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**Ocean Productivity Trends in the Northwest Atlantic During 2013**

by

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**Abstract**

Biological and chemical variables collected in 2013 from coastal high frequency monitoring stations, semi-annual oceanographic transects, and ships of opportunity ranging from the Labrador-Newfoundland and Grand Banks Shelf (Subareas 2 and 3), extending west into the Gulf of St. Lawrence (Subarea 4) and further south along the Scotian Shelf and the Bay of Fundy (Subarea 4) and into the Gulf of Maine (Subarea 5) are presented and referenced to previous information from earlier periods when available. We review the interannual variations in inventories of nitrate, chlorophyll *a* and indices of the spring bloom inferred from satellite ocean colour imagery, as well as the abundance of major functional taxa of zooplankton collected as part of the 2013 Atlantic Zone Monitoring Program (AZMP). In general, nitrate inventories in both the upper and lower water-column continue to remain below normal along the northern transects across the Labrador-Newfoundland Shelf and Grand Bank while levels are near normal to above average across the northwest Gulf of St. Lawrence and generally mixed along the Scotian Shelf transects and fixed stations in 2013. The chlorophyll *a* inventories inferred from the seasonal AZMP oceanographic surveys were predominately below normal over the various transects, particularly in the northern Subareas (2J to 3L) and Gulf of St. Lawrence (4ST) in 2013. Satellite remote ocean colour imagery, which provides large-scale synoptic information on the distribution of surface chlorophyll *a*, indicated lower biomass and weaker spring blooms over the NW Atlantic in 2013 consistent with the AZMP seasonal surveys. The peak and initiation timing of the spring bloom was generally close to normal throughout the northern Subareas into the Gulf of St. Lawrence but, shifted substantially to earlier and longer duration over the western Scotian Shelf (4X) in 2013. The abundance anomalies for the different functional zooplankton taxa showed some clear spatial gradients in 2013. The zooplankton abundance anomalies for small grazing copepods were generally positive over much of the survey area with the highest abundance levels observed over the northern Subareas from 3K to 3LNO. The abundance anomalies for large grazing copepods were near to slightly above normal along the northern Subareas in contrast to a clear declining trend through the Gulf of St. Lawrence down to the eastern Scotian Shelf followed by mixed conditions further south. Reduction in total copepod taxa characterized the Gulf of St. Lawrence and most of the Scotian Shelf transects and fixed stations while positive anomalies in abundance were observed for the northeast Newfoundland Shelf and Grand Bank Subareas. The non-copepod taxa, principally carnivorous zooplankton, gelatinous invertebrates, and meroplankton, showed substantial positive anomalies extending from 3K with a declining trend southwards across the Gulf of St. Lawrence and Scotian Shelf transects.

## Introduction

We review biological and chemical oceanographic conditions on the Newfoundland (NF) and Labrador (LB) Shelves, Grand Bank (GB), Gulf of St. Lawrence (GSL), Scotian Shelf (SS), and in the Bay of Fundy (BoF) and Gulf of Maine (GoM) during 2013, and reference earlier periods when data are available. More frequent directed sampling from research vessels on oceanographic transects and ships of opportunity at coastal fixed stations by the Atlantic Zone Monitoring Program (AZMP<sup>1</sup>) and the completion of seasonal oceanographic surveys during 2013 provided good spatial and temporal series coverage of standard variables which affords a foundation for comparison with previous years. Additional details regarding biological and chemical oceanographic conditions on the Newfoundland and Labrador (NL) Shelf, GB, GSL, SS, and the GoM in 2013 and earlier years can be found in Pepin *et al.* (2013) and Johnson *et al.* (2013), Harvey and Devine (2009), Dufour *et al.* (2010), DFO (2013).

## Methods

Collections of standard AZMP variables are based on sampling protocols outlined by Mitchell *et al.* (2002). Observations for 2013 and earlier years presented in this document are based on seasonal surveys conducted during the spring through the autumn (typically March through December). The coastal stations are typically sampled at twice monthly to monthly intervals during ice-free conditions. The location of the standard oceanographic transects and coastal stations are shown in Figure 1.

Phytoplankton biomass was estimated from ocean colour data collected by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS; <http://seawifs.gsfc.nasa.gov/SEAWIFS.html>) and Moderate Resolution Imaging Spectroradiometer (MODIS) “Aqua” sensor (<http://modis.gsfc.nasa.gov/>). The SeaWiFS time series began in the September of 1997 and MODIS data stream began in July, 2002. Satellite data do not provide information on the vertical structure of chlorophyll *a* (chl*a*) in the water column but do provide highly resolved (~1.5 km) data on their geographical distribution in surface waters at the large scale. Two week composite images of chl*a* for the entire NW Atlantic (39-62.5° N Latitude 42-71° W Longitude) were routinely produced from SeaWiFS/MODIS data<sup>2</sup>. Basic statistics (mean, range, standard deviation, etc.) were extracted from the composites for selected statistical sub-regions as shown in Figure 1. We constructed an ocean colour time series from 1998 to 2013 using data from both satellite sensors and averaging during the overlap period from 2002 to 2010.

Scorecard indices were developed as a method of summarizing the many variables used to represent the state of lower trophic levels. To simplify the information, the time-series of the annual estimate of inventory or abundance for each summary variable was standardized to a mean of zero (for the period 1999 – 2010) and unit standard deviation ( $[\text{observation} - \text{mean}]/\text{SD}$ ). The standard deviation provides a measure of the variability of an index. The result of this standardization yields a series of anomalies. The scorecards serve to illustrate departures from the long term mean across the range of variables by colour coding anomalies as either being above/late than (red) or below/earlier than (blue) the long term average, with darkening shades serving to represent the increasing magnitude of that departure. The specific method used to compute the annual means is described further in Pepin *et al.* 2011 and Harrison *et al.* 2009. For the chemical-biological observations, the key variables selected were: (1) near surface (0-50 m) and deep (50-150 m) nitrate inventories, and (2) 0-100m integrated chl*a*, satellite indices of background chl*a*, magnitude and amplitude, initiation, peak timing and duration of the spring bloom (Zhai *et al.* 2011), and zooplankton abundance for different functional zooplankton taxa (*Pseudocalanus spp.*, *Calanus finmarchicus*, total copepods, and total non-copepod zooplankton) for the AZMP fixed stations and seasonal transects.

<sup>1</sup> <http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html>

<sup>2</sup> (<http://www.bio.gc.ca/science/newtech-technouvelles/sensing-teledetection/index-eng.php>)

### Annual Variability in Nutrient, Phytoplankton, and Zooplankton Conditions in NAFO Subareas

Based on the available data, the upper water-column (0-50m integral) nitrate inventories were generally below normal from the southern LB Shelf (2J) down to the northeast and Centre GSL transects, with near-normal to above average levels observed in the northwest and southern GSL in 2013 (Figure 2). Mixed conditions prevailed across the SS transects with the high frequency fixed sampling station HL-2 (4W) showing a substantial decline in upper column nitrate inventories in 2013. The trend in anomalies of deep (50m-150m or bottom if shallower) nitrate inventories, a proxy index of nutrient availability to fuel the base of the marine food chain in the subsequent year, were consistently negative across the northern Subareas down to the southern Grand Bank (GB), while mixed conditions prevailed across the GSL and SS in 2013 (Figure 2). In general, the annual anomaly trends in nitrate inventories in the upper 50m layer have remained below normal since 2008 across the northern Subareas (2J to 3LNO including the central and northeast GSL) while inventories along the western and southern GSL and SS returned to above normal in 2013 from lower levels observed in recent years (Figure 3). A significant reduction in deep nitrate inventories initiated in 2008-2009 along the northern Subareas, propagated into the GSL in 2010 and negative into 2011 (Figure 3). Deep inventories continue to remain well below normal over the southern LB and NF Shelf and GB while levels have increased above the long-term mean throughout the GSL and SS Subareas in 2013 (Figure 3). The *chl a* inventories inferred from the seasonal oceanographic surveys, which provides an index of phytoplankton biomass throughout the water-column, were consistently below normal over much of the northern Subareas in 2013 including the GSL and SS with only the southern GB and central SS (4W) showing above normal levels (Figure 4). The annual trends in *chl a* inventories were below normal in northern Subareas in recent years consistent with observed trends in both shallow and deep nitrate inventories suggesting the potential importance of this nutrient in limiting phytoplankton biomass in northern Subareas (Figure 5). Higher *chl a* inventories characterize the SS while near to slightly below normal levels prevailed across the GSL in recent years (Figure 5). We also examined the trends in composite summed anomalies across the NL Shelf, GB, GSL, and SS transects and fixed stations during the 15-year time series. The composite index for the upper water-column nitrate inventories tended to show a slight negative trend although high interannual variability is clearly evident over the GSL and SS Subareas (Figure 6). In addition, these Subareas also show large amplitude changes and high interannual variability in deep nitrate inventories that appear to be strongly coupled (Figure 6). A clear downward trend in deep inventories over the NL Shelf and GB has been ongoing since 2008 (Figure 6). Large interannual variability in composite indices of *chl a* inventories that characterized the early time period, has been less apparent in the latter half of the series although levels remain below normal in recent years across the NL Shelf, GB, and SS-GoM Subareas (Figure 6).

The temporal pattern in phytoplankton growth varies considerably over the different NAFO Subareas. Surface *chl a* concentrations across the subarctic sub-regions show nearly continuous production starting in late spring, peaking in summer and propagating until early autumn (Figure 7). Further south, along the NL Shelf sub-regions, concentrations are discontinuous with intense spring blooms with more limited growth in the autumn (Figure 7). The GSL sub-regions were characterized by both continuous and discontinuous peak *chl a* concentrations with the highest levels observed over the Estuary (Figure 9). The production cycle along the GB sub-regions also show intense spring and more limited autumn blooms (Figure 10). Similarly, the SS-GoM sub-regions show both continuous and discontinuous spring/autumn blooms with the highest concentrations observed over the southwest SS Shelf and Georges Bank (Figure 11).

A number of different metrics derived from satellite imagery were examined to characterize the extent (background *chl a*, magnitude and amplitude and timing (peak timing, duration, and initiation) indices of the spring bloom. The 1998-2010 reference period means used in computation of standardized anomalies, showed clear spatial gradients across the different sub-regions (Figure 12). Background *chl a* mean concentrations ranged from 0.1 mg m<sup>-3</sup> in the northern sub-regions to slightly greater than 1.0 mg m<sup>-3</sup> in the southern areas and were typically higher than expected based on latitude within the GSL (Figure 12). No spatial trends were observed in the climatological means for magnitude and amplitude of the spring bloom which ranged from 35-1385 mg m<sup>-2</sup> d<sup>-1</sup> and 1-10 mg m<sup>-3</sup> respectively. The initiation and peak timing mean values also followed predictable light and thermal gradients based on latitude with earlier blooms in the southern (initiating in March and peaking in mid-April) and later production in the northern sub-regions (initiating in May-June and peaking in June-July). A slight spatial gradient was evident in long-term mean values for the duration of blooms ranging from 30-170 days with the tendency for slightly higher values further north compared to the lower latitudes (Figure 12). Exceptional long-term bloom durations > 100 days

were noted for the Hudson Strait, Central Labrador Sea, and GSL-Estuary sub-regions that characterize many sub-arctic production cycles. The exceptional blooms observed in the GSL Estuary are likely driven by anthropogenic inputs of nutrients and stratification from numerous freshwater input sources.

Annual anomalies were computed for each ocean colour metric during 2013 to evaluate spatial patterns across the different statistical sub-regions. Overall, background *chl a* concentration was higher in 2013 with positive anomalies observed in 19 of 24 sub-regions (Figure 13). The magnitude (integral of *chl a* biomass) and amplitude (peak intensity) of the spring bloom was below normal across most of the northwest Atlantic with 19 of 24 sub-regions showing negative anomalies (Figure 13). The only positive anomalies were observed on the NE NL Shelf, GSL, southern GB and eastern SS (Figure 13). The peak and initiation timing of the spring bloom was substantially earlier and duration longer over the western SS with negative (earlier timing) anomalies also noted for the GSL and GB sub-regions in 2013 (Figure 13). Positive (later timing) anomalies were observed over the NE NL and over most of the SS-GoM with shorter duration blooms (Figure 13).

Significant coherent changes in enhanced background *chl a* levels have been observed in recent years over the NL Shelf extending southwards to the SS-GoM which has not been detected observed in the earlier records (Figure 14). No coherent trends were detected in the magnitude or amplitude of blooms across the sub-regions except for a higher percentage of negative anomalies across most of the Subareas in 2012 and 2013 (Figure 15-16). The initiation and peak times of blooms have shown some coherent shifts with delayed production that characterized the 2000-2003 period followed by earlier timing in recent years during 2010-2013 (Figures 17 and 19). The duration of the production cycle showed a large degree of variability with no apparent trends during the 16-year time series (Figure 18). The duration of the spring bloom has been in decline in the Subarctic, GB, and SS Subareas in recent years with longer cycles in the GSL region, particularly in 2012 and 2013.

We developed composite indices for each of the ocean colour metrics by summing all of the annual SeaWiFS/MODIS anomalies across the sub-regions located in the subarctic, NL Shelf, GSL, GB, and SS-GoM to evaluate trends during the 16-year series. The composite index for background *chl a* levels has remained near normal over the last decade (2000-2010) but increased substantially in 2011 from LB, throughout the GSL, and GB (Figure 20). Interannual variability in the magnitude of the spring bloom has remained high during the last decade although the frequency of strong positive anomalies has also increased in the later records from 2008-2013 (Figure 20). The amplitude (peak intensity) of the spring bloom has also increased throughout the NW Atlantic in recent years with the exception of the subarctic sub-regions (Figure 20). The trends for the composite timing indices (initiation and peak timing) have tended to shift to earlier timing since 2003, particularly for the GB and GSL sub-regions (Figure 20). The duration composite anomalies varied throughout the time series with no apparent overall trend but also show higher interannual variability in recent years along the GB and GSL sub-regions (Figure 20).

The pattern of annual anomalies for the different functional zooplankton groups showed both coherent trends and spatial gradients across the northern and southern transects in 2013. The zooplankton abundance anomalies for a key small grazer, *Pseudocalanus spp.*, were generally positive over much of the survey area with the highest abundance levels observed over the northern Subareas from 3K to 3LNO (Figure 21). These small copepods are an important potential prey to early life stages of fish and invertebrates. The abundance anomalies for large grazing copepod, *Calanus finmarchicus*, an important link to higher trophic levels, were near to slightly above normal in the north in contrast to a clear declining trend through the GSL down to the eastern SS followed by mixed conditions further south (Figure 21). Reduction in total copepods characterized the GSL and most of the SS transects and fixed stations while positive anomalies were noted for the northeast NL Shelf and GB (Figure 21). The non-copepod (mostly larval stages of benthic invertebrates, gelatinous and carnivorous zooplankton) taxa showed a clear spatial gradient in 2013 with substantial positive anomalies extending from 3K, with some transects showing values in excess of +3 SD units above normal, but declining to near normal down to the SS (Figure 21).

The scorecard indices for small grazing copepods has remained mostly above normal since 2006 along many of the northern transects although large negative anomalies were noted in the GSL in 2012 and during 2009-2012 along the SS transects (Figure 22). The scorecard for *Calanus finmarchicus* showed a similar pattern with small grazers with near to above normal levels along the northern transects with a clear shift to negative trends across the GSL and extending down SS transects in recent years (Figure 22). Abundance trends for total copepods continue to remain above normal while levels have consistently declined south of the GB transects in recent years (Figure 23). The non-

copepod taxa, also continue to show substantial increased abundance along the northern transects and into the GSL with more mixed levels evident further south in recent years (Figure 23).

The composite indices summing each of the zooplankton abundance indices across the NL Shelf, GB, GSL and SS Subareas revealed some contrasting patterns during the 15-year time series. The composite abundance anomalies for the small copepod *Pseudocalanus* spp. showed relatively consistent near-normal levels on the NL Shelf and GB, high variability over the GSL and record highs observed in 2010-2011, and an overall decline on the SS transects since the start of monitoring (Figure 24). Composite abundance anomalies for the large grazing copepod *Calanus finmarchicus* were also near normal over the extent of the time series on the NL Shelf and GB in contrast to a negative trend along the GSL and SS transects in recent years (Figure 24). The composite anomalies for total copepods showed a near normal trend on the NL Shelf with a general increasing trend observed over the GB and GSL transects but declining sharply thereafter in 2011 in the GSL (Figure 24). The composite values for the non-copepods were relatively near normal over the NL Shelf, GB and SS with much larger changes observed over the GSL and GB transects in recent years (Figure 24).

