Northeast Fisheries Science Center Reference Document 13-12

An Atlas of the Dominant Zooplankton Collected Along a Continuous Plankton Recorder Transect Between Massachusetts USA and Cape Sable NS, 1961-2008

by Jack W. Jossi and Joseph Kane

June 2013

Northeast Fisheries Science Center Reference Document 13-12

An Atlas of the Dominant Zooplankton Collected Along a Continuous Plankton Recorder Transect Between Massachusetts USA and Cape Sable NS, 1961-2008

by Jack W. Jossi and Joseph Kane

NOAA National Marine Fisheries Serv., 28 Tarzwell Drive, Narragansett, RI 02882

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Narragansett, Rhode Island

June 2013

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been copublished in both paper and electronic versions. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, or if a desired document is one of the pre-April 2001 documents available only in the paper version, you can obtain a paper copy by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

Information Quality Act Compliance: In accordance with section 515 of Public Law 106-554, the Northeast Fisheries Science Center completed both technical and policy reviews for this report. These predissemination reviews are on file at the NEFSC Editorial Office.

This document may be cited as:

Jossi JW, Kane J. 2013. An atlas of the dominant zooplankton collected along a Continuous Plankton Recorder transect between Massachusetts USA and Cape Sable NS, 1961-2008. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 13-12; 104 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

TABLE OF CONTENTS

INTRODUCTION

From 1961 through 1974 the Oceanographic Laboratory in Edinburgh, Scotland, conducted monthly monitoring of the zooplankton and larger phytoplankton between Cape Sable, Nova Scotia and Boston, Massachusetts using the Hardy Continuous Plankton Recorder (CPR) (Hardy, 1939). In 1972 the U.S. National Marine Fisheries Service (NMFS), and the U.K. National Environmental Research Council developed an Aide Memoir for the extension of the long-term CPR survey into additional areas of the western North Atlantic, and for the joint development of instrumented towed bodies to use in this survey. On the U.S. side the resulting monitoring program has been designated as the Ships of Opportunity Program, or SOOP, currently operated by the Oceanography Branch of the Northeast Fisheries Science Center. In the U.K. the program is termed the Continuous Plankton Recorder Survey, and is now managed by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in Plymouth, England. The four SOOP monthly sampling routes along the U.S. northeast coast that have resulted from this cooperation, as well as SAHFOS routes in the northwest Atlantic are illustrated in Figure 1, with details of the routes off the northeast coast of the United States presented in Table 1.

In 1978, as part of an agreement with the U.S. Maritime Administration (MARAD) and the NOAA National Ocean Service (NOS), concurrent measurements of water column temperature and surface salinity were added. In 1991, through SAHFOS, depth, temperature, salinity, and chlorophyll measurements were added to the CPRs towed on the Georges Bank route, and through NOS, near surface temperature and salinity measurements were added for all routes.

This atlas presents detailed methods used for the collection of the CPR and the concurrent temperature and salinity data along the Gulf of Maine route. It describes the CPR samples identification, staging, and counting, and the quality control steps employed on the CPR, and the concurrent environmental data. The resulting database content and specifications are also described. Techniques used for deriving means, variances, annual peak abundances, and anomalous conditions are described in the methods section. In graphic form, the atlas presents time-space mean conditions for thirty-one of the most dominant zooplankton organisms, plus total zooplankton, along the Gulf of Maine SOOP transect for the base period of 1978 through 2007. Over the time span of 1961 through 2008 it presents changes in the seasonal cycle, and time of annual maximum abundance for each taxon within three sections (Massachusetts Bay, central Gulf of Maine, and western Scotian Shelf) of the transect. Within these three sections, it shows standardized anomalies of abundance of each taxon for the 1961 through 2008 time span. Also shown for these three transect sections are the annual variations of relative contribution to the total catch of the six most abundance taxa.

The derived data used in preparing the atlas, much of which involved gridding, are available as supplemental data sets, in space-delimited ascii format suitable for input to most analytical software.

This descriptive work, including nearly 50 years of data, is intended to be a reference from which more analytic hypotheses can be tested.

METHODS

The Gulf of Maine Transect

Since 1961 a variety of military, academic, and commercial vessels have towed CPRs across the Gulf of Maine. Differing missions, weather and other circumstances have resulted in spatial variability between repeated transects. In addition, since 1977, regular surveys by research vessels have taken water column temperature and salinity data from the region along the transect. In 1991 a composite of all CPR samples was mapped (Fig. 2), and polygons were drawn around the scatter of samples with the object of minimizing cross-polygon variations relative to those along the polygon. The resulting Gulf of Maine polygon (Fig. 3) has corners at 43°-30'N, 71°-00'W; 43°-30'N, 65o-37'W; 43°-00'N, 65°-37'W; and 42°-00'N, 71°-00'W. Out-of-polygon CPR and concurrent temperature and salinity (taken since 1978) data are excluded from the Gulf of Maine data base. The Gulf of Maine route crosses strikingly different ecological areas, with distinct seasonal patterns, water column structure, bathymetry, and circulation. Thus, analyses of the transect as a whole can be misleading, e.g., up-trending patterns on the eastern end of the transect often coincide with down-trending patterns on the western end. To allow examination of such along-transect differences, the radial distance between a reference point at 43°-02.8'N; 64°-00.0'W and each data point (the center of a 10 n mi CPR sample) was calculated, and offset by the distance between the reference point and Boston Harbor. This provided the distance to each value from Boston Harbor. A reference position well outside of the polygon was chosen to minimize the cross-polygon curvature of like-distance data. The reference distance variable was used to extract and analyze sections of the transect, and to provide axis values for gridding of plankton, temperature, and salinity data.

Sampling Frequency

Monthly sampling for phytoplankton and zooplankton with the CPR, water column temperature using expendable bathythermographs (XBTs), and salinity measurements at selected depths was the goal. Supplemental temperature and salinity data within the Gulf of Maine polygon from research vessels were generally available since 1976, every 60 days through the year, and was the sole source of 10 m salinity data. Monthly sampling by the CPR, from 1961 through 2008, averaged 71 percent—like sampling of temperature and salinity since 1976 averaged 90 percent. Details of these coverages are shown in Appendix I.

CPR Sample Collection

Numerous descriptions of the Continuous Plankton Recorder (CPR), and the standard method employed during sample collection appear in the literature (Hardy, 1939; Batten, Clark et al, 2003; John and Reid, 2001; Jonas, Walne, Beaugrand, Gregory, and Hays 2004; Reid et al, 2003; Warner and Hays, 1994; and Richardson et al, 2006). Over the course of the US CPR survey in the Gulf of Maine, towed bodies (Fig. 4) underwent the same modification from the original design to a box tail arrangement as those used at SAHFOS. This was to account for the increasing merchant ships towing speeds.

The CPR was towed by an 8 mm diameter, 6x7 galvanized cable, leading inboard to a davit and block affixed to the stern quarter of the cooperating vessel, and then to a mooring capstan. A launch position was set for each transect. With the vessel running at normal cruising speed (ranging from 15-28 km/hour (8-15 knots)), the CPR was launched, and the towing wire was paid out until a whipping approximately 22 m from the CPR reached the water's surface. This resulted in the CPR sampling at somewhere between 7 and 10 m, depending on the vessel's cruising speed. Except for severe weather or other problems, the towing wire and body remained unattended until the recovery position. While towing, water enters the body through a 1.27 cm square aperture, passes through an expanding tunnel to reduce the flow rate, encounters a band of 60 XXXX silk bolting cloth with aperture of 270 µm (225 x 235 µm when wet) crossing the tunnel, and exits at the rear of the device. The filtering silk is slowly moved across the tunnel by connection to an external impeller, driven by the movement of the CPR through the water. After leaving the tunnel, this filtering silk is joined by a covering silk sandwiching the plankton between them. The double band of silk and plankton is then wound onto a take-up spool in a tank containing formalin. A continuous sample of the plankton along the vessel track is obtained, where approximately 10.16 cm (4 inches) of silk sandwich represents 10 nautical mile (n mi) of track distance and 2.876 m^3 of water filtered. This volume is based on 100% filtration of a 0.0127 m x 0.0127 m x 18520 m cuboid. It should be noted that due to the continuously moving silk, each sample contains plankton from a 15 n mi length of the transect, with 25% from the first 5 n mi section, 50% from the central 5 n mi section, and 25% from the last 5 n mi section (Richardson et al, 2006). Upon retrieval, the CPR is secured on deck until returning to port where it is checked, unloaded and replaced/re-outfitted by a survey representative.

CPR Sample Processing

Navigation and Sample Definition

Logged information was exposed to range and reasonableness checking, e.g., speed of the vessel was calculated between logged times and positions. Once the logged data were considered clean, the time and position of the CPR launch, the intervening XBT stations, and the CPR haul were used to determine the total distance sampled by the CPR. This value combined with the length of silk filtering material which crossed the tunnel, permitted the division of the silk into 10 n mi pieces. Software calculated the location for marking and cutting the continuous silk record into 10 n mi sections. These samples, termed “blocks” by SAHFOS, are termed substations in the US database, to distinguish them from the stations, e.g., XBT, which were collecting data and were being logged while the CPR was being towed. The time, date, latitude, and longitude of the center point of each substation was calculated. Each was labeled as a day or night sample on the basis of local sunrise and sunset, and the substation’s time and position.

After cutting the silk into 10 n mi pieces, a section of the silk may remain which was too short to make into a 10 mile block, but which sampled an appropriate amount of water for the length it did sample. If this short sample (partial block) represents at least 2.5 n mi along the tow path, it is processed, and will occasionally be analyzed and added to the data base to fill gaps in the spatial coverage, or provide information about unusual conditions.

Identification and Staging

No less than alternate substations were examined from each monthly occupation of the transect. When unusual taxa appeared, or significant ecosystem events were suspected, additional substations were examined. The two SAHFOS standard zooplankton examinations were performed on each sample, as thoroughly described by Richardson et al (2006). These examinations have remained unchanged for Gulf of Maine CPR samples. The first examination is a stepped traverse (Fig. 5) of the filtering and covering silk to enumerate the smaller zooplankton (those less in size than *Metridia lucens*, c. 5, or approximately < 2 mm total length). Different microscopes were used over the history of this survey resulting in a varying fraction of the silks being examined. Stage micrometer measurements of each microscope’s field diameter during the traverse were made and used to determine the fraction of the silk actually examined. For different microscopes $1/43^{rd}$, $1/46^{th}$, and $1/48^{th}$ of the silk were examined. This contrasts to SAHFOS, where a fixed $1/50^{th}$ fraction was used.

These different fractions were used in calculating the abundances for their respective samples. The inverse of these fractions (aliquot factors), are used when calculating sample abundance.

Maintenance of the CPRs includes adjustments to produce a movement of silk across the CPR tunnel of 9.16 cm (4 inches) of silk/10 n mi of towing. However, the achieved silk transport rates vary. Departures from the ideal 4 inches/10 n mi affect the fraction of the silk examined during the traverse. These departures, termed correction or scaling factors, are expressed as the ratio between actual length and the ideal length, and generally range from 0.7 to 1.3. Rather than applying them to the aliquot factors, mentioned above, these correction factors are applied to traverse counts prior to assignment to a counting category (see below).

Samples from the 1961-1974 period were examined at the Edinburgh Oceanographic Laboratory (predecessor of SAHFOS). Subsequent samples were examined at the Narragansett Laboratory and at the Morski Instytut Rybacki (MIR) laboratory in Gdynia, Poland. In all cases, a category system of counting was employed (Table 2). Counts of each taxon/stage seen in the traverse were first multiplied by the correction factor, and were then assigned to a category representing a somewhat geometric progression of count ranges. An experienced analyst can sometimes avoid counting all individuals in the traverse when, e.g., part way through the traverse it becomes obvious that there are more than 500, but less than 1000 individuals of the taxon/stage-- a category 10 is assigned. This time saving technique was used prior to 2000, after which all individuals in the traverse and eyecount were enumerated.

The second examination of CPR zooplankton is termed an eye count, where all individuals greater than *Metridia lucens*, c.5 in size (>2mm in total length) are counted. Eye counts were not adjusted by a correction factor since organisms on the entire silk were counted. Results of the eye count were assigned to a category according to Table 2 as with the traverse,

More than 100 taxa and stages have been encountered on the Gulf of Maine transect (App. II). The level to which the organisms were identified and staged was largely based upon log sheets in use at the Edinburgh Oceanographic Laboratory in 1972. Sample examinations at Narragansett and in Poland logged counts to these predetermined taxa/stages. Entries where no preprinted taxon/stage was available were written in; no attempt at lower level identification or refined staging beyond the predetermined levels was made. In large part this was to maintain time series consistency for as large a list of taxon/stages as possible. As non-printed taxa/stages became common in the samples they were added to the log sheets, and the start date of their consistency documented.

Substation data were added to a data base, linkable to separate, CPR phytoplankton, and CPR zooplankton data bases (not reported on here) by the variables, cruise name (CRUNAM) and substation (SUBSTA).

Category values from both the traverse and the eye count were converted to “accepted values” according to Table 2. These accepted values were not the arithmetic mean of each count range, but rather the result of actual counts performed on samples collected in 1938 and 1939 (Rae and Rees, 1947). Further explanation of accepted values can be found in Warner and Hays (1994). For traverse records, the accepted values are multiplied by the microscope-specific aliquot factors described above. For eye count records no adjustment for aliquots is required. The resulting records then contain the number of each taxon/stage per sample (equivalent to number/block for SAHFOS samples). Since (1) partial blocks (samples less than 10 n mi) are occasionally analyzed, and (2) there was an initial desire to compare CPR abundance data with research vessel data from Bongo nets (Posgay and Marak, 1980), the number of each taxon and stage per sample is also normalized to units of #/100m^3.

Temperature and Salinity Data Collection

Beginning in 1978 water column temperature (expendable bathythermograph-XBT) and surface salinity measurements were taken at hourly intervals along the Gulf of Maine transect, and in 1991 thermosalinographs were installed in the towing vessels to increase the horizontal, spatial resolution of these measurements (Appendix I). At this same time the US was conducting research vessel surveys of the northeast continental shelf, six to twelve times per year (Jossi and Marak, 1983; Jossi and Griswold, 2000). The water column temperature and salinity data within the polygon surrounding the Gulf of Maine transect from the research vessel surveys was extracted to supplement the concurrent data collected by the ships of opportunity (included in Appendix I).

Temperature and Salinity Data Processing

Early XBT collections involved the digitization of analog traces. Minimum values retained were surface, inflection points, and the bottom (if reached). Since the 10 m towing depth of the CPR didn't always coincide with a temperature inflection point, 10 m temperature often had to be estimated by linear interpolation between the values surrounding 10 m. With the advent of digital XBT recording, a 10 m temperature was kept in addition to the inflection points, if necessary. Temperature and salinity data from research vessel surveys initially came from bottle casts, sometimes making 10 m interpolation necessary. After the introduction of conductivity-temperature-depth (CTD) instruments these values were measured directly. For further details on the collection of these data, see Benway, et al, 1993 and Taylor and Bascunan, 2000.

Calculations and calibrations involved in the use of XBT and CTD data followed recognized international standards, and will not be repeated here. See Steinhart and Hart (1968); Georgi et al (1981); UNESCO (1981); and Benway et al (1993). The station, the depth-temperature pairs, and the depth-salinity pairs data are added to an environmental data base, which is linkable to the CPR data bases by the variable, reference distance (REFDST). See Gridding section below for a description of reference distance.

Gridding

To overcome problems associated with irregular sampling in both space and time, both the physical and biological data were subjected to a gridding procedure. The design of the gridding method was developed in part with other research at the NOAA Narragansett Laboratory (Goulet, 1990; Jossi et al, 1991; Thomas, 1992). For each irregular raw data matrix, the gridding technique was used to calculate a curved planar surface from interpolated data values at regular, spatial-temporal grid points. Reference distance was used as the spatial variable; yearday (decimal value of the sample's day within a year containing 354.25 days) and decimal year were used as temporal variables. Those gridded data values were contoured, producing three-dimensional representations of space by time by scalar. Furthermore, gridding was used to calculate mean values and standard deviations over a 30 year base period (1978 though 2007); and to compare individual-year data to base period mean values, via algebraic anomalies and standardized anomalies. Additionally, time (yearday) by time (decimal year) by scalar grid were generated to examine the multidecadal variations of seasonality for the different data types. Physical data exposed to gridding was used without transformation. To produce more normal distributions, biological data were transformed to logarithmic values as follows:

$$\text{Log Value} = \log_{10}(\#/100m^3 + 1)$$

Because the grid dimensions were uniform for all data types, the grids could be exposed to matrix algebra, e.g., calculations of correlation coefficients between grids. A graphical representation of the gridding process is shown in Figure 6, and a complete set of parameters for the difference grids is listed in Table 3.

Base Period Mean Grids

Grids were defined by time (range: 0-365.25 days) along the x-axis, and polygon reference distance (range: 0-452 km) along the y-axis. The x-axis maximum of 365.25 was used to account for leap years and to permit calculations on multiyear files. The grids were dimensioned such that grid points occurred at intervals of 7.609 days and 8.692 km. At every grid point, a z-value was calculated by performing an elliptical search of 15 days and 38 km for all data occurring from 1978 through 2007, and calculated the arithmetic mean of the data found. In the event of fewer than one observation within the search ellipse at a given point, that grid point was assigned a missing value, which likewise produced missing values for that grid point in any subsequent derivations.

Standard Deviation Grids

Gridding parameters used in producing standard deviation grids were identical to those employed for base period mean grids, resulting, among other things, in identical data sets used for mean and std calculations at each grid point.

Anomaly Grids

Base period mean grids were replicated sufficient times to cover the number of years for which anomalies were to be calculated. The time, or x-axis of the replicated grid was rescaled to decimal year values, resulting in an axis range for this atlas of 1961 to 2009.0 (cpr data), and 1976.0 to 2009.0 (temperature and salinity data). The base period mean grid surface value at each of the irregularly spaced observed data locations was subtracted from these observed values to produce a data set of residuals. Residuals were at the observed time-space locations. Gridding the residuals produced a multiyear anomaly grid defined by time (range: 1961.0 or 1978.0 to 2009.0 years) along the x-axis, and polygon reference distance (range: 0-452 km) along the y-axis. Grid points continued to occur at 7.609 day (0.0208 year), and 8.692 km intervals. Note that some gridding parameters used for anomaly gridding differ from those used for mean grids (Table 3).

Zscore Grids

To standardize the anomalies, standard deviation grids were replicated in the same manner as were the mean grids, described above. The anomaly grids were then divided by the standard deviation grids to produce Zscore grids having identical dimensions as anomaly grids.

Seasonality Grids

The time-space grids so far produced indicate significant along-transect variation. Since the seasonality grids have no spatial component, they are produced for sections of the transect where cluster and other analyses has shown spatially coherent features (Thomas, 1992). These grids were defined by time (range:-365.25 to 0 days along the x-axis, and time (range: 1961.0 or 1978.0 to 2009.0 years) along the y-axis. For portrayal, these grids were rotated 90^o clockwise, with absolute values of yearday used for axis labels. Thus, portrayals appear to have decimal year increasing to the right on the x-axis, and positive yearday increasing upwards on the y-axis. The grids were dimensioned such that grid points occurred at intervals of 7.609 days in both dimensions. See Table 3 for gridding method and parameters. As with all grids, in the event of fewer than one observation within the search ellipse at a given point, that grid point was assigned a missing value, which likewise produced missing values for that grid point in any subsequent derivations. Seasonality grids were generated for the Massachusetts Bay (reference distance 0-96 km), central Gulf of Maine (reference distance 96-339 km), and western Scotian Shelf (reference distance 339-452 km).

Annual Peak Abundance

Portrayals of the seasonality grids suggest variations in the timing of seasonal events between years. To further explore these variations a center of gravity of the yearday producing the highest annual abundance was calculated for each year. To avoid bias due to differing coverage in different years, the input data set for this calculation was obtained by extracting the interpolated abundances for each grid point in the seasonality grids. Annual center of gravity values were obtained by the following steps/calculations:

Weighted abundance= grid abundance * yearday

Grid abundances and weighted abundance were then summed by year.

Center of gravity= weighted abundance sum/grid abundance sum

Center of gravity values were then plotted against year for the three sections of the Gulf of Maine transect.

Zscore Time Series

To illustrate the significance and persistence of abundance departures from the base period, monthly Zscores were calculated for the three sections of the Gulf of Maine transect. For those years with missing monthly abundance values (YerMonMean), interpolated values were calculated if three or more of the highest six base period months were sampled in that year. Zscore values were generated by the following steps/calculations:

MonMean= mean abundance for each of the 12 months using 1978 through 2007 data.

MonStd= standard deviation of the mean abundance for each of the 12 months using 1978 through 2007 data.

Interpolated YerMonMean values = (sum of abundances of the three or more high-six months sampled in the year) / sum of the base period mean abundances for the same months) x the missing months base period mean value.

YerMonZscore= (YerMonMean - MonMean) / MonStd

Year and month values were combined to create decimal year values.

Monthly Zscore values were then plotted against year for the three sections of the Gulf of Maine transect.

Relative Contribution of Taxa

The annual contributions of the six top-ranking taxon/stages to the total catch through the time series were calculated. This was done only for those years where, either all months were sampled, or where missing months could be interpolated using the technique described for the Zscore time series, above. Cumulative percentages were then calculated for the six taxon/stages plus the remaining (other) components of the catch.

RESULTS AND DISCUSSION

The results consist of two major parts. The first, contained in this document, describes collection and processing methods used for the biological and physical data, and provides graphical depictions of the biological data. The second part consists of supplemental data sets used in preparing the atlas which may be useful for further analysis.

Part 1 is made up of graphical depictions of variations of thirty-one of the most dominant zooplankton taxa/life stages (in descending order of overall abundance), plus total zooplankton, during the period 1961 through 2008. These results are arranged with the intention of viewing each taxon/life stage in a two-page series beginning with Figure 7 and continuing through Figure 38. The first page consists of two panels. Panel I, "1978 - 2007 Mean Abundances," portrays time-space mean abundances for the entire transect, with the three coherent sections of the transect indicated along the x-axis. Panel I is based on the Mean Grid. Panel II, "Interannual Variations of Seasonality," presents contoured abundances by yearday over the time span of 1961 through 2008 for the three sections of the transect. These contoured graphs are based on the Seasonality Grids. The bottom of panel II shows the annual day of maximum abundance (center of gravity) for the above three transect sections and time span. Panel III begins on the second page with "Interannual Departures from Mean Abundances." This illustrates monthly Zscores during the period 1961 through 2008 for the three sections of the Gulf of Maine transect.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

Panel IV, "Comments," provides discussion of the more significant taxon/stage time and space distributions presented on these two pages.

An additional part 1 product consists of graphs and comments on the annual relative contribution of the six most abundant taxa to the total catch, for the three sections of the Gulf of Maine between 1961 and 2008 (Figures 39-41).

Part 2 consists of ascii grid files for each of the graphical depictions and for related statistics, e.g., standard deviations grids for each mean grid. Grid files are also presented for 10 meter temperature and 10 meter salinity values with grid dimensions identical to those of the biological files. These files, along with documentation are available at:

http://www.nefsc.noaa.gov/epd/ocean/MainPage/soop.html.

Requests for raw data from the Continuous Plankton Recorder survey should be directed to:

Chief, Oceanography Branch
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Northeast Fisheries Science Center
Narragansett RI 02882

ACKNOWLEDGEMENTS

Since its beginning on the Northeast Continental Shelf, dozens of commercial, military, academic and private vessels have participated in the Continuous Plankton Recorder survey. The enthusiasm and dedication of hundreds of officers and crew members, and the generosity of the owners have been the major factor in this program's success. Current collaborators for the Gulf of Maine route are Eimskipafelag, Icelandic Steam Shipping Company, Reykjavik, Iceland; NOAA National Weather Service; NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML); and Sir Alister Hardy Foundation for Ocean Science, Plymouth, U.K.

The staff of the Oceanographic Laboratory, Edinburgh completed all the examinations of Gulf of Maine samples for the period 1961-1974, and generously shared these data with us. That staff, and succeeding staffs of SAHFOS continued this generosity in the areas of logistics, sample design, data processing and analyses until the present time.

Since 1998, staff at the Zaklaad Sortowania I Oznaczania Planktonu in Gdynia and Szczecin Poland, examined all Gulf of Maine CPR samples. Their professionalism and volume of timely data products have provided a key link in the program's success.

In the northeast United States, Robert Marak and John Colton, used CPR's in the Gulf of Maine in the 1950s to collect fish eggs and larvae contributing greatly to the early years of the program at Narragansett. William Brennan delivered CPR's to ships for us before he went on to become director of the National Marine Fisheries Service. Steven Cook joined us, bringing with him the Ships of Opportunity Program, which was making physical oceanographic measurements from merchant ships in the North and South Atlantic and Gulf of Mexico. Chris Melrose and Jon Hare, more recently have joined the survey and have applied technology and fresh ideas that have been needed for a long time.

Last, but by far not least, we want to express our thanks to Robert Benway, Julien Goulet, Daniel Smith, Carolyn Griswold, and Jay O'Reilley. Until his recent retirement, Bob ran the survey like a fine watch. There was not a detail he didn't worry about, a gesture to a ship's captain and crew that he forgot about, or a loose end he didn't tend to. Given the simplest or most complex problem, Julien became silent, went to the blackboard, and produced the equations that settled the issue. His English was just fine, but his mathematics were superb. Daniel, in the early years produced the plankton data from hundreds of CPR cruises, maintained the towed bodies and loaded, and still loads, the internal mechanisms. His corporate memory has saved the day many times. Carolyn recruited volunteers to ride the volunteer ships, made computer runs and filed the data making analyses so much easier. Jay's continuing interest in the survey resulted in numerous improvements to data quality, and especially to the quality of the atlas graphics.

REFERENCES CITED

Batten SD, Clark RA, Flinkman J, Hays GC, John EH, John AW, Jonas T, Lindley JA, Stevens DP, Walne A. 2003. CPR sampling - the technical background, materials and methods, consistency and comparability. Progress in Oceanography 58:175-191.

Benway RL, Jossi JW, Thomas KP, Goulet JR. 1993. Variability of temperature and salinity in the Middle Atlantic Bight and Gulf of Maine. MARMAP Atlas Monograph No. 4. NOAA Technical Report NMFS-F/NEC 112:1-108.

Georgi DT, Dean JP, Chase JA. 1980. Temperature calibration of expendable bathythermographs. Ocean Engineering 7: 491-499.

Goulet JR. 1990. Stochastic surfaces in large marine ecosystems. Poster Presentation, Ecological Society of America, Annual Meeting, Snow Bird, Vermont, 29 July - 2 August, 1990.

Hardy AC. 1939. Ecological investigations with the Continuous Plankton Recorder: Object, plan, and methods. Hull Bulletin of Marine Ecology 1:1-57.

John AW, Reid PC. 2001. Continuous plankton records. In Steele JH, editor. Encyclopedia of Ocean Science. Harcourt Press: 502-512.

Jossi JW, Griswold CA, editors. 2000. MARMAP ecosystem monitoring: Operations manual. Unpublished Manuscript: 241.

Jossi JW, Marak RR. 1983. MARMAP plankton survey manual. NOAA Technical Memorandum NMFS-F/NEC 21: 259.

Jossi JW, John AW, Sameoto DD. 2003. Continuous Plankton Recorder sampling off the east coast of North America- history and status. In: Reid PC, Matthews JBL, Smith MA, editors. Achievements of the continuous plankton recorder survey and a vision for its future. Progress in Oceanography 58:313-325.

Posgay JA, Marak RR. 1980. The MARMAP Bongo zooplankton samplers. Journal of Northwest Atlantic Fisheries Science 1:91-99.

Ray KM, Rees CB. 1947. Continuous Plankton Records: the Copepoda in the North Sea, 1938-1939. Hull Bulletins of Marine Ecology 2: 95-134.

Reid PC, Colebrook JM, Matthews JBL, Aiken J, Continuous Plankton Recorder Team. 2003. The Continuous Plankton Recorder: concepts and history, from Plankton Indicator to undulating recorders. Progress in Oceanography 58: 117-173.

Richardson AJ, Walne AW, John AWG, Honas TD, Lindley JA, Sims DW, Stevens DWM. 2006. Using continuous plankton recorder data. Progress in Oceanography 68: 27-74.

Steinhart, J.S., and S.R. Hart. 1968. Calibration curves for thermistors. Deep Sea Research, 15: 497-503.

Taylor MH, Bascunan C. 2000. CTD data collection on Northeast Fisheries Science Center cruises: standard operating procedures. NOAA Northeast Fisheries Science Center Reference Document 00-11, 28p.

Thomas KP. 1992. Initiation and decline of Ceratium tripos blooms in the Gulf of Maine: Dependence upon water column structure. Thesis, Master of Science, University of Rhode Island, Kingston, Rhode Island, 1-127.

UNESCO. 1981. Background papers and supporting data on the practical salinity scale 1978. UNESCO Technical Papers in Marine Scinece 37, UNESCO, Paris: 144.

Warner AJ, Hays GC. 1994. Sampling by the continuous plankton recorder survey. Progress in Oceanography 34: 237-256.

Table 1. Details of Continuous Plankton Recorder routes off the northeast coast of the United States as of 31 December, 2011. "Samples" are the number of samples examined with values in the data base. The numbers collected and archived are approximately double these values, since only alternate samples are routinely examined.

Route	Start	Finish	Location	Tows/ Samples	Years Sampled
A0	1974	1980	east of Chesapeake Bay	65/ 650	7
B0	1976	Current	southeast of New York City	448/ 4301	36
C0	1961	Current	Gulf of Maine	427/ 4598	51
EB	1961 1991	1976 & Current	outer flank of Georges Bank	322/ 6328 Estimated	37
EC	1965	1974	southeast of Nantucket Is.	5/ ?	4
N0	1998	2009	Narragansett Bay	94/ 787	12

Table 2. Counting category system for the Continuous Plankton Recorder zooplankton traverse and eyecount examinations.

Number of Organisms Counted	**Category**	**Accepted Value** (representative value for category based on actual counts)
1	1	1
2	2	2
3	3	3
4-11	4	6
12-25	5	17
26-50	6	35
51-125	7	75
126-250	8	160
251-500	9	310
501-1000	10	640
1001-2000	11	1300
2001-4000	12	2690

Table 3. Gridding parameters used for Continuous Plankton Recorder, temperature and salinity data.

Grid Type	Grid Line Geometry								Grid Interpolation									
	X				Y													
	Min	Max	Lines	Intervals	Min	Max	Lines	Intervals	Method	Sectors Searched	Max Data to Use	Blank if Less Data Points Than	X-Search Radius	Y-Search Radius	Search Ellipse Angle	Weight	Use Data Outside Grid?	Output Format
BASE PERIOD MEAN GRID X=yearday Y=refdst Z= mean	0 days	365.25 days	49	7.609 days	0 km	452 km	53	8.692 km	Algebraic Mean	1	all	1	15 days	38 km	0°	none	yes	ascii
BASE PERIOD STD GRID X=yearday Y=refdst Z=std	0 days	365.25 days	49	7.609 days	0 km	452 km	53	8.692 km	Algebraic Mean	1	all	1	15 days	38 km	0°	none	yes	ascii

Table 3 cont. Gridding parameters used for Continuous Plankton Recorder, temperature and salinity data.

Grid Type	Grid Line Geometry								Grid Interpolation									
	X				Y													
	Min	Max	Lines	Intervals	Min	Max	Lines	Intervals	Method	Sectors Searched	Max Data to Use	Blank if Less Data Points	X-Search Radius	Y-Search Radius	Search Ellipse Angle	Weight	Use Data Outside Grid?	Output Format
ANOMALY GRID X=year Y=refdst Z= obs – base period mean	1961 yrs (cpr) 1976 yrs (tmp & sal)	2009 yrs (cpr) 2009 yrs (tmp & sal)	2305 (cpr) 1585 (tmp & sal)	0.0208 years	0 km	452 km	53	8.692 km	Inverse Distance to a Power	1	all	1	0.1232 years	76 km	0°	power of 2	yes	ascii
ZSCORE GRID X=year Y=refdst Z=anomaly grid / period std grid	1961 yrs (cpr) 1976 yrs (tmp & sal)	2009 yrs (cpr) 2009 yrs (tmp & sal)	2305 (cpr) 1585 (tmp & sal)	0.0208 years	0 km	452 km	53	8.692 km	Matrix Algebra: Zscore Grid= Anomaly Grid / Standard Deviation Grid									ascii

Table 3 cont. Gridding parameters used for Continuous Plankton Recorder, temperature and salinity data.

Grid Type	Grid Line Geometry								Grid Interpolation									
	X				Y													
	Min	Max	Lines	Intervals	Min	Max	Lines	Intervals	Method	Sectors Searched	Max Data to Use	Blank if Less Data Points	X-Search Radius	Y-Search Radius	Search Ellipse Angle	Weight	Use Data Outside Grid?	Output Format
SEASONALITY GRID[1] X=negative yearday[2] Y=year Z=weighted mean	-365.25 days	0 days	49	7.609 days	1961 yrs (cpr) 1976 yrs (tmp & sal)	2009 (cpr) 2009 (tmp & sal)	2305 (cpr) 1585 (tmp & sal)	7.609 days	Inverse Distance to a Power	1	all	1	365 days	5 years	-5^{o}	power of 2	yes	ascii

[1] Seasonality grids have no space component. Thus, separate grids have been generated for three spatially coherent sections of the Gulf of Maine transect.

[2] For portrayal, these grids are rotated 90^{o} clockwise, with absolute values of yearday used for axis labels. Thus, portrayals appear to have decimal year increasing to the right on the x-axis, and positive yearday increasing upwards on the y-axis.

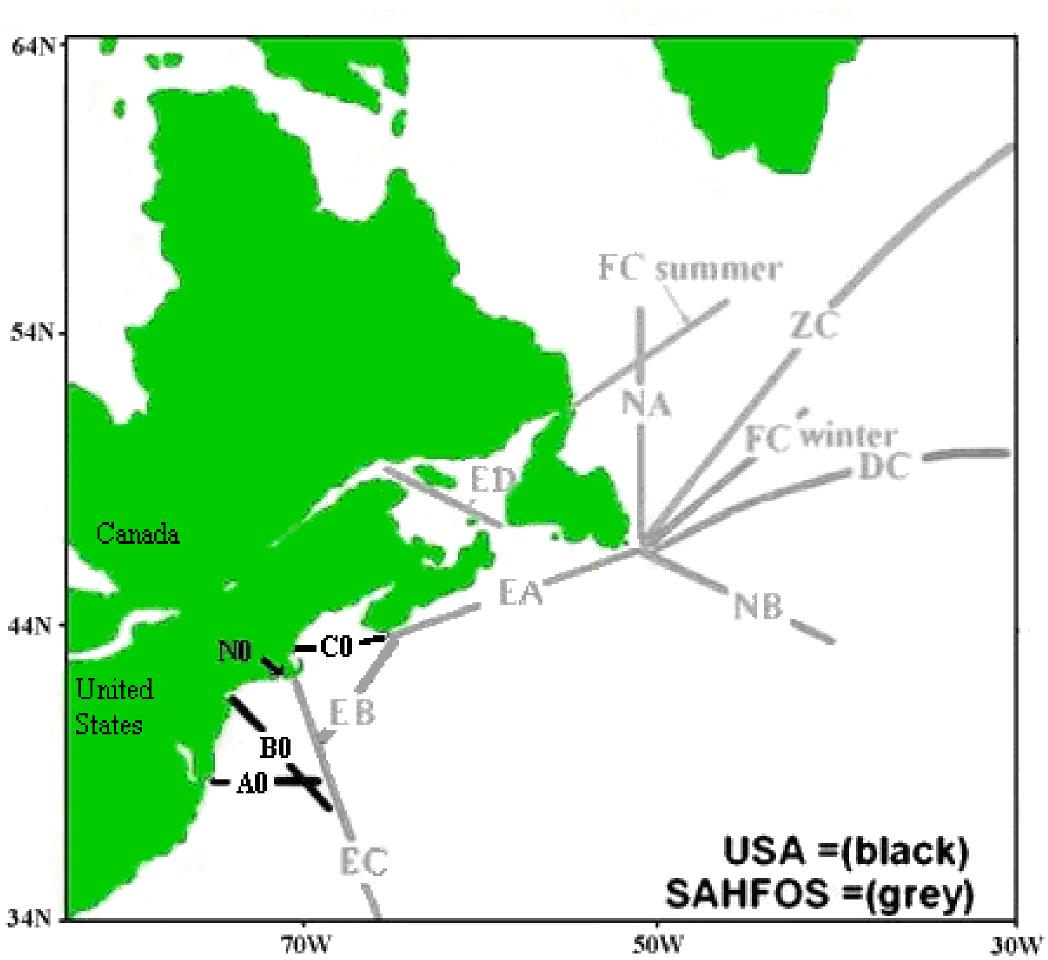

Figure 1. Continuous Plankton Recorder (CPR) routes in the northwest Atlantic Ocean. After Jossi, John, and Sameoto, 2003.

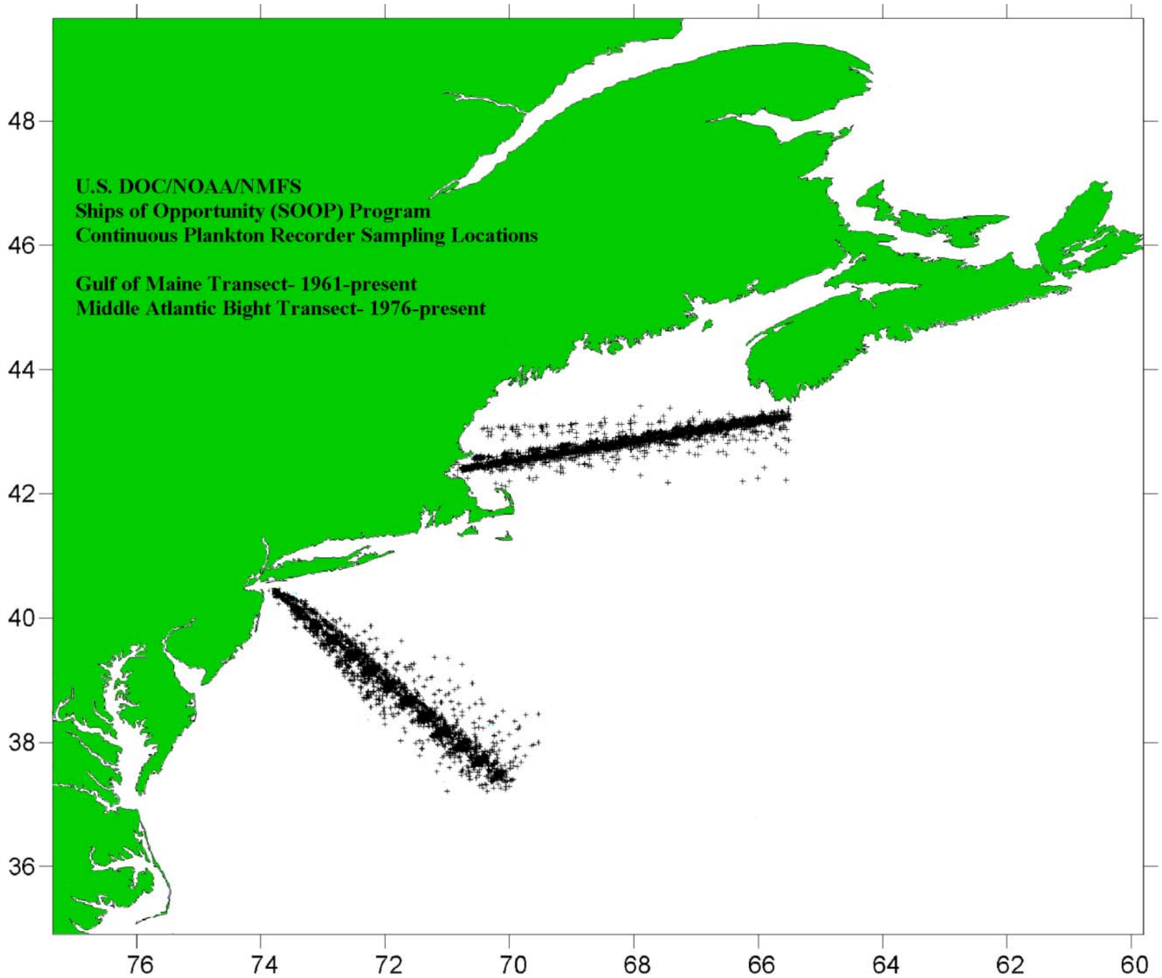

Figure 2. Composite of Continuous Plankton Recorder (CPR) samples locations along the Gulf of Maine and Middle Atlantic Bight transects as of 1991. These locations were used to define transect polygons.

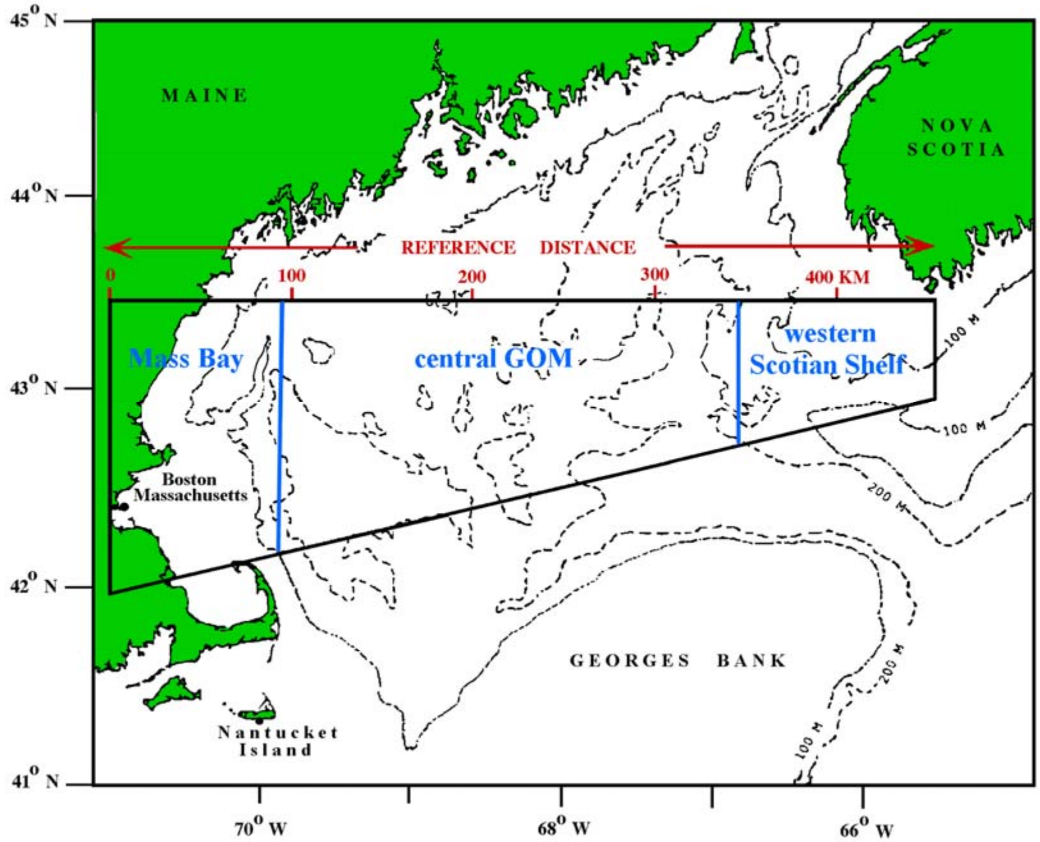

Figure 3. The polygon within which Gulf of Maine transects were conducted. Data located outside of the polygon were excluded from the analysis in this atlas. Reference distance to each data point is show in red. Sections of the Gulf of Maine transect used to show seasonal variations are shown in blue.

