An ecological status report for phytoplankton and microbial plankton in the North Atlantic and adjacent seas

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An ecological status report for phytoplankton and microbial plankton in the North Atlantic and adjacent seas

1. Context and timeline
2. Ecological status report
3. Pan-North Atlantic patterns
4. Case studies
5. Future plans

WGPME (Working Group on Phytoplankton and Microbial Ecology)

ICES Mission

To advance the scientific capacity to give advice on human activities affecting, and affected by, marine ecosystems.

What is ICES?

The International Council for the Exploration of the Sea (ICES) coordinates and promotes marine research on oceanography, the marine environment, the marine ecosystem, and on living marine resources in the North Atlantic. Members of the ICES community now include all coastal states bordering the North Atlantic and the Baltic Sea. ICES cooperates with organizations and institutes on an international scale.

ICES Member Countries (20)

Belgium
Canada
Denmark (including Greenland and Faroe Islands)
Estonia
Finland
France
Germany
Iceland
Ireland
Latvia
Lithuania
Netherlands
Norway
Poland
Portugal
Russia
Spain
Sweden
United Kingdom
United States of America

WGPME (Working Group on Phytoplankton and Microbial Ecology)

ICES PGPYME Report 2007

ICES Oceanography Committee
ICES CM 2007/OCC:01
Ref. OCC

Report of the
Planning Group on
Phytoplankton and Microbial Ecology
(PGPYME)

By correspondence

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

2007 – by correspondence

1 Terms of Reference

A Planning Goup on Phytoplankton and Microbial ecology (PGPYME) (Chairs: J. Steele, USA, Franciscus Colijn Germany, and Ted Smayda USA) will be established and work by correspondence to:

a) consider the formation of a new expert group covering the field of microbial dynamics including phytoplankton ecological processes;
b) formulate initial TORs for such a group
c) suggest Chair and potential members

PGPYME will report by 1 February 2007 for the attention of the Oceanography Committee.

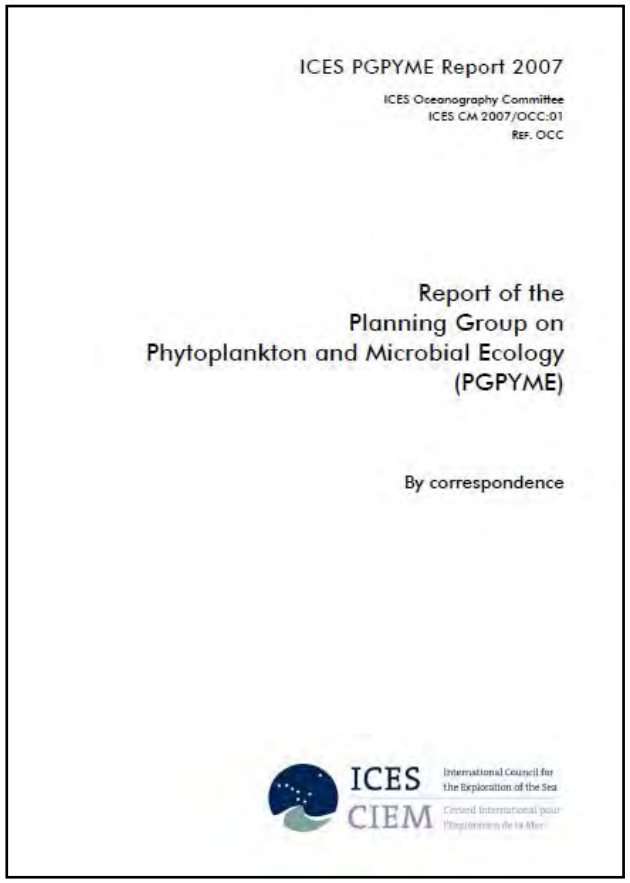
2008 - Halifax

The limited size of a microbial community within ICES leads to the following recommendations:

1) The expert/working groups WGPBI, WGZE and WGRP are asked to consider building bridges to lower trophic levels by incorporating experience from microbial dynamics.
2) To use microbial dynamics as a focus for cooperation with other research organisations such as EUROceans.

There was also a very full and lively discussion of this topic at the second OCC meeting where several speakers re-iterated the need to maintain ICES involvement in this important component of ecosystem studies. Dr William Li of the Bedford Institute offered to continue exploration of the possible range of topics within the ICES community and this offer was warmly welcomed.

WGPME (Working Group on Phytoplankton and Microbial Ecology)



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ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

2009 - Berlin

SCICOM Steering Group on Ecosystems Function (SSGEF)
Resolutions 2009

2009/2/SSGEF07 The **Working Group on Phytoplankton and Microbial Ecology** (WGPME), chaired by William Li*, Canada and Xosé Anxelu G. Morán*, Spain, will be established and will meet at the Marine Laboratory, Aberdeen, UK, 3–5 March 2010 to:

a) Develop an action plan to provide a primary focus for phytoplankton and other unicellular microbes within the ICES Science Plan.

b) Establish the conceptual and operational foundations for undertaking a comparative analysis of multiyear time series data of phytoplankton and microbial plankton.

WGPME (Working Group on Phytoplankton and Microbial Ecology)

ICES WGPME REPORT 2010

SCICOM Steering Group on Ecosystem Functions

ICES CM 2010/SSGEF:07

Ref. SSGEF, SCICOM

ICES WGPME REPORT 2011

SCICOM Steering Group on Ecosystem Functions

ICES CM 2011/SSGEF:04

Ref. SCICOM

ICES WGPME REPORT 2012

SCICOM Steering Group on Ecosystem Functions

ICES CM 2012/SSGEF:05

Ref. SCICOM

Report of the Working Group on Phytoplankton and Microbial Ecology (WGPME)

26–29 March 2012

Malaga, Spain

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

2010 Aberdeen

ICES Science Plan 2009-2013

3 Thematic areas

16 Research topics

Thematic area 1 - Understanding Ecosystem Functioning

- **Climate change processes and predictions of impacts;**
- Fish life history information in support of ecosystem approach to management (EAM);
- Biodiversity and the health of marine ecosystems;
- The role of coastal-zone habitat in population dynamics of commercially exploited species;
- Top predators (marine mammals, seabirds, and large pelagics) in marine ecosystems;
- Sensitive ecosystems (deep-sea coral, seamounts, Arctic) as well as rare and data-poor species;
- Integration of surveys in support of EAM.

Thematic area 2 - Understanding Interactions of Human Activities with Ecosystems

- Impacts of fishing on marine ecosystems;
- Carrying capacity and ecosystem interactions associated with mariculture;
- Influence of development of renewable energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota;
- Population and community level impacts of contaminants, eutrophication, and habitat changes in the coastal zone;
- Introduced and invasive species, their impacts on ecosystems and interactions with climate change processes.

Thematic area 3 - Development of options for sustainable use of ecosystems

- Marine living resource management tools;
- Operational modelling combining oceanographic, ecosystem, and population processes;
- Marine spatial planning, including the effectiveness of management practices (e.g. Marine Protected Areas (MPAs)), and its role in the conservation of biodiversity;
- Contributions to socio-economic understanding of ecosystem goods and services, and forecasting of the impact of human activities.

Not to be cited without prior reference to the authors ICES CM 2011/B:02

Towards an ecological status report for phytoplankton and microbial plankton in the North Atlantic

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[4]Appendix

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Abstract

The ecological links between the physical environment of the ocean and the mid to upper trophic levels of pelagic food webs are the lower trophic levels comprising microbial primary producers (phytoplankton) and microbial secondary producers (bacterioplankton, heterotrophic protists). In the North Atlantic Ocean, standardized annual average anomalies of oceanic hydrography (WGOH) and of mesozooplankton (WGZE) derived from time series observations at monitoring sites located across the entire basin provide long term trends suitable for discerning climate variability and change. Here we (WGPME) describe work in progress aimed at establishing contemporaneous trends at similar scales of space and time for phytoplankton and other microbial plankton (and associated variables such as inorganic nutrients), with a view towards understanding climatic and anthropogenic signal propagation through ocean ecosystems. Preliminary analysis hints at a widespread increase in the annual average abundance of smaller phytoplankton cells that presumably may alter the flux of energy from lower to higher trophic levels.

Keywords:
phytoplankton, microbial plankton, ecological status, WGPME

Introduction

The *ICES Science Plan* places a high priority on understanding the functioning of ecosystems through research on key topics that include climate change and biodiversity resilience. To these ends, it is important to discern changes in distributional patterns at the species and community levels, as well as to define indicators that contain information on ecosystem attributes, conditions of change, and external pressures. These are the outcomes towards which the Working Group on Phytoplankton and Microbial Ecology (WGPME) are striving.

A perspective on changing conditions in the world's Large Marine Ecosystems indicate no significant trends in chlorophyll or primary production in the various LMEs of the North Atlantic, except on the East Greenland Shelf and in the Barents Sea where chlorophyll concentrations have been increasing (Sherman and Hempel 2009). However, the evidence in this perspective was drawn largely from satellite ocean colour measurements made over a relatively short time duration (1998-2006). Although these findings have been considered in the context of other existing data (Bode et al. 2011), there remains an ongoing need to examine species, functional groups, and community descriptors since microbial attributes may prove important for indicating systemic change. Here, we report on the progress of WGPME towards an ecological status report for phytoplankton and microbial plankton in the North Atlantic. Such a report would contribute to the observational description of lower trophic levels required in any ecosystem-based assessment of the state of the North Atlantic Ocean.

Methods

The cooperative research agenda for phytoplankton and microbial plankton is based on the successful model of WGZE for the ICES zooplankton status report (O'Brien et al. 2011). To date, WGPME has a collection of data from 22 discrete monitoring stations. Long-term records of sea surface temperature (1900-2010) and ocean colour (1998-2010) at every monitoring site are extracted from the Hadley Centre SST (http://badc.nerc.ac.uk/data/hadisst/) and the GlobColour (http://www.globcolour.info/) databases respectively. Multidecade records (1958-2009) of diatoms, dinoflagellates and phytoplankton colour index

ICES
Annual Science Conference
19-23 September 2011
Gdańsk, Poland

Towards an ecological status report for phytoplankton and microbial plankton in the North Atlantic

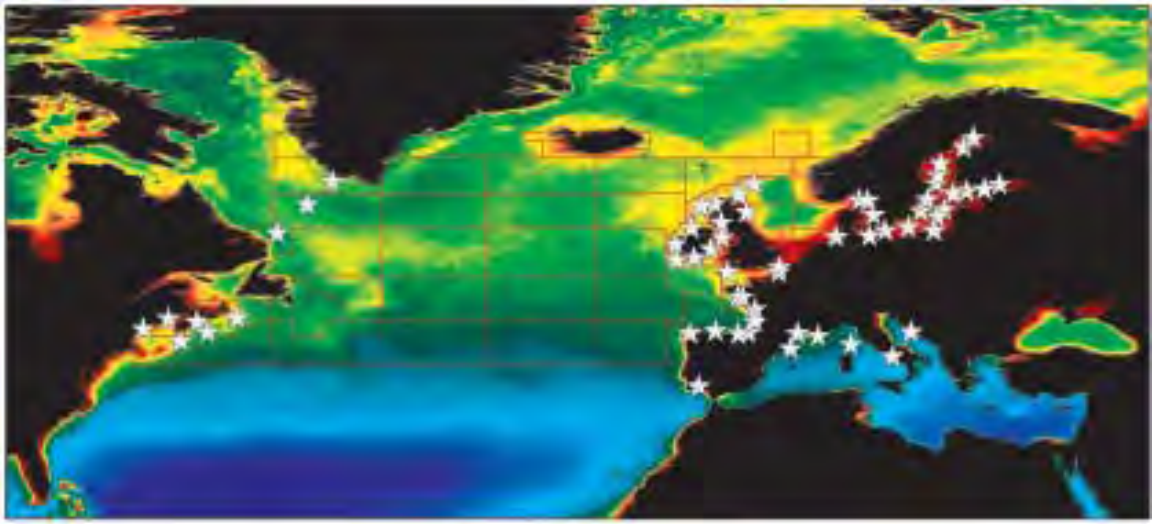
Here we (WGPME) describe work in progress aimed at establishing trends at various scales of space and time for phytoplankton and other microbial plankton (and associated variables such as inorganic nutrients), with a view towards understanding climatic and anthropogenic signal propagation through ocean ecosystems.

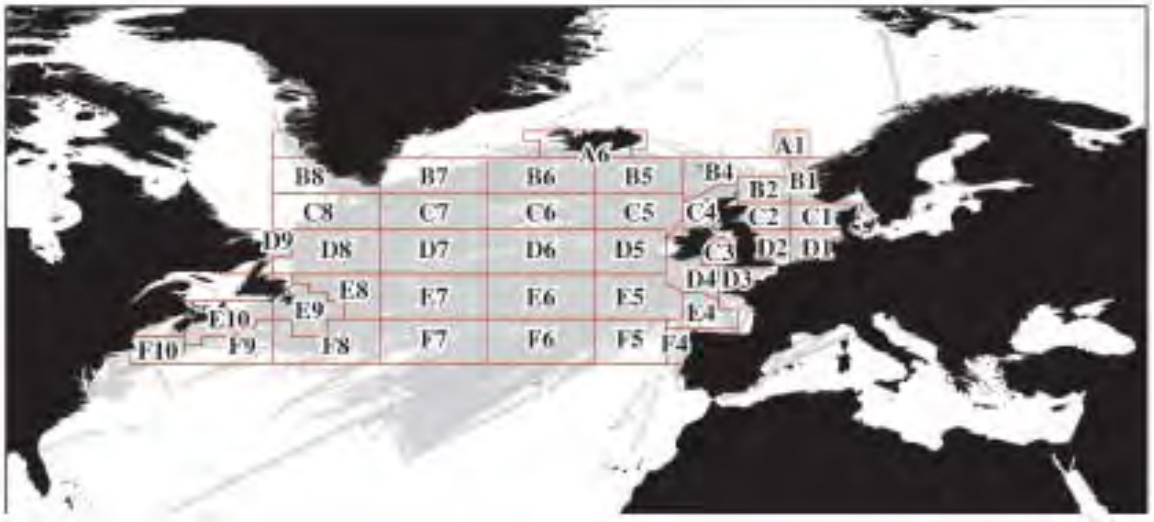
WGPME (Working Group on Phytoplankton and Microbial Ecology)

ICES Phytoplankton and Microbial Plankton Status Report

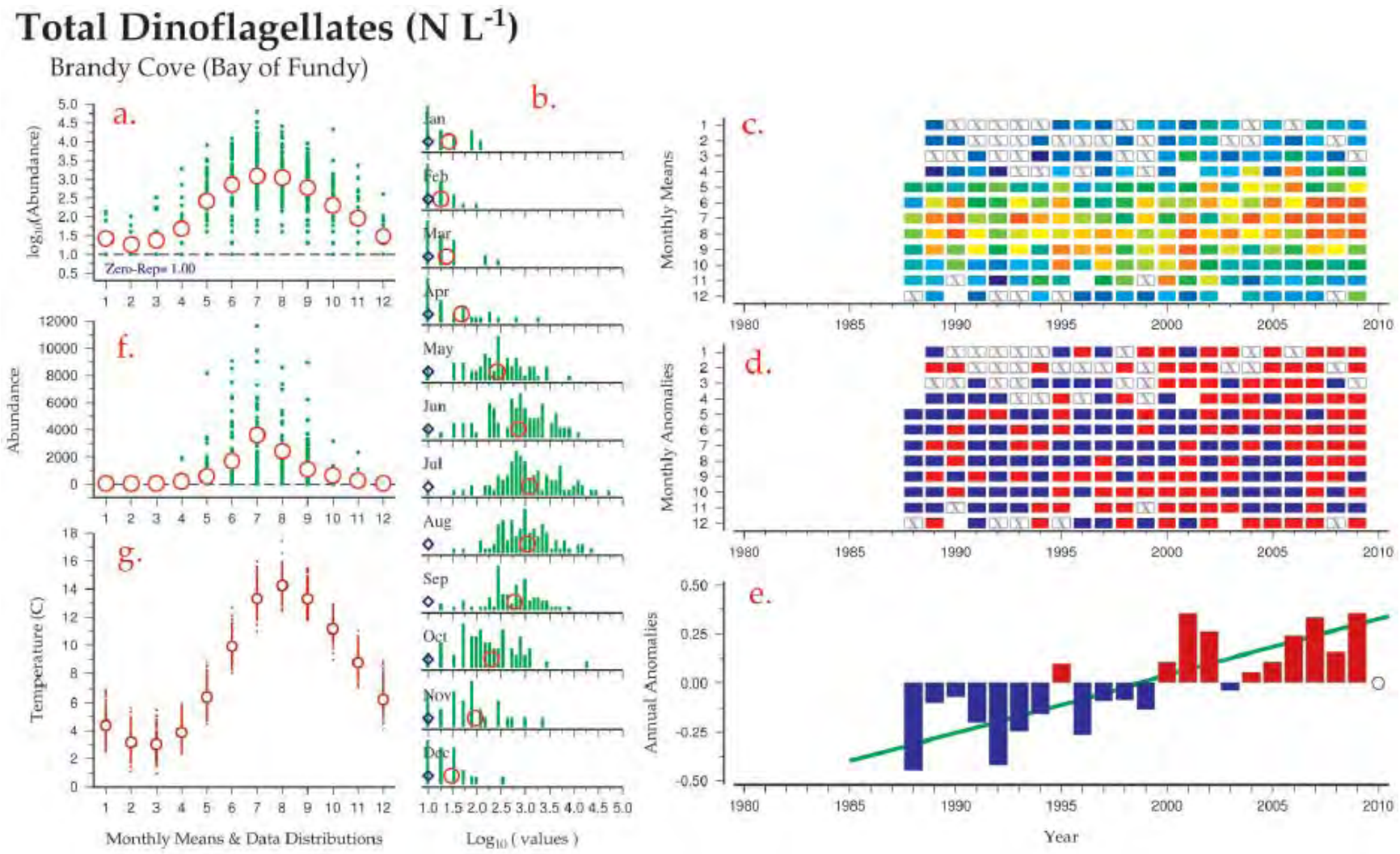
In this first full report, the ecological status of phytoplankton and microbial plankton of the North Atlantic and adjacent seas is presented by reference to seven geographical regions containing 61 monitoring locations, and to 40 standard areas of the Continuous Plankton Recorder survey. Coverage stretches from the subpolar waters of the Labrador Sea to the subtropical waters of southwestern Iberia, and extends into the Mediterranean Sea.

North Atlantic Sites

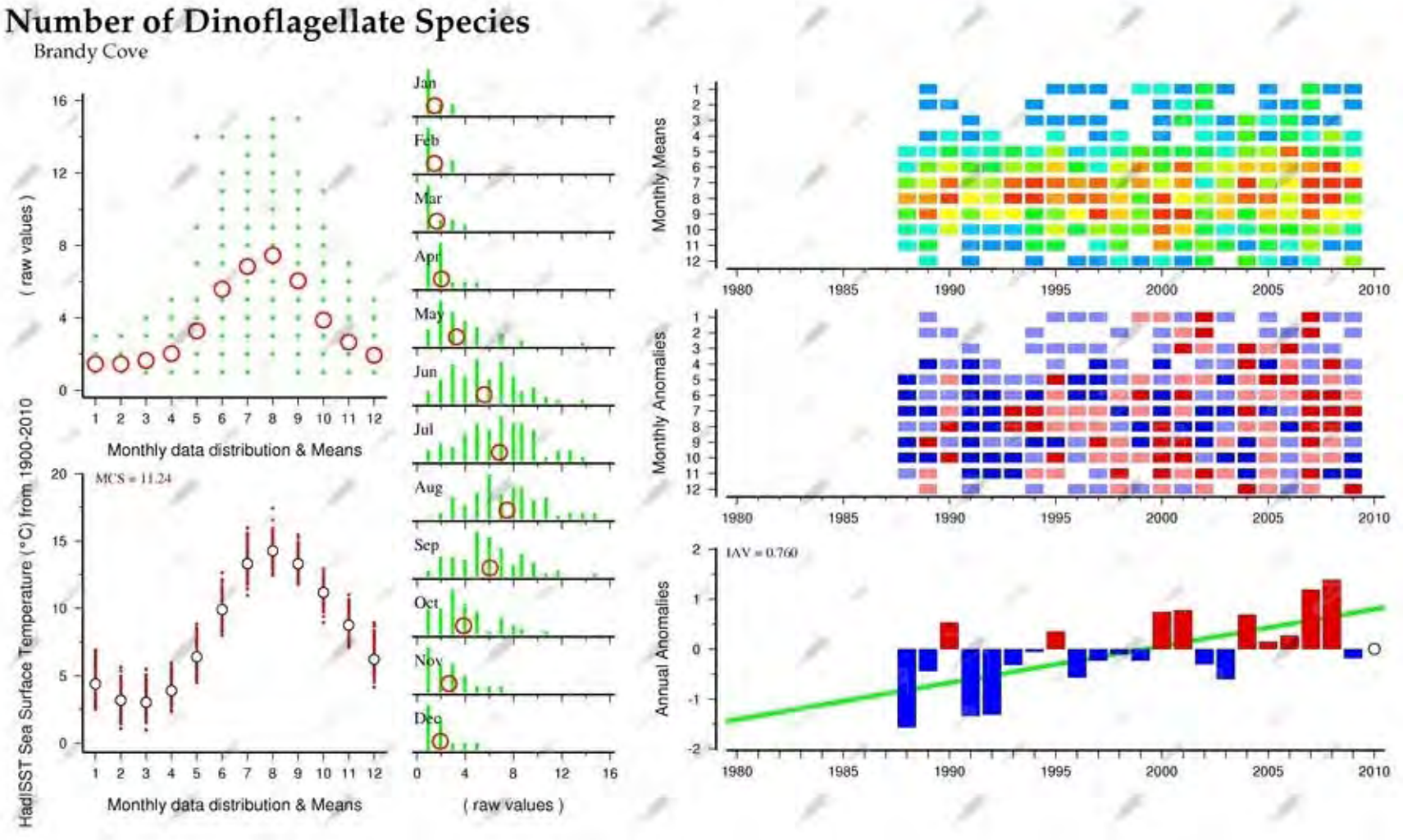




Site analysis: monthly-adjusted multi-year trend



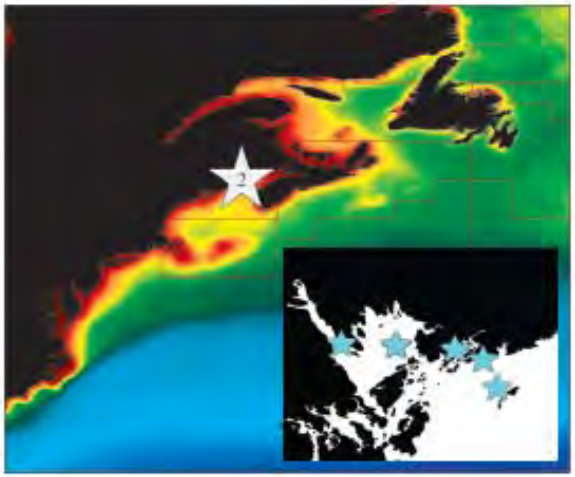
Site analysis: monthly-adjusted multi-year trend

