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Biological and Chemical Oceanographic Conditions on the Newfoundland and Labrador Shelf, Grand Banks, Scotian Shelf, and the Gulf of Maine During 2011

by

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Abstract

Biological and chemical variables collected in 2011 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 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 information concerning the interannual variations in inventories of nutrients (nitrate), chlorophyll *a* and indices of the spring bloom inferred from satellite imagery, as well as the abundance of major taxa of zooplankton collected as part of the 2011 Atlantic Zone Monitoring Program (AZMP). In general, nitrate inventories in NAFO Subareas 2 and 3 were above normal within the upper 50m, consistent with data further south in Subareas 4 in 2011. In contrast, the deeper inventories of nitrate that represent the main limiting nutrient for the following year showed a large reduction in 2011 across the entire zone compared to previous years. The nutrient anomaly and composite time series for the NAFO Subareas show large interannual and spatial variability throughout the 13-year record. Ship-based observations of phytoplankton standing stock along ocean transects, which provides sub-surface information, revealed enhanced levels along the eastern and central Scotian Shelf while the Newfoundland and Labrador Shelf had lower chlorophyll *a* inventories in 2011. The duration of the spring bloom was mostly reduced along the northwest Atlantic in 2011 with few exceptions. The timing of the spring bloom varied across the NAFO Subareas with near-normal conditions in the northern areas (2J, 3K), delayed blooms across the northern Grand Banks (3L-3M), to earlier blooms observed from the southern Grand Banks to the central Scotian Shelf (3L to 4W) in 2011. Enhanced abundances of large and small copepods as well as total copepod zooplankton were observed for the northern Subareas in 2011 with 1 to 2 standard deviation units above normal in the 13-year time series. Negative trends in abundance of these same functional zooplankton groups were observed across the Scotian Shelf in 2011 on the order of 1 to 3 standard deviation units below normal. The zooplankton dry weight anomalies were below normal across NAFO Subareas 2 to 4 in 2011. This was particularly apparent across the Scotian Shelf with large negative anomalies. The composite indices summing each of the zooplankton abundance indices across the NAFO Subareas revealed some contrasting patterns during the available time series.

Introduction

We review biological and chemical oceanographic conditions on the Newfoundland and Labrador Shelves, Grand Banks, Scotian Shelf, and in the Bay of Fundy and Gulf of Maine during 2011, and reference earlier periods when data were 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[1]) and the completion of seasonal oceanographic surveys during 2011 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 Shelf, Grand Banks, Scotian Shelf, and the Gulf of Maine in 2011 and recent years can be found in Pepin *et al*. (2012) and Johnson *et al*. (2012).

Methods

Collections of standard AZMP variables are based on sampling protocols outlined by Mitchell *et al*. (2002). Observations for 2011 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/). Technical problems encountered with the MODIS sensor developed in 2011 and corrections to the data products were not available for inclusion in the report this year. The main technical problem was linked to signal degradation of the sensor during 2011 and likely resulted in underestimation of ocean colour. 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 surface chlorophyll for the entire NW Atlantic (39-62.5° N Latitude 42-71° W Longitude) were routinely produced from SeaWiFS/MODIS data[2]. Basic statistics (mean, range, standard deviation, etc.) were extracted from the composites for selected sub-regions as shown in Figure 1. We constructed an ocean colour time series from 1998 to 2011 using data from both satellite sensors and averaging during the overlap period from 2003 to 2007.

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 – 2011) and unit standard deviation ([observation – mean]/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/later 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* (excluded for 2011), chl*a* biomass (excluded for 2011), duration and timing of the peak of the spring bloom, and zooplankton abundance (*Calanus finmarchicus, Pseudocalanus spp*., total copepods, and total non-copepod zooplankton) and biomass (dry weight) for the AZMP fixed stations and seasonal transect surveys.

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

Based on the available data, the upper water-column nitrate inventories were generally above normal from the Grand Banks extending down to the Scotian Shelf, with near-normal levels observed in the northeast Newfoundland Shelf (3K) and southern Labrador Shelf (2J) in 2011 (Figure 2). The trend in anomalies of the deep nitrate inventories, a measure of what is available to fuel the base of the marine food chain in the subsequent year, were generally negative across the NAFO Subareas in 2011. The chl*a* inventories inferred from the dedicated seasonal oceanographic surveys, which provides an index of phytoplankton biomass throughout the water-column, were below normal over much of the northern Subareas (2J to 3LNO) and southern extent of the Scotian Shelf in 4X,

[1] http://www.meds-sdmm.dfo-mpo.gc.ca/zmp/main_zmp_e.html
[2] (http://www.mar.dfo.mpo.gc.ca/science/ocean/ias/seawifs/seawifs_1.html)

while the pattern was reversed across the eastern and central Scotian Shelf (Figure 2). In general, the annual trends in nitrate inventories in the upper 50m layer have increased in 2011 compared to recent years which showed below normal levels across the NAFO Subareas (Figure 3). The annual trends in deep nitrate inventories have remained well below normal during 2009-2011, particularly along the northern Subareas. The annual trends in chl*a* inventories were below normal from the Grand Banks (3L, 3M) up to the southern Labrador Shelf (2J) in comparison to previous years that were near normal across the NAFO Subareas (Figure 3). Overall, large interannual and spatial variability in nitrate and chl*a* inventories are apparent throughout the time series (Figure 3). We also examined the trends in composite summed anomalies across the Newfoundland and Labrador Shelves (NL/LAB) and Scotian Shelf (SS) during the 13-year time series (Figure 4). The composite index for the upper water-column nitrate inventories exhibited high interannual variability and were mostly out of phase between NL/LAB and SS Subareas (Figure 4). Large year to year changes were also noted in the composite deep nitrate inventories across the SS Subarea in contrast to lower variability observed in the NL/LAB Subareas. We observed a downward trend in the summed anomalies for chl*a* inventories across the SS Subareas during 1999 to 2006, and they varied nearly in phase with the composite trends in the NL/LAB Subareas thereafter (Figure 4).

Given the technical difficulties encountered with the MODIS sensor, we were unable to compute the standardized anomalies of standing stock (background and chl*a* biomass) of phytoplankton in 2011. We felt more confident in the timing indices based on the satellite data. The duration of the spring production cycle revealed shorter blooms in the northern Subareas across the Newfoundland and Labrador Shelves while the Scotian Shelf showed variable results in 2011. Significant coherent changes in the timing of the production cycle observed in 2010 were not apparent during 2011. The timing of the peak spring bloom inferred from satellite imagery varied throughout the Subareas in 2011 with northern areas (3K and north) near-normal, later blooms across the northeast Shelf and northern Grand Banks, and substantially earlier blooms on the southern Grand Banks and Scotian Shelf (Figure 5). Work is currently underway to assess the extent of the MODIS sensor degradation on estimation of chlorophyll *a* concentrations but the re-analysis of the data for this time period is not yet available.

The standardized time series anomalies inferred from satellite imagery showed interannual variability in average background chl*a* levels with some regional coherence across the NAFO Subareas (Figure 6). The duration of the production cycle showed a large degree of variability in both the spatial and temporal scales with both large negative and positive anomalies during the 13-year time series (Figure 8). The duration of the spring bloom was typically shorter in northern Subareas compared to longer periods observed in the southern regions in recent years. The timing of the peak spring bloom revealed a coherent shift to earlier timing across Subarea 0B to 4X with only a few exceptions in 2010. In 2011, we also observed a similar shift to earlier spring blooms along the southern Grand Banks and Scotian Shelf but this was not apparent in the northern Subareas (Figure 9). We developed similar composite indices for each of the ocean colour metrics by summing all of the annual SeaWiFS/MODIS anomalies across the northern (NL/LAB) and southern (SS/GoM) NAFO Subareas to evaluate annual trends during the 13-year series. The composite index for background chl*a* across both Subareas declined steadily during the first decade (1998-2008) until an abrupt increase was observed in 2009-2010 (Figure 10). In contrast, the composite chl*a* biomass anomalies generally increased during the time series. The duration and peak timing composite anomalies varied throughout the time series with no apparent overall trend (Figure 10). One of the notable trends in all of the composite satellite indices was the tight coupling between the northern and southern Subareas which suggests the importance of large-scale physical forcing.

The principal zooplankton indices indicated that abundance was generally higher than average on the Grand Banks to the southern Labrador Shelf (2J-3K), with positive anomalies of large Calanoid and small copepods in most parts of these areas in 2011 (Figure 11). The other copepod groups represented by "total copepods" were most abundant on the Grand Banks and only slightly above normal on the northeast Newfoundland and southern Labrador Shelf in 2011. There was evidence of a north-to-south gradient in the anomalies of these zooplankton groups in 2011, with a clear shift to negative anomalies on the oceanographic transects and at fixed stations south of the Grand Banks. The pattern of anomalies for the non-copepod taxa was variable across the Subareas in 2011 in contrast to the copepod taxa (Figure 11). The anomalies for the non-copepods were generally positive across the southern Grand Banks, Eastern and Central Scotian Shelf while large negative anomalies were noted for the southern extent of Subarea 4.