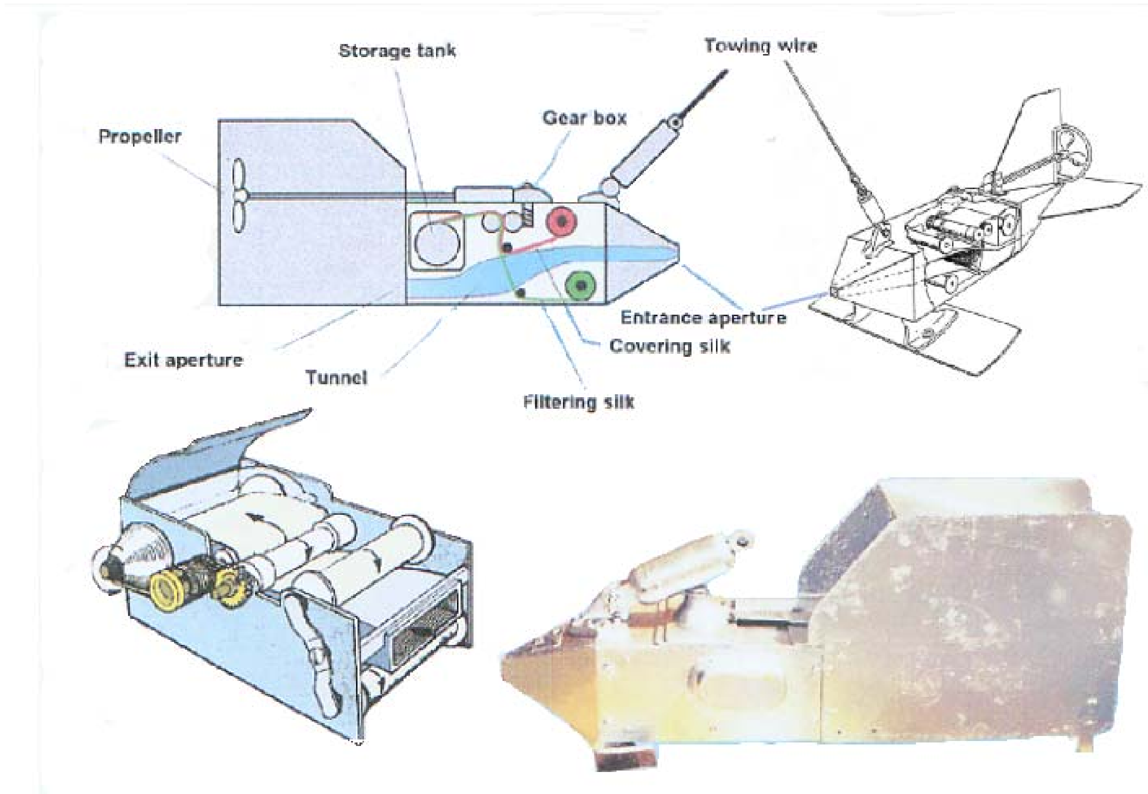

Figure 4. The original Continuous Plankton Recorder body (upper right), its current modification with box tail (lower right), and a cross-section showing the workings of the internal mechanism (After Richardson et al, 2006).

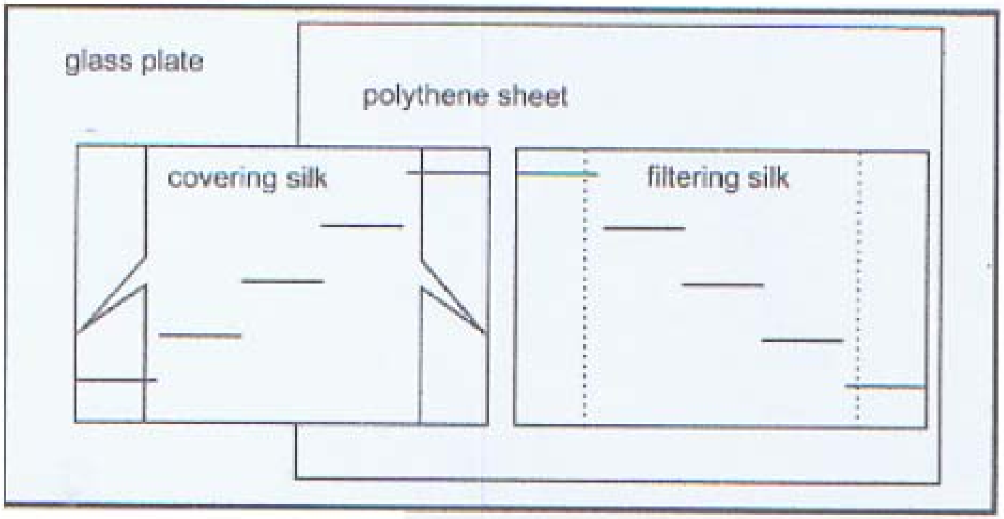

Figure 5. The stepped path across the covering and filtering silk followed during a zooplankton traverse examination. Organisms are counted when viewed along the solid horizontal lines. Dotted vertical lines indicate the width of the filtering silk in the water tunnel, although plankton is often present to the silk edges.

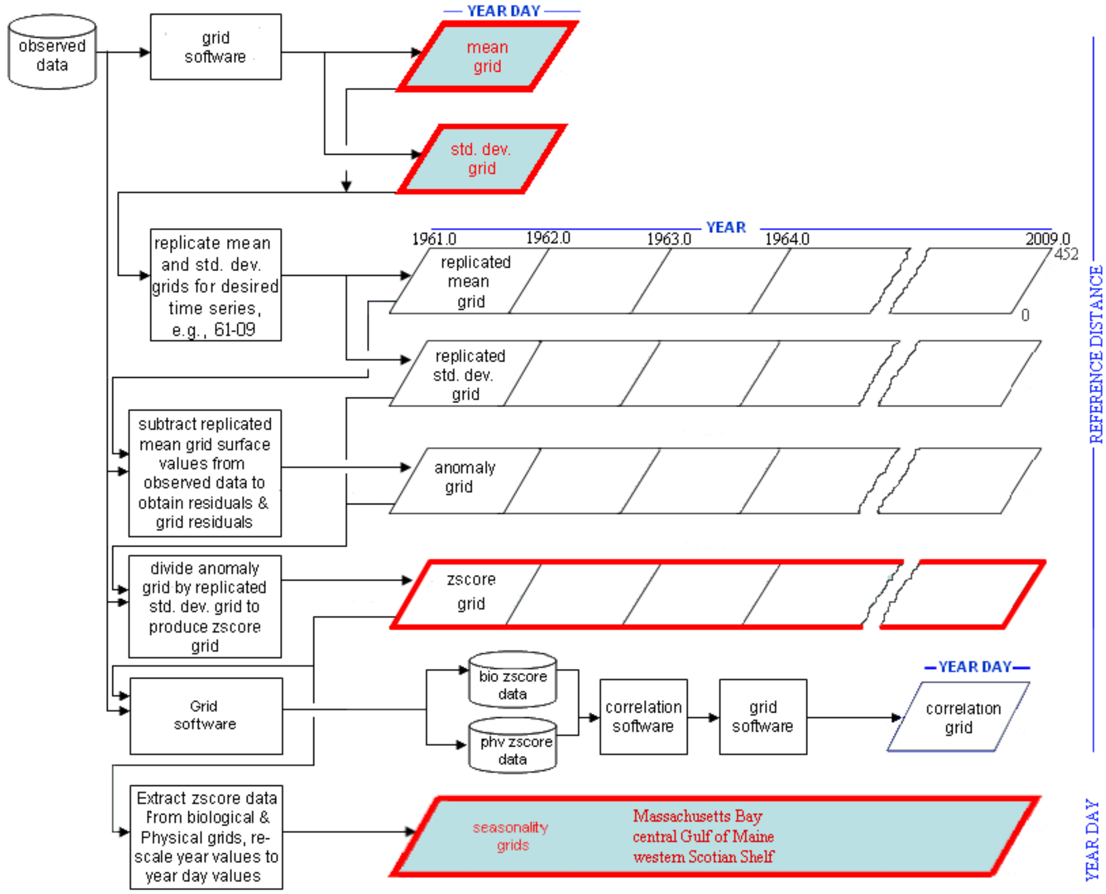

Figure 6. Overview of gridding procedure used on Continuous Plankton Recorder, temperature, and salinity data. This atlas contains portrayals of the mean and seasonality grids. The standard deviation grid data are available in supplemental data sets.

Calanus, Leach, 1819, copepodite stages 1-4.

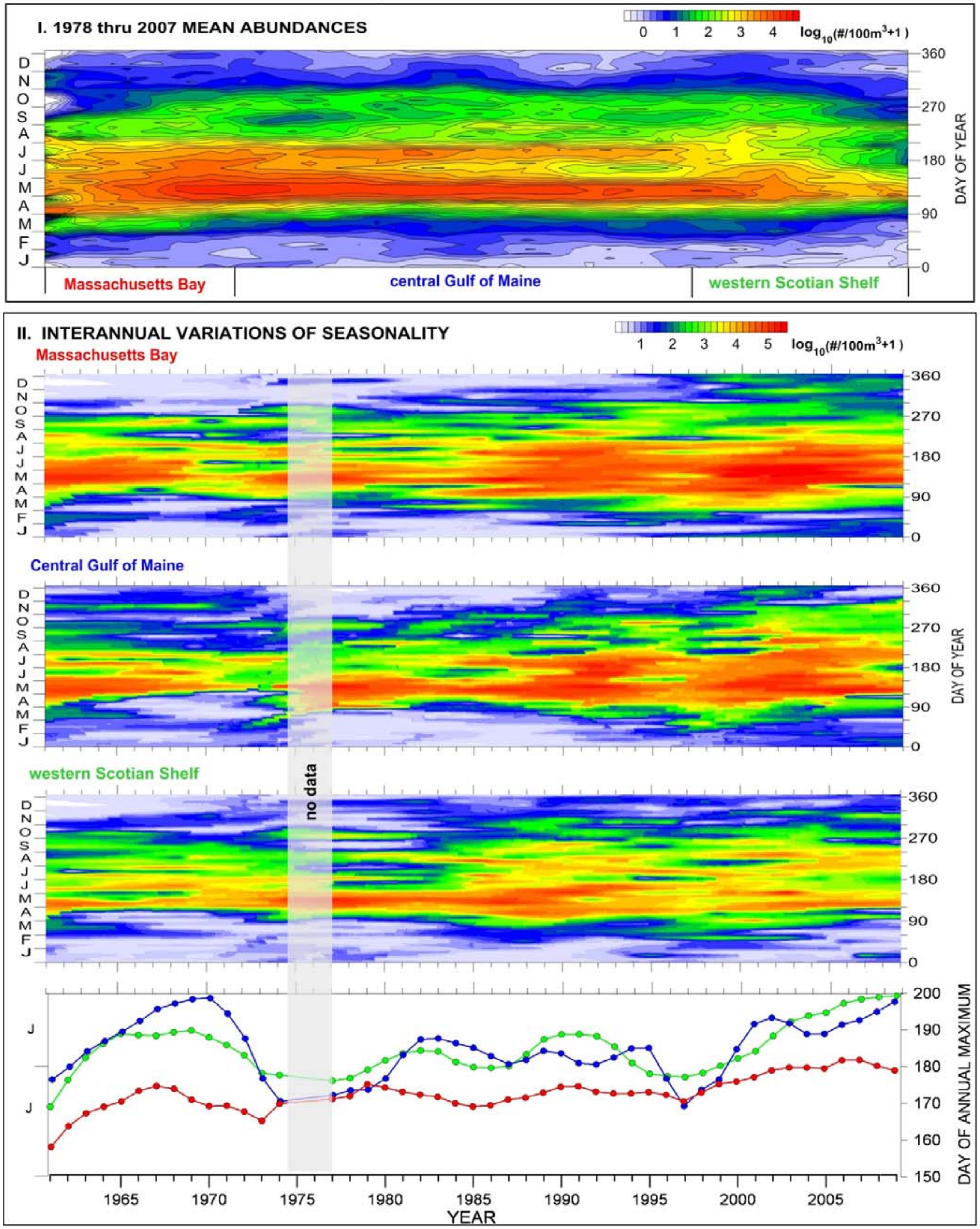

Figure 7. *Calanus* c. 1-4 variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Calanus*, Leach, 1819, copepodite stages 1-4.**

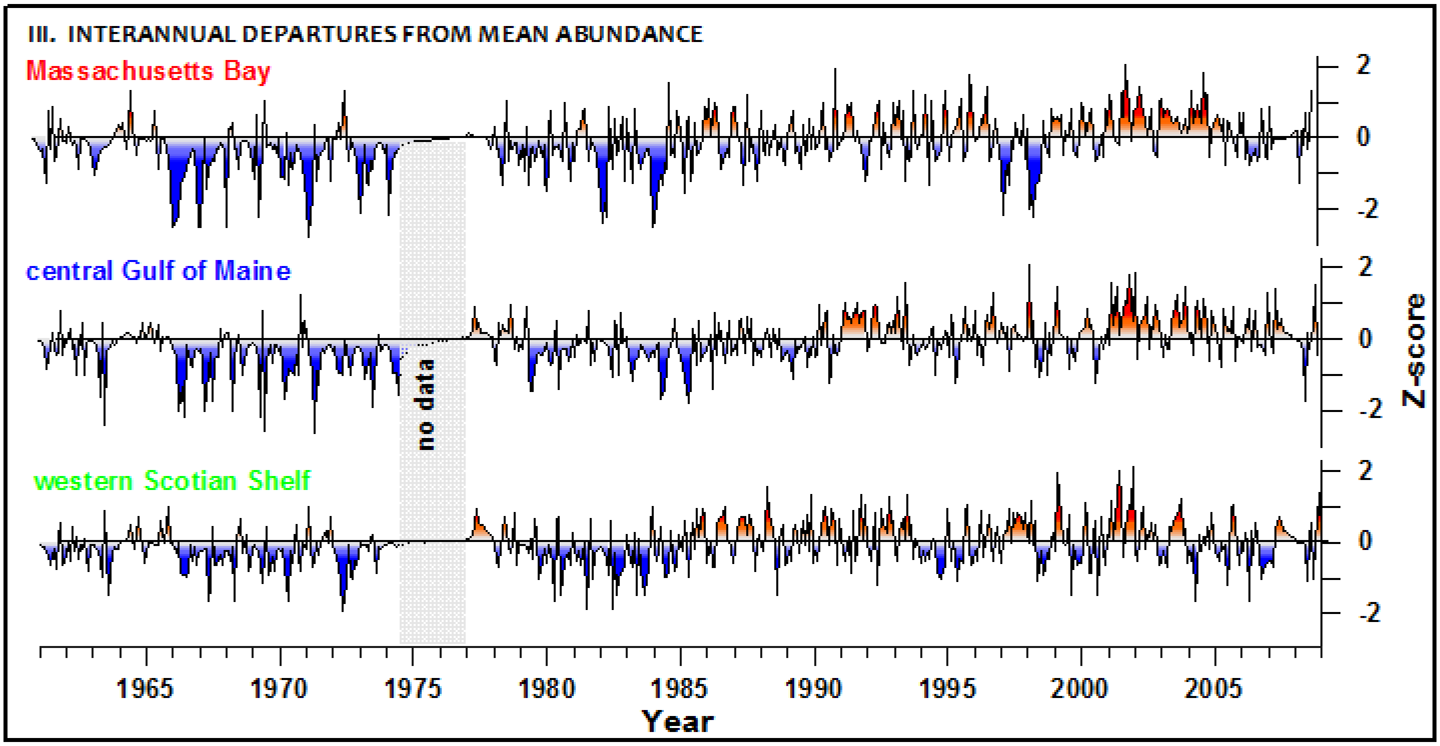

Figure 7 (cont.). *Calanus* c. 1-4 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

In CPR samples from the Gulf of Maine, the young stages of *Calanus* are primarily the early life stages of *Calanus finmarchicus*, a dominant large copepod found throughout sub-Arctic waters of the North Atlantic. Due to its large size, it is a major contributor to the annual biomass cycle in the region. *Calanus* is a key prey item essential for the sustenance of vital fisheries and the endangered North Atlantic Right Whale population.

Mean abundances increased in March from winter lows across the transect, peaking in May followed, except for the eastern end of the transect, by a lesser peak in late June. Greatest abundances occurred over outer Massachusetts Bay and the central Gulf of Maine. Peak values generally declined from west to east. In early August abundance began a decline, returning to winter levels by early October.

Relatively larger differences in the day of annual maximum between transect sections occurred from 1961 into the early 1970s than was seen during the rest of the series. A general latening of the peak was seen for the central Gulf of Maine and the western Scotian Shelf, especially after 1997.

Monthly abundance departures from the 1978-2007 base period showed negative values from 1961 into the mid-1980s, positive anomalies from 1985-2005 (except in the central Gulf of Maine), and a return to average or slightly negative conditions thereafter. Notable exceptions were the large negative Zscores in 1997 and 1998, and the mixed departures in the central Gulf of Maine from 1985 to 2002.

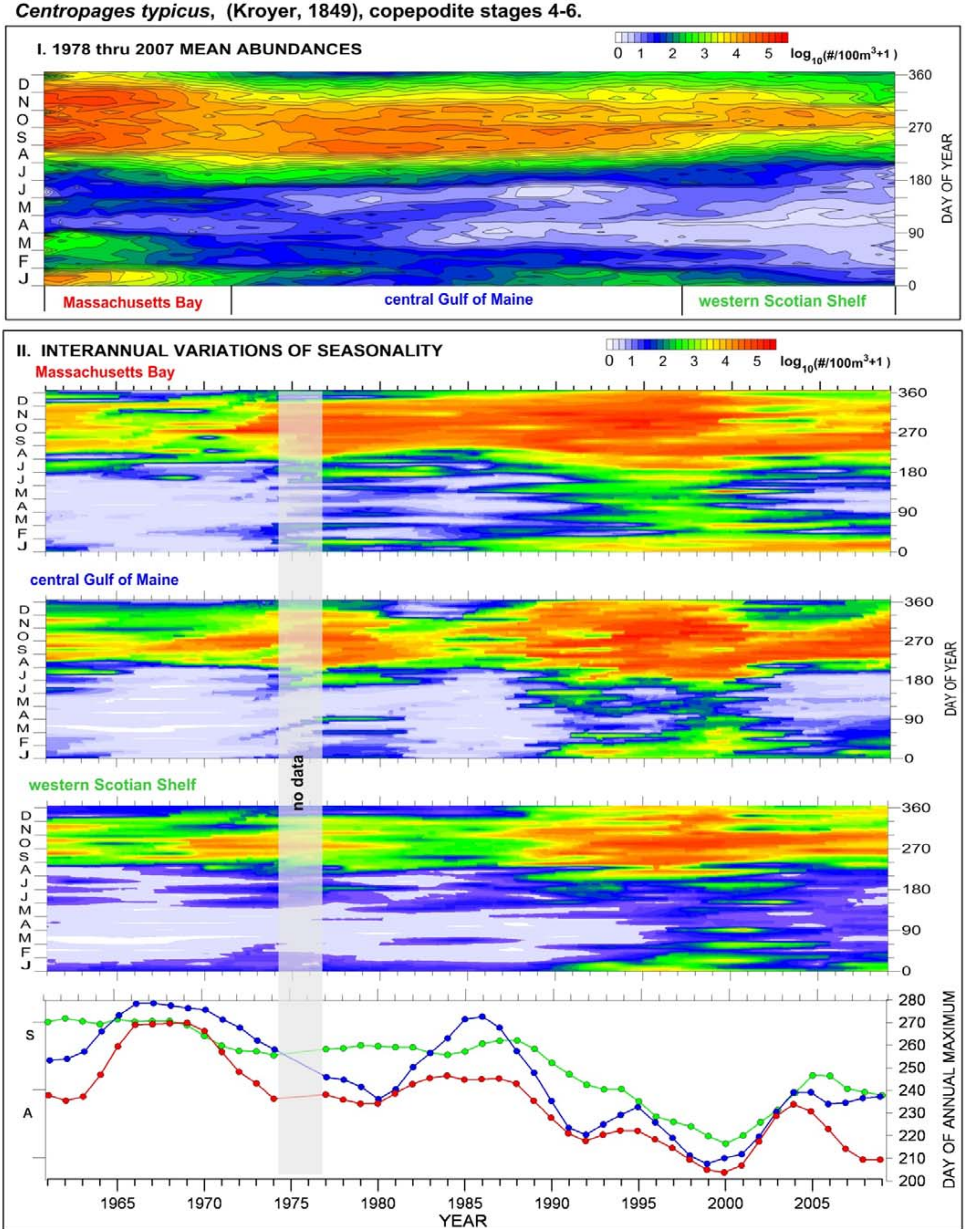

Figure 8. *Centropages typicus c. 4-6* variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Centropages typicus*, (Kroyer, 1849), copepodite stages 4-6.**

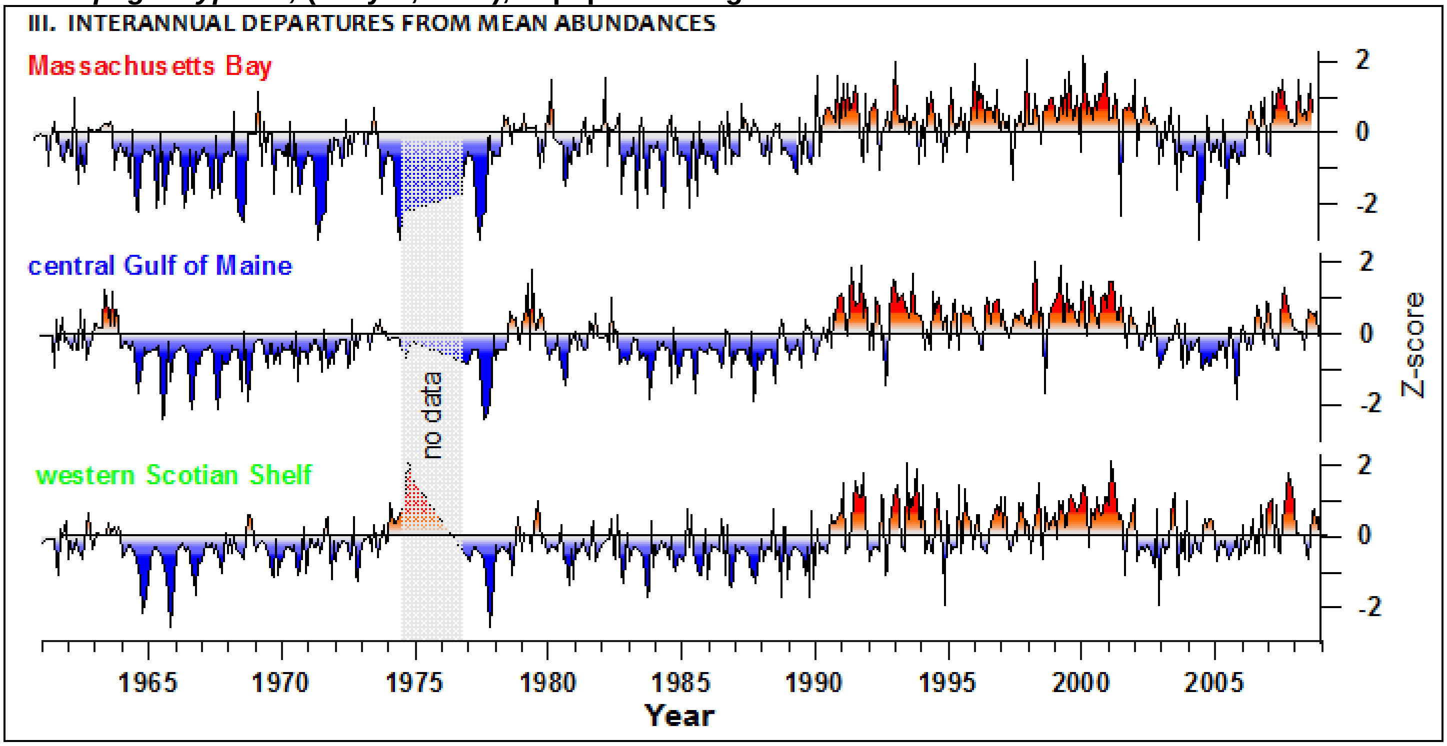

Figure 8 (cont.). *Centropages typicus c. 4-6* variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Centropages typicus is a relatively large, omnivorous calanoid copepod. When food resources are available, temperature appears to be the key factor that determines its spatial and temporal range. Its abundance is highest in waters that range from 13^{o}to 20^{o}C.

High mean values occurred in Massachusetts Bay in January, as remnants of the previous year's swarm. Likewise, moderate abundances were found over the eastern portions of the central Gulf of Maine and the western extremes of the western Scotian Shelf. Moderate abundances continued in Massachusetts Bay through March. Until July, most of the transect exhibited low values. Thereafter, abundance rose rapidly in the west, more slowly in the east, and peaked in October. The peak persisted in Massachusetts Bay to nearly the end of the year, whereas a decline began on the western Scotian Shelf by the end of October.

Beginning in 1990 the seasonal pattern, which had been fairly stable during the previous three decades, changed considerably, with moderate abundances occurring for most of the January through July period in all three sections of the transect. By about 2005 this seasonality change had somewhat reverted to the pre-1990 state. The day of annual maximum abundance showed an earlying trend for all three transect sections.

The period prior to 1990 had consistently negative anomalies. From 1990-2003 the departures where consistently positive, followed by about three years of below average abundances, and then ending the series on the positive side.

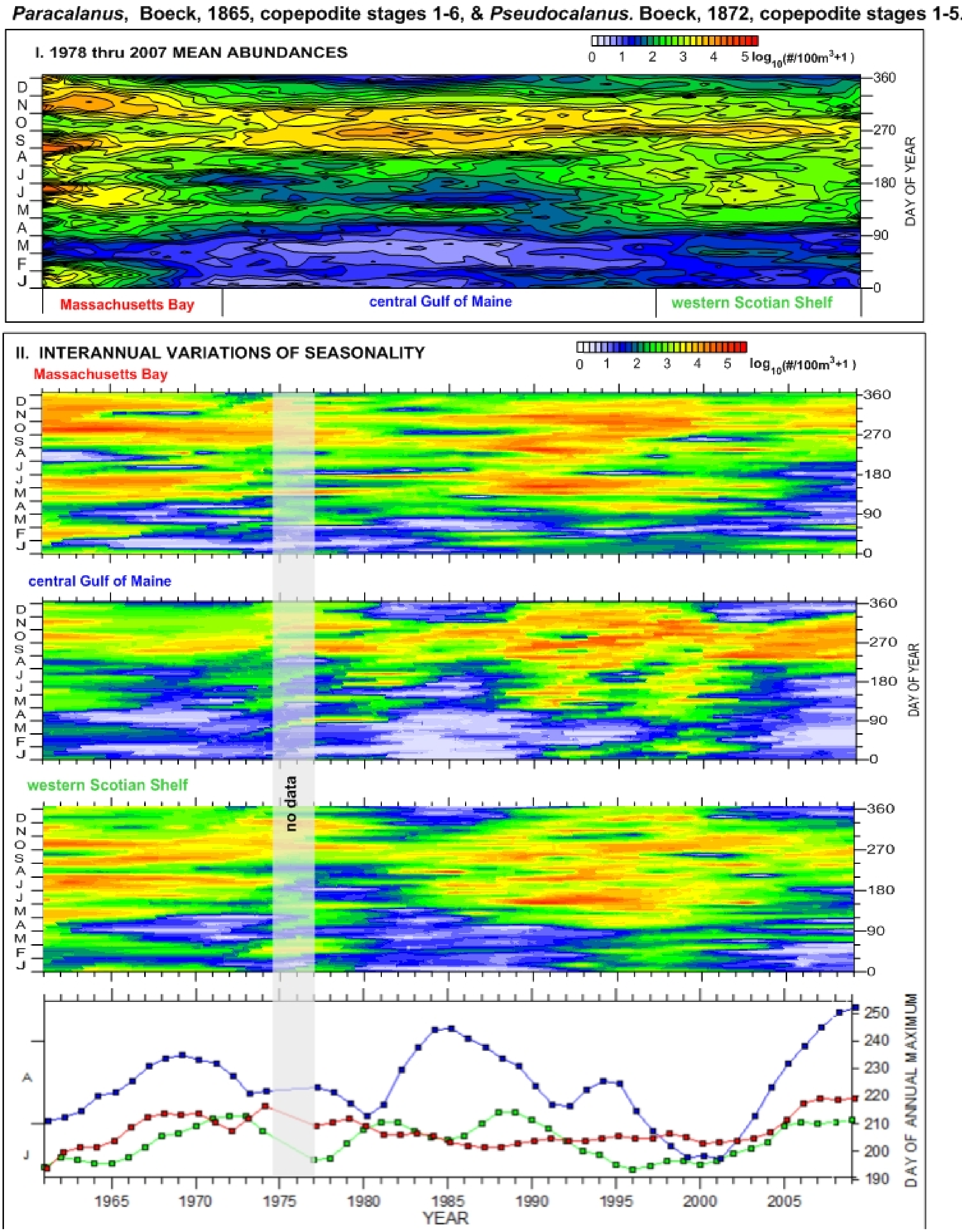

Figure 9. *Paracalanus* c.1-6 & *Pseudocalanus* c.1-5 variations along the Gulf of Maine Continuous Plankton Recorder transect.

Paracalanus, **Boeck, 1865, copepoditte stages 1-6 &** ***Pseudocalanus,*** **Boeck, 1872, copepodite stages 1-5.**

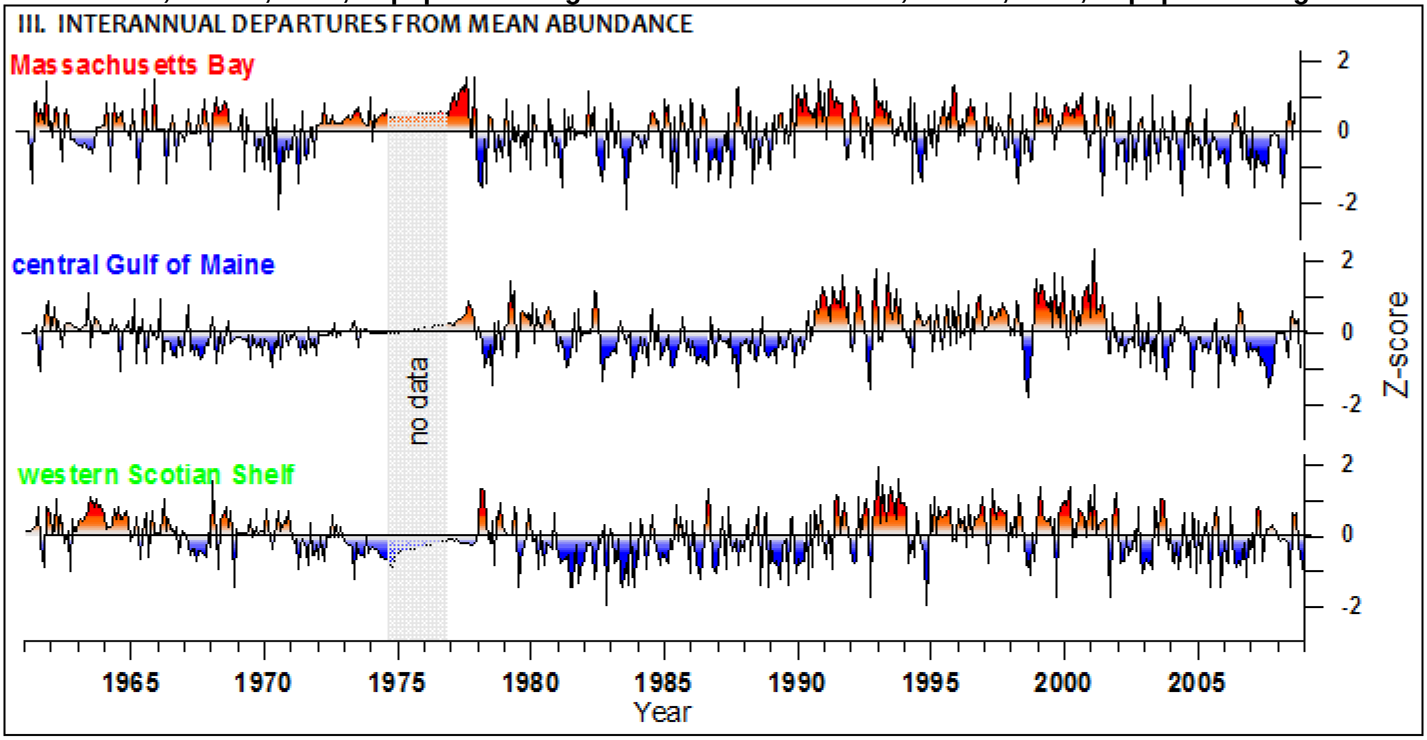

Figure 9 (cont.). ***Paracalanus*** **c.1-6 &** ***Pseudocalanus*** **c.1-5 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

IV. COMMENTS

To expedite the identification and staging of these two similar sized and shaped copepod species, adults of *Pseudocalanus* were enumerated (see below), but all other stages from the two species were collectively assigned to this one category. These relatively small copepods play an important role in the trophic ecology of temperate and boreal pelagic ecosystems. They are an important prey item of several larval fish species.

Mean abundance of these copepods increased from their winter low in early spring and become common inshore at both ends of the transect by April. Abundance was highest in Massachusetts Bay where three distinct pulses occurred during the year. These inshore concentrations spread across the central Gulf of Maine during summer and transect abundance peaked during early autumn. Numbers remained high through the autumn months until a sharp decline was observed from December to January, except for Massachusetts Bay waters, where it sometimes remained abundant till mid-February.

Seasonality of these copepods in Massachusetts Bay and the western Scotian Shelf remained relatively steady during the series. However, the central Gulf of Maine day of annual maximum values showed considerable variation with earlier peaks centered in 1961, 1980, and 2000, and later peaks centered in 1969, 1985, and 2008.

Anomalies were positive throughout the Gulf of Maine during the early 1960s. Departures were variable from 1965 until a sustained low period was measured in the mid to late 1980s. From approximately 1990-2001 positive anomalies dominated, followed by negative values to near the end of the series.

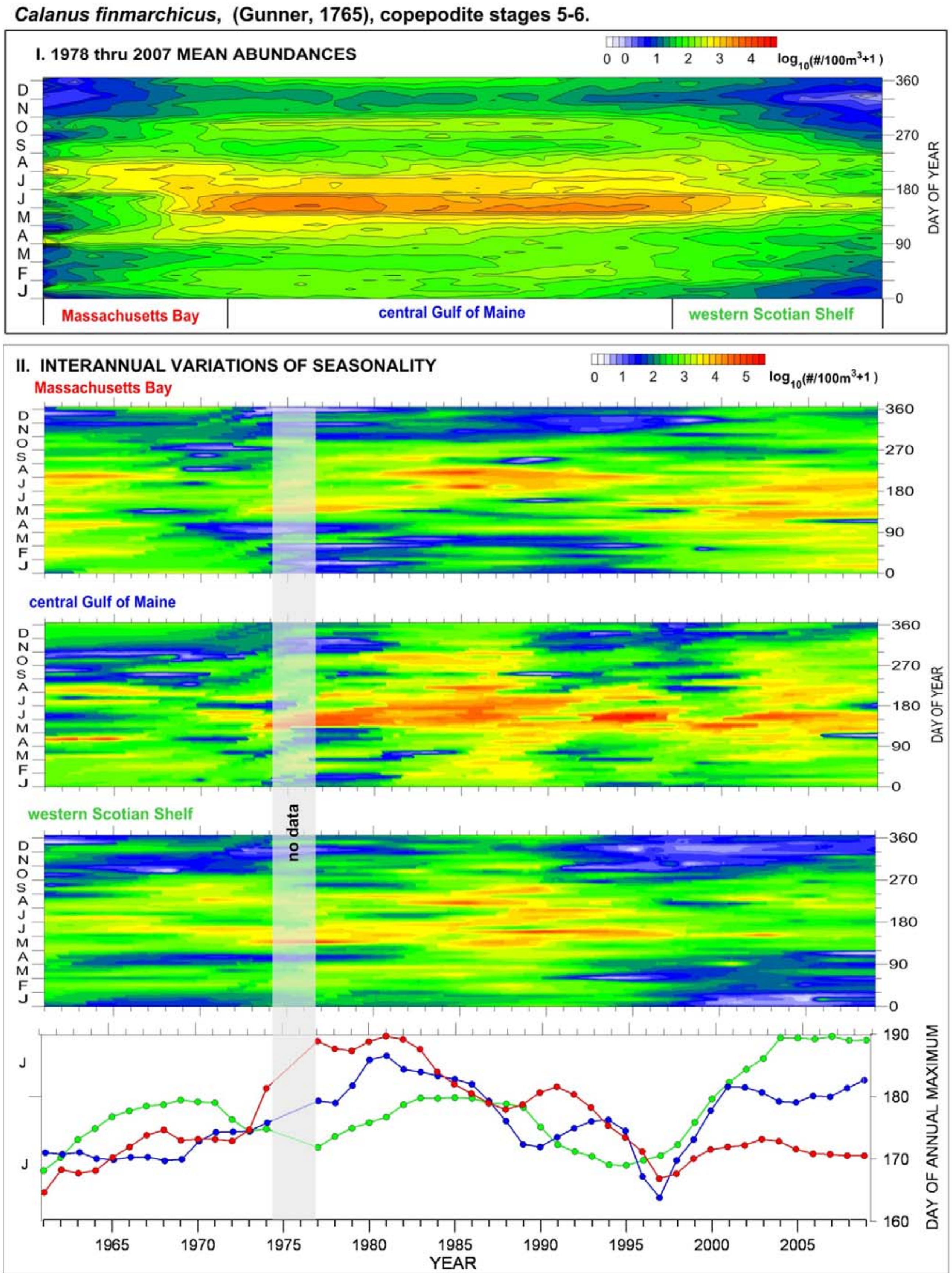

Figure 10. ***Calanus finmarchicus*** **c.5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

Calanus finmarchicus, (Gunner. 1765), copepodite stages 5-6

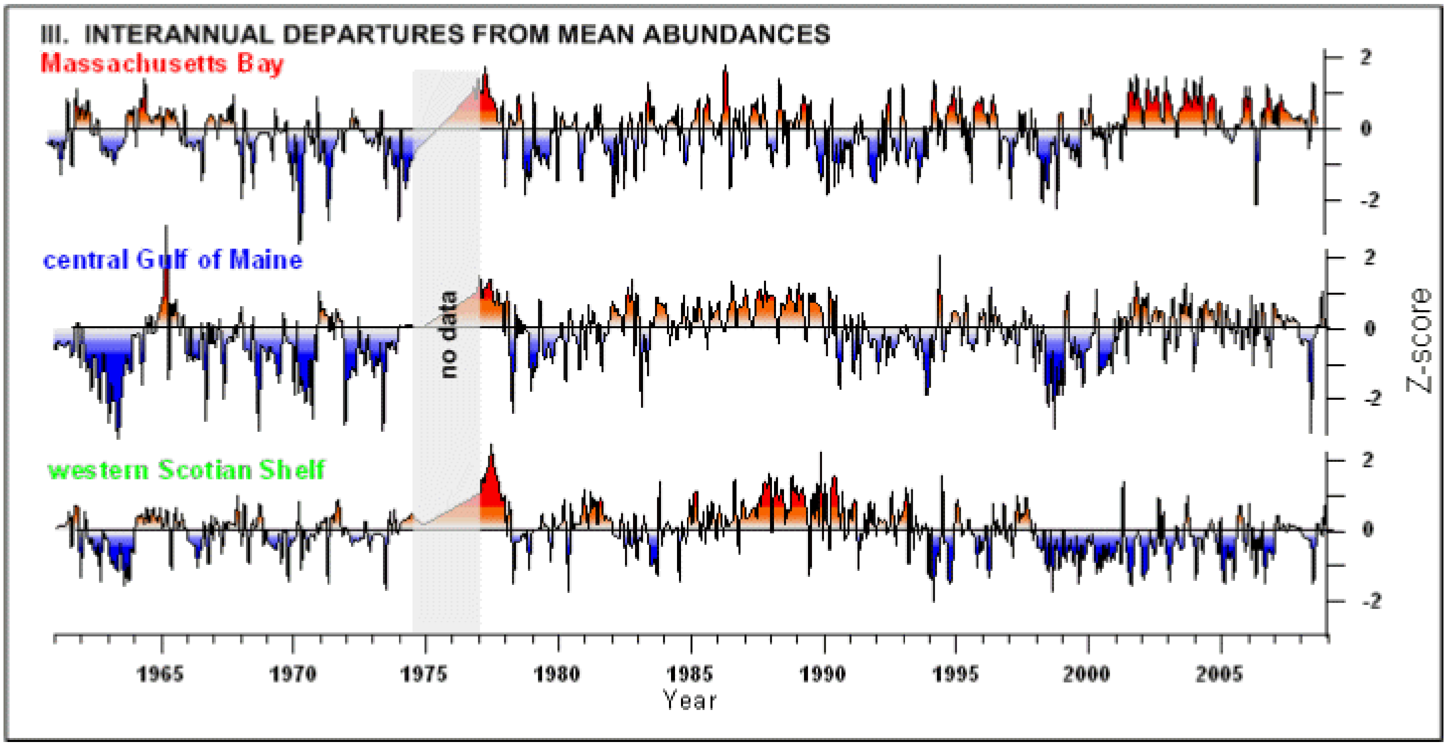

Figure 10 (cont.). *Calanus finmarchicus* c.5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

These copepods play a key role in the Gulf of Maine food web transferring energy from primary producers to upper trophic levels. They overwinter in the deep water basins as stage 5 copepodites that rise to the surface layers in early winter, molt to the adult stage, and begin to reproduce. Some individuals are transported onto Georges Bank, while others remain and either spawn a second generation or enter dormancy. Their life cycle is also dependent on external processes, e.g., restocking from upstream sources.

Mean abundance began to increase in early winter with higher numbers located in the central Gulf of Maine. Abundances increased through the spring and reached maximum levels in late spring-early summer. The concentrations advanced inshore into Massachusetts Bay for a brief period in August. Numbers declined slowly thereafter until the annual minimum was reached by late autumn.

Variation in seasonality occurred for all three transect sections. Annual abundance peaks in Massachusetts Bay and the central Gulf of Maine occurred in mid-June from 1961-1973, but occurred about 15 days later from the late 1970s – 1984. From then until 1997, peaks occurred earlier, followed by a latening in the central Gulf of Maine. Western Scotian Shelf timing was fairly steady until 1995 when latening amounted to nearly 20 days by 2008.

Anomalies in the central Gulf of Maine were mostly negative during the 1960s and 1970s. Positive departures occurred during the 1980s over the central Gulf of Maine and western Scotian Shelf, and after 2001 in the western two sections. Persistent lows occurred in these sections in the late 1990s, and in the western Scotian Shelf section until the end of the series. Temporal coherence between transect sections is less obvious for this taxon than for the previous, more abundant taxa.