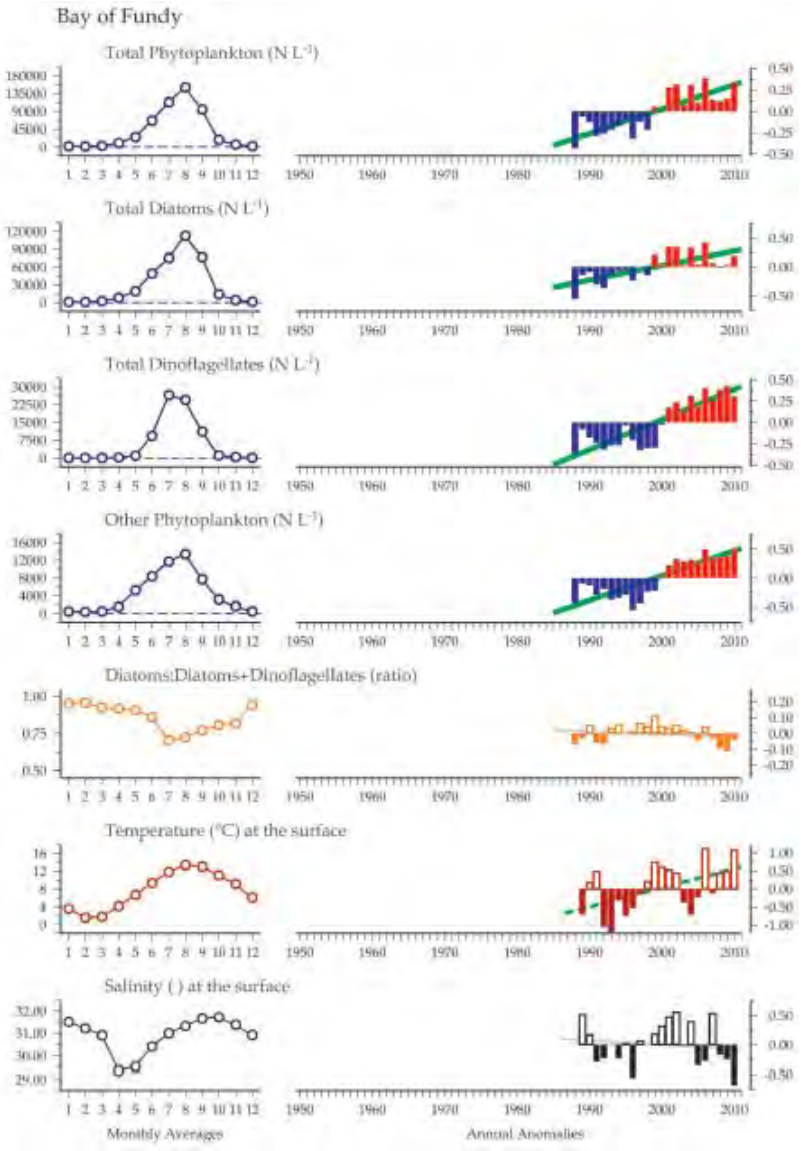


Site overview

3.2 Bay of Fundy (Site 2)

Jennifer Martin and Murielle LeGresley





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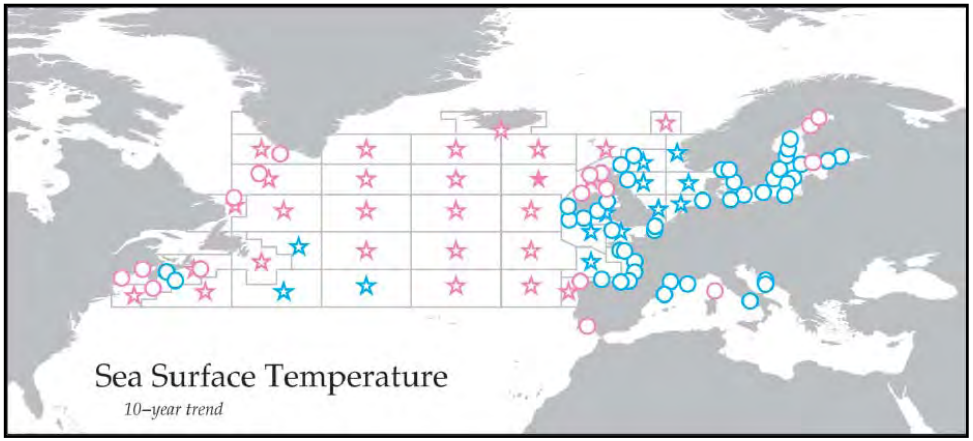
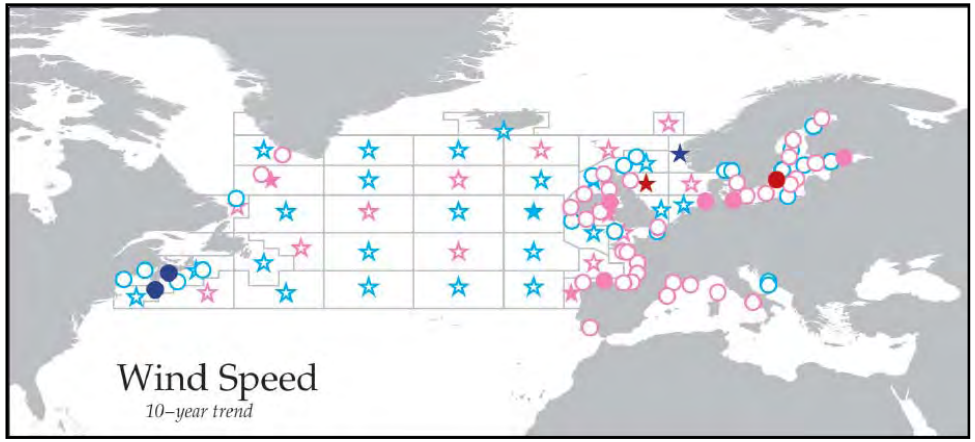
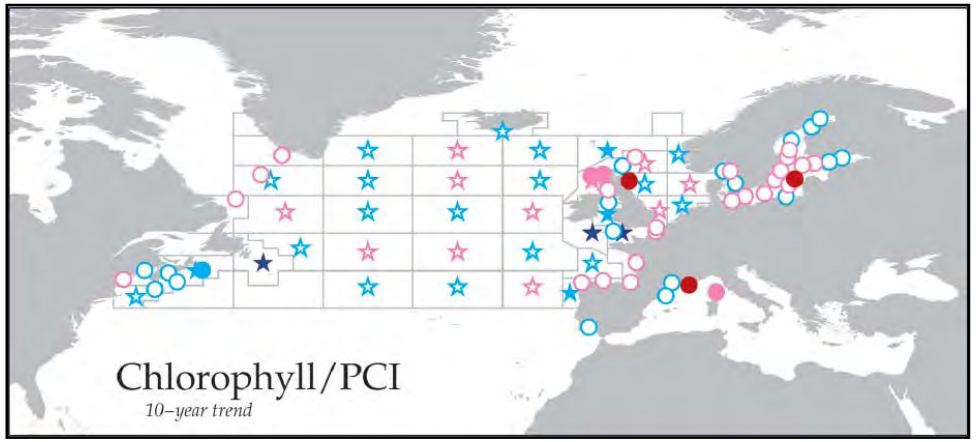
Pan-North Atlantic description (2001-2010)







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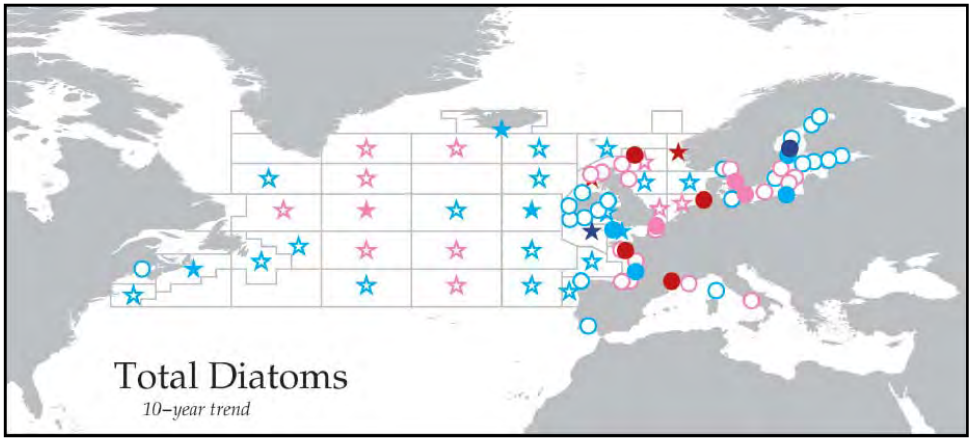
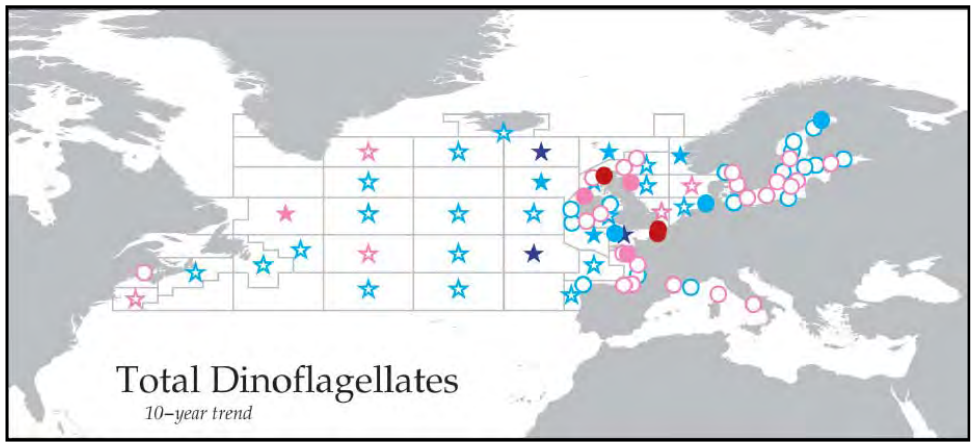
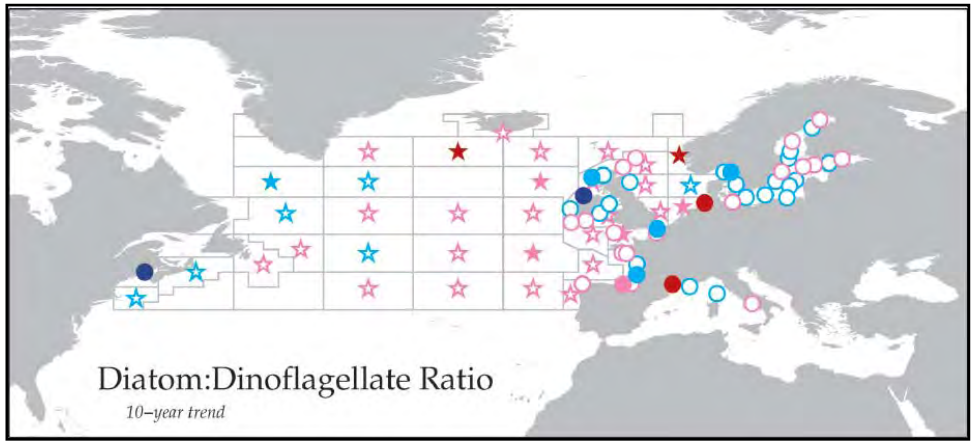
Pan-North Atlantic description (2001-2010)







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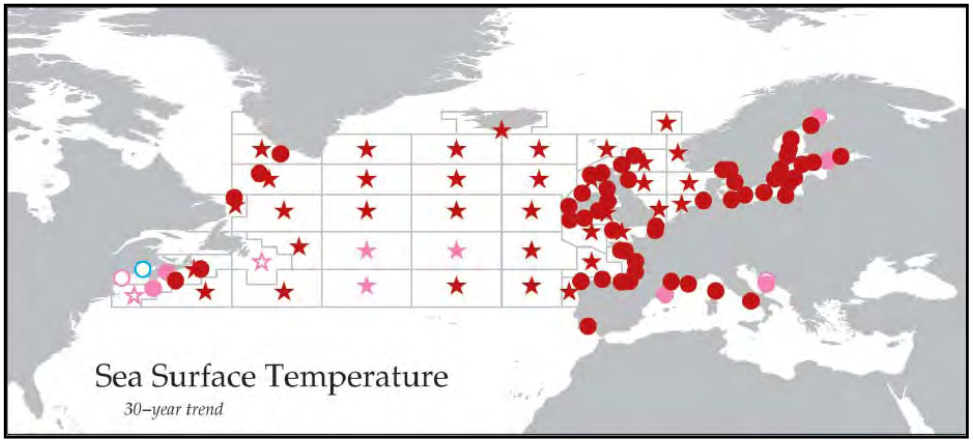
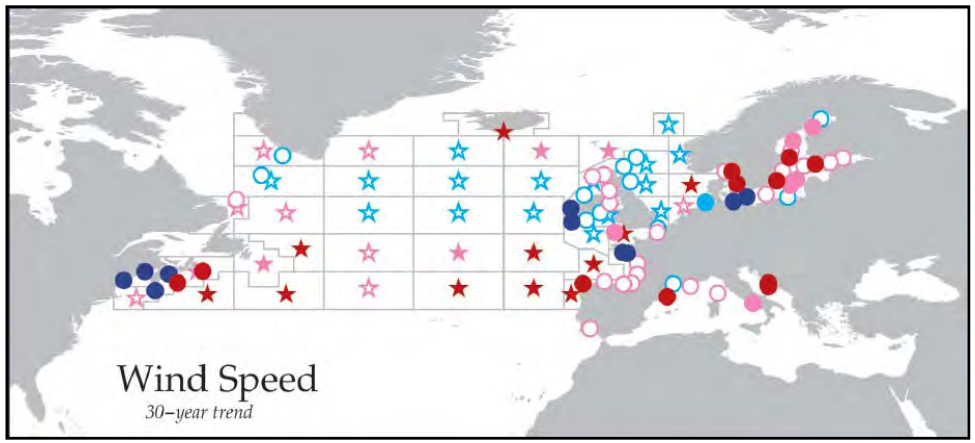
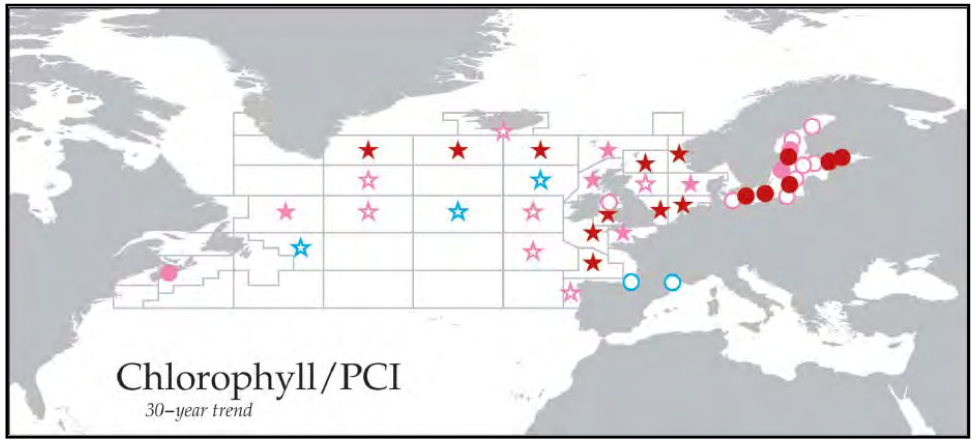
Pan-North Atlantic description (1981-2010)







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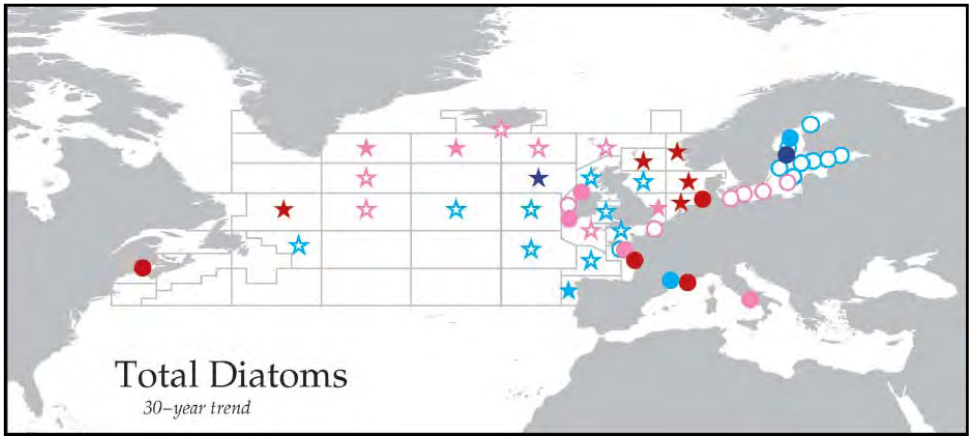
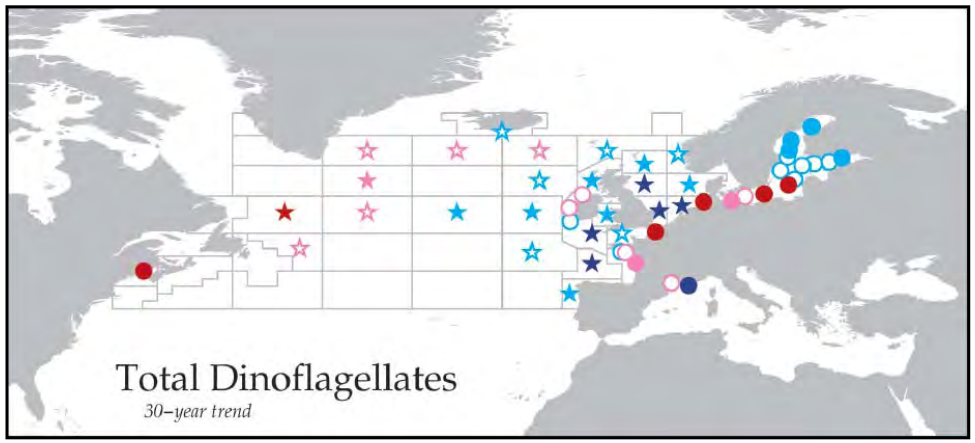
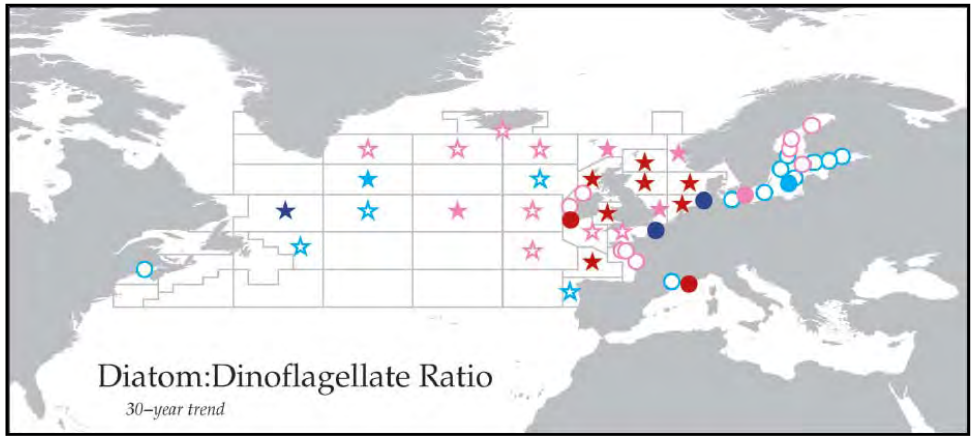
Pan-North Atlantic description (1981-2010)







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61 sites (2001-2010)

Region	Station #	Site Name	Sea Surface Temperature	Wind Speed	Chlorophyll	Total Diatoms	Total Dinoflagellates	Diatoms to Dinoflagellates ratio	Picoeukaryotes	Synechococcus	Bacteria
Northwest Atlantic Shelf	1	Booth Bay - Maine	0.064 (++)	-0.142 (--)	-0.001 (--)					0.025 (++)	0.022 (++)
	2	Bay of Fundy	0.050 (++)	-0.166 (--)	-0.107 (--)	-0.027 (--)	-0.010 (--)	-0.021 (---)			
	3	Bedford Basin	-0.109 (--)	-0.329 (---)	-0.054 (--)				0.038 (+++)	0.087 (+++)	-0.004 (--)
	4	Western Scotian Shelf	0.025 (++)	0.151 (+++)	-0.060 (--)				0.025 (++)		0.029 (+++)
	5	Central Scotian Shelf	-0.020 (--)	-0.107 (--)	-0.050 (--)				0.010 (++)		
	6	Eastern Scotian Shelf	0.029 (++)	-0.107 (--)					0.004 (++)	0.021 (++)	-0.007 (--)
Labrador Sea	7	Labrador Shelf and Slope	0.020 (++)	-0.088 (--)	0.010 (++)				-0.013 (--)	0.042 (++)	0.022 (++)
	8	Labrador Basin	0.008 (++)	0.028 (++)	0.027 (++)				0.026 (++)	0.013 (++)	0.010 (++)
	9	Greenland Shelf and Slope	0.005 (++)	0.013 (++)	0.008 (++)				-0.013 (--)	-0.004 (--)	-0.023 (--)
Baltic Sea	10	Bothnian Bay F2	0.134 (++)	0.175 (++)	-0.007 (--)	-0.008 (--)		0.054 (++)			
	11	Bothnian Bay BO3	0.055 (++)	-0.066 (--)	-0.006 (--)	-0.068 (--)	-0.018 (--)	-0.032 (--)			
	12	Bothnian Sea US9b	0.009 (++)	0.000 (++)	-0.002 (--)	-0.002 (--)	-0.004 (--)	0.010 (++)			
	13	Bothnian Sea SR5	0.019 (++)	-0.067 (--)	0.014 (++)	0.278 (+++)	0.013 (++)	-0.133 (--)			
	14	Åland Sea F64	-0.007 (--)	0.109 (++)	0.012 (++)		0.050 (++)	-0.437 (--)			
	15	Gulf of Finland LL3a	-0.029 (--)		-0.006 (--)	-0.021 (--)	-0.222 (--)	0.043 (++)			
	16	Gulf of Finland LL7	-0.012 (--)	-0.013 (--)	0.008 (++)	-0.017 (--)	0.024 (++)	-0.021 (--)			
	17	Gulf of Finland LL12	0.035 (++)	0.066 (++)	0.012 (++)	-0.727 (--)	-0.948 (--)	0.009 (++)			
	18	Baltic Proper LL19	-0.027 (--)	-0.013 (--)	0.013 (++)	-0.007 (--)	-0.093 (--)	0.021 (++)			
	19	Baltic Proper LL23	-0.008 (--)	-0.005 (--)	0.010 (++)	0.010 (++)	-0.004 (--)	0.016 (++)			
	20	Baltic Proper BY38	-0.008 (--)	0.097 (+++)	-0.027 (--)	-0.008 (--)	0.020 (++)	-0.013 (--)			
	21	Baltic Proper BY15	-0.013 (--)	0.014 (++)	0.032 (+++)	0.162 (++)	0.166 (++)	-0.098 (--)			
	22	Gdańsk Basin	-0.019 (--)	-0.012 (--)	-0.015 (--)		-0.183 (--)	-0.939 (---)			
	23	Eastern Gotland Basin	-0.018 (--)	0.018 (++)	0.024 (++)	0.013 (++)	0.059 (++)	-0.008 (--)			
	24	Bornholm Basin	-0.043 (--)	0.063 (++)	0.028 (++)	0.044 (++)	0.043 (++)	-0.006 (--)			
	25	Arkona Basin	-0.024 (--)	0.079 (++)	0.019 (++)		-0.028 (--)	-0.039 (--)			
	26	Mecklenburg Bight	-0.012 (--)		0.013 (++)	-0.021 (--)	-0.088 (--)	0.004 (++)			
	27	SMHI Arkona East	-0.013 (--)	0.039 (++)	-0.002 (--)		0.035 (++)	-0.004 (--)			
	28	SMHI Slupsk	-0.020 (--)	-0.205 (--)	-0.007 (--)	-0.010 (--)	0.043 (++)				
	29	SMHI A17	-0.012 (--)	-0.006 (--)	0.009 (++)	-0.004 (--)	-0.012 (--)	-0.008 (--)			
North Sea and English Channel	30	Helgoland Roads	-0.013 (--)			0.043 (+++)		0.015 (+++)			
	31	Scalloway - Shetland Islnd	-0.007 (--)	-0.133 (--)	0.010 (++)	0.068 (+++)	0.028 (++)	0.005 (++)			
	32	Scapa Bay - Orkney	-0.009 (--)	-0.067 (--)	-0.005 (--)	0.013 (++)	0.025 (++)	-0.005 (--)			
	33	Stonehaven	-0.027 (--)	0.026 (++)	0.022 (+++)	0.010 (++)		-0.008 (--)			
	34	REPHY Point 1 SRN Boulogne	-0.013 (--)	0.017 (++)	0.016 (++)		0.299 (+++)				
	35	REPHY At Sc	-0.013 (--)	-0.008 (--)	0.005 (++)	0.052 (++)	0.123 (+++)	0.010 (++)			
	36	Plymouth L4	-0.014 (--)	-0.014 (--)	-0.013 (--)			0.013 (++)			
Northwest Atlantic Shelf	37	Loch Ewe	0.013 (++)	0.016 (++)		0.010 (++)	0.047 (+++)	-0.018 (--)			
	38	Loch Maddy	0.017 (++)	-0.129 (--)		-0.010 (--)	-0.010 (--)				
	39	Millport	0.010 (++)	0.166 (++)	0.010 (++)						
	40	Cypris Station - Isle of Man	-0.010 (--)		0.004 (++)	-0.012 (--)	-0.017 (--)	-0.008 (--)			
	41	East Coast Ireland	-0.014 (--)	0.016 (++)		-0.014 (--)	0.010 (++)	-0.006 (--)			
	42	South Coast Ireland	-0.017 (--)	0.150 (++)		-0.009 (--)	-0.116 (--)	0.102 (++)			
	43	Southwest Coast Ireland	-0.009 (--)	-0.008 (--)		-0.022 (--)	-0.043 (--)	0.020 (++)			
	44	West Coast Ireland	-0.009 (--)	0.013 (++)		-0.016 (--)	-0.053 (--)	0.030 (++)			
	45	Northwest Coast Ireland	0.004 (++)	0.023 (++)		-0.028 (--)		-0.025 (---)			
Bay of Biscay and western Iberian Shelf	46	REPHY Mer et Rade	-0.043 (--)	0.048 (++)		0.044 (++)	0.021 (++)	0.019 (++)			
	47	REPHY Ouest Loscolo	-0.045 (--)	0.031 (++)		0.283 (+++)		0.102 (++)			
	48	REPHY Le Cornard	-0.035 (--)	0.065 (++)	0.018 (++)	0.016 (++)	0.011 (++)	-0.005 (--)			
	49	REPHY Teychan Bis	-0.031 (--)	0.003 (++)			0.160 (++)				
	50	AZTI Station D2	-0.019 (--)	0.000 (++)	0.018 (++)	0.000 (++)	0.054 (++)	0.000 (++)			
	51	Nerv/in River Estuary	-0.029 (--)	0.153 (++)		0.005 (++)	0.029 (++)				
	52	BADIALES Gijón/Xixón Station 2	0.007 (++)		0.004 (++)				-0.009 (--)	0.012 (++)	0.012 (++)
	53	BADIALES A Coruña Station 2	0.000 (++)	0.171 (++)	0.009 (++)	-0.003 (--)	-0.007 (--)	0.004 (++)		-0.030 (--)	
	54	Guadiana Estuary	0.027 (++)	0.000 (++)	-0.004 (--)	-0.007 (--)					
Mediterranean Sea	55	Blanes Bay	-0.004 (--)	0.017 (++)	-0.009 (--)				-0.002 (--)	0.002 (++)	-0.004 (--)
	56	Thau Lagoon	-0.003 (--)	0.029 (++)	-0.004 (--)	0.060 (+++)	0.010 (++)	0.033 (+++)	-0.015 (--)	0.013 (++)	
	57	REPHY Luscon A	-0.005 (--)	0.047 (++)	0.022 (+++)	0.014 (++)	-0.005 (--)	-0.005 (--)			
	58	REPHY Diana Centre	-0.020 (--)	0.016 (++)		-0.033 (--)	-0.033 (--)	-0.016 (--)			
	59	Gulf of Naples LTER-MC	-0.022 (--)	0.134 (++)		0.012 (++)	0.016 (++)	0.032 (++)			
	60	Kalloni Bay	-0.009 (--)	-0.424 (--)							
	61	Stoníca	-0.010 (--)	-0.139 (--)							-0.007 (--)
Percent of Positive Slopes (Number of Positive Slopes)			22% (13 of 61)	62% (38 of 61)	69% (28 of 41)	47% (21 of 45)	34% (16 of 47)	34% (14 of 41)	30% (6 of 20)	63% (10 of 16)	38% (3 of 8)

61 sites (1981-2010)