Although many of the zooplankton abundance indices reached their highest levels in 2010-2011 in the northern Subareas, the time series of anomalies indicated relatively weak secondary production during 2000 through 2009 (Figure 12). We observed near-record levels of all zooplankton abundance indices in 1999 along the southern

Subareas (Scotian Shelf) while the conditions in the northern Subareas (Grand Banks and northeast Newfoundland Shelf) were substantially below normal (Figure 12). We detected a negative gradient in zooplankton dry weight anomalies extending southwards across the Subareas in 2011 with near-normal levels in the north and low levels across the Scotian Shelf (Figure 13). The time series of zooplankton dry weight anomalies indicated low biomass in the early (1999-2000) and later (2008, 2011) years with a period of high abundance during 2001-2004 (Figure 14). The composite indices summing each of the zooplankton abundance indices across the NL/LAB and SS Subareas revealed some contrasting patterns during the time series. The composite anomalies for the large copepods were at its lowest level in 2011 on the SS compared to the highest level on the NL/LAB Subareas (Figure 15). In addition, we observed a steady decline in the composite anomalies for small copepods on the SS from 1999 to 2011 while more stable levels in the NL/LAB Subarea. The composite anomalies for total copepods showed an upward trend on the NL/LAB in contrast to a downward trend on the SS Subarea during the 13-year time series (Figure 15). The composite values for the non-copepods were relatively stable throughout the time record for both Subareas. The composite dry weight anomalies on the SS have declined steadily from 1999 and reached a record low in 2011 (Figure 16). This may be related to the reduction in both abundant large and small copepods observed on the SS during the monitoring program that typically make up a large proportion of the total biomass. Composite anomalies for zooplankton dry weight on the NL/LAB Subarea were mostly positive during 2002 to 2007 with large negative levels observed in 1999-2000 and again in 2008 (Figure 16).

Although the chemical and biological time series are becoming invaluable in detecting trends and changes in the lower trophic levels along both spatial and temporal scales, there remains considerable uncertainty in the estimates of nutrient inventories and overall abundance of phytoplankton and zooplankton. This uncertainty is related to variation in water masses, and the short life histories of phytoplankton and zooplankton along with their patchy distribution, and by the limited coverage of the NAFO Subareas by the environmental monitoring program.

Biological and Chemical Highlights

- Nitrate inventories were generally above normal within the upper 50m from the Grand Banks extending down to the Scotian Shelf, with near-normal levels observed in the northeast Shelf and southern Labrador Shelf in 2011.
- In contrast, the deeper inventories of nitrate that represent the main limiting nutrient for the following year showed a large reduction in 2011 across the entire zone compared to previous records.
- Overall, large interannual and spatial variability in nutrient levels are apparent during the time series from 1999-2011.
- Seasonal monitoring of ocean transects and coastal stations, which provide information throughout the water column, revealed enhanced phytoplankton standing stocks along the eastern and central Scotian Shelf, in contrast to the information from satellites, with lower inventories on the Newfoundland and Labrador Shelves in 2011.

Biological and Chemical Highlights

- We observed a high degree of similarity in the timing of the spring bloom off Labrador, northeast Newfoundland Shelf, and the Scotian Shelf in 2011 which supports the importance of regional forcing conditions on the production cycle.
- The duration of the spring bloom was shorter than normal along NAFO Subareas 2 to 4 in 2011 but with some notable exceptions including the southwest portion of the Grand Banks and Central Scotian Shelf with prolonged bloom periods.
- One of the notable trends in all of the composite satellite indices was the tight coupling between the northern and southern Subareas which suggests the importance of large-scale physical forcing.

- Enhanced abundance of large and small copepods as well as total copepod zooplankton was observed for the northern Subareas in 2011 with 1 to 2+ standard deviation units above normal in the 13-year time series.

- Negative trends in abundance of these same functional zooplankton groups were observed across the Scotian Shelf in 2011 on the order of 1 to 3 standard deviation units below normal.

- The zooplankton dry weight anomalies were below normal across NAFO Subareas 2 to 4 in 2011.

Acknowledgements

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Figure 1. Location of the NAFO Regulatory Areas (white boxes) and standard Atlantic Zone Monitoring Program 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, NLS=northern Labrador Shelf, HB=Hamilton Bank (Seal Island), SAB=St. Anthony Basin, NENS=northeast Newfoundland Shelf, AC=Avalon Channel, CS=Cabot Strait, FP=Flemish Pass, HIB=Hibernia, SPB=St. Pierre Bank, SES=southeast Shoal, ESS=eastern Scotian Shelf, WB=Western Bank, CSS=central Scotian Shelf, WSS=western Scotian Shelf, LS=Lurcher Shoal, GB=Georges Bank.

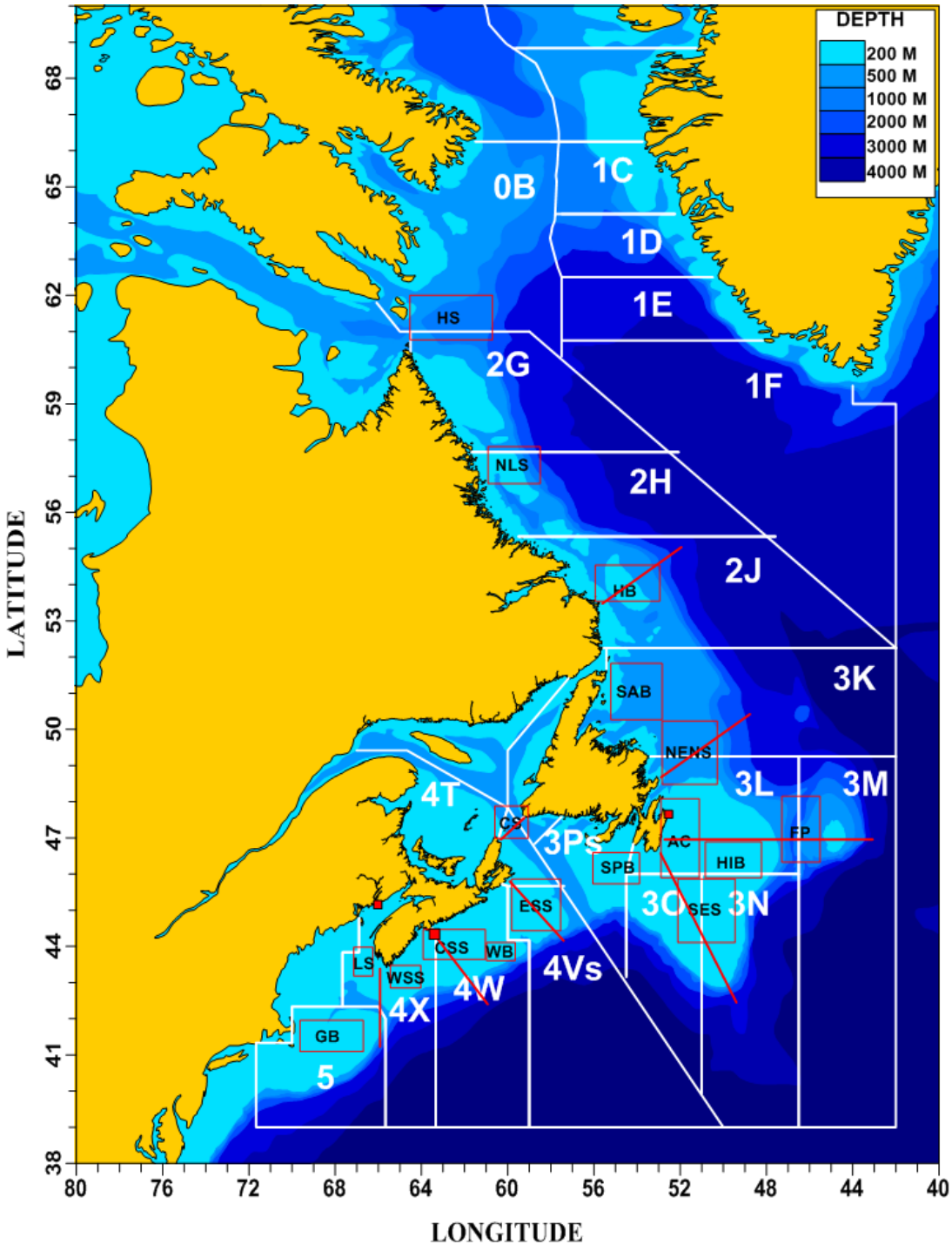


Figure 2. Summary of nitrate (combined nitrate and nitrite which represents the principal limiting nutrient in the system) and chlorophyll *a* anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2011. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1999-2011) divided by the standard deviation. The nutrient and chlorophyll 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.