Patterns of variation in the lower trophic levels, consisting of standing stocks of nitrate, phytoplankton and zooplankton, appear dominated by short term fluctuations that may be related to different water masses and physical properties, the patchy distribution of organisms and relatively short life histories, along with the limited sampling coverage by the monitoring program. The current state of the lower trophic levels appears to demonstrate some spatial structuring, with transitions in biogeochemical conditions often associated between the NL and the GSL-SS Subareas. This was particularly evident in the zooplankton standing stocks with reversals in standardized anomalies of large grazers and total copepods between these Subareas and north-south spatial trends in the non-copepod taxa across the Atlantic Zone.

### Ocean Productivity Highlights in 2013

- Nitrate inventories within the upper 50m were generally below normal from the southern Labrador Shelf (2J) down to the northeast Gulf of St. Lawrence, with near to above normal levels observed in the northwest and southern Gulf down to the central Scotian Shelf in 2013.
- Deep (>50m) nitrate inventories continue to remain well below normal over the southern Labrador and Newfoundland Shelf and Grand Bank while levels have increased above the long-term mean throughout the Gulf of St. Lawrence and Scotian Shelf in 2012-2013.
- The *chl a* inventories inferred from the seasonal AZMP oceanographic surveys, which provides an index of phytoplankton biomass throughout the water-column, were consistently below normal over transects in 2013 with only the southern Grand Bank and central Scotian Shelf showing above normal levels.
- Overall, background *chl a* concentration was higher in 2013 with positive anomalies observed in 19 of 24 sub-regions while the magnitude and amplitude of the spring bloom was below normal across most of the northwest Atlantic with an identical number of sub-regions showing negative anomalies.
- The peak and initiation timing of the spring bloom was substantially earlier and duration longer over the western Scotian Shelf with negative (earlier timing) anomalies in 2013. Positive (later timing) anomalies were observed over the northeast Newfoundland Shelf and over most of the SS-GoM with shorter duration blooms in 2013.
- The zooplankton abundance anomalies for small grazers - *Pseudocalanus* spp. were generally positive over much of the survey area in 2013 with the highest abundance levels observed over the northern Subareas from 3K to 3LNO.
- The abundance anomalies for large grazing copepods - *Calanus finmarchicus* were near to slightly above normal in 2013 along the northern Subareas in contrast to a clear declining trend through the Gulf of St. Lawrence down to the eastern Scotian Shelf followed by mixed conditions further south.

### **Ocean Productivity Highlights in 2013 (continued)**

- Reduction in total copepods characterized the GSL and most of the SS transects and fixed stations while positive anomalies were noted for the northeast Newfoundland Shelf and Grand Bank Subareas in 2013.
- The non-copepod taxa showed a clear spatial gradient with substantial positive anomalies extending from 3K and declining southwards across the Gulf of St. Lawrence and Scotian Shelf transects in 2013.

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Figure 1. Location of the NAFO Regulatory Areas (white boxes) and standard Atlantic Zone Monitoring Program (AZMP) fixed coastal stations (closed red squares) and oceanographic transects (red lines). The statistical sub-regions (Petrie Boxes) shown by the open red boxes (HS=Hudson Strait, GS=Greenland Shelf, CLS=central Labrador Sea, NLS=northern Labrador Shelf, LS=Labrador Shelf, HB=Hamilton Bank (Seal Island), SAB=St. Anthony Basin, NENS=northeast Newfoundland Shelf, AC=Avalon Channel, FP=Flemish Pass, FC=Flemish Cap, HIB=Hibernia, SPB=St. Pierre Bank, SES=southeast Shoal, CS=Cabot Strait, MS=Magdalen Shallows, NEGSL=northeast Gulf of St. Lawrence, NWGSL=northwest Gulf of St. Lawrence, EST = Estuary, ESS=eastern Scotian Shelf, WB=Western Bank, CSS=central Scotian Shelf, WSS=western Scotian Shelf, LS=Lurcher Shoal, GB=Georges Bank. The standard AZMP transects are SI=Seal Island, BB=Bonavista Bay, FC=Flemish Cap, SEGB=southeast Grand Bank, TESL=Lower St. Lawrence Estuary, TSI=northwest Gulf of St. Lawrence, TASO=southwest Anticosti, TBB=Bonne Bay (northeast Gulf of St. Lawrence), TCEN=Centre Gulf of St. Lawrence, TIDM=Magdalen Shallows, TDC=Cabot Strait, LL=Louisbourg Line, HL=Halifax Line, BBL=Browns Bank Line, and fixed stations (Station 27, Rimouski, Anticosti Gyre, Gaspé Current, Shediac Valley, Halifax-2, and Prince-5).

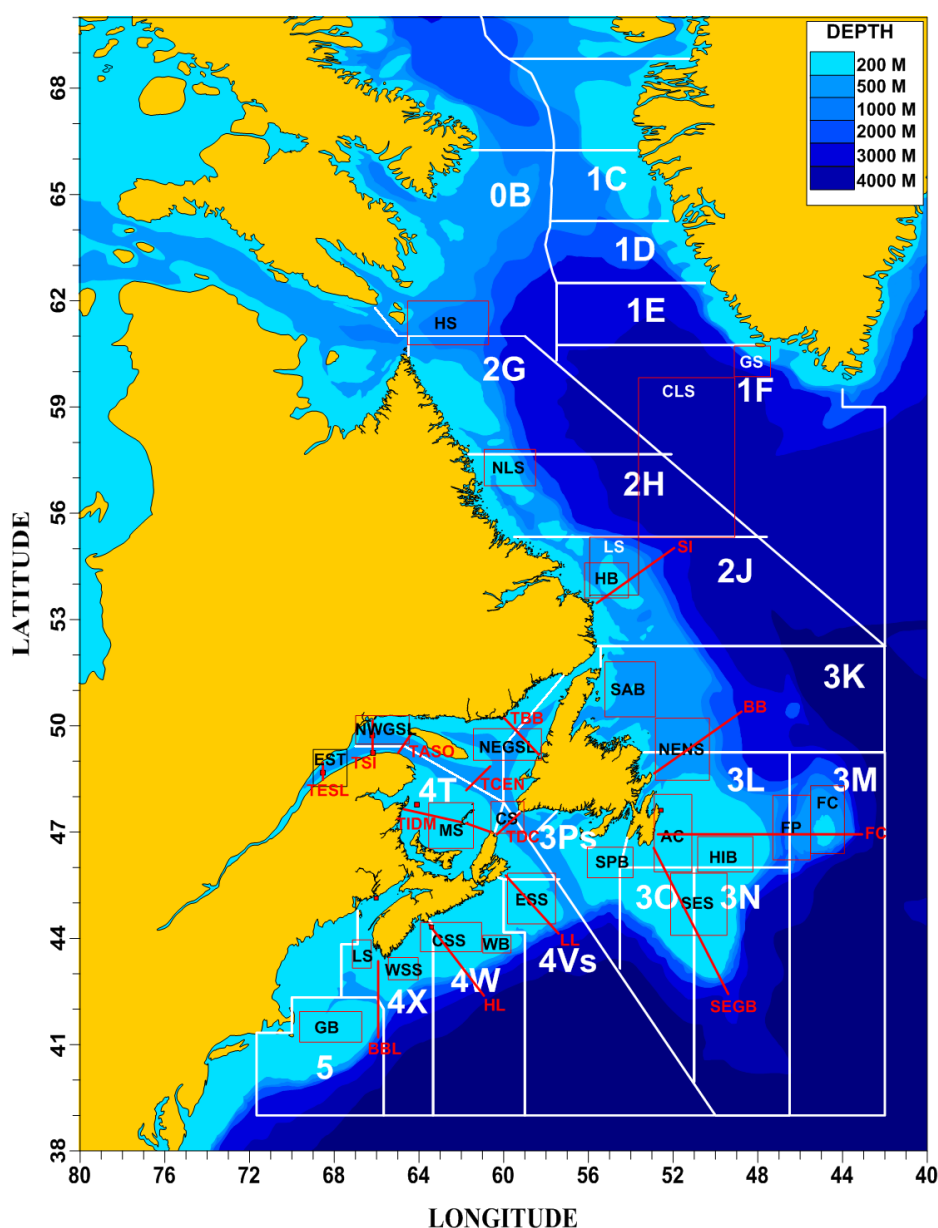


Figure 2. Summary of nitrate (combined nitrate and nitrite which represents the principal limiting nutrient in the system) from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2013. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1999-2010) divided by the standard deviation. The nutrient anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

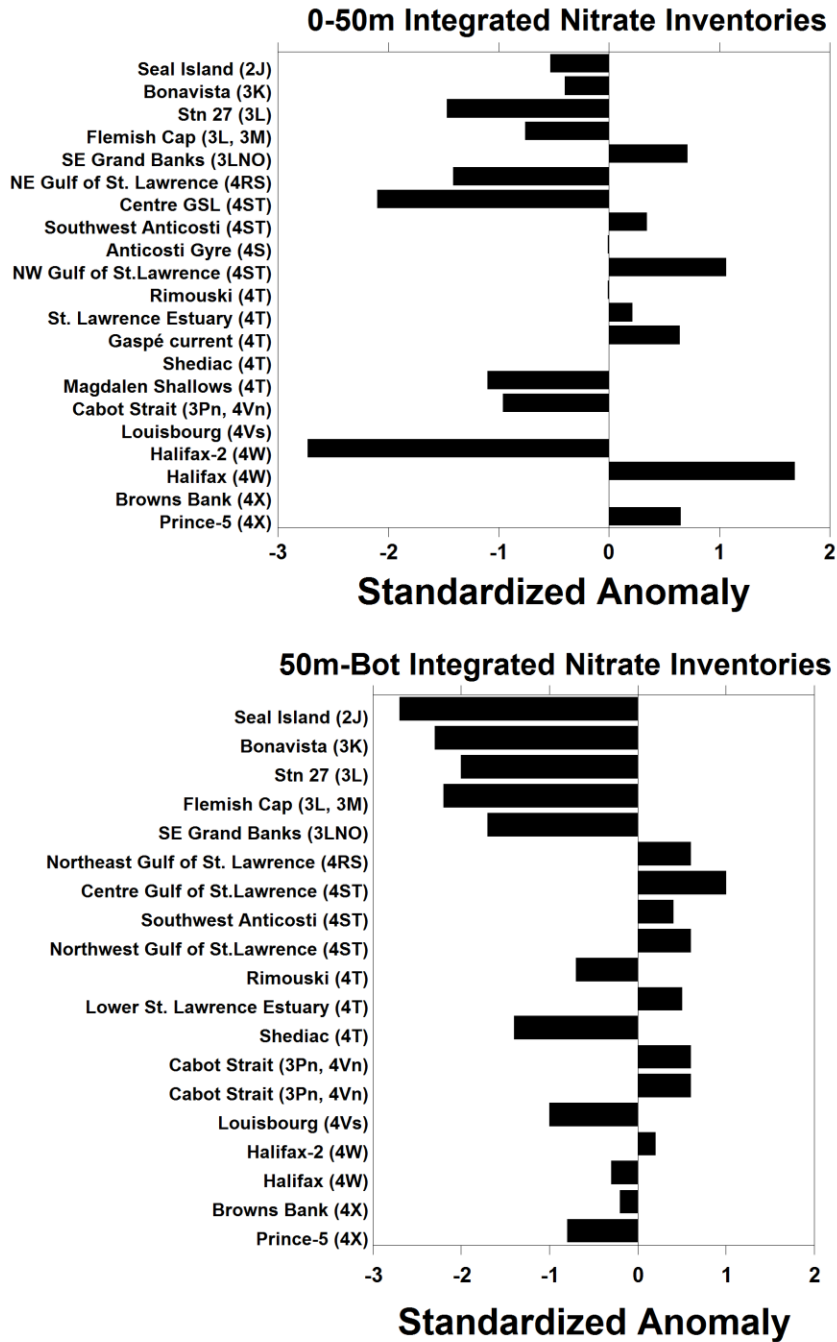




Figure 3. Time series of shallow (0-50m) and deep (50m-bottom) nitrate (combined nitrite and nitrate) inventory anomalies from different oceanographic transects and fixed stations (in bold) from the Atlantic Zone Monitoring Program during 1999-2013. The anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. Empty white cells indicate missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences in the annual average value from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted roughly by latitude from north (top) to south (bottom) regions.