Region	Station #	Site Name	Sea Surface Temperature	Wind Speed	Chlorophyll	Total Diatoms	Total Dinoflagellates	Diatoms to Dinoflagellates ratio	Picoeukaryotes	Synechococcus	Bacteria
Northwest Atlantic Shelf	1	Booth Bay - Maine	0.505 (+)	-0.389 (--)							
	2	Bay of Fundy	-0.034 (--)	-0.393 (--)		0.025 (+++)	0.032 (+++)	-0.033 (--)			
	3	Bedford Basin		0.351 (--)							
	4	Western Scotian Shelf		-0.332 (--)							
	5	Central Scotian Shelf	0.032 (+++)	0.032 (+++)							
	6	Eastern Scotian Shelf	0.031 (+++)	0.033 (+++)							
Labrador Sea	7	Labrador Shelf and Slope	0.038 (+++)	0.006 (++)							
	8	Labrador Basin	0.054 (+++)	-0.027 (--)							
	9	Greenland Shelf and Slope	0.046 (+++)	-0.023 (--)							
Baltic Sea	10	Bothnian Bay F2		-0.018 (--)							
	11	Bothnian Bay BO3	0.041 (+++)		0.009 (++)	-0.194 (--)		0.002 (++)			
	12	Bothnian Sea US9b	0.044 (+++)		0.005 (++)			0.002 (++)			
	13	Bothnian Sea SR5	0.044 (+++)	0.004 (++)		0.025 (++)		0.002 (++)			
	14	Åland Sea F64	0.045 (+++)	0.045 (+++)	0.013 (+++)	-0.038 (--)	-0.007 (--)	-0.013 (--)			
	15	Gulf of Finland LL3a	0.029 (+++)	0.007 (++)	0.014 (+++)	-0.125 (--)		0.001 (++)			
	16	Gulf of Finland LL7		0.018 (++)	0.005 (+++)	-0.223 (--)	-0.008 (--)	-0.009 (--)			
	17	Gulf of Finland LL12	0.030 (+++)	0.039 (+++)	0.004 (++)	-0.022 (--)	-0.005 (--)	-0.011 (--)			
	18	Baltic Proper LL19	0.035 (+++)	0.005 (++)	0.006 (++)	-0.004 (--)	-0.004 (--)	0.006 (++)			
	19	Baltic Proper LL23	0.049 (+++)	0.017 (++)		-0.003 (--)	-0.002 (--)	-0.002 (--)			
	20	Baltic Proper BY38	0.051 (+++)	0.033 (+++)							
	21	Baltic Proper BY15	0.051 (+++)		0.006 (++)	-0.025 (--)	-0.005 (--)	-0.004 (--)			
	22	Gdańsk Basin	0.052 (+++)	-0.007 (--)	-0.002 (--)						
	23	Eastern Gotland Basin	0.042 (+++)		0.013 (+++)	-0.004 (--)	0.016 (+++)				
	24	Bornholm Basin	0.051 (+++)	0.026 (++)	0.009 (+++)	-0.017 (--)	0.018 (+++)	0.006 (++)			
	25	Arkona Basin	0.056 (+++)	-0.041 (--)	0.006 (+++)	-0.016 (--)	-0.016 (--)				
	26	Mecklenburg Bight	0.054 (+++)	0.046 (--)	0.010 (++)	-0.024 (--)		-0.007 (--)			
	27	SMHI Arkona East	0.055 (+++)	0.052 (+++)							
	28	SMHI Slupsk	0.051 (+++)	0.051 (+++)							
	29	SMHI A17	0.049 (+++)	0.029 (++)							
North Sea and English Channel	30	Helgoland Roads	0.052 (+++)			0.043 (+++)	0.031 (+++)	-0.008 (--)			
	31	Scalloway - Shetland Islnd	0.032 (+++)	-0.024 (--)							
	32	Scapa Bay - Orkney	0.029 (+++)	-0.014 (--)							
	33	Stonehaven	0.039 (+++)	-0.008 (--)							
	34	REPHY Point 1 SRN Boulogne	0.047 (+++)	-0.012 (--)							
	35	REPHY At Sc	0.041 (+++)	0.002 (++)		-0.002 (--)	0.035 (+++)	-0.003 (--)			
	36	Plymouth L4	0.025 (+++)								
Northeast Atlantic Shelf	37	Loch Ewe	0.022 (+++)	0.024 (++)							
	38	Loch Maddy	0.019 (+++)	0.003 (++)							
	39	Millport	0.024 (+++)	0.021 (++)							
	40	Cypris Station - Isle of Man	0.034 (+++)	0.003 (++)	0.003 (++)						
	41	East Coast Ireland	0.029 (+++)	-0.015 (--)							
	42	South Coast Ireland	0.023 (+++)	-0.034 (--)							
	43	Southwest Coast Ireland	0.023 (+++)	-0.045 (--)			-0.022 (--)	0.010 (+++)			
	44	West Coast Ireland	0.026 (+++)	-0.055 (--)		0.018 (++)	0.010 (++)	0.007 (++)			
	45	Northwest Coast Ireland	0.023 (+++)	-0.027 (--)			0.020 (++)	0.002 (++)			
Bay of Biscay and western Iberian Shelf	46	REPHY Mer et Rade	0.035 (+++)	-0.033 (--)		-0.018 (--)	-0.012 (--)	0.002 (++)			
	47	REPHY Ouest Loscolo	0.029 (+++)	-0.045 (--)			0.004 (++)	0.002 (++)			
	48	REPHY Le Cornard	0.029 (+++)	0.009 (++)		0.025 (+++)		0.007 (++)			
	49	REPHY Teychan Bis	0.030 (+++)	0.024 (++)							
	50	AZTI Station D2	0.011 (+++)	0.009 (++)	-0.002 (--)						
	51	Nerv/in River Estuary	0.003 (+++)	0.011 (++)							
	52	BADIALES Gijón/Xixón Station 2	0.008 (+++)	0.010 (++)							
	53	BADIALES A Coruña Station 2	0.027 (+++)	0.042 (+++)							
	54	Guadiana Estuary	0.023 (+++)	0.009 (++)							
Mediterranean Sea	55	Blanes Bay		0.022 (+++)							
	56	Thau Lagoon	0.033 (+++)	-0.023 (--)	-0.001 (--)		0.006 (++)	-0.002 (--)			
	57	REPHY Luscon A	0.025 (+++)	0.008 (++)		0.035 (+++)	-0.027 (--)	0.013 (+++)			
	58	REPHY Diana Centre	0.043 (+++)	0.017 (++)							
	59	Gulf of Naples LTER-MC	0.023 (+++)								
	60	Kalloni Bay	0.011 (++)	0.142 (+++)							
	61	Stoníca		0.214 (+++)							
Percent of Positive Slopes (Number of Positive Slopes)			98% (60 of 61)	82% (50 of 61)	89% (17 of 19)	33% (10 of 29)	45% (13 of 29)	38% (11 of 29)			

CPR Areas (2001-2010)

Region	Site Name	Sea Surface Temperature	Wind Speed	Phytoplankton Colour Index	Total Diatoms	Total Dinoflagellates	Diatoms to Dinoflagellates ratio
Western North Atlantic	CPR-F10	0.029 (+)	-0.187 (-)	-0.027 (-)	-0.039 (--)	0.030 (+)	-0.005 (-)
	CPR-E10	0.029 (+)	-0.162 (-)			-0.019 (-)	-0.007 (-)
	CPR-E09	0.026 (+)	0.025 (+)				
	CPR-E08	0.029 (+)	-0.138 (-)	-0.027 (---)	-0.021 (-)	-0.025 (-)	0.006 (+)
	CPR-D09	0.018 (+)	0.025 (+)				
	CPR-F09	-0.007 (-)	-0.160 (-)				
	CPR-D10	-0.034 (-)	0.020 (+)	0.029 (+)	-0.039 (-)	-0.029 (-)	0.010 (+)
	CPR-D08	0.028 (+)	-0.165 (-)	0.002 (+)	0.020 (+)		-0.040 (--)
	CPR-C09	0.043 (+)		-0.035 (-)	-0.017 (+)		
	CPR-E09	0.007 (+)	-0.101 (-)				
Central North Atlantic	CPR-F07	-0.008 (-)	-0.120 (-)	-0.018 (-)	-0.031 (-)	-0.035 (-)	0.001 (+)
	CPR-E07	0.036 (+)	-0.164 (-)	0.010 (+)	0.009 (+)	0.004 (+)	-0.010 (-)
	CPR-D07	0.022 (+)	0.000 (+)	-0.013 (-)		-0.030 (-)	0.006 (+)
	CPR-C07	0.022 (+)	-0.050 (-)	-0.004 (-)	-0.014 (-)	-0.033 (-)	-0.007 (-)
	CPR-B07	0.028 (+)	-0.078 (-)	-0.010 (-)	-0.019 (-)	0.013 (+)	0.000 (+)
	CPR-F06	0.018 (+)	-0.102 (-)	-0.017 (-)	-0.009 (-)	-0.024 (-)	0.005 (+)
	CPR-E06	0.027 (+)	0.011 (+)	-0.007 (+)	-0.002 (+)	-0.033 (-)	0.001 (+)
	CPR-D06	0.022 (+)	-0.058 (-)	-0.009 (-)	0.003 (+)	-0.025 (-)	0.007 (+)
	CPR-C06	0.017 (+)	0.121 (+)	-0.536 (---)			
	CPR-B06	0.013 (+)	-0.130 (-)	0.000 (+)	0.007 (+)	-0.010 (-)	0.017 (+++)
	CPR-A06	0.013 (+)	-0.168 (-)	-0.017 (-)		-0.006 (-)	0.014 (+)
Eastern North Atlantic	CPR-F05	0.018 (+)	-0.180 (-)	-0.000 (+)	-0.023 (-)		0.078 (+)
	CPR-E05	0.012 (+)	-0.169 (-)	-0.024 (-)	-0.027 (-)	-0.078 (---)	
	CPR-D05	0.028 (+)		-0.035 (---)		-0.030 (-)	-0.003 (-)
	CPR-C05		-0.059 (-)	-0.017 (-)	-0.021 (-)		
	CPR-B05	0.018 (+)	0.032 (+)	0.014 (-)	-0.023 (-)	-0.030 (---)	0.010 (+)
	CPR-F04	0.007 (+)			-0.031 (-)	-0.037 (-)	0.013 (+)
	CPR-E04	-0.007 (-)	0.027 (+)	-0.013 (-)	-0.023 (-)	-0.031 (-)	0.008 (+)
	CPR-D04	0.023 (-)	-0.160 (-)	-0.032 (---)	-0.053 (---)		0.001 (+)
	CPR-C04	0.013 (+)	-0.332 (-)	-0.002 (+)	0.037 (+++)	-0.006 (-)	0.035 (+)
	CPR-B04	0.008 (+)	0.030 (+)		-0.017 (-)		0.009 (+)
	CPR-D03	-0.030 (-)	0.001 (+)	-0.023 (---)		-0.062 (---)	
	CPR-C03	-0.010 (-)			-0.017 (-)	-0.008 (-)	0.002 (+)
North Sea	CPR-D02	-0.030 (-)	-0.189 (-)	-0.000 (+)	0.000 (+)	0.018 (+)	0.000 (+)
	CPR-C02	-0.020 (-)	0.140 (+++)	-0.010 (-)	-0.009 (-)	-0.020 (-)	0.013 (+)
	CPR-B02	-0.025 (-)	-0.180 (-)	-0.001 (+)	0.000 (+)	-0.007 (-)	0.013 (+)
	CPR-D01	-0.021 (-)	-0.103 (-)	-0.004 (-)	-0.007 (+)	-0.020 (-)	
	CPR-C01	-0.031 (-)	0.055 (+)	0.002 (+)	-0.006 (-)	0.016 (+)	-0.006 (-)
	CPR-B01	-0.037 (-)	-0.120 (---)	0.004 (-)	-0.001 (+++)		0.033 (+++)
	CPR-A01	0.007 (+)	0.005 (+)				

Percent of Positive Slopes	67%	88%	71%	38%	10%	79%
Number of Positive Slopes	21 of 40	36 of 41	15 of 21	11 of 29	3 of 31	27 of 34

CPR Areas (1981-2010)

Region	Site Name	Sea Surface Temperature	Wind Speed	Phytoplankton Colour Index	Total Diatoms	Total Dinoflagellates	Diatoms to Dinoflagellates ratio
Western North Atlantic	CPR-F10	0.017 (+)	0.011 (+)				
	CPR-E10	0.033 (+++)					
	CPR-E09	0.048 (+++)	0.028 (+++)				
	CPR-E08	0.019 (+)					
	CPR-D09	0.033 (+++)	0.022 (+)				
	CPR-F08	0.046 (+++)	0.035 (+++)				
	CPR-E06	0.061 (+++)	0.062 (+++)	0.000 (-)	-0.006 (-)	0.007 (+)	-0.004 (-)
	CPR-D08	0.038 (+++)	0.004 (+)		0.015 (+++)	0.013 (+++)	-0.009 (---)
	CPR-C08	0.029 (+++)	0.000 (-)				
	CPR-B09	0.054 (+++)	0.043 (+)				
	CPR-F07		0.013 (+)				
	CPR-E07		0.033 (+)				
	CPR-D07	0.046 (+++)	-0.026 (-)	0.000 (+)	0.008 (+)	0.004 (+)	-0.003 (-)
	CPR-C07	0.035 (+++)	-0.007 (-)	0.002 (+)	0.011 (+)		
	CPR-B07	0.028 (+++)	0.007 (+)	0.014 (+++)		0.013 (+)	0.000 (+)
	CPR-F06	0.023 (+++)	0.030 (+++)				
	CPR-E06						
	CPR-D06	0.031 (+++)	0.009 (-)	0.000 (-)	-0.013 (-)		
	CPR-C06	0.009 (+++)	-0.003 (-)				
	CPR-B06	0.042 (+++)	0.008 (-)	0.015 (+++)		0.006 (+)	0.003 (+)
	CPR-A06	0.035 (+++)	0.024 (+++)	0.006 (+)	0.005 (+)	-0.001 (-)	0.005 (+)
Eastern North Atlantic	CPR-F05	0.022 (+++)	0.041 (+++)				
	CPR-E05	0.022 (+++)	0.028 (+++)	0.001 (+)	-0.006 (-)	-0.016 (-)	0.002 (+)
	CPR-D05	0.026 (+++)	-0.005 (-)	0.008 (+)	-0.007 (-)		0.002 (+)
	CPR-C05	0.033 (+++)	-0.025 (-)	-0.003 (-)	-0.012 (---)	-0.008 (-)	-0.003 (-)
	CPR-B05	0.035 (+++)		0.013 (+++)	0.010 (+)	0.006 (+)	0.000 (+)
	CPR-F04	0.019 (+++)	0.031 (+++)	0.004 (+)			-0.003 (-)
	CPR-E04	0.030 (+++)	0.032 (+++)	0.009 (+++)	-0.002 (-)	-0.016 (---)	0.006 (+++)
	CPR-D04	0.022 (+++)	-0.007 (-)	0.013 (+++)	0.002 (+)	-0.014 (---)	0.002 (+)
	CPR-C04	0.018 (+++)	0.010 (-)		-0.001 (-)		0.006 (+++)
	CPR-B04	0.033 (+++)			0.008 (+)	-0.006 (-)	
	CPR-D03	0.026 (+++)	0.032 (+++)		-0.007 (-)	-0.012 (-)	0.002 (+)
	CPR-C03	0.030 (+++)	-0.004 (-)	0.006 (+++)	-0.003 (-)		0.005 (+++)
North Sea	CPR-D02	0.026 (+++)	-0.010 (-)	0.007 (+++)		-0.016 (---)	
	CPR-C02	0.045 (+++)	-0.018 (-)	0.002 (+)	-0.002 (-)	-0.037 (---)	0.013 (+++)
	CPR-B02	0.038 (+++)	-0.010 (-)	0.008 (+++)	0.009 (+++)		0.009 (+++)
	CPR-D01	0.017 (+++)	0.018 (+)	0.011 (+++)	0.017 (+++)	-0.016 (---)	0.005 (+++)
	CPR-C01	0.050 (+++)	0.026 (+++)		0.010 (+++)		0.007 (+++)
	CPR-B01	0.038 (+++)	-0.010 (-)	0.015 (+++)	0.015 (+++)	-0.001 (-)	
	CPR-A01	0.043 (+++)	0.009 (-)				

Percent of Positive Slopes	100%	68%	55%	56%	23%	76%
Number of Positive Slopes	40 of 40	28 of 41	12 of 22	18 of 32	7 of 31	26 of 34

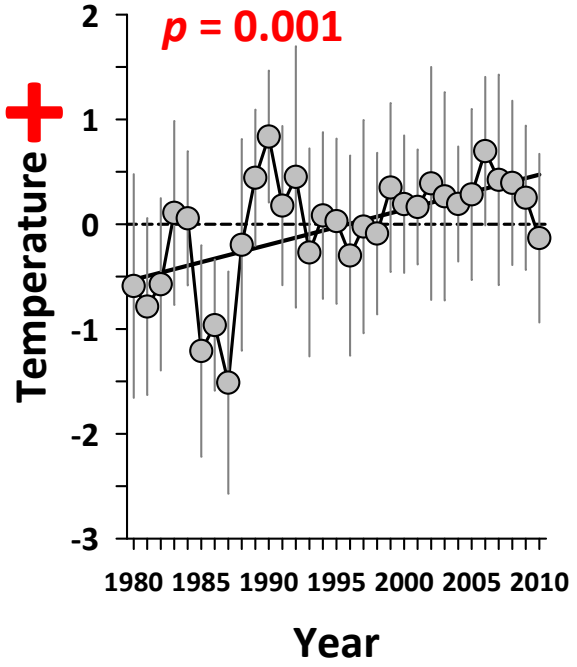
Pan-North Atlantic description: simple count

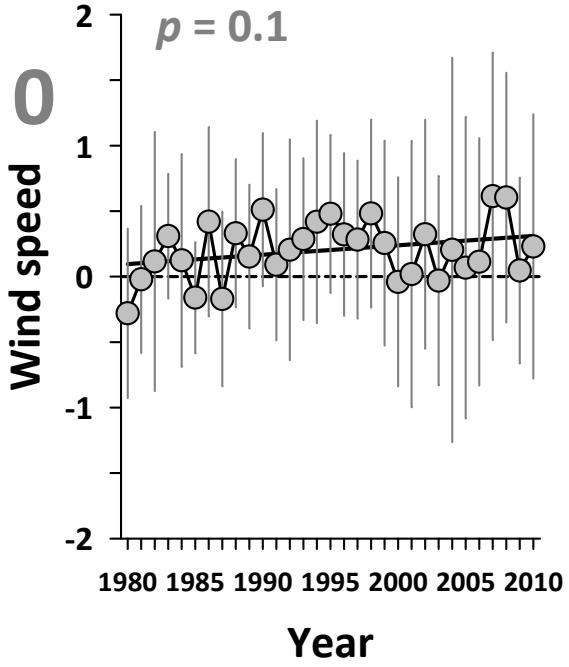
> 50% positive

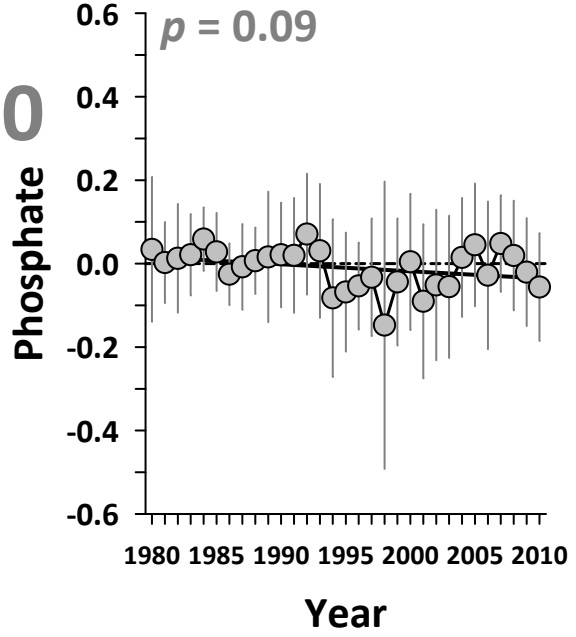
> 50% negative

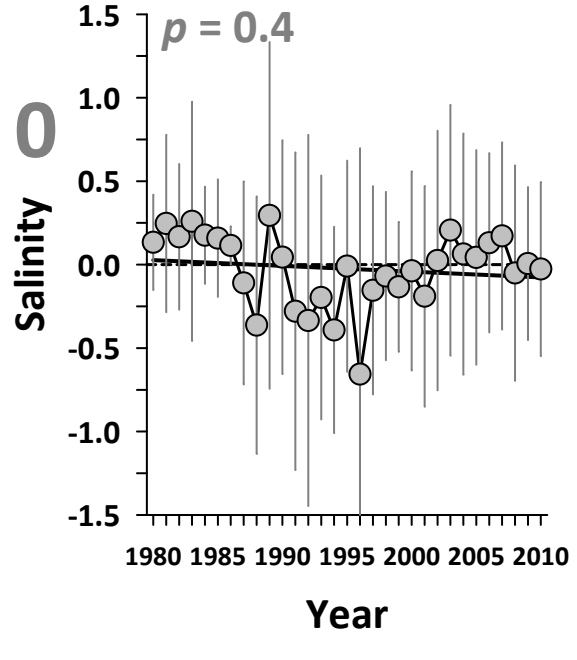
			Sea surface temperature	Wind speed	Chlorophyll	Diatoms	Dinoflagellates	Diatom/(Diatom+Dinoflagellate)	Picoeukaryotic algae	*Synechococcus*	Bacteria
2001-2010	Local Sites	Percent of positive slopes	27%	62%	60%	47%	59%	44%	80%	83%	38%
		(number of positive slopes)	*17/61*	*38/61*	*29/48*	*23/48*	*28/47*	*21/47*	*8/10*	*10/12*	*5/13*
1981-2010	Local Sites	Percent of positive slopes	98%	62%	89%	53%	48%	48%			
		(number of positive slopes)	*60/61*	*38/61*	*17/19*	*14/26*	*12/25*	*12/25*			
2001-2010	CPR areas	Percent of positive slopes	67%	40%	31%	38%	18%	79%			
		(number of positive slopes)	*27/40*	*16/40*	*11/35*	*13/34*	*6/32*	*27/34*			
1981-2010	CPR areas	Percent of positive slopes	100%	60%	88%	56%	28%	76%			
		(number of positive slopes)	40/40	24/40	22/25	14/24	7/25	19/25			

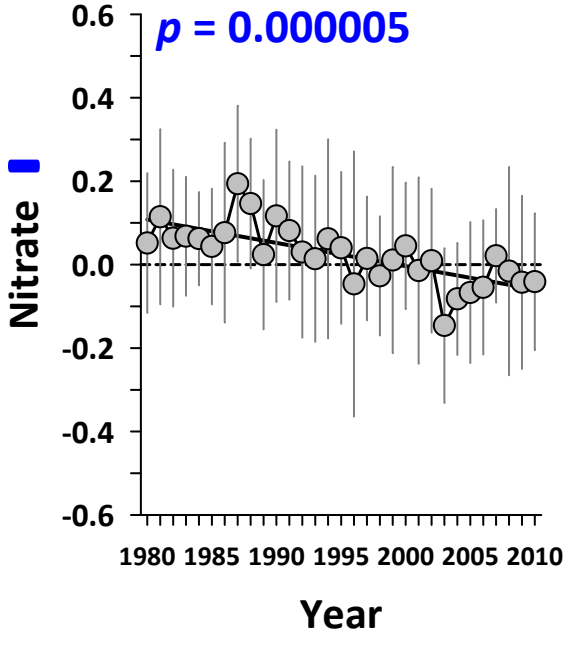
Pan-North Atlantic description: site-averaged annual average anomaly