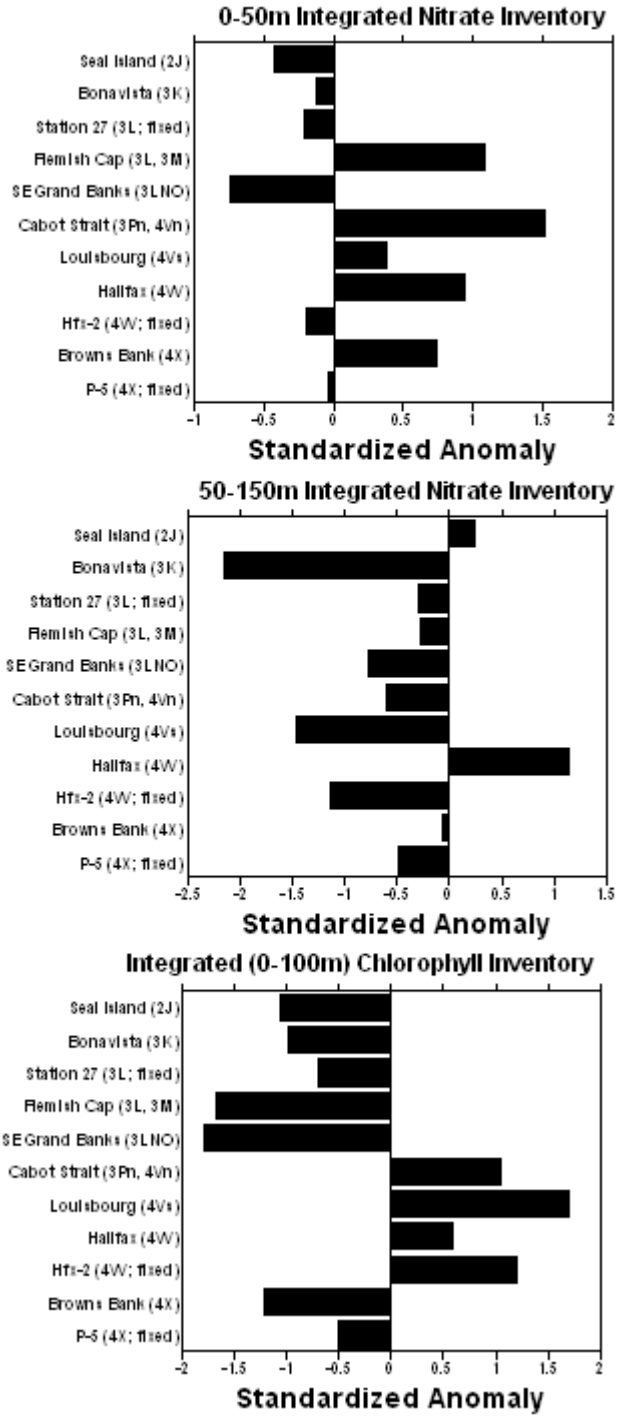


Figure 3. Time series of nutrient (combined nitrite and nitrate) and chlorophyll *a* anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2011. The nutrient and chlorophyll anomalies for transects were calculated using a general linear 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 in the annual average value from the long-term mean (1999-2011) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

Index	Section ID	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Nitrate Inventory	Seal Island (2J)		-0.35	0.17	0.63		1.87	0.43	-1.64	0.84	-1.26	0.41	-0.69	-0.42
0-50m	Bonavista (3K)		-0.61	-0.53	1.44	1.66	0.47	-0.31	-1.67	1.24	-0.44	-0.64	-0.49	-0.13
	Station 27 (3L; fixed)		0.07	-0.03	-0.34	0.20	0.04	0.13	-0.18	0.33	0.12	-0.25	-0.81	-0.21
	Flemish Cap (3L, 3M)		-0.95	0.09	0.98	1.90	0.40	-0.77	-0.44	0.51	-0.58	-0.67	-1.54	1.08
	SE Grand Banks (3LNO)		-0.40	-0.03	0.34	2.51	0.76	-0.47	-1.01	0.75	-0.02	-0.63	-1.05	-0.74
	Cabot Strait (3Pn, 4Vn)	1.52	-1.57	-0.91		-1.09	-0.41	0.42	-0.07	1.04	1.27	0.16	-0.36	1.51
	Louisbourg (4Vs)	1.78	-0.69	-1.17		0.48	-0.37	-0.28	0.65	0.93	0.59	0.02		0.38
	Halifax (4W)	2.03	-0.82	0.14		-0.68	-0.73	-0.30	0.11	-0.40	1.77	-0.31	0.41	0.94
	Hfx-2 (4W; fixed)	-2.18	1.16	1.25	-0.74	-0.19	0.09	-0.58	0.28	0.19	1.19	0.39	-0.87	-0.19
	Browns Bank (4X)	0.08	-0.58	-0.84		0.67	-0.34	0.15	0.27	-1.78	1.98	1.17		0.74
	P-5 (4X; fixed)	-1.01	-0.49	-0.59	0.72	1.13	0.06	-0.88	1.44	-0.40	0.09	1.49	-1.54	-0.04
	Section ID	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	Seal Island (2J)		0.43	0.33	0.37		0.78	0.46	0.38	1.20	-1.57	-0.52	-2.09	0.25
Nitrate Inventory	Bonavista (3K)		0.75	-0.88	0.11	0.86	0.86	0.37	0.71	1.09	-0.17	-0.32	-1.24	-2.16
50-150m	Station 27 (3L; fixed)		0.65	-0.22	0.09	-0.18	-0.12	-0.15	-0.10	0.34	0.37	-0.23	-0.67	-0.29
	Flemish Cap (3L, 3M)		0.60	-0.21	-0.97	0.99	0.09	0.35	1.70	0.95	-0.31	-1.08	-1.85	-0.27
	SE Grand Banks (3LNO)		-0.35	-0.44	1.22	0.41	1.34	0.62	1.04	0.16	-0.25	-2.06	-0.93	-0.77
	Cabot Strait (3Pn, 4Vn)	-0.02	1.73	-0.92		-0.12	1.24	-0.68	0.11	-1.27	0.62	1.16	-1.13	-0.60
	Louisbourg (4Vs)	0.48	1.55	-1.28		0.70	-0.61	0.45	0.37	-1.91	-0.11	0.39		-1.46
	Halifax (4W)	0.42	0.65	-0.14		-0.10	-0.77	-1.98	0.46	-1.11	1.09	1.48	0.73	1.14
	Hfx-2 (4W; fixed)	-0.66	0.80	-0.83	0.15	1.49	-0.76	-1.06	1.71	-0.68	-0.30	1.03	-0.88	-1.14
	Browns Bank (4X)	-1.96	-0.21	0.12		1.21	1.13	-0.45	0.23	-1.02	-0.09	0.91		-0.06
	P-5 (4X; fixed)	-0.84	-0.45	-1.26	0.88	1.07	-0.31	-0.60	1.12	-0.43	0.42	1.69	-1.28	-0.48
	Section ID	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	Seal Island (2J)		0.73	1.96	0.76	-1.00	-0.35	0.29	0.74	-1.26	-0.76	0.70	-0.72	-1.07
Chlorophyll *a* Inventory	Bonavista (3K)		1.25	0.08	-1.23	-1.60	0.47	0.51	0.65	0.36	-0.91	1.58	-0.18	-0.99
	Station 27 (3L; fixed)	1.89	0.50	0.30	0.01	-0.30	0.14	-0.28	0.04	-0.13	-0.49	-0.12	-0.04	-0.69
	Flemish Cap (3L, 3M)		0.38	0.09	-0.73	-1.63	0.30	1.29	-0.37	1.00	-0.23	1.37	0.22	-1.67
	SE Grand Banks (3LNO)		-1.25	0.78	0.20	-0.76	0.12	-0.47	-0.37	1.61	1.36	0.22	0.36	-1.79
	Cabot Strait (3Pn, 4Vn)	0.85	0.99	-0.75		-0.04	-0.39	-0.72	-1.25	-0.09	-0.40	0.07	-0.68	1.05
	Louisbourg (4Vs)	1.05	0.45	-0.43		1.85	-0.35	-0.29	-1.47	-0.03	-0.21	0.40		1.69
	Halifax (4W)	-0.49	0.44	-0.47		0.37	-0.49	0.23	-2.14	1.65	0.73	0.38	0.86	0.59
	Hfx-2 (4W; fixed)	2.58	0.75	0.48	-0.23	0.37	-0.56	-0.54	-1.15	-0.82	-0.86	-0.10	0.07	1.20
	Browns Bank (4X)	1.20	-0.52	0.10		1.93	-1.28	-0.87	-0.63	0.92	0.07	0.54		-1.21
	P-5 (4X; fixed)	1.38	1.68	0.56	0.19	-0.58	0.21	-0.82	-1.23	-0.47	-1.07	-0.90	1.07	-0.50

Figure 4. Composite sums of annual anomalies across the Newfoundland and Labrador Subareas (NL/LAB) and Scotian Shelf (SS) for shallow and deep nitrate and chlorophyll *a* inventories during 1999-2011.