<b>Nitrate (0-50m)</b>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seal Island (2J)	-1.0	-0.6	-0.2	0.2		1.4	0.1	-1.9	0.4	-0.5	0.7	1.4	1.0	0.7	-1.1
Bonavista (3K)	0.0	-0.1	-0.3	1.6	1.6	0.3	-0.8	-1.4	1.2	-0.4	-0.3	-1.3	0.2	-0.4	-0.5
<b>Stn 27 (3L)</b>		-0.1	1.8	-0.5	0.7	0.7	0.1	-0.8	0.6	0.2	-0.6	-2.1	-0.5	-1.2	-0.6
Flemish Cap (3L, 3M)	0.0	-0.8	0.3	1.1	2.1	0.6	-0.4	-0.5	0.6	-0.7	-0.7	-1.6	1.5	-0.8	-0.7
SE Grand Banks (3LNO)	0.0	-0.5	-0.1	0.2	2.5	0.7	0.2	-0.9	0.3	-0.5	-0.4	-1.6	-0.8	0.2	-1.4
Northeast Gulf of St. Lawrence (4RS)	0.4	0.4	0.7	-0.1	1.8	-2.0	-0.7	-1.1	1.0	0.1	-0.1	-0.5	-0.9	-1.4	-1.3
Centre Gulf of St. Lawrence (4ST)					1.2	-1.4	-0.4	0.1	1.1	0.5	0.2	-1.3	-2.3	-2.1	0.2
Southwest Anticosti (4ST)	0.7	-0.8	0.7	2.2	0.2	-0.7	-1.2	-1.0	0.1	0.8	-0.9	-0.2	-1.8	0.3	1.2
Northwest Gulf of St. Lawrence (4ST)	1.2	-0.6	1.3	1.6	0.9	-1.3	-1.2	-0.3	-0.9	0.2	-0.5	-0.2	-0.8	1.1	1.1
<b>Rimouski (4T)</b>	-0.3	0.6	0.1	1.1	-0.3	0.8	-0.3	0.0	-0.1	0.4	-0.4	-1.3	-0.6	-0.3	0.1
Lower St. Lawrence Estuary (4T)	2.6	0.1	0.0	1.0	-0.6	-0.6	0.5	-0.1	-0.9	-0.3	-0.9	-0.9	-0.5	0.2	0.2
<b>Shediac (4T)</b>	0.2	0.7	-0.3	0.2	0.2	0.6	-0.2	0.7	-1.1	-0.1	0.7	-1.2	-0.9	0.2	-0.8
Îles-de-la-Madeleine (4T)	-1.8	1.3	0.0	0.0	-0.4	0.5	0.1	1.7	-0.4	0.6	0.0	-1.5	-1.3	-1.1	0.5
Cabot Strait (3Pn, 4Vn)	1.0	1.4	-0.3	1.8	-0.3	-1.6	-0.4	-0.1	-0.3	0.4	-0.3	-1.3	-2.0	-1.0	0.1
Cabot Strait (3Pn, 4Vn)	1.6	0.3	-0.3			-1.1	-0.1	-0.3	0.9	1.1	-0.4	-1.6	1.2	0.4	2.2
Louisbourg (4Vs)	1.3	1.1	-0.9	-2.3	0.4	-0.7	-0.3	0.3	0.3	0.9	-0.3	0.3	0.0	-0.4	0.8
<b>Halifax-2 (4W)</b>	-2.3	1.2	1.3	-0.7	0.4	0.1	-0.3	0.3	0.1	0.7	0.3	-1.0	-0.7	-3.4	1.5
Halifax (4W)	1.8	0.0	0.2	-0.9	-1.2	-1.0	-0.4	-0.1	-0.7	1.9	-0.2	0.6	0.7	1.3	1.6
Browns Bank (4X)	-0.2	1.5	0.2	-0.9	0.3	-0.7	-0.4	-0.2	-2.0	1.6	0.6	0.1	0.5	-1.5	0.1
<b>Prince-5 (4X)</b>	-1.5	-0.4	-0.6	0.6	1.0	0.1	-0.8	1.4	-0.3	0.2	1.5	-1.4	0.1	0.6	-0.6
<b>Nitrate (50-150m)</b>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seal Island (2J)	0.0	0.5	0.4	0.4		0.8	0.5	0.4	1.3	-2.0	-0.8	-1.4	-0.7	-1.6	-2.7
Bonavista (3K)	0.8	0.8	-1.3	0.0	0.8	0.7	-0.1	0.7	0.8	-0.4	-0.6	-2.3	-1.2	-1.1	-2.3
<b>Stn 27 (3L)</b>		1.4	0.2	0.2	-0.7	-0.6	0.0	-0.2	0.9	1.4	-0.8	-1.9	-1.0	-0.9	-2.0
Flemish Cap (3L, 3M)	0.9	0.6	-0.4	-1.1	0.7	-0.1	0.6	1.5	0.7	-0.3	-1.1	-1.9	-0.2	-2.3	-2.2
SE Grand Banks (3LNO)	1.5	-0.4	-0.2	0.9	0.3	1.0	0.1	0.5	0.1	-0.2	-2.3	-1.1	-0.4	-0.3	-1.7
Northeast Gulf of St. Lawrence (4RS)	-2.6	-0.2	0.0	0.5	1.1	-1.0	-0.1	0.9	0.7	0.1	-0.1	0.7	0.4	0.4	0.6
Centre Gulf of St. Lawrence (4ST)						-1.5	-0.3	1.2	0.7	0.3	0.7	-1.1	-0.9	-0.3	1.0
Southwest Anticosti (4ST)	-0.1	-1.5	0.2	1.4	0.9	-1.0	-1.0	1.0	-0.1	1.1	0.4	-1.3	-0.5	2.2	0.4
Northwest Gulf of St. Lawrence (4ST)	0.0	-1.4	0.7	1.2	0.9	-1.4	-0.9	0.7	-0.2	1.3	-1.1	-0.1	-0.5	1.1	0.6
<b>Rimouski (4T)</b>		-0.3	0.5	1.0	-0.7	-0.1	-0.3	0.6	0.7	-0.4	0.2	-1.2	-1.1	0.1	-0.7
Lower St. Lawrence Estuary (4T)			1.0	1.6	0.2	-1.3		0.5	0.0	-0.5	0.1	-1.5	-1.2	1.0	0.5
<b>Shediac (4T)</b>	-0.2	1.0	0.2	0.7	-0.1	0.5	-0.2	0.6	-1.2	0.1	-0.1	-1.4	-1.5	-0.4	-1.4
Cabot Strait (3Pn, 4Vn)	-1.1	1.9	-1.3	0.0	0.3	-1.1	-0.6	1.5	-0.3	0.5	0.4	-0.1	-0.5	1.8	0.6
Cabot Strait (3Pn, 4Vn)	0.2	1.5	-0.9			-0.3	-0.4	1.4	-0.9	-0.3	1.1	-1.4	-0.4	1.4	0.6
Louisbourg (4Vs)	0.2	1.3	-1.4	-0.5	1.2	-0.5	-0.7	1.7	-1.0	-0.9	0.2	0.4	-1.0	0.3	-1.0
<b>Halifax-2 (4W)</b>	0.0	1.4	-0.5	0.8	1.4	-0.8	-1.9	0.7	-0.8	-0.1	0.4	-0.6	-1.0	1.7	0.2
Halifax (4W)	0.8	0.9	-0.4	-0.9	0.5	-0.4	-2.0	0.6	-1.2	1.4	0.4	0.3	-0.8	-0.4	-0.3
Browns Bank (4X)	-0.9	0.2	0.0	-1.4	2.1	1.1	-0.7	0.2	-1.2	-0.3	0.2	0.7	0.6	1.1	-0.2
<b>Prince-5 (4X)</b>	-1.0	-0.5	-1.0	0.9	1.0	-0.2	-0.7	1.1	-0.4	0.3	1.8	-1.3	-0.7	0.9	-0.8

Figure 4. Summary of chlorophyll *a* inventories (0-100m integral) from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2013. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1999-2010) divided by the standard deviation. The chlorophyll *a* anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

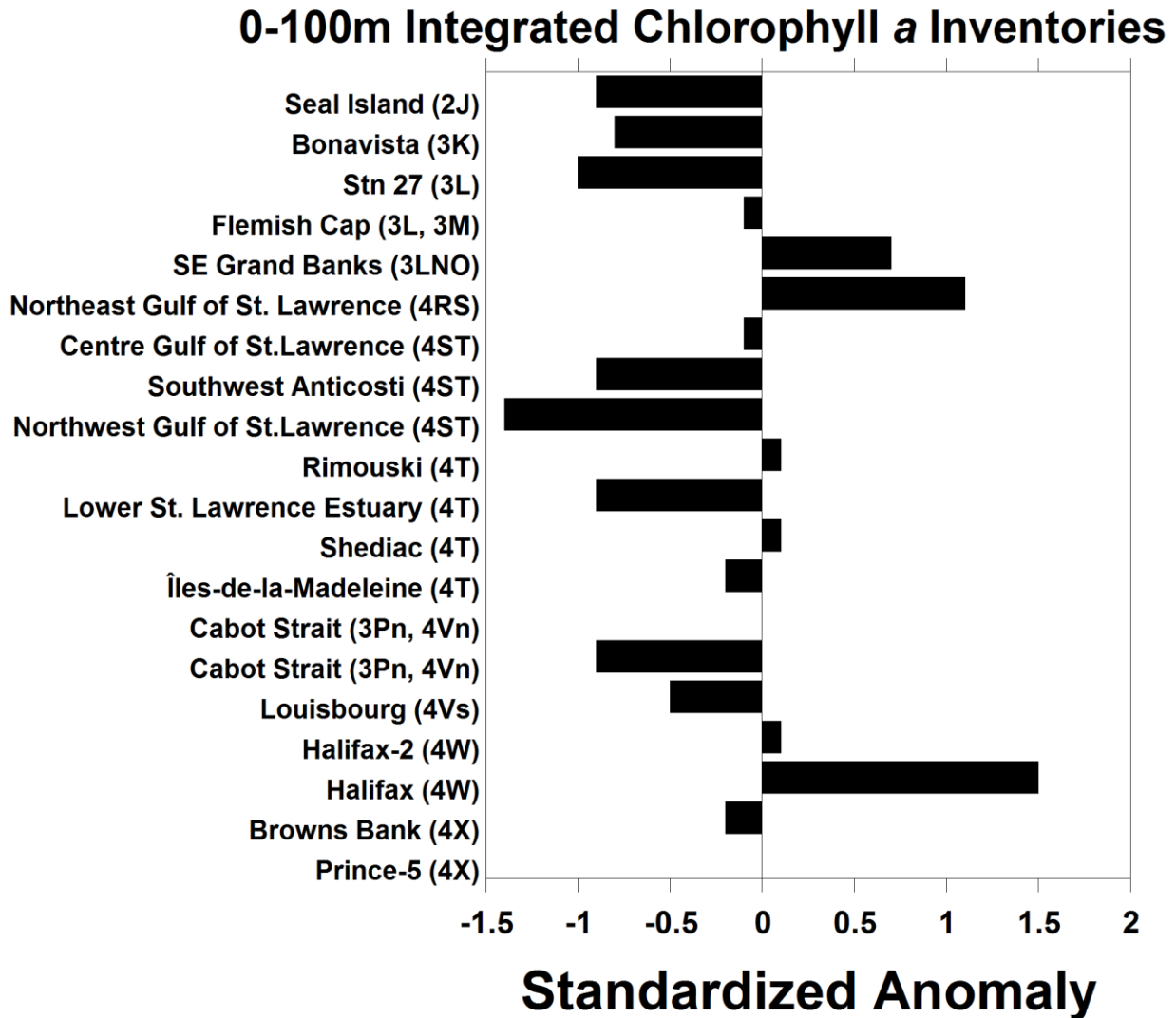


Figure 5. Time series of chlorophyll *a* (0-100m) inventory anomalies from different oceanographic transects and fixed stations (in bold) from the Atlantic Zone Monitoring Program during 1999-2013. The anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. Empty white cells indicate missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences in the annual average value from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted roughly by latitude from north (top) to south (bottom) regions.

Chlorophyll <i>a</i> (0-100m) Biomass	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seal Island (2J)	2.7	0.1	0.8	0.1	-0.8	-0.4	-0.1	0.1	-0.9	-0.9	0.0	-0.7	-1.0	-1.0	-0.9
Bonavista (3K)	-1.3	1.2	0.1	-1.2	-1.5	0.6	0.7	0.6	0.3	-0.9	1.4	0.2	-1.3	-1.7	-0.8
<b>Stn 27 (3L)</b>	3.1	-0.1	0.0	-0.1	-0.4	-0.2	-0.6	-0.2	-0.3	-0.7	-0.1	-0.3	-0.7	-0.4	-1.0
Flemish Cap (3L, 3M)	2.1	-0.2	-0.2	-0.9	-1.7	0.1	0.2	-0.7	0.9	-0.5	1.0	-0.1	-1.9	-1.5	-0.1
SE Grand Banks (3LNO)	2.1	-1.3	0.3	-0.3	-1.0	-0.3	0.6	-0.6	0.7	-1.1	1.1	-0.2	-1.9	-0.9	0.7
Northeast Gulf of St. Lawrence (4RS)	-0.9	-0.5	-0.8	1.7	0.1	2.2	-0.7	-0.9	0.1	0.1	-0.4	0.0	0.0	0.2	1.1
Centre Gulf of St. Lawrence (4ST)						-1.2	-1.0	-0.9	0.1	1.2	0.5	-0.1	-1.3	-0.6	-0.1
Southwest Anticosti (4ST)	-0.7	-1.1	-0.9	2.6	-0.1	0.3	0.6	0.3	-0.8	0.7	-0.6	-0.4	-0.6	-0.1	-0.9
Northwest Gulf of St. Lawrence (4ST)	-0.5	-1.8	-0.4	1.8	-0.1	0.9	-0.4	0.0	0.0	1.5	-1.0	-0.1	-0.6	0.2	-1.4
<b>Rimouski (4T)</b>	1.7	-0.2	0.0	-0.3	0.5	-0.8	-0.4	-0.5	0.5	-0.9	0.2	0.0	-0.3	0.6	0.1
Lower St. Lawrence Estuary (4T)	-1.0	-1.2	1.2	-0.5	1.9	-0.5	-0.9	-0.6	1.3	-0.1	0.2	0.1	-0.1	0.3	-0.9
<b>Shediac (4T)</b>	-0.4	-0.7	-0.3	1.1	0.2	-0.5	-0.6	-0.1	0.5	0.6	0.1	-0.3	-0.7	-0.1	0.1
Îles-de-la-Madeleine (4T)	-0.5	-1.5	-0.7	0.9	0.3	-0.2	0.1	-0.2	-0.4	2.5	-0.6	0.4	-0.6	-0.3	-0.2
Cabot Strait (3Pn, 4Vn)	1.5	-1.1	-0.1	2.4	-0.5	-0.7	-0.9	0.1	-0.1	-0.6	0.1	-0.1	-0.7	-0.6	0.0
Cabot Strait (3Pn, 4Vn)	1.7	1.4	-0.4			0.0	-0.4	-1.5	0.3	0.0	0.3		-1.3	0.3	-0.0
Louisbourg (4Vs)	0.7	0.3	-0.5	0.5	2.4	-0.4	-0.3	-1.2	0.0	-0.2	0.0	-1.5	1.5	-0.9	-0.5
<b>Halifax-2 (4W)</b>	2.5	0.8	0.4	-0.1	0.5	-0.6	-0.6	-1.1	-0.7	-0.9	0.2	-0.4	1.0	1.2	0.1
Halifax (4W)	0.1	-0.3	-0.4	-0.8	0.6	-0.2	0.4	-2.3	1.9	0.5	0.3	0.2	1.1	-0.7	1.5
Browns Bank (4X)	0.9	-0.6	0.1	-1.0	2.3	-1.2	-0.8	-0.6	0.8	-0.1	0.3	-0.4	-1.2	2.4	-0.2
<b>Prince-5 (4X)</b>	0.0	2.0	0.8	0.6	-0.3	0.3	-0.7	-1.2	-0.4	-1.2	-0.9	1.1	-0.5	1.4	

Figure 6. Composite sums of annual anomalies across Labrador and the northeast Newfoundland (LAB-NL) Shelf, Grand Bank and Flemish Cap (GB-FC), Gulf of St. Lawrence (GSL), Scotian Shelf and Bay of Gulf of Maine (SS-GoM) transects and fixed stations for shallow (0-50m) and deep (50m-bottom) nitrate and chlorophyll *a* inventories during 1999-2013.

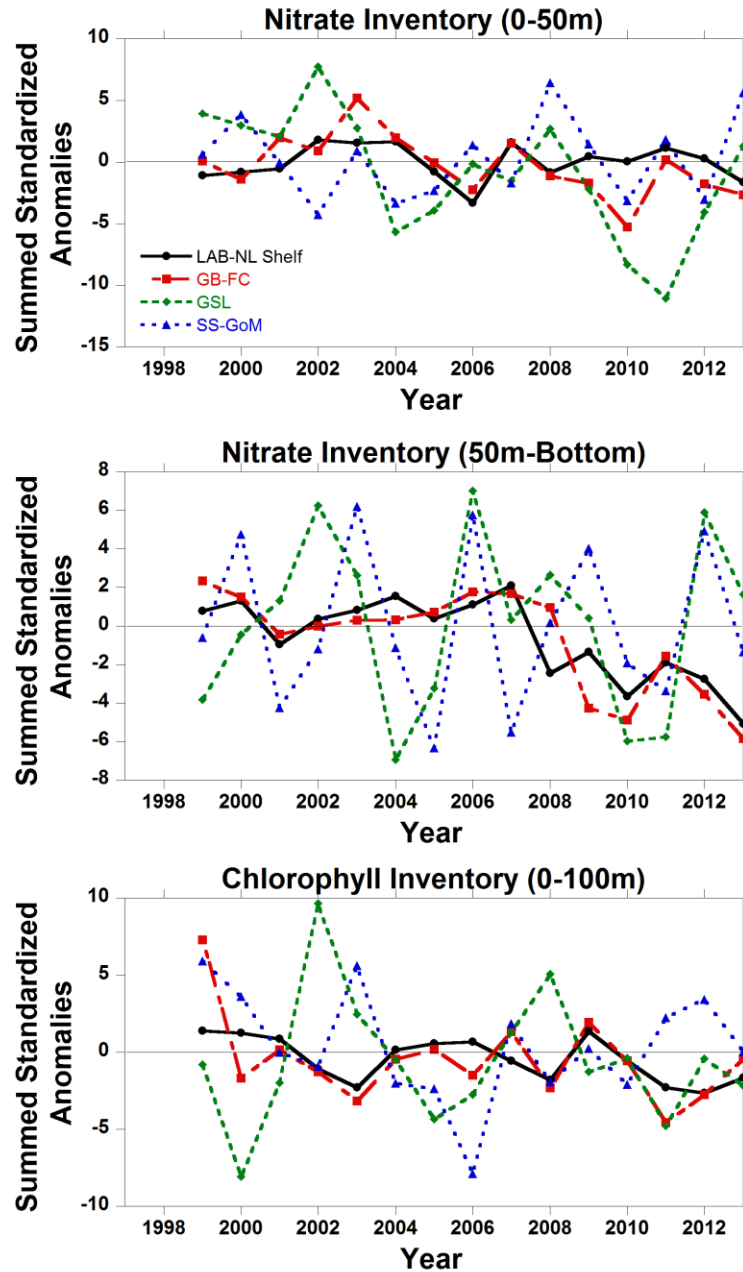


Figure 7. Time-series of surface chlorophyll *a* concentrations (log-transformed + 1;  $\text{mg m}^{-3}$ ), from combined SeaWiFS and MODIS ocean colour data along the Subarctic sub-regions during 1998-2013. See Figure 1 for locations of statistical sub-regions. Normal ice-covered/cloud periods and unavailable data are blocked out in white.