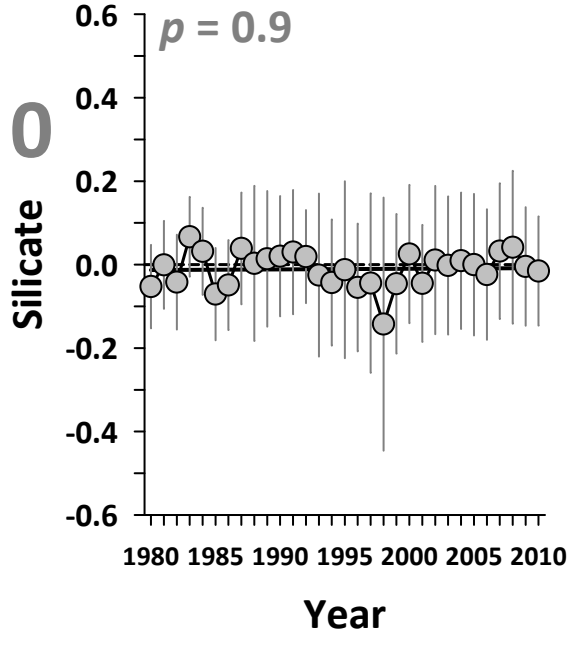




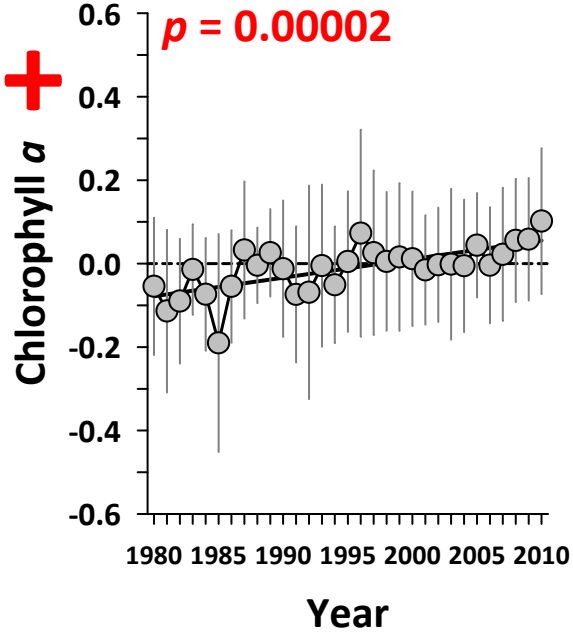


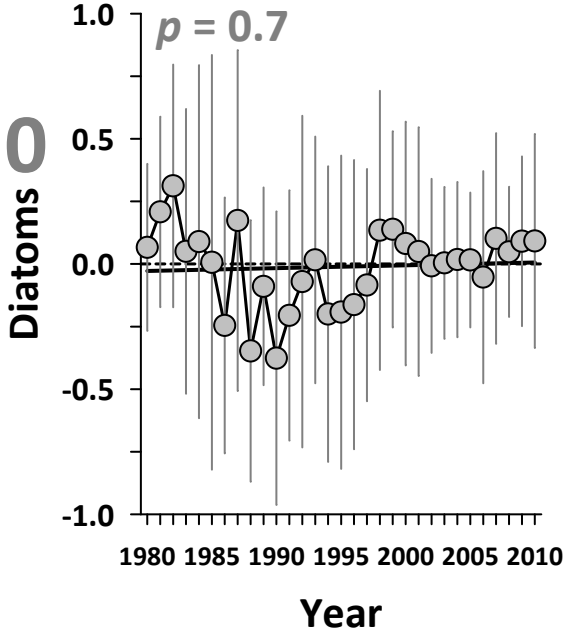


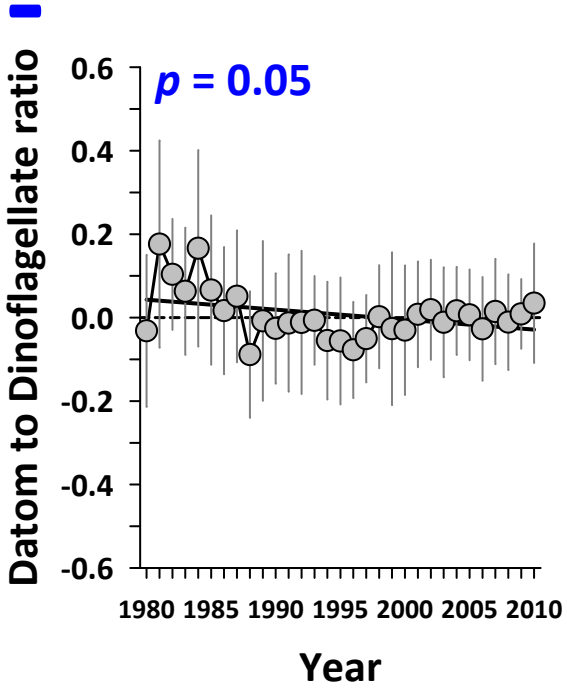


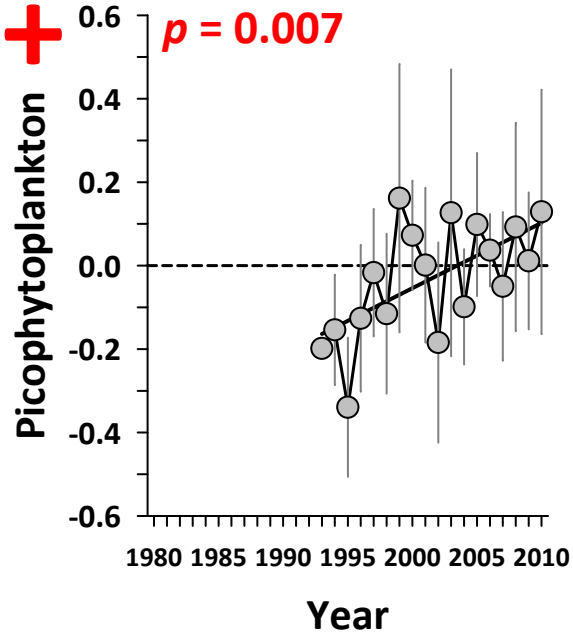


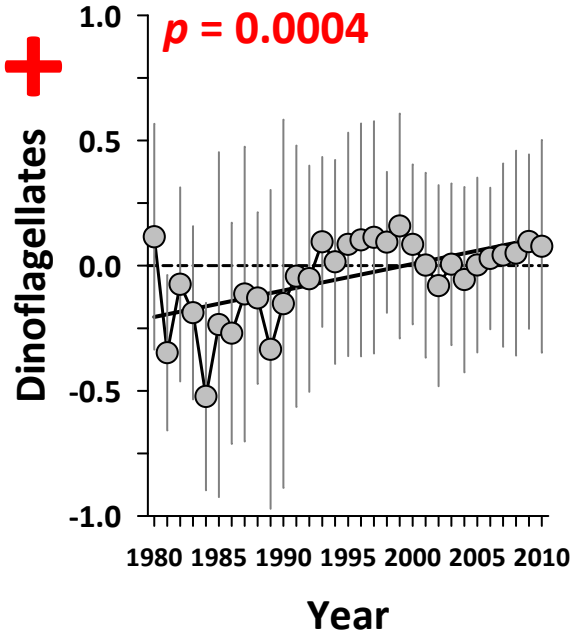
Pan-North Atlantic description: site-averaged annual average anomaly











Site-averaged annual average anomaly : Gross summary 1980-2010

INCREASE	DECREASE	NO CHANGE
Temperature	Nitrate	Salinity
Chlorophyll *a*	Diatom:Dinoflagellate ratio	Wind speed
Picophytoplankton		Phosphate
Dinoflagellates		Silicate
		Diatoms

Site-averaged annual average anomaly : Gross summary 1980-2010

INCREASE	DECREASE	NO CHANGE
Temperature	Nitrate	Salinity
Chlorophyll *a*	Diatom:Dinoflagellate ratio	Wind speed
Picophytoplankton		Phosphate
Dinoflagellates		Silicate
		Diatoms

?

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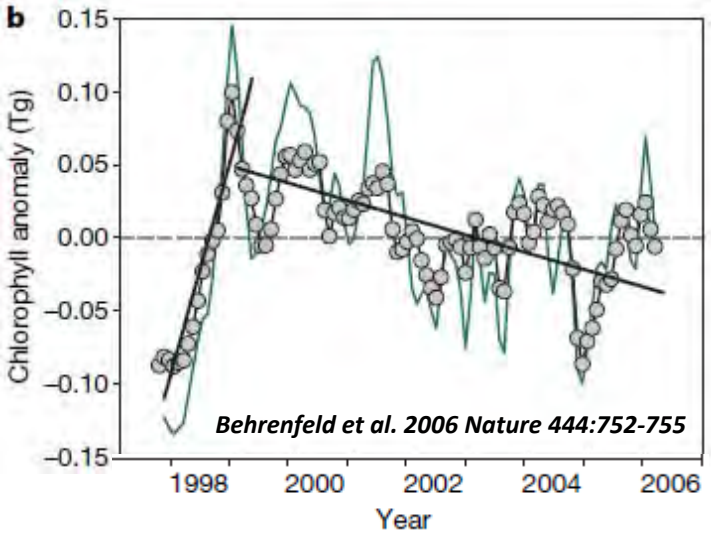
NEWS & VIEWS

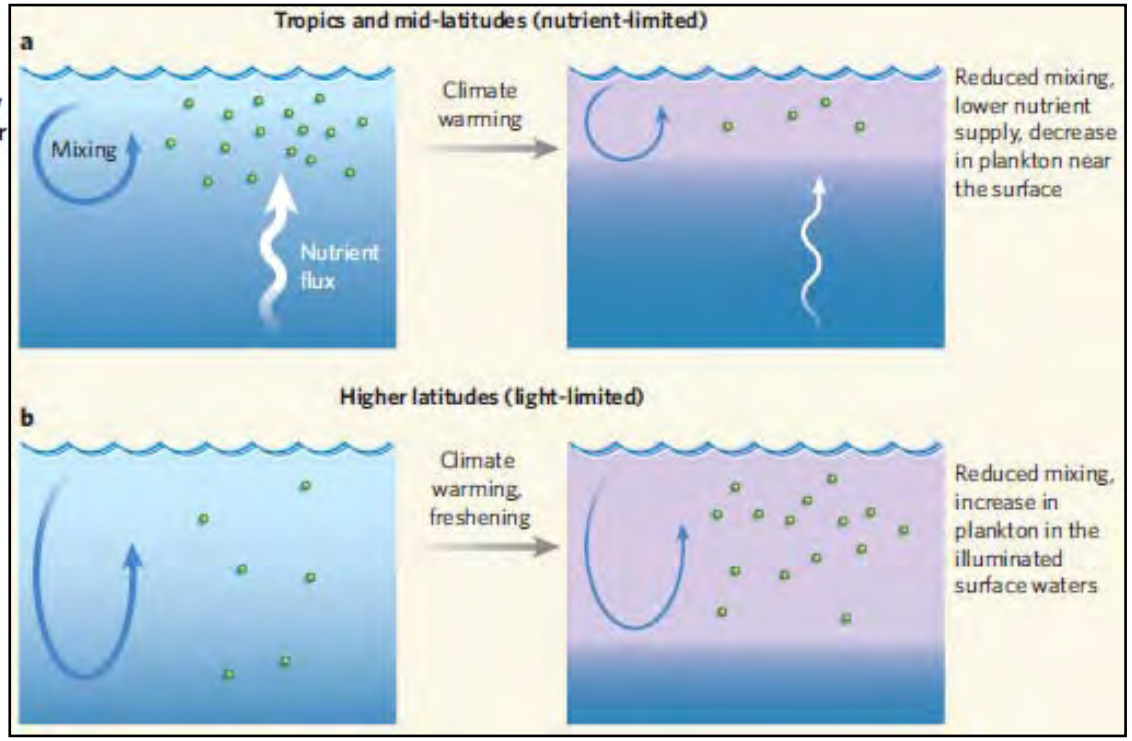
OCEANOGRAPHY

Plankton in a warmer world

Scott C. Doney

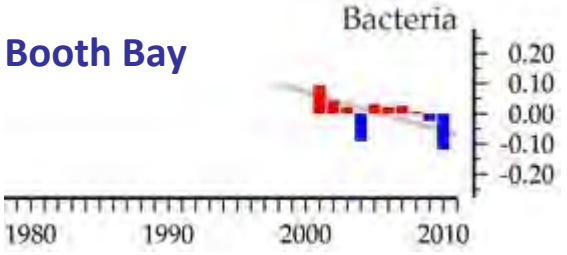
Satellite data show that phytoplankton biomass and growth generally decline as the oceans' surface waters warm up. Is this trend, seen over the past decade, a harbinger of the future for marine ecosystems?



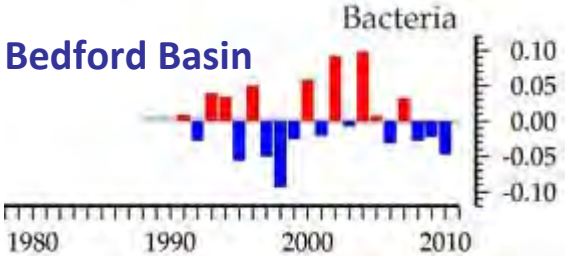


Bacteria

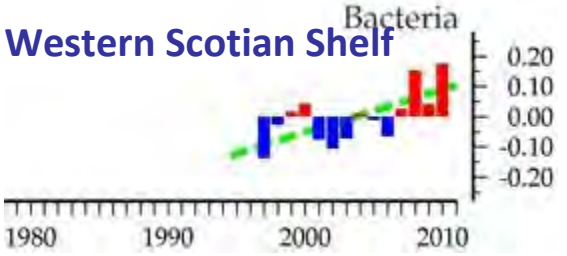
Booth Bay



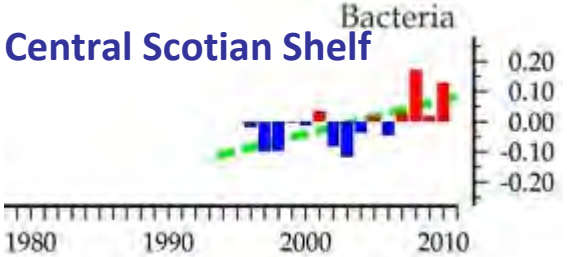
Bedford Basin



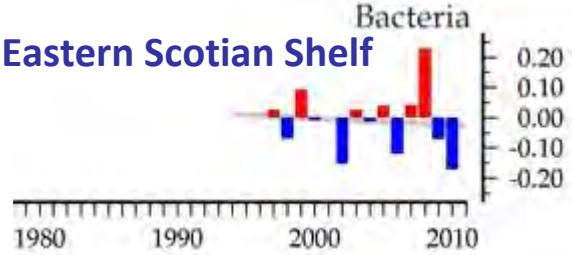
Western Scotian Shelf



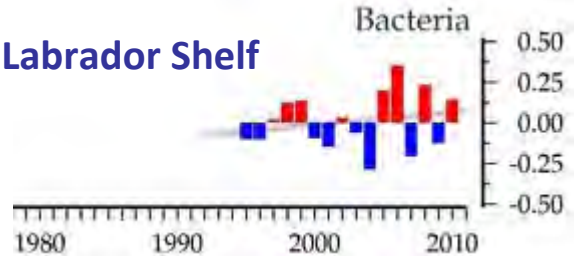
Central Scotian Shelf



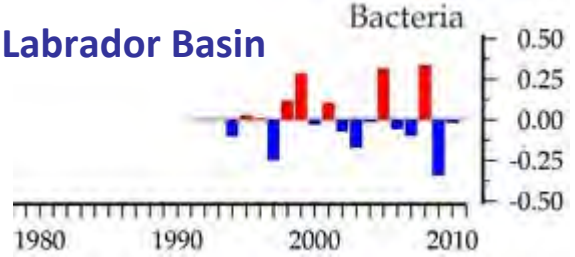
Eastern Scotian Shelf



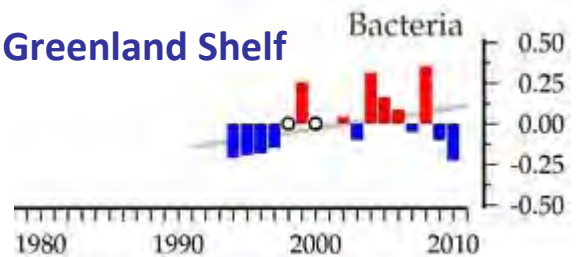
Labrador Shelf



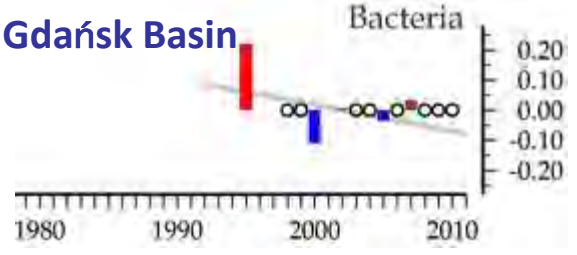
Labrador Basin



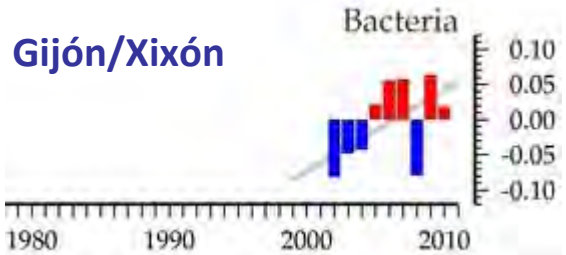
Greenland Shelf



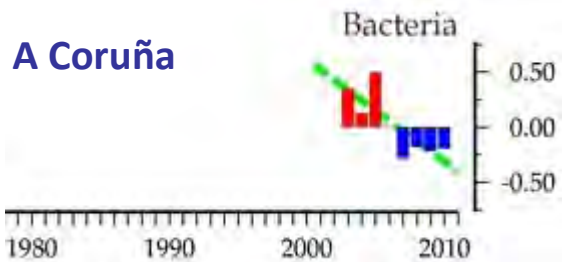
Gdańsk Basin



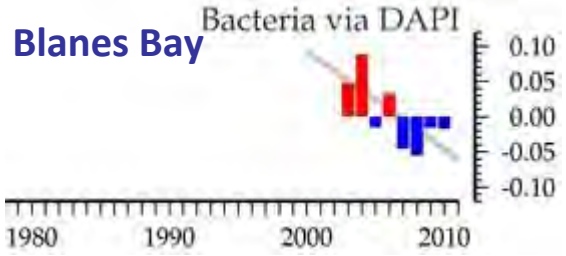
Gijón/Xixón



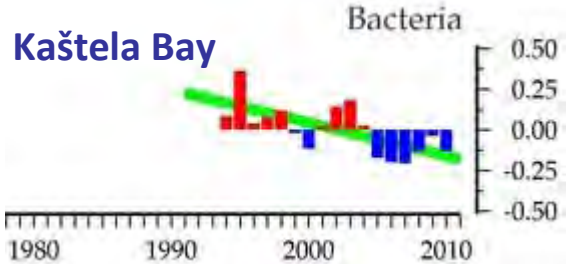
A Coruña



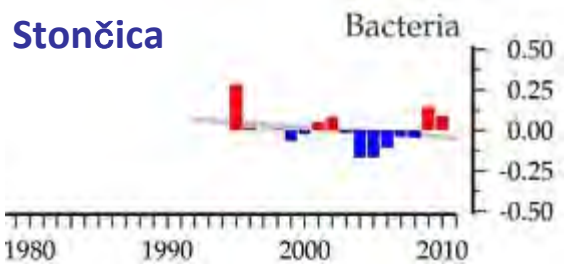
Blanes Bay



Kaštela Bay

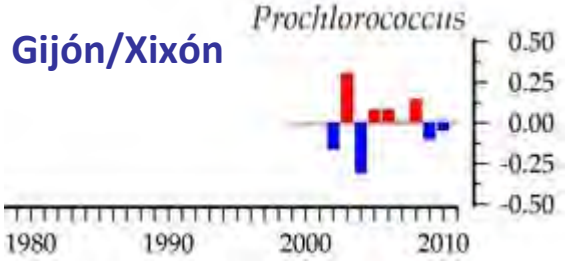


Stončica



Procholorococcus

Gijón/Xixón



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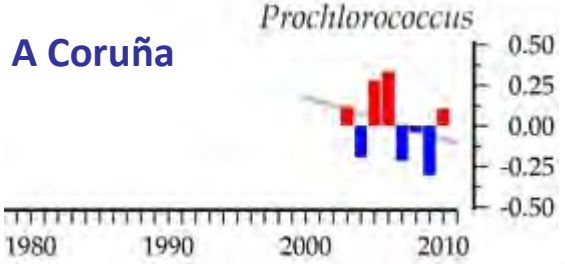

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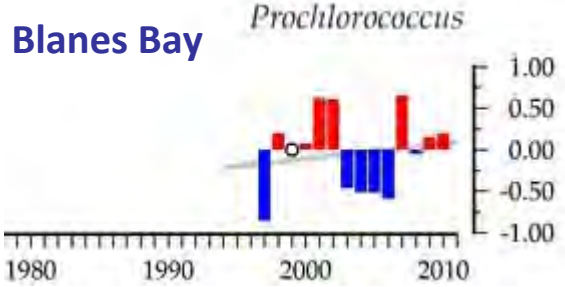
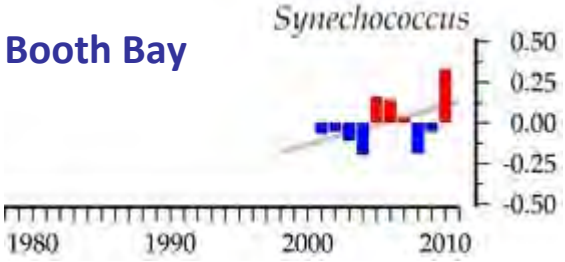
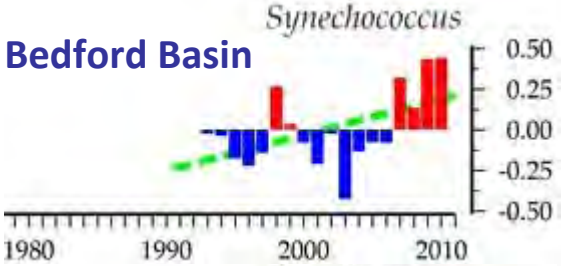


Synechococcus

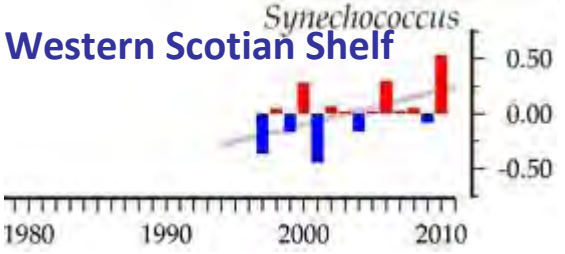
Booth Bay



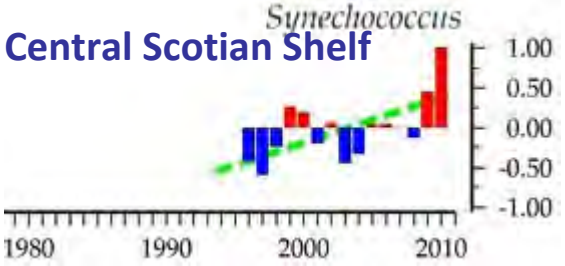
Bedford Basin



Western Scotian Shelf



Central Scotian Shelf



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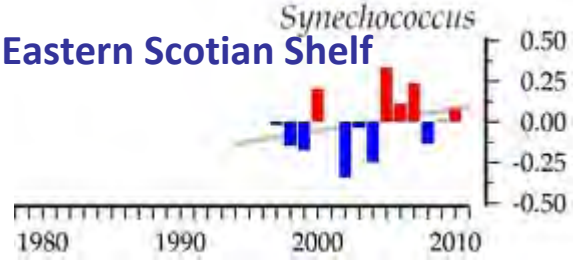
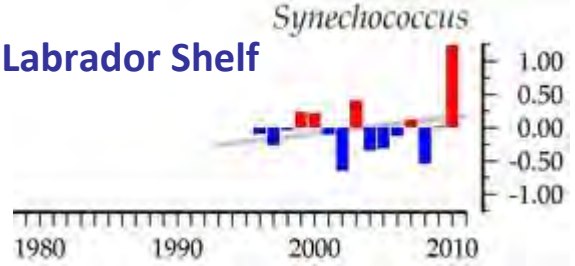
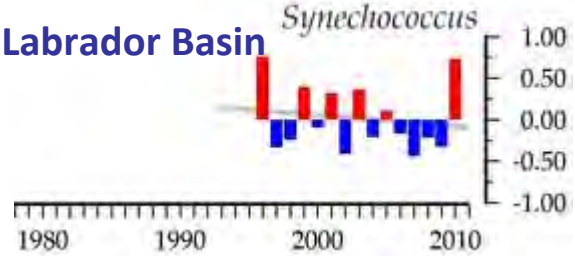


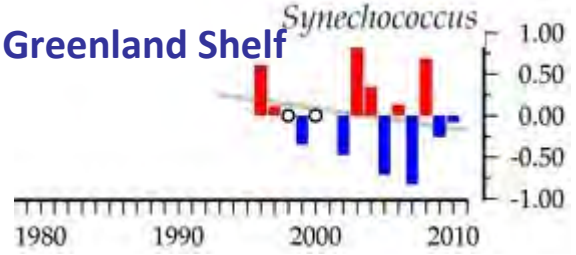
Labrador Shelf



Labrador Basin



Greenland Shelf



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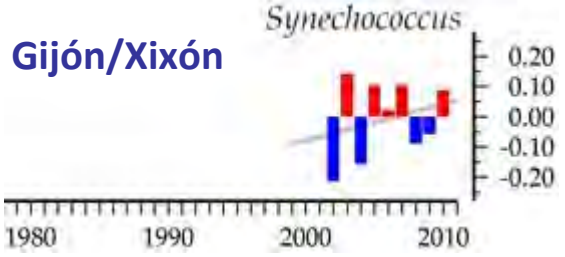
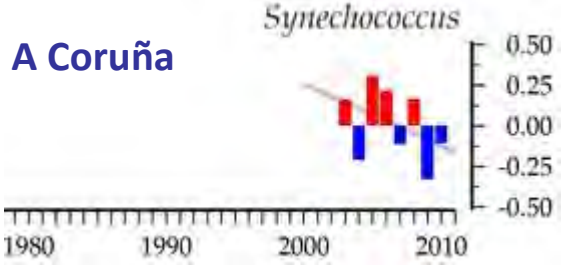
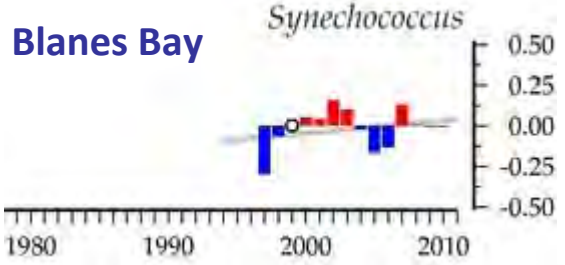