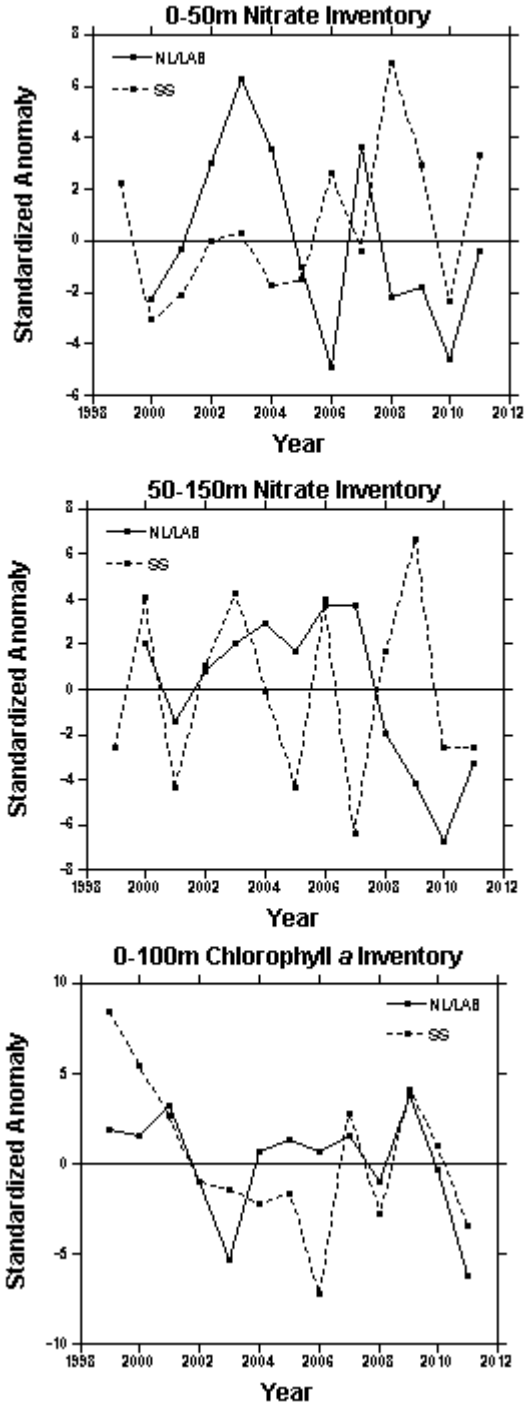
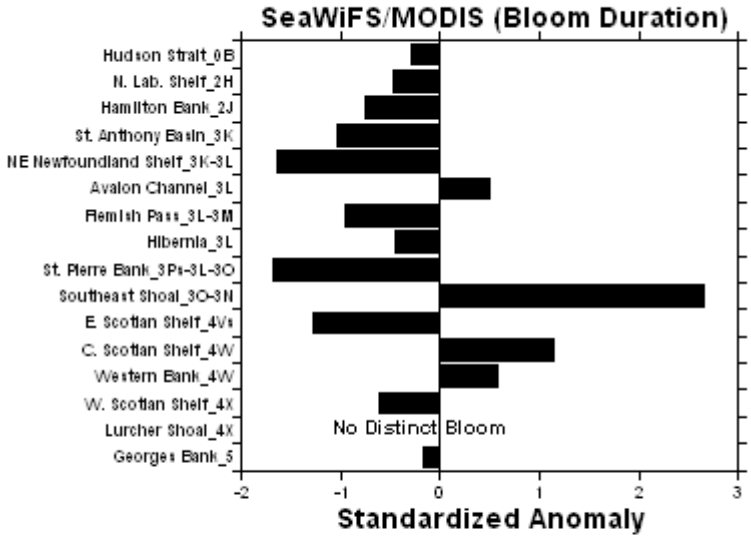


Figure 5. Summary of ocean colour anomalies from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) "Aqua" sensor imagery across the different statistical sub-regions during 2011. The standardized anomalies are the differences between the annual average for a given year and the long-term mean (1998-2011) divided by the standard deviation. We excluded the 2011 results for background and chlorophyll *a* biomass due to technical difficulties with the MODIS sensor. The ocean colour 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 from northern (top) to southern (bottom) regions. Negative anomalies for the timing indices (duration and peak timing) indicate earlier/shorter blooms while positive anomalies indicate the reverse.



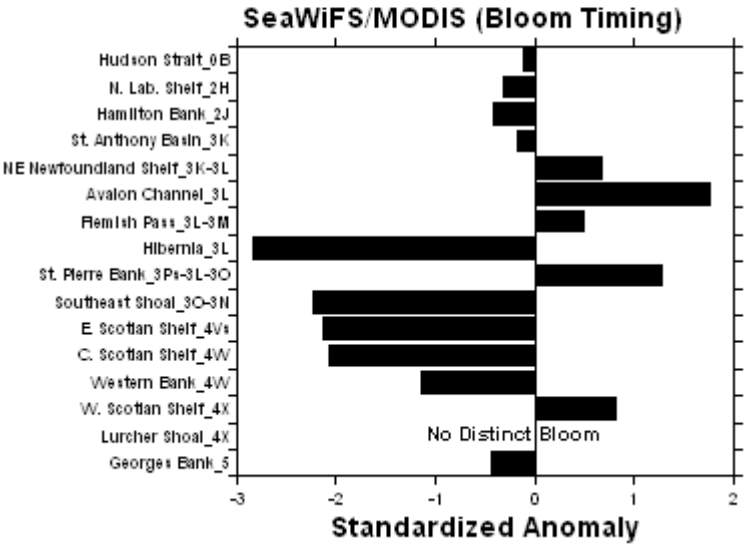


Figure 6. Annual anomalies of background chlorophyll *a* (before and after spring bloom) derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2010. The 2011 results were excluded due to technical difficulties with the MODIS sensor. The background 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. 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 standardized anomalies. The numbers in the coloured cells are the differences from the long-term mean (1998-2010) divided by the standard deviation.

NAFO Subarea	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hudson Strait_0B	-0.22	-0.42	-0.12	-0.54	-0.17	-0.50	0.46	0.11	-0.56	-0.38	-0.65	-0.60	3.26	
N. Lab. Shelf_2H	-0.58	-0.52	-0.70	0.17	-0.82	-0.29	0.63	-0.49	0.10	-0.67	-0.03	-1.00	1.76	
Hamilton Bank_2J	0.82	-0.46	-0.96	0.38	-0.40	0.20	1.49	-0.46	-1.71	-0.74	-0.62	-0.29	1.97	
St. Anthony Basin_3K	1.55	-0.20	0.43	-0.41	2.18	-0.15	0.11	-0.87	-0.52	0.45	-1.74	-0.89	0.45	
NE Newfoundland Shelf_3K-3L	0.83	-0.95	0.79	0.06	1.37	-0.98	-0.02	-0.06	-0.34	-1.12	-0.94	0.25	2.14	
Avalon Channel_3L	0.16	0.40	0.21	-0.74	0.19	-0.53	-0.68	-0.73	-0.33	-0.10	-0.38	-0.40	3.23	
Flemish Pass_3L-3M	0.63	1.09	1.48	0.29	1.88	-0.46	-0.65	0.08	-0.52	-0.18	-1.26	0.09	-1.35	
Hibernia_3L	0.58	-0.18	0.36	0.03	1.46	1.29	-0.62	-0.66	-0.10	-0.42	-1.54	-1.23	1.79	
St. Pierre Bank_3Ps-3L-3O	0.27	1.88	0.21	-0.22	1.46	-0.50	-0.59	-0.31	-0.13	-0.93	-0.85	-1.10	1.69	
Southeast Shoal_3O-3N	-0.57	-0.66	-0.51	-0.11	0.80	1.03	-0.45	-0.69	-0.56	-0.47	1.86	1.55	0.49	
E. Scotian Shelf_4Vs	-0.03	1.94	0.69	-0.64	-0.35	-0.28	-0.22	-0.66	-0.65	-1.48	0.62	1.38	1.00	
C. Scotian Shelf_4W	0.08	1.00	0.46	-0.23	-0.09	-0.81	-0.10	-0.80	-0.73	-0.36	-0.55	1.05	2.52	
Western Bank_4W	0.42	-1.73	0.26	0.17	0.21	-0.67	0.65	0.07	0.47	2.44	-0.21	0.19	-1.08	
W. Scotian Shelf_4X	0.69	1.68	-0.80	-0.16	0.71	-0.68	-0.26	-0.41	-1.09	-0.91	-0.53	1.14	1.73	
Lurcher Shoal_4X	-1.50	-1.44		1.02	-1.07	0.11	0.13	0.58	-0.05	0.63	-0.39	0.09	1.89	
Georges Bank_5	0.42	2.04	-0.35	1.22	0.04	-0.93	-0.34	-0.07	0.33	1.34	-0.44	-0.68	-1.05	

Figure 7. Annual anomalies of mean phytoplankton biomass derived from SeaWiFS and MODIS "Aqua" sensor imagery across the different NAFO Subareas extending from Georges Bank to the Hudson Strait during 1998-2010. The 2011 results were excluded due to technical difficulties with the MODIS sensor. The biomass 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 standardized anomalies. The numbers in the coloured cells are the differences from the long-term mean (1998-2010) divided by the standard deviation.