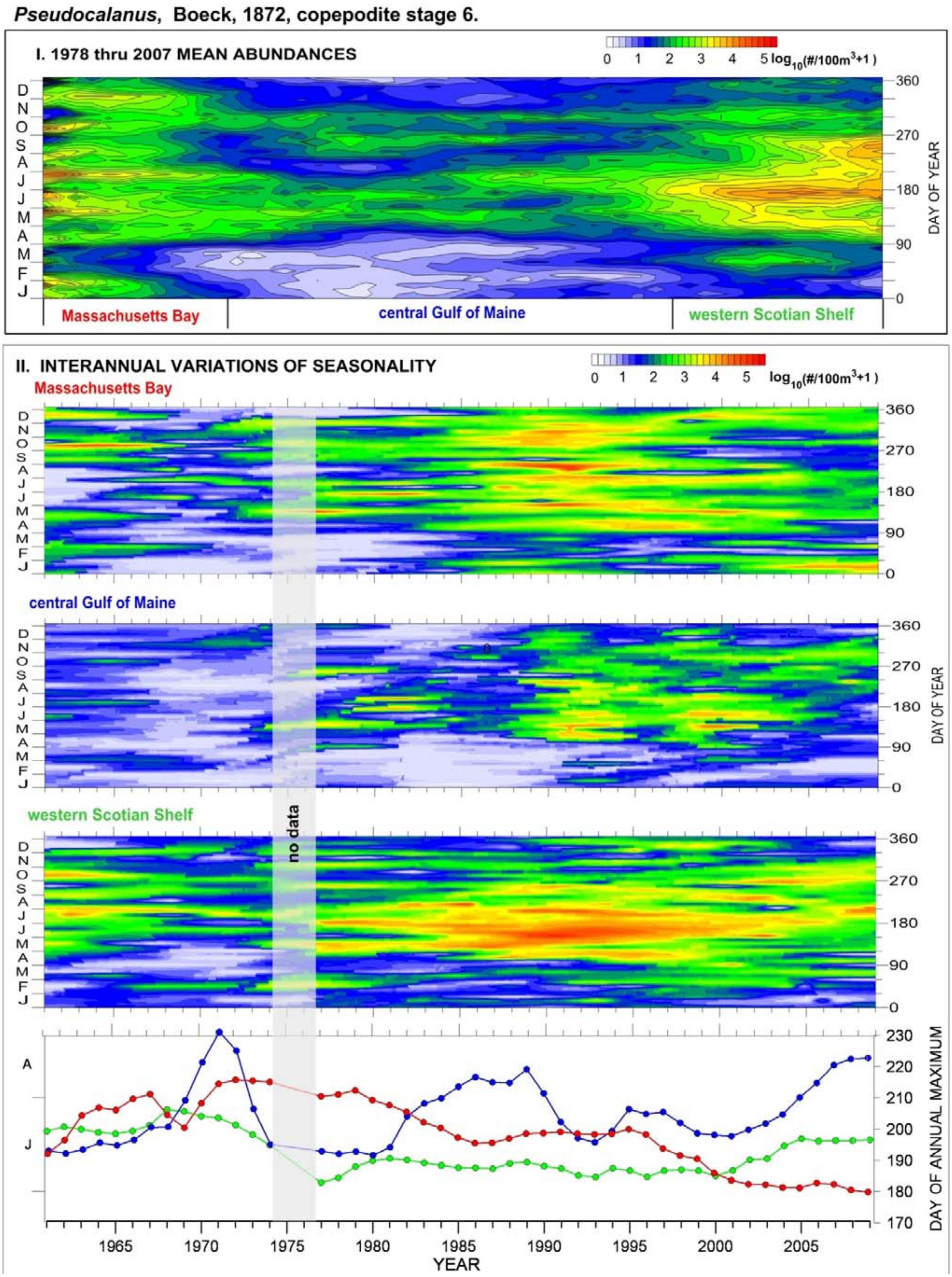

Figure 11. ***Pseudocalanus*** **c. 6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

***Pseudocalanus*, Boeck, 1872, copepodite stage 6.**

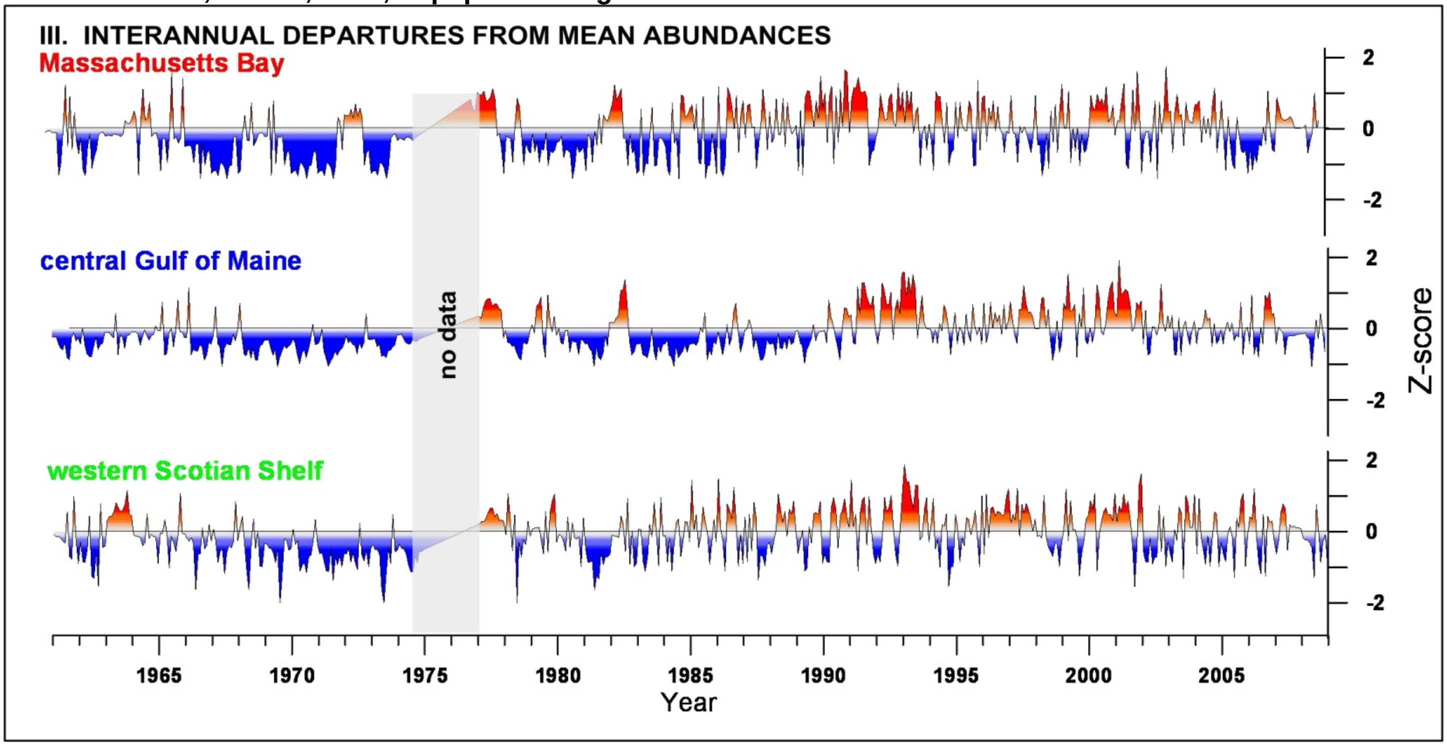

Figure 11 (cont.). *Pseudocalanus* c. 6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Pseudocalanus is a northern genus of small calanoid copepod that have a widespread distribution. There are two species common in the Gulf of Maine: *P. moultoni (*more inshore) and *P. newmani* (more offshore). Since they cannot be readily distinguished by visual examination alone, they are combined here. There is a large body of evidence indicating that these species are the predominant prey item of many larval fish found in northern waters.

Mean abundances were highest over the Massachusetts Bay and western Scotian Shelf sections, with the latter predominating. For Massachusetts Bay, two somewhat connected high periods existed from April to August and August through the end of the year, extending through the following January. These two periods were in evidence across the central Gulf of Maine, but at lower levels. On the western Scotian Shelf, abundance began to increase in early March, peaked by late June, then began to decline in amount and spatial extent, reaching seasonal lows by December.

Complicated patterns of seasonality occurred through the series. Four fairly distinct periods can be seen: 1961-1967; 1967-1972; 1972-2004; and 2004-2009. Examination of the day of annual maximum suggests that these four patterns were due more to series changes in abundance than to changes in seasonal timing.

Monthly anomalies for the three sections were mostly negative prior to the mid- 1970s. In Massachusetts Bay and the central Gulf of Maine this condition persisted with slightly less consistency into the mid- to late 1980s. During this period on the western Scotian Shelf the departures were more mixed. From 1990 to about 2005 positive anomalies prevailed, after which somewhat mixed departures were seen.

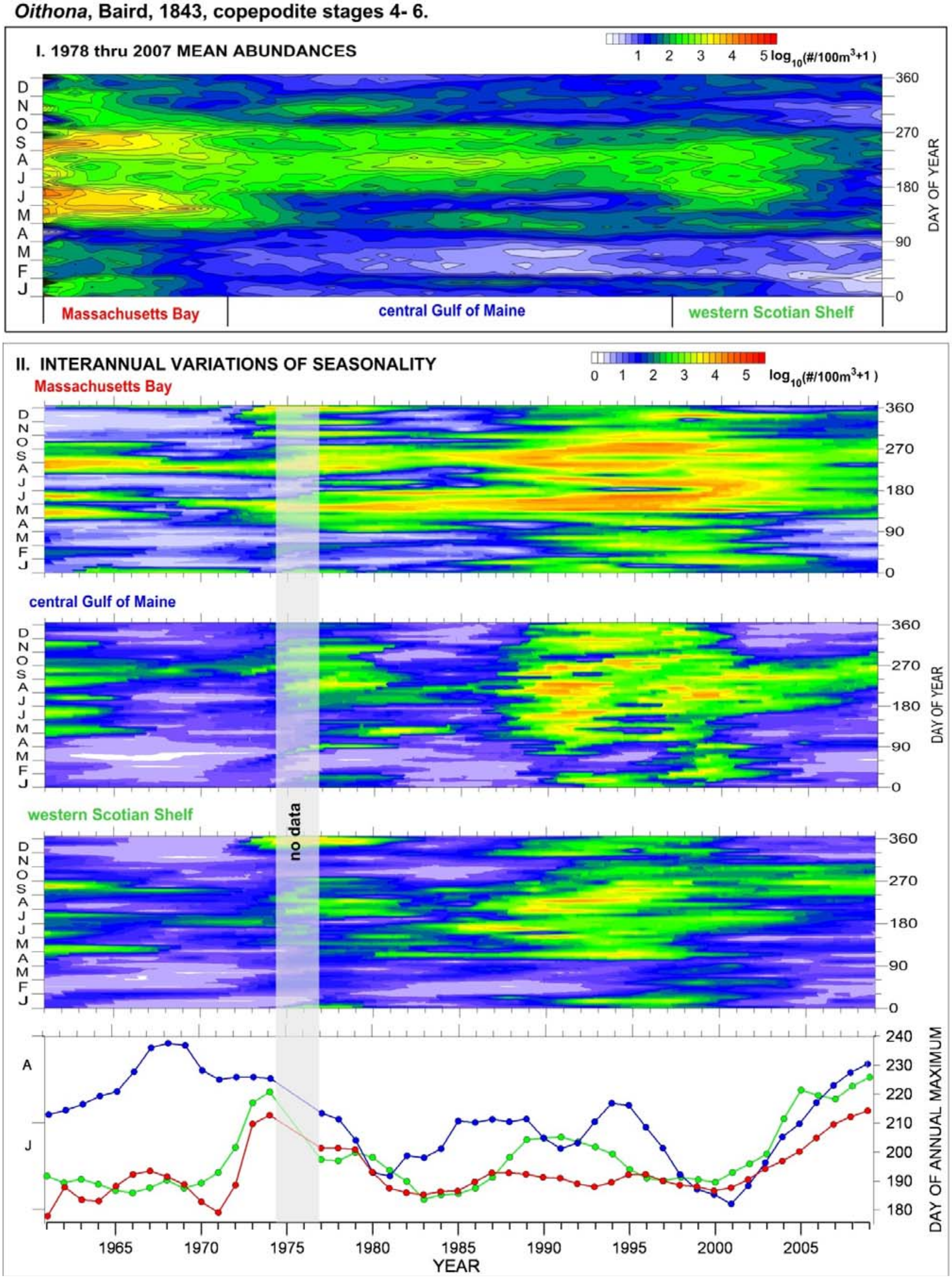

Figure 12. ***Oithona*** **c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

Oithona, Baird, 1843, copepodite stages 4-6

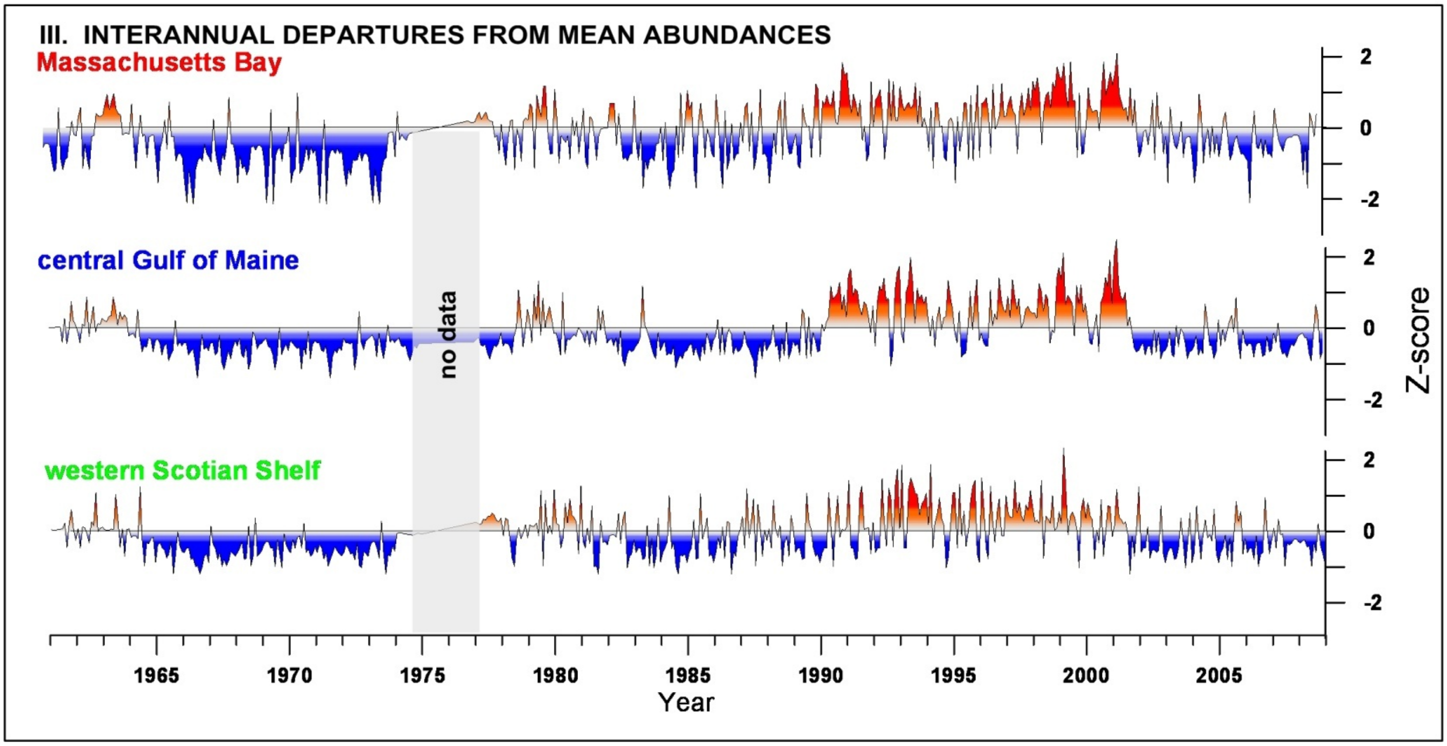

Figure 12 (cont.). *Oithona* c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Oithona is one of the most abundant and ubiquitous copepods found throughout global coastal and oceanic areas. This cyclopoid copepod has been described as a eurythermal, euryhaline, and omnivorous genera. It usually constitutes a major fraction of the total number of organisms found in the zooplankton community.

Oithona was fairly abundant in Massachusetts Bay during most of the year, unlike the other two transect sections. Vernal increase began in early May across the transect. Two strong pulses (July and September) occurred in Massachusetts Bay, while a single peak in the other two sections occurred in late July. A significantly lower seasonal peak was seen at the eastern extreme of the transect. By early November central Gulf of Maine and western Scotian Shelf abundances began to decline, not reaching winter lows until February or March of the following year. Considerably higher abundances occurred in Massachusetts Bay than the other sections.

Interannual variations of seasonality for Massachusetts Bay and the western Scotian Shelf was fairly steady from 1961-2002, except for a brief latening reaching about 30 days in 1973. After 2002 there was a steady latening until the end of the series. In the central Gulf of Maine, in the early 1960s, annual abundance peaked in early August, by 1973 in late August, and then showed an irregular earlying that by 2001 had reached early July. By the end of the series the day of maximum abundance wasn’t reached until the latter part of August.

Across the transect, departures from average were negative from 1965 to 1974, from 1981-1990, and from 2002 to the end of the series. Positive anomalies occurred briefly during 1963-1964, 1978-1979, and nearly continuously from 1990-2001. Interannual abundance anomalies were quite consistent for the three transect sections through the series.

Thecosomata, (Blainville, 1821), unstaged.

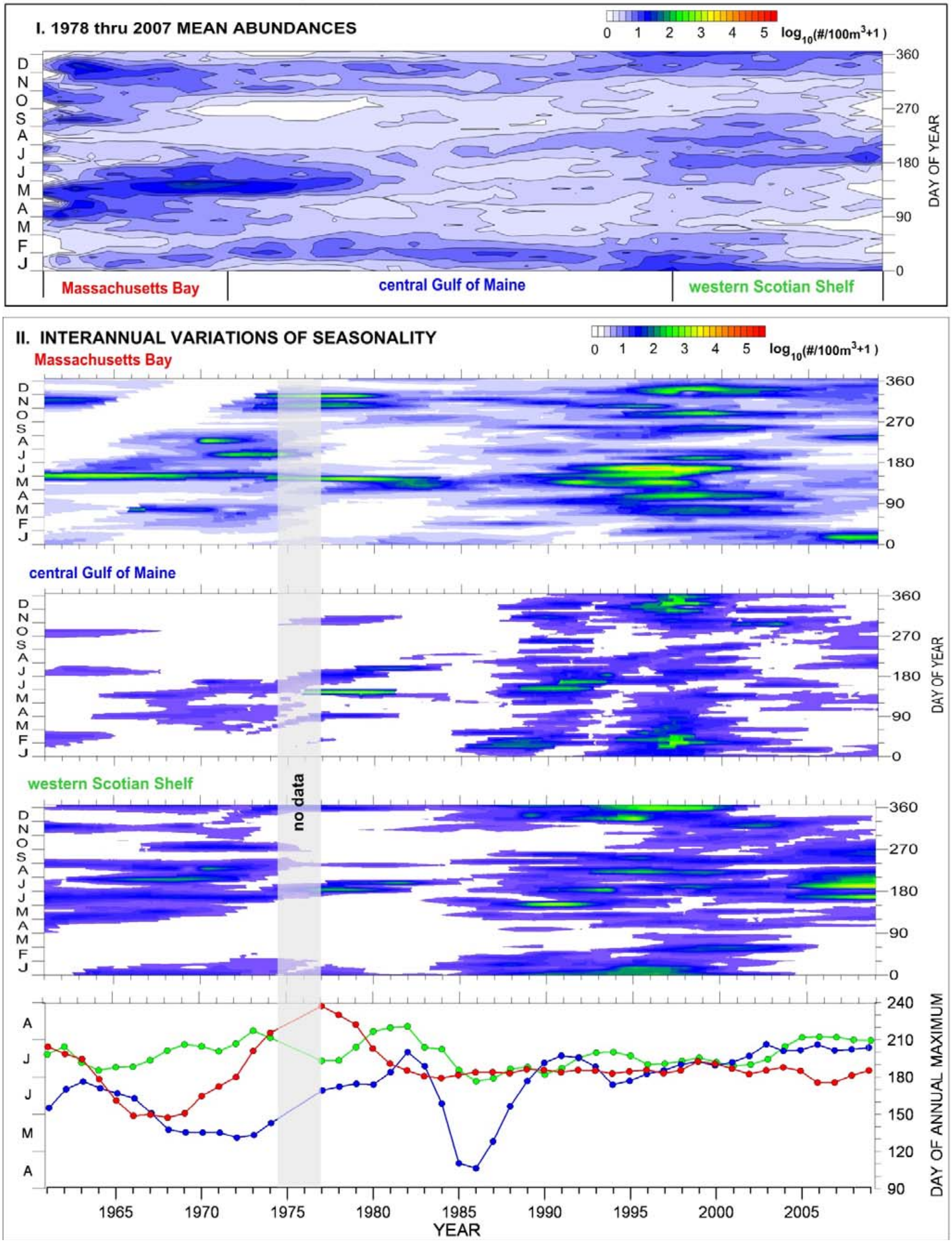

Figure 13. Thecosomata unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

Thecosomata (Blainville), 1821, unstaged

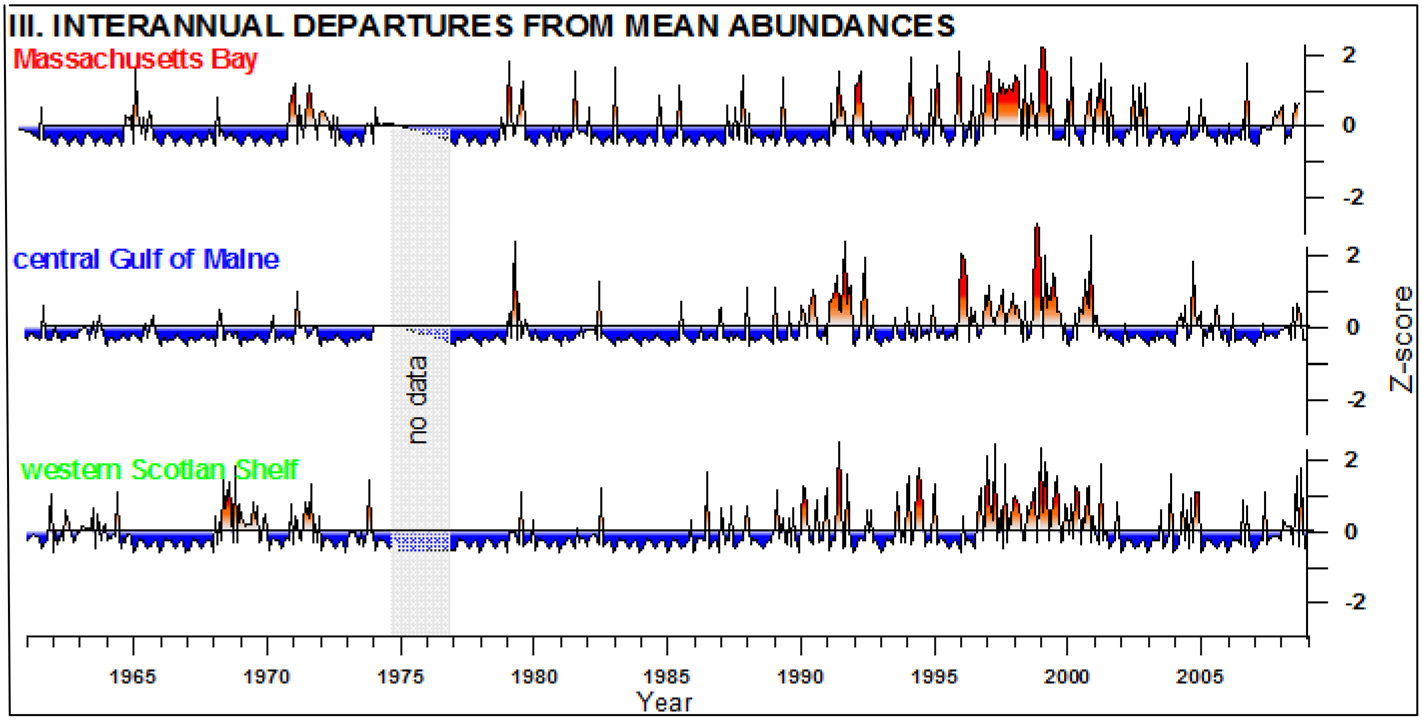

Figure 13 (cont.). Thecosomata unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The thecosomata are shelled pteropods that spend their entire life in the plankton. Many species produce a large spherical mucous web to filter-feed on phytoplankton as well as small zooplankton. The thecosomata have been targeted as critical study species regarding the impact of ocean acidification on marine life because their shell formation may be impacted by the acidifying effects of elevated atmospheric carbon dioxide levels.

Mean abundances showed them present along the entire transect from January through February. Their seasonal peak in Massachusetts Bay occurred in late May-early June, followed by a late summer low and a secondary high from September through December. On the western Scotian Shelf, abundance peaked from late June to mid-July. Low values for much of the central Gulf of Maine existed until October and November.

Seasonal peaks prior to the mid-1980s fluctuated by more than 30 days in all three sections of the transect. Except for the mid-1980s dramatic earlying in the central Gulf of Maine, timing of peaks remained much more stable until 2004, after which they occurred somewhat earlier over Massachusetts Bay and somewhat later over central Gulf of Maine and the western Scotian Shelf.

Negative anomalies dominated all three sections prior to 1990, with notable exceptions of above average conditions in the late 1960s to early 1970s on the western Scotian Shelf, and the early 1970s over Massachusetts Bay. Positive departures dominated all three sections from 1990-2001,followed by mixed phase conditions to the end of the series.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

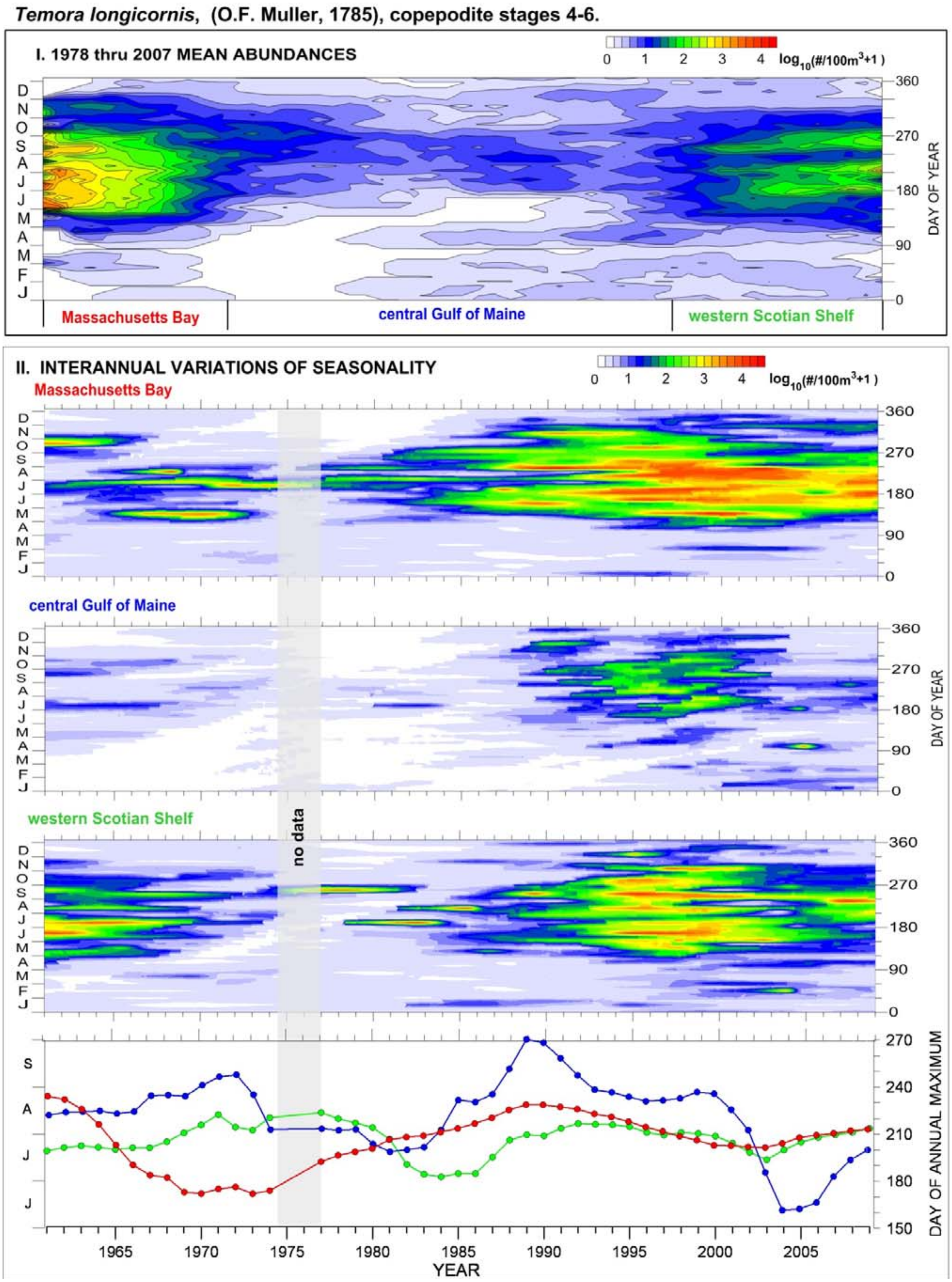

Figure 14 ***Temora longicornis*** **c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

***Temora longicornis*, (O.F. Muller, 1785), copepodite stages 4-6**

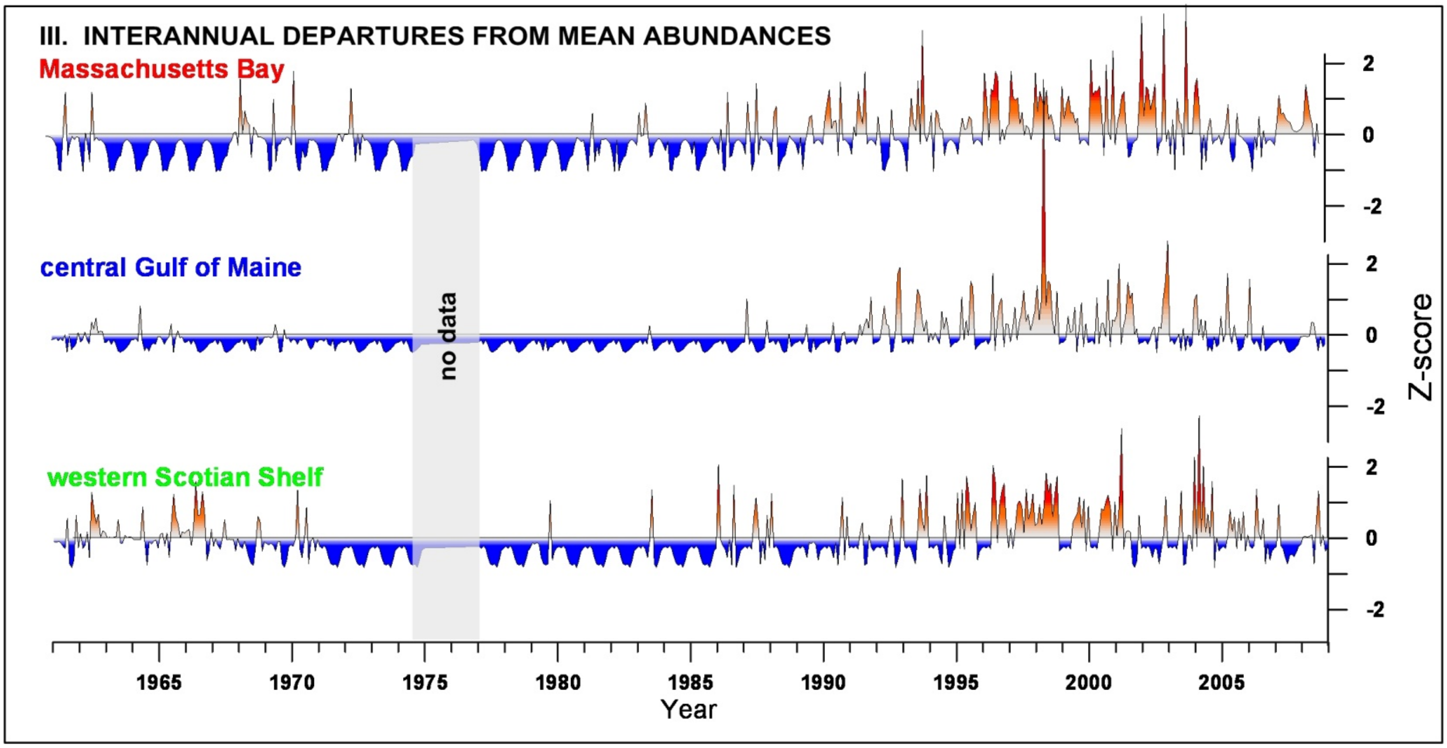

Figure 14 (cont.). *Temora longicornis* c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The calanoid copepod *Temora longicornis* is usually a common component of the zooplankton assemblage that resides in coastal waters of the northern hemisphere. It is omnivorous, feeding on phytoplankton as well as on ciliates and other zooplankton. Since it has high metabolic requirements and low energy reserves, its grazing impact can be substantial on the standing stock of selected prey items. During the spring, this species can dominate copepod biomass and remove up to 50% of the daily primary production.

Except for low values in the summer, abundances in the central Gulf of Maine were zero to near zero. On the two extremities of the transect, vernal increases began in mid-April, peaked from early June to early August, and again from late August to early October, over both Massachusetts Bay and the western Scotian Shelf. Abundances reached levels several orders of magnitude greater over inner Massachusetts Bay than over the western Scotian Shelf. By December abundances had declined to near zero across the transect.

Seasonal peak in Massachusetts Bay occurred in late August followed by a steady earlying to late June by 1969, and lasting until 1974. Then began a long, but steady latening reaching mid-August in 1990. Following this, peaks occurred earlier, reaching mid-July by 2000, and then remained steady till the end of the series. Western Scotian Shelf peaks varied inversely until about 1985 when their pattern began to match that in Massachusetts Bay. Changes in seasonal timing for relatively low abundance taxa are sometimes overshadowed by the large changes in abundance. Also the selection of the base period is important.

Except for positive anomalies on the western Scotian Shelf prior to 1967, and several months in Massachusetts Bay in the late 1960s, departure were below 1978-2007 means till 1990. Thereafter, positive anomalies predominated over all three transect sections.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

Copepoda, Milne-Edwards, 1840, nauplius.

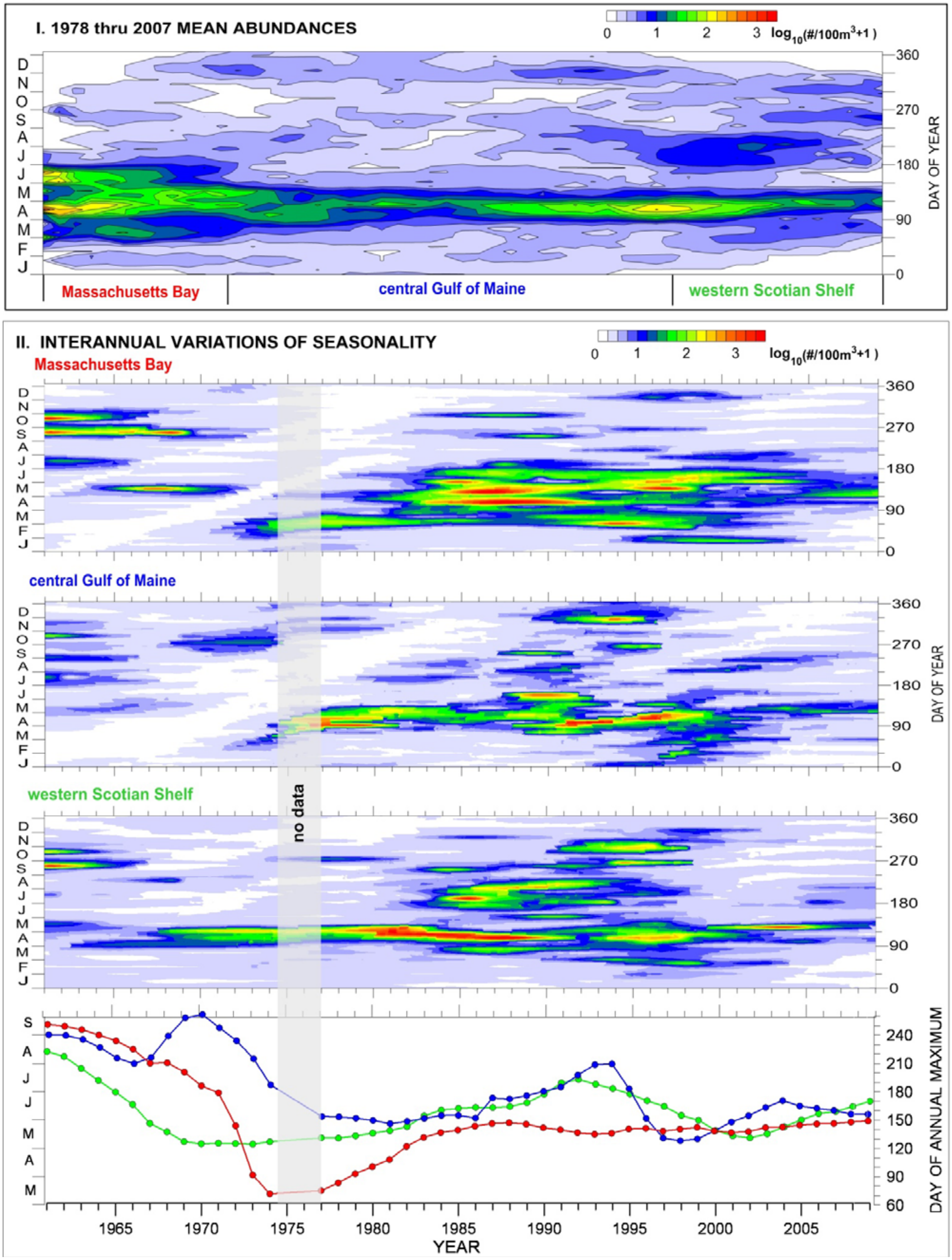

Figure 15. Copepoda nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

Copepoda, Milne Edwards, 1840, nauplius

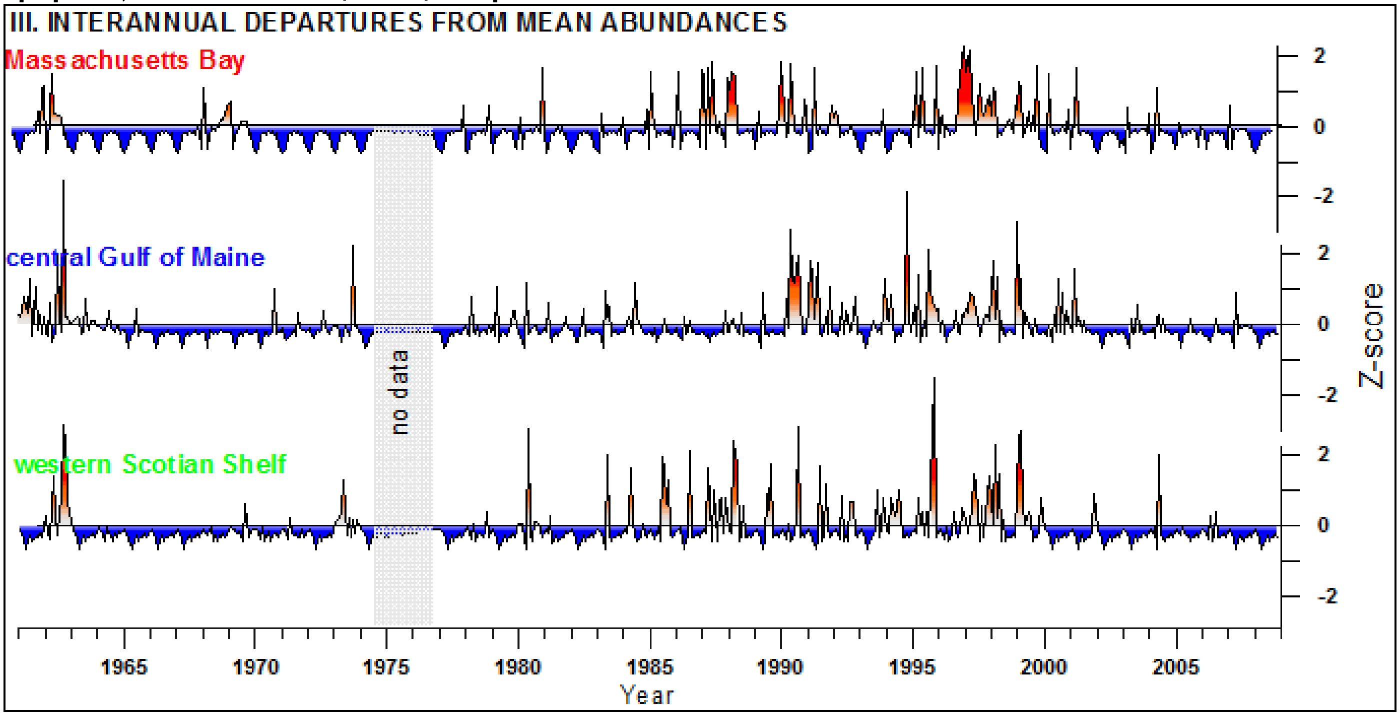

Figure 15 (cont.). Copepoda nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Copepods emerge from an egg as nauplii and have six progressively larger, free-swimming nauplier stages. They represent an important trophic link between the microbial and classical food webs. The importance of copepod nauplii as the natural first food of larval fish in the sea has been widely reported.

Mean conditions for copepod nauplii showed low levels across the transect from January until early March in Massachusetts Bay and on the western Scotian Shelf, and, until late March, over the central Gulf of Maine. Peak abundances occurred in mid-April, with highest values showing in western Massachusetts Bay and at the western edge of the western Scotian Shelf. A secondary peak in inner Massachusetts Bay occurred in early June, after which abundances returned to low levels. Higher abundances persisted on the western Scotian Shelf from July to mid-August, and in patchy time-space areas through November.

Seasonal patterns prior to 1974 in Massachusetts Bay and the central Gulf of Maine departed significantly from the base period means. This is also shown in the day of annual maximum plots. Despite attempts to minimize bias resulting from sampling coverage, these early series patterns should be used with caution. Variation of seasonality after 1977 remained relatively static.

Significant positive anomalies occurred in 1962 in all three transect sections. Otherwise, negative monthly anomalies dominated the series in Massachusetts Bay until the mid-1980s, in the central Gulf of Maine until the early 1990s, and on the western Scotian Shelf until about 1983. Positive departures prevailed in Massachusetts Bay from the mid-1980s to the early 1990s, and again from 1995 to 2001. Above average conditions occurred in the central Gulf of Maine from 1990 to 2001 and on the western Scotian Shelf from 1983 to 2000. Thereafter, all three sections were below average.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis

Figure 15 (cont.).

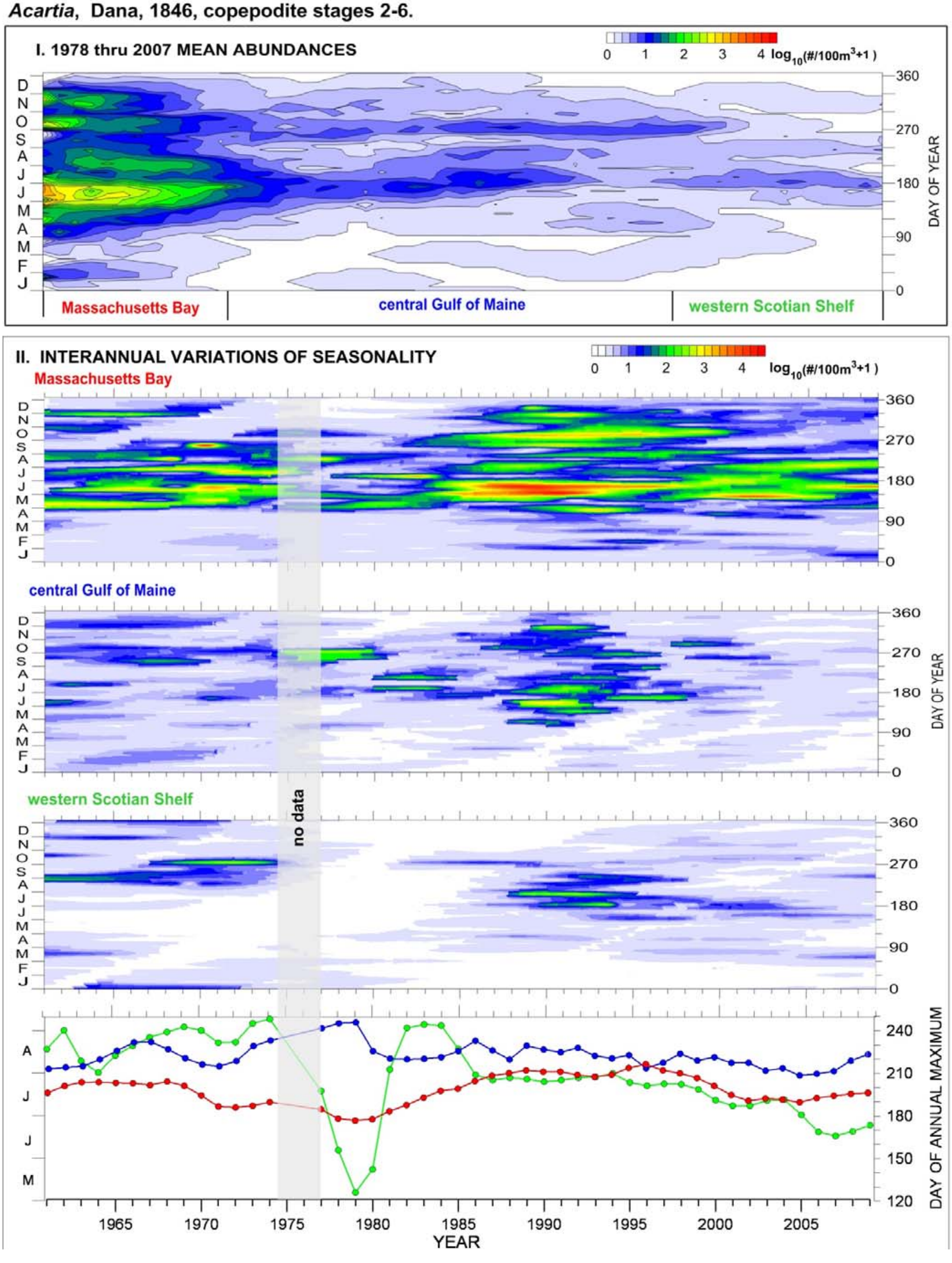

Figure 16. ***Acartia*** **c.2-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

***Acartia*, Dana, 1846, copepodite stages 2-6**

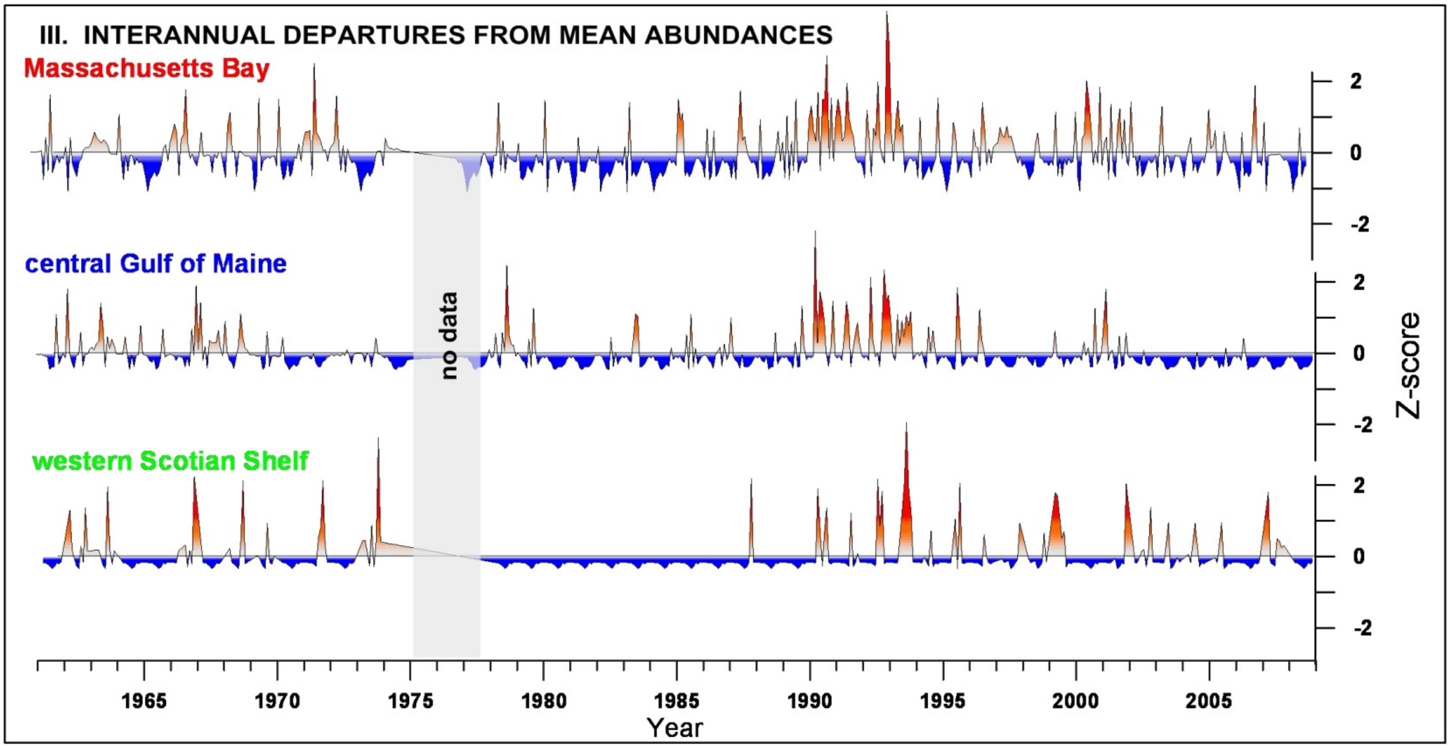

Figure 16 (cont.). *Acartia* c.2-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Acartia can dominate zooplankton assemblages in the estuaries and coastal waters of the Northwest Atlantic. Their ability to thrive and propagate in reduced salinities permits exploitation of inshore environments denied to potential competitors. *Acartia* feed primarily on phytoplankton, but also consumes ciliates, rotifers, and their own eggs and nauplii. Many species produce resting eggs that sink to the bottom and allow the species to survive through unfavorable environmental periods.