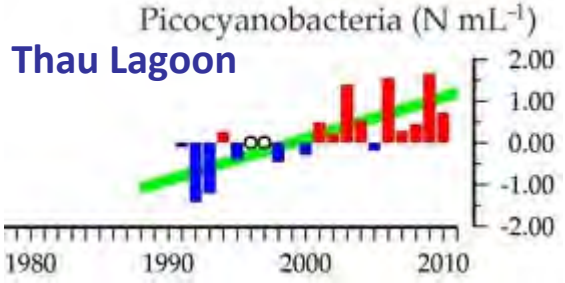
A Coruña



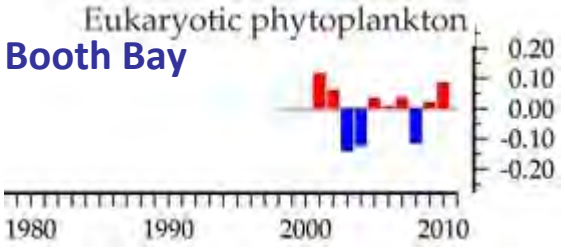
Blanes Bay

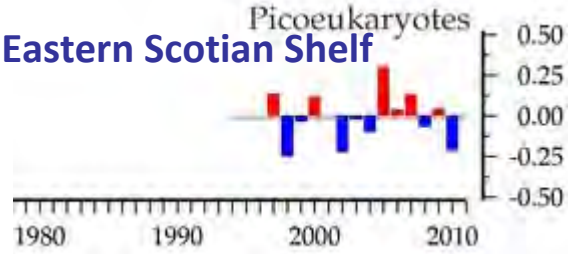


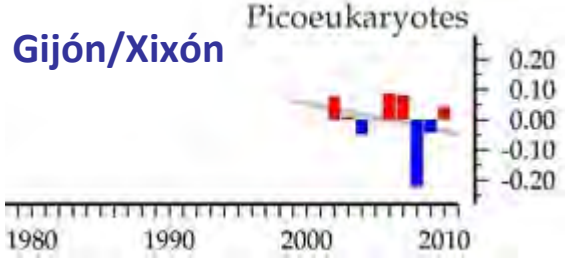
Thau Lagoon

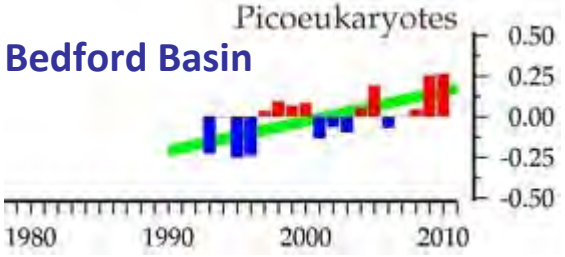


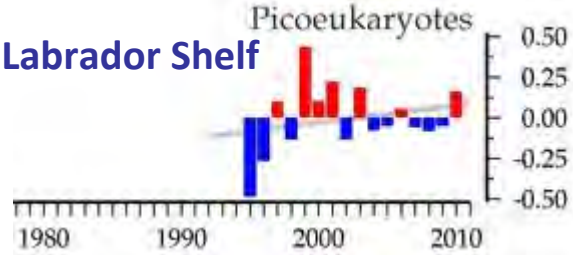
Picoeukaryotic algae

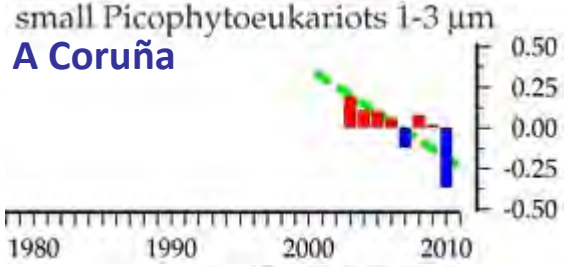


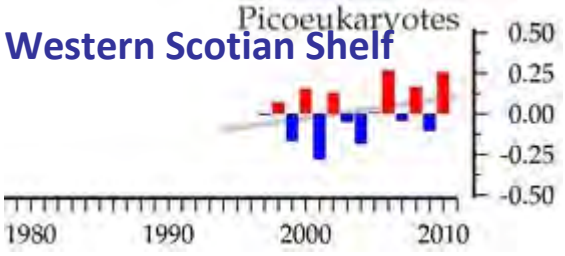


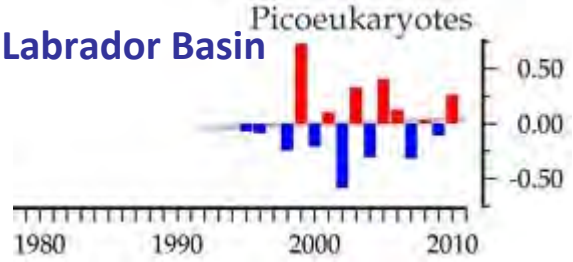


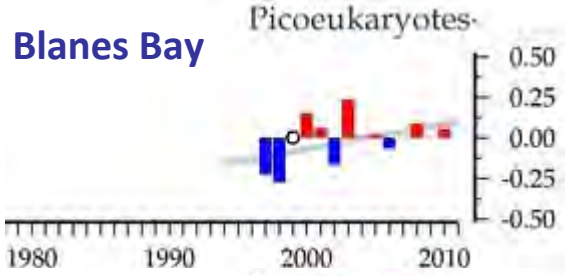


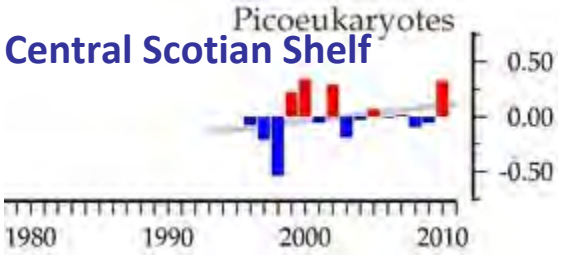


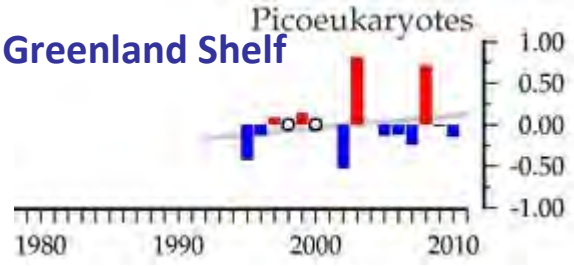


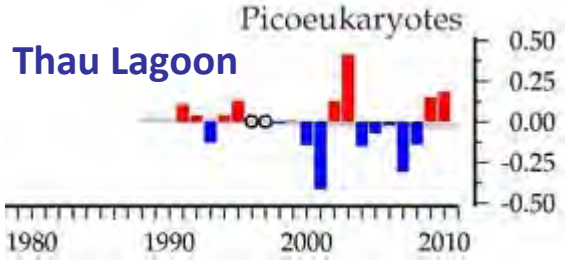




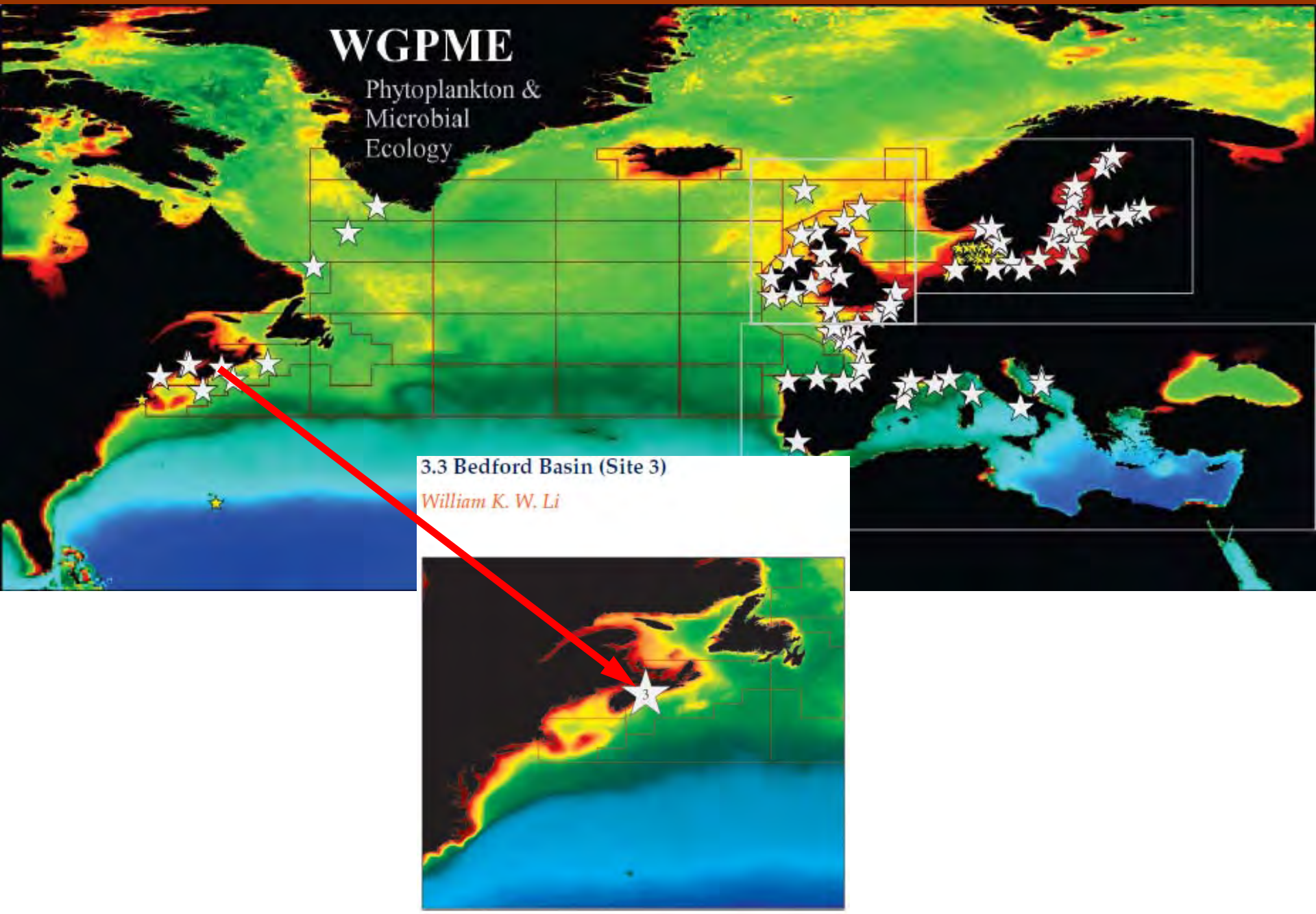




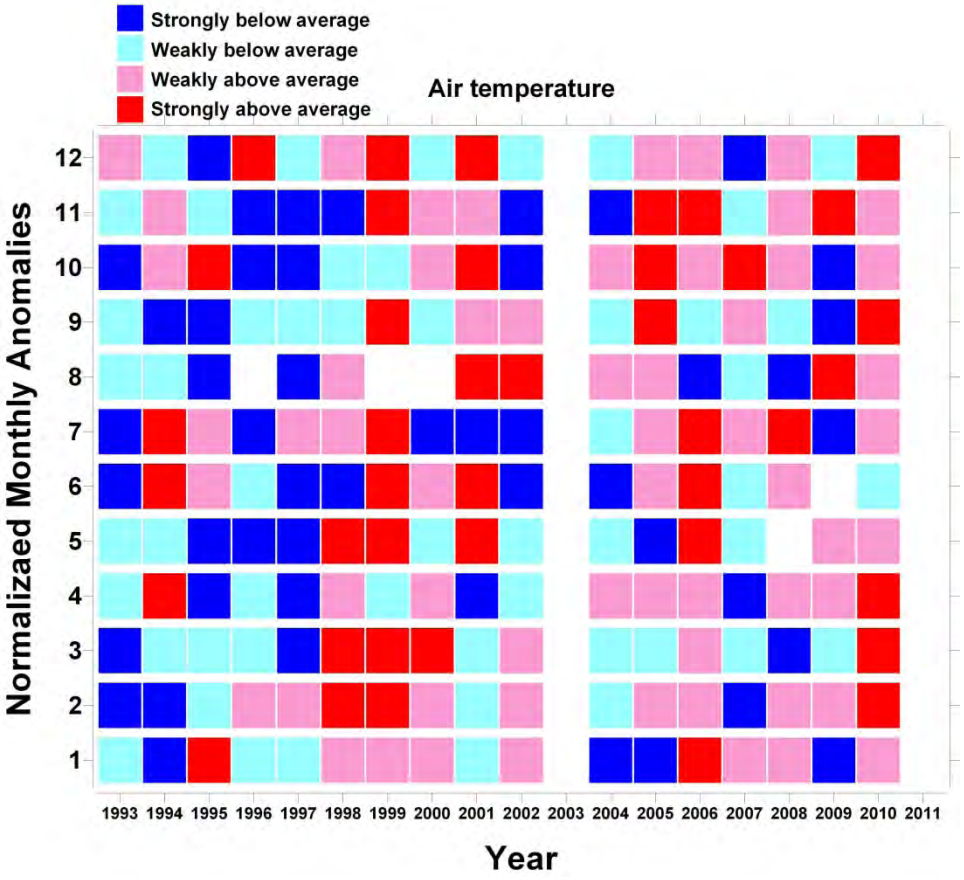


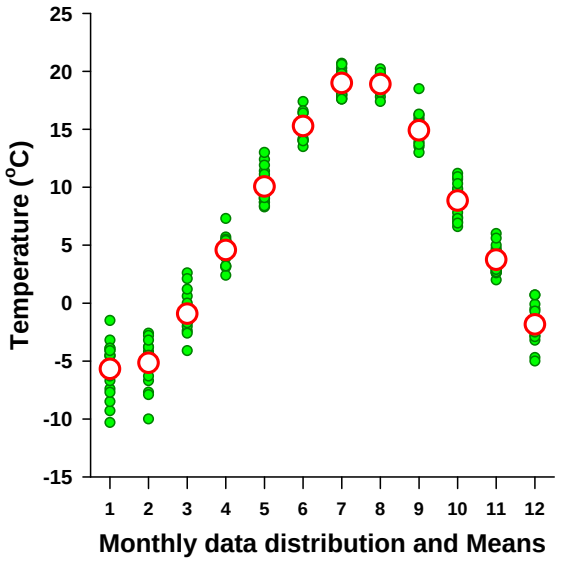


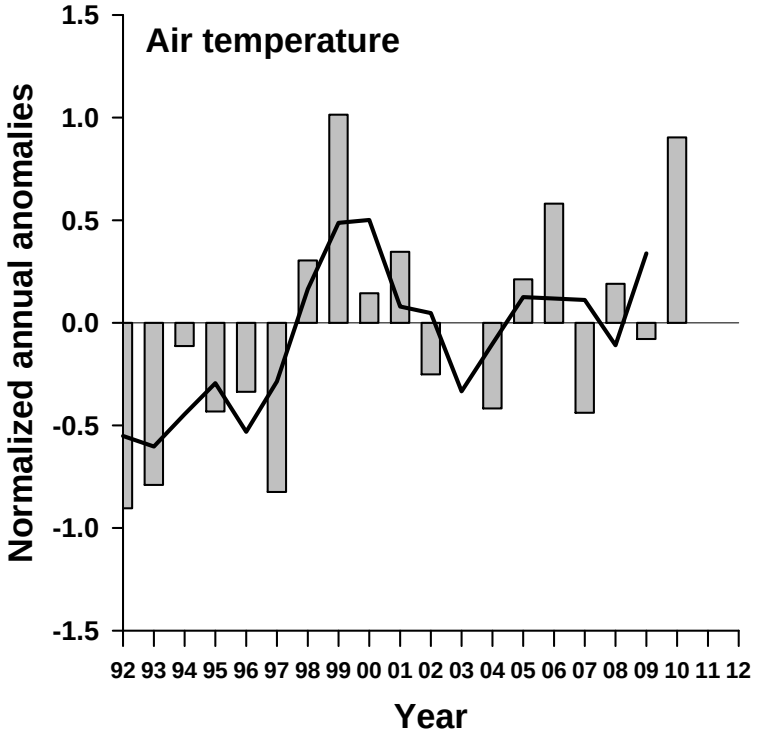
Bedford Basin (Site 3)



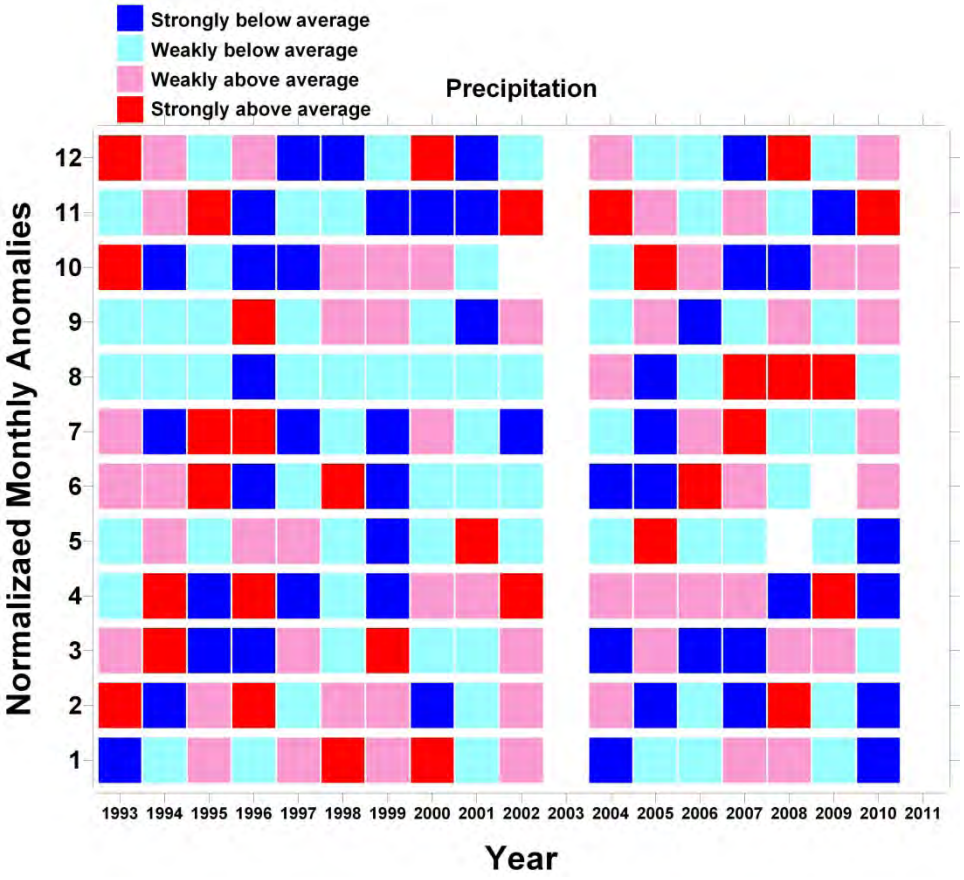
Meteorology (Shearwater) : AIR TEMPERATURE

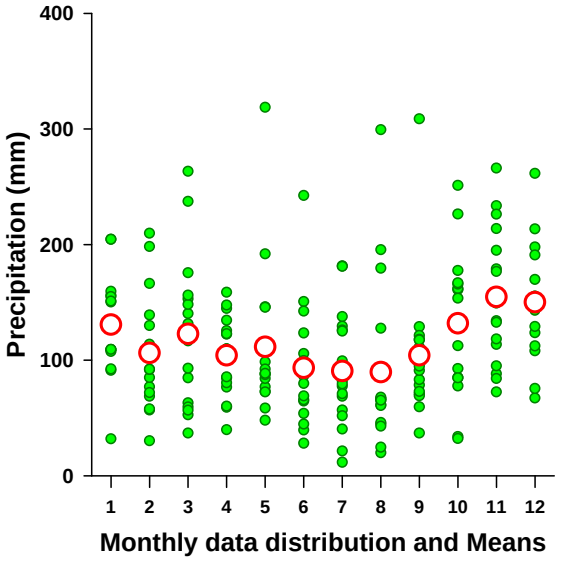


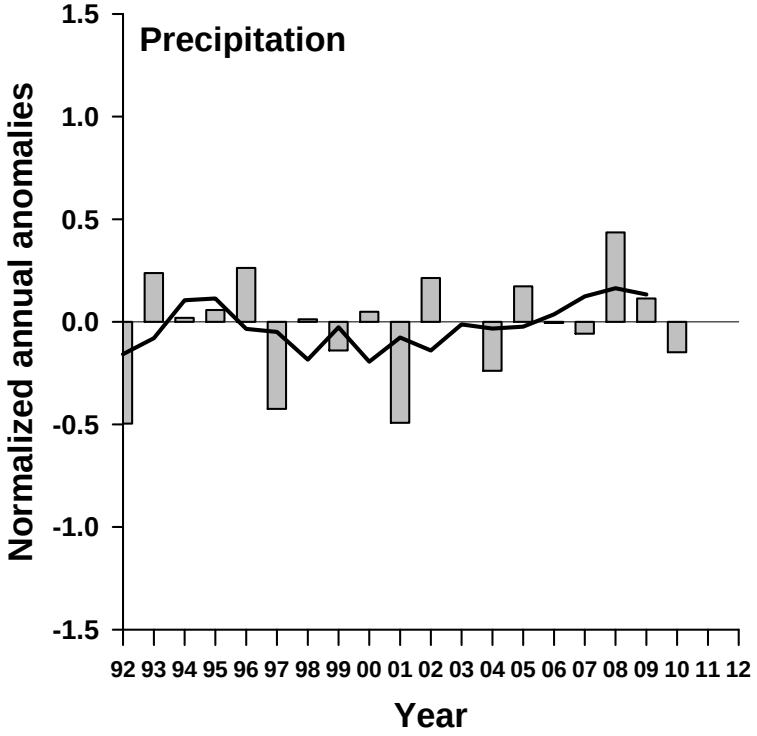




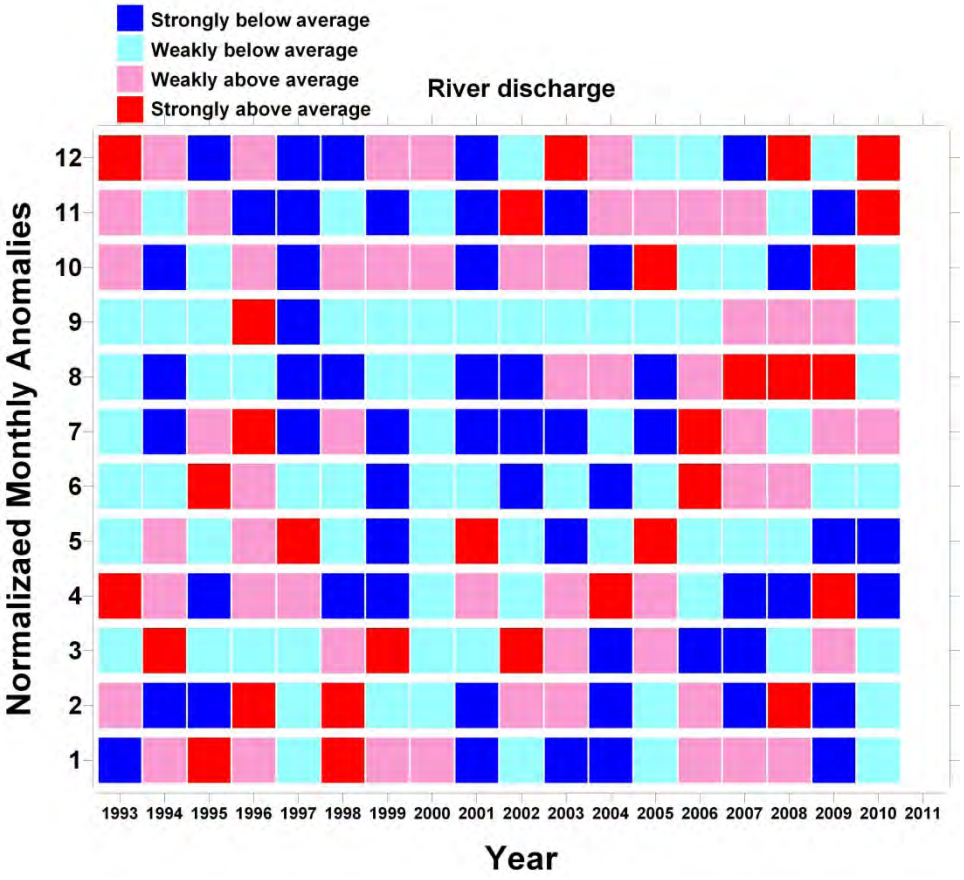
Meteorology (Shearwater) : PRECIPITATION

