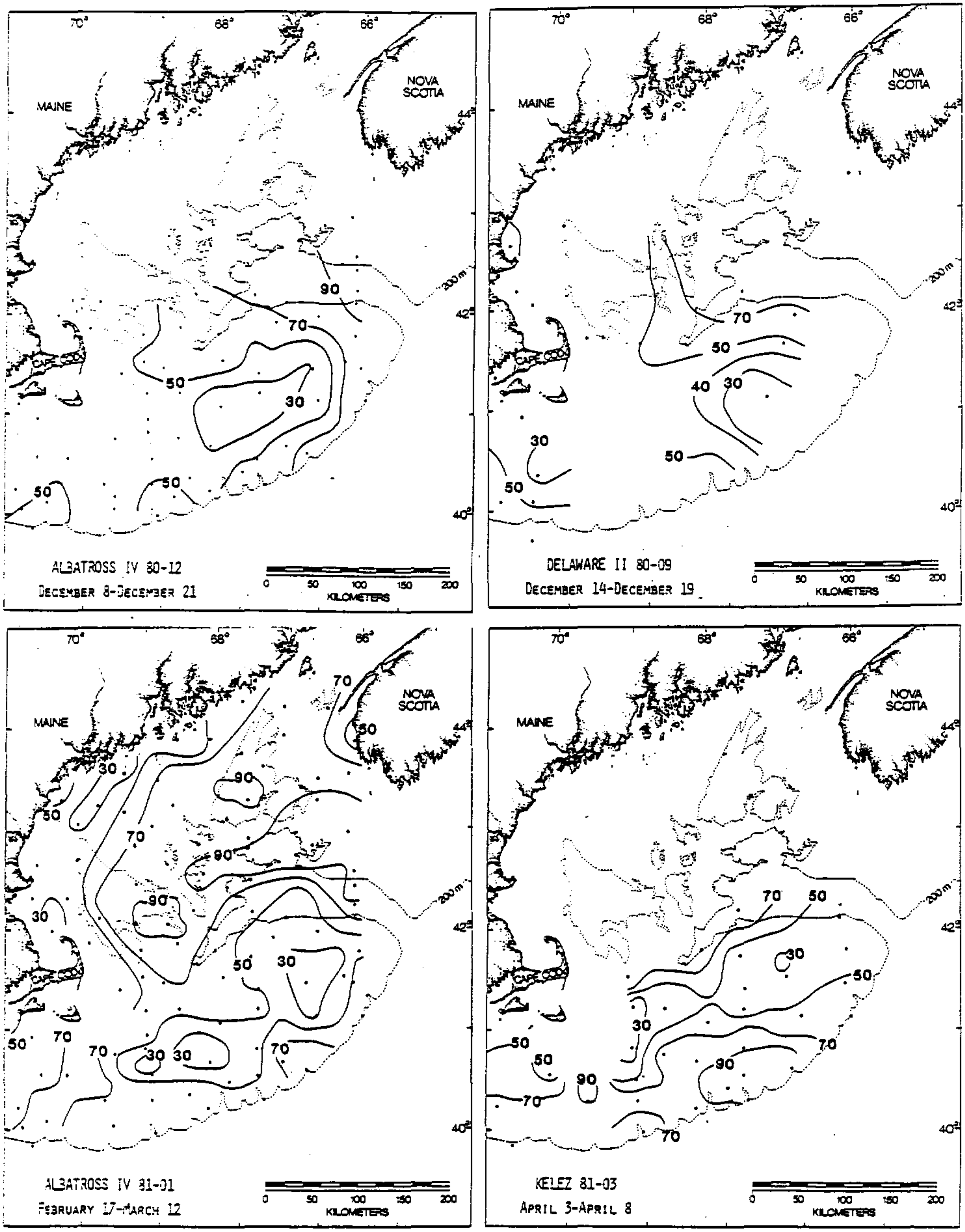

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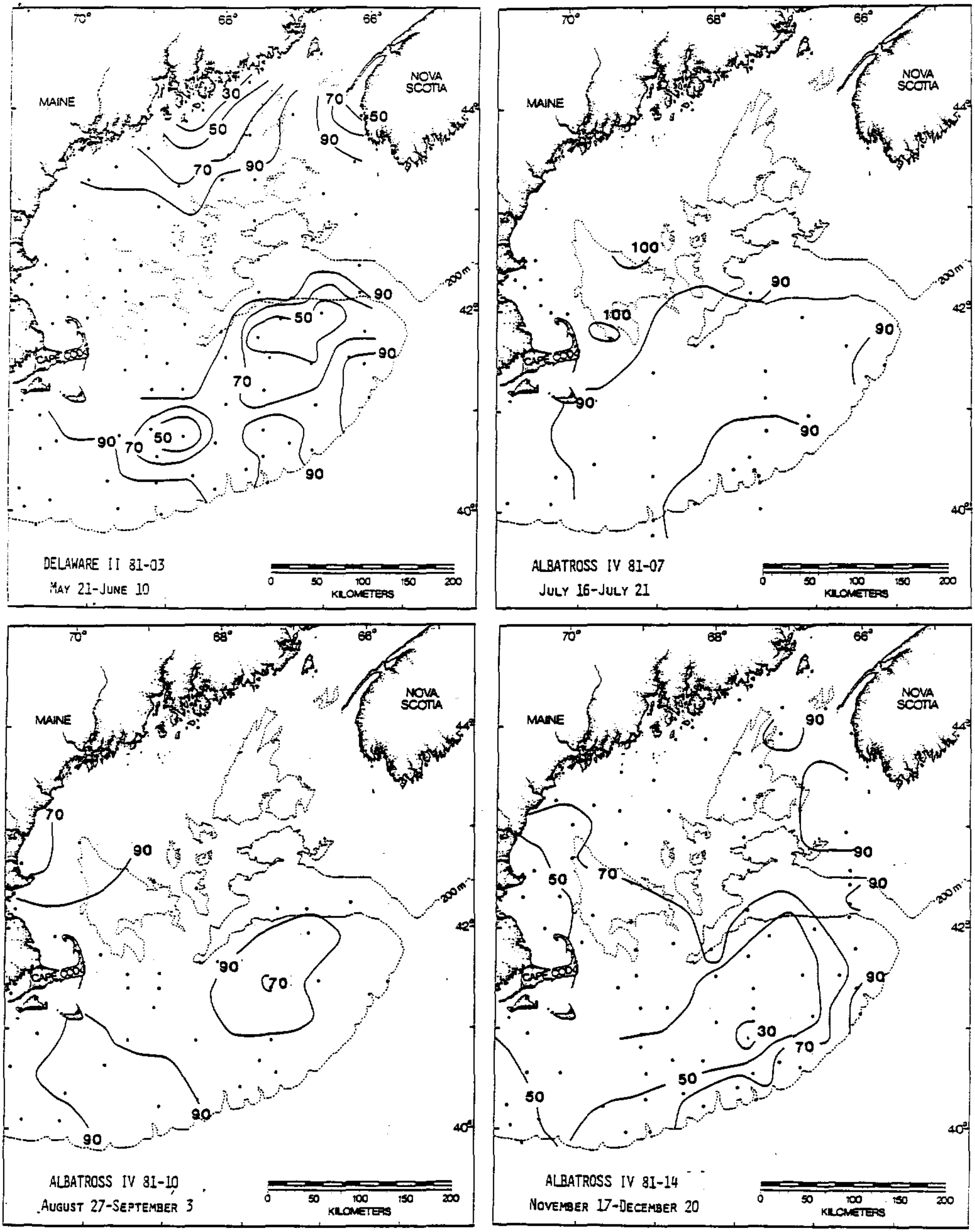
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