NAFO Subarea	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hudson Strait_0B	1.47	-0.38	0.44	-0.51	0.02	0.50	0.21	0.41	1.89	-0.75	0.36	-0.40	-1.58	
N. Lab. Shelf_2H	-0.10	-0.15	-0.69	0.63	-0.99	0.65	-0.52	-0.03	0.70	-0.58	2.79	0.16	-1.10	
Hamilton Bank_2J	-0.37	0.33	-0.71	0.30	-0.61	-0.21	-0.26	-0.31	3.08	-0.74	0.20	0.70	-0.59	
St. Anthony Basin_3K	-0.79	-0.91	-0.61	-1.67	1.18	-0.48	0.21	-0.66	1.29	1.56	1.17	-0.34	-0.56	
NE Newfoundland Shelf_3K-3L	0.01	0.21	0.62	-1.38	0.11	-0.40	-0.81	-1.01	1.19	0.20	-0.76	2.56	-0.43	
Avalon Channel_3L	-1.08	-0.45	-0.39	-0.06	0.35	-0.03	-0.24	-0.74	0.43	0.20	-0.21	0.82	2.80	
Flemish Pass_3L-3M	-0.95	-0.13	0.14	-0.77	1.57	-0.38	0.17	0.65	-0.30	-0.22	-0.86	1.21	1.67	
Hibernia_3L	-0.39	2.20	-0.58	-0.77	0.06	-1.16	0.70	-0.99	-0.25	0.24	1.46	0.71	0.00	
St. Pierre Bank_3Ps-3L-3O	-0.62	-0.21	-0.94	1.40	-0.19	-0.36	-0.09	-0.13	0.18	-0.26	-0.60	1.60	1.91	
Southeast Shoal_3O-3N	-0.37	0.57	-1.69	0.02	1.43	0.08	-0.81	-1.21	-0.28	-0.64	1.73	0.42	1.26	
E. Scotian Shelf_4Vs	0.94	-0.74	0.18	-1.08	0.57	-0.07	-0.28	-0.99	0.13	2.17	1.08	-0.53	0.27	
C. Scotian Shelf_4W	-1.08	-0.02	0.64	-0.71	0.30	1.12	-0.67	-1.15	0.18	1.42	1.06	1.04	-0.27	
Western Bank_4W	-0.57	2.89	-0.69	-0.43	-0.46	0.07	-0.42	-0.83	-0.66	0.36	-0.84	0.15	1.07	
W. Scotian Shelf_4X	-0.89	-0.48	-0.15	-0.50	0.14	1.79	-0.02	-1.25	-0.04	1.42	0.96	0.80	0.02	
Lurcher Shoal_4X	-0.74	0.37		1.23	0.81	0.17	-1.04	-1.16	0.12	-0.94	-0.72	-0.16	2.06	
Georges Bank_5	-0.96	-0.56	-0.37	-0.18	0.27	0.60	0.09	-0.67	-0.41	-0.67	-0.53	1.74	2.47	

Figure 8. Annual anomalies of duration 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 1998-2011. The duration 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 standardized anomalies. The numbers in the coloured cells are the differences from the long-term mean (1998-2011) divided by the standard deviation.

NAFO Subarea	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hudson Strait_0B	1.59	-0.75	0.30	-0.97	0.16	1.17	0.75	-0.31	1.57	-0.08	-0.69	-0.62	-1.85	-0.28
N. Lab. Shelf_2H	0.39	-0.21	-0.56	1.52	-0.82	-0.07	-0.04	-0.78	0.62	-0.53	2.58	-0.91	-0.71	-0.48
Hamilton Bank_2J	0.12	-0.70	0.01	0.82	0.21	-0.64	0.41	0.10	2.94	-0.60	-1.02	-0.12	-0.78	-0.74
St. Anthony Basin_3K	-0.17	0.04	0.14	-0.72	-0.32	-0.73	-0.27	-0.80	-0.82	0.29	2.83	0.68	0.88	-1.03
NE Newfoundland Shelf_3K-3L	0.73	1.43	0.37	-0.36	-0.69	-0.03	-0.40	-0.84	-0.72	0.94	0.36	1.89	-1.04	-1.63
Avalon Channel_3L	-0.25	0.12	-0.22	1.40	1.63	-0.58	0.92	1.33	-1.19	-1.16	-0.61	-0.70	-1.18	0.50
Flemish Pass_3L-3M	-0.28	-0.35	-0.04	0.71	-0.49	-0.38	0.97	-0.37	-0.28	-0.65	-0.64	-0.22	2.99	-0.96
Hibernia_3L	0.20	-0.39	0.60	0.11	2.05	1.54	0.50	-0.25	-0.61	-1.44	-1.38	0.43	-0.90	-0.44
St. Pierre Bank_3Ps-3L-3O	-0.50	-0.83	-0.44	-0.25	0.38	-0.45	0.41	-0.99	-0.36	0.07	1.16	1.73	1.74	-1.68
Southeast Shoal_3O-3N	0.76	0.14	-0.94	-0.58	-0.25	-0.89	-0.34	0.46	-0.44	-0.94	-0.37	1.22	-0.47	2.66
E. Scotian Shelf_4Vs	-0.26	-0.72	0.22	-0.83	-0.28	-0.82	-0.44	0.15	-0.61	1.88	1.44	1.74	-0.20	-1.27
C. Scotian Shelf_4W	0.23	0.50	-0.82	2.18	-0.76	-0.74	-0.82	-1.46	0.62	-0.67	0.63	-0.66	0.63	1.13
Western Bank_4W	-0.37	2.66	-0.08	-0.25	-0.51	-0.18	-0.57	-0.82	-0.76	-0.84	-0.53	0.11	1.58	0.58
W. Scotian Shelf_4X	0.45	-0.11	0.67	-0.34	-0.25	-0.13	-0.10	-0.58	-1.34	0.12	3.03	-0.17	-0.67	-0.60
Lurcher Shoal_4X	-0.46	-0.32		-0.97	1.79	-0.98	-0.51	1.65	-1.01	-0.52	-0.07	0.32	1.08	
Georges Bank_5	-0.73	0.00	-0.35	-0.50	0.94	-0.43	-0.37	-0.36	-0.59	-0.31	-0.49	0.19	3.17	-0.16

Figure 9. Annual anomalies of peak timing 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 1998-2011. The timing 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 standardized anomalies. The numbers in the coloured cells are the differences from the long-term mean (1998-2011) divided by the standard deviation.