Mean conditions showed only moderate abundances east of Massachusetts Bay. Except for the short pulse in late January, *Acartia* increased above winter conditions in March, reaching a peak in June when its abundance could be seen along the entire transect. This was followed by a decline, and then a second peak in early October, again in evidences across most of the transect. Values remained high in Massachusetts Bay until early December. Throughout the year the highest abundances occurred very near the western-most end of the transect.

Seasonal timing varied slightly through the series, with a possible slight earlying trend for the western Scotian Shelf. The precipitous drop in the "day of annual maximum" curve, centered at 1979 is interesting since it is not an isolated pattern change, but is during a period of very low abundance.

Mixed-phase anomalies dominated the three section before 1975. From the late-1970s to late-1980s negative departure prevailed. Above average conditions in the two western sections were the rule from 1990-1995, after which a more mixed-phase pattern returned.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

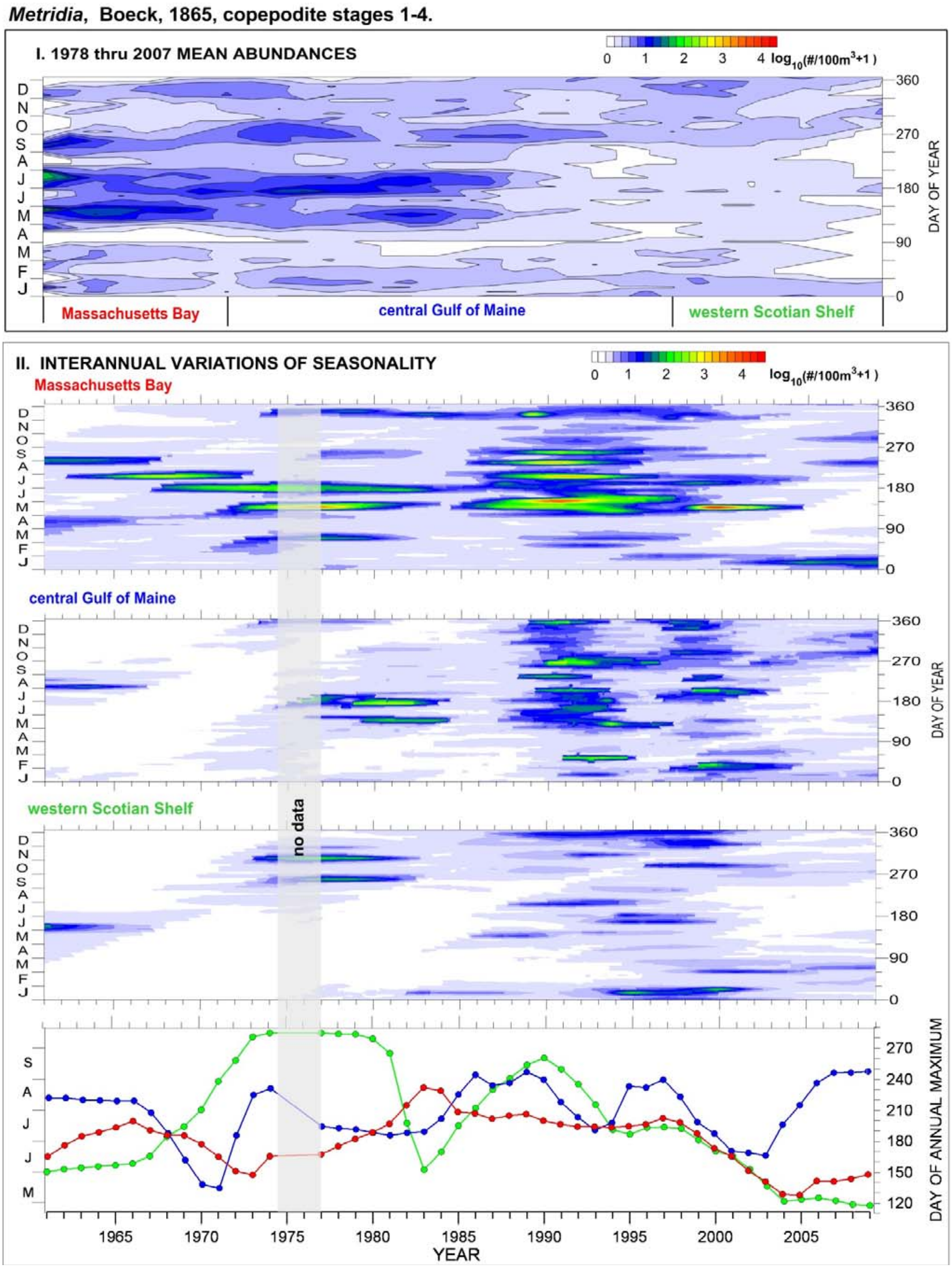

Figure 17. ***Metridia*** **c.1-4 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

***Metridia*, Boeck, 1865, copepodite stages 1-4**

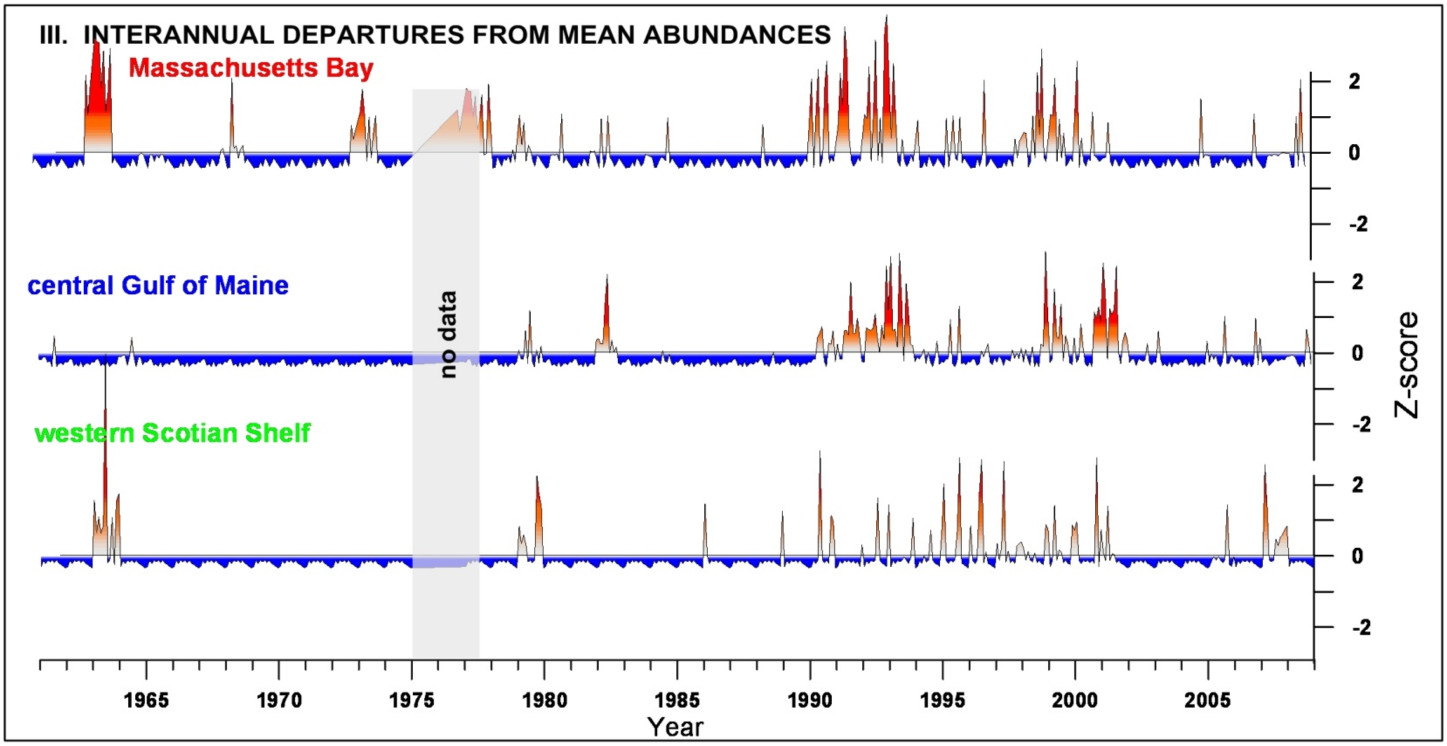

Figure 17 (cont.). *Metridia* c.1-4 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The genus *Metridia* has both coastal and oceanic representatives in the temperate and boreal waters of the North Atlantic. Specimens from the Gulf of Maine CPR survey could be either *M. lucens* or *M. longa*, but given the much higher abundance of the former in the Gulf of Maine, it seems likely that most of these early copepodites are *M. lucens.* They are strong vertical migrators and have been found to spend longer periods of time near the surface than the older stages.

Mean conditions showed the taxon present along most of the transect, with zero abundance common much of the time on the eastern end. Abundance pulses occurred over the western half of the transect with peaks in May, July, September, and December. This relatively large discontinuity of production may have been a result of the mixed species involved.

Changes in the seasonal pattern were most dramatic on the western Scotian Shelf, where abundances were lowest. Earlier peaking was seen in Massachusetts Bay in the early 1970s and after 2000, with slight latening after 2005. A similar pattern, with differing magnitude, was seen for the central Gulf of Maine.

Significant positive anomalies occurred during much of 1963 and 1973 over Massachusetts Bay, and during 1963 and 1979 over the western Scotian Shelf. The central Gulf of Maine had a lesser positive departure during 1983. Otherwise, the three sections were below average until 1990. Anomalies were positive from 1990 to 1994, and 1998 to 2002 in Massachusetts Bay and the central Gulf of Maine, followed to the end of the series by negative departures. Over the western Scotian Shelf anomalies were mixed from 1990 to 2002, negative till 2005, and mixed thereafter.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

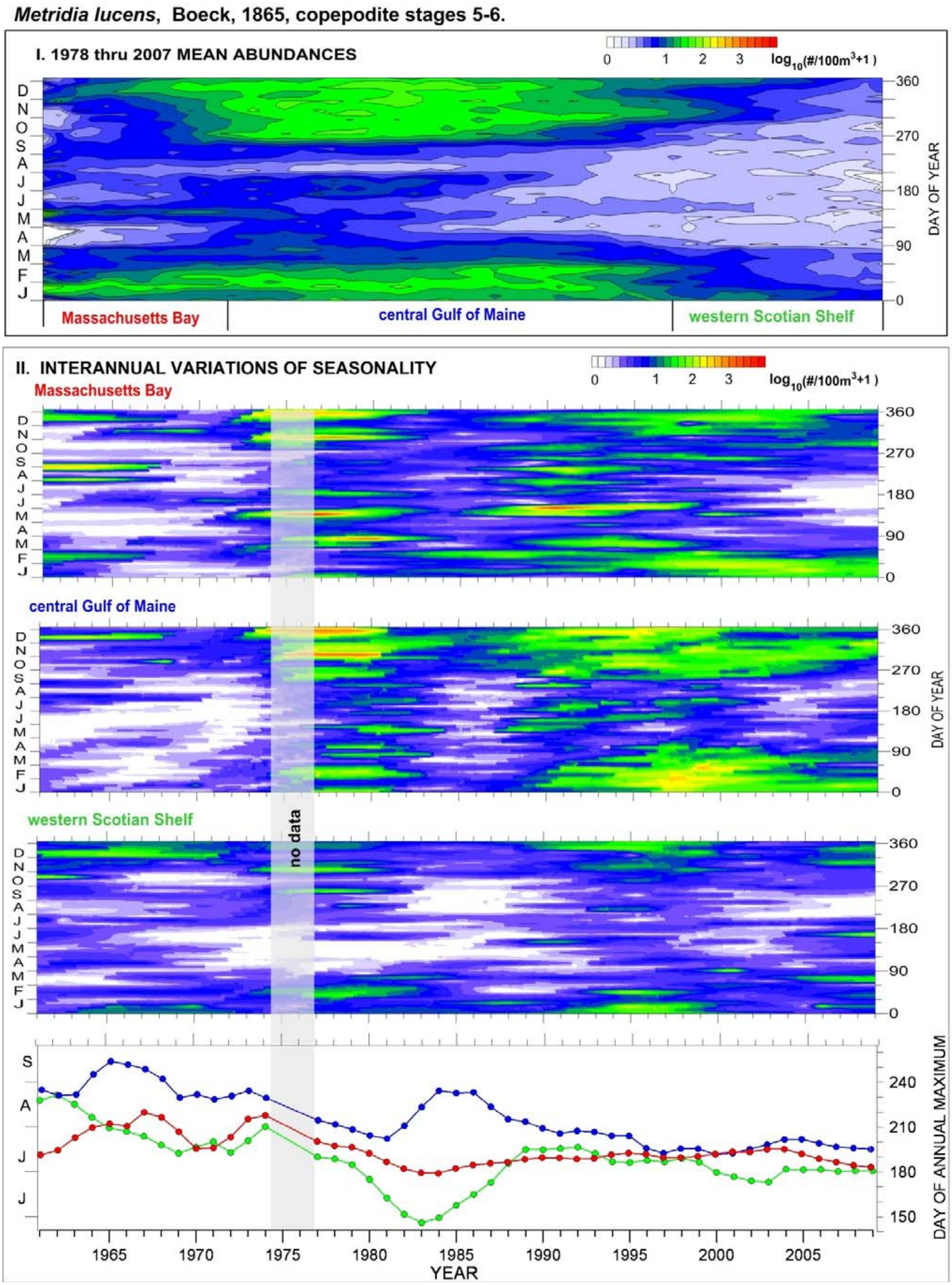

Figure 18. ***Metridia lucens*** **c.5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

***Metridia lucens*, Boeck, 1865, copepodite stages 5-6.**

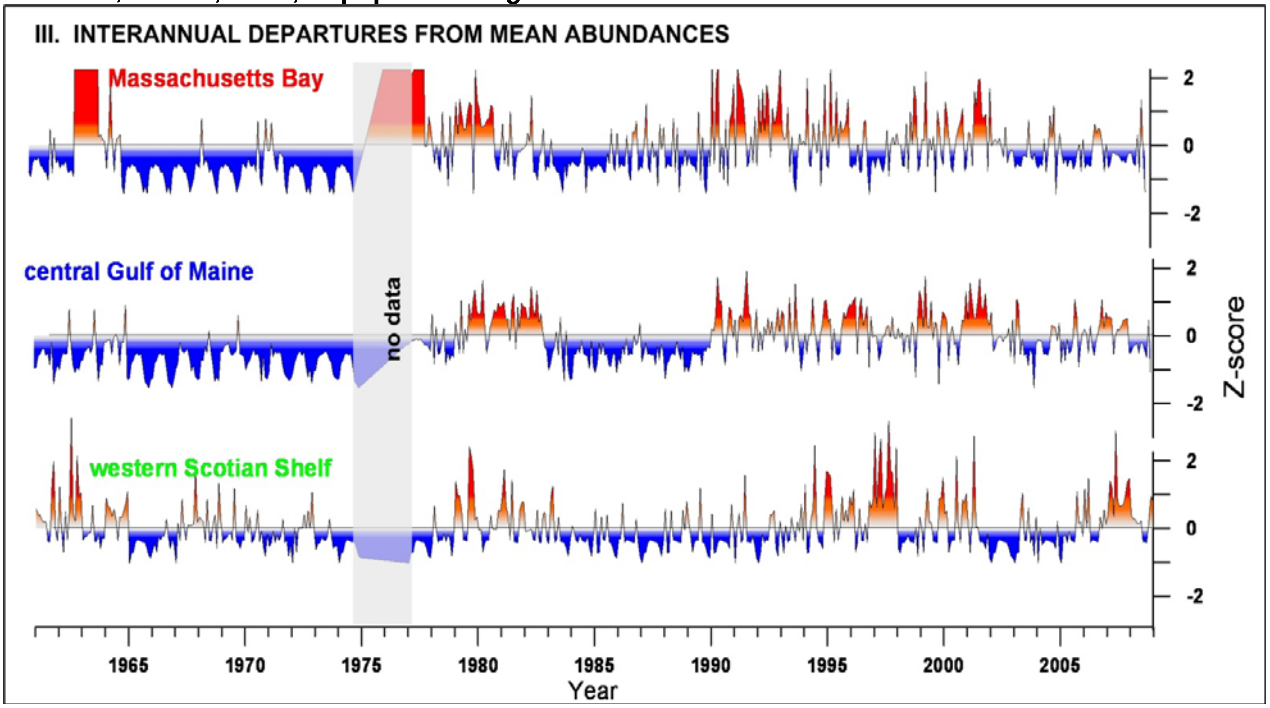

Figure 18 (cont.). *Metridia lucens* c.5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Metridia lucens is one of the larger copepod species and is distinguished by being one of the few luminescent ones found in the Gulf of Maine. The adults are strong vertical migrators, demonstrating a strong bimodal day-night distribution. As a result, they are primarily caught by the CPR at night when they concentrate in the surface waters to feed and/or avoid predators. *Metridia lucens* are omnivores that have been observed to be voracious predators on small zooplankton.

On average, they occurred through most of the Gulf of Maine with lower abundances over the western Scotian Shelf. Higher values occurred in January and February in Massachusetts Bay and the central Gulf of Maine, with a reduction until late September, when the major seasonal pulse occurred over the central Gulf of Maine and extended into the following year, spreading again into Massachusetts Bay.

A general earlying of the day of annual maximum occurred during the series in all three sections of the Gulf of Maine. In Massachusetts Bay it varied from late July/early August in the mid- 1960s to early July by the end of the series. More dramatic changes occurred in the central Gulf of Maine, varying from mid- to late August in the early years to mid-July by 2009; and on the western Scotian Shelf occurring also from mid- to late August in 1961 to early July by the end of the series. A major departure from this Gulf-wide earlying trend occurred in the early to mid-1980s when the day of maximum latened by nearly a month in the central Gulf of Maine and occurred nearly a month earlier on the western Scotian Shelf.

Positive abundance anomalies in Massachusetts Bay occurred in 1964,from 1977 to 1982,1990 to 1996,and 1999 through 2001. With the exception 10 1964, a somewhat similar pattern occurred in the central Gulf of Maine, with additional, but scattered positive departures occurring after 2005. On the western Scotian Shelf above average abundances although less consistent than those to the west, occurred during those times seen in Massachusetts Bay, but with two notable additions: scattered positive anomalies in the late 1960s to early 1970s, and more consistent positive departures after 2007. The period, 1965 to 1975 showed below average abundances in Massachusetts Bay, the central Gulf of Maine, and to a lesser extent, the western Scotian Shelf. A second prolonged period of negative abundance occurred from 1982 to 1990 in all three sections. After 2002 in Massachusetts Bay negative conditions prevailed, while in the central Gulf of Maine departures were mixed. From 2002 to 2006 on the western Scotian Shelf negative anomalies dominated.

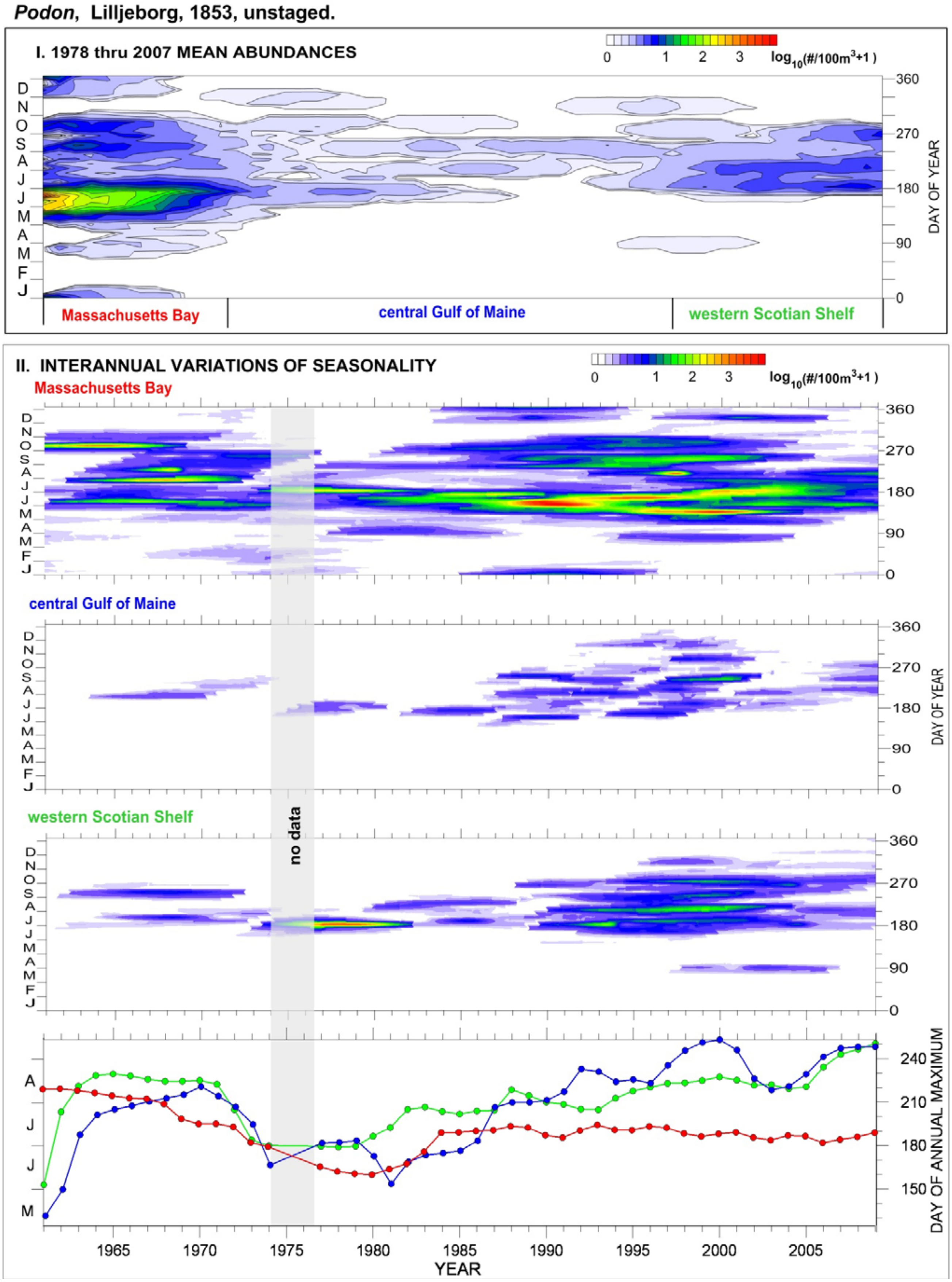

Figure 19. ***Podon*** **unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.**

Podon, Lillgeborg, 1853, unstaged

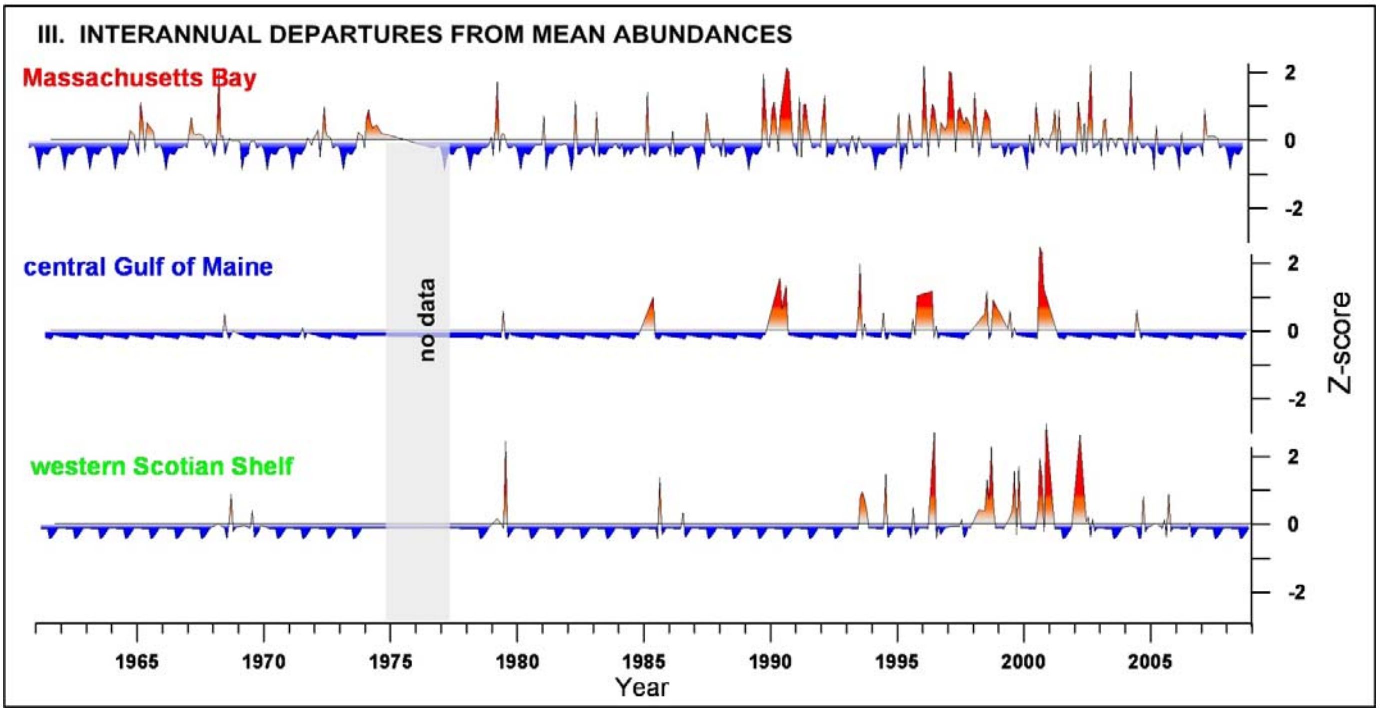

Figure 19 (cont.). *Podon* unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Cladocerans of the genus *Podon* are common in coastal waters throughout the world's ocean. These "water fleas" are distinguished by large, dark eyes on a head that is clearly separated from a round carapace that surrounds the body. Though their feeding ecology has not been well studied, their well developed eyes suggest they are raptorial feeders that perceive and select individual prey. Cladocerans reproduce by parthenogenesis and have short generation times that can lead to fast population blooms when environmental factors are favorable.

Except at times of annual peak abundance *Podon* was confined to the Massachusetts Bay and western Scotian Shelf sections of the transect. Spring increase began in the former in May, peaked in June, remained high until the end of October (including a secondary peak in late September), then resurged in December and early January. Over the western Scotian Shelf the spring increase started one and one half months later than in Massachusetts Bay, dropped off sharply in mid-October, and did not reach the abundance levels seen in Massachusetts Bay.

Seasonal variation in Massachusetts Bay showed a departure from mean conditions from 1977 through 1983 where an earlier, but isolated peak appeared and the mean peak largely disappeared after mid-July. The shortened, peak period was seen again after 2004. Over the western Scotian Shelf similar patterns of peak period duration were seen.

Prior to 1990 in Massachusetts Bay, above average abundances, of several months duration occurred in 1965, 1967, and 1974. More prolonged positive departure occurred from 1990-1993 and 1996-1999. Otherwise anomalies were generally negative. Several periods in central Gulf of Maine after 1985 had abundances higher than the usual low levels. Prior to 1993 the western Scotian Shelf was mostly below the base period, an exception being in 1979. From 1993-2003 *Podon*, like most of the other dominant zooplankton exhibited positive anomalies.

Note: Standardized anomaly values for taxa with large numbers of observed abundances equal to, or near zero, raises the question of whether near normal data distributions are obtained via the logarithmic transformations. Thus, more emphasis should be put on the persistence of anomalies than on their absolute values.

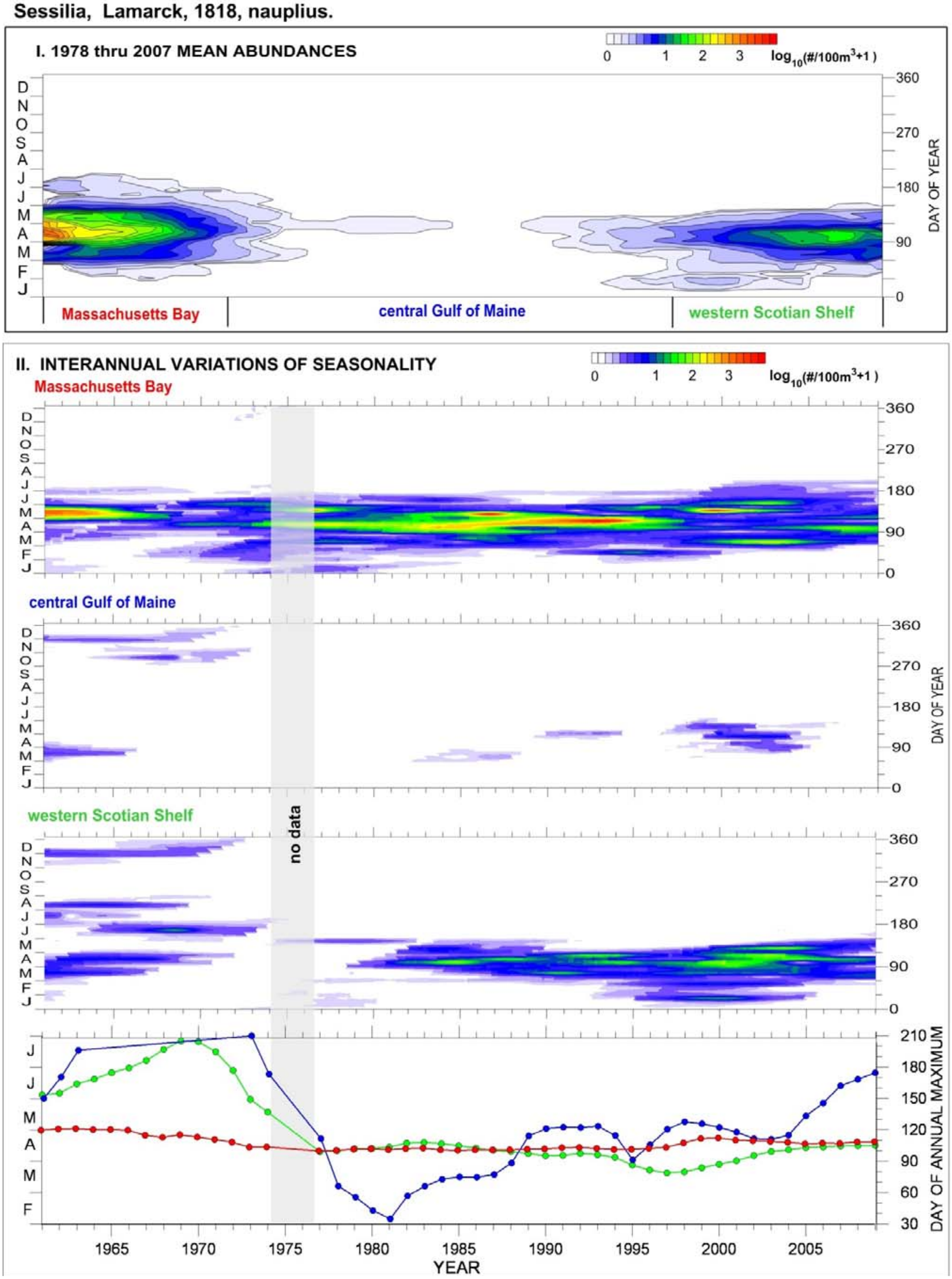

Figure 20. Sessilia nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

Sessilia, Lamarck, 1818, nauplius

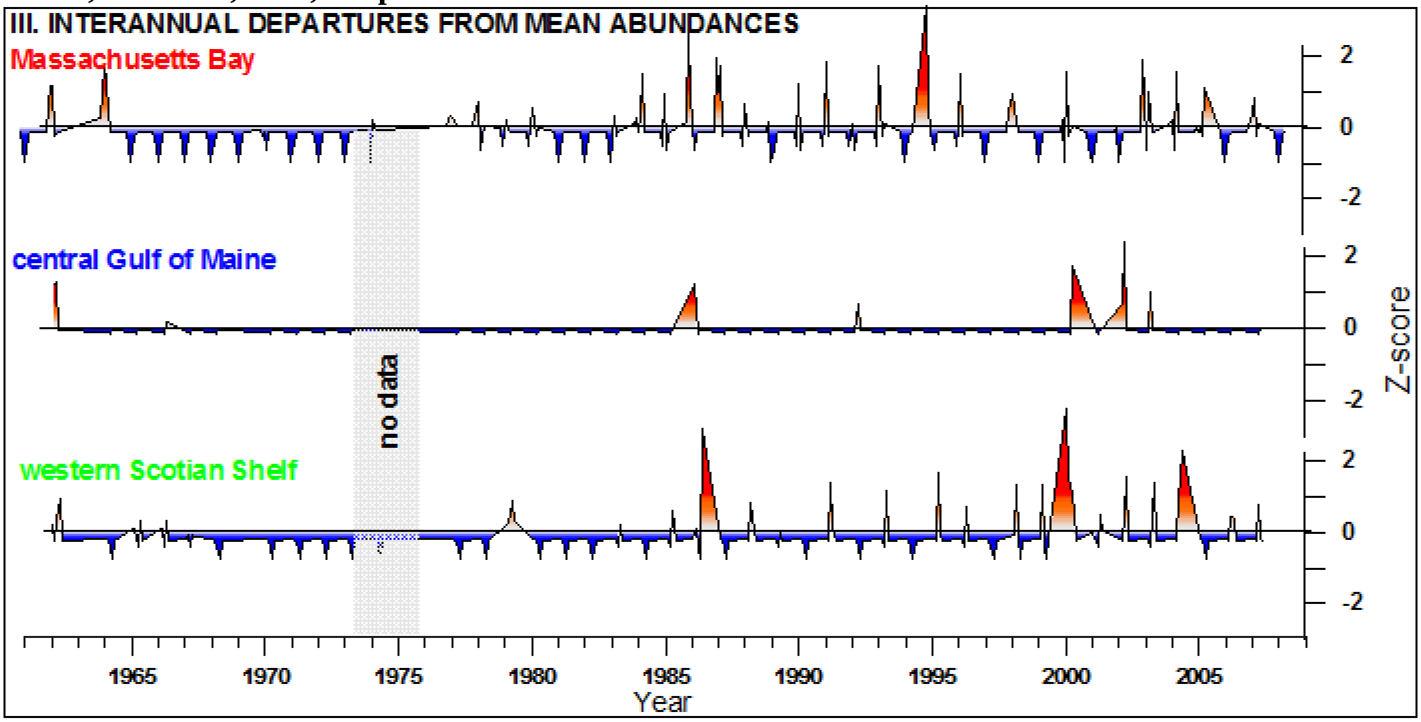

Figure 20 (cont.). Sessilia nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The adults of these nauplii are commonly known as barnacles, which is a widespread marine group that dominate rocky littoral zones. The first larval stages are planktonic, and pass through six nauplier stages before metamorphizing into the non-feeding cypris larvae. Barnacle nauplii feed on phytoplankton and microzooplankton and are important prey of fish larvae and other planktonic predators.

Mean abundances showed very distinct time-space boundaries. Presence is confined to the two shelf sections. In Massachusetts Bay the nauplii appear in late February,peak in April, and are absent after mid-July. Over the western Scotian Shelf a small patch of nauplii was seen in late January, but the bulk of the abundance appeared after mid-February, peaked in April, and was absent from the samples after May. Peak values over the western Scotian Shelf were about one order of magnitude less than those in Massachusetts Bay.

Variations of seasonality in Massachusetts Bay were quite small, as can be seen in the “day of annual maximum” graphic. On the western Scotian Shelf, prior to the early 1970s, sessilia occurred at several times through the year, ranging from March to early December. After 1980 its seasonal pattern stabilized, and with the exception of some high abundance years after 1995, resembled the mean pattern.

Positive anomalies in Massachusetts Bay occurred before 1964 and again in the mid-1980s and mid-1990s. From 1965-1985 departures were below average. Otherwise the pattern was mixed. On the western Scotian Shelf negative anomalies prevailed until nearly 2000, with positive exceptions in 1979 and 1986. Significantly positive departures occurred in 1999 and 2004. Otherwise, anomalies were mixed.

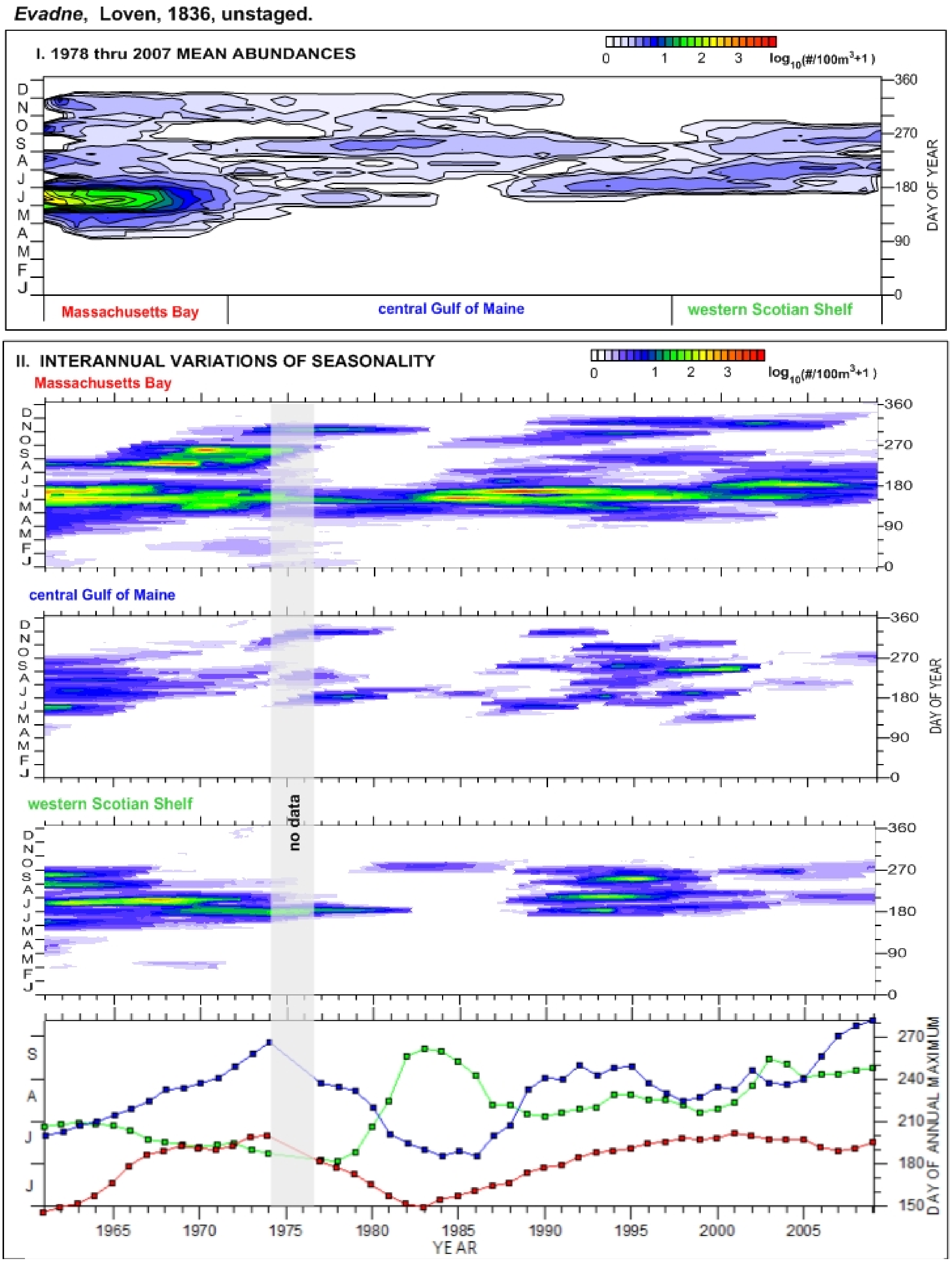

Figure 21. Evadne unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Evadne*, Loven, 1836, unstaged**

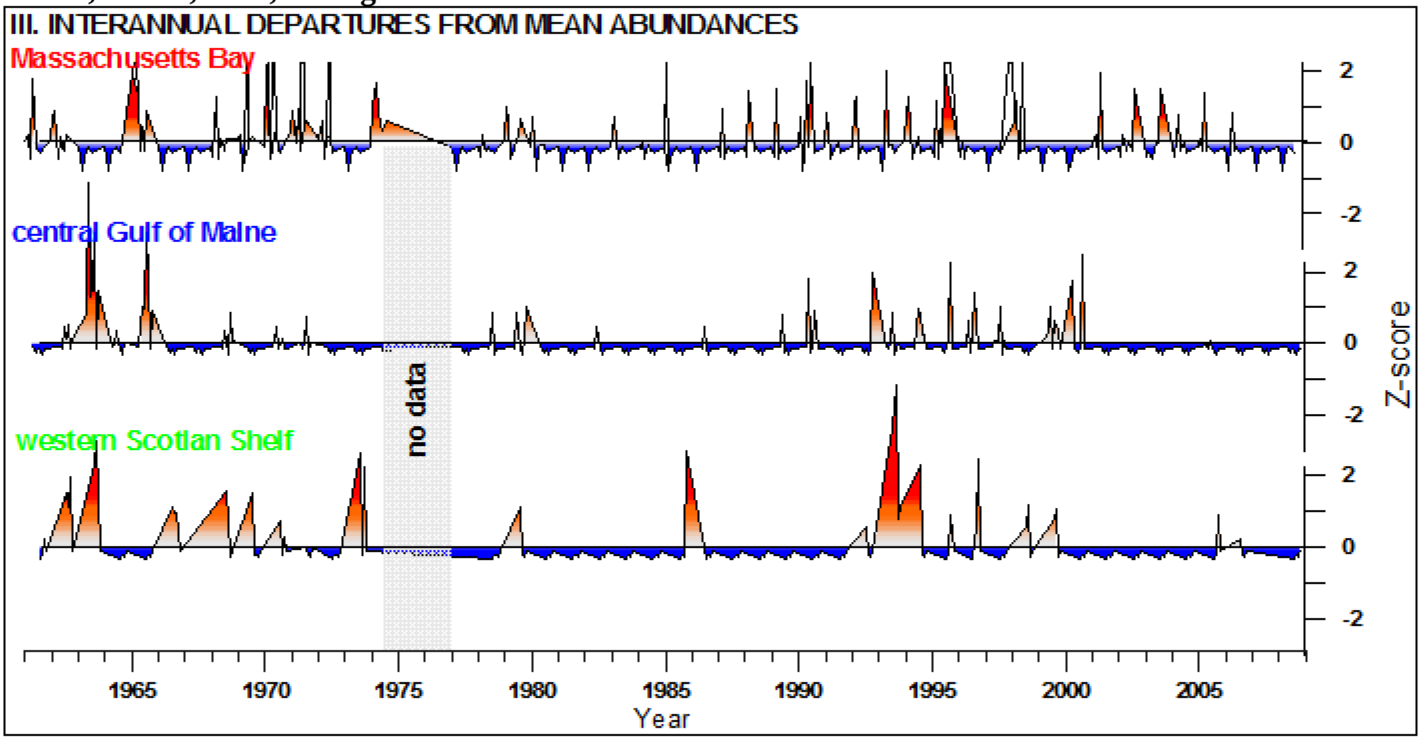

Figure 21 (cont.). *Evadne* unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

This genus of marine cladocerans is widely distributed throughout the world's oceans. It has a transparent, teardrop-shaped body and its principal mode of reproduction is parthenogenesis. Populations can bloom quickly under favorable environmental factors that are usually linked to vertical stability. It has been found in the larval diets of commercially important fish species that inhabit the Gulf of Maine.