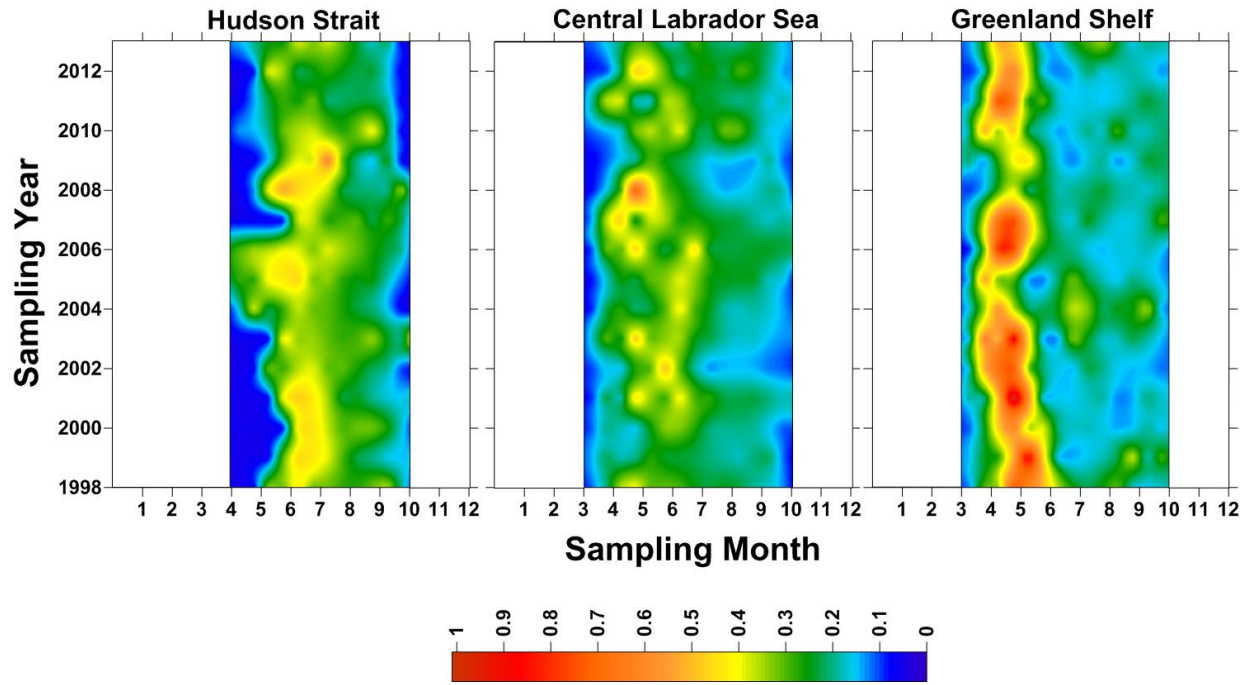


Figure 8. Time-series of surface chlorophyll *a* concentrations (log-transformed + 1;  $\text{mg m}^{-3}$ ), from combined SeaWiFS and MODIS ocean colour data along the Labrador and northeast Newfoundland Shelf Sub-Regions during 1998-2013. See Figure 1 for locations of statistical sub-regions. Normal ice-covered/cloud periods and unavailable data are blocked out in white.

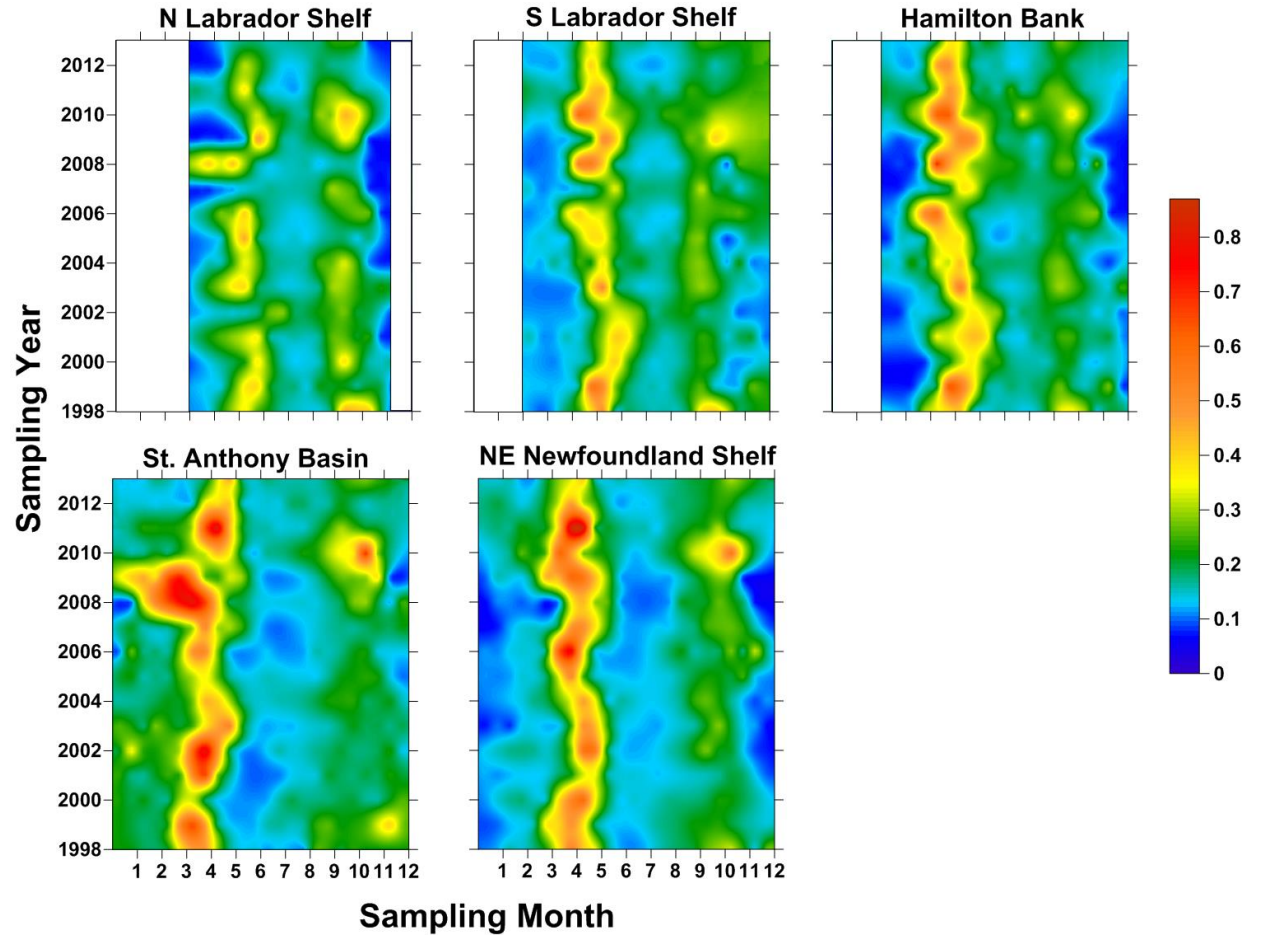




Figure 9. Time-series of surface chlorophyll *a* concentrations (log-transformed + 1;  $\text{mg m}^{-3}$ ), from combined SeaWiFS and MODIS ocean colour data along the Gulf of St. Lawrence sub-regions during 1998-2013. See Figure 1 for locations of statistical sub-regions. Normal ice-covered/cloud periods and unavailable data are blocked out in white.

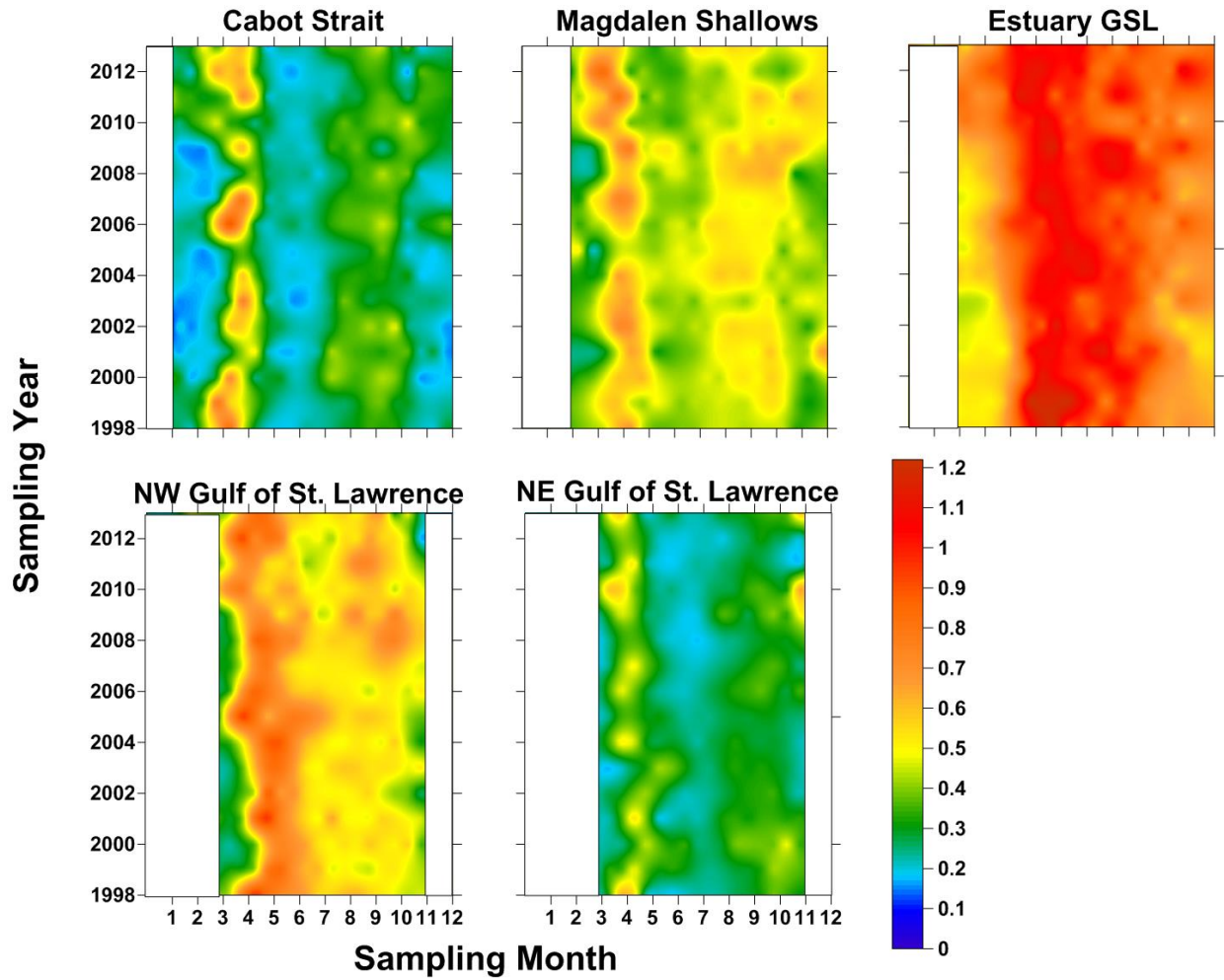


Figure 10. Time-series of surface chlorophyll *a* concentrations (log-transformed + 1;  $\text{mg m}^{-3}$ ), from combined SeaWiFS and MODIS ocean colour data along the Grand Bank sub-regions during 1998-2013. See Figure 1 for locations of statistical sub-regions. SeaWifs data for the Flemish Cap was not available prior to July 2002. Normal ice-covered/cloud periods and unavailable data are blocked out in white.

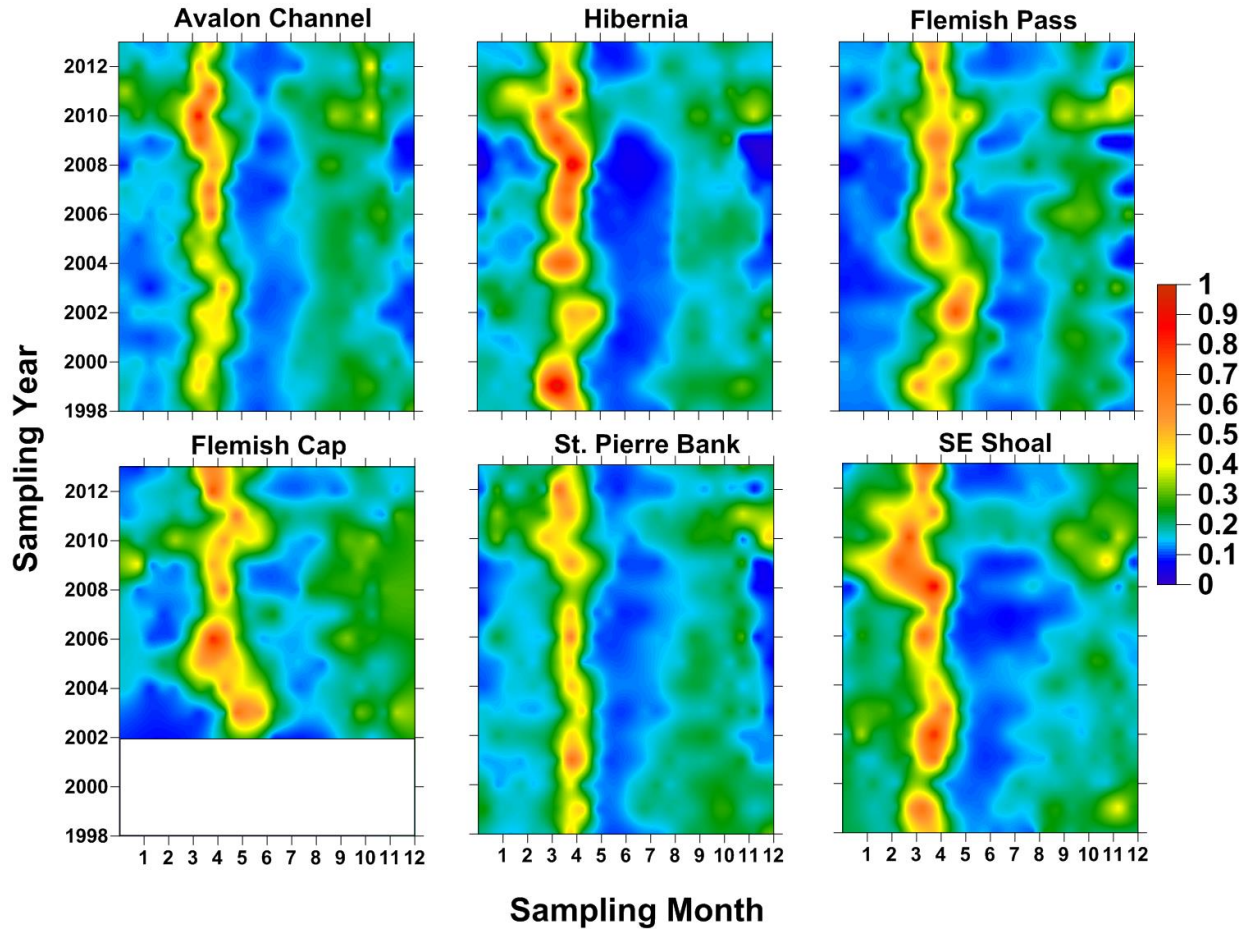




Figure 11. Time-series of surface chlorophyll *a* concentrations (log-transformed + 1;  $\text{mg m}^{-3}$ ), from combined SeaWiFS and MODIS ocean colour data along the Scotian Shelf and Gulf of Maine sub-regions during 1998-2013. See Figure 1 for locations of statistical sub-regions. Normal ice-covered/cloud periods and unavailable data are blocked out in white.