NAFO Subarea	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hudson Strait_0B	0.88	0.32	0.99	0.06	0.34	0.68	-0.11	-0.57	-0.27	0.79	-0.39	0.43	-3.03	-0.10
N. Lab. Shelf_2H	-0.36	0.28	0.76	-0.38	2.03	-0.86	-0.12	-0.40	-0.50	0.47	-2.25	0.96	0.68	-0.32
Hamilton Bank_2J	-0.49	-0.12	1.20	0.84	1.65	0.26	-0.57	-0.41	-0.39	0.86	-1.09	0.78	-2.12	-0.42
St. Anthony Basin_3K	-0.05	-0.30	1.06	0.60	1.29	0.86	-0.19	-1.28	-1.42	0.45	0.07	1.07	-1.99	-0.17
NE Newfoundland Shelf_3K-3L	-0.41	-1.20	0.10	1.29	1.21	1.18	0.51	-0.84	-1.02	0.38	0.52	-0.44	-1.95	0.67
Avalon Channel_3L	-0.17	-1.23	-0.63	0.82	0.22	1.81	-0.06	-0.70	0.11	-0.10	0.58	-0.88	-1.53	1.76
Flemish Pass_3L-3M	-0.22	-1.61	0.26	1.19	1.15	1.95	0.38	-0.65	-1.25	-0.19	-0.18	-0.20	-1.12	0.50
Hibernia_3L	0.61	-0.38	-0.24	0.71	1.28	0.58	0.13	0.31	0.14	0.32	0.75	-0.42	-0.97	-2.83
St. Pierre Bank_3Ps-3L-3O	-0.17	0.76	-0.37	0.30	0.14	1.10	0.30	-0.71	0.07	-0.29	0.30	0.22	-2.91	1.28
Southeast Shoal_3O-3N	0.29	-0.19	-0.54	0.57	0.72	1.56	0.81	0.03	0.01	0.73	0.56	-1.39	-0.93	-2.24
E. Scotian Shelf_4Vs	0.12	-1.14	0.54	1.32	0.34	0.93	0.80	-0.68	-0.30	-0.05	0.41	1.10	-1.26	-2.12
C. Scotian Shelf_4W	-0.30	-1.57	1.83	0.55	0.22	0.86	0.48	0.01	-0.55	0.41	-0.01	0.79	-0.64	-2.07
Western Bank_4W	0.22	-2.44	1.33	-0.03	0.42	0.58	0.54	-0.06	-0.50	0.93	0.83	0.40	-1.09	-1.14
W. Scotian Shelf_4X	-0.69	-2.12	0.66	1.27	-0.80	0.34	0.19	-0.62	1.86	-0.23	-0.01	0.10	-0.78	0.82
Lurcher Shoal_4X	0.55	-0.17		0.59	-2.48	0.33	0.81	0.69	-0.46	0.07	1.18	0.04	-1.15	
Georges Bank_5	-0.26	-1.09	-0.80	0.35	0.39	-0.07	-0.22	0.03	-0.54	-0.19	-0.19	-0.16	3.19	-0.44

Figure 10. Composite sums of annual anomalies across the Newfoundland and Labrador Subareas (NL/LAB) and Scotian Shelf and Gulf of Maine (SS/GoM) for satellite ocean colour indices during 1998-2011. The 2011 results for background and chlorophyll *a* biomass were excluded due to technical difficulties with the MODIS sensor.

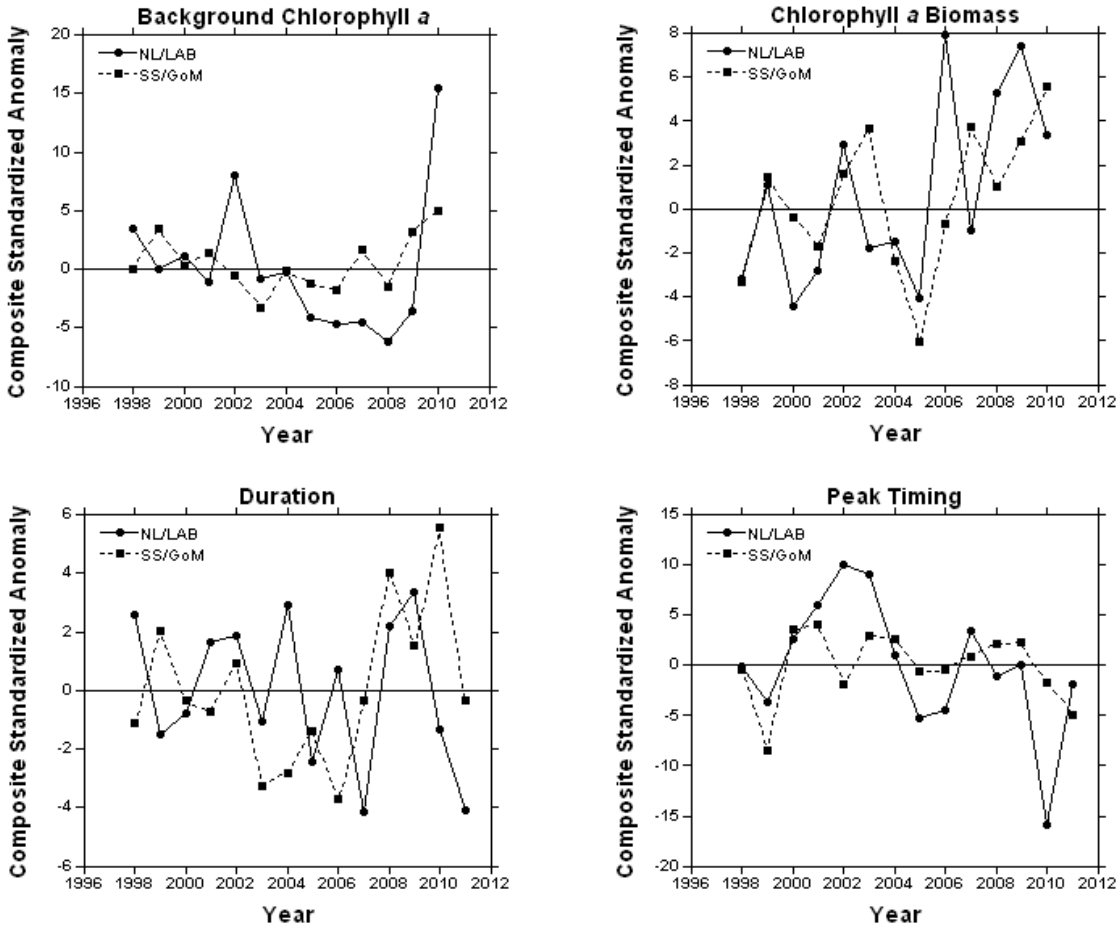


Figure 11. Summary of zooplankton abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2011. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year while the fixed stations only used season and year as inputs and were based on all available seasonal data. The NAFO Subareas are sorted from the southern Labrador Shelf - 2J (top) to southern Scotian Shelf - 4X (bottom).

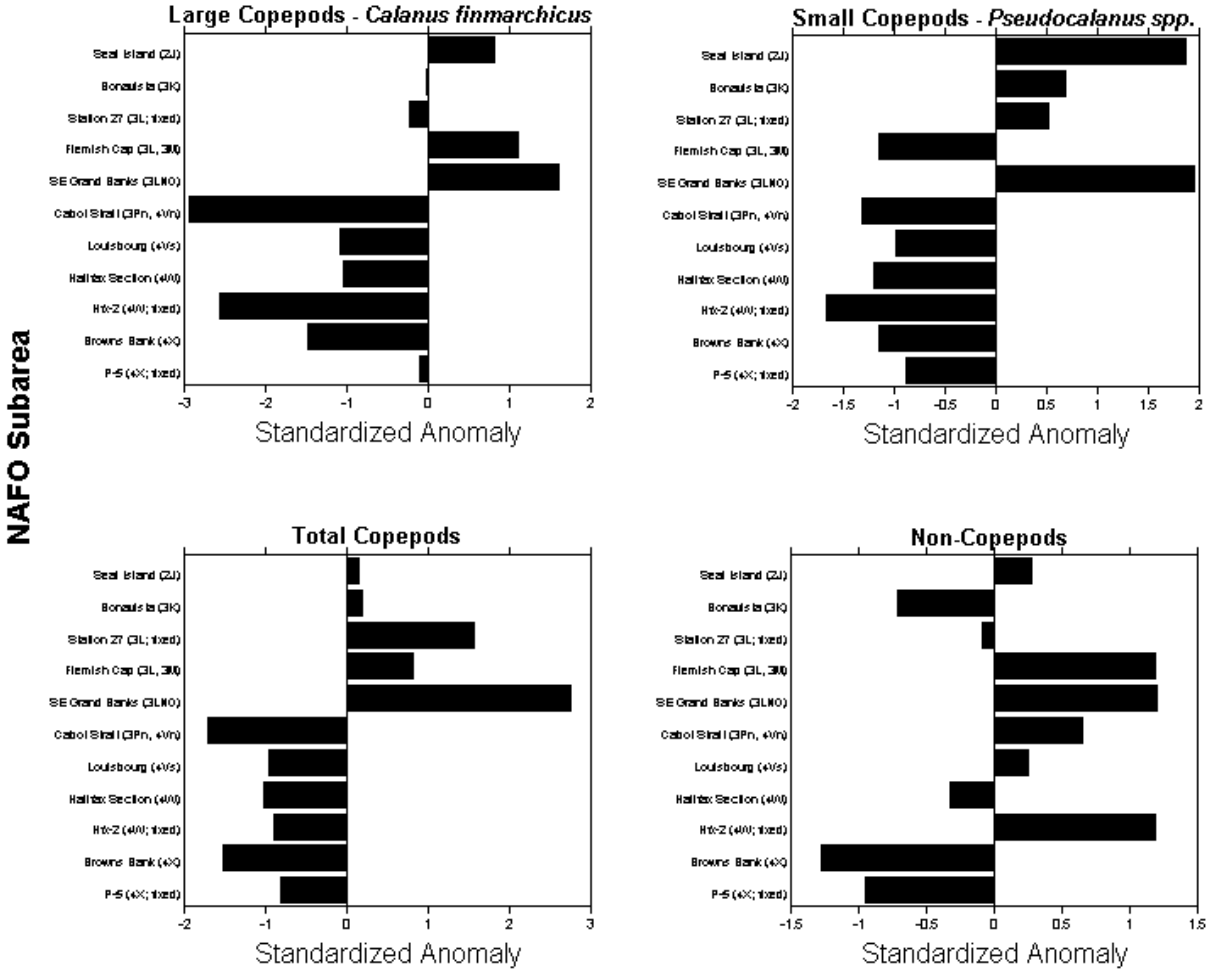


Figure 12. Time series of zooplankton abundance anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2011. The zooplankton abundance anomalies for transects were calculated using a general linear model using station, season, and year 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 (1999-2011) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