Mean abundances were concentrated in Massachusetts Bay from late April to late August, peaking in June, followed by a secondary swarm from October through November. In the central Gulf of Maine the taxon appeared in July, connected to the western Scotian Shelf's annual pulse, and again from August through September. Over the western Scotian Shelf, moderate abundances were seen from July through mid-August, and again from September through late October. Maximum Gulf of Maine mean values occurred over inner-Massachusetts Bay.

Peak abundances in Massachusetts Bay occurred later each year from 1961 through 1974, then steadily occurred earlier until 1983. A steady latening followed until about 2001, after which the timing remained fairly constant. Prior to 1983 in the central Gulf of Maine the pattern followed that seen in Massachusetts Bay. Thereafter, to the end of the series, peak annual abundance latened by 185 days. The main features on the western Scotian Shelf were the absence of the early summer swarm in the early 1980s and the overall latening of the peak through the series.

Departures from 1978-2007 means had less continuity than some of the other taxa. One exception was the prolonged above average conditions over the western Scotian Shelf prior to 1974. The commonly seen positive anomalies for many other zooplankton taxa in the 1990s were also seen for *Evadne* in all three sections. The positive departures over the western Scotian Shelf in 1986 and approaching 1995 are especially noteworthy.

Appendicularia, unstaged.

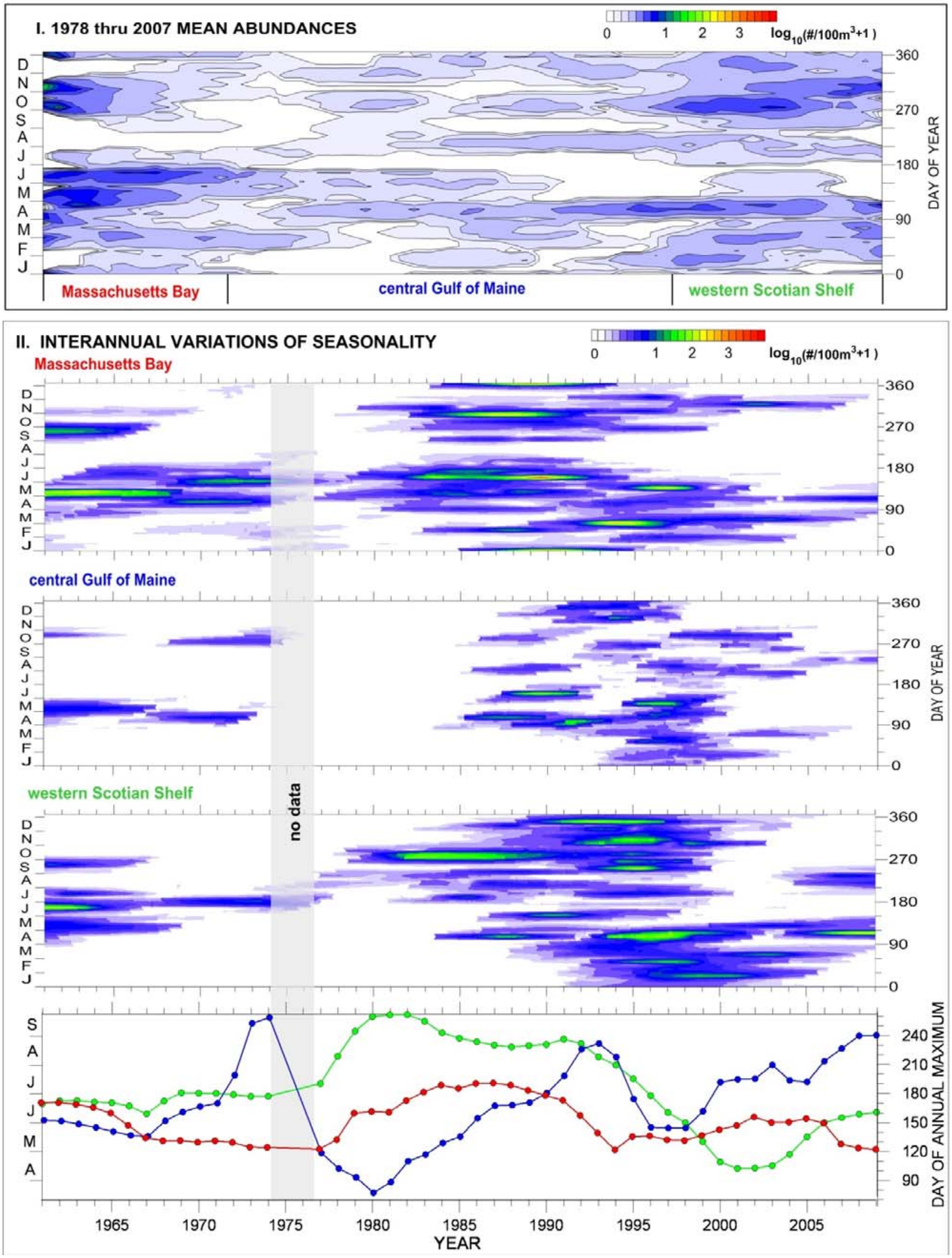

Figure 22. Appendicularia unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

Appendicularia, unstaged

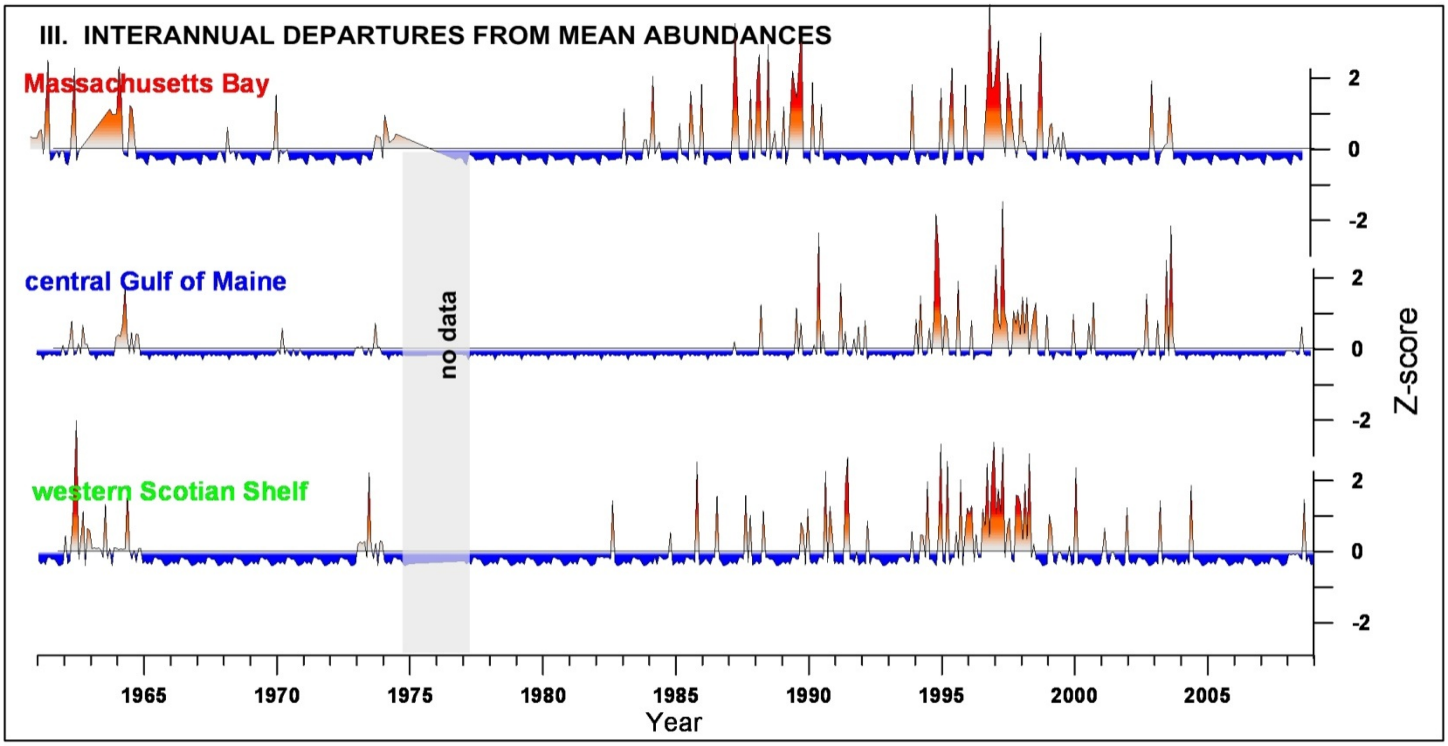

Figure 22 (cont.). Appendicularia unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Appendicularia are small, fragile, free swimming tunicates with a body consisting of a short trunk and a muscular tail. They secrete around themselves a gelatinous mass in which are incorporated elaborate structures used to filter food items. These "houses" need to be discarded and replaced several times per day because they become clogged by large particles or are simply worn down. Since these structures are rich with mucous and trapped food, they comprise a rich source of food for several pelagic and benthic organisms.

Mean values showed a patchy distribution of this taxon. Over Massachusetts Bay, it was present in early January, mid-February to late June (peaking in May and June), October-November, and late December into January of the next year. It was sparse in the central Gulf of Maine with most notable presence in April, connecting to a pulse on the western Scotian Shelf. Over the western Scotian Shelf it was present through much of the year, except May, June, and August. Peak abundances for this section occurred in April, October and November.

Seasonality for Massachusetts Bay was fairly steady through the series, with the exception of the 1980' to mid-1990s when latening occurred. Timing for the central Gulf of Maine steadily latened from 1966-1974, becoming much earlier by 1980, and then tending towards later peaks by the end of the series. Western Scotian Shelf timing latened from 1961-1980, then became earlier to 2001, after which it returned to 1960 values.

All three section exhibited positive anomalies in the early 1960s, followed by mostly negative anomalies through 1985. Significant above average conditions occurred in Massachusetts Bay from 1985-1991 and from 1994-2000. Three periods of positive anomalies occurred in the central Gulf of Maine from 1990-2003, and over the western Scotian Shelf positive departures occurred in the early 1990s and especially from 1994-1999.

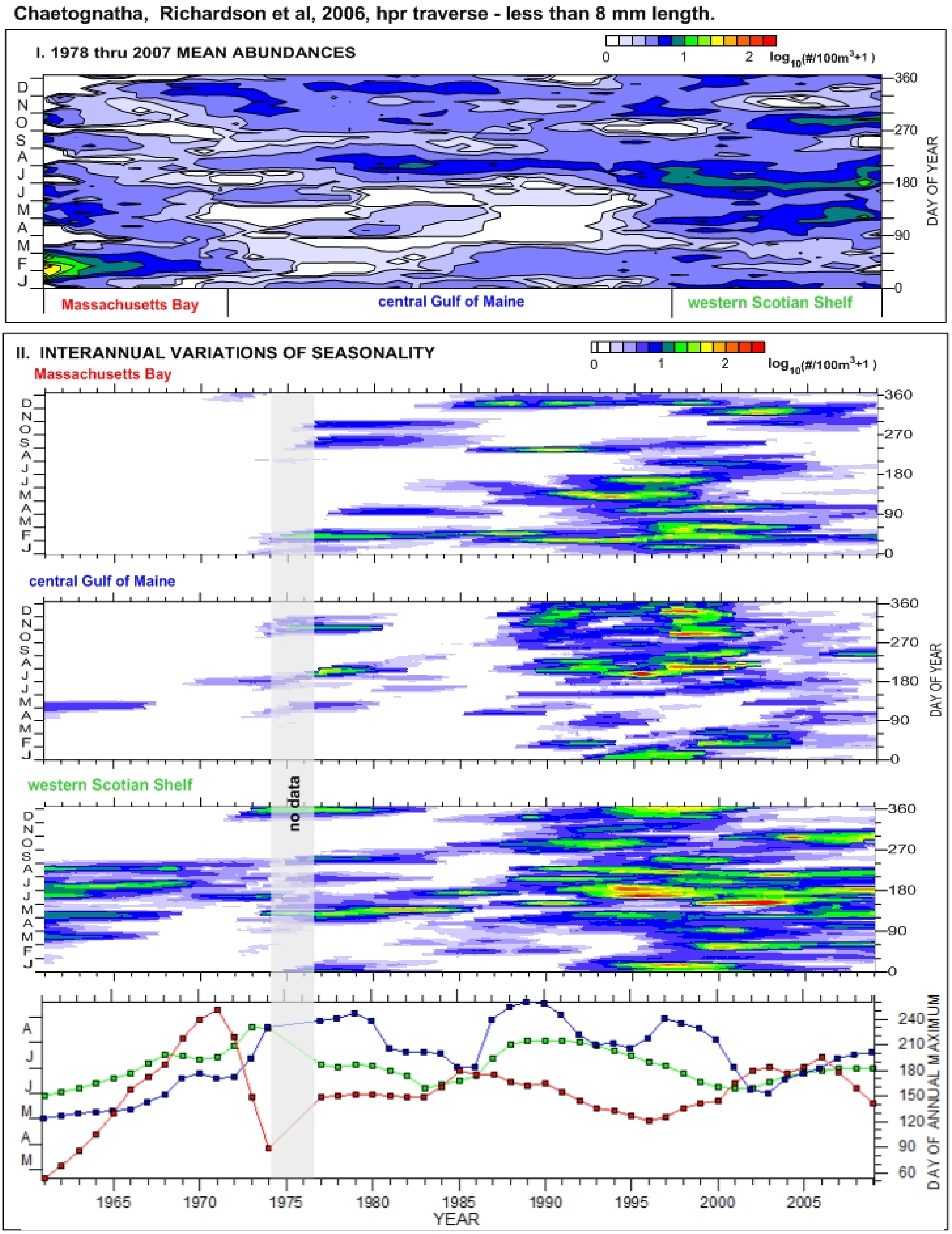

Figure 23. Chaetognatha hpr traverse (less than 8 mm length) variations along the Gulf of Maine Continuous Plankton Recorder transect.

Chaetognatha, Richardson et al, 2006, hpr traverse- less than 8 mm length

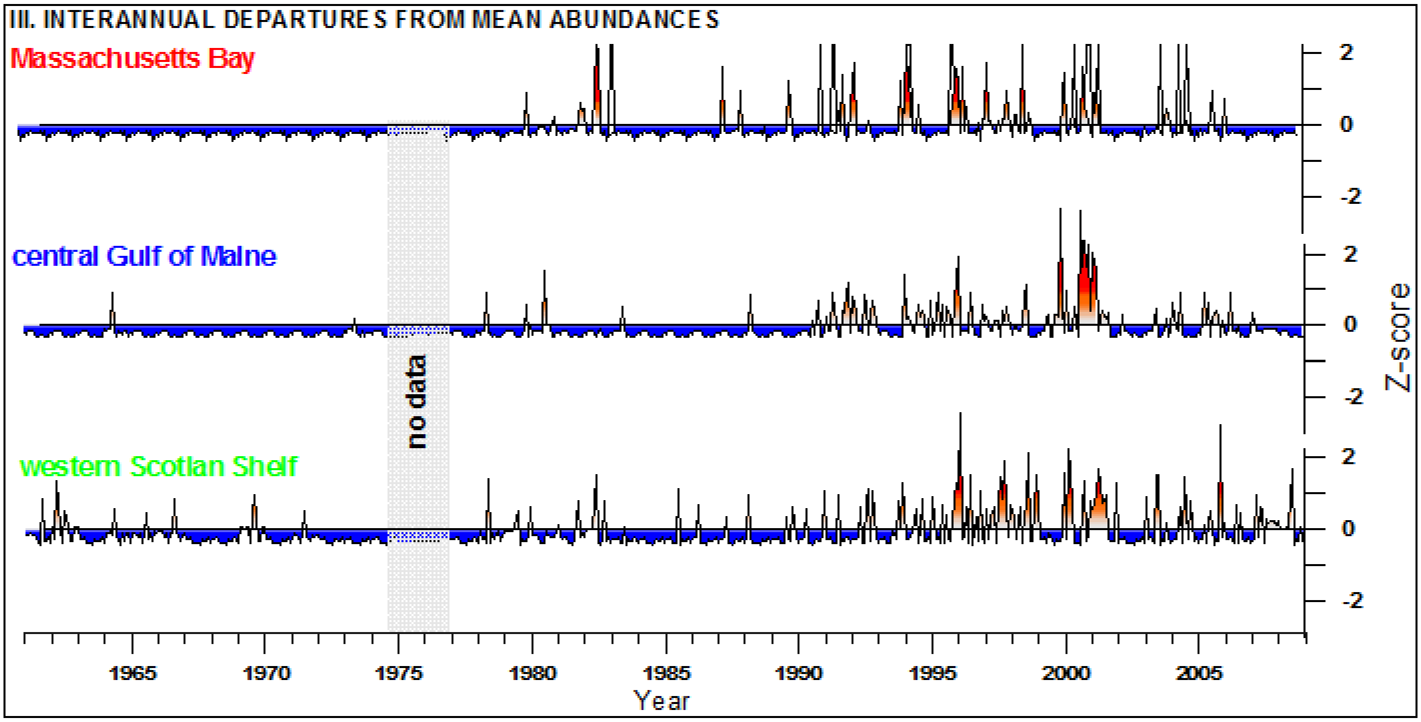

Figure 23 (cont.). Chaetognatha hpr traverse (less than 8 mm length) variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Chaetognaths are transparent, torpedo-shaped plankters commonly called "arrow worms". Those reported on here, are specimens less than 8 mm in length. They are voracious predators equipped with a series of movable spines on their heads which they use to grab and ingest prey. Chaetognaths are probably one of the main sources of predation pressure on the copepod community and also feed on larval fish, crustaceans, and other chaetognaths. These active predators are also an important food source for fish and other animals higher in the food web.

They were most abundant over the shelf sections of the transect, but except for spring and early summer were present in moderate amounts in the central Gulf of Maine. Peak abundances in Massachusetts Bay occurred in late January, and over the western Scotian Shelf in early May, July, and October.

Examination of the variations of seasonality show that the 1978-2007 mean portrayal is often not representative of the taxon's space-time distribution. Also, the multiple, seasonal peaks make determination of seasonality changes difficult. There does seem to be a latening of the "day of annual maximum" from the start to the end of the series.

The major pattern in the monthly anomalies was the change from predominantly below average to above average conditions in about 1990. This change persisted on the western Scotian Shelf through the remainder of the series. It persisted to a lesser extent in Massachusetts Bay, but returned to nearer normal in the central Gulf of Maine after 2003.

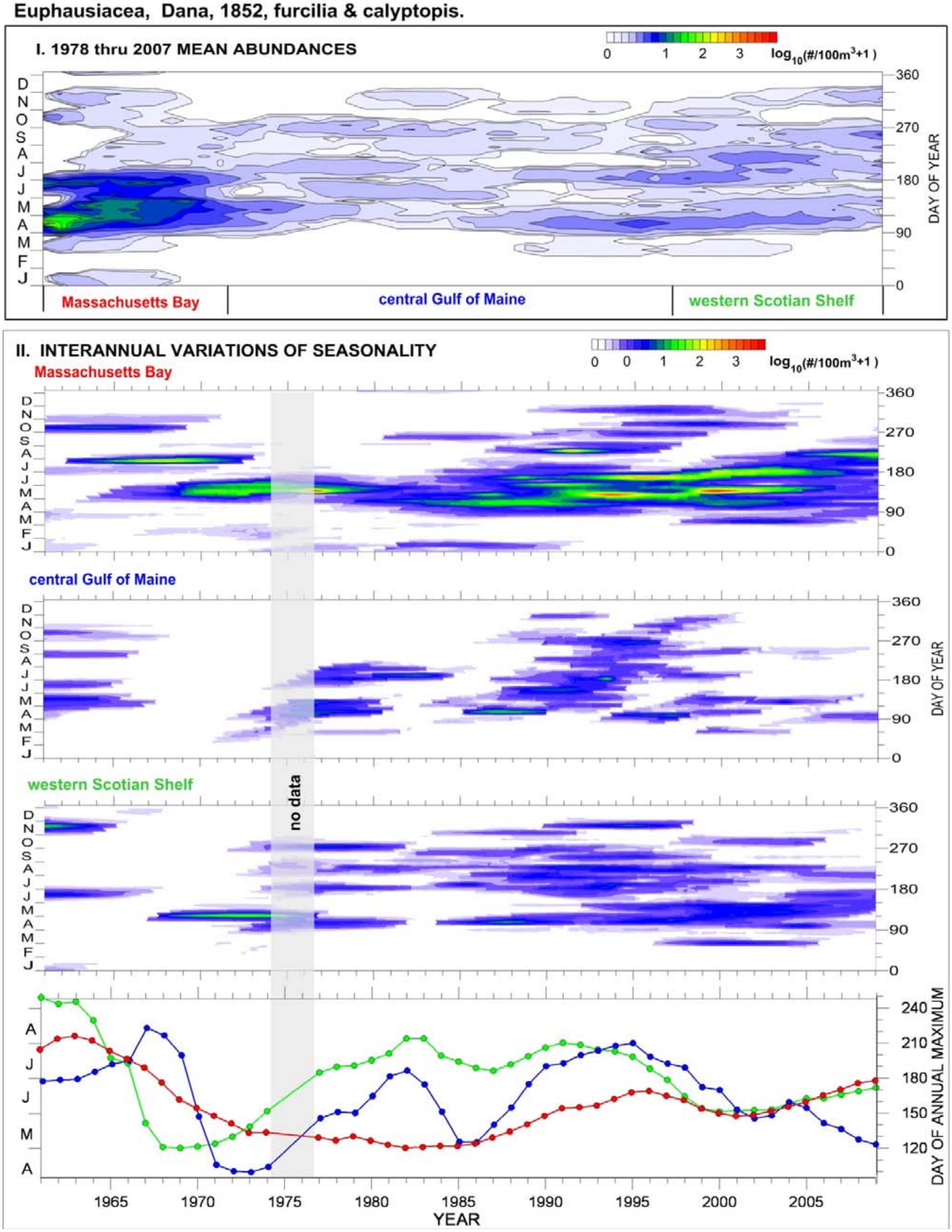

Figure 24. Euphausiacea furcilia and calyptopis variations along the Gulf of Maine Continuous Plankton Recorder transect.

Euphausiacea, Dana, 1852, furcilia & calyptopis

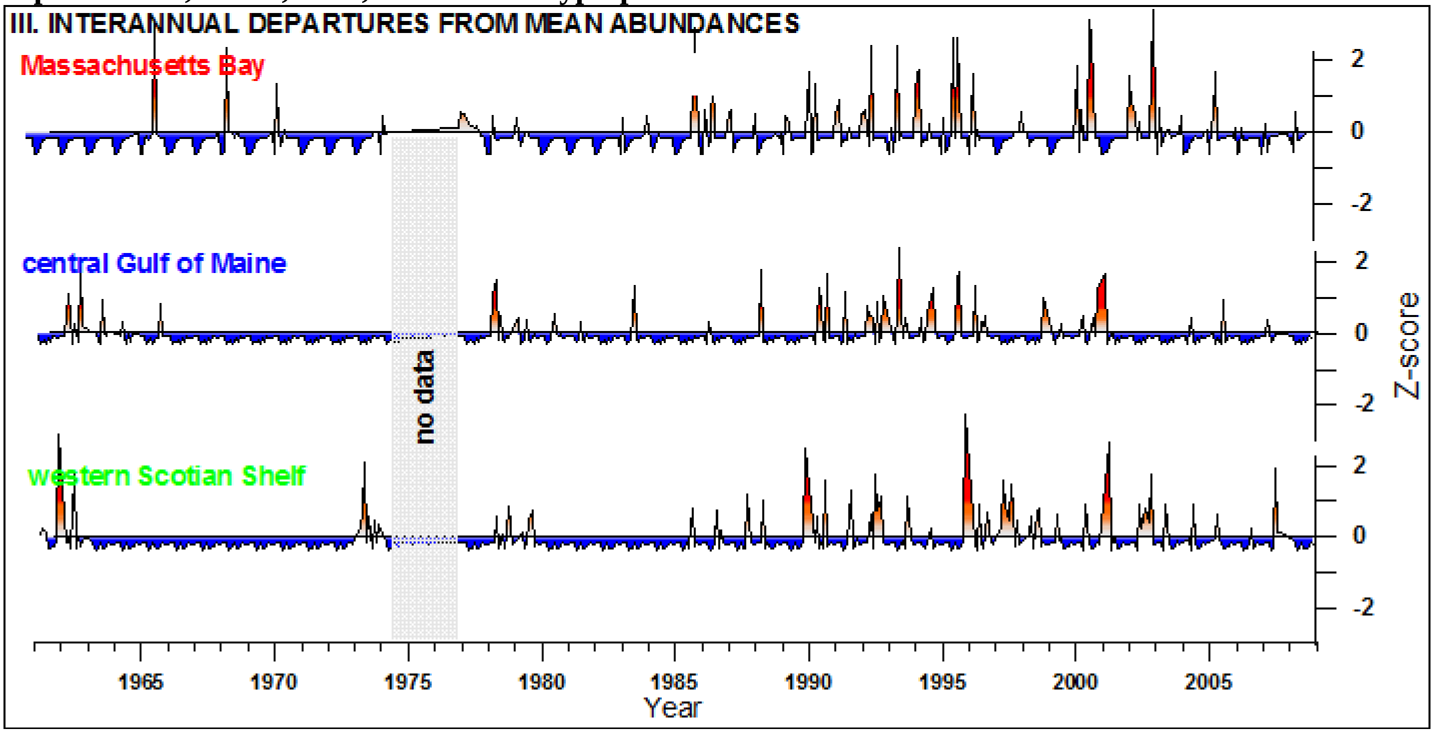

Figure 24 (cont.). Euphausiacea furcilia and calyptopis variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Euphausiids, or krill, are a group of crustaceans found throughout the world's ocean. They are notable for their strong swimming capabilities, and in certain species, they can occur in dense concentrations or swarms. In the Gulf of Maine, they are an important trophic connection in the pelagic food web. They feed near the bottom of the food chain on plankton and are important prey items for many commercial fish species and marine mammals. Three life stages are separated during CPR examination. The combined furcilia and calyptopis stages are reported here.

Mean abundances were concentrated in spring and early summer over Massachusetts Bay; and during April-May, and July-September in the eastern part of the central Gulf of Maine, and on the western Scotian Shelf. Highest abundances are found over Massachusetts Bay.

The day of annual maximum for all sections in the early 1960s was considerably later than subsequent years, especially than after 2000. Massachusetts Bay seasonality from 1965-2005 was fairly steady, after which changes occurred. Higher abundances generally coincided with prolonged seasonal highs.

Negative conditions in Massachusetts Bay dominated the 1961-1990 period, except for positive spikes in 1965, 1968,1970, and 1985. 1990-1996 was above average, followed by a four year low. Positive departures returned from 2000-2004, followed by slightly lower values to the end of the series. The pre-1990 low period in the central Gulf of Maine was broken in the early 1960s, and in 1978 by brief positive departures. Subsequent anomalies resembled those in Massachusetts Bay with a longer low period starting in 2001. The western Scotian Shelf followed the central Gulf of Maine to a large extent, except for a positive departure in 1973 and more mixed conditions after 2003.

Euphausiacea, Dana,1852, post calyptopis.

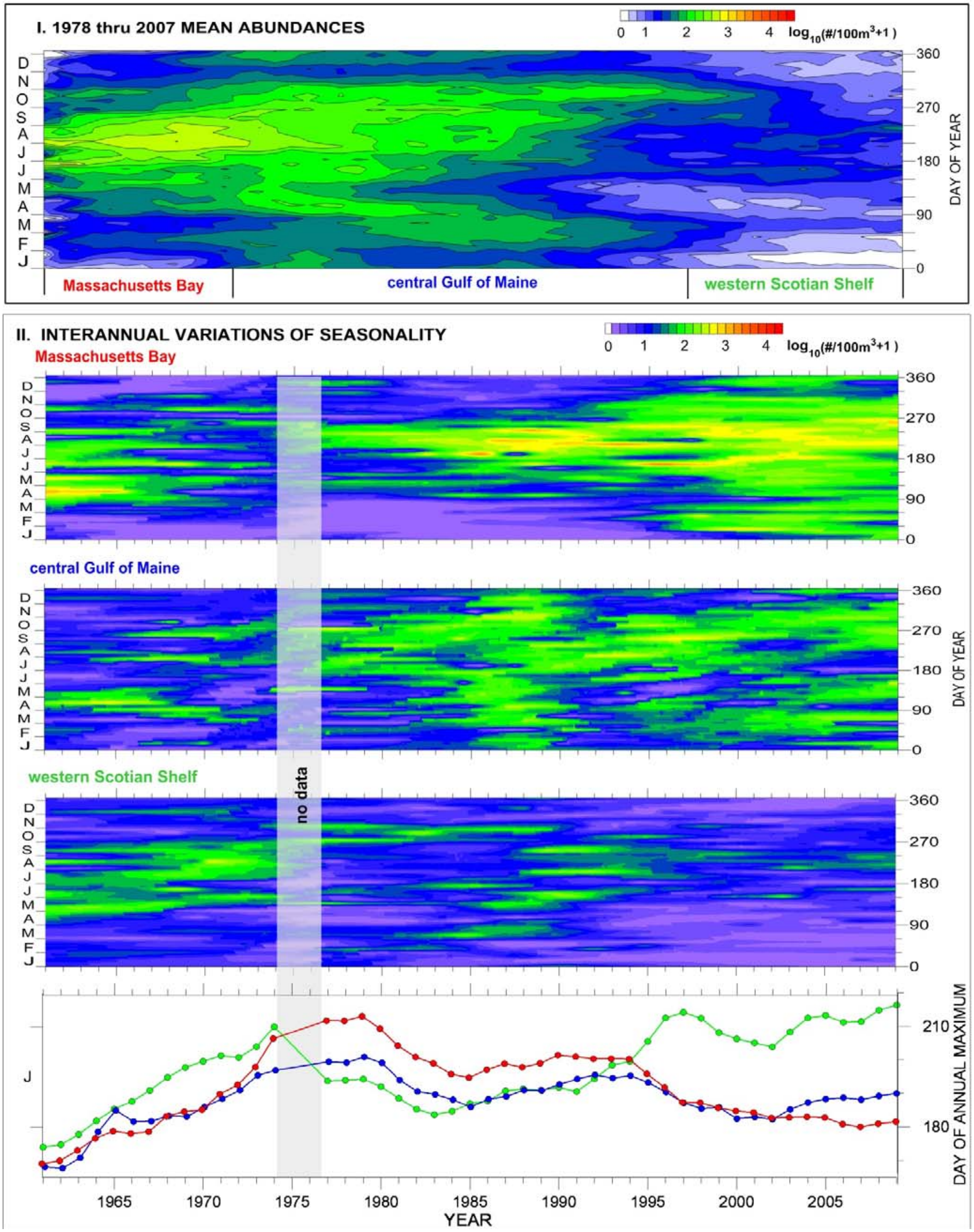

Figure 25. Euphausiacea post calyptopis variations along the Gulf of Maine Continuous Plankton Recorder transect.

Euphausiacea, Dana, 1852, post calyptopis

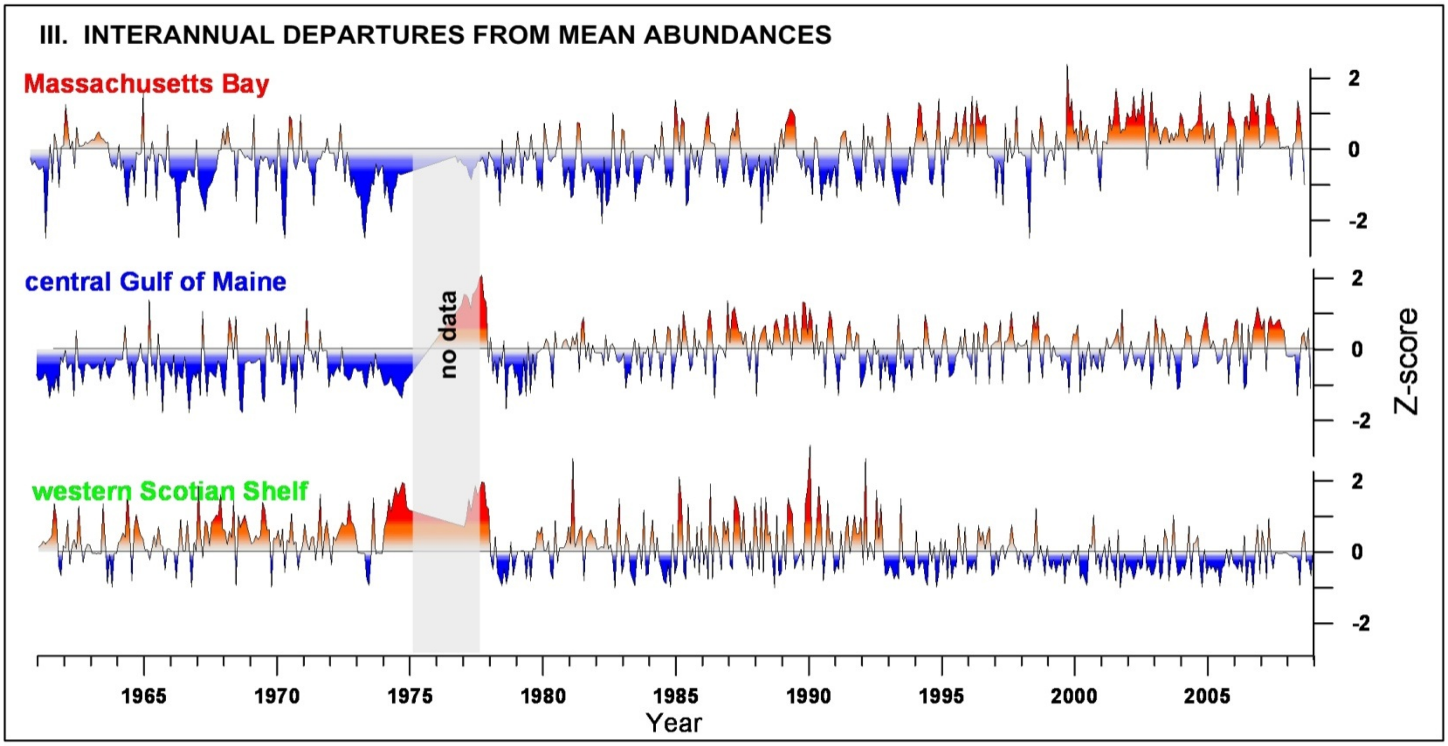

Figure 25 (cont.). Euphausiacea post calyptopis variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Euphausiids, or krill, are a group of crustaceans found throughout the world's ocean. They are notable for their strong swimming capabilities, and in certain species, they can occur in dense concentrations or swarms. In the Gulf of Maine, they are an important trophic connection in the pelagic food web. They feed near the bottom of the food chain on plankton and are important prey items for many commercial fish species and marine mammals. Three life stages are separated during CPR examination. The post calyptopis stage is reported here.

Mean abundances in Massachusetts Bay ere low to moderate from January-April. Values increased, peaking in August, and slowly decreased, reaching seasonal lows by November. A more prolonged high period was seen in the western portion of the central Gulf of Maine, with higher values extending through much of the year, but without a clear seasonal peak. The western Scotian Shelf had considerably lower values (zero abundance in January) than the rest of the transect. Highest period was from April to October.

A general latening trend was seen in the day of annual maximum values for all three sections of the transect. This was most marked for the western Scotian Shelf.

Anomalies in Massachusetts Bay were predominantly negative till 1994 after which the reverse was the case. In the central Gulf of Maine below average conditions prevail till 1980, positive departures from 1984-1991, mixed values till 2007 followed by over a year of above average departures. The western Scotian Shelf pattern as a near mirror image of that for Massachusetts Bay with positive departures dominating from 1961-1993 and negative anomalies prevailing thereafter.

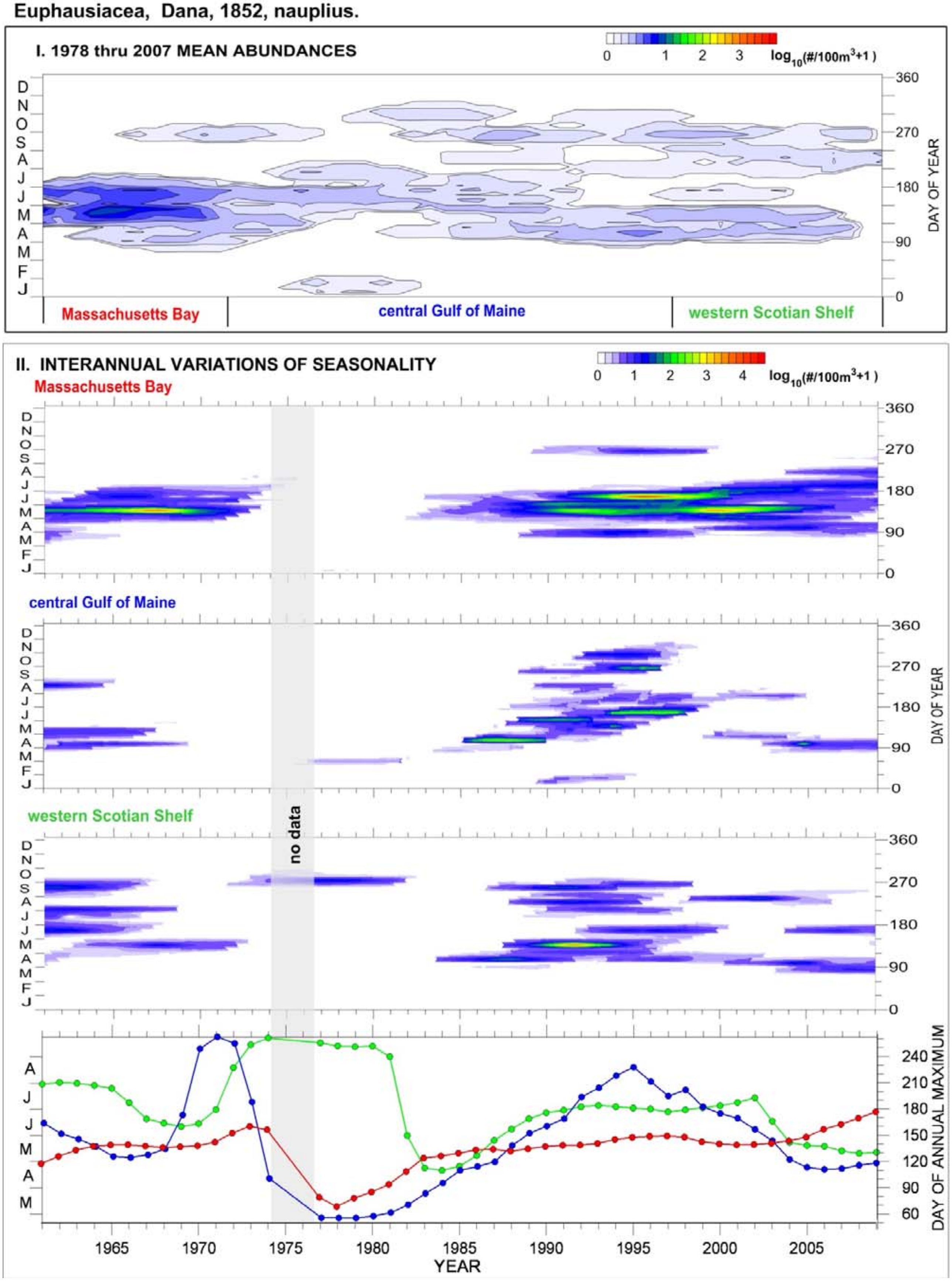

Figure 26. Euphausiacea nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

Euphausiacea, Dana, 1852, nauplius

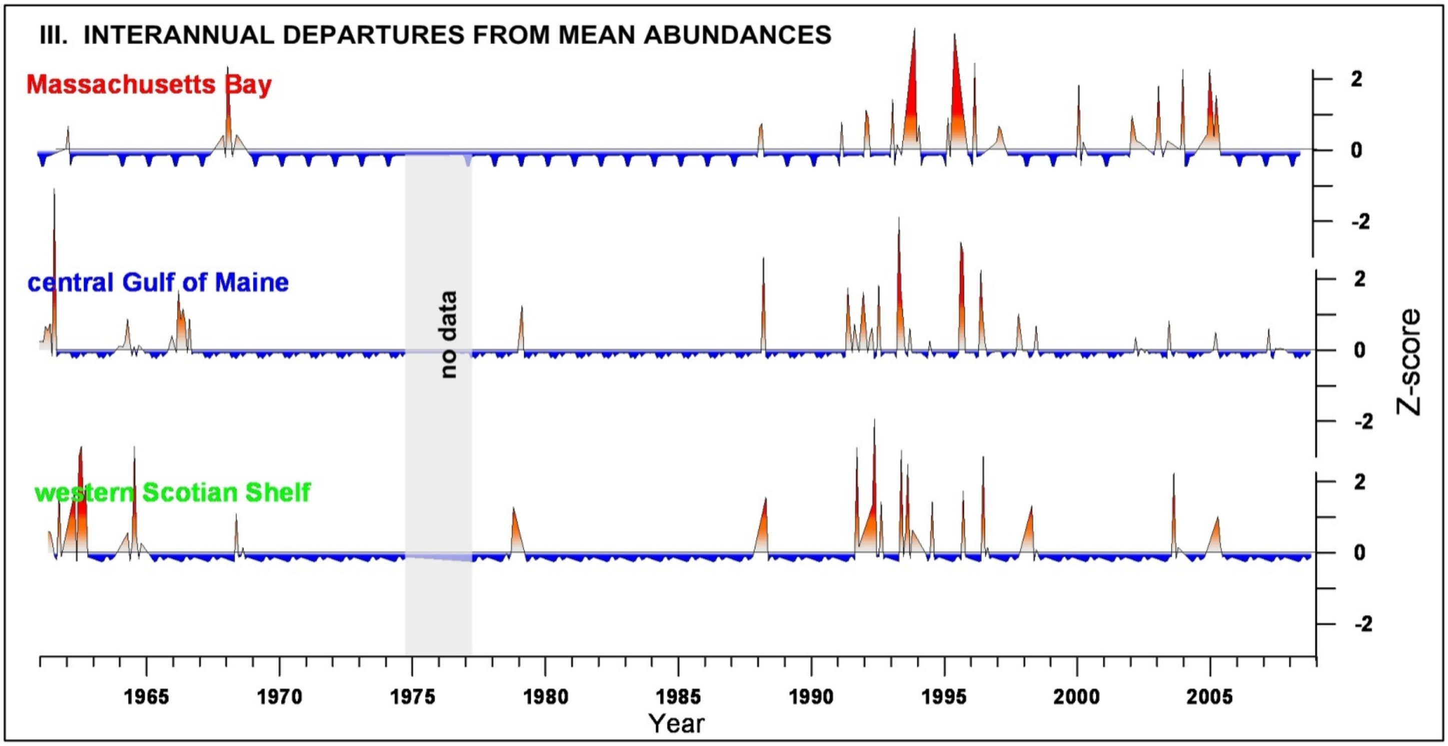

Figure 26 (cont.). Euphausiacea nauplius variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Euphausiids, or krill, are a group of crustaceans found throughout the world's ocean. They are notable for their strong swimming capabilities, and in certain species, they can occur in dense concentrations or swarms. In the Gulf of Maine, they are an important trophic connection in the pelagic food web. They feed near the bottom of the food chain on plankton and are important prey items for many commercial fish species and marine mammals. Three life stages are separated during CPR examination. The nauplius stage is reported here.

Nauplii were nearly absent from the Gulf of Maine except for the April to mid-July period. Values peaked in May in Massachusetts Bay, and declined to the eastward. Three low abundance time-space patches occur in late September in all three sections.

Seasonality was fairly steady in Massachusetts Bay, but was interrupted from 1974-1985. The more temporally disconnected pattern in the central Gulf of Maine was also interrupted during this period, as can be seen in the day of annual maximum plot. This period of interruption differs on the western Scotian Shelf, where a late season event was in evidence. The prolonged high period for the eastern two sections seen from the mid-1980s to 1997 reverted to the several short pulses seen earlier in the series.

Negative departures dominated all three sections until the late 1980s. A few notable exceptions were Massachusetts Bay, 1968; central Gulf of Maine, 1961 and 1966; and western Scotian Shelf, 1961, 1962, 1964, and 1978. Above average conditions prevailed during the 1990s in all sections, and during the early 2000s over Massachusetts Bay and the western Scotian Shelf.

Centropages hamatus, Lilljeborg, 1853, copepodite stages 4-6.