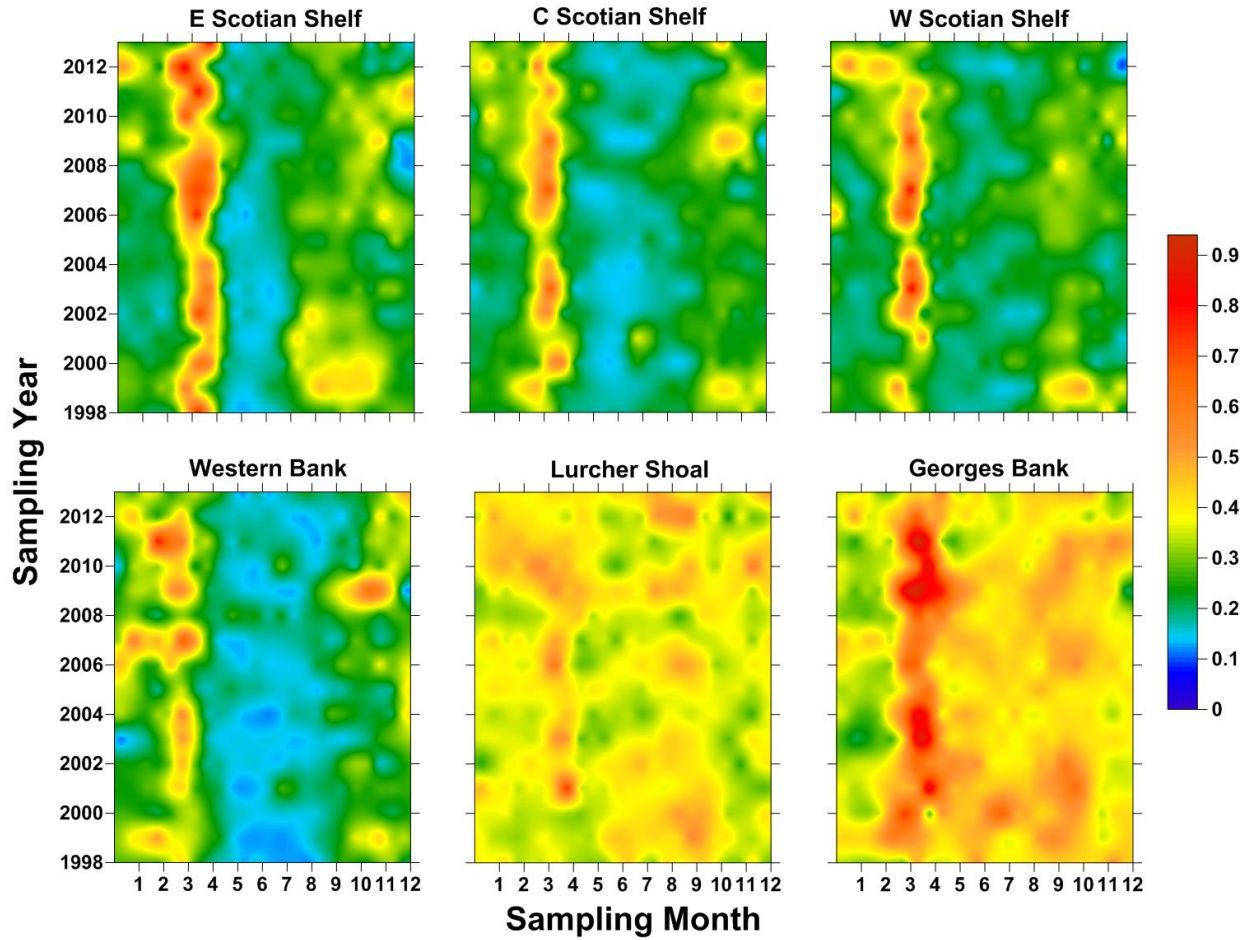


Figure 12. Climatological means (1998-2010) in unstandardized units for the ocean colour metrics describing the extent and timing indices of the spring bloom across the different statistical sub-regions from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) “Aqua” sensors.

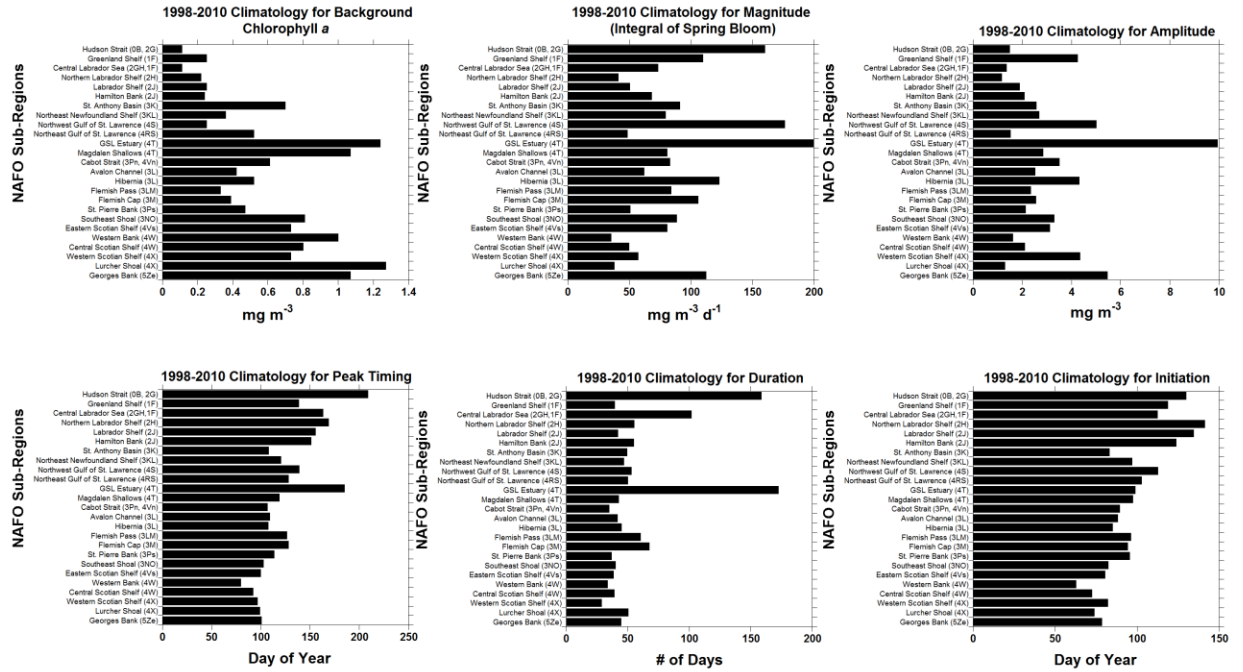


Figure 13. Summary of annual ocean colour anomalies from SeaWiFS and MODIS “Aqua” sensor across the different statistical sub-regions during 2013. The top panels show the extent (background chlorophyll *a* concentration, magnitude, and amplitude) of the spring production cycle while the bottom panels indicate the different timing (peak timing, bloom duration, and initiation) indices. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1998-2010) divided by the standard deviation. The NAFO Subareas are sorted from northern (top) to southern (bottom) regions. Negative anomalies for the timing indices (initiation, peak timing, and duration) indicate earlier/shorter blooms while positive anomalies indicate the opposite.

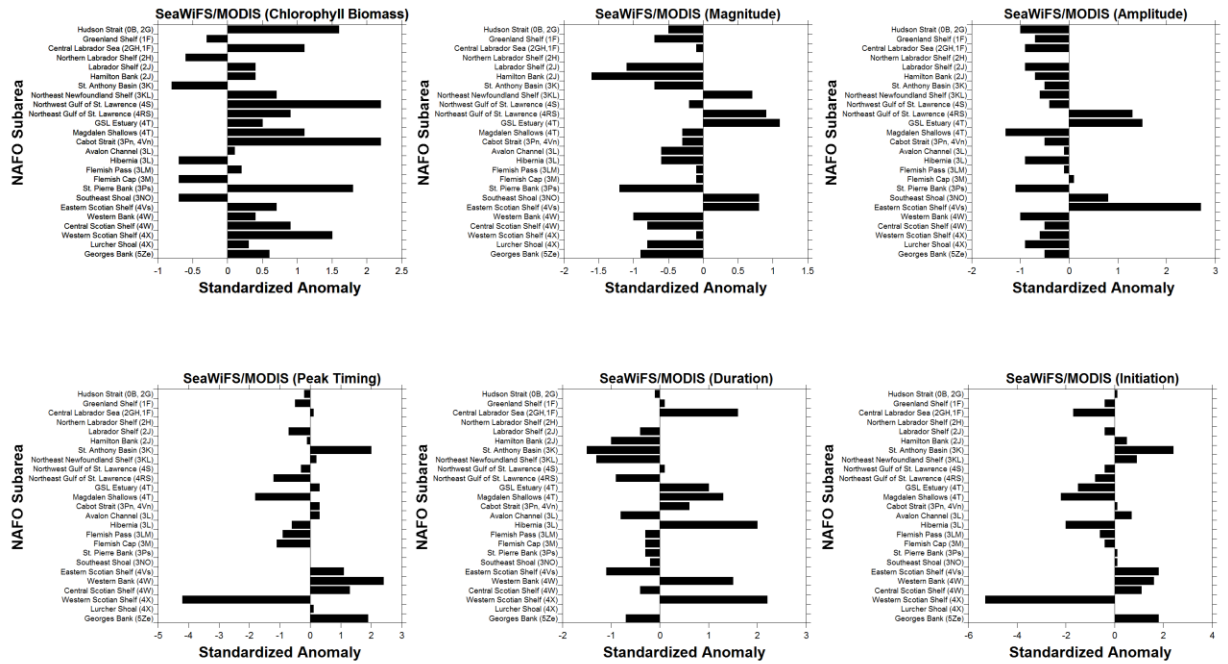


Figure 14. Annual anomalies of background chlorophyll *a* (before and after the spring bloom) derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate lower than normal levels and red cells indicate higher than normal levels. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	-0.8	-0.5	-0.4	-0.6	-0.1	0.5	1.8	-0.2	-1.6	0.2	-0.9	1.7	0.9	0.1	-0.7	1.6
Greenland Shelf (1F)	-0.6	0.7	-0.4	0.1	0.1	2.2	-1.3	-1.1	-1.0	0.5	-0.6	1.1	0.2	1.6	0.9	-0.3
Central Labrador Sea (2GH,1F)	-0.8	-0.3	-0.4	0.0	1.0	-1.1	0.4	-0.7	1.2	-1.1	0.9	1.9	-1.1	1.1	-1.2	1.1
Northern Labrador Shelf (2H)	-0.7	-0.4	-0.7	0.4	0.1	-0.8	1.1	-0.7	0.7	0.0	0.0	-1.5	2.4	5.7	-1.3	
Labrador Shelf (2J)	1.1	0.1	0.5	0.9	-1.6	-0.7	1.3	0.6	-1.6	0.0	-1.4	0.2	0.6	4.2	0.9	0.4
Hamilton Bank (2J)	0.7	-1.4	-0.8	0.5	-0.7	0.0	1.9	-0.4	0.1	-0.8	-0.7	-0.3	1.9	2.5	-0.1	0.4
St. Anthony Basin (3K)	-0.3	-0.3	-0.2	-0.1	0.7	0.5	-0.6	-0.3	-0.5	-0.3	-1.3	2.9	-0.3	0.5	-1.3	-0.8
Northeast Newfoundland Shelf (3KL)	0.6	-1.0	0.5	-0.2	1.0	-1.1	0.2	-0.3	-0.3	-0.2	-1.4	-0.1	2.4	2.6	0.8	0.7
Northwest Gulf of St. Lawrence (4S)	-0.5	-0.1	1.3	0.3	-0.2	-0.8	0.9	-1.0	-1.0	0.0	-1.4	0.4	2.1	3.7	0.4	2.2
Northeast Gulf of St. Lawrence (4RS)	0.9	1.7	0.0	1.5	0.9	-0.7	-0.8	-1.4	-0.2	-0.3	-1.4	-0.1	-0.1	4.4	0.1	0.9
GSL Estuary (4T)	-0.9	0.4	-0.2	-1.2	0.7	-1.1	1.0	0.0	-0.3	0.0	-1.0	0.2	2.4	2.8	0.7	0.5
Magdalen Shallows (4T)	0.2	0.7	-0.3	-0.6	0.4	0.0	-1.2		1.6	1.4	-1.4	-1.3	0.5	2.4	-0.1	1.1
Cabot Strait (3Pn, 4Vn)	0.9	2.1	-0.9	-0.1	-1.2	-0.7	-0.3	0.0	0.5	-0.5	-0.6	-0.8	1.5	2.9	-0.2	2.2
Avalon Channel (3L)	0.0	0.0	-0.3	-1.1	-0.1	-0.7	-0.7	-0.8	0.1	0.5	0.0	-0.1	3.0	4.3	1.1	0.1
Hibernia (3L)	0.1	-0.3	-0.3	-0.3	0.7	1.0	-0.9	-0.5	0.3	-0.2	-1.2	-0.9	2.6	4.2	-0.1	-0.7
Flemish Pass (3LM)	-0.1	0.5	0.7	-0.4	1.0	-1.1	-1.0	0.5	-0.6	-0.1	-1.4	-0.2	2.3	0.6	1.2	0.2
Flemish Cap (3M)						-1.4	-0.3	0.3	-0.3	0.0	-0.2	-0.2	2.2	0.7	1.1	-0.7
St. Pierre Bank (3Ps)	0.1	1.9	-0.2	-0.6	1.8	-0.2	-0.7	-0.4	0.7	-0.5	-0.6	-1.7	0.2	6.6	3.0	1.8
Southeast Shoal (3NO)	-0.8	-0.7	-0.7	-0.5	0.5	0.7	-0.5	-0.6	-0.6	-0.6	1.5	2.4	0.0	0.4	-0.1	-0.7
Eastern Scotian Shelf (4Vs)	-0.3	1.8	0.7	-0.5	-1.0	-0.6	0.1	-0.8	0.3	-2.0	1.0	0.5	0.9	1.1	-2.4	0.7
Western Bank (4W)	-0.3	1.2	-0.4	-0.3	-0.4	-1.2	0.1	-0.6	-0.3	2.7	-0.8	0.2	0.1	-0.7	0.1	0.4
Central Scotian Shelf (4W)	-0.5	0.3	-0.1	-0.6	-0.9	-1.4	-0.1	-1.2	0.1	0.0	0.7	1.6	2.0	1.4	1.9	0.9
Western Scotian Shelf (4X)	-0.2	0.6	-0.1	-1.1	-0.5	-0.7	-0.9	-0.2	-0.7	-0.1	-0.1	1.5	2.5	0.6		1.5
Lurcher Shoal (4X)	-0.2	-0.6	-5.1	0.4	-2.4	0.5	-0.1	1.0	0.6	1.3	-0.8	-0.4	0.6			0.3
Georges Bank (5Ze)	0.5	1.8	0.2	0.5	-0.4	-1.4	0.1	0.1	-0.2	1.2	-0.7	-2.0	0.2	-0.3	1.4	0.6