Large Copepods	**Section - Subarea**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
C. finmarchicus	Seal Island (2J)		-1.79	-0.66	-0.02	0.05	1.18	0.94	0.30	0.32	-0.24	-1.06	0.01	0.80
	Bonavista (3K)	-1.95	-0.98	0.07	0.29	0.36	0.83	0.26	1.12	0.66	0.19	0.25	0.50	-0.02
	Station 27 (3L; fixed)	1.52	0.50	0.46	0.61	-0.19	-1.78	-0.39	-0.73	-0.64	-4.94	-0.40	1.80	-0.23
	Flemish Cap (3L, 3M)	-1.87	-1.22	0.60	0.67	0.24	0.15	0.55	0.90	0.10	0.29	0.17	0.92	1.09
	SE Grand Banks (3LNO)	-1.92	-1.13	0.36	0.78	0.65	0.19	0.90	0.18	0.32	0.16	0.72	0.85	1.59
	Cabot Strait (3Pn, 4Vn)	1.45	-1.15	-1.11		1.52	-0.18	0.10	-0.33	0.90	-0.50	-1.24	0.53	-2.95
	Louisbourg (4Vs)	1.38	-1.00	-0.84		-1.11	-0.17	-0.61	-0.33	-0.59	1.04	-0.53		-1.08
	Halifax Section (4W)	1.83	-0.28	-0.16		0.17	-0.96	0.70	0.49	-1.33	0.06	1.24	-0.17	-1.05
	Hfx-2 (4W; fixed)	0.86	0.73	1.76	-0.25	0.38	-0.89	-1.15	-0.83	-0.26	1.04	-1.50	0.17	-2.56
	Browns Bank (4X)	-0.10	-1.01	0.71		1.64	-1.07	-0.98	0.59	-1.06	1.05	0.70		-1.49
	P-5 (4X; fixed)	-1.06	-1.16	1.44	-1.16	0.62	0.02	0.53	1.88	-0.73	-0.02	0.20	-0.57	-0.11
Small Copepods		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Pseudocalanus	Seal Island (2J)		-0.56	0.67	-0.95	0.63	-0.33	-1.09	1.63	3.31	0.18	-1.24	0.44	1.86
	Bonavista (3K)	-1.61	-1.17	1.16	0.30	0.71	0.30	-0.53	0.83	-0.11	0.21	1.04	1.53	0.67
	Station 27 (3L; fixed)	-0.50	1.14	0.59	0.79	0.56	-1.96	-0.02	-0.59	0.81	-1.60	2.19	1.17	0.52
	Flemish Cap (3L, 3M)	2.15	0.39	-0.48	0.43	-0.56	-0.66	-1.00	-0.27	-0.73	-0.61	-0.33	0.51	-1.16
	SE Grand Banks (3LNO)	-2.09	1.03	0.46	0.74	-0.45	0.08	0.66	-0.43	0.43	-0.48	0.05	0.57	1.95
	Cabot Strait (3Pn, 4Vn)	0.94	-1.41	-0.52		2.07	-0.20	-0.40	-0.61	-0.11	0.61	-1.08	0.69	-1.33
	Louisbourg (4Vs)	2.35	-1.17	0.61		0.11	-0.62	-0.83	0.04	-0.45	0.27	-0.84		-0.98
	Halifax Section (4W)	1.27	0.81	0.85		0.82	-0.32	0.26	-2.01	-1.20	-0.04	-0.32	-0.94	-1.21
	Hfx-2 (4W; fixed)	1.54	0.45	0.05	-0.26	1.00	1.02	0.28	-1.79	-1.30	0.47	-0.56	-0.89	-1.67
	Browns Bank (4X)	1.21	-0.02	2.04		1.47	-0.71	-0.69	-0.52	-0.86	-0.23	-0.97		-1.16
	P-5 (4X; fixed)	0.31	0.51	2.16	0.21	-0.05	-0.69	-0.87	-1.13	-0.35	0.75	-1.52	0.67	-0.88
		1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Total Copepods	Seal Island (2J)		-1.71	-0.86	-0.15	0.13	0.99	0.78	0.82	-0.03	-0.61	-0.76	-0.26	0.15
	Bonavista (3K)	-1.95	-0.81	0.15	-0.10	0.71	0.62	0.12	1.27	0.76	0.65	0.97	1.16	0.18
	Station 27 (3L; fixed)	-0.71	1.06	-0.72	1.67	0.54	-1.27	-0.18	-0.39	1.05	-1.44	3.63	2.18	1.56
	Flemish Cap (3L, 3M)	-1.85	-0.65	0.46	0.09	-0.33	-0.03	0.85	1.45	0.71	0.82	0.97	2.36	0.80
	SE Grand Banks (3LNO)	-2.11	0.61	-0.64	0.28	0.25	0.45	1.18	-0.03	0.92	0.34	0.99	1.14	2.74
	Cabot Strait (3Pn, 4Vn)	1.32	-1.33	-1.03		1.18	0.29	0.22	-1.00	-0.38	-0.02	-0.75	1.49	-1.72
	Louisbourg (4Vs)	2.68	-0.78	0.19		0.32	-0.64	0.03	0.21	-0.83	0.62	-0.82		-0.97
	Halifax Section (4W)	2.13	0.92	0.13		-0.37	-1.32	1.19	-0.60	-0.44	-0.64	0.48	-0.65	-1.03
	Hfx-2 (4W; fixed)	1.87	0.94	0.69	-1.43	0.03	0.14	0.65	-1.00	-1.40	-0.25	0.46	-0.69	-0.90
	Browns Bank (4X)	1.28	1.37	0.45		1.29	-1.30	-0.53	-0.24	-1.07	0.52	-0.55		-1.52
	P-5 (4X; fixed)	-0.11	1.21	1.56	-0.78	0.50	-0.25	-1.28	0.72	-1.06	-0.38	-1.24	1.10	-0.82
Non-Copepods		**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
	Seal Island (2J)		-1.02	-0.50	-1.01	-0.44	0.79	0.58	1.59	-0.25	-1.69	-0.84	-0.56	0.27
	Bonavista (3K)	-2.02	-0.81	0.49	0.39	0.45	0.05	0.17	1.28	0.27	0.07	0.96	0.96	-0.71
	Station 27 (3L; fixed)	-0.95	1.03	1.29	0.33	0.07	0.32	-0.35	-1.74	-0.24	-2.89	-1.28	0.73	-0.09
	Flemish Cap (3L, 3M)	-2.21	0.48	0.63	0.90	-0.32	-0.39	0.31	0.59	0.03	0.50	0.40	2.17	1.18
	SE Grand Banks (3LNO)	-2.23	1.24	0.32	0.21	0.07	-0.19	0.54	0.05	-0.26	0.05	0.08	1.10	1.20
	Cabot Strait (3Pn, 4Vn)	1.14	-0.98	-0.77		0.48	1.46	-0.64	0.21	-1.28	-0.54	-0.53	1.46	0.65
	Louisbourg (4Vs)	0.73	-0.99	1.72		-0.98	-0.28	0.00	1.42	-0.97	0.60	-0.90		0.25
	Halifax Section (4W)	2.53	0.61	-0.68		0.25	-0.44	0.87	-0.91	-0.81	0.25	-0.64	-0.89	-0.33
	Hfx-2 (4W; fixed)	2.77	0.30	-0.09	-0.93	-0.26	0.22	0.59	-0.57	-0.94	-0.01	-0.31	-0.77	1.19
	Browns Bank (4X)	1.97	0.74	-0.54		1.42	-1.03	0.66	-0.97	-0.96	0.16	-0.82		-1.28
	P-5 (4X; fixed)	0.96	1.06	1.09	0.24	-1.09	-0.41	-1.29	-0.54	-0.56	-0.38	-0.87	1.78	-0.95

Figure 13. Summary of zooplankton dry weight anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 2011. The dry weight 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 from the southern Labrador Shelf - 2J (top) to southern Scotian Shelf - 4X (bottom).