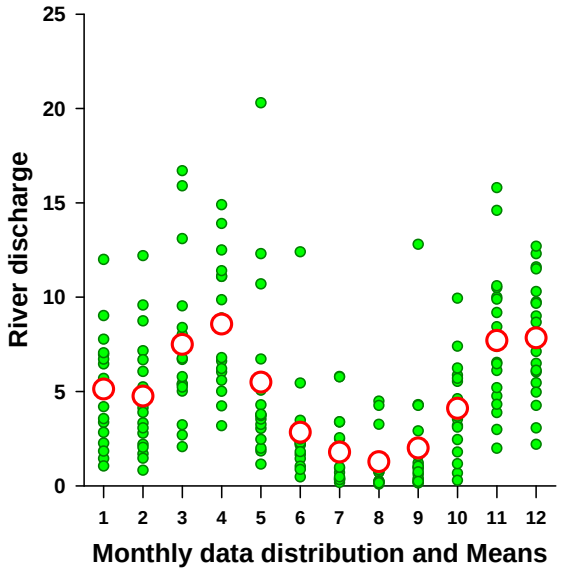


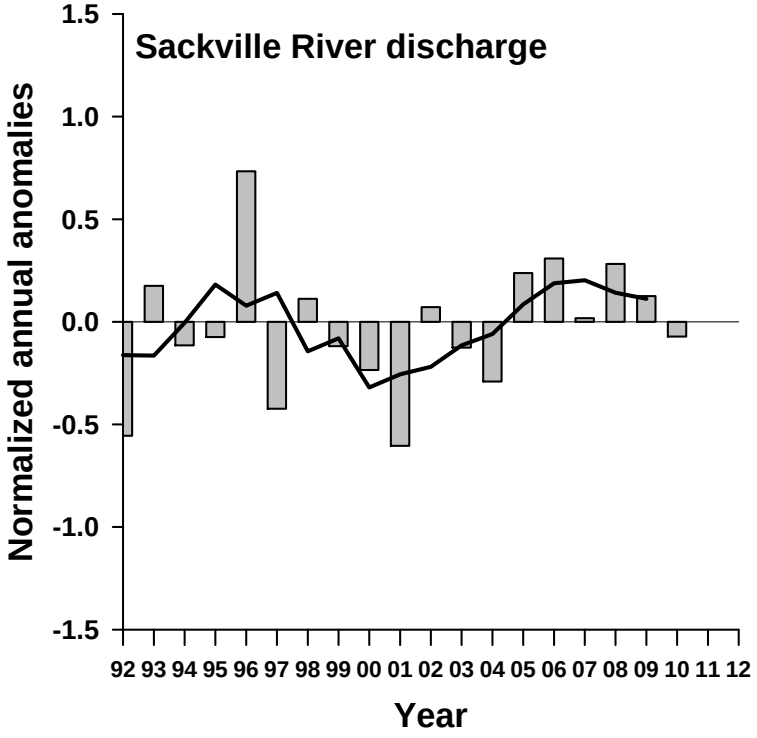




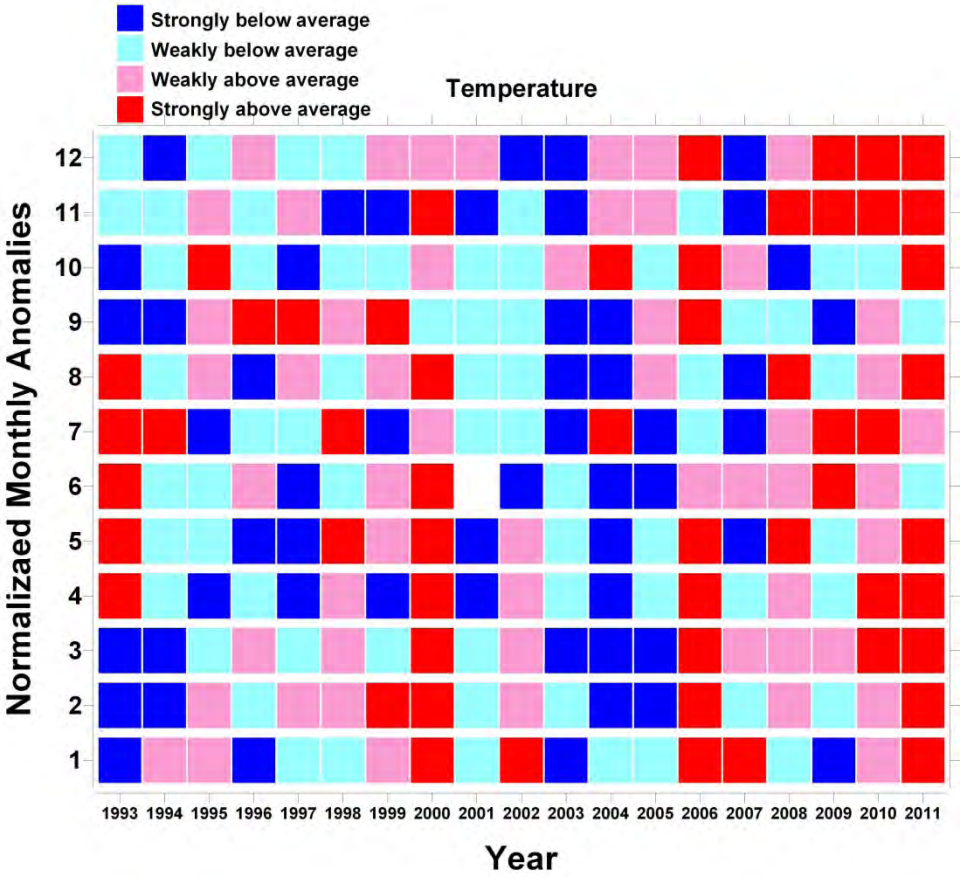
Hydrometry (Sackville River) : FRESHWATER DISCHARGE

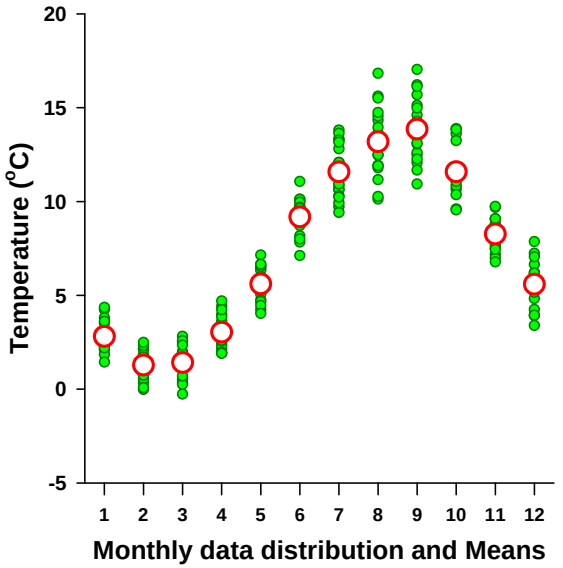


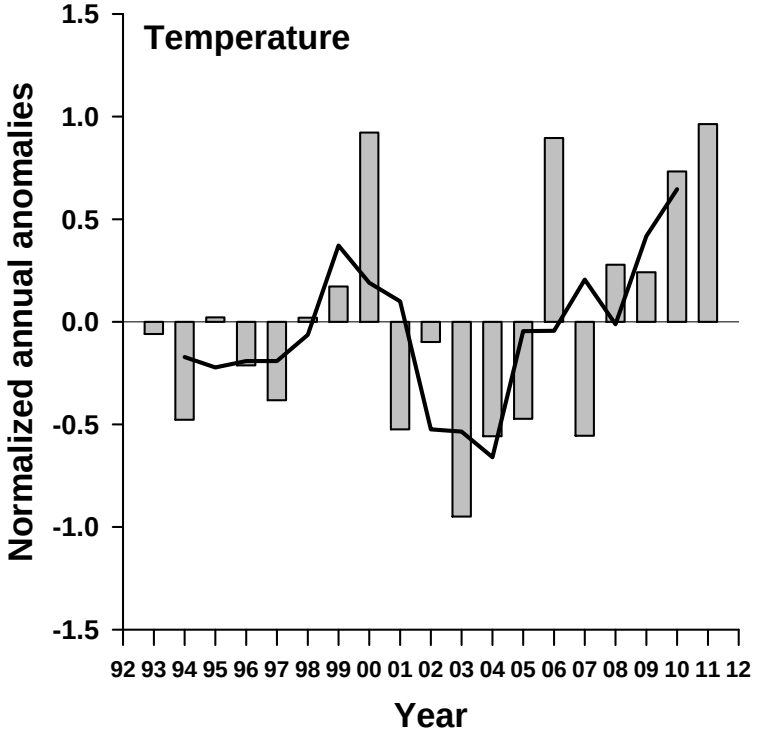




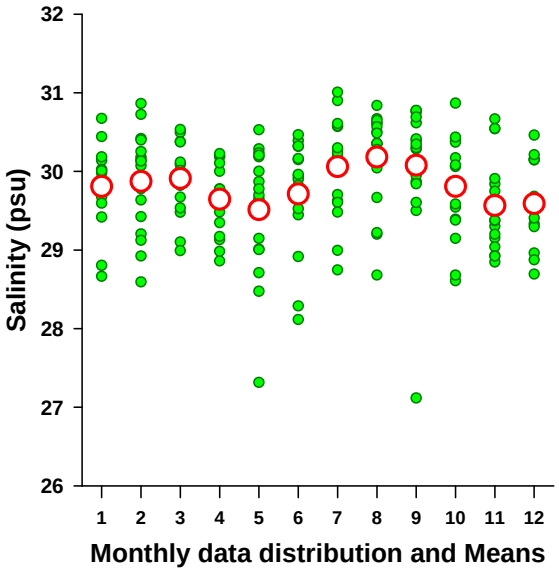
Bedford Basin : TEMPERATURE

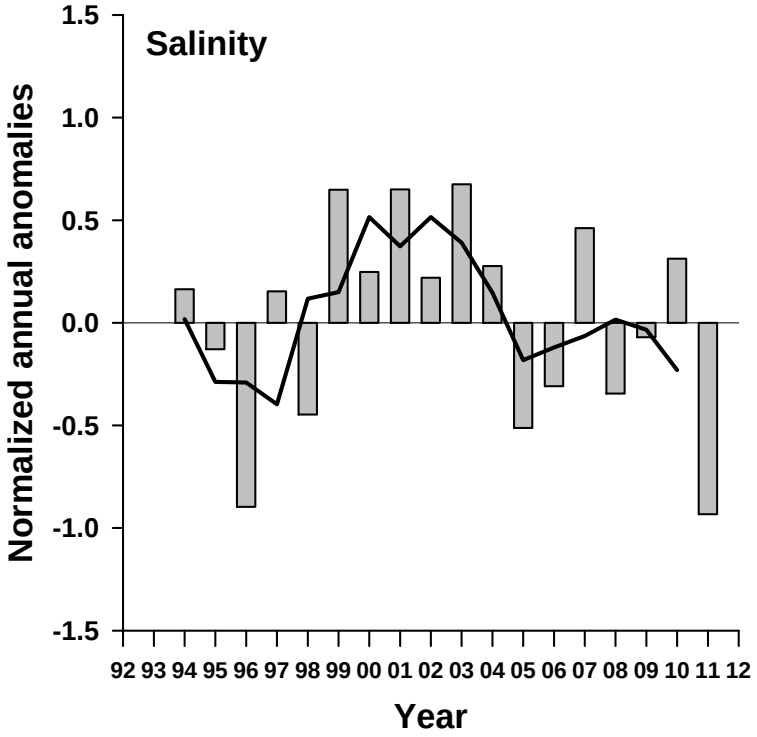




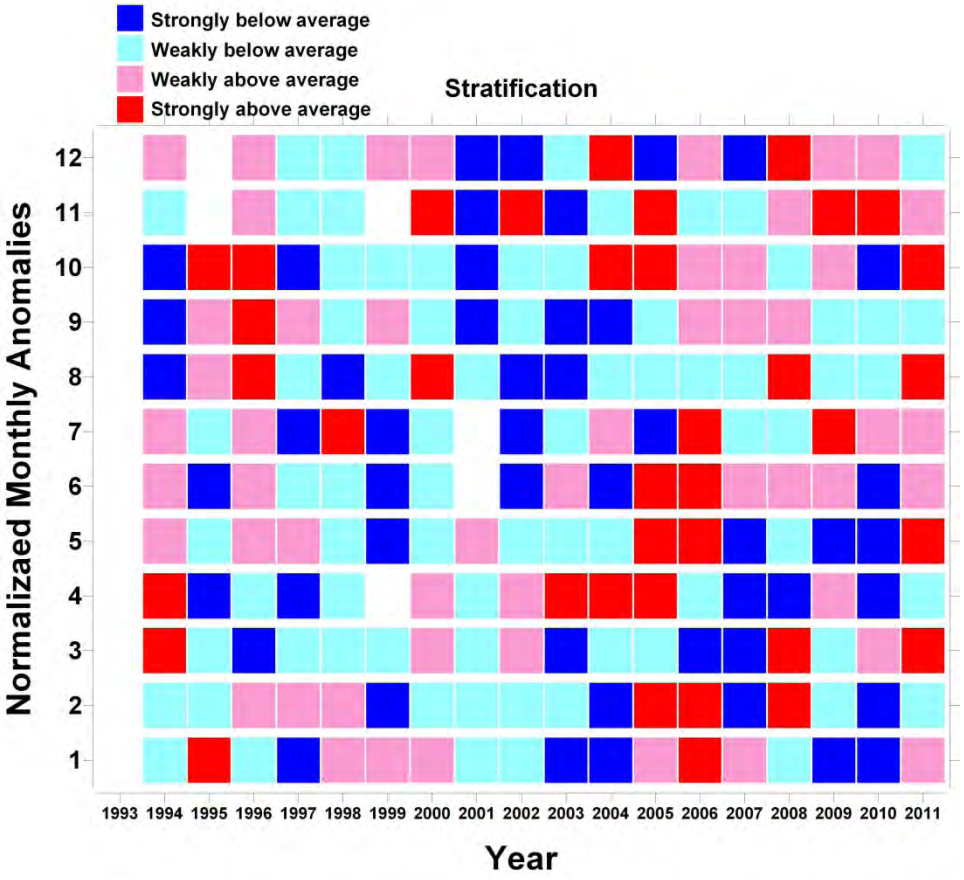


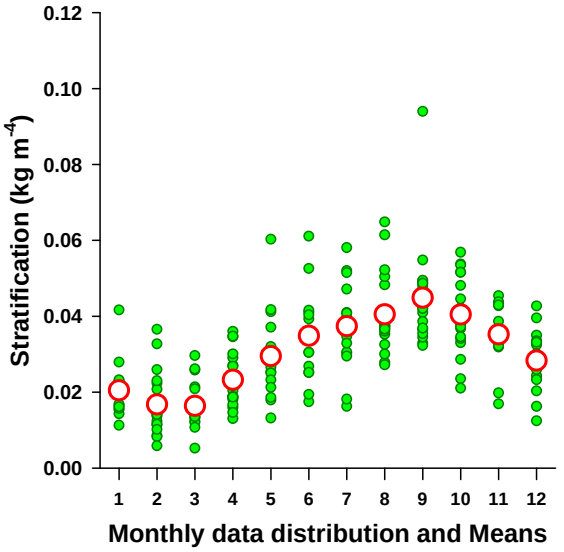
Bedford Basin : SALINITY

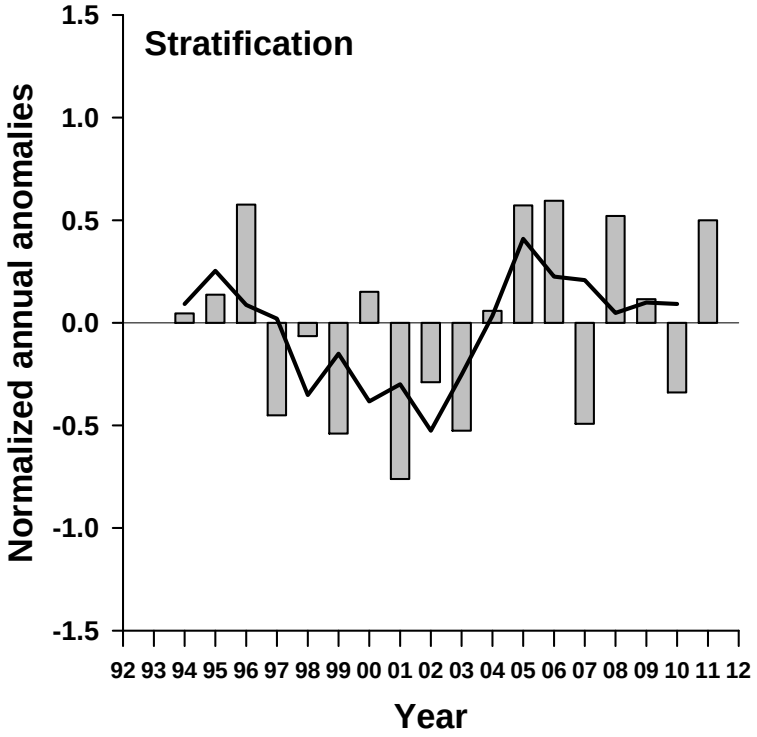




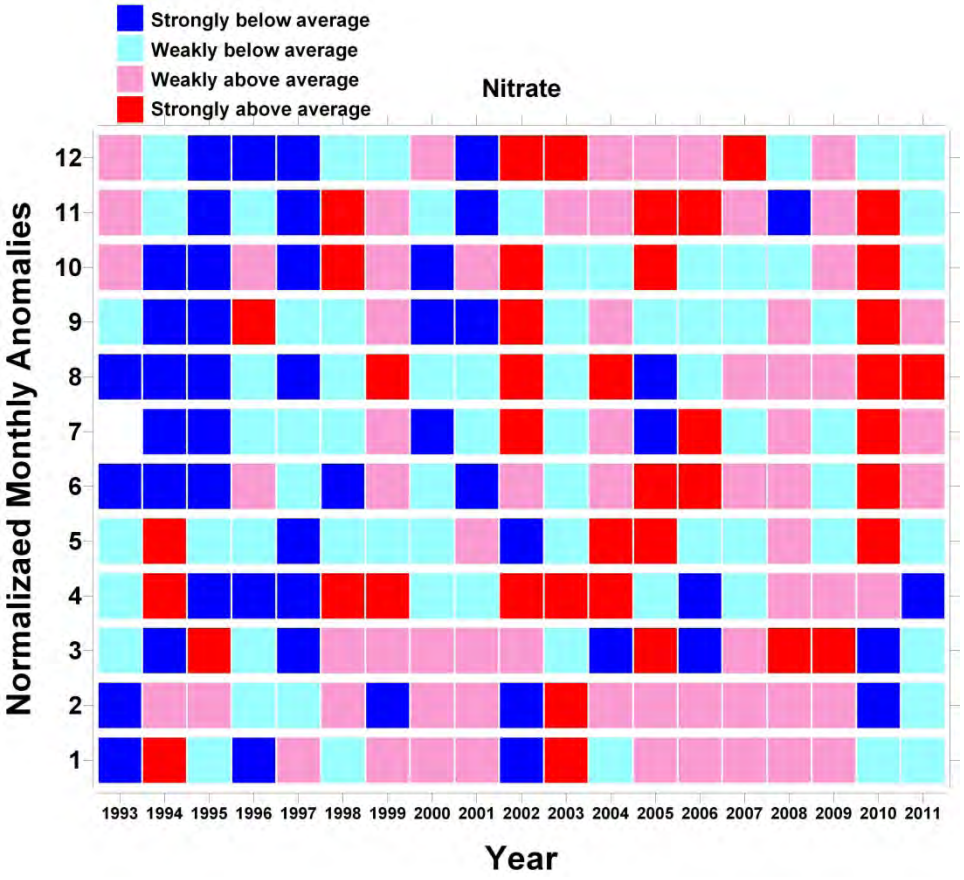
Bedford Basin : STRATIFICATION

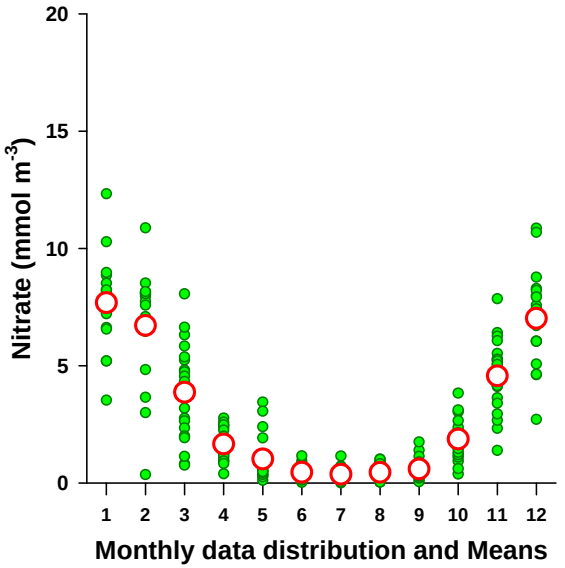


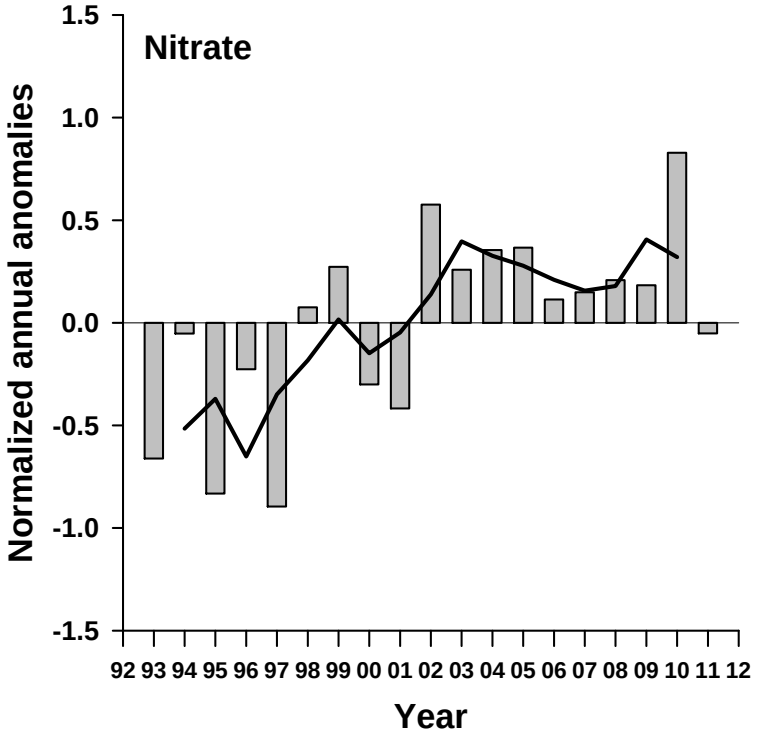




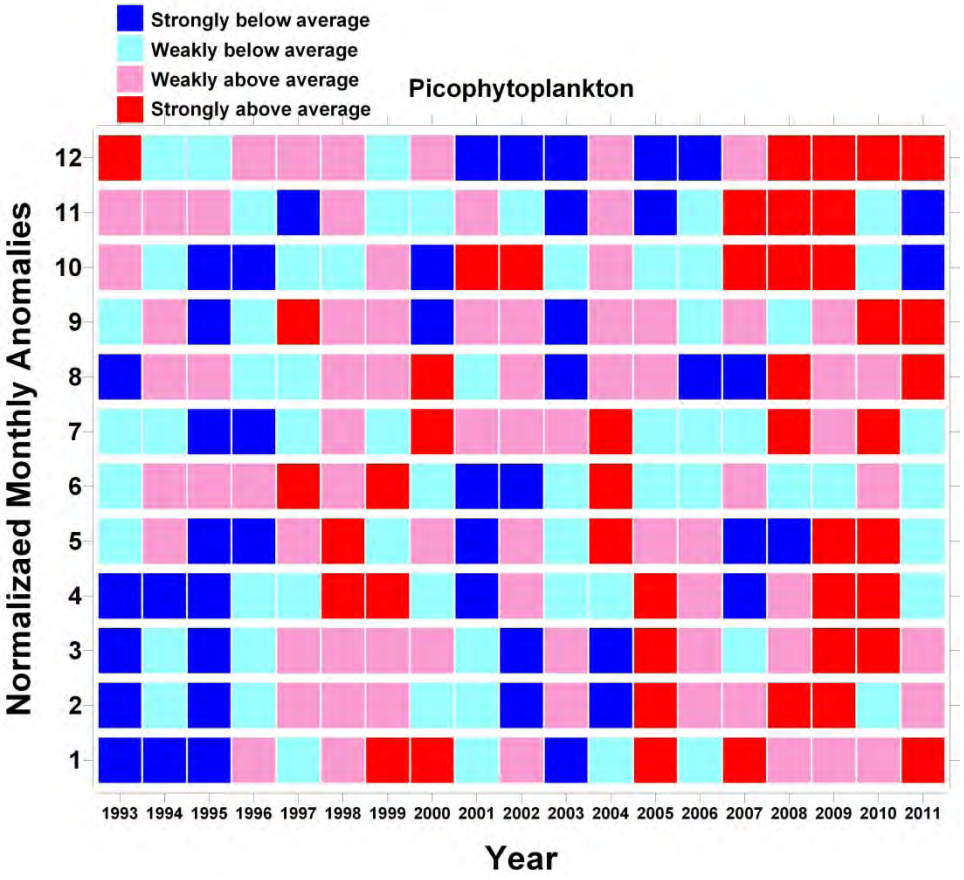
Bedford Basin : NITRATE (+NITRITE)