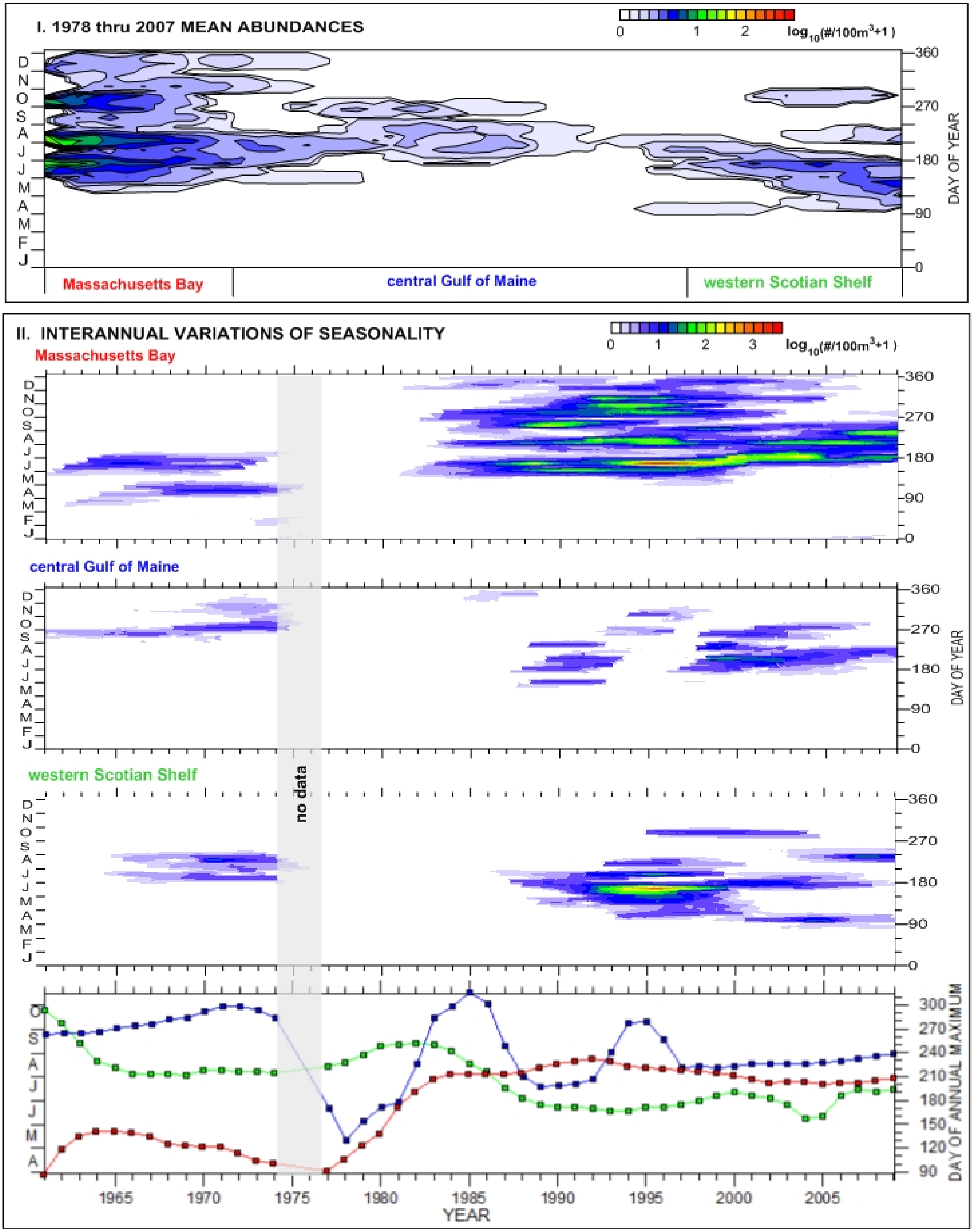

Figure 27. *Centropages hamatus* c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Centropages hamatus*, Lillgeborg, 1853, copepodite stages 4-6**

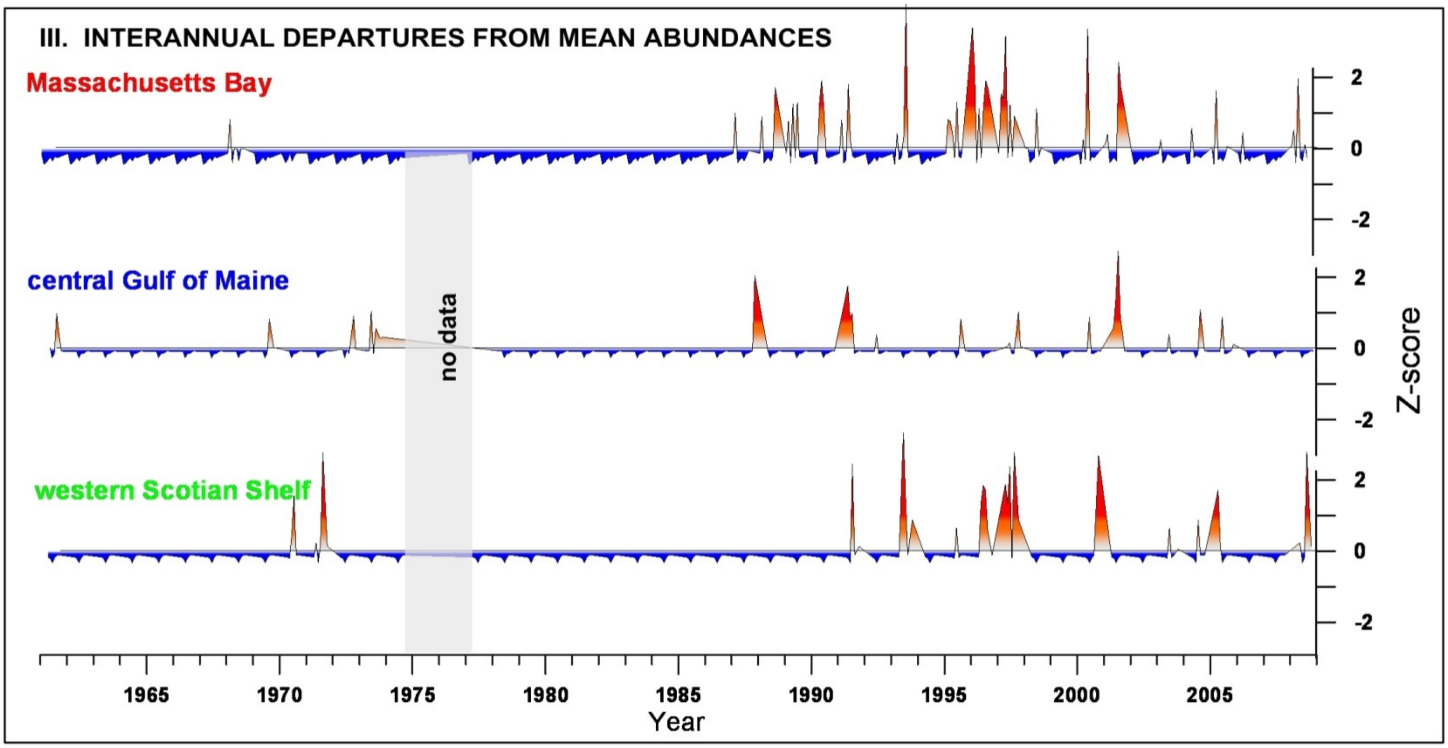

Figure 27 (cont.). *Centropages hamatus* c.4-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

This calanoid copepod is one of the most abundant members of the zooplankton community found within shelf waters of the North Atlantic. *Centropages hamatus* has a wide latitudinal range and a strong onshore-offshore abundance gradient. The copepod is omnivorous and its abundance in the northern part of its range appears to be most influenced by food limitation. The species has been found to produce subitaneous eggs during breeding season and resting ones in response to temperature cues.

Specimens were absent in Massachusetts Bay CPR samples prior to May, had a brief peak in July, a secondary peak in October, and then declined towards the end of the year. A good deal of this time they are absent very near the western end of the transect. The Massachusetts Bay pattern extends into the western portion of the central Gulf of Maine during July through September. The copepod was absent from the western Scotian Shelf until mid-April, reaching maximum abundance in June, followed by a rapid decline. Small time-space patches occurred in August and October on the eastern end of the transect.

The May to December period of production seen in Massachusetts Bay means was not evident prior to 1994. An extended period of production on the western Scotian Shelf coincided with years of higher abundance, e.g., 1990-2005.

With only a few exceptions, the period prior to 1987 had negative departures from the 1978-2007 means. From then until the early 2000s above average conditions occurred much of the time, especially in Massachusetts Bay and on the western Scotian Shelf. Thereafter anomalies in Massachusetts Bay were mixed, in the central Gulf of Maine, mostly negative, and on the western Scotian Shelf, mixed.

Bivalvia, Linnaeus, 1758, larva.

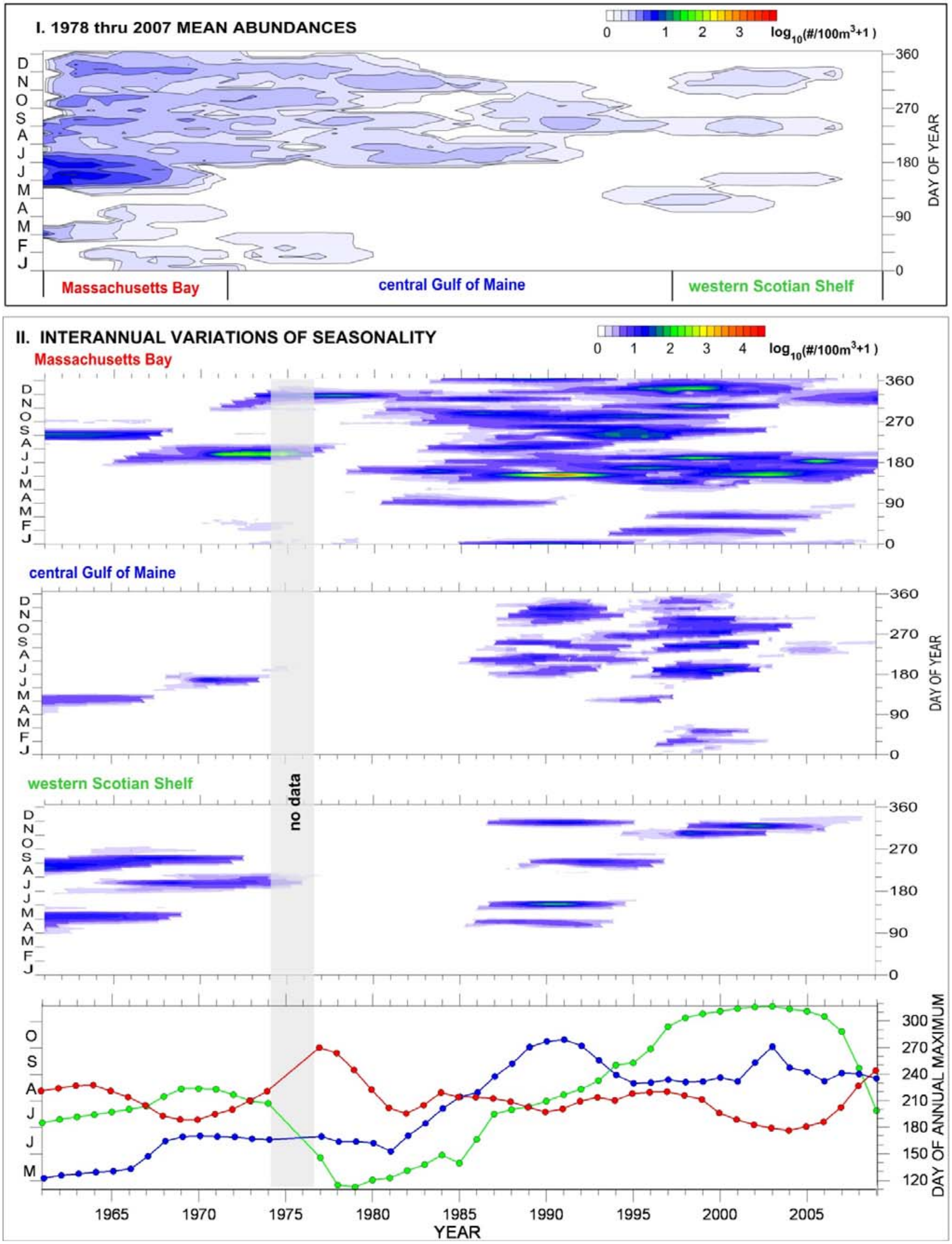

Figure 28. Bivalvia larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

Bivalvia, Linnaeus, 1758, larva

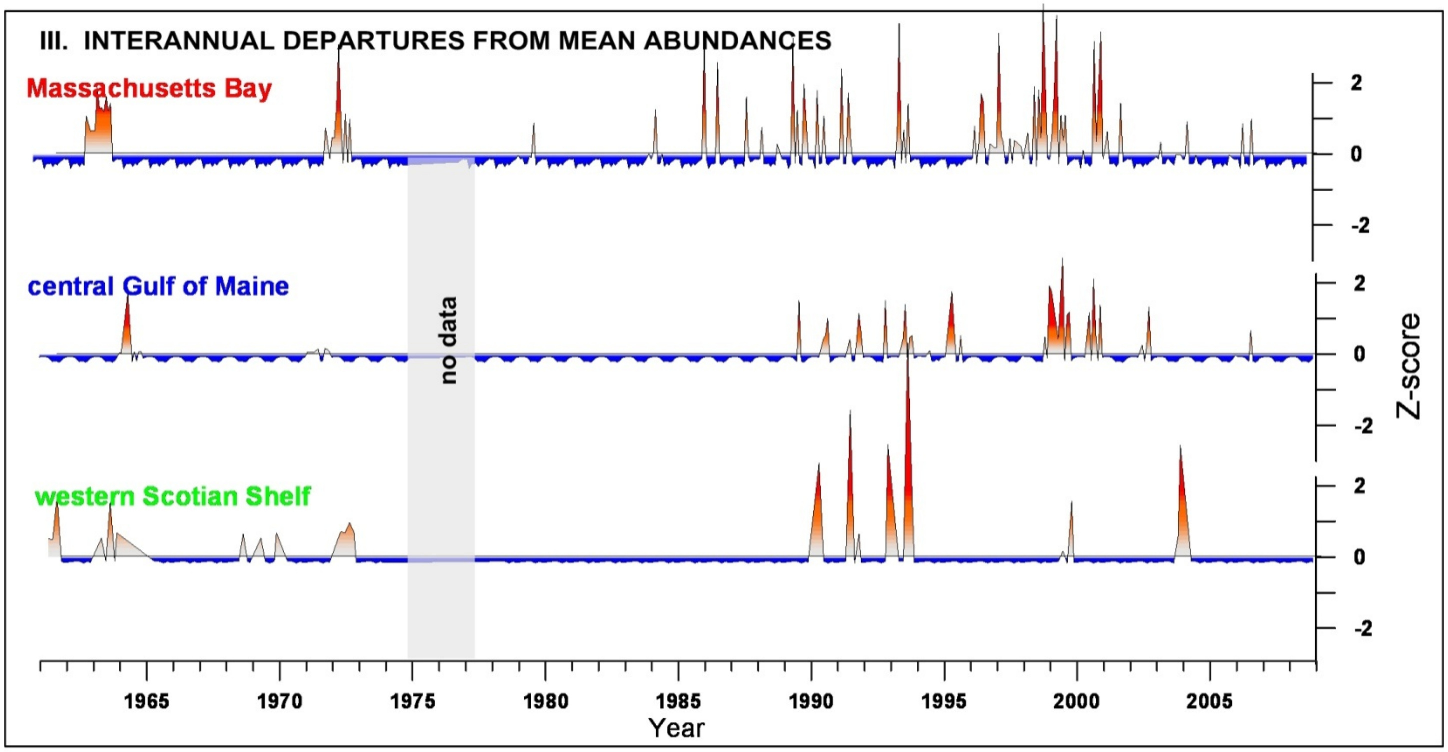

Figure 28 (cont.). Bivalvia larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Bivalves are a class of mollusks whose adults are easily recognized by their two-halved shell. The life cycle of most marine bivalves include a free-swimming veliger larval stage that is routinely captured by the CPR. The larva looks like a miniature bivalve with a ciliated structure that extends outside the shell and is used for both swimming and particulate food collection. Most larvae feed on phytoplankton for weeks to months before they settle to the seabed and transform into an adult.

Mean patterns showed bivalve larvae very nearly absent from the CPR samples on the western Scotian Shelf. In Massachusetts Bay they first appearred briefly in early March and then in late May, reaching peak abundance over inner Massachusetts Bay in June. Slightly lower values persisted till the end of the calendar year. After August, larvae were absent from the western extreme of Massachusetts Bay. Tongues of the Massachusetts Bay abundance extended into the western portion of central Gulf of Maine, particularly in July and November.

Years prior to the beginning of the 1978-2007 base period exhibited different season patterns than those during the base period. This can also be seen in the latened day of annual maximum curves for the central Gulf of Maine and the western Scotian Shelf in the later years.

Massachusetts Bay anomalies were largely negative until the late 1980s, with the exception of 1962-1963 and 1972-1973. Positive departures, with occasional reversal, continued until 2002. Below average conditions prevailed after 2002. The central Gulf of Maine departures were equally negative until the early to mid-1990s, followed by Massachusetts Bay-like positive anomalies lasting until about 2002, and followed by below average conditions to the end of the series. On the western Scotian Shelf small departures from the near-zero mean abundances produced dramatic Zscores. Nonetheless, the pattern there was somewhat similar to the other two sections.

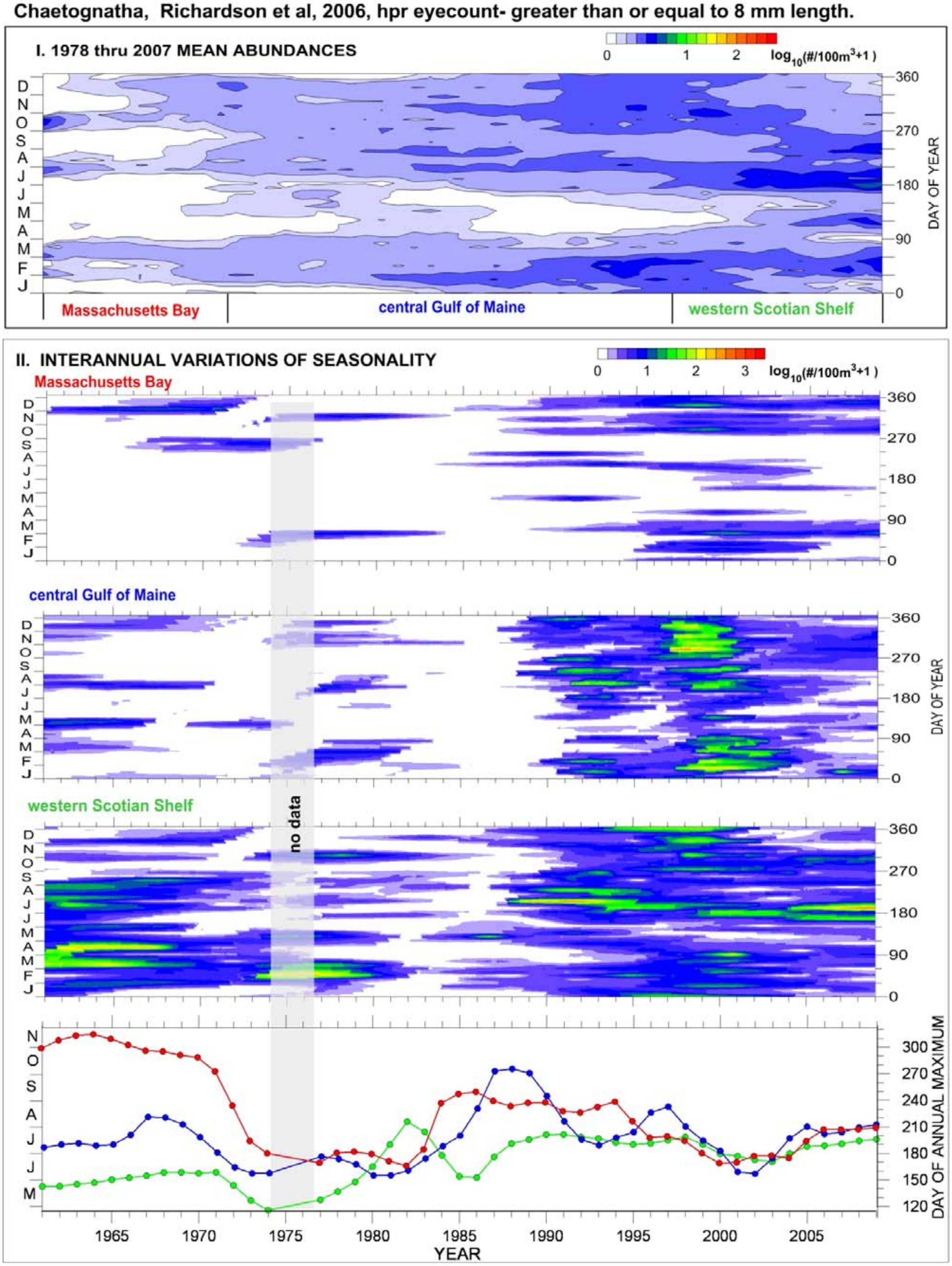

Figure 29. Chaetognatha hpr eyecount (≥ 8 mm length) variations along the Gulf of Maine Continuous Plankton Recorder transect.

Chaetognatha, Richardson et al, 2006, hpr eyecount- greater than or equal to 8 mm length

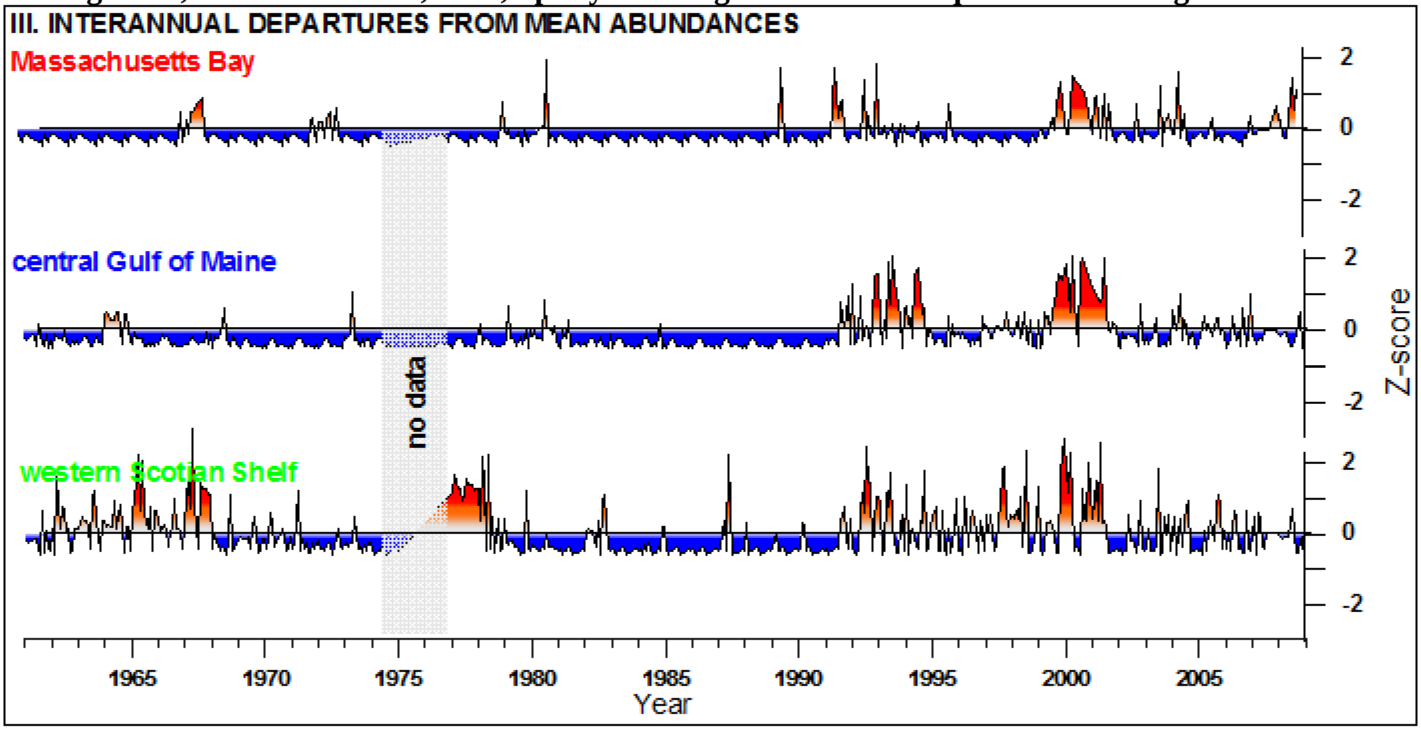

Figure 29 (cont.). Chaetognatha hpr eyecount (≥ 8 mm length) variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Chaetognaths are transparent, torpedo-shaped plankters commonly called "arrow worms". Those reported on here, are specimens greater than or equal to 8 mm in length. They are voracious predators equipped with a series of movable spines on their heads which they use to grab and ingest prey. Chaetognaths are probably one of the main sources of predation pressure on the copepod community and also feed on larval fish, crustaceans, and other chaetognaths. These active predators are also an important food source for fish and other animals higher in the food web.

Mean patterns showed a good portion of Massachusetts Bay through the year, most of the central Gulf of Maine from April-June, and portions of the western Scotian Shelf during January, April, and December bereft of these chaetognaths. Major concentrations occurred from January to March; from June-July; and September-December over the eastern two transect sections.

Day of annual maximum values for the three sections, disparate during the 1961-1970 period, converged especially after 1990, indicating peak abundances in July. Pulses through most of the calendar year over the eastern two sections persisted even in the low abundance years.

Pre-1990 anomalies in Massachusetts Bay were largely negative. The early 1990' were above average, the late 1990s negative, 1999-2002 above average, and the rest of the series somewhat mixed. The central Gulf of Maine displayed departures very much like those of Massachusetts Bay. Over the western Scotian shelf positive departures dominated from 1962-1968, followed by a below average period (briefly interrupted in 1977) until 1991. The rest of the series for the western Scotian Shelf follows patterns in the other two sections.

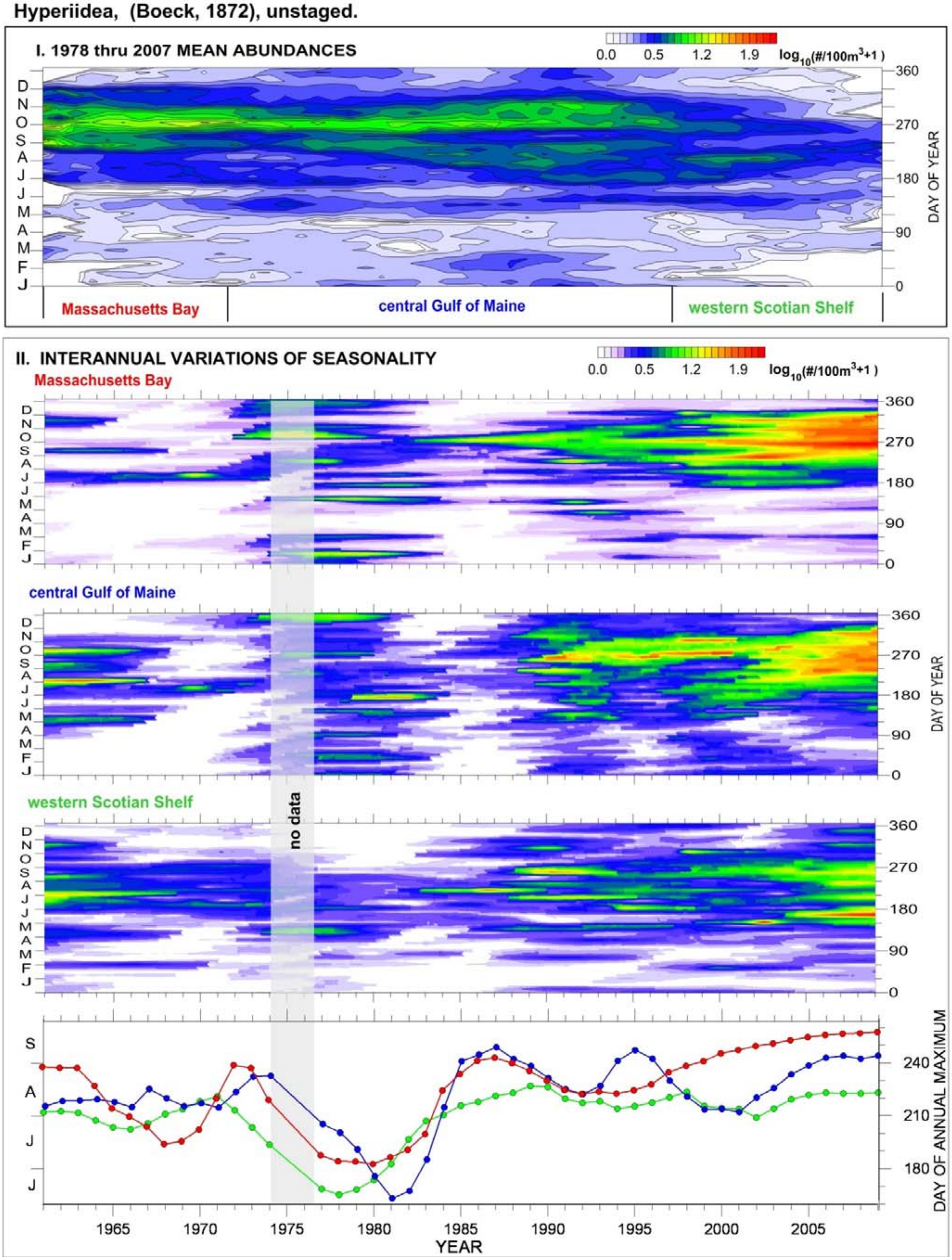

Figure 30. Hyperiidea unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

Hyperiidea, (Boeck, 1872), unstaged

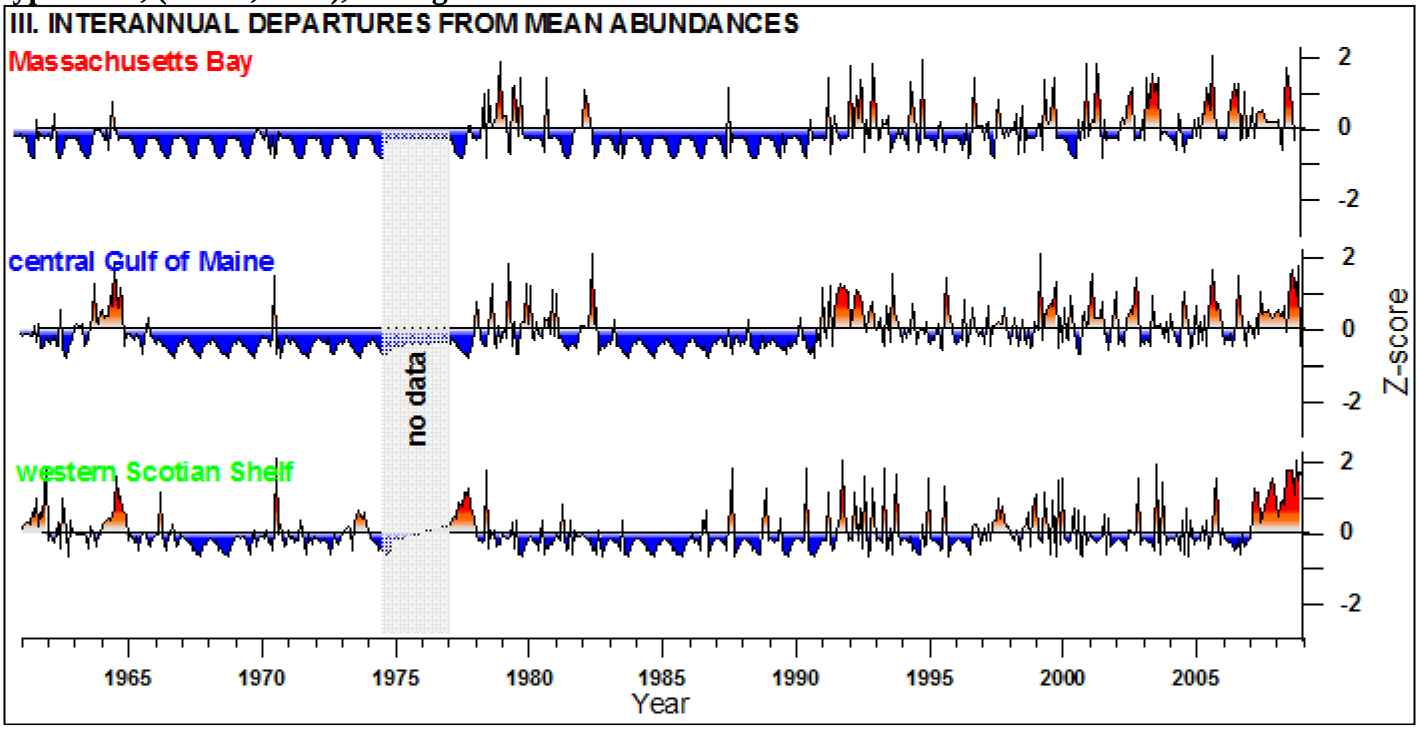

Figure 30 (cont.). Hyperiidea unstaged variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Hyperiid amphipods are marine pelagic crustaceans that occur in all oceans. Hyperiids have a laterally compressed body with large compound eyes that cover all of the head. May species are mutualistic or parasitic with gelatinous organisms during some part of their life cycle. Pelagic amphipods are known to occur in dense swarms and are the preferred prey of many seabirds, fish, and whales.

They were absent to present in low abundance across much of the transect during the first third of the year. A rapid increase began in mid-April, peaking by early August (somewhat earlier on the western Scotian Shelf). Decline began in November (more rapidly at the transect extremes), and reached annual lows by December.

Seasonal timing in Massachusetts Bay from 1961-1967 became earlier, then latened till 1972. Timing in the other two sections remained steady during this period. The day of annual maximum then occurred progressively earlier till the late 1970s/early 1980s, followed by a latening till the late 1980s. This timing latened slightly in Massachusetts Bay, but remained fairly steady in the other two sections through the rest of the series. There appeared to be a slight latening trend in the day of annual maximum through the series.

Sustained positive anomalies in Massachusetts Bay occurred in 1978-1979, 1992, 1994, and after 2004. Except as just mentioned, the period from 1961-1991 was below average. The same below average period in the central Gulf of Maine was interrupted by positive departures in 1963-1964 and 1978-1982. After 1991, above average values dominated. From 1961-1964 positive anomalies existed on the western Scotian Shelf; largely negative conditions prevailed until 1991 with the exception of high values in 1977; above average condition occurred in 1991-1993, 1997-2000, and especially beginning in 2007. Other periods were mixed.

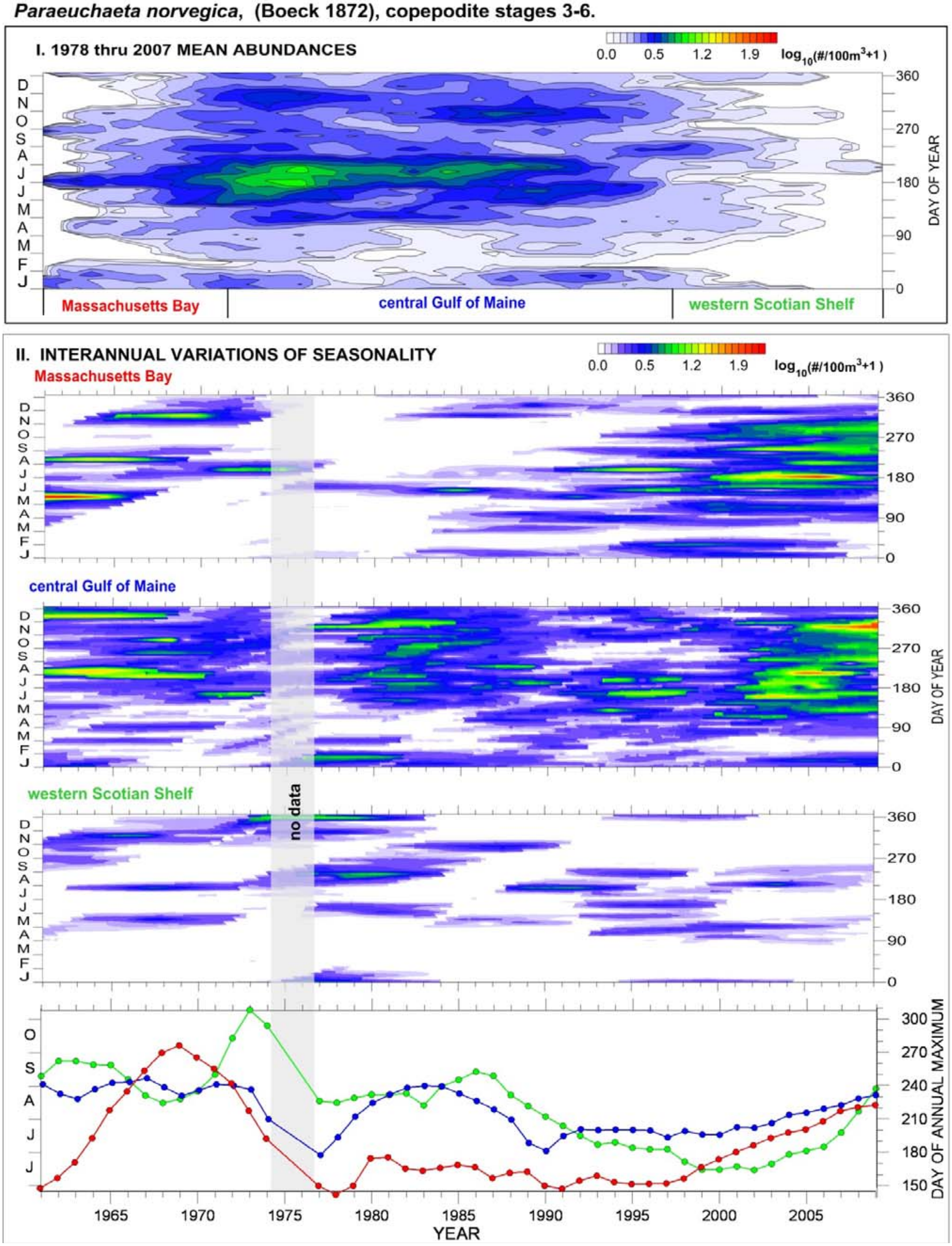

Figure 31. *Paraeuchaeta norvegica* c. 3-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Paraeuchaeta norvegica*, (Boeck 1872), copepodite stages 3-6**

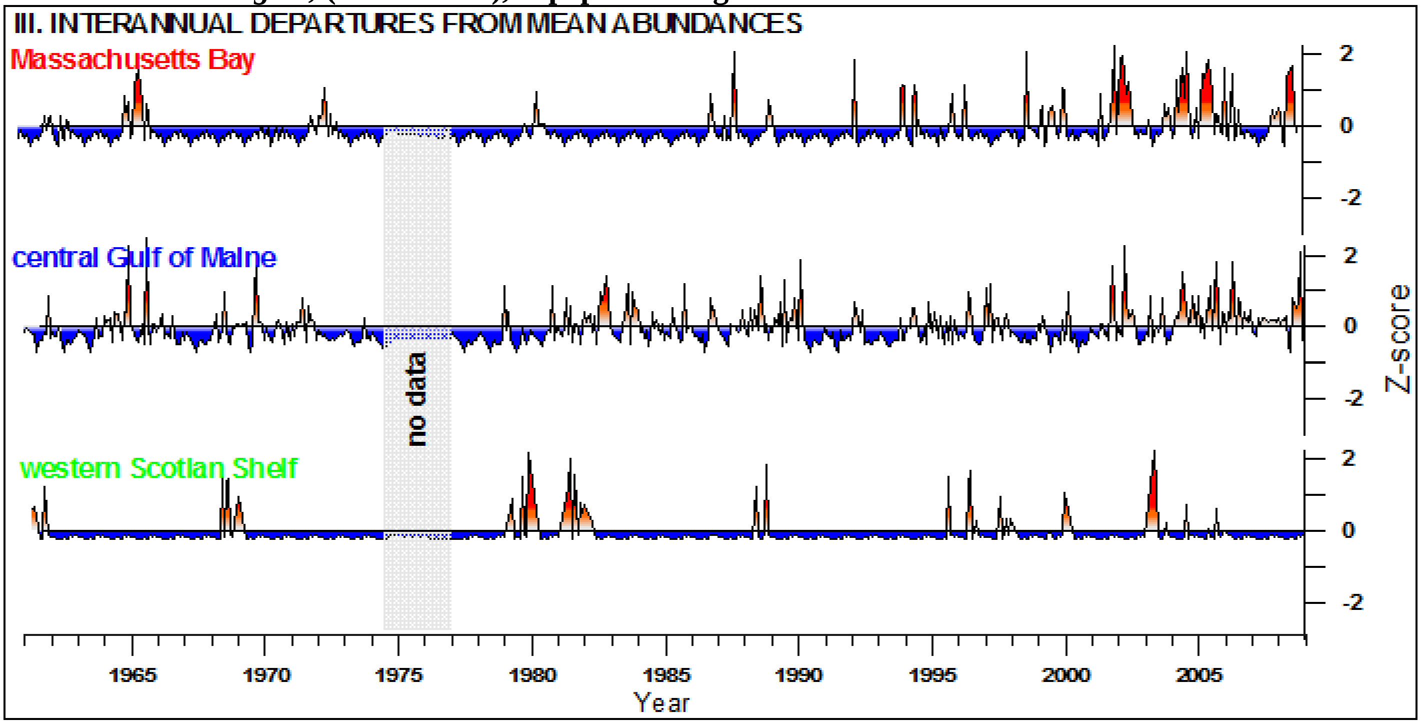

Figure 31 (cont.). *Paraeuchaeta norvegica* c. 3-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Paraeuchaeta norvegica is a large carnivorous, calanoid copepod that has a widespread distribution in the North Atlantic. It is a strong vertical migrator that avoids visual predators by living deep during the day and ascending into the upper waters to feed at night. It is a tactile predator that is very efficient at capturing small copepods. In spite of its known vertical migration, its abundance ranking and consistency of identification and staging through the series, resulted in atlas inclusion.

Except for brief periods in January, early July, and late September, this copepod was absent in samples from the western extremes of the transect, absent throughout the year during February, and absent from the easternmost 50 km of the transect. It existed from March to year’s end, peaking over the western portion of central Gulf of Maine in late June and July.

Seasonal patterns varied considerably during the series for all sections of the transect. However, after 1990 they became more steady, with more similar peak times, and a slight latening to the end of the series.

Brief periods of above average conditions occurred in Massachusetts Bay from 1961 through about 2000. Otherwise this period was dominated by negative anomalies. From 2002 to 2007, and in 2008, departures were above average. Except for 1972-1980 when negative departures dominated in the central Gulf of Maine, conditions were mixed until 2001. Above average abundance prevailed to the end of the series. Absent to very low abundances on the western Scotian Shelf especially reduce the value of the negative Zscores. However, numerous periods of above average abundances are indicated.