Figure 15. Annual anomalies of the magnitude (integral of chlorophyll *a* concentration during the bloom in  $\text{mg m}^{-2} \text{d}^{-1}$ ) of the spring bloom derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate lower than normal levels and red cells indicate higher than normal levels. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	0.2	-0.7	-0.3	-0.8	-0.5	3.0	-0.4	0.1	0.8	-0.5	-0.4	-0.6	0.1	-0.8	-0.6	-0.5
Greenland Shelf (1F)	0.0	0.7	-0.5	1.7	0.9	0.3	-0.9	-1.2	1.0	0.8	-1.5	-1.0	-0.4	0.9	-0.4	-0.7
Central Labrador Sea (2GH,1F)	0.0	-0.5	-1.1	-1.2	-0.8	1.0	0.6	1.5	-0.9	1.3	0.5	-1.3	0.9	4.3	-0.6	-0.1
Northern Labrador Shelf (2H)	0.0	0.0	-0.7	0.6	-1.0	0.7	-0.7	-0.1	-0.1	-0.5	2.8	0.0	-1.1	-0.8	-0.7	
Labrador Shelf (2J)	-0.2	0.8	-0.6	-0.1	-0.7	-0.1	-1.5	-0.2	0.8	-1.4	2.0	0.1	1.1	-0.4	-0.8	-1.1
Hamilton Bank (2J)	-0.4	0.7	-1.1	1.5	-1.0	-0.5	-1.0	-0.2	0.9	-1.5	0.5	1.0	1.1	-0.9	-0.1	-1.6
St. Anthony Basin (3K)	-0.3	0.3	-0.9	0.0	0.7	-0.3	-0.5	-0.8	-0.3	-0.6	3.0	0.3	-0.5	0.7	-0.5	-0.7
Northeast Newfoundland Shelf (3KL)	0.6	-1.0	0.5	-0.2	1.0	-1.1	0.2	-0.3	-0.3	-0.2	-1.4	-0.1	2.4	2.6	0.8	0.7
Northwest Gulf of St. Lawrence (4S)	1.0	-0.2	-0.2	0.9	-1.4	0.6	1.5	0.0	0.6	-1.0	0.8	-1.7	-1.0	-1.8	3.9	-0.2
Northeast Gulf of St. Lawrence (4RS)	1.7	-1.0	-1.2	-0.1	-0.7	-0.3	0.4	-0.6	-0.2	0.3	-0.5	-0.1	2.3	-0.2	-0.3	0.9
GSL Estuary (4T)	-0.6	-0.1	-0.7	0.1	0.2	0.0	-0.1	-0.2	-0.1	-0.4	3.2	-0.7	-0.5	-0.7	-0.4	1.1
Magdalen Shallows (4T)	-0.3	-1.4	0.6	-0.2	0.9	0.5	-0.7		-1.5	1.4	-1.0	0.8	1.0	0.6	3.0	-0.3
Cabot Strait (3Pn, 4Vn)	1.1	0.3	0.0	-0.8	0.2	0.3	-0.6	-1.2	2.1	1.0	-1.3	-0.1	-1.0	0.1	1.6	-0.3
Avalon Channel (3L)	-1.5	-0.7	-0.7	-0.2	0.4	-0.3	-0.4	-0.8	0.2	0.4	-0.2	1.3	2.4	0.8	-0.9	-0.6
Hibernia (3L)	-0.6	1.7	1.7	-0.9	-0.2	-1.3	0.6	-1.1	-0.3	-0.3	1.0	0.3	-0.5	-0.1	-1.0	-0.6
Flemish Pass (3LM)	-1.5	-0.4	0.0	-1.2	1.8	-0.3	0.3	0.6	-0.3	-0.2	-1.1	1.5	0.9	-1.5	-0.8	-0.1
Flemish Cap (3M)						0.6	0.1	0.8	1.2	-1.6	-0.7	-1.0	0.6	-1.0	-0.2	-0.1
St. Pierre Bank (3Ps)	-0.8	-0.4	-1.1	1.7	-0.2	-0.7	0.0	-0.5	0.1	-0.2	-1.0	1.8	1.3	0.5	1.4	-1.2
Southeast Shoal (3NO)	-0.4	0.5	-1.6	0.0	1.3	-0.5	-0.8	-1.0	0.2	-0.8	1.9	1.0	0.2	0.5	-0.9	0.8
Eastern Scotian Shelf (4Vs)	0.9	-1.0	0.1	-1.2	0.4	-0.3	-0.5	-1.1	0.5	2.2	1.0	-0.7	-0.3	1.0	2.0	0.8
Western Bank (4W)	-0.4	-0.4	-0.7	0.0	-0.1	1.2	0.4	-1.1	-0.5	1.7	-1.4	1.8	-0.4	6.1	-0.6	-1.0
Central Scotian Shelf (4W)	-1.3	-0.1	0.7	-0.1	0.2	1.5	-0.6	-1.6	0.2	1.7	-0.2	0.7	-1.1	-0.6	0.3	-0.8
Western Scotian Shelf (4X)	-0.9	-0.6	-1.3	-0.6	0.1	1.7	-1.4	1.3	1.3	0.2	0.2	0.4	-0.5	-0.7		-0.1
Lurcher Shoal (4X)	-0.9	-1.0	-1.1	0.6	0.5	0.1	-0.7	-0.9	0.1	-0.3	-0.6	0.6	2.5			-0.8
Georges Bank (5Ze)	-1.1	-0.5	-0.5	-0.3	0.8	0.7	0.4	-0.6	-0.5	-0.7	-0.6	2.7	0.1	1.2	-0.7	-0.9

Figure 16. Annual anomalies of the amplitude (peak intensity in  $\text{mg m}^{-3}$ ) of the spring bloom derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate lower than normal levels and red cells indicate higher than normal levels. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	-0.7	0.4	-0.4	0.8	-0.9	1.0	-1.3	-0.1	-0.2	-1.3	1.4	1.7	-0.7	-2.0	-1.7	-1.0
Greenland Shelf (1F)	0.0	1.1	-0.6	2.1	0.1	0.9	-0.7	-0.6	0.9	0.2	-1.2	-1.1	-1.0	3.8	-0.5	-0.7
Central Labrador Sea (2GH,1F)	-0.4	-0.9	-0.6	1.0	0.4	-0.2	-0.5	-0.3	0.0	-0.2	2.9	-0.8	-0.4	-0.1	0.3	-0.9
Northern Labrador Shelf (2H)	-0.4	0.1	-0.2	-0.5	-0.8	0.0	-0.5	1.0	-0.2	-0.7	0.1	2.9	-0.7	-0.1	-0.6	
Labrador Shelf (2J)	1.4	1.5	-0.7	-0.7	-1.3	0.5	-0.5	-0.8	-0.7	-1.1	0.9	0.5	1.2	-0.3	-0.6	-0.9
Hamilton Bank (2J)	-0.7	1.3	-1.0	-0.5	-0.9	0.3	-0.9	-0.6	0.5	-0.7	2.1	0.1	1.0	-0.3	0.1	-0.7
St. Anthony Basin (3K)	-0.5	0.5	-1.1	0.8	1.8	-0.4	-0.8	-1.2	-0.2	-0.4	1.6	0.6	-0.8	2.2	-0.8	-0.5
Northeast Newfoundland Shelf (3KL)	-0.5	-0.7	0.0	-1.2	0.4	-0.5	-0.7	-0.4	1.9	2.1	-0.8	0.0	0.3	4.0	-0.7	-0.6
Northwest Gulf of St. Lawrence (4S)	1.1	-0.1	-1.2	1.3	1.7	-0.2	0.3	0.9	-0.2	-0.7	-0.3	-1.6	-1.0	-1.5	0.2	-0.4
Northeast Gulf of St. Lawrence (4RS)	2.4	-0.3	-0.6	0.6	-0.8	-0.7	0.3	-1.2	-0.1	0.1	-0.9	-0.2	1.4	2.7	-0.8	1.3
GSL Estuary (4T)	0.1	1.1	-0.6	0.0	0.0	-0.4	-0.2	-0.5	-0.5	-0.5	2.9	-0.6	-0.9	-0.6	-0.7	1.5
Magdalen Shallows (4T)	0.3	-1.4	-1.1	-0.2	0.4	-0.7	1.1		-0.3	0.5	-1.0	2.2	0.2	6.6	2.9	-1.3
Cabot Strait (3Pn, 4Vn)	1.1	1.0	0.3	-0.7	-0.4	0.6	-0.4	-1.3	1.7	0.8	-1.3	-0.3	-1.1	0.1	-0.2	-0.5
Avalon Channel (3L)	-1.0	-0.6	-0.5	-0.7	-0.6	-0.1	-0.6	-0.9	0.6	0.9	0.0	1.0	2.5	1.1	0.4	-0.1
Hibernia (3L)	-0.7	1.4	1.4	-1.0	-0.8	-1.3	-0.1	-1.0	0.1	0.0	1.8	0.2	0.0	0.7	-0.8	-0.9
Flemish Pass (3LM)	-0.9	-0.1	-0.4	-1.4	2.0	-0.3	-1.0	0.9	0.0	1.2	0.3	0.7	-1.0	0.0	1.6	-0.1
Flemish Cap (3M)						0.4	-0.6	-0.4	2.1	-1.0	0.6	-0.3	-0.8	0.1	2.1	0.1
St. Pierre Bank (3Ps)	-0.4	0.4	-1.0	2.1	-0.7	-0.3	-0.3	1.0	1.5	-0.2	-1.4	-0.1	-0.6	-0.1	4.7	-1.1
Southeast Shoal (3NO)	-0.9	0.1	-1.5	0.3	1.2	0.1	-0.9	-1.3	0.5	-0.3	1.9	-0.1	0.9	-1.1	-0.4	0.8
Eastern Scotian Shelf (4Vs)	1.5	-0.6	-0.1	-1.1	0.9	0.3	-0.6	-1.3	1.6	0.7	-0.2	-1.5	0.3	1.7	2.1	2.7
Western Bank (4W)	-0.5	-0.5	-0.9	-0.4	-0.1	0.3	0.4	-0.6	-0.2	2.9	-1.1	0.4	0.2	2.2	-0.2	-1.0
Central Scotian Shelf (4W)	-1.2	-0.7	0.8	-1.2	0.5	1.3	-0.1	-0.9	-0.5	1.8	0.3	0.8	-1.0	-0.3	6.6	-0.5
Western Scotian Shelf (4X)	-0.6	-0.4	-0.7	-0.4	0.1	3.0	-0.7	0.6	0.7	-0.5	-0.5	0.0	-0.3	-0.6		-0.6
Lurcher Shoal (4X)	-0.6	-0.9	-1.2	2.6	-0.7	0.9	-0.3	-0.8	0.8	-0.2	-0.3	-0.4	-0.1			-0.9
Georges Bank (5Ze)	-0.6	-0.6	-0.1	3.2	-0.6	0.2	0.0	-0.5	-0.2	-0.6	-0.4	0.1	0.1	0.3	-0.5	-0.5

Figure 17. Annual anomalies of the peak timing (day of year) of the spring bloom derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate earlier and red cells indicate later than normal blooms. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	0.4	-0.3	0.6	-0.7	-0.1	2.4	-0.7	-1.2	-0.7	0.9	-1.2	0.1	0.5	-0.1	-0.5	-0.2
Greenland Shelf (1F)	0.8	1.7	0.1	0.5	-0.4	0.4	-0.9	-2.0	-0.4	0.0	0.0	1.2	-1.0	-0.3	0.2	-0.5
Central Labrador Sea (2GH,1F)	-0.9	0.1	1.1	-0.9	0.6	-0.6	1.2	1.5	-1.3	-0.9	-1.1	0.2	1.0	-1.5	-0.9	0.1
Northern Labrador Shelf (2H)	-0.4	-0.1	0.1	-0.4	0.8	-0.7	-0.3	-0.4	-0.4	2.8	-1.4	0.3	0.1	-0.4	-0.2	
Labrador Shelf (2J)	-0.2	-0.4	1.0	1.4	1.5	-0.1	-0.1	-0.5	-1.5	1.0	-1.1	0.5	-1.4	-0.3	-0.8	-0.7
Hamilton Bank (2J)	-0.5	-0.2	1.1	0.8	1.6	0.2	-0.1	-0.5	-1.8	0.8	-1.2	0.7	-1.0	-0.3	-0.9	-0.1
St. Anthony Basin (3K)	-0.2	-0.7	-1.0	0.1	0.2	1.8	0.8	0.1	-0.1	0.4	-1.1	-1.7	1.4	1.1	1.5	2.0
Northeast Newfoundland Shelf (3KL)	-0.3	-1.2	0.2	1.4	1.3	1.2	0.7	-0.9	-1.0	0.0	0.6	-0.3	-1.6	0.0	-0.7	0.2
Northwest Gulf of St. Lawrence (4S)	-0.6	1.0	1.6	0.1	0.5	0.8	0.7	-1.5	-0.4	0.0	0.1	-0.4	-2.0	-1.1	-0.9	-0.3
Northeast Gulf of St. Lawrence (4RS)	-0.6	0.1	1.2	0.1	0.8	2.4	-0.7	0.0	-0.9	0.0	-0.1	-0.8	-1.5	-0.4	-0.7	-1.2
GSL Estuary (4T)	-0.8	-0.4	-0.9	0.7	0.3	0.2	0.5	0.3	-0.3	-0.6	2.7	-0.8	-1.0	-1.7	-1.3	0.3
Magdalen Shallows (4T)	0.5	-1.2	1.0	1.3	0.1	-0.1	0.1		0.2	0.0	0.2	0.4	-2.5	-1.2	-2.6	-1.8
Cabot Strait (3Pn, 4Vn)	-0.7	-1.5	-0.4	1.2	0.1	0.7	0.6	0.4	-0.6	0.4	1.5	0.3	-2.0	0.8	-0.7	0.3
Avalon Channel (3L)	0.0	-1.2	-0.5	1.1	0.4	2.1	-0.2	-0.9	0.3	0.0	1.0	-0.9	-1.3	0.1	-0.7	0.3
Hibernia (3L)	0.7	-0.9	-0.9	0.9	1.7	0.4	-0.3	0.2	0.1	0.1	0.9	-0.8	-2.1	0.3	-0.5	-0.6
Flemish Pass (3LM)	-0.3	-1.7	0.2	1.1	1.1	1.8	0.2	-0.8	-1.4	-0.2	-0.2	-0.3	0.6	-0.1	-0.6	-0.9
Flemish Cap (3M)						2.0	0.8	-0.9	-0.8	-0.5	-0.3	-0.8	0.5	1.2	-0.8	-1.1
St. Pierre Bank (3Ps)	-0.1	0.9	-0.3	0.4	0.2	1.3	0.3	-0.7	0.2	-0.2	0.6	0.2	-2.8	-0.5	-1.2	0.0
Southeast Shoal (3NO)	0.2	-0.4	-0.8	0.5	0.7	1.6	0.7	0.0	-0.1	0.7	0.6	-2.1	-1.5	-0.7	-0.3	0.0
Eastern Scotian Shelf (4Vs)	-0.1	-1.7	0.5	1.5	0.2	0.9	0.8	-1.0	-0.5	-0.2	0.2	1.1	-1.7	0.0	-2.1	1.1
Western Bank (4W)	0.1	-2.7	1.5	-0.1	0.4	0.4	0.5	-0.2	-0.9	1.0	0.3	0.0	-0.3	-2.0	0.0	2.4
Central Scotian Shelf (4W)	-0.6	-2.1	1.9	0.9	0.0	0.8	0.2	-0.4	-0.6	0.2	0.1	0.6	-1.0	0.9	-1.7	1.3
Western Scotian Shelf (4X)	-0.5	-2.1	1.3	1.6	-0.7	0.7	-0.4	-0.7	-0.4	0.7	0.7	0.3	-0.5	1.0		-4.2
Lurcher Shoal (4X)	-0.3	-0.8	-6.8	0.8	-2.2	0.4	0.8	0.5	-0.2	0.1	1.6	0.4	-1.0			0.1
Georges Bank (5Ze)	0.0	-1.9	-1.8	1.2	1.4	0.3	0.0	0.6	-0.8	0.0	0.0	0.1	0.9	0.0	-0.3	1.9