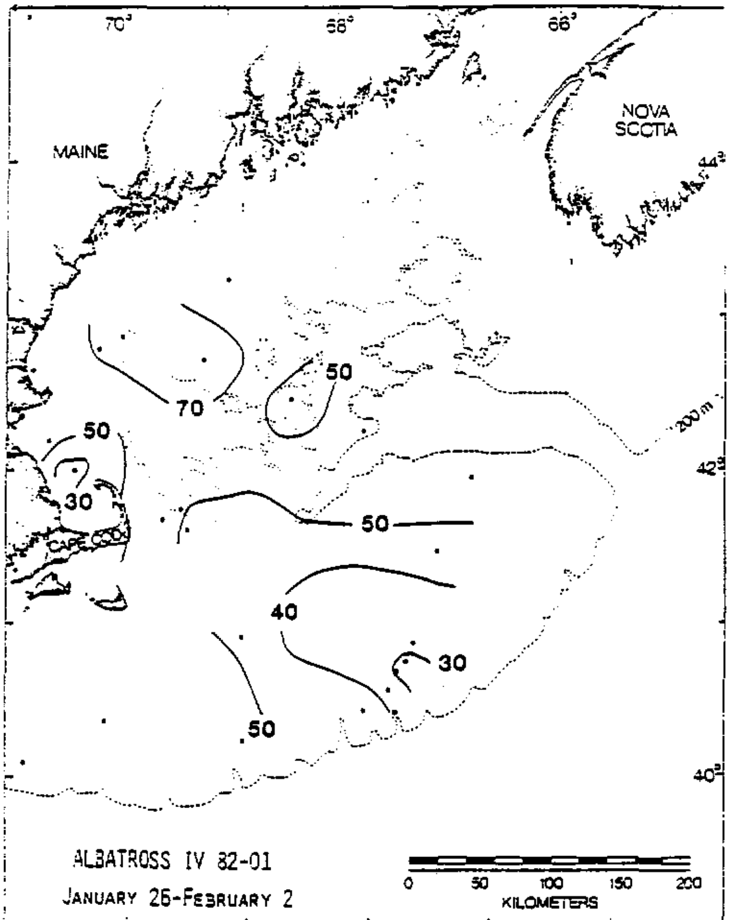
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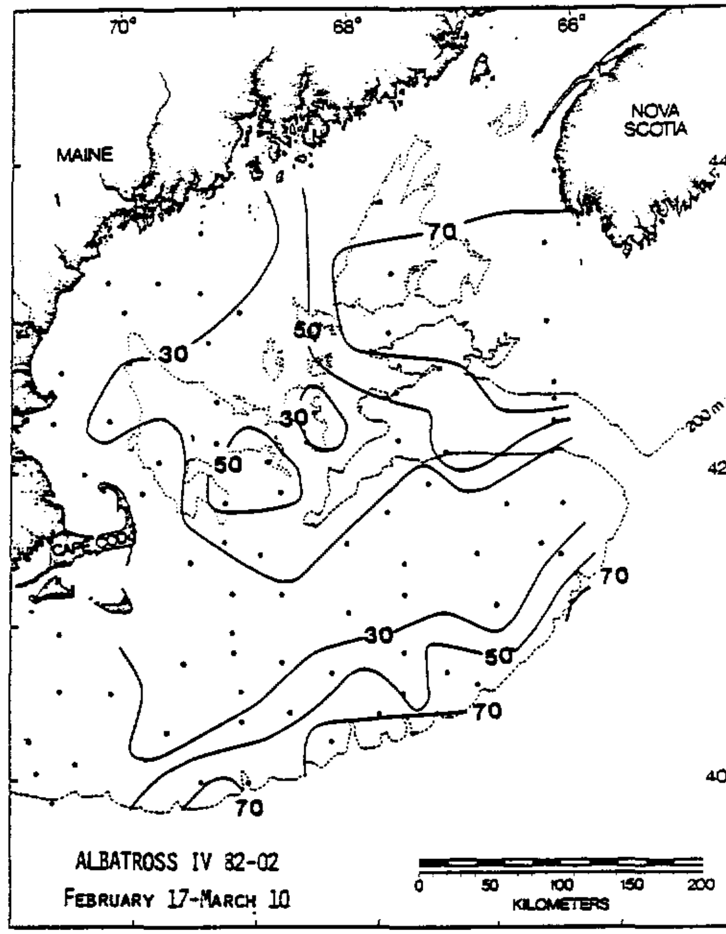
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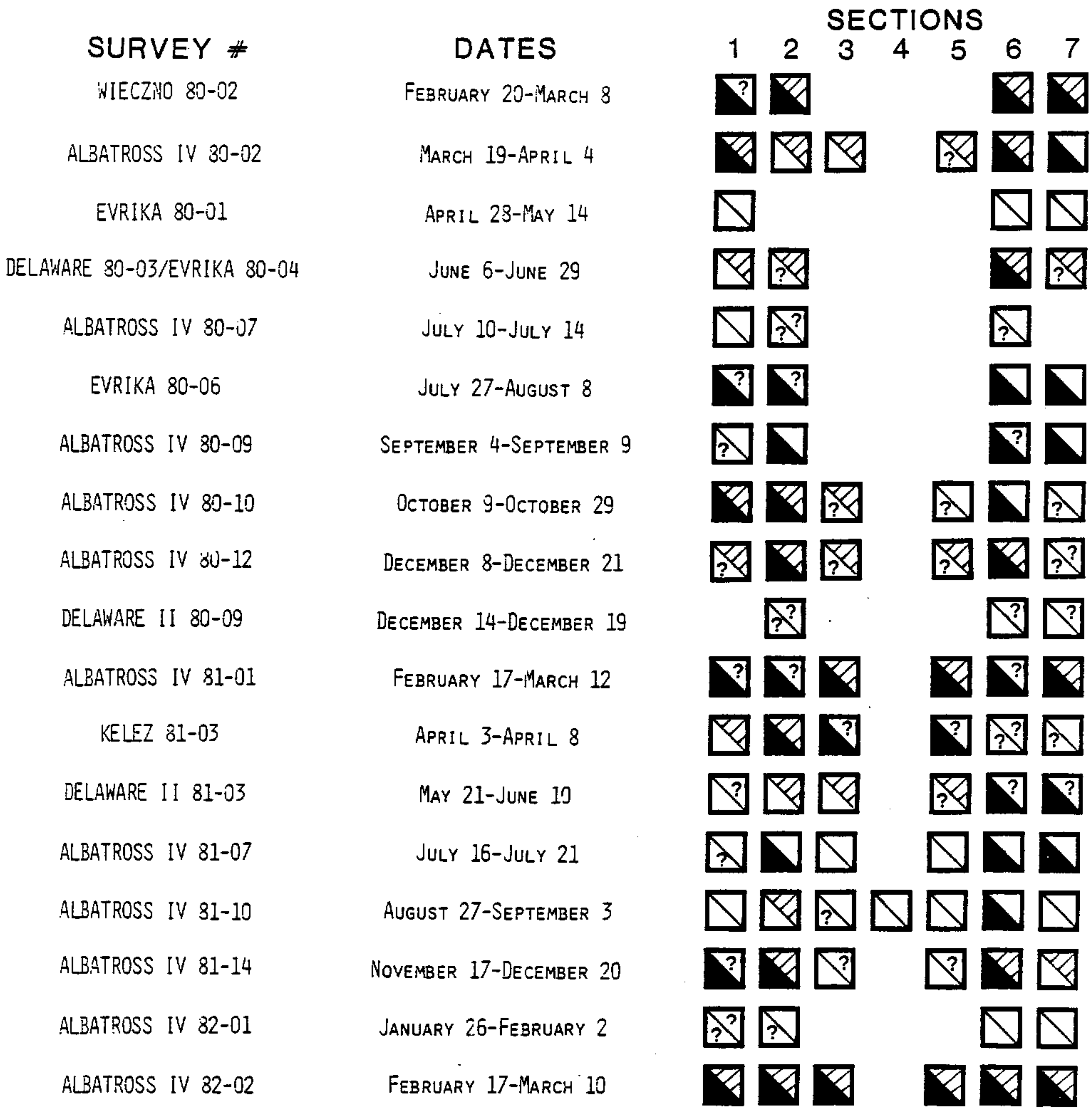

Figure 4. Cruise by cruise summary of the presence or absence of gradients in seven sections of Georges Bank based upon distribution of total surface pigments (chlorophyll a mg m^{-3} plus phaeophytin a mg m^{-3}) and percentage nannoplankton; ◣ marked gradient (total pigments); ◸ marked gradient (% nannoplankton); ⧅ gradient absent; ? gradient possible but ambiguous.