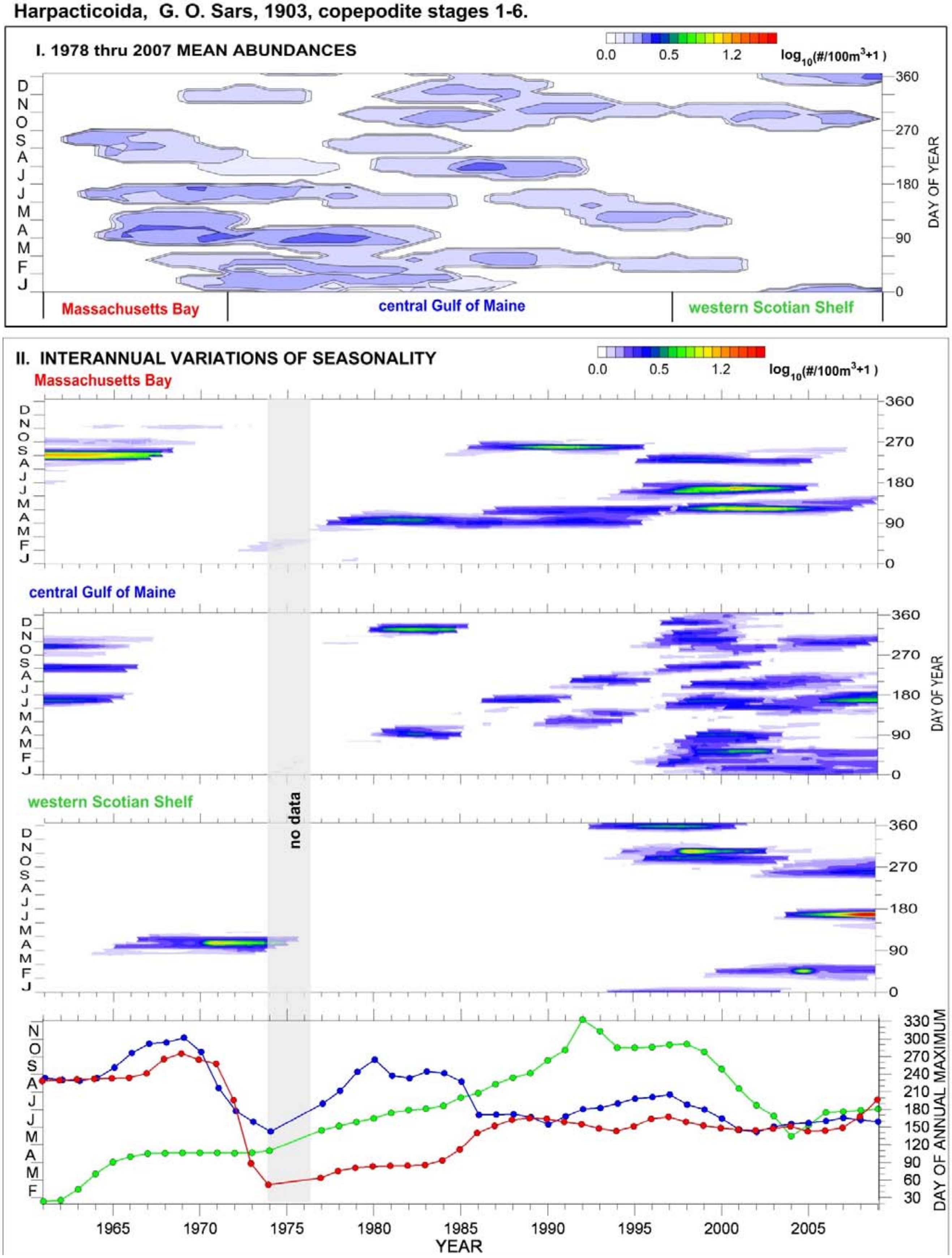

Figure 32. Harpacticoida c.1-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

Harpacticoida, G. O. Sars, 1903, copepodite stages 1-6

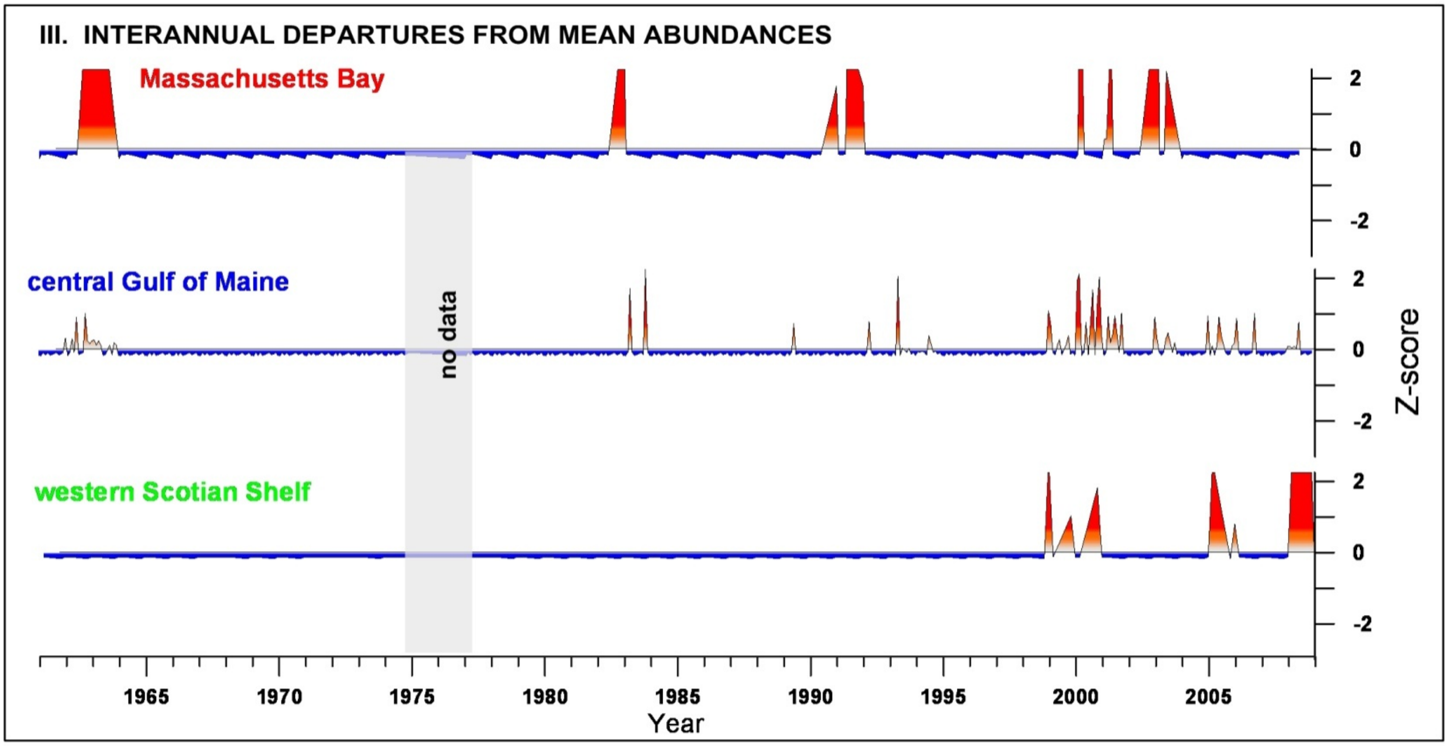

Figure 32 (cont.). Harpacticoida c.1-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Harpacticoids are an order of copepods distinguished by the presence of only a very short pair of first antennae. They typically have a wide abdomen and often there are not obvious divisions between the main regions of the body. The vast majority of them are benthic, but representatives of the genus Alteutha are frequently captured by plankton samplers in the shelf waters of the northwest Atlantic.

The 1978-2007 means provided little to aid in describing this taxon's seasonal cycle or spatial preference. Small areas of abundances surrounded by absences were spread throughout most of the time-space domain. The largest contiguous area appeared during March and April over the outer Massachusetts Bay and western portion of the central Gulf of Maine.

The lack of a clearly defined seasonal cycle precluded any simple discussion of interannual changes in seasonality.

As with other relatively low abundance taxa, the Zscore time series of Harpacticoids illustrated times of positive departures, but offers less detail when departures were negative (usually zero abundance). Aside from the notable positive anomalies in Massachusetts Bay and the central Gulf of Maine in the early 1960s and early 1980s, the early years of the series had below average abundances. Isolated positive anomalies in Massachusetts Bay occurred in the early 1990s and 2000s. A more sustained period of above average abundance occurred in the central Gulf of Maine after 1999. From 1999-2001, and during 2005 and 2008 positive anomalies occurred on the western Scotian Shelf.

Polychaeta, larva.

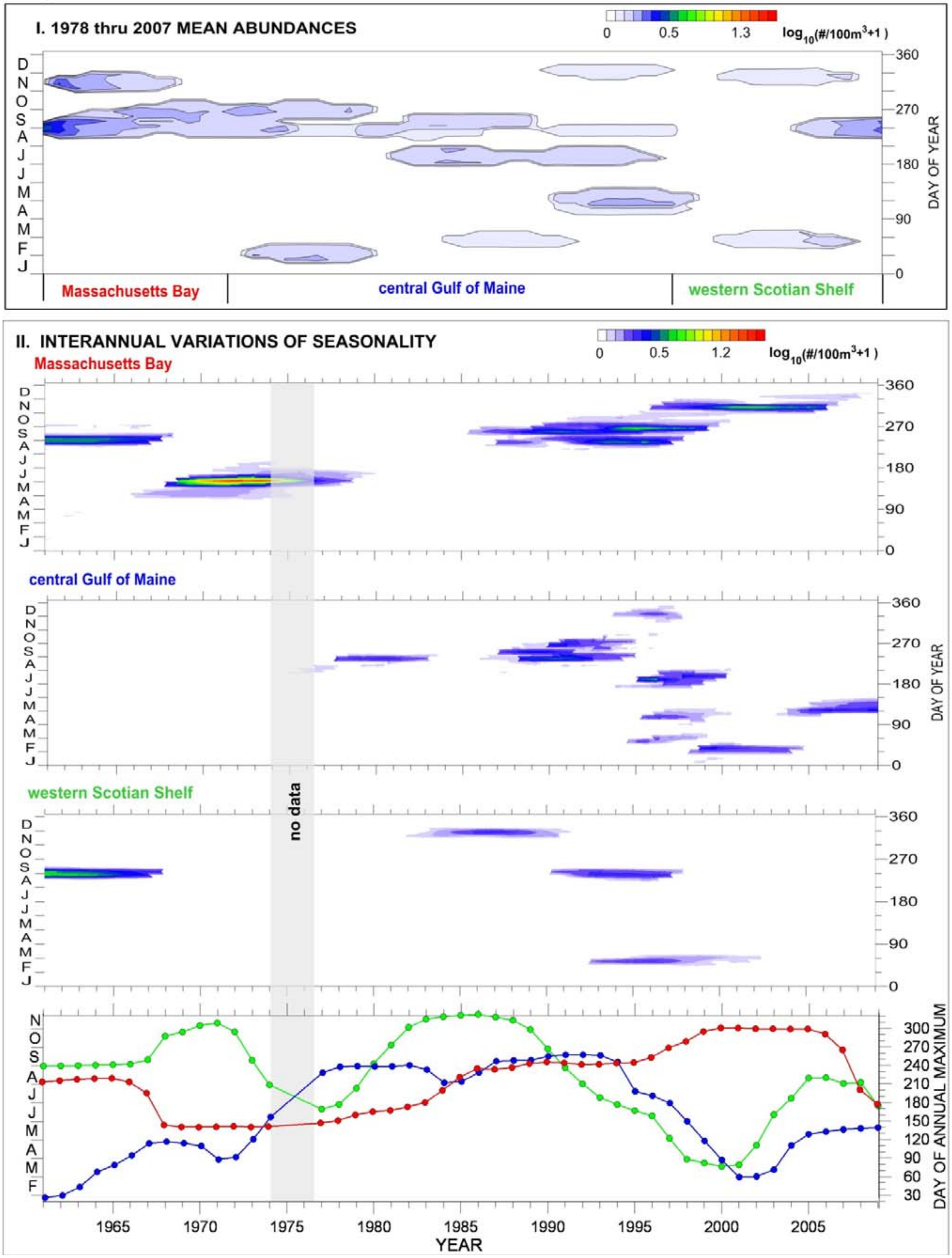

Figure 33. Polychaeta larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

Polychaeta, larva

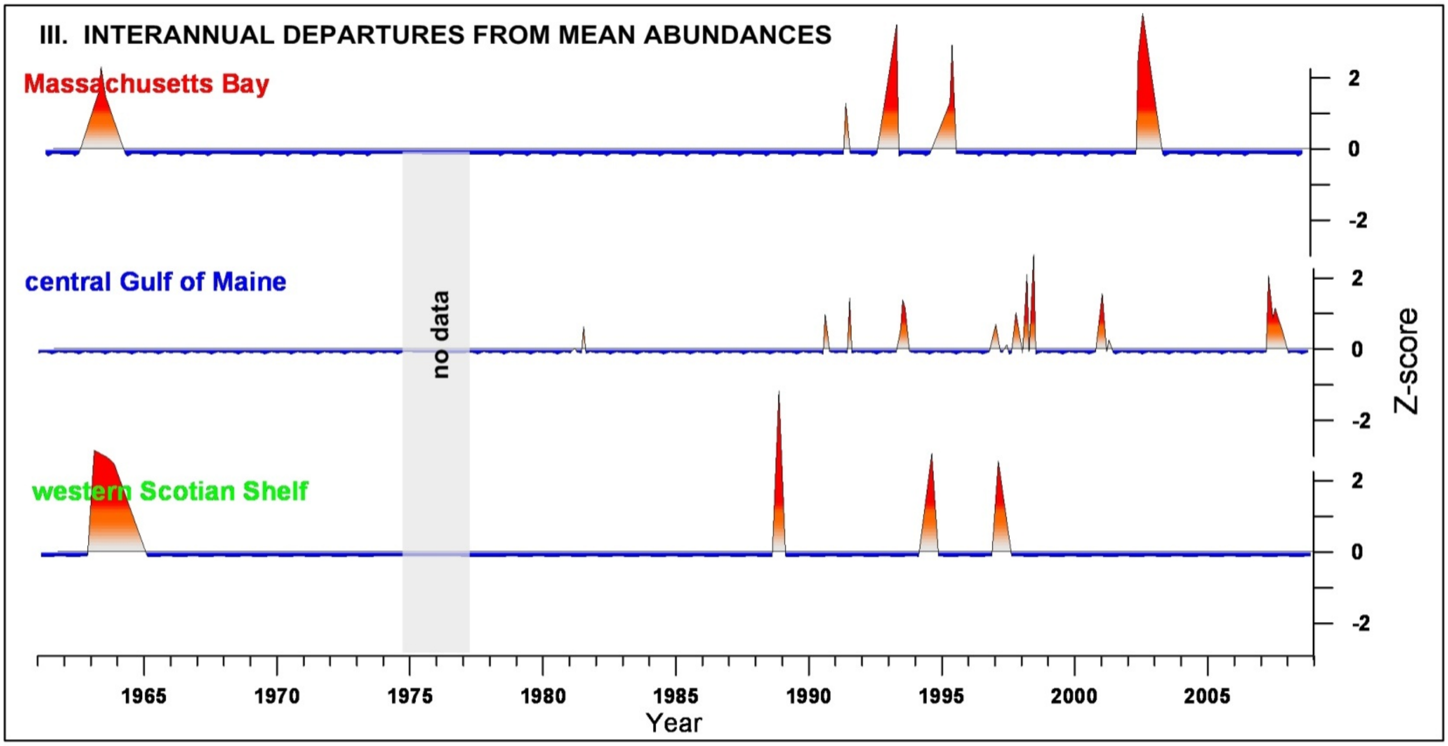

Figure 33 (cont.). Polychaeta larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The polychaetes are a large class of segmented worms that can be found on the bottom of the deepest oceans, floating free near the surface, or burrowing in the mud and sand of the beach. The life history of many polychaetes is unknown, but studies have shown that there is an enormous diversity of reproductive strategies. Some species have eggs that hatch into a planktonic trochophore larva that can last a few hours or several weeks. The transparent larva usually weakly swims with ciliated girdles and, during certain periods, can be a major component of the zooplankton community.

Isolated catches of these larvae occurred in all three sections of the transect, and at most times except early winter and early spring. Major abundances were concentrated near inner Massachusetts Bay in late April/early May, and again in November. On the eastern extreme of the transect polychaete larvae showed their highest abundance in late August/early September.

The day of annual maximum values for Massachusetts Bay showed a consistent latening from 1968 to 2000. In the central Gulf of Maine these values were relatively later in the year from 1977-1992. From 1986 to 2000 this peak occurred progressively earlier over the western Scotian Shelf. Like several other taxa, the peaks for the three transect sections converged near the series end.

Abundances in the three sections prior to 1989 were below the 1978-2007 means, except over the shelf sections in 1962-1965. Positive anomalies occurred in Massachusetts Bay in the 1990s and in 2003. Above average conditions in the central Gulf of Maine occurred through the 1990s and in 2007, and on the western Scotian Shelf in 1988, 1994, and 1997.

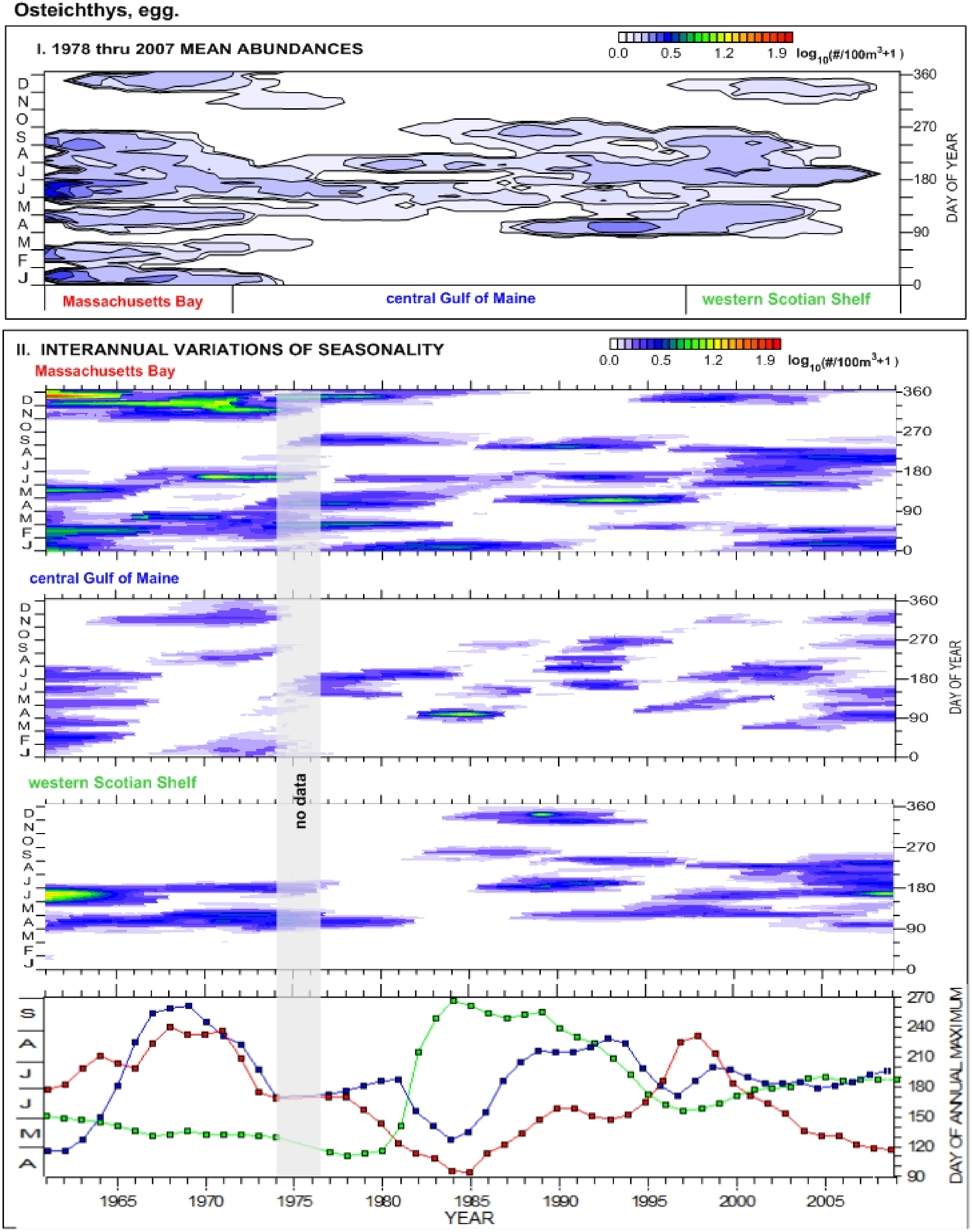

Figure 34. Osteichthys egg variations along the Gulf of Maine Continuous Plankton Recorder transect.

Osteichthys, egg

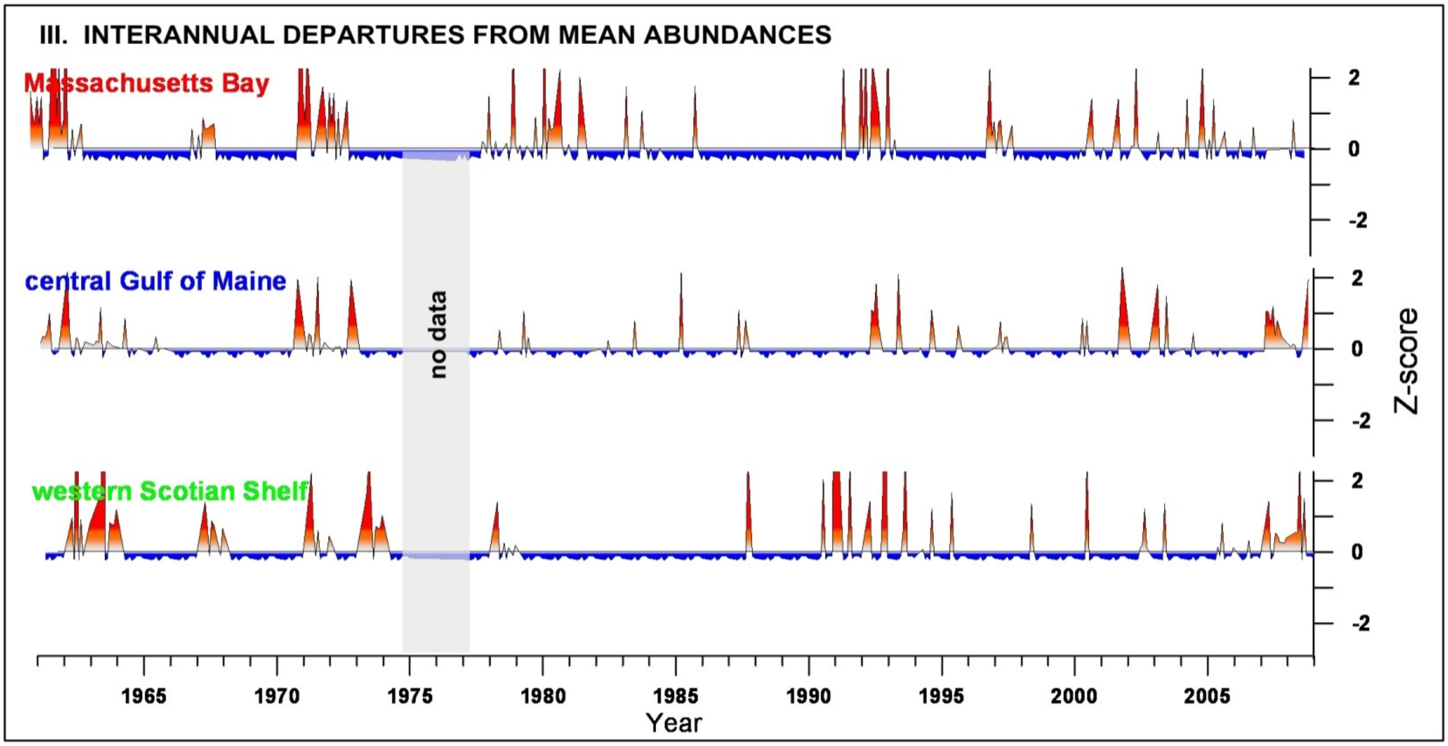

Figure 34 (cont.). Osteichthys egg variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The majority of fishes that reproduce in the Gulf of Maine shed their eggs and sperm directly into the surrounding water. The resultant fertilized eggs may float freely in the plankton until they hatch into larvae.

Mean abundances showed multi-pulses of fish eggs in Massachusetts Bay, reflecting the multi-species of fish represented. Fairly distinct pulses occurred in January, February, late April, late May to early July, early August, September, and December. Patches occurred in the central Gulf of Maine in late July and September. Over the outer western Scotian Shelf and into the central Gulf of Maine two high periods occurred: April and May, and late June to mid-September.

Because of the multi-species nature of these samples, comments on change in seasonality are not offered.

Numerous groups of years with above average abundance are seen. Examination of these monthly values, together with knowledge of the different Gulf of Maine fish species spawning times, could reveal useful information.

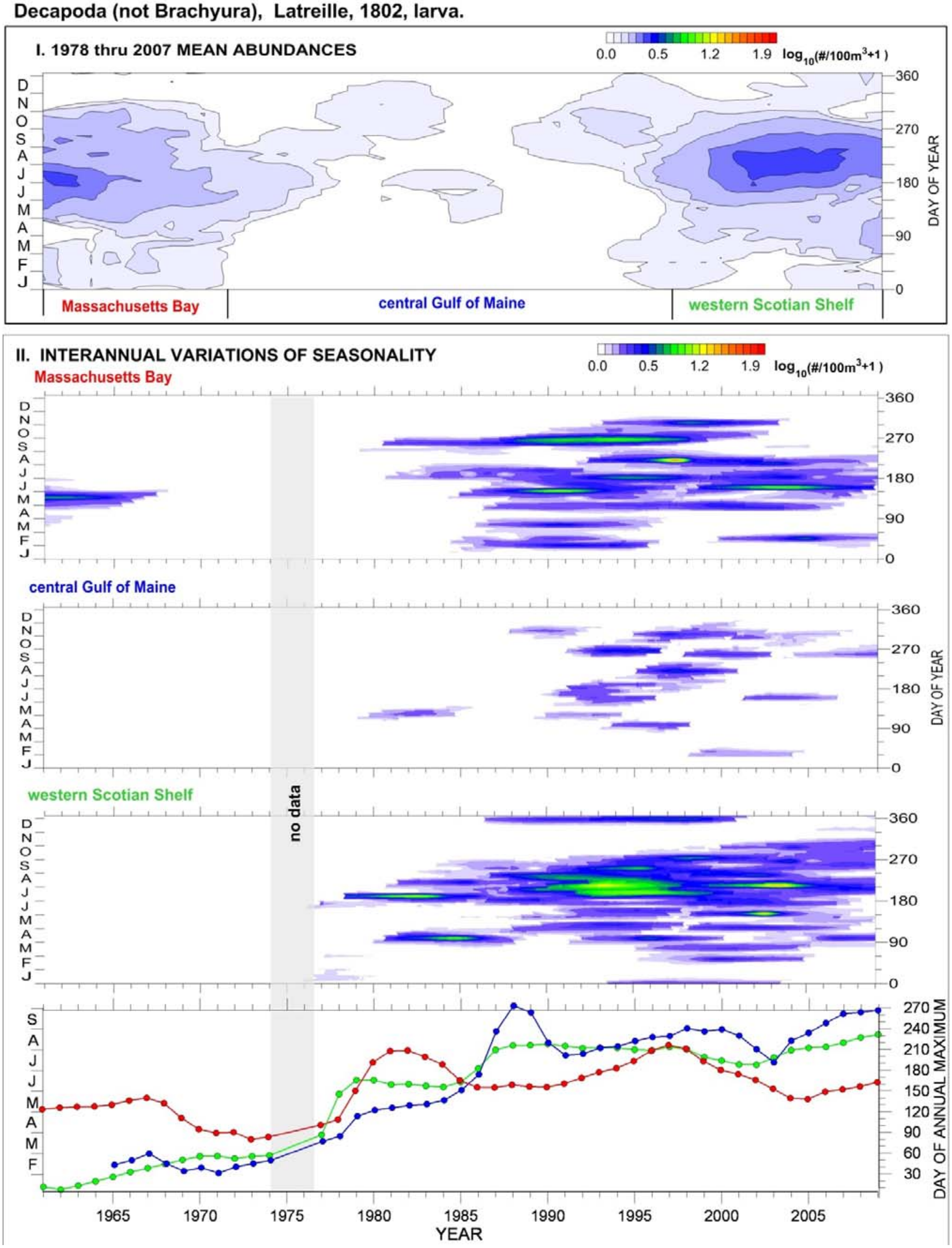

Figure 35. Decapoda (not Brachyura) larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

Decapoda (not Brachyura), Latreille, 1802, larva

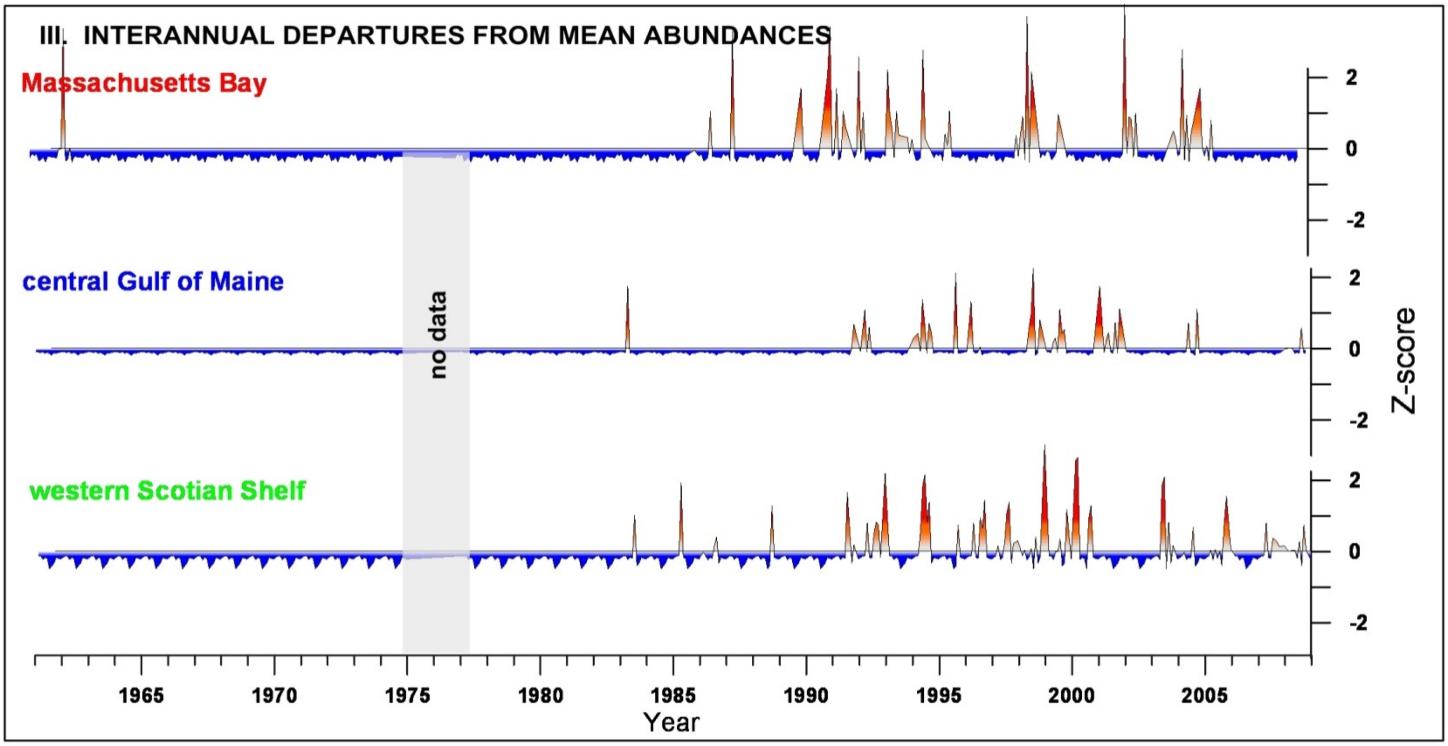

Figure 35 (cont). Decapoda (not Brachyura) larva variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

The decapods are an order of crustaceans whose members include many groups that are harvested commercially (e.g., lobster, shrimp, and crayfish). The infraorder Brachyura (true crabs) is excluded from the taxon reported here. Most decapods have retained a planktonic larval phase that bears little resemblance to the adult. The four larval stages, distinguished by mode of locomotion are nauplius, protozoea, zoea, and postlarva. During some seasons, decapod larvae can be major component of zooplankton biomass and play a significant role in food web dynamics.

Mean concentrations were located in Massachusetts Bay and over the western Scotian Shelf, with zero, or near zero abundances in the central Gulf of Maine after April. In Massachusetts Bay near-zero values prevailed from January-April and peak values occurred from late June to early July. Values declined rapidly by November. On the western Scotian Shelf the taxon was present in low numbers from January-June, peaked from July to mid-September over a larger time/space area than the Massachusetts Bay peak. Western Scotian Shelf values also declined after November, but remained slightly above zero through the end of the year.

Seasonality in Massachusetts Bay resembled the means during the 1960s. From the mid-1980s to the end of the series the period of high abundance was much lengthened. The productive part of the season in the central Gulf of Maine changed from non-existent prior to 1980, to much longer thereafter. On the western Scotian Self the variation of seasonality is similar to the central Gulf of Maine. A latening trend of the day of annual maximum occurred in all sections throughout the series.

The monthly departures for the three transect sections mirrorred the variations of seasonality.

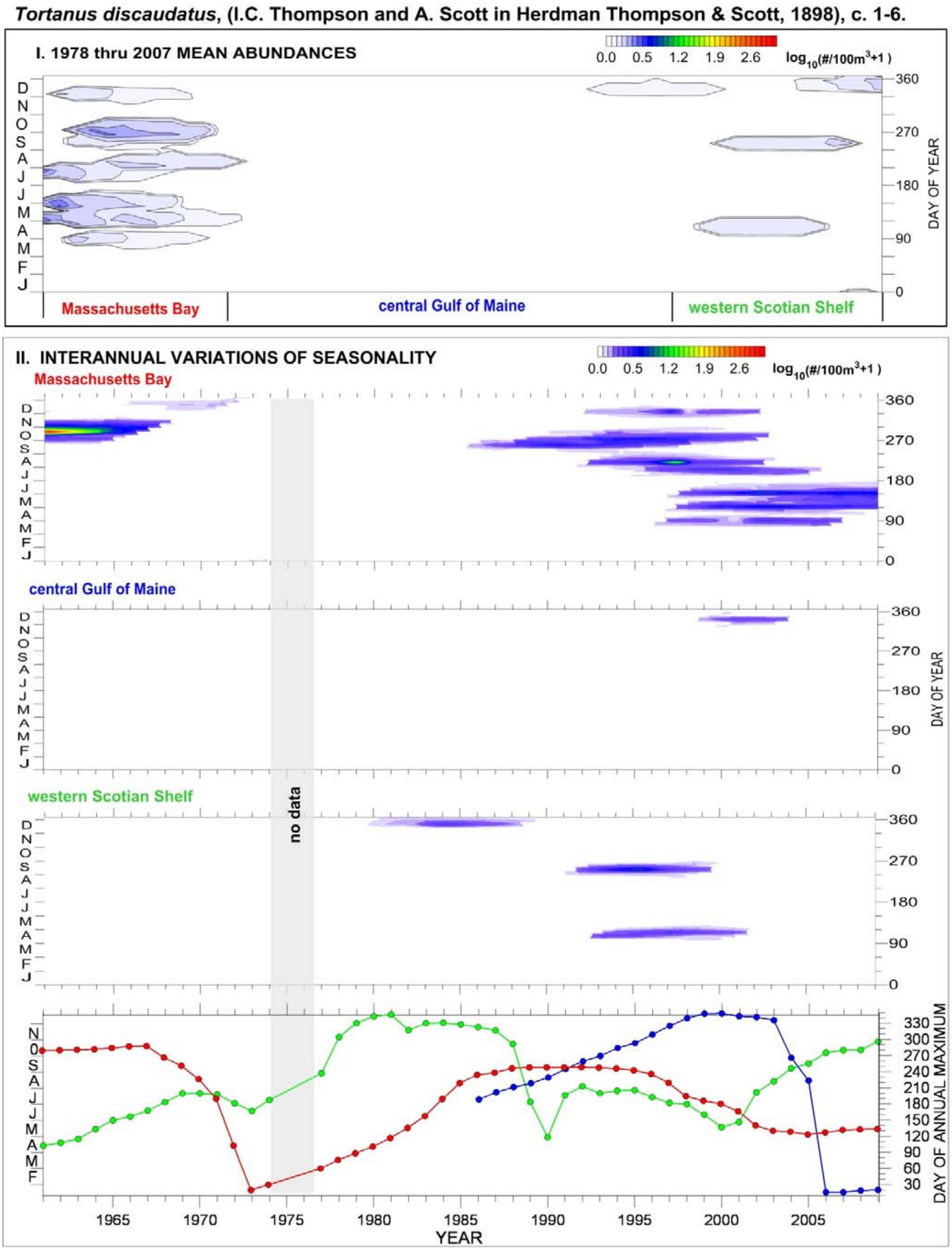

Figure 36. *Tortanus discaudatus* c.1-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Tortanus discaudatus*, (I.C. Thompson and A. Scott. In Herdman, Thompson, & Scott, 1898), c. 1-6**

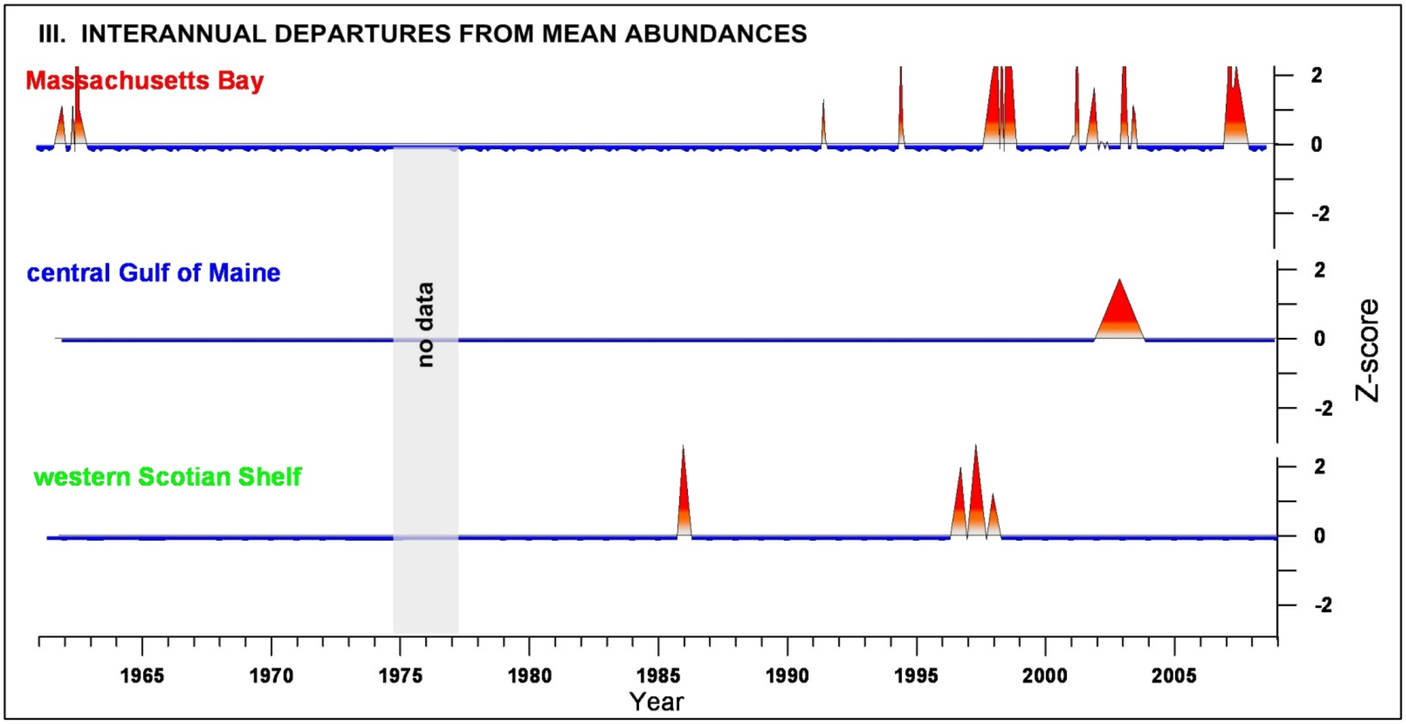

Figure 36 (cont.). *Tortanus discaudatus* c.1-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Tortanus discaudatus is a highly predaceous, neritic copepod occurring mainly in subarctic waters of the North American east and west coasts. It is a non-visual predator that actively darts to encounter and catch copepod nauplii and copepodites. It is not usually captured in large numbers, but it likely has an important role in coastal communities.

Mean concentrations of this taxon were located in Massachusetts Bay from mid-March to mid-December as separated pulses centered in late March, late May, July, late September, and early December. *T. discaudatus* was all but absent in the central Gulf of Maine. Separated pulses were seen on the western Scotian Shelf in late April-early May, September, and December. Values were lower here than in Mass Bay.

Seasonality seems to be closely tied with levels of abundance and with the years chosen for the base period.

Positive anomalies occurred in Massachusetts Bay in the early 1960s, and not again until 1992. Subsequent highs occurred in 1994, 1997-1998, 2001-2003, and 2007. The sole positive departure in the central Gulf of Maine occurred during 2006-2008. The western Scotian Shelf was below average except for large positive anomalies in 1985 and 1996-1998.

Candacia armata, (Boeck, 1872), copepodite stages 5-6.

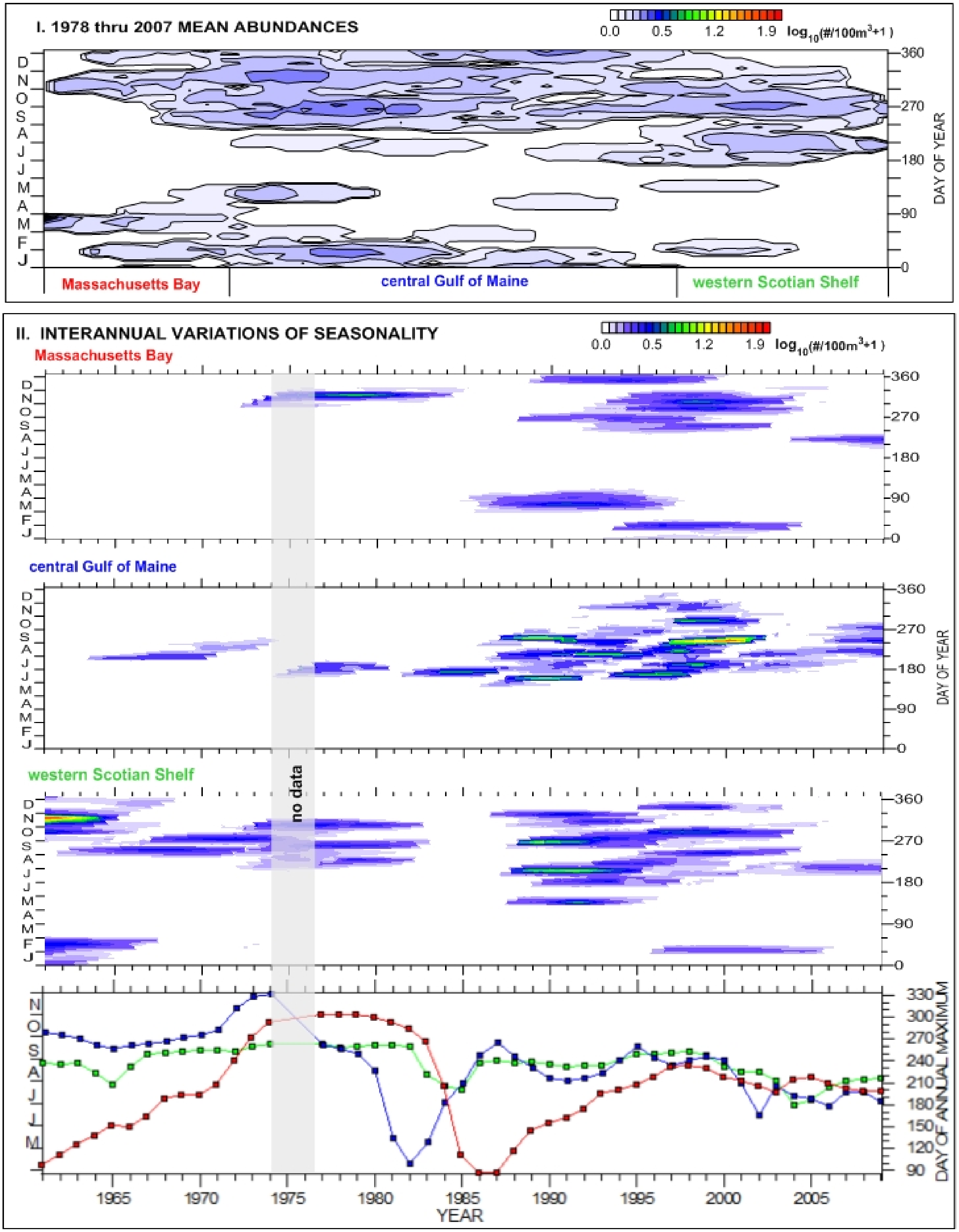

Figure 37. *Candacia armata* c. 5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.