Figure 18. Annual anomalies of the duration (in days) of the spring bloom derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate lower duration and red cells indicate higher than normal duration of blooms. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	0.7	-1.0	-0.3	-1.2	-0.2	2.3	0.2	0.1	1.1	0.0	-1.0	-1.2	0.5	0.2	0.2	-0.1
Greenland Shelf (1F)	-0.3	-0.6	0.2	-0.6	1.0	-0.8	-0.4	-1.2	-0.2	0.6	-1.1	0.8	2.4	-1.7	0.2	0.1
Central Labrador Sea (2GH,1F)	0.1	1.2	-0.7	-1.4	-1.1	0.5	0.9	1.2	-1.0	0.9	-1.2	-0.5	1.0	2.8	-0.9	1.6
Northern Labrador Shelf (2H)	0.3	-0.3	-0.7	1.3	-0.6	0.6	-0.4	-0.9	-0.1	0.2	2.4	-1.3	-0.8	-0.9	-0.3	
Labrador Shelf (2J)	-1.1	-0.6	-0.1	0.7	1.3	-0.7	-1.3	0.7	2.0	-0.8	0.5	-0.5	-0.3	-0.3	-0.4	-0.4
Hamilton Bank (2J)	0.6	-1.0	0.4	2.3	0.7	-1.0	0.3	0.6	-0.3	-0.7	-1.4	0.2	-0.7	-0.8	-0.5	-1.0
St. Anthony Basin (3K)	0.6	-0.1	-1.0	-1.0	-0.6	-0.1	0.3	0.5	-0.3	-1.2	2.6	-0.3	0.7	-0.9	0.5	-1.5
Northeast Newfoundland Shelf (3KL)	0.8	1.4	0.4	-0.3	-0.6	-0.3	0.0	-0.8	-0.5	-1.6	0.2	2.2	-0.9	-0.7	-0.4	-1.3
Northwest Gulf of St. Lawrence (4S)	-0.3	-0.3	1.5	-0.5	-2.3	0.8	0.9	-0.9	0.7	-0.4	1.1	-0.1	-0.1	-0.7	3.3	0.1
Northeast Gulf of St. Lawrence (4RS)	-1.1	-1.1	-0.8	-1.1	0.4	1.0	-0.2	2.3	-0.3	-0.1	1.1	-0.1	0.0	-2.1	1.1	-0.9
GSL Estuary (4T)	-1.1	-0.4	-1.2	0.6	0.6	0.6	0.2	0.0	0.4	-0.5	2.5	-1.1	-0.5	-1.2	-0.2	1.0
Magdalen Shallows (4T)	-0.5	-0.4	2.1	-0.2	0.3	1.1	-1.3		-1.3	0.6	-0.2	-0.8	0.6	-1.7	0.1	1.3
Cabot Strait (3Pn, 4Vn)	-0.1	-1.5	-1.0	-0.6	2.3	-0.8	-0.8	1.0	0.5	0.4	-0.3	0.5	0.5	-0.3	6.0	0.6
Avalon Channel (3L)	-0.1	0.1	-0.3	1.4	1.6	-0.6	0.8	1.5	-0.9	-1.1	-0.7	-0.7	-1.1	-1.0	-1.6	-0.8
Hibernia (3L)	0.4	-0.1	-0.1	0.3	2.1	1.2	1.1	-0.5	-1.0	-0.8	-1.1	-0.1	-1.3	-1.5	-0.8	2.0
Flemish Pass (3LM)	-0.3	-0.5	0.0	1.2	-0.7	-0.2	1.5	-0.6	-0.4	-1.0	-1.0	-0.2	2.2	-1.1	-1.3	-0.3
Flemish Cap (3M)						-0.1	0.7	0.9	-0.7	-0.8	-1.0	-0.7	1.7	-1.0	-1.1	-0.3
St. Pierre Bank (3Ps)	-0.6	-0.8	-0.4	-0.4	0.4	-0.6	0.1	-1.1	-1.0	-0.2	0.8	1.6	2.1	0.5	-1.2	-0.3
Southeast Shoal (3NO)	1.7	0.6	-0.6	-0.7	0.0	-1.1	0.1	1.0	-0.5	-1.3	-0.2	1.7	-1.0	5.7	-1.2	-0.2
Eastern Scotian Shelf (4Vs)	-0.5	-0.9	0.1	-0.7	-0.5	-0.8	-0.2	0.1	-0.8	1.4	1.6	1.9	-0.8	-0.5	0.0	-1.1
Western Bank (4W)	0.2	0.1	1.5	0.9	-0.3	0.9	-0.3	-1.2	-0.7	-1.3	-0.1	1.6	-1.2	2.0	-0.9	1.5
Central Scotian Shelf (4W)	0.4	0.6	-0.4	2.9	-0.5	-0.4	-0.6	-0.8	0.5	-0.6	-0.6	-0.5	0.0	-0.4	-1.6	-0.4
Western Scotian Shelf (4X)	0.6	-0.2	0.5	-0.4	-0.6	-1.2	-0.7	-0.5	-0.6	2.0	2.0	-0.3	-0.5	0.4		2.2
Lurcher Shoal (4X)	-0.7	-0.5	-1.0	-0.6	1.8	-0.5	-0.6	-0.6	-0.5	-0.3	-0.5	0.9	2.0			0.0
Georges Bank (5Ze)	-0.7	0.7	-0.7	-1.1	2.8	-0.2	-0.1	-0.2	-0.5	-0.1	-0.4	1.0	-0.4	0.0	-0.4	-0.7



Figure 19. Annual anomalies of the initiation (20 % of the bloom amplitude in day of year) of the spring bloom derived from SeaWiFS and MODIS “Aqua” sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2013. Blue cells indicate earlier and red cells indicate later than normal blooms. More intense colours indicate larger standardized anomalies. The numbers in the coloured cells are the differences between 2013 and the long-term mean (1998-2010) divided by the standard deviation during the reference period. The statistical sub-regions are sorted from northern (top) to southern (bottom) boxes. Blank cells indicate the fitting routine could not be achieved or spring bloom not detected. Data for Flemish Cap are not yet available during 1998-2002 (grey cells).

Petrie Box	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Hudson Strait (0B, 2G)	-0.5	1.0	0.8	1.0	0.1	-1.0	-0.8	-1.0	-1.9	0.6	0.3	1.5	-0.2	-0.3	-0.6	0.1
Greenland Shelf (1F)	0.8	1.7	0.0	0.7	-0.8	0.7	-0.6	-1.0	-0.2	-0.3	0.5	0.6	-2.1	0.6	0.0	-0.4
Central Labrador Sea (2GH,1F)	-0.6	-1.3	1.4	1.0	1.6	-0.9	-0.3	-0.5	0.3	-1.5	0.6	0.7	-0.5	-4.0	0.5	-1.7
Northern Labrador Shelf (2H)	-0.5	0.0	0.3	-0.8	0.8	-0.7	-0.1	0.0	-0.3	2.3	-2.0	0.6	0.3	0.0	-0.1	
Labrador Shelf (2J)	0.4	0.0	0.9	0.8	0.5	0.2	0.6	-0.7	-2.2	1.2	-1.2	0.6	-1.0	-0.1	-0.4	-0.4
Hamilton Bank (2J)	-1.0	0.6	0.9	-0.8	1.2	1.0	-0.3	-1.0	-1.7	1.4	-0.2	0.6	-0.6	0.3	-0.5	0.5
St. Anthony Basin (3K)	-0.4	-0.5	-0.4	0.5	0.5	1.6	0.6	-0.1	0.0	0.8	-2.1	-1.4	0.9	1.3	1.1	2.4
Northeast Newfoundland Shelf (3KL)	-0.7	-1.7	-0.1	1.2	1.3	1.0	0.5	-0.1	-0.4	1.0	0.3	-1.6	-0.6	0.5	-0.2	0.9
Northwest Gulf of St. Lawrence (4S)	-0.5	1.2	1.0	0.3	1.6	0.5	0.4	-1.1	-0.7	0.2	-0.3	-0.4	-2.0	-0.9	-2.4	-0.4
Northeast Gulf of St. Lawrence (4RS)	0.0	0.6	1.6	0.6	0.5	1.8	-0.6	-1.1	-0.7	0.0	-0.7	-0.7	-1.4	0.7	-1.2	-0.8
GSL Estuary (4T)	1.2	0.4	1.4	-0.4	-0.8	-0.9	0.2	0.2	-0.9	0.4	-2.0	1.3	0.0	0.5	-0.9	-1.5
Magdalen Shallows (4T)	0.7	-0.7	-0.6	1.1	-0.1	-0.8	0.9		1.0	-0.4	0.3	0.8	-2.3	0.2	-2.1	-2.2
Cabot Strait (3Pn, 4Vn)	-0.7	-1.0	-0.2	1.3	-0.5	0.9	0.8	0.2	-0.7	0.3	1.5	0.2	-2.0	0.8	-2.2	0.1
Avalon Channel (3L)	0.1	-1.0	-0.3	0.0	-0.6	2.1	-0.6	-1.7	0.8	0.7	1.2	-0.3	-0.4	0.7	0.4	0.7
Hibernia (3L)	0.5	-0.9	-0.9	0.7	0.6	-0.3	-1.1	0.6	0.8	0.7	1.8	-0.8	-1.6	1.3	0.0	-2.0
Flemish Pass (3LM)	0.0	-1.2	0.2	0.0	1.6	1.8	-1.1	-0.2	-0.9	0.7	0.7	-0.2	-1.4	0.8	0.5	-0.6
Flemish Cap (3M)						1.5	-0.2	-1.5	0.1	0.5	0.8	0.1	-1.3	1.7	0.6	-0.4
St. Pierre Bank (3Ps)	0.3	1.0	0.1	0.4	-0.1	1.1	0.1	0.2	0.7	0.0	-0.1	-0.8	-2.9	-0.6	-0.1	0.1
Southeast Shoal (3NO)	-0.4	-0.6	-0.5	0.6	0.6	1.7	0.6	-0.3	0.1	1.0	0.5	-2.3	-0.9	-2.5	0.1	0.1
Eastern Scotian Shelf (4Vs)	0.2	-1.0	0.4	1.9	0.5	1.4	0.8	-1.0	0.1	-1.1	-0.9	-0.3	-1.0	0.4	-2.0	1.8
Western Bank (4W)	0.0	-2.6	0.7	-0.6	0.5	0.0	0.6	0.4	-0.5	1.6	0.3	-0.8	0.3	-2.9	0.4	1.6
Central Scotian Shelf (4W)	-0.7	-1.8	1.5	-1.6	0.4	0.8	0.6	0.4	-0.8	0.6	0.5	0.7	-0.6	0.9	0.2	1.1
Western Scotian Shelf (4X)	-0.9	-1.5	0.6	1.7	-0.1	1.6	0.3	-0.1	0.2	-1.2	-1.2	0.5	0.0	0.5		-5.3
Lurcher Shoal (4X)	0.4	0.0	-2.1	0.7	-2.1	0.5	0.7	0.6	0.2	0.3	1.0	-0.5	-1.8			0.0
Georges Bank (5Ze)	0.7	-1.8	-0.5	1.7	-1.7	0.4	0.1	0.6	0.0	0.0	0.4	-0.9	1.0	0.0	0.2	1.8

Figure 20. Composite (sum of anomalies) annual anomalies across the Sub-Arctic (Greenland Shelf, Hudson Strait, Central Labrador Sea); Labrador (LAB) and Newfoundland (NL) Shelf (Northern Labrador Shelf, Labrador Shelf, Hamilton Bank, St. Anthony Basin, northeast Newfoundland Shelf); Gulf of St. Lawrence (NE and NW Gulf of St. Lawrence, Estuary, and Magdalen Shallows, Cabot Strait); Grand Bank (GB) and Flemish Cap (FC) (Avalon Channel, Hibernia, Flemish Pass/Cap, St. Pierre Bank and SE Shoal) and Scotian Shelf (SS) and Gulf of Maine (GoM) (Eastern-Central-Western Scotian Shelf, Western Bank, Lurcher Shoal, Georges Bank) for satellite ocean colour indices during 1998-2013.

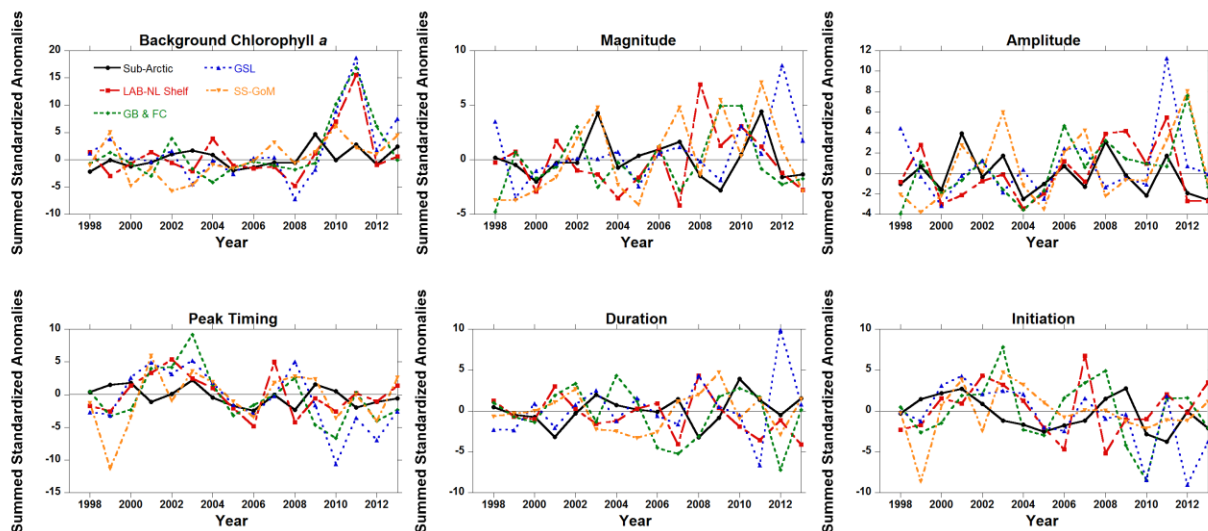


Figure 21. Summary of zooplankton abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2013. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted by latitude from the southern Labrador Shelf - 2J (top) to southern Scotian Shelf - 4X (bottom).

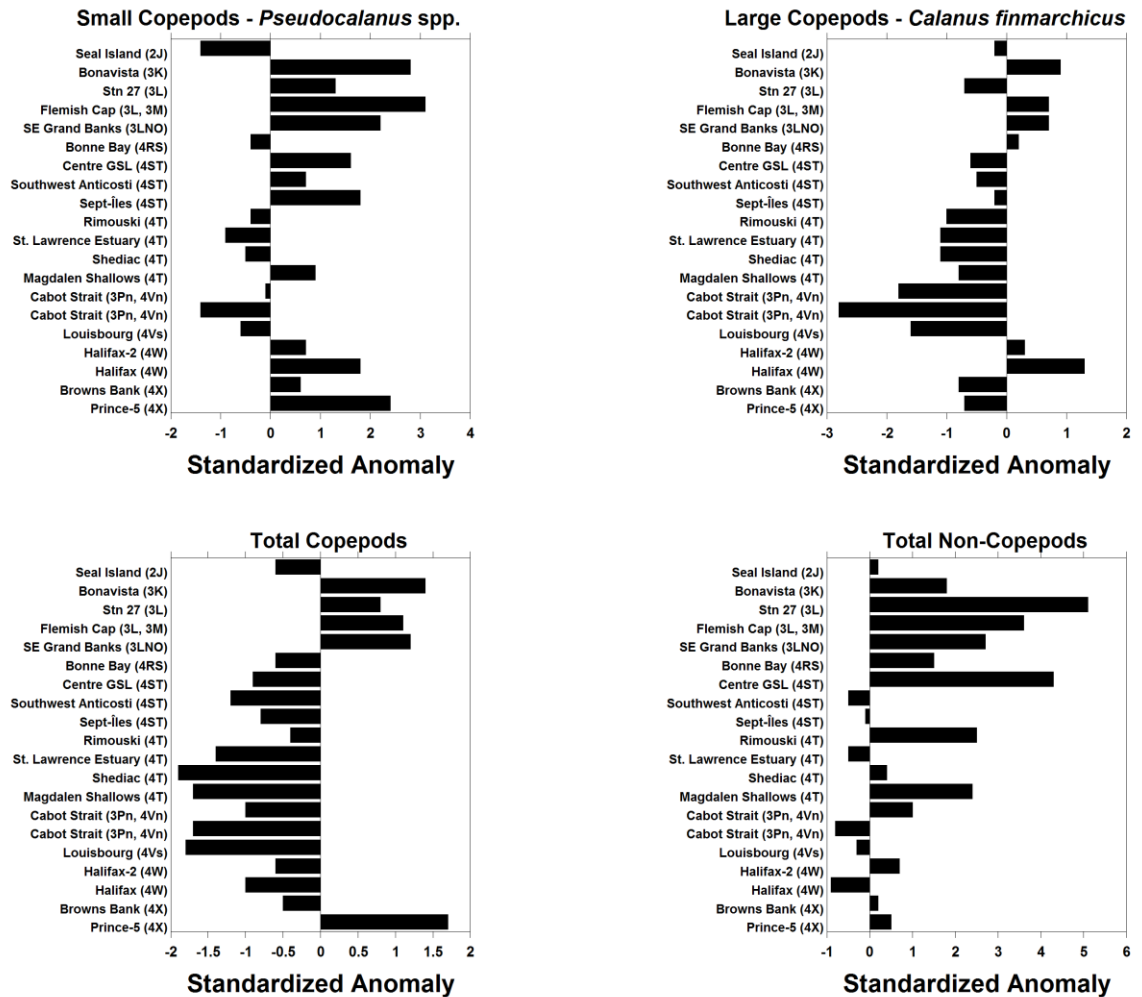


Figure 22. Time series of dominant copepods *Pseudocalanus spp.* (top panel), and *Calanus finmarchicus* (lower panel) abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2013. The copepod abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. A empty white cell indicates missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) Subareas.