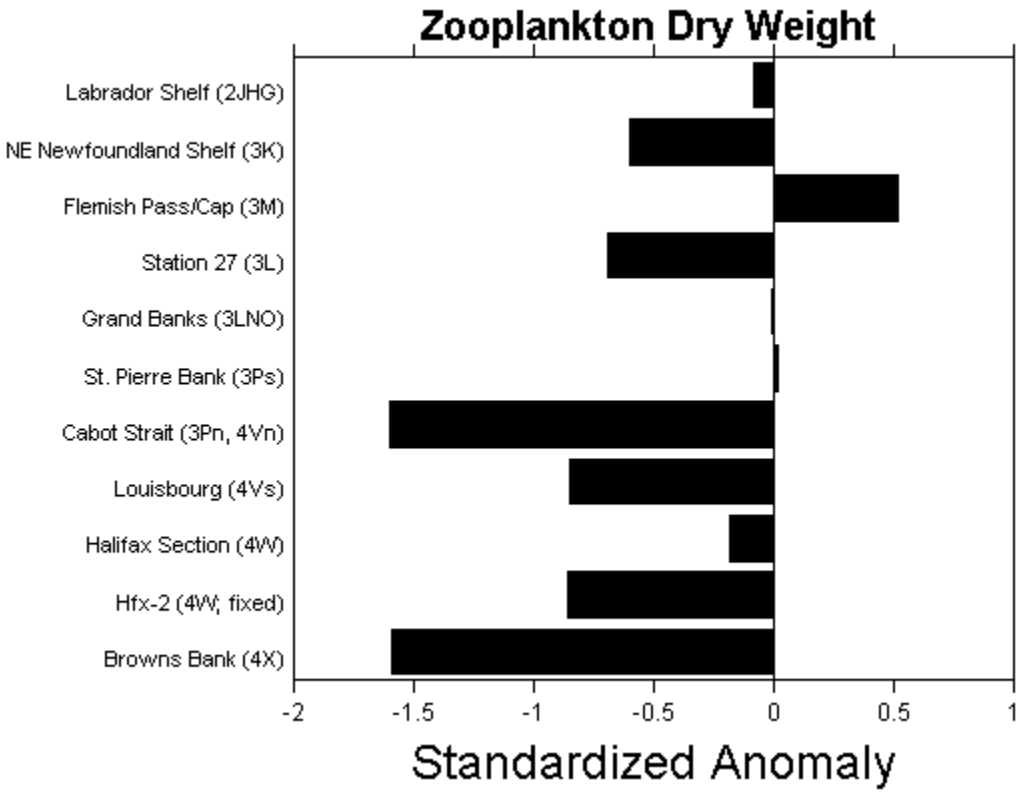


Figure 14. Time series of zooplankton dry weight anomalies from different oceanographic transects and fixed stations from the Atlantic Zone Monitoring Program during 1999-2011. The dry weight anomalies for transects were calculated using a general linear model using station, season, and year while the 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 (1999-2011) divided by the standard deviation. The NAFO Subareas are sorted by latitude from north (top) to south (bottom) regions.

NAFO Subarea	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Labrador Shelf (2JHG)	-0.48	-2.25	-0.37	0.71	0.74	-0.56	0.55	0.25	2.04	-0.43	-0.60	0.34	0.07
NE Newfoundland Shelf (3K)	-1.16	-1.69	-0.12	-0.48	0.89	2.05	0.55	0.35	0.28	-0.83	-0.43	1.01	-0.43
Flemish Pass/Cap (3M)	-0.65	-1.97	-0.08	1.23	-0.56	-1.29	0.71	0.11	0.25	-0.71	1.27	1.07	0.60
Station 27 (3L)	-0.31	1.30	0.72	1.19	-0.57	1.24	0.97	-0.26	-0.08	-1.75	-0.44	-1.29	-0.69
Grand Banks (3LNO)	-1.02	-0.54	0.07	2.51	0.12	1.26	-0.23	0.34	0.47	-1.14	-0.43	0.22	-0.30
St. Pierre Bank (3Ps)										-1.34	0.27	1.06	0.02
Cabot Strait (3Pn, 4Vn)	2.31	-0.54	0.72		0.85	0.77	-0.59	-0.32	-0.87	-0.80	-0.03	-0.20	-1.29
Louisbourg (4Vs)	-0.45	-1.32	2.26	1.36	0.71	0.39	-0.27	-0.65	-1.10	-0.20	0.09	0.02	-0.84
Halifax Section (4W)	-0.66	2.71	0.54	-0.91	1.30	-0.44	-0.48	-0.62	-0.29	-0.27	-0.07	-0.63	-0.18
Hfx-2 (4W; fixed)	-1.08	0.42	1.15	-0.49	-0.30	0.27	2.43	-0.82	-0.75	-0.66	0.81	-0.12	-0.84
Browns Bank (4X)	0.02	1.01	1.67	0.98	0.95	-0.67	-0.86	-0.36	0.15	0.23	-0.02	-1.78	-1.32

Figure 15. Composite sums of annual anomalies across the Newfoundland and Labrador Subareas (NL/LAB) and Scotian Shelf (SS) for each zooplankton abundance index during 1999-2011.

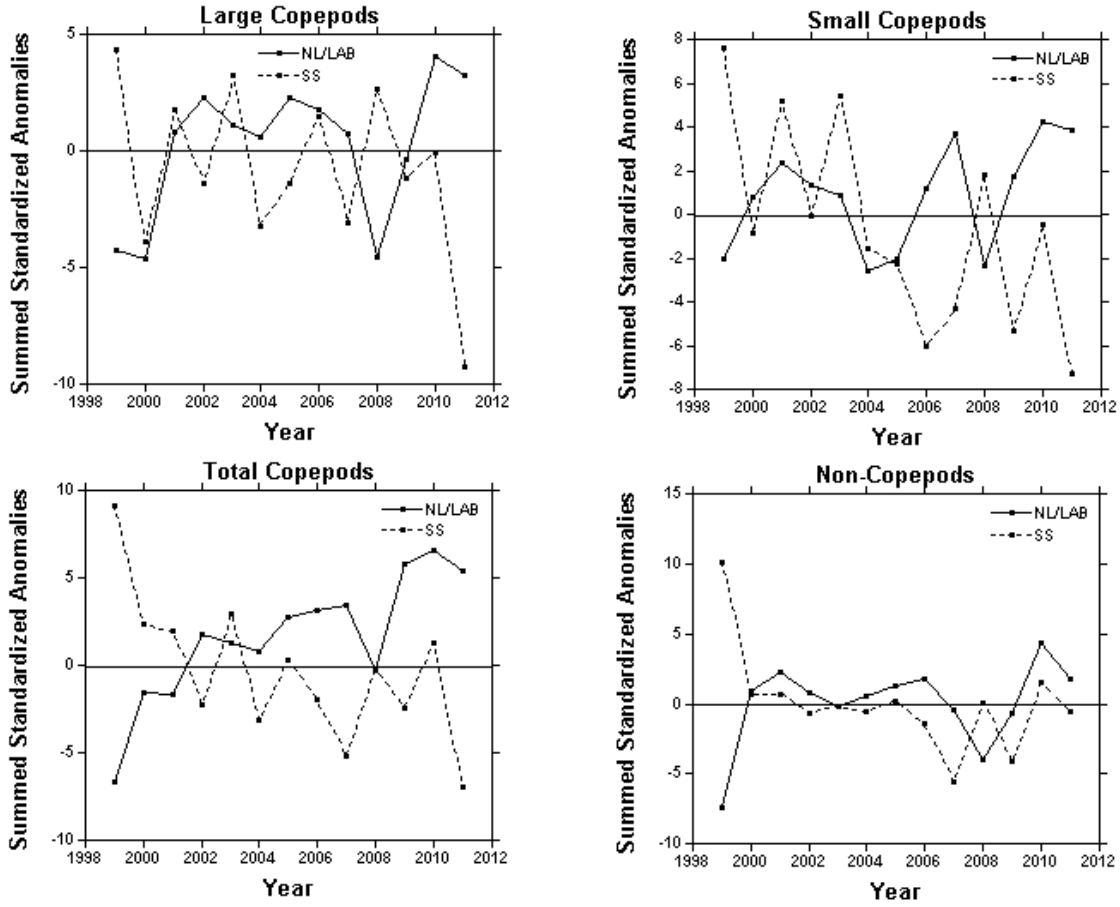


Figure 16. Composite sum of annual anomalies across the Newfoundland and Labrador Subareas (NL/LAB) and Scotian Shelf (SS) for dry weight index during 1999-2011.