***Candacia armata*, (Boeck, 1872), copepodite stages 5-6**

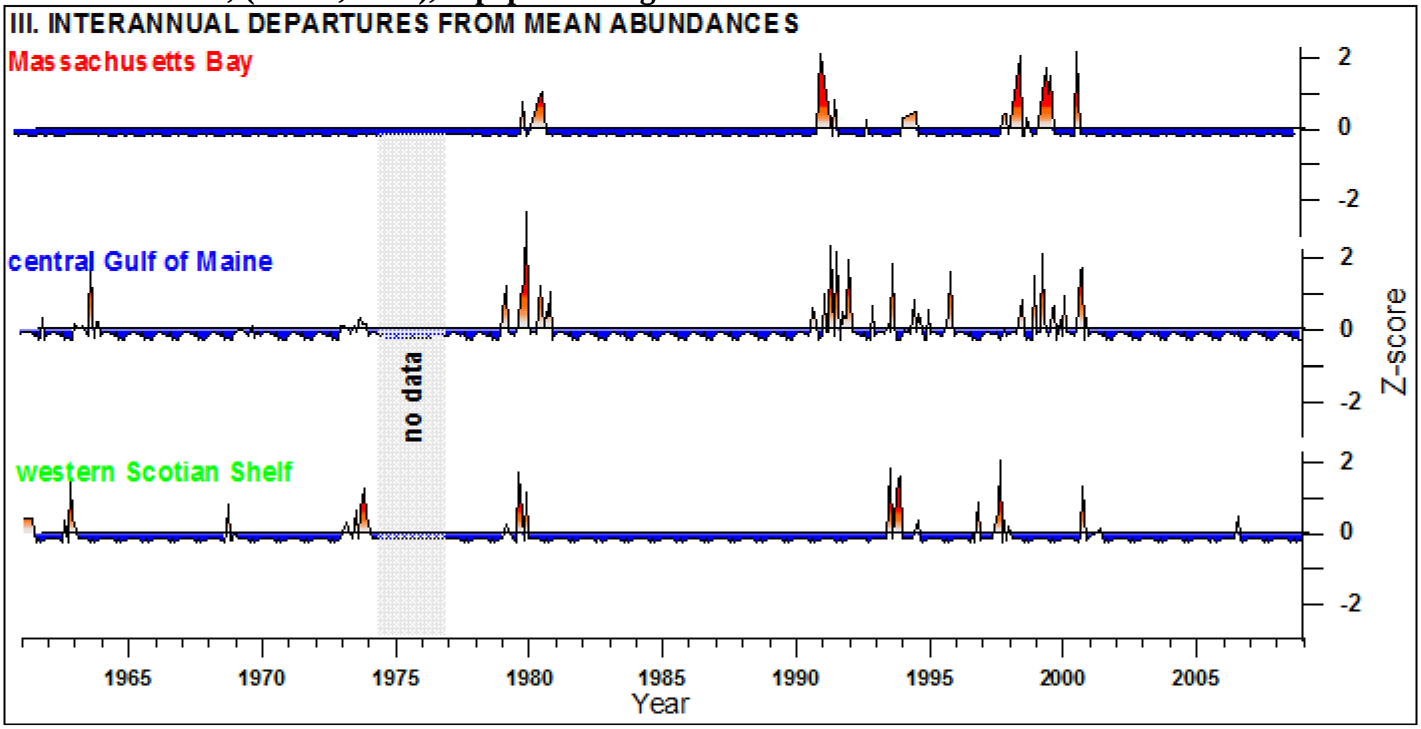

Figure 37 (cont.). ***Candacia armata*** **c. 5-6 variations along the Gulf of Maine Continuous Plankton Recorder transect.**

IV. COMMENTS

Candacia armata is an oceanic copepod that can be numerous in shelf waters when offshore water is advected inshore. It occurs throughout the Atlantic Ocean and is routinely used in the North Sea as an oceanic indicator species to track strong inflow into the region. It has been described as a carnivorous copepod that actively pursues its prey.

Mean abundances in January appeared to be connected to the previous year's production, where they occurred in Massachusetts Bay and the central Gulf of Maine. By February they displayed highest abundances in the central Gulf of Maine and also appeared in portions of the western Scotian Shelf. During April, they were present only in Massachusetts Bay, and in May over the outer Massachusetts Bay with a patch in the central Gulf of Maine. Except for a small patch on the western Scotian Shelf, late spring appeared to be the annual low. An increase in abundance began in July on the western Scotian Shelf, and across most of the transect by August with various peaks, the highest being over the western portion of the central Gulf of Maine in September. High values continued through the end of the year, with diminishing ones at the transect ends.

Two seasonality features were worthy of note: 1) the early- to mid-1960s earlying of the day of annual maximum in all three transect sections, and the convergence of this metric in the late 2000s.

Positive departures in the central Gulf of Maine occurred in 1963 and on the western Scotian Shelf in 1961-1962. After 1977 the three transect sections display similar periods of positive anomalies, namely the early 1980s, and early 1990s to early 2000s.

All Taxa, all stages.

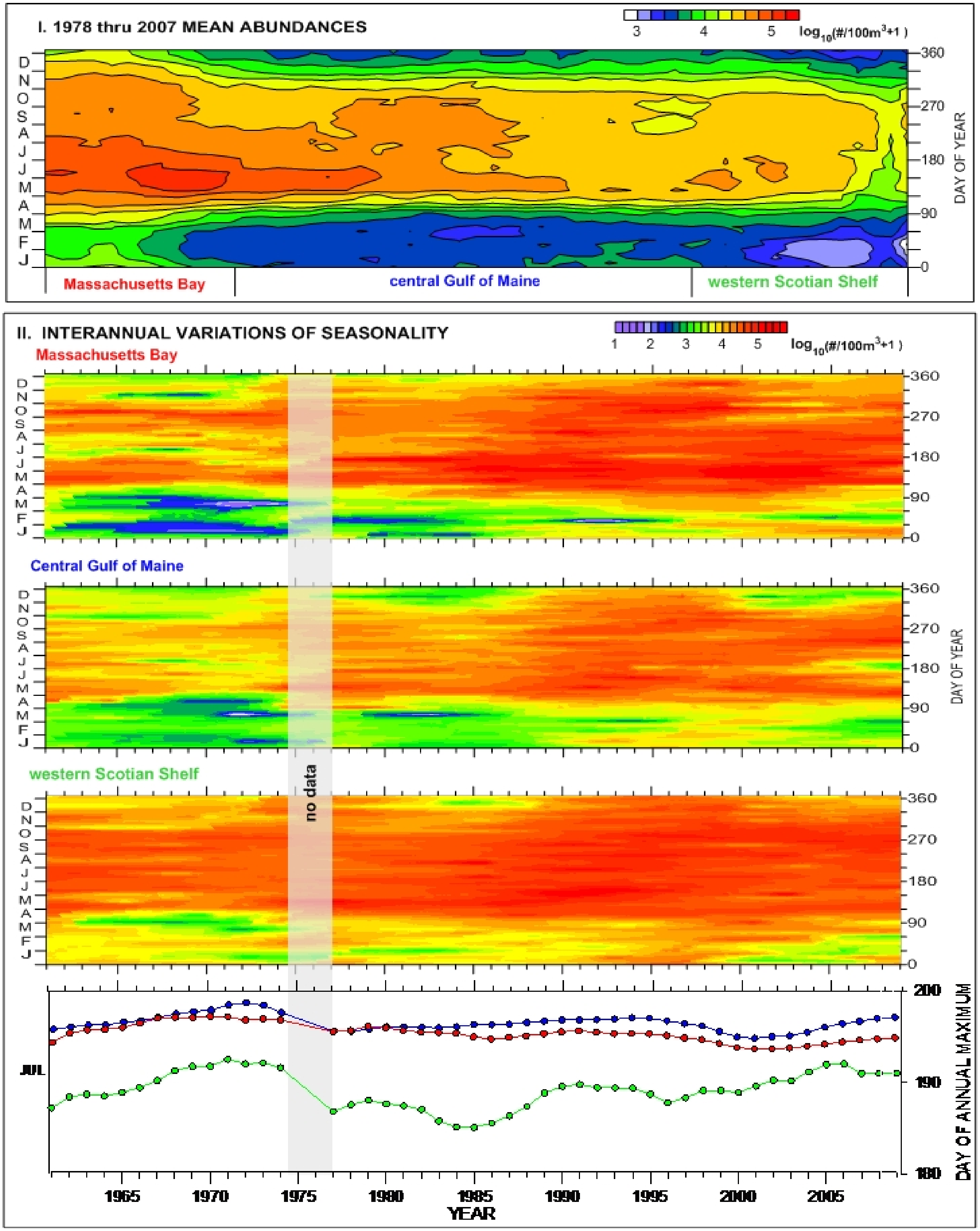

Figure 38. All taxa, all stages, variations along the Gulf of Maine Continuous Plankton Recorder transect.

All Taxa, all stages

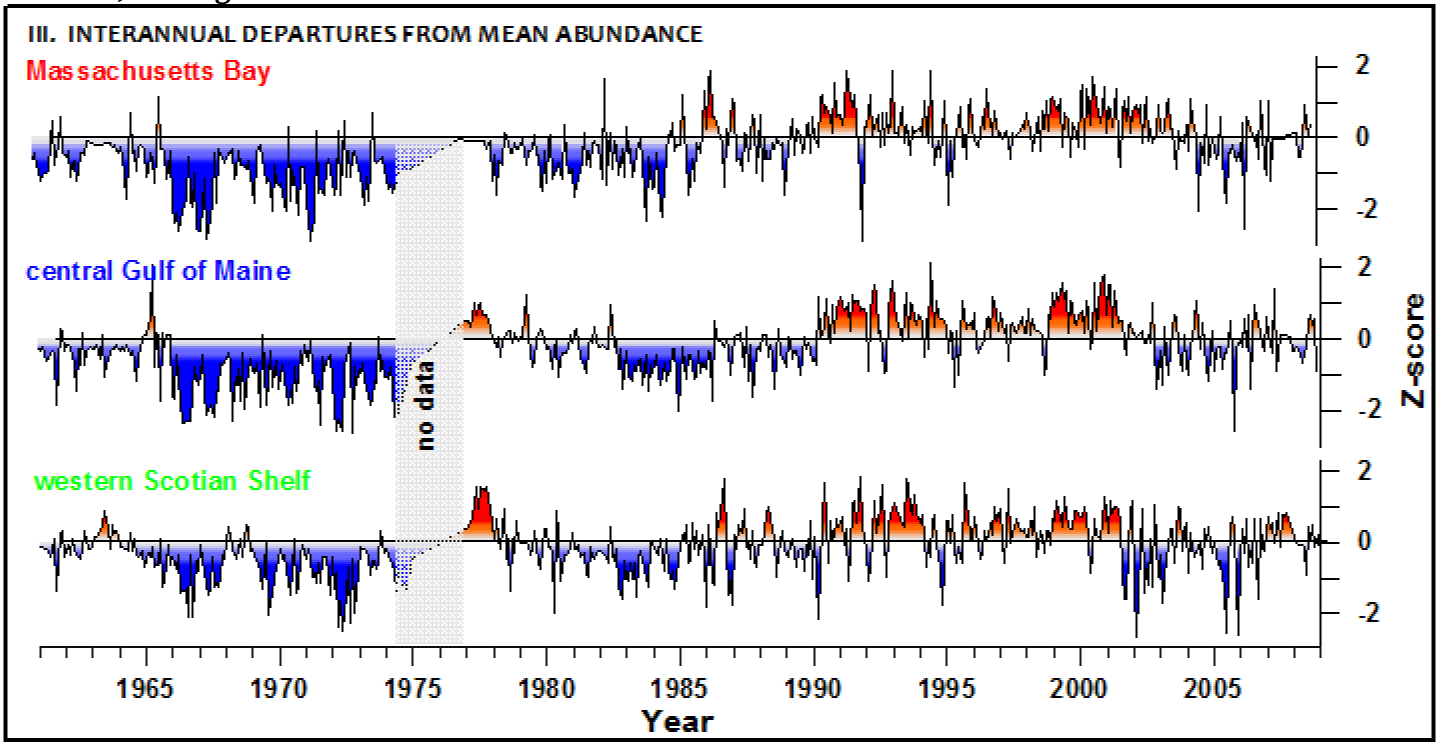

Figure 38 (cont.). All taxa, all stages, variations along the Gulf of Maine Continuous Plankton Recorder transect.

IV. COMMENTS

Mean abundances of all taxa and stages combined lie below appproximately 3.8 log 10 units (with the exception of the western Massachusetts Bay until March. A rapid abundance increat in March and April leads to annual high values extending to nearly November along the entire transect. Highest annual abundances occur over the western half of the transect, the highest occurring from May to August in eastern Massachusetts Bay. A fall decrease begins in October on the Scotian Shelf, mid-November in Massachusetts Bay, reaching annual low values during Decmber.

A general broadening of the period of high abundances can be seen from 1961 to 2007 in all sections of the Gulf of Maine. This is particularly evident from the period 1990 through early 2000, but continued through the end of the series.

Changes through the series for the day of the annual maximum abundance for the Massachusetts Bay and central Gulf sections were minor, and the patterns for the two sections were quite similar. This timing on the western Scotian Shelf was relatively more variable, with earlier peaks in the early 1960s, late 1970s- 1990. Later peaks occurred from the later 1960s to mid-1970s and again around 2005.

Monthly abundance departures from the baseperiod means were negative, with only very brief exceptions, for all three sections from 1961 through the late 1980s. This is followed by a period of positive anomalies across the transect until about 2003 when negative departures prevailed until close to the end of the series.

I.

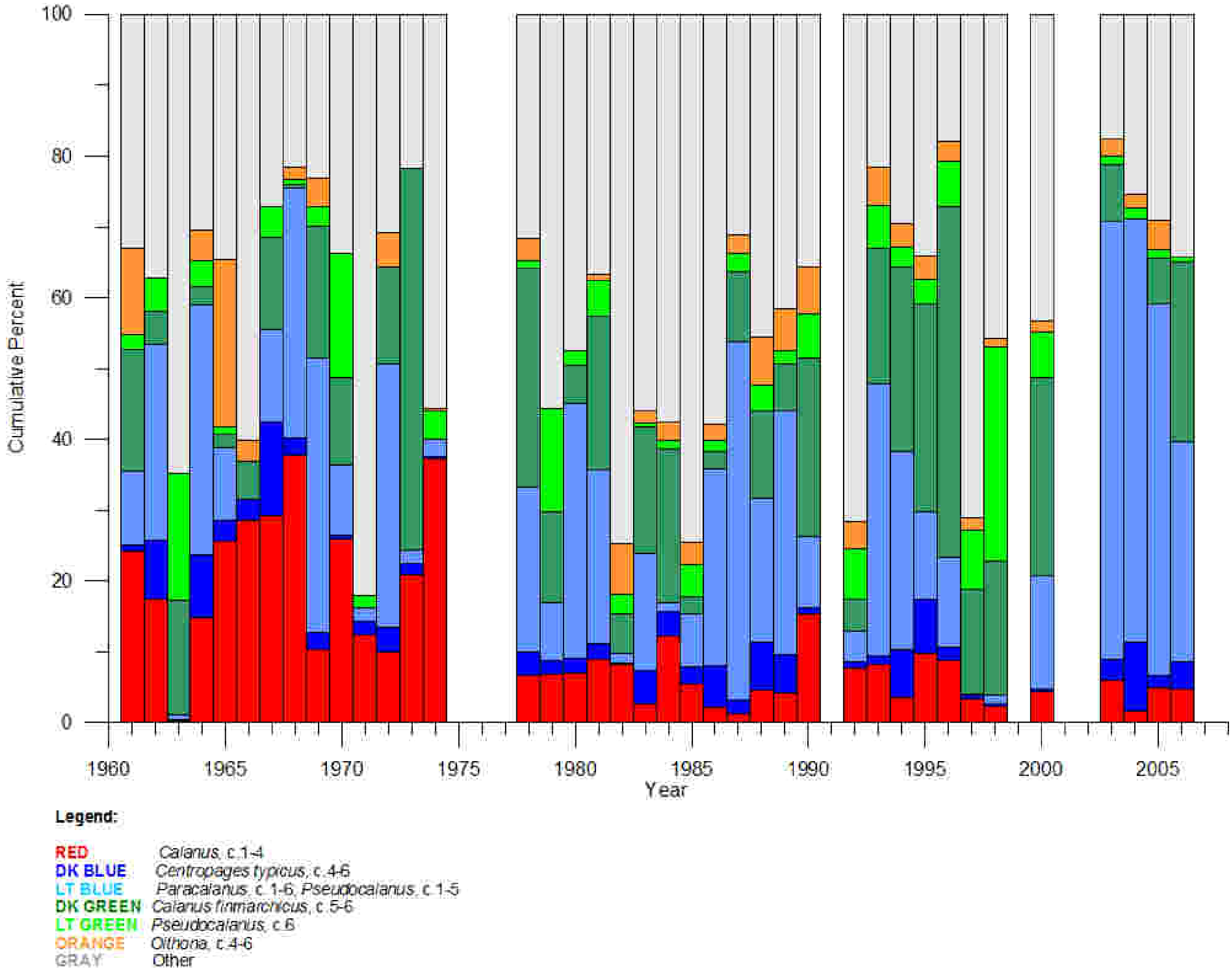

Figure 39. Annual cumulative percent contribution of six taxa to Continuous Plankton Recorder catches for the Massachusetts Bay section of the Gulf of Maine transect. Data are presented only for years where all twelve months were either sampled, or could be interpolated.

II. COMMENTS

For the Massachusetts Bay section of the Gulf of Maine CPR transect during 1961 through 2006, the contribution of these six taxa to the annual total CPR catch had a mean of 57.9% (STD=17.7). Mean for *Calanus*, c.1-4 was 11.4% (STD=10.0); *Centropages typicus*, 4-6 was 3.3% (STD=3.0); *Paracalanus*, 1-6 and *Pseudocalanus*, c.1-5 was 20.6% (STD=17.7); *Calanus finmarchicus*, c.5-6 was 14.5% (STD=12.6); *Pseudocalanus*, c.6 was 4.7% (STD=6.0); and *Oithona*, c.4-6 was 3.3% (STD=4.2). Contributions between years varied considerably as can be seen by the standard deviation values in parentheses, above. Most striking was the declining contribution of early stages of *Calanus* (mostly *Calanus finmarchicus)* through the period, and the increase of the *Paracalanus/Pseudocalanus* complex. The decline in the early stages of *Calanus* is not evident in the late stages of *Calanus finmarchicus*, nor is the *Paracalanus/Pseudocalanus* increase apparent for *Pseudocalanus* adults. *Centropages typicus* and *Oithona* show no clear trends through the period, but *Oithona* was nearly absent from samples in1963, 1967,1970, 1974,1979, 1981, and 2006.

For several years, e.g., 1963, 1971, 1982, 1985, 1992, and 1997, the six taxa's contribution was considerably less than average. A number of explanations for this are possible. Often, samples are briefly dominated by larval stages of non-copepod organisms, e.g., barnacle larvae or decapod larvae. However, annual means should be less altered by this than would monthly data. Daylight and darkness passages over sections of the transect could alter the catch of the CPR sample from 10 meters for organisms going through vertical migrations. An examination of the "other" component of catches , and of the time of day for passages over the Massachusetts Bay section of the transect remain to be done.
Figure 39. (cont.).

I.

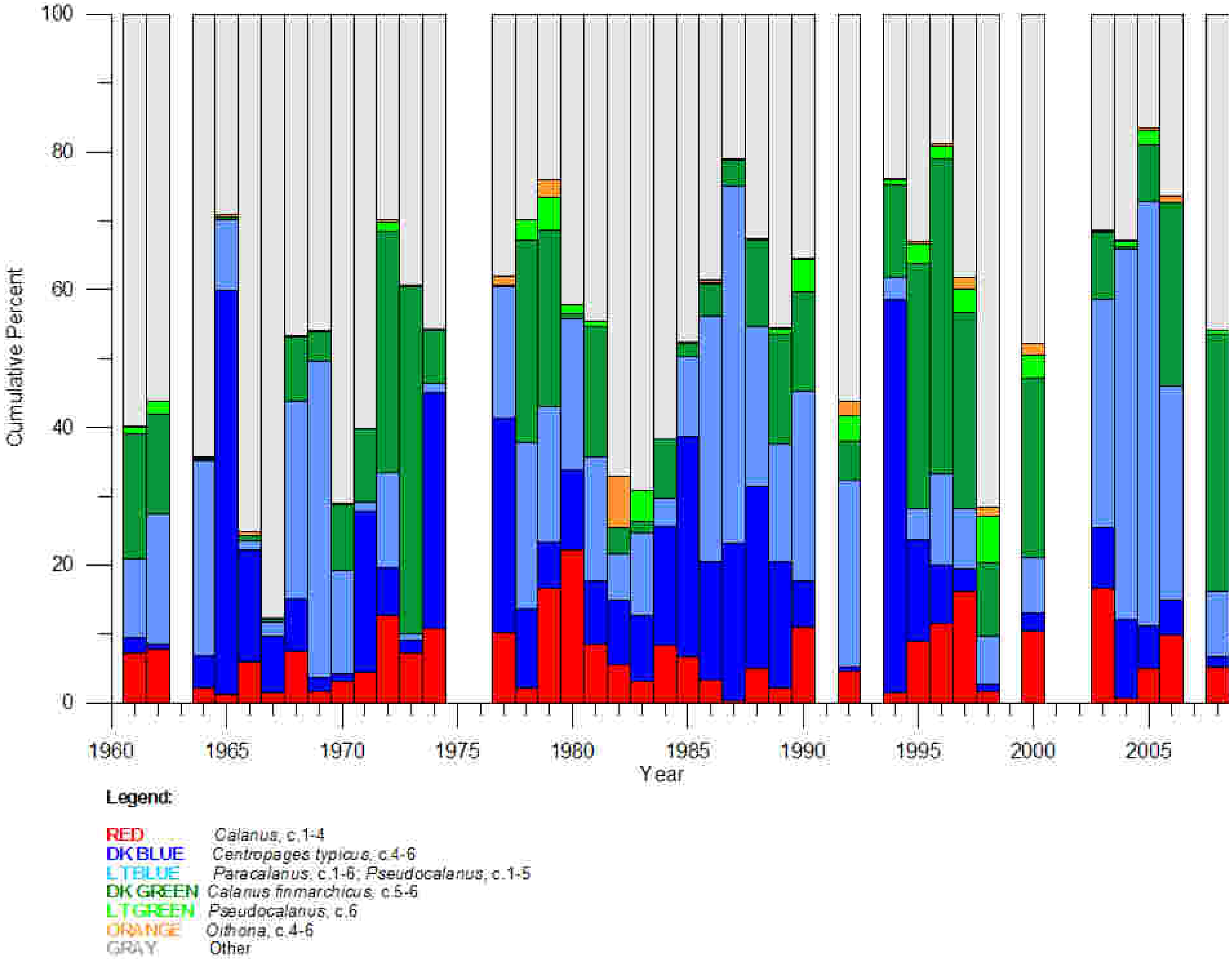

Figure 40. Annual cumulative percent contribution of six taxa to Continuous Plankton Recorder catches for the central section of the Gulf of Maine transect. Data are presented only for years where all twelve months were either sampled, or could be interpolated.

II. COMMENTS

For the central section of the Gulf of Maine CPR transect during 1961 through 2006, the contribution of these six taxa to the annual total CPR catch had a mean of 55.1% (STD=17.4). Mean for *Calanus*, c.1-4 was 7.0% (STD=5.1); *Centropages typicus*, 4-6 was 13.3% (STD=13.9); *Paracalanus*, 1-6 and *Pseudocalanus*, c.1-5 was 18.8% (STD=15.4); *Calanus finmarchicus*, c.5-6 was 14.1% (STD=13.5); *Pseudocalanus*, c.6 was 1.3% (STD=1.7); and *Oithona*, c.4-6 was 0.6% (STD=1.3). Contributions between years varied considerably as can be seen by the standard deviation values in parentheses, above. The down trend of early stages of *Calanus* seen in Massachusetts Bay was not apparent in the central Gulf. Slightly higher contributions were seen from the early 1970s to early 1980s and again from the mid-1990s to about 2003. Adult *Calanus finmarchicus* showed considerable inter-annual variability, but no clear trend. Interestingly it was nearly absent from samples in 1964-1967, 1977, and 2004. The *Paracalanus/Pseudocalanus* complex exhibited the same increasing trend seen in Massachusetts Bay, with exceptions in the late 1990s and again at the end of the series. Adult *Pseudocalanus* and *Oithona* were lesser contributors here than over the shallower waters of Massachusetts Bay, and were nearly absent from catches in a number of the years.

Again, for several years, e.g., 1966, 1967, 1982-1984, and 1998, the six taxa’s contribution was considerably less than average. As commented on for Massachusetts Bay, the possible reasons for this remain to be sought.

I.

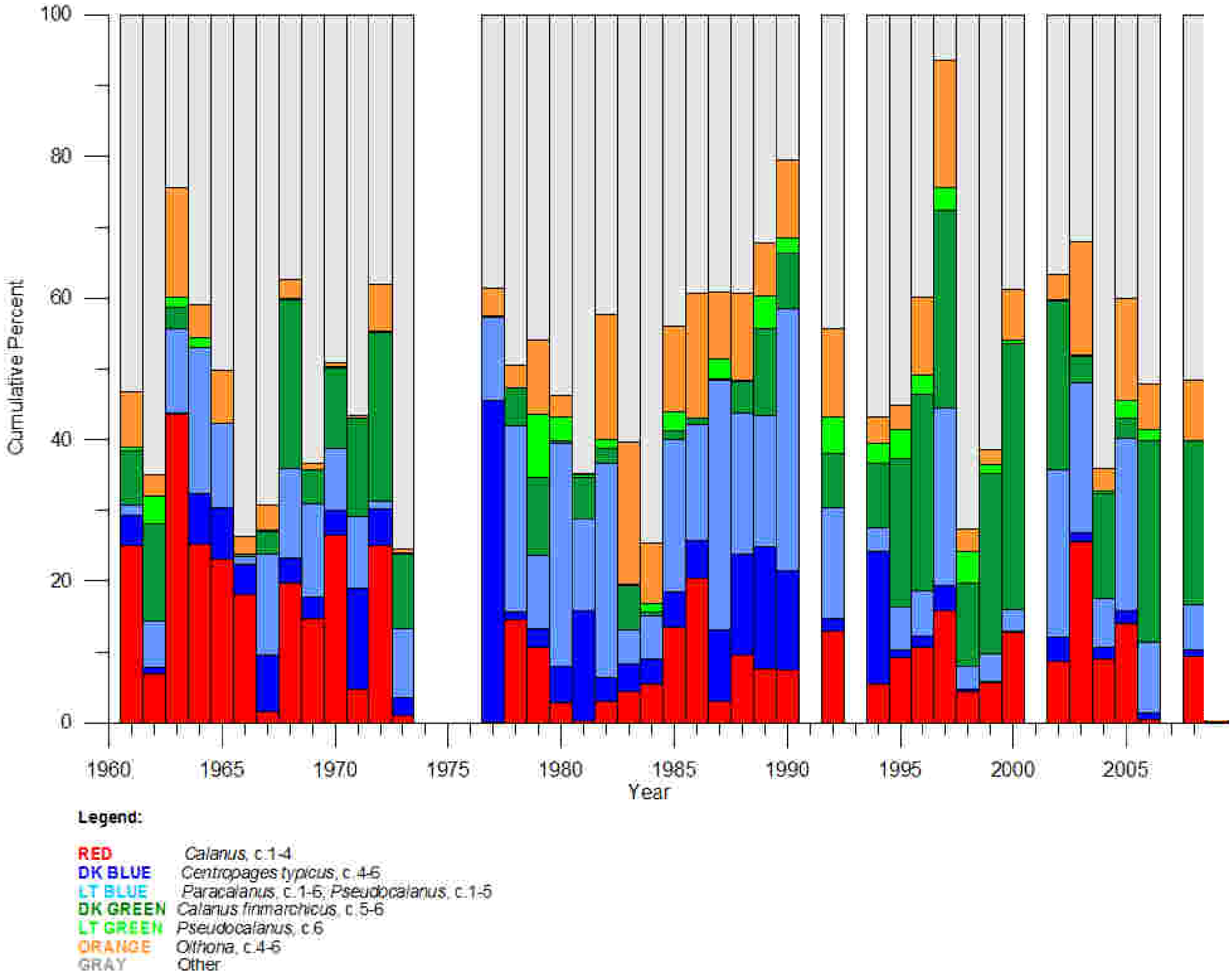

Figure 41. Annual cumulative percent contribution of six taxa to Continuous Plankton Recorder catches for the western Scotian Shelf section of the Gulf of Maine transect. Data are presented only for years where all twelve months were either sampled, or could be interpolated.

II. COMMENTS

For the western Scotian Shelf section of the Gulf of Maine CPR transect during 1961 through 2006, the contribution of these six taxa to the annual total CPR catch had a mean of 51.4% (STD=15.4). Mean for *Calanus*, c.1-4 was 11.8% (STD=9.4); *Centropages typicus*, 4-6 was 6.0% (STD=8.1); *Paracalanus*, 1-6 and *Pseudocalanus*, c.1-5 was 13.8% (STD=9.7); *Calanus finmarchicus*, c.5-6 was 10.7% (STD=10.1); *Pseudocalanus*, c.6 was 1.6% (STD=1.9); and *Oithona*, c.4-6 was 7.4% (STD=5.7 Contributions between years varied considerably as can be seen by the standard deviation values in parentheses, above. Most noteworthy was the declining contribution of early stages of *Calanus* (mostly *Calanus finmarchicus)* through the period (although less clear cut than in Massachusetts Bay), and the increase of the *Paracalanus/Pseudocalanus* complex. As was the case in Massachusetts Bay, the decline in the early stages of *Calanus* was not evident in the late stages of *Calanus finmarchicus C fin.* actually shows an increase in contribution during the late 1990s compared to earlier years)., nor is the *Paracalanus/Pseudocalanus* increase apparent for *Pseudocalanus* adults. *Centropages typicus* contributed significantly in 1977 and had high values in 1981, from 1988-1990, and again in 1994. Otherwise its contribution was relatively steady. *Oithona* contributed more to western Scotian Shelf samples than to those from the other two sections of the transect. However, it was nearly absent from the samples in 1971 and 1981.

For several years, e.g., 1962, 1966, 1967, 1973, 1984, and 1997, the six taxa’s contribution was considerably less than average. As commented on for Massachusetts Bay, the possible reasons for this remain to be sought.

Appendix I. Continuous Plankton Recorder (black), surface or 10 m temperature (blue), and surface or 10 m salinity (red) data collected by year-month along the Gulf of Maine ships of opportunity (SOOP) transect, 1961 - 2009.

MONTH	1961	1962	1963	1964	1965	1966	1967	1968	1969
12	CPR			CPR					
11	CPR					CPR	CPR	CPR	
10	CPR	CPR	CPR		CPR	CPR		CPR	CPR
9	CPR	CPR		CPR				CPR	CPR
8	CPR		CPR		CPR	CPR			CPR
7	CPR	CPR	CPR	CPR	CPR			CPR	CPR
6		CPR	CPR				CPR	CPR	CPR
5		CPR		CPR	CPR	CPR		CPR	
4					CPR	CPR	CPR	CPR	
3		CPR			CPR	CPR	CPR		
2		CPR						CPR	
1							CPR	CPR	

Appendix I cont.

MONTH	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
12										CPR TMP SAL
11	CPR	CPR	CPR					TMP SAL	CPR TMP SAL	CPR TMP SAL
10	CPR			CPR				TMP SAL	CPR TMP SAL	CPR TMP SAL
9		CPR	CPR						CPR TMP SAL	CPR TMP SAL
8	CPR	CPR		CPR				TMP SAL	CPR TMP SAL	CPR TMP SAL
7	CPR		CPR						TMP SAL	CPR TMP SAL
6		CPR		CPR					CPR TMP SAL	CPR TMP
5	CPR			CPR	CPR		TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
4	CPR	CPR			CPR			TMP	CPR TMP SAL	CPR TMP SAL
3	CPR	CPR	CPR						CPR TMP SAL	CPR TMP SAL
2									CPR	
1	CPR	CPR	CPR							CPR TMP SAL

Appendix I cont.

MONTH	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
12	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
11	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
10	TMP SAL		CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
9	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
8	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
7	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
6	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
5	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
4	CPR TMP SAL	TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
3	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
2	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
1	TMP SAL			CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL

Appendix I cont.

MONTH	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
12	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP		CPR TMP	CPR TMP SAL
11	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP SAL	CPR	CPR TMP SAL	CPR TMP SAL
10	CPR TMP SAL	TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL
9	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP	CPR TMP SAL	CPR TMP SAL
8	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
7	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP SAL	CPR	CPR TMP
6	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR	CPR TMP	CPR TMP	TMP	TMP SAL	TMP SAL
5	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP	CPR TMP	CPR TMP	CPR TMP	
4	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL
3	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP	CPR TMP	TMP SAL	TMP SAL	CPR TMP SAL
2	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP	CPR TMP	CPR	CPR	CPR TMP SAL
1	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	TMP SAL	TMP SAL	CPR TMP SAL

Appendix I cont.

MONTH	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
12	CPR	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	TMP SAL	CPR TMP SAL		CPR TMP	CPR TMP
11	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL
10	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP
9	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL		CPR TMP SAL	CPR TMP
8	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL
7	CPR TMP	CPR TMP SAL		CPR TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL		CPR TMP	CPR TMP SAL
6	CPR TMP SAL	TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR	CPR TMP
5	CPR TMP SAL	TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP		CPR TMP SAL	CPR TMP SAL	TMP SAL	TMP SAL
4	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP SAL
3	CPR TMP SAL	CPR TMP	CPR TMP	CPR TMP SAL	TMP SAL	TMP SAL	CPR TMP SAL	CPR TMP SAL	TMP SAL	CPR TMP
2	CPR	CPR TMP	CPR TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP	CPR TMP SAL	TMP SAL	CPR TMP SAL
1	CPR TMP	TMP	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL	CPR TMP SAL		CPR TMP

Appendix II. Taxa names, authorities (Integrated Taxonomic Information System (http://www.itis.gov) when available), and life stage names of organisms collected along the Gulf of Maine Continuous Plankton Recorder transect, 1961-2008. Taxa ranks and cumulative percentage contributions to total catch, based on 1978 through 2007 data, are presented for those taxa considered for atlas inclusion. Taxa not consistently counted through the 1961-2009 series and the 1978-2007 base period are not ranked. A slash separates ranks in plain type (all taxa considered), from ranks in bold type (taxa included).

Taxonomic Name	Authority	Life Stage Name	Rank: %
Absent	Jossi & Marak, 1983	unstaged	
Acartia	Dana, 1846	copepodite II-VI	12/**10**: 94.91
Acartia danae	Giesbrecht, 1889	copepodite II-VI	
Acartia longiremis	(Lilljeborg, 1853)	copepodite II-VI	
Amphipoda	Latreille, 1816	unstaged	
Appendicularia		unstaged	18/**16**: 98.18
Bivalvia	Linnaeus, 1758	larva	24/**22**: 99.69
Brachyura	Latreille, 1802	nauplius	
Calanus	Leach, 1819	copepodite I-IV	1/ **1**: 28.97
Calanus finmarchicus	(Gunner, 1765)	Copepodite V-VI	4/**4**: 69.75
Calanus glacialis	Jaschnov, 1955	copepodite I-IV	
Calanus helgolandicus	(Claus, 1863)	copepodite V-VI	
Calanus hyperboreus	Kroyer, 1838	copepodite III-VI	
Calocalanus	Giesbrecht, 1888	copepodite I-IV	
Candacia	Dana, 1846	copepodite III-IV	
Candacia armata	(Boeck, 1872)	copepodite V-VI	35/**31**: 99.99
Carinariidae	Blainville, 1818	unstaged	
Cavoliniidae	H. and A. Adams, 1854	unstaged	
Centropages	Kroyer, 1849	copepodite I-IV	
Centropages bradyi	Wheeler, 1899	copepodite VI	
Centropages hamatus	(Lilljeborg, 1853)	copepodite IV-VI	23/**21**: 99.51

Centropages typicus	Kroyer, 1849	copepodite IV-VI	2/**2**: 49.08
Chaetognatha hpr eyecount	Richardson et al, 2006	unstaged	26/**23**: 99.82
Chaetognatha hpr traverse	Richardson et al, 2006	unstaged	19/**17**: 98.57
Cladocera	Latreille, 1829	unstaged	
Clausocalanus	Giesbrecht, 1888	copepodite IV-V	
Clione	Pallas, 1774	immature (sexually), or juvenile	
Clytemnestra	Dana, 1849	copepodite V-VI	
Cnidaria	Hatschek, 1888	medusa	
Copepoda	Milne-Edwards, 1840	nauplius	10/**9**: 93.20
Copepoda	Milne-Edwards, 1840	Copepodite I-V	

Appendix II cont.

Taxonomic Name	Authority	Life Stage Name	Rank: %
Corycaeus	Dana, 1846	copepodite I-VI	
Ctenophora	Meigen, 1803	unstaged	
Cumacea	Kroyer, 1846	unstaged	
Decapoda	Latreille, 1802	larva	
Decapoda (not Brachyura)	Latreille, 1802	larva	33/**29**: 99..99
Echinoderemata	Klein, 1734	egg	
Ectoprocta		cyphonautes	
Eucalanus	Dana, 1852	copepodite I-VI	
Euchaeta acuta	Giesbrecht, 1892	copepodite V-VI	
Euchaeta marina	Prestandrea, 1833	copepodite I-IV	
Euchirella rostrata	(Claus, 1866)	copepodite V-VI	
Euphausiacea	Dana, 1852	Furcilia & calyptopis	20/**18**: 98.85
Euphausiacea	Dana, 1852	Nauplius	22/**20**: 99.33
Euphausiacea	Dana, 1852	Post calyptopis	21/**19**: 99.13
Eurytemora	Giesbrecht, 1881	copepodite I-IV	
Eurytemora americana	L.W. Williams, 1906	copepodite VI	
Eurytemora herdmani	I.C. Thompson and A. Scott, 1897	unstaged	
Evadne	Loven, 1836	unstaged	17/**15** : 97.71
Foraminiferida		unstaged	
Gammaridea	Latreille, 1802	unstaged	
Gastropoda	Cuvier, 1797	larva	
Gymnosomata	Blainville, 1824	unstaged	
Halithalestris croni		unstaged	
Harpacticoida	G.O. Sars, 1903	copepodite I-VI	29/**26**: 99.45
Heterorhabdus papilliger	(Claus, 1863)	unstaged	
Homarus americanus	H. Milne Edwards, 1837	larva	
Hydrozoa	Owen, 1843	medusa	

Hyperiidea	Milne-Edwards, 1830	unstaged	27/**24**: 99.87
Invertebrate		egg	
Isopoda	Latreille, 1817	larva	
Limacina	Bosc, 1817	unstaged	
Lucicutia flavicornis	(Claus, 1863)	copepodite VI	
Lucifer typus	H. Milne Edwards, 1837	immature (sexually), juvenile, or adult	
Macrosetella gracilis	(Dana, 1847)	copepodite I-VI	
Mecynocera clausi	I.C. Thompson, 1888	copepodite V-VI	
Metridia	Boeck, 1865	copepodite I-IV	13/**11**: 95.58

Appendix II cont.

Taxonomic Name	**Authority**	**Life Stage Name**	**Rank: %**
Metridia longa	(Lubbock, 1854)	Copepodite V-VI	
Metridia lucens	Boeck, 1865	copepodite V-VI	14/**12**: 96.14
Microsetella rosea	(Dana, 1849)	copepodite I-IV	
Musca		unstaged	
Mysida	Haworth, 1825	unstaged	
Nannocalanus minor	(Claus, 1863)	copepodite V	
Nemata		unstaged	
Oithona	Baird, 1843	copepodite IV-VI	6/**6**: 83.47
Oncaea	Philippi, 1843	copepodite VI	
Osteichthyes		egg	32/**28**: 99.98
Ostracoda	Latreille, 1802	immature (sexually), juvenile, or adult	
Paedoclione doliiformis	Danforth, 1907	unstaged	
Paracalanus	Boeck, 1865	copepodite VI	
Paracalanus or Pseudocalanus	Richardson et al, 2006	copepodite I-V (Pseudocalanus / copepodite I-VI (Paracalanus)	3/**3**: 59.41
Paraeuchaeta norvegica	(Boeck, 1872)	Copepodite III-VI	28/**25**: 99.91
Penilia avirostris	Dana, 1849	unstaged	
Pleuromamma	Giesbrecht, 1898	copepodite II-VI	
Pleuromamma borealis	(F.Dahl, 1893)	copepodite VI	
Pleuromamma piseki	Farran, 1929	copepodite V-VI	
Pleuromamma robusta	(F. Dahl, 1893)	copepodite V-VI	
Pneumodermopsis paucidens	(Boas, 1886)	unstaged	
Podon	Lilljeborg, 1853	unstaged	15/**13**: 96.70
Polychaeta		larva	30/**27**: 99.96
Pseudocalanus	Boeck, 1872	copepodite VI	5/**5**:

			77.68
Pycnogonida		unstaged	
Rhincalanus	Dana, 1852	copepodite VI	
Rhincalanus nasutus	Giesbrecht, 1888	copepodite V-VI	
Sarcodina (not Foraminiferida)		unstaged	11/**na**: 94.08
Scolecithricella	G.O. Sars, 1902	unstaged	
Sessilia	Lamarck, 1818	cyris	25/**na**: 99.76
Sessilia	Lamarck, 1818	nauplius	16/**14**: 97.23
Siphonophorae		unstaged	
Siphonostomatoida	Thorell, 1859	unstaged	
Sipuncula		unstaged	
Stellate Bodies	Richardson et al, 2006	unstaged	

Appendix II cont.

Taxonomic Name	**Authority**	**Life Stage Name**	**Rank: %**
Stomatopoda	Latreille, 1817	larva	
Temora longicornis	(O.F. Muller, 1785)	copepodite IV-VI	9/**8**: 92.14
Temora stylifera	(Dana, 1849)	copepodite IV-V	
Temora turbinata	(Dana, 1849)	copepodite IV-VI	
Thalia democratica		unstaged	
Thaliacea		unstaged	31/**na**: 99.97
Thecosomata	Blainville, 1824	unstaged	8/**7**: 90.44
Tintinnidae		unstaged	7/**na**: 88.35
Tortanus discaudatus	(I.C. Thompson and A. Scott in Herdman, Thompson and A. Scott, 1898)	copepodite I-VI	34/**30**: 99.9935/
Undeuchaeta plumosa	(Lubbock, 1856)	copepodite V-VI	

Procedures for Issuing Manuscripts in the *Northeast Fisheries Science Center Reference Document* (CRD) Series

Clearance

All manuscripts submitted for issuance as CRDs must have cleared the NEFSC's manuscript/abstract/webpage review process. If any author is not a federal employee, he/she will be required to sign an "NEFSC Release-of-Copyright Form." If your manuscript includes material from another work which has been copyrighted, then you will need to work with the NEFSC's Editorial Office to arrange for permission to use that material by securing release signatures on the "NEFSC Use-of-Copyrighted-Work Permission Form."

For more information, NEFSC authors should see the NEFSC's online publication policy manual, "Manuscript/abstract/webpage preparation, review, and dissemination: NEFSC author's guide to policy, process, and procedure," located in the Publications/Manuscript Review section of the NEFSC intranet page.

Organization

Manuscripts must have an abstract and table of contents, and (if applicable) lists of figures and tables. As much as possible, use traditional scientific manuscript organization for sections: "Introduction," "Study Area" and/or "Experimental Apparatus," "Methods," "Results," "Discussion," "Conclusions," "Acknowledgments," and "Literature/References Cited."

Style

The CRD series is obligated to conform with the style contained in the current edition of the United States Government Printing Office Style Manual. That style manual is silent on many aspects of scientific manuscripts. The CRD series relies more on the CSE Style Manual. Manuscripts should be prepared to conform with these style manuals.

The CRD series uses the American Fisheries Society's guides to names of fishes, mollusks, and decapod crustaceans, the Society for Marine Mammalogy's guide to names of marine mammals, the Biosciences Information Service's guide to serial title abbreviations, and the ISO's (International Standardization Organization) guide to statistical terms.

For in-text citation, use the name-date system. A special effort should be made to ensure that all necessary bibliographic information is included in the list of cited works. Personal communications must include date, full name, and full mailing address of the contact.

Preparation

Once your document has cleared the review process, the Editorial Office will contact you with publication needs – for example, revised text (if necessary) and separate digital figures and tables if they are embedded in the document. Materials may be submitted to the Editorial Office as files on zip disks or CDs, email attachments, or intranet downloads. Text files should be in Microsoft Word, tables may be in Word or Excel, and graphics files may be in a variety of formats (JPG, GIF, Excel, PowerPoint, etc.).

Production and Distribution

The Editorial Office will perform a copy-edit of the document and may request further revisions. The Editorial Office will develop the inside and outside front covers, the inside and outside back covers, and the title and bibliographic control pages of the document.

Once both the PDF (print) and Web versions of the CRD are ready, the Editorial Office will contact you to review both versions and submit corrections or changes before the document is posted online.

A number of organizations and individuals in the Northeast Region will be notified by e-mail of the availability of the document online.

Research Communications Branch
Northeast Fisheries Science Center
National Marine Fisheries Service, NOAA
166 Water St.
Woods Hole, MA 02543-1026

MEDIA
MAIL

Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

NOAA Technical Memorandum NMFS-NE -- This series is issued irregularly. The series typically includes: data reports of long-term field or lab studies of important species or habitats; synthesis reports for important species or habitats; annual reports of overall assessment or monitoring programs; manuals describing program-wide surveying or experimental techniques; literature surveys of important species or habitat topics; proceedings and collected papers of scientific meetings; and indexed and/or annotated bibliographies. All issues receive internal scientific review and most issues receive technical and copy editing.

Northeast Fisheries Science Center Reference Document -- This series is issued irregularly. The series typically includes: data reports on field and lab studies; progress reports on experiments, monitoring, and assessments; background papers for, collected abstracts of, and/or summary reports of scientific meetings; and simple bibliographies. Issues receive internal scientific review and most issues receive copy editing.

Resource Survey Report (formerly *Fishermen's Report*) -- This information report is a regularly-issued, quick-turnaround report on the distribution and relative abundance of selected living marine resources as derived from each of the NEFSC's periodic research vessel surveys of the Northeast's continental shelf. This report undergoes internal review, but receives no technical or copy editing.

TO OBTAIN A COPY of a *NOAA Technical Memorandum NMFS-NE* or a *Northeast Fisheries Science Center Reference Document*, either contact the NEFSC Editorial Office (166 Water St., Woods Hole, MA 02543-1026; 508-495-2350) or consult the NEFSC webpage on "Reports and Publications" (http://www.nefsc.noaa.gov/nefsc/publications/). To access *Resource Survey Report*, consult the Ecosystem Surveys Branch webpage (http://www.nefsc.noaa.gov/femad/ecosurvey/mainpage/).