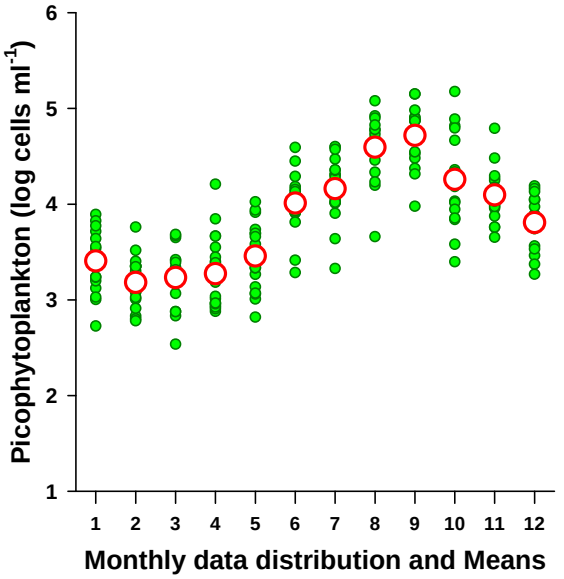


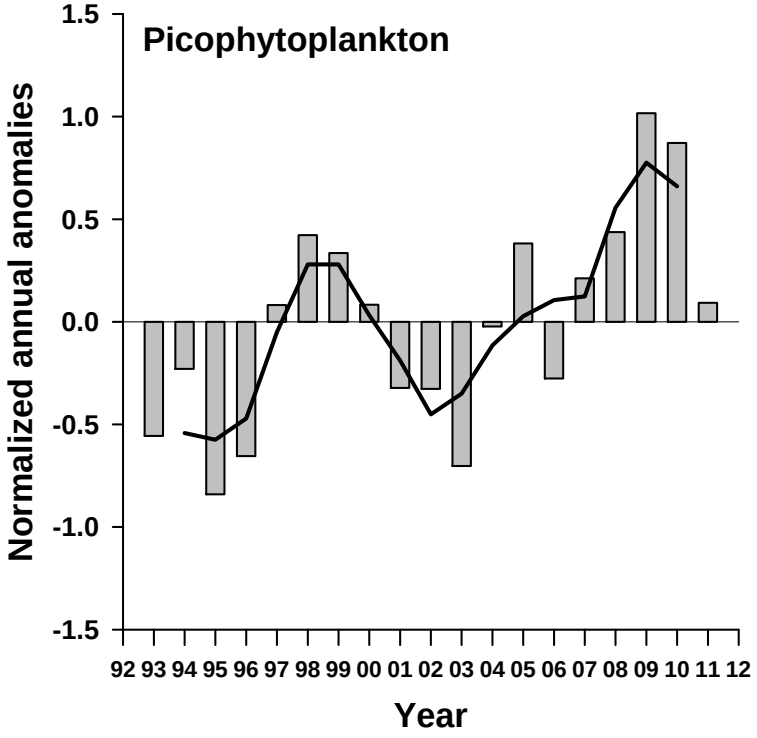




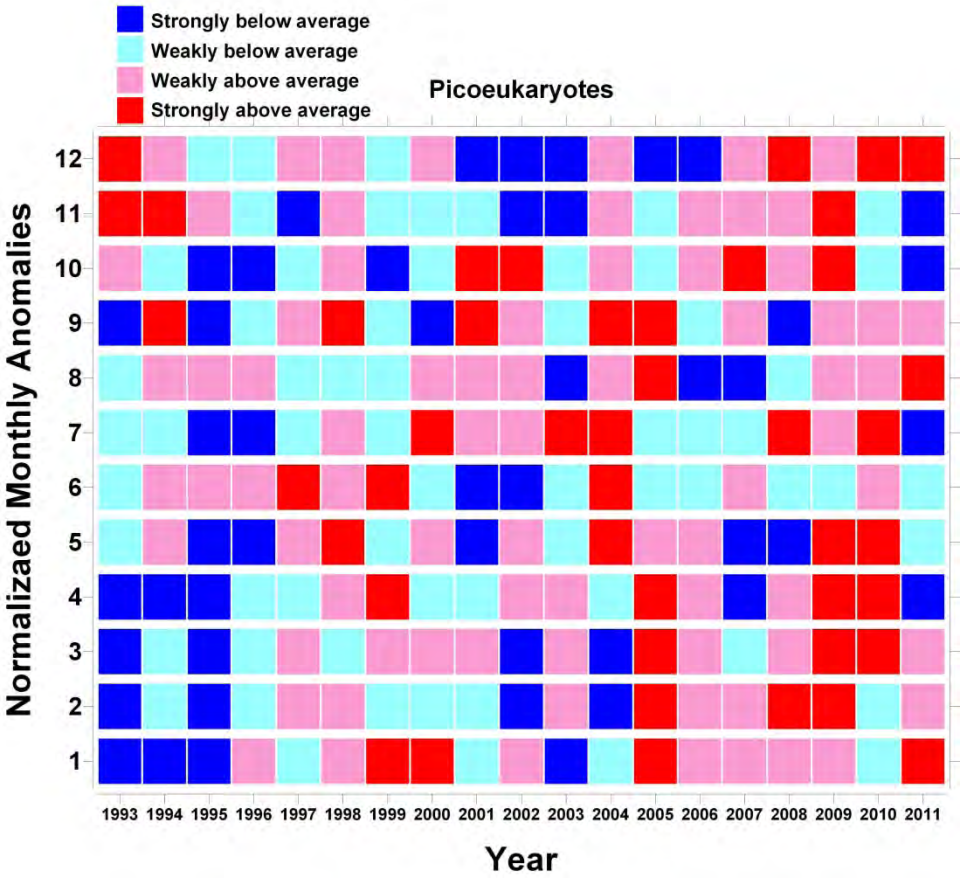
Bedford Basin : PICOPHYTOPLANKTON

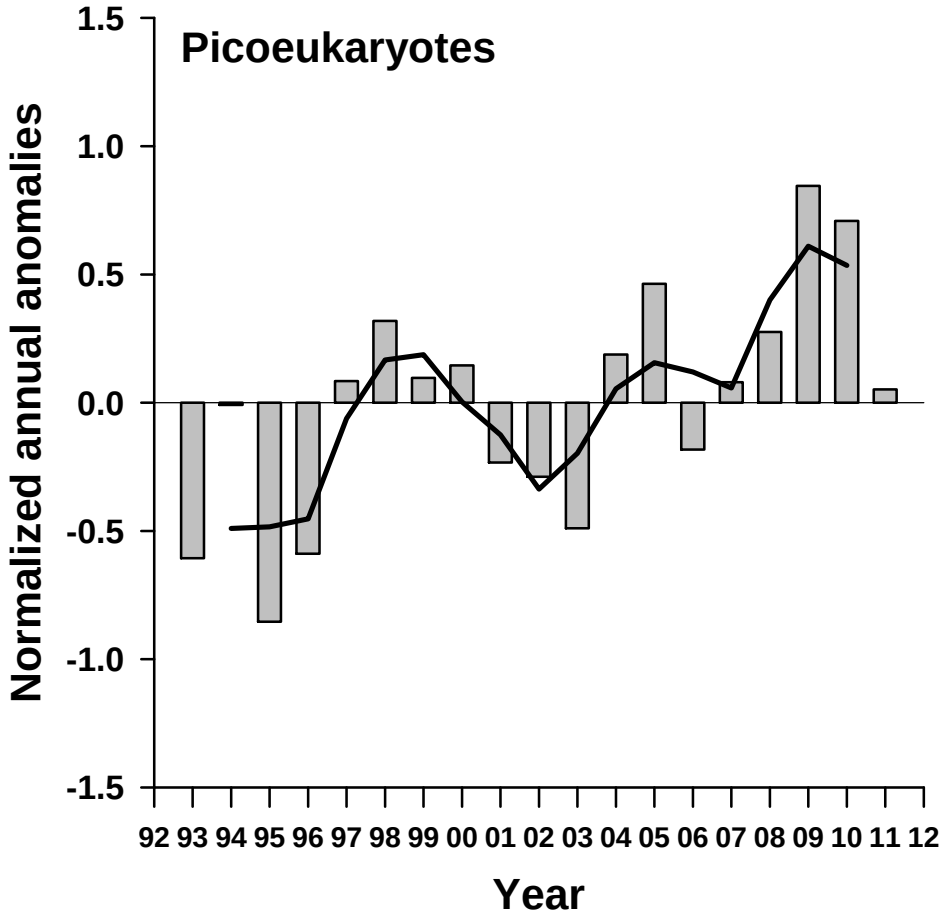




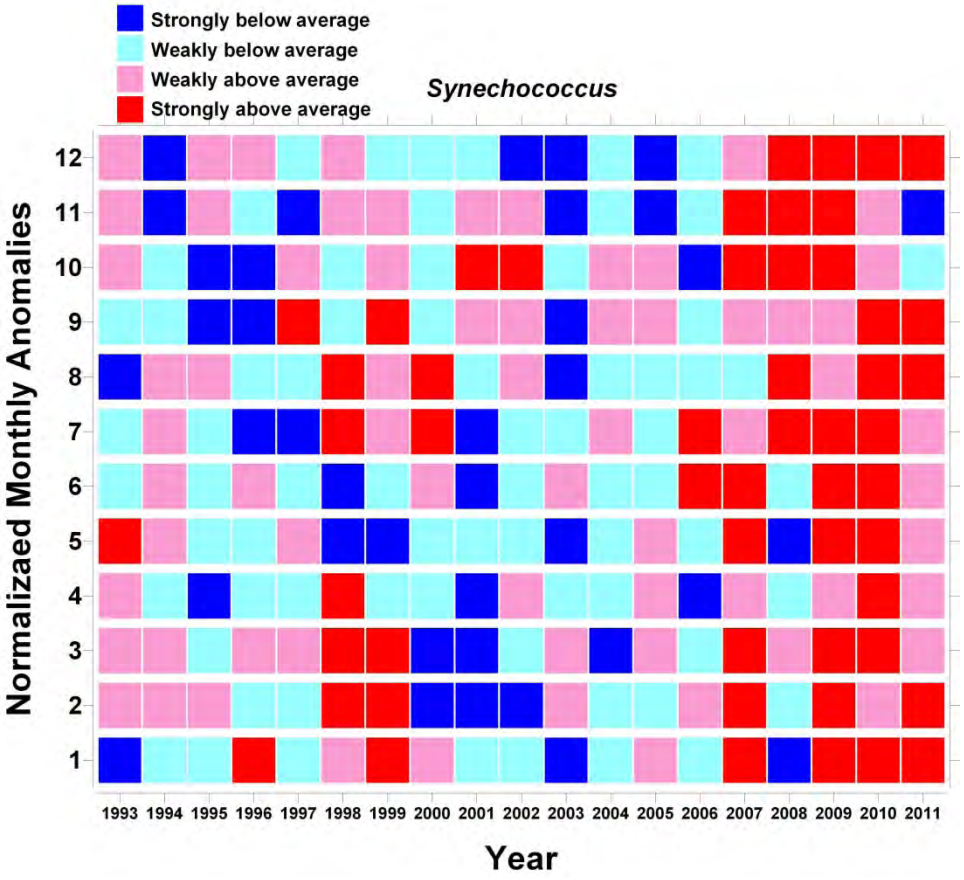


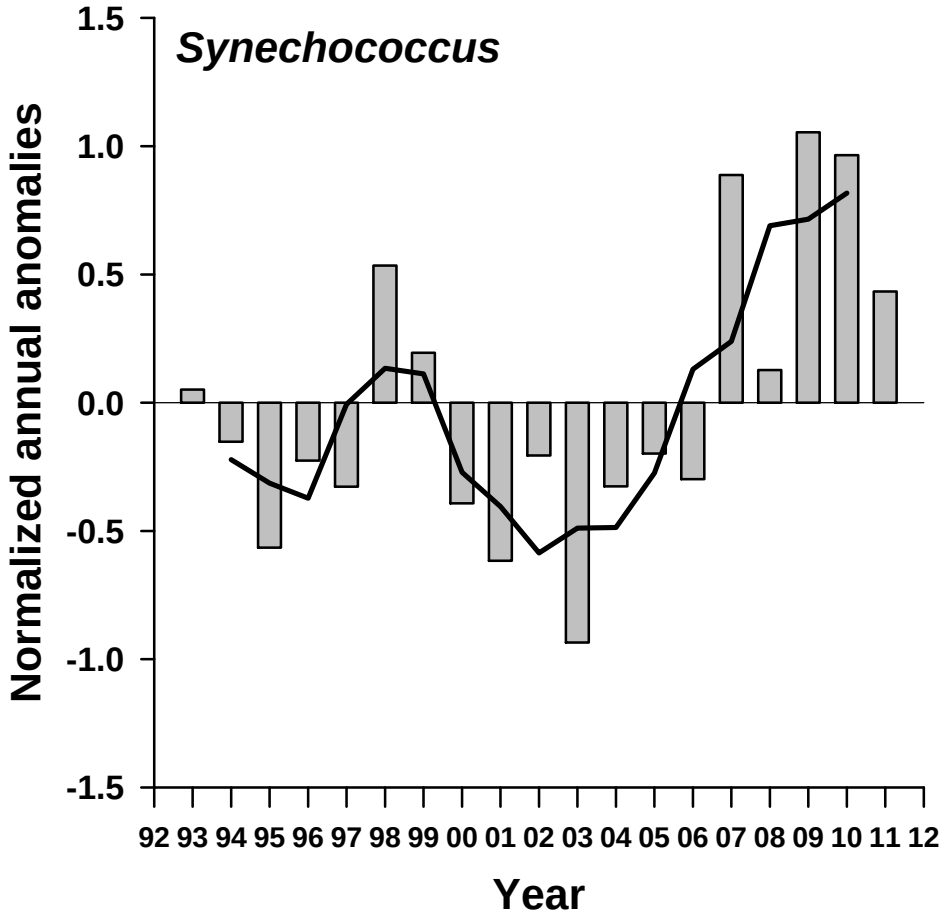
Bedford Basin : PICOEUKARYOTIC ALGAE



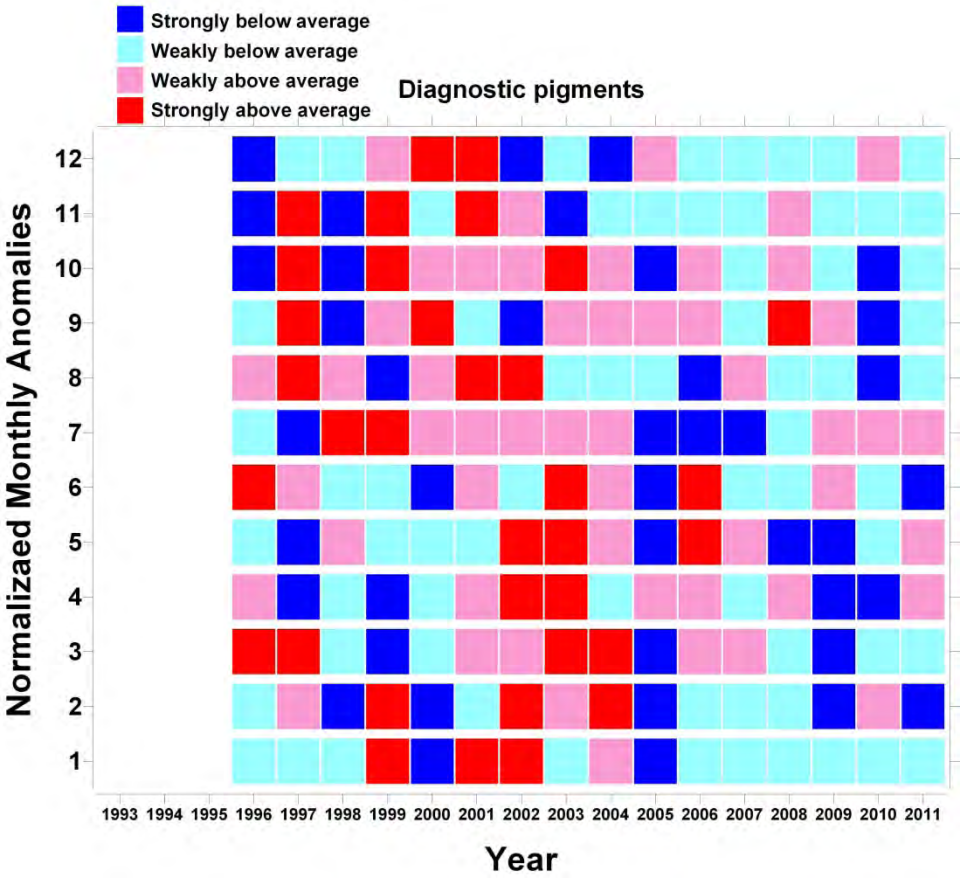


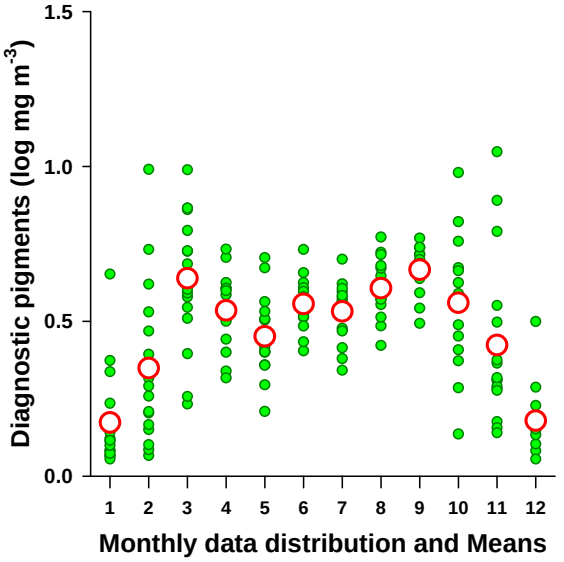
Bedford Basin : PICOPROKARYOTIC CYANOBACTERIA

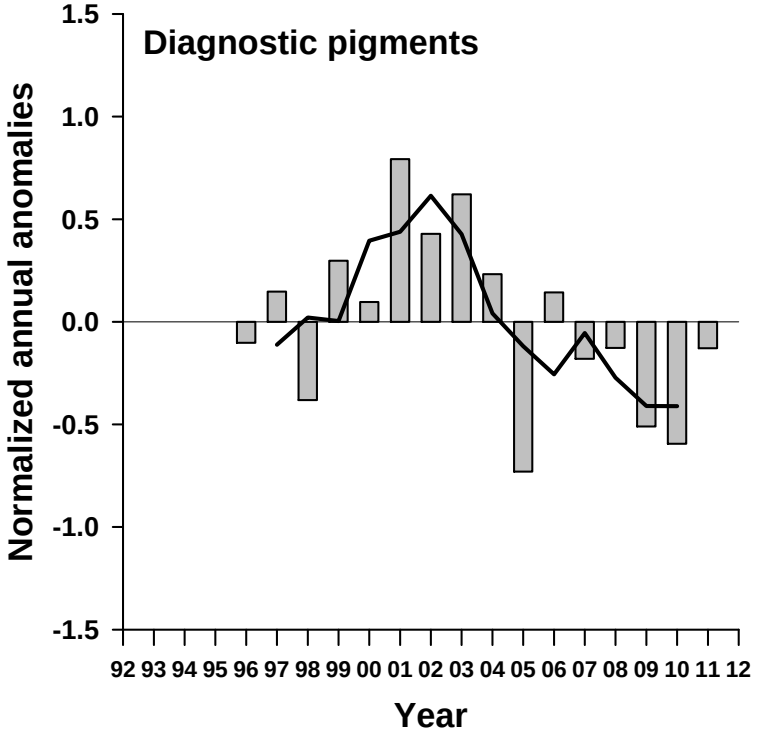




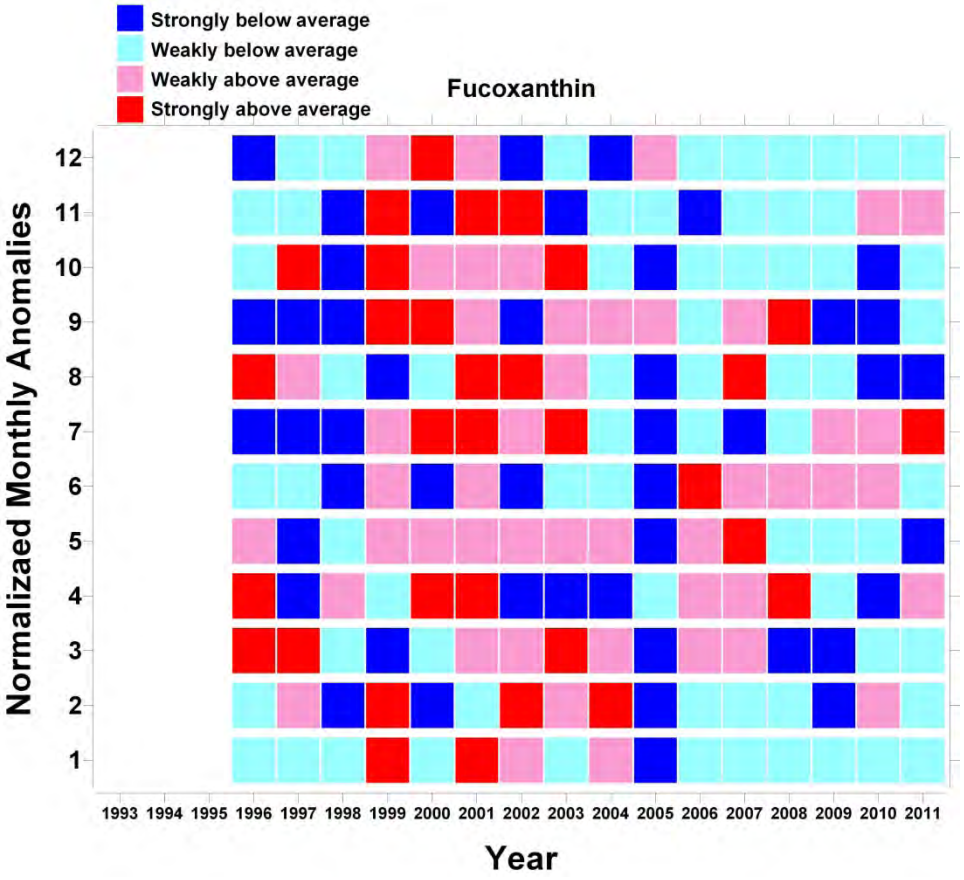
Bedford Basin : DIAGNOSTIC PIGMENTS (BUT-FUCO, HEX-FUCO, ALLO, FUCO, PERID, CHLB, ZEA)