<b>Pseudocalanus spp.</b>	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Seal Island (2J)	-0.3	-0.7	0.2	-1.1	0.2	-0.6	-1.2	1.0	2.3	0.4	-0.7	0.6	0.7	0.9	-1.4
Bonavista (3K)	-1.2	-1.8	1.1	0.0	0.5	0.0	-1.0	0.6	-0.5	-0.1	0.9	1.5	-0.6	-0.2	2.8
<b>Stn 27 (3L)</b>	-0.6	0.8	0.3	0.5	0.3	-1.7	-0.2	-0.7	0.5	-1.5	1.7	0.8	0.2	0.2	1.3
Flemish Cap (3L, 3M)	0.0	1.4	-0.3	1.5	-0.5	-0.8	-1.5	0.1	-0.8	-0.6	-0.1	1.6	-1.6	-0.3	3.1
SE Grand Banks (3LNO)	-2.5	1.2	0.6	0.8	-0.6	0.0	0.7	-0.5	0.4	-0.6	0.0	0.6	1.3	-0.7	2.2
Bonne Bay (4RS)		2.4	-1.1	-0.7	-0.8	0.3	-0.5	-0.5	-0.4	0.6	0.7	0.0	0.5	-0.1	-0.4
Centre GSL (4ST)					1.8	-0.1	-1.9	-0.1	0.0	0.0	0.1	0.1	3.2	0.5	1.6
Southwest Anticosti (4ST)		0.9	-1.8	-0.1	-0.9	-0.4	-1.1	0.6	1.4	0.1	0.2	1.2	1.7	-1.4	0.7
Sept-Îles (4ST)		0.3	-1.3	-0.6	-0.9	-0.5	-0.8	0.4	0.5	-0.3	1.0	2.2	0.1	-1.1	1.8
<b>Rimouski (4T)</b>							-1.2	-0.4	0.7	-0.7	0.1	1.5	1.6	-1.1	-0.4
St. Lawrence Estuary (4T)		0.2	-1.3	-1.2	-0.5	1.5	-1.0	1.3	1.1	-0.6	-0.1	0.4	-0.2	-1.1	-0.9
<b>Shediac (4T)</b>	1.3	-0.9	1.9	-0.4	-0.4	-0.6	0.5	-1.5	-0.8	-0.4	0.4	0.8	2.2	-0.2	-0.5
Magdalen Shallows (4T)		0.7	0.3	-1.0	-0.3	0.1	-1.3	0.7	-1.2	-0.5	0.5	2.0	0.2	-0.5	0.9
Cabot Strait (3Pn, 4Vn)		1.0	-1.4	-1.1	-0.2	1.1	0.2	0.5	-1.2	0.1	-0.6	1.6	0.8	-1.1	-0.1
Cabot Strait (3Pn, 4Vn)	0.7	-1.4	-0.6		2.1	-0.2	-0.3	-0.6	-0.3	0.6	-1.0	0.8	-1.3	-1.5	-1.4
Louisbourg (4Vs)	2.4	-1.1	0.7	1.2	0.0	-0.5	-0.8	-0.1	-0.6	0.3	-0.8	-0.6	-0.9	-1.7	-0.6
<b>Halifax-2 (4W)</b>	1.6	0.5	0.1	-0.3	1.0	1.1	0.0	-1.7	-1.2	0.5	-0.5	-1.0	-1.5	-2.0	0.7
Halifax (4W)	1.7	0.8	0.6	1.0	0.5	-0.5	0.0	-1.9	-0.9	0.0	-0.2	-1.1	-1.2	-0.4	1.8
Browns Bank (4X)	1.2	0.0	2.1	0.4	1.4	-0.7	-0.6	-0.8	-0.8	0.1	-0.9	-0.8	-1.2	-0.2	0.6
<b>Prince-5 (4X)</b>	-0.1	0.5	2.3	0.2	0.1	-0.7	-0.8	-1.1	-0.3	0.8	-1.5	0.7	-0.8	-0.8	2.4
<b>Calanus finmarchicus</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
Seal Island (2J)	-0.5	-2.1	-1.0	-0.2	0.1	1.6	1.2	0.7	0.8	-0.3	-0.5	0.3	0.2	-0.4	-0.2
Bonavista (3K)	-1.6	-2.1	-0.1	-0.2	0.3	0.6	-0.1	1.3	0.2	-0.1	0.4	1.2	-0.6	-0.6	0.9
<b>Stn 27 (3L)</b>	1.0	0.4	0.2	0.5	0.0	-0.7	-0.1	-0.1	-0.2	-2.7	0.3	1.3	0.5	-0.3	-0.7
Flemish Cap (3L, 3M)	-1.4	-2.3	0.7	0.7	-0.5	-0.1	0.3	1.0	0.1	0.1	0.1	1.2	0.5	1.0	0.7
SE Grand Banks (3LNO)	-2.4	-1.8	0.4	0.5	0.4	0.4	0.7	0.2	0.4	0.3	0.3	0.6	0.8	0.6	0.7
Bonne Bay (4RS)		-0.3	-0.7	-0.3	-0.6	1.5	0.1	-1.0	0.7	2.0	-0.7	-0.7	-0.2	0.5	0.2
Centre GSL (4ST)					1.8	-0.5	-0.6	-0.4	1.3	-0.1	-0.5	-0.9	-0.7	-0.1	-0.6
Southwest Anticosti (4ST)		-0.2	-0.8	-0.4	0.0	-0.3	-0.5	2.7	0.9	-0.3	-0.6	-0.6	-0.6	-0.2	-0.5
Sept-Îles (4ST)		0.1	-0.8	-0.7	1.1	0.0	-0.8	2.1	1.1	-0.5	-0.8	-0.8	-0.7	-0.7	-0.2
<b>Rimouski (4T)</b>							-0.9	0.0	1.8	0.3	-0.2	-0.9	-0.8	-0.6	-1.0
St. Lawrence Estuary (4T)		-0.1	-0.7	0.3	0.4	0.0	-0.2	-0.2	2.7	-0.2	-0.7	-1.2	-1.1	-1.0	-1.1
<b>Shediac (4T)</b>	-0.6	-0.3	-0.2	-0.4	2.4	1.3	-0.6	0.2	-0.4	0.5	-1.0	-1.0	-1.0	-0.3	-1.1
Magdalen Shallows (4T)		-1.4	0.5	0.9	0.0	0.4	-1.1	0.9	0.1	1.7	-1.0	-1.0	-1.5	0.4	-0.8
Cabot Strait (3Pn, 4Vn)		1.4	-1.1	0.3	0.0	1.9	-0.3	0.6	-0.2	-0.3	-1.1	-1.1	0.5	-0.7	-1.8
Cabot Strait (3Pn, 4Vn)	1.5	-1.1	-1.1		1.5	-0.2	0.1	-0.3	0.9	-0.5	-1.2	0.5	-2.9	-3.0	-2.8
Louisbourg (4Vs)	1.4	-1.0	-0.8	-1.6	-1.1	-0.2	-0.6	-0.3	-0.6	1.0	-0.5	1.1	-1.1	-1.9	-1.6
<b>Halifax-2 (4W)</b>	0.9	0.7	1.8	-0.2	0.4	-0.9	-1.2	-0.8	-0.3	1.0	-1.6	0.2	-2.6	-3.6	0.3
Halifax (4W)	0.8	-0.2	-0.1	-1.8	0.3	-1.0	0.9	0.6	-1.4	0.3	1.7	-0.1	-1.1	-2.6	1.3
Browns Bank (4X)	0.0	-1.0	0.7	-0.6	1.7	-1.1	-1.0	0.6	-1.1	1.1	0.5	-1.1	-1.5	-1.4	-0.8
<b>Prince-5 (4X)</b>	-1.2	-1.1	1.4	-1.1	0.6	0.0	0.6	1.9	-0.7	0.0	0.2	-0.5	-0.1	-1.1	-0.7

Figure 23. Time series of total copepod (top panel) and non-copepod (lower panel) abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2013. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. A grey cell indicates missing data; a blue cell indicates lower than normal levels and a red cell indicates higher than normal levels. More intense colours indicate larger anomalies. The numbers in the coloured cells are the differences from the long-term mean (1999-2010) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) Subareas.

<b>Copepods</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
Seal Island (2J)	-0.9	-2.0	-0.9	0.0	0.4	1.5	1.2	1.2	0.2	-0.3	-0.5	0.1	0.2	-0.7	-0.6
Bonavista (3K)	-1.8	-1.7	-0.4	-0.7	0.5	0.3	-0.3	1.2	0.5	0.4	0.8	1.1	0.0	-1.2	1.4
<b>Stn 27 (3L)</b>	-0.5	0.3	-0.5	0.5	0.2	-1.2	0.0	-1.2	0.4	-1.2	2.1	1.1	1.1	-0.3	0.8
Flemish Cap (3L, 3M)	-1.5	-1.3	0.0	-0.4	-0.9	-0.5	0.4	1.1	0.2	0.4	0.5	2.0	0.2	0.8	1.1
SE Grand Banks (3LNO)	-2.6	0.4	-1.0	0.0	-0.1	0.1	1.0	-0.3	0.7	0.1	0.8	1.0	1.5	1.0	1.2
Bonne Bay (4RS)		1.1	-1.8	-0.1	-0.6	1.8	-0.4	-1.2	0.2	0.5	0.4	0.0	0.7	-0.3	-0.6
Centre GSL (4ST)					1.5	-0.7	-1.3	-0.7	0.2	-0.1	-0.2	1.4	0.5	-0.3	-0.9
Southwest Anticosti (4ST)		-0.2	-1.6	-0.4	-0.9	-0.6	-0.5	2.1	0.0	0.9	0.4	0.8	0.0	-0.9	-1.2
Sept-Îles (4ST)		1.0	-1.3	-1.1	-1.0	-0.7	-0.7	0.9	0.2	0.8	0.2	1.6	-0.3	-1.4	-0.8
<b>Rimouski (4T)</b>							-1.5	-0.7	0.9	0.0	1.1	0.2	1.3	-0.4	-0.4
St. Lawrence Estuary (4T)		-0.4	-1.6	-1.2	-1.3	0.0	0.9	0.5	1.3	0.5	0.5	0.9	-0.6	-1.6	-1.4
<b>Shediac (4T)</b>	0.7	-0.9	-0.1	-0.4	0.1	-0.7	-0.3	-0.6	0.3	2.8	-0.6	-0.3	0.4	-0.5	-1.9
Magdalen Shallows (4T)		-0.7	-0.3	0.5	-0.8	-0.7	-1.8	1.0	-0.2	1.6	1.1	0.3	0.0	0.2	-1.7
Cabot Strait (3Pn, 4Vn)		1.6	-2.2	0.1	-0.2	0.4	-0.7	1.1	-0.3	0.7	-0.5	-0.1	0.4	-1.0	-1.0
Cabot Strait (3Pn, 4Vn)	1.5	-1.2	-1.0		1.1	0.2	0.2	-1.0	-0.4	-0.1	-0.7	1.4	-1.7	-1.0	-1.7
Louisbourg (4Vs)	2.7	-0.7	0.1	-0.9	0.3	-0.6	0.0	0.2	-0.8	0.6	-0.8	-0.1	-0.8	-0.6	-1.8
<b>Halifax-2 (4W)</b>	2.0	0.9	0.6	-1.4	0.0	0.1	0.6	-1.0	-1.4	-0.3	0.4	-0.7	-0.9	-1.4	-0.6
Halifax (4W)	2.3	0.8	0.0	-0.9	-0.4	-1.2	1.1	-0.7	-0.5	-0.7	0.3	-0.1	-0.9	-0.9	-1.0
Browns Bank (4X)	1.5	1.3	0.4	0.1	1.3	-1.3	-0.5	-0.2	-1.1	0.5	-0.6	-1.3	-1.5	-0.1	-0.5
<b>Prince-5 (4X)</b>	-0.1	1.2	1.6	-0.8	0.5	-0.2	-1.3	0.7	-1.0	-0.4	-1.3	1.1	-0.8	0.8	1.7
<b>Non-copepods</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>
Seal Island (2J)	-1.6	-0.8	-0.2	-0.7	-0.1	1.2	0.9	2.0	0.1	-0.9	0.0	0.2	0.2	-1.0	0.2
Bonavista (3K)	-1.5	-1.9	0.2	0.1	0.3	-0.4	-0.2	1.6	0.0	-0.4	1.1	1.1	-0.4	-0.7	1.8
<b>Stn 27 (3L)</b>	-1.5	1.3	0.0	0.7	0.7	0.2	0.6	-0.9	0.3	-1.8	-0.6	1.1	0.9	1.9	5.1
Flemish Cap (3L, 3M)	-1.9	0.1	0.3	0.7	-0.8	-0.9	0.0	0.3	-0.4	0.2	0.1	2.2	0.6	1.9	3.6
SE Grand Banks (3LNO)	-2.6	1.4	0.3	0.1	0.0	-0.4	0.5	0.0	-0.4	-0.1	0.0	1.2	0.5	1.0	2.7
Bonne Bay (4RS)		0.9	-1.7	0.3	-1.6	0.3	0.9	1.6	0.1	0.0	0.0	-0.7	7.9	1.0	1.5
Centre GSL (4ST)					-1.7	-0.1	0.3	1.5	1.1	-0.1	-0.6	-0.4	3.8	-0.3	4.3
Southwest Anticosti (4ST)		-0.5	-0.8	-0.7	-0.7	-0.7	-0.6	0.8	2.2	1.4	0.0	-0.3	1.5	0.2	-0.5
Sept-Îles (4ST)		-0.7	-0.8	-0.8	-0.1	-0.7	-0.6	2.3	1.4	0.1	-0.2	0.1	1.5	-0.5	-0.1
<b>Rimouski (4T)</b>							-1.0	-0.7	1.3	-1.0	0.5	0.9	1.9	-1.1	2.5
St. Lawrence Estuary (4T)		-0.4	-0.6	-0.6	0.4	-0.5	-0.6	0.0	2.9	-0.4	-0.1	-0.1	-0.4	-0.4	-0.5
<b>Shediac (4T)</b>	2.1	-1.1	0.6	-0.2	-1.2	-0.8	0.9	0.3	0.0	0.9	-1.0	-0.5	0.3	4.6	0.4
Magdalen Shallows (4T)		-0.7	-0.9	-0.3	-0.7	-0.8	0.5	-0.2	0.1	-0.1	0.2	2.7	1.9	1.7	2.4
Cabot Strait (3Pn, 4Vn)		-1.0	-1.2	-1.0	-0.8	0.1	1.8	0.9	1.3	-0.1	0.2	-0.2	2.6	-0.8	1.0
Cabot Strait (3Pn, 4Vn)	1.1	-1.1	-0.8		0.5	1.5	-0.6	0.2	-1.3	-0.5	-0.5	1.5	0.7	-0.9	-0.8
Louisbourg (4Vs)	0.7	-1.0	1.7	-0.6	-1.0	-0.3	0.0	1.4	-1.0	0.6	-0.9	-1.0	0.2	-1.3	-0.3
<b>Halifax-2 (4W)</b>	2.8	0.3	-0.1	-0.9	-0.2	0.2	0.6	-0.6	-0.9	0.0	-0.3	-0.8	1.1	0.3	0.7
Halifax (4W)	2.4	0.7	-0.8	-0.1	0.3	-0.4	1.1	-1.0	-0.8	0.2	-0.6	-0.9	-0.3	-0.1	-0.9
Browns Bank (4X)	2.0	0.7	-0.5	-0.4	1.4	-1.0	0.6	-1.0	-1.0	0.1	-0.8	-0.2	-1.3	-0.4	0.2
<b>Prince-5 (4X)</b>	1.2	1.0	0.6	0.2	-1.1	0.0	-1.6	-0.5	-0.2	-0.4	-1.0	1.7	-1.4	2.5	0.5

Figure 24. Composite sums of annual anomalies across the Labrador and northeast Newfoundland Shelf (LAB-NL Shelf), Grand Bank-Flemish Cap (GB-FC), Gulf of St. Lawrence (GSL), and Scotian Shelf – Gulf of Maine (SS-GoM) for the different functional zooplankton abundance indices during 1999-2013.