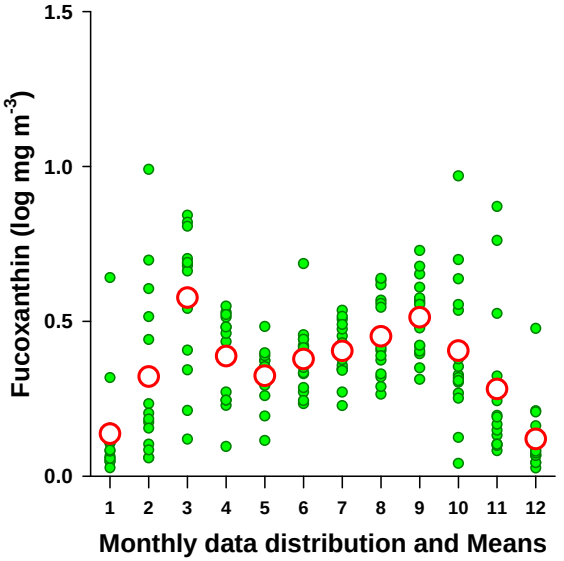


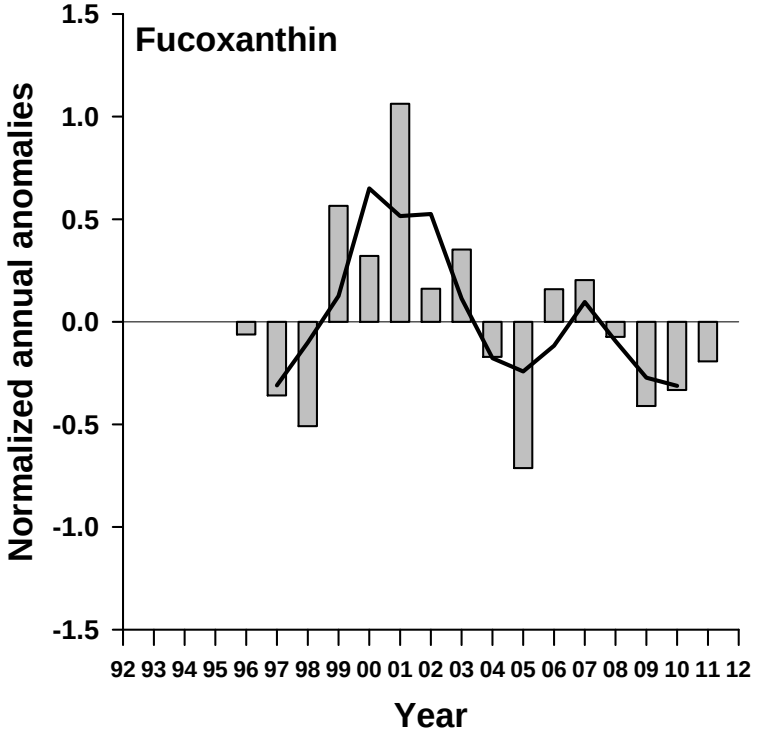




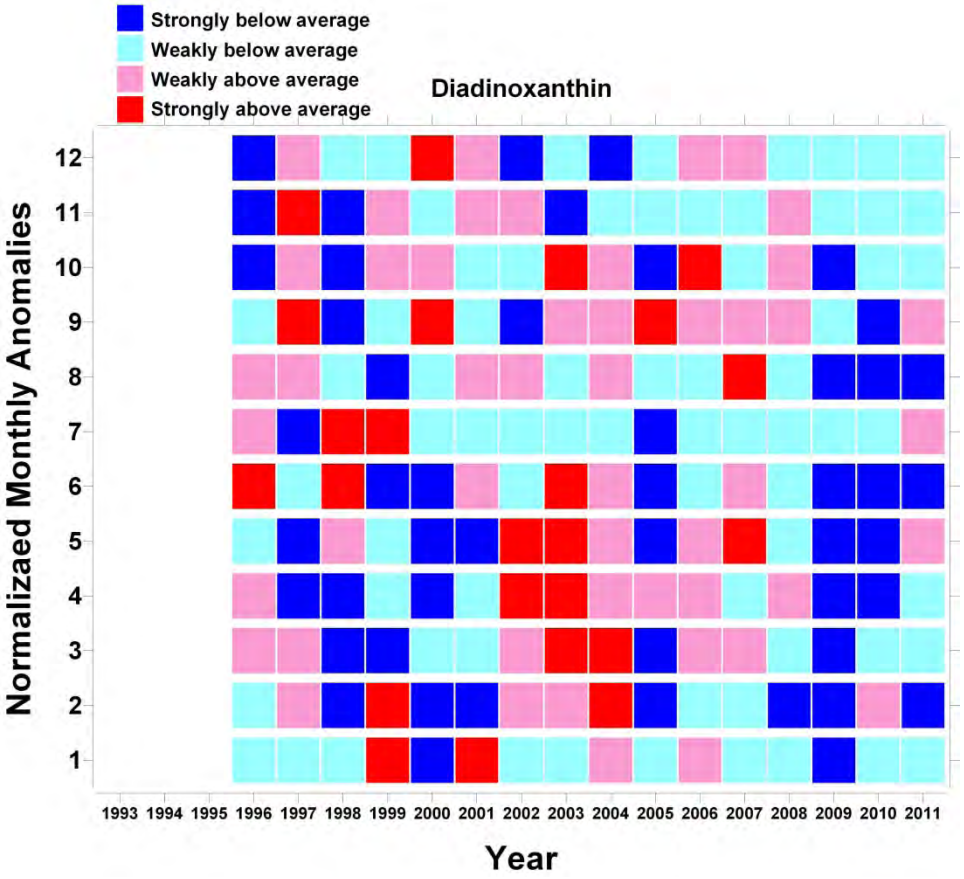
Bedford Basin : FUCOXANTHIN

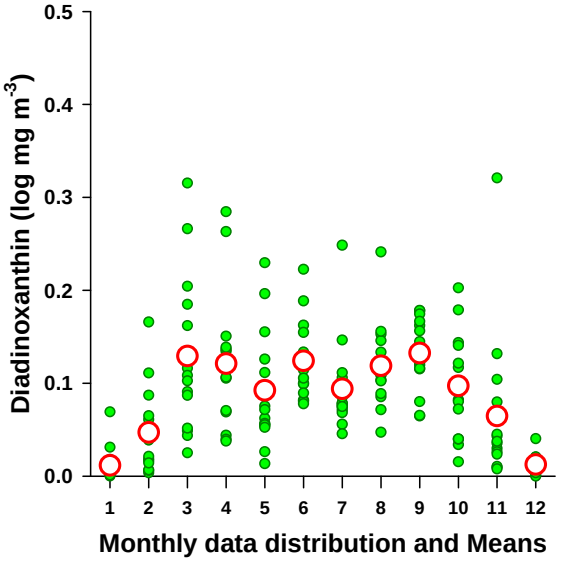


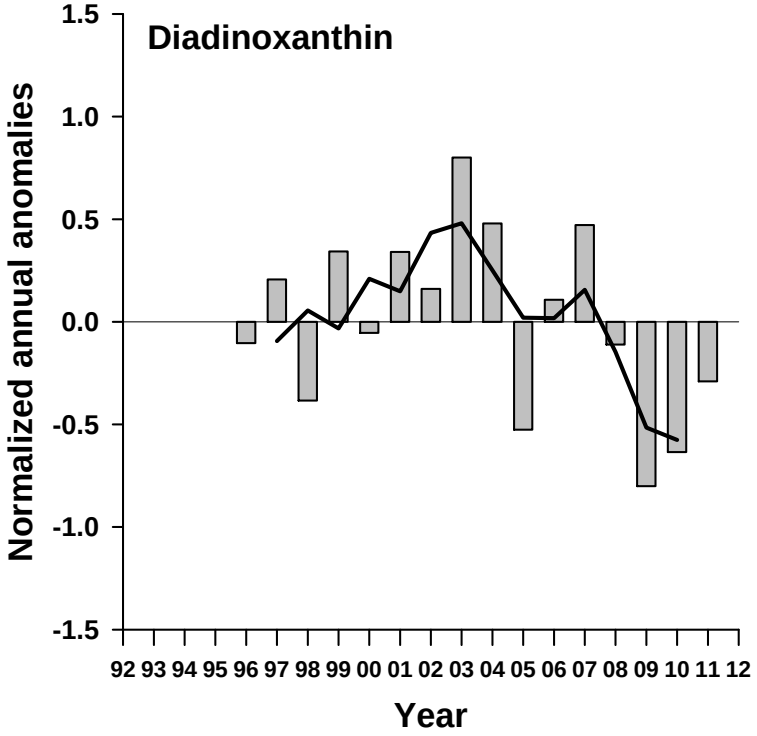




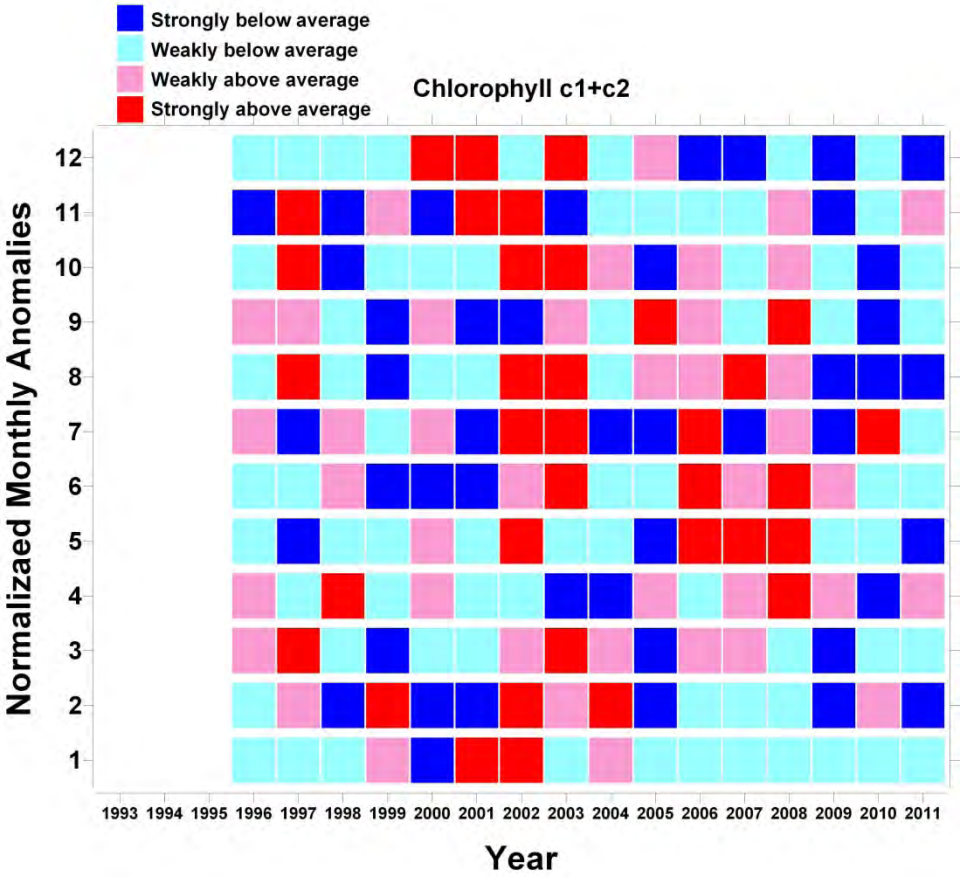
Bedford Basin : DIADINOXANTHIN

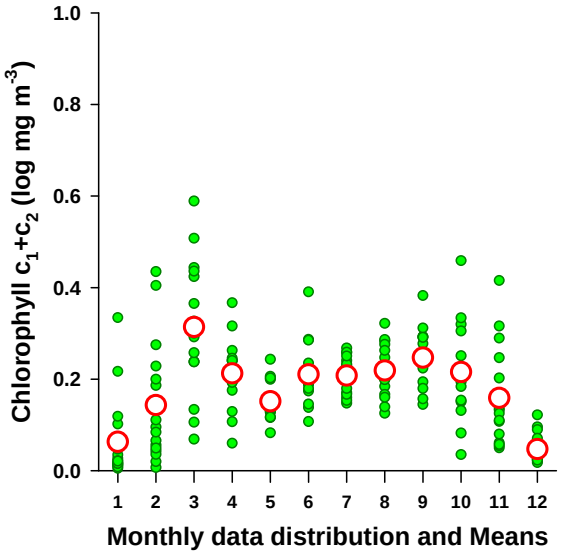


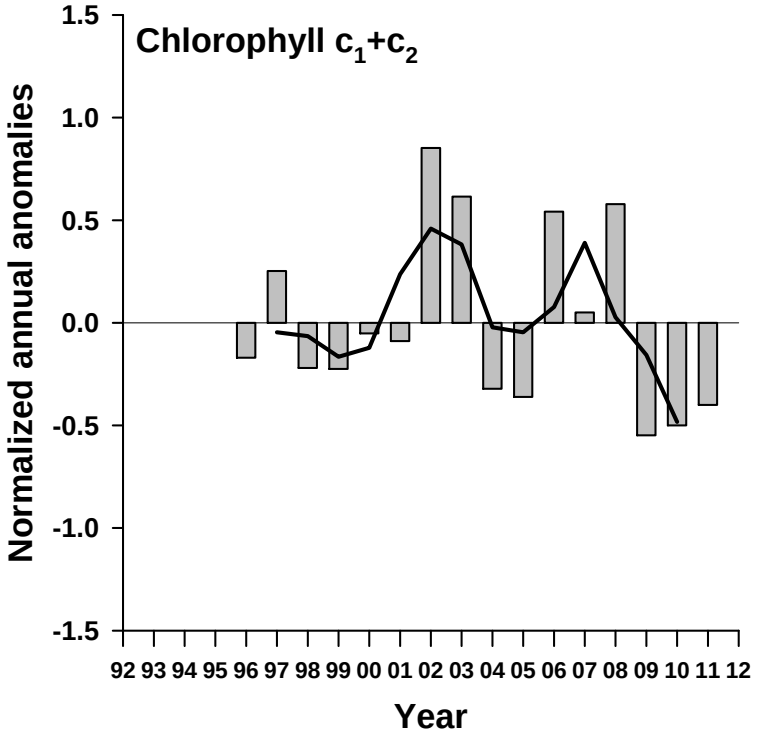


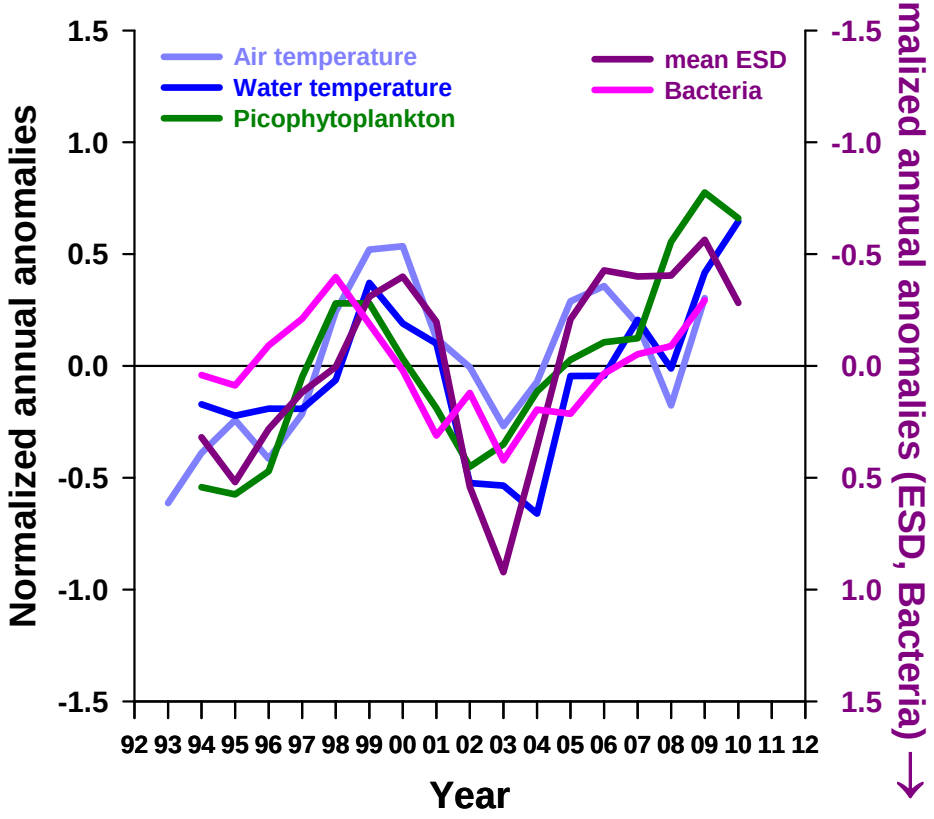


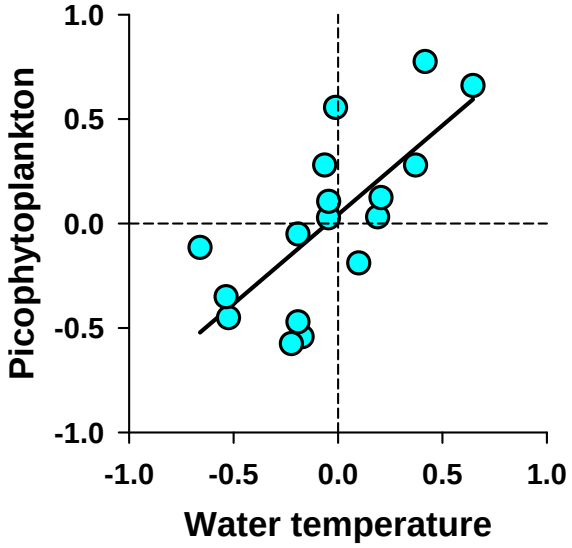
Bedford Basin : CHLOROPHYLL c_1+c_2

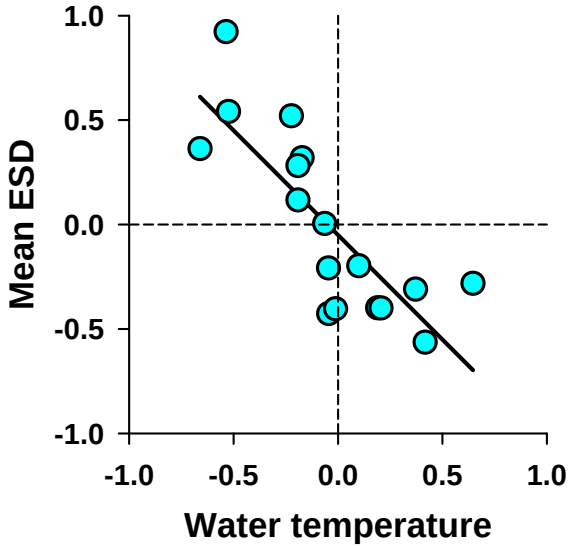




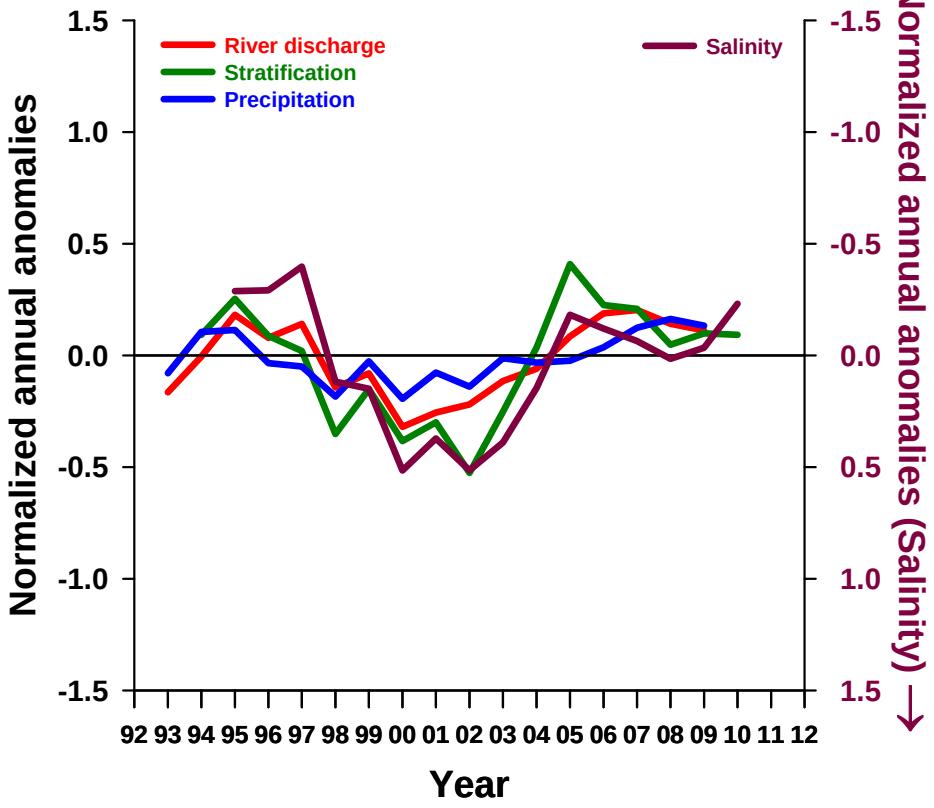


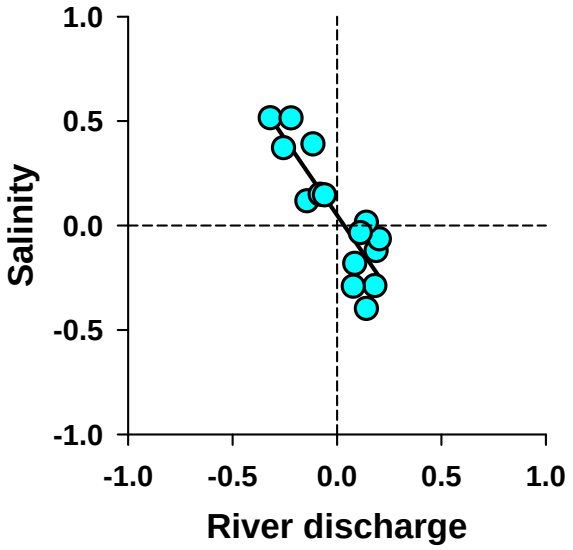

Air temperature
Water temperature
Picophytoplankton
mean ESD
Bacteria
Normalized annual anomalies
Normalized annual anomalies (ESD, Bacteria) →
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12
Year

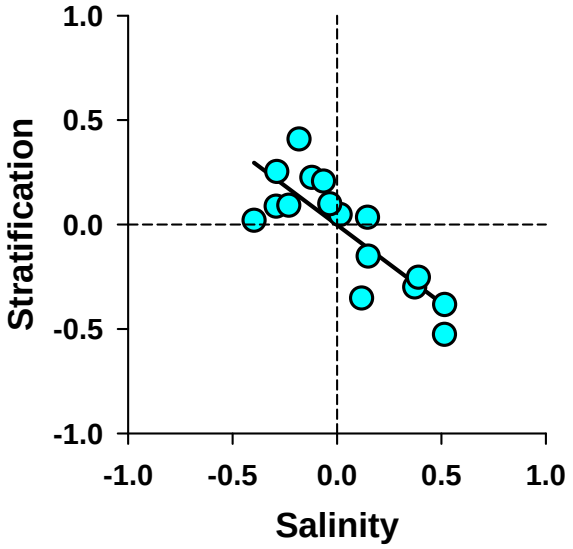

Picophytoplankton
Water temperature
1.0
0.5
0.0
-0.5
-1.0


Mean ESD
Water temperature
1.0
0.5
0.0
-0.5
-1.0

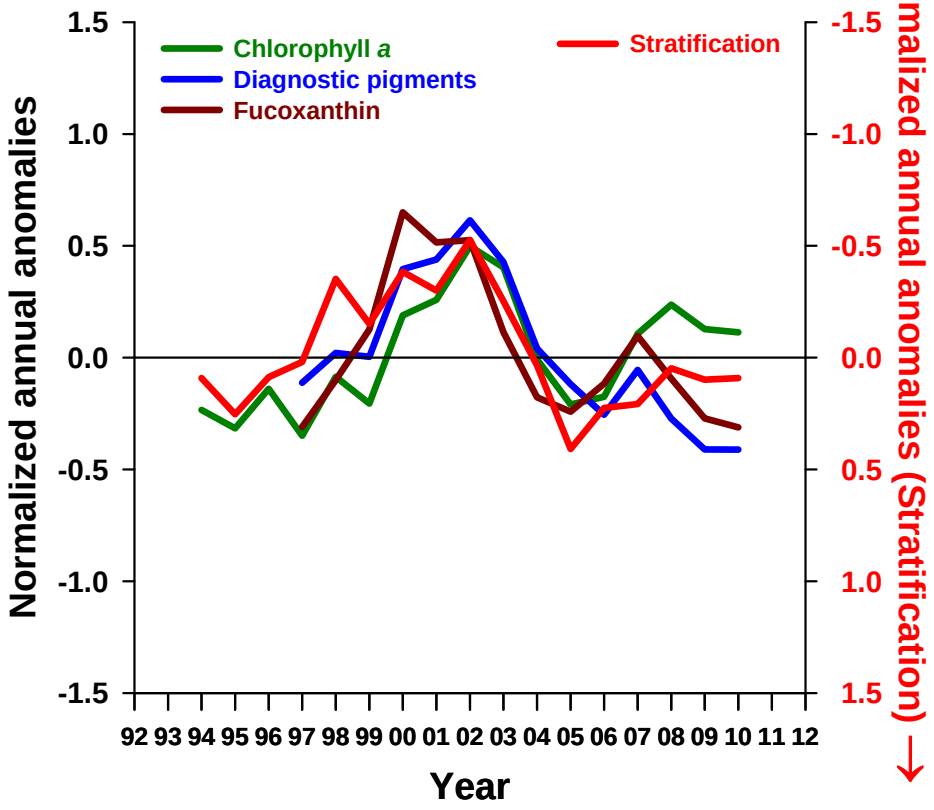
PRECIPITATION → RIVER DISCHARGE → SALINITY → STRATIFICATION

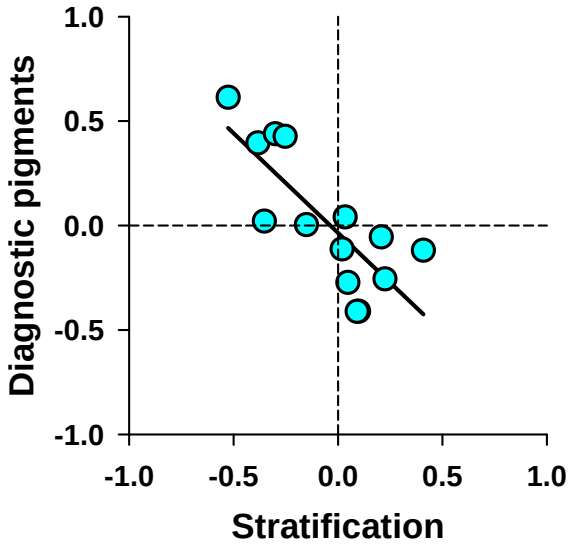


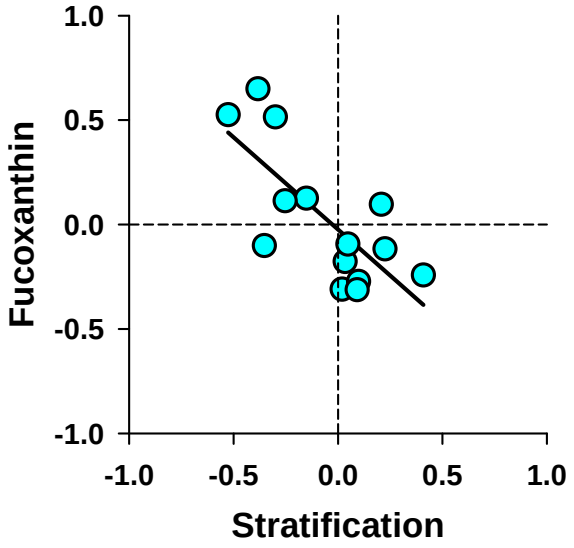




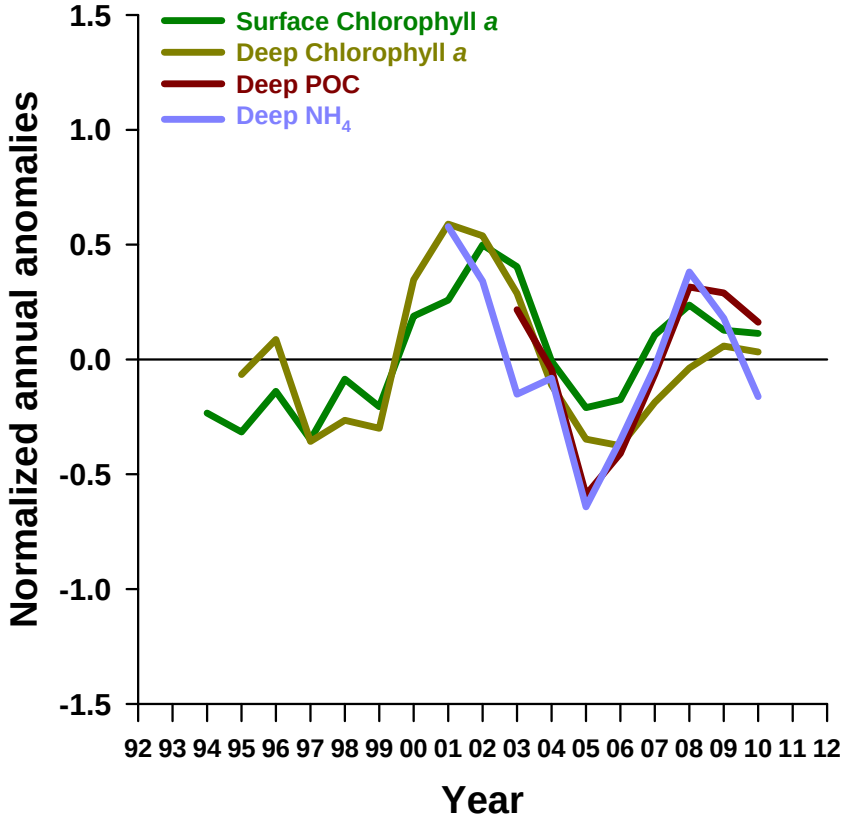
STRATIFICATION → CHLOROPHYLL *a* → DIAGNOSTIC PIGMENTS → FUCOXANTHIN

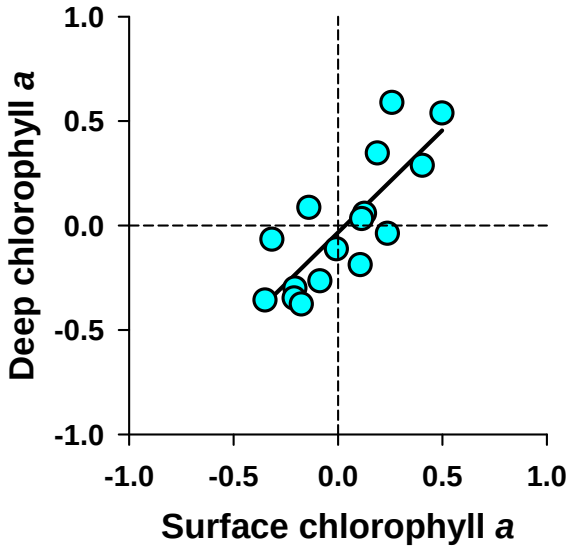


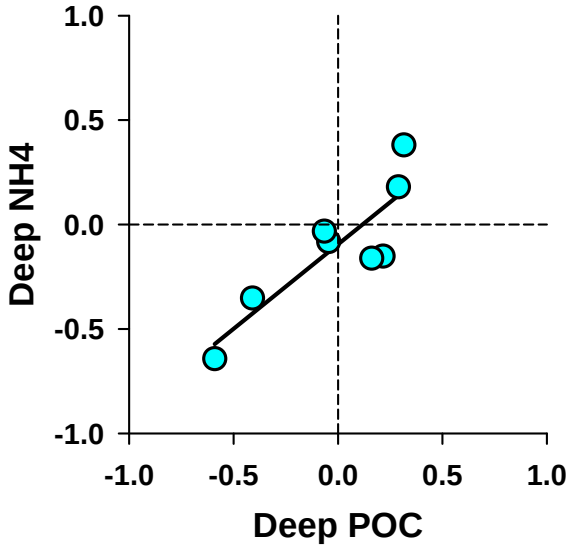




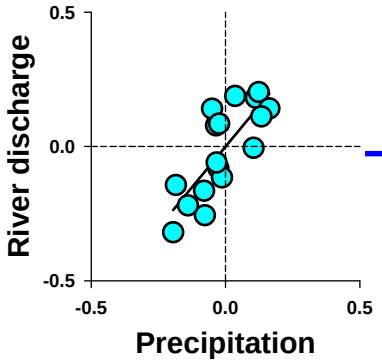
SURFACE CHL *a* → DEEP CHL a → DEEP POC → DEEP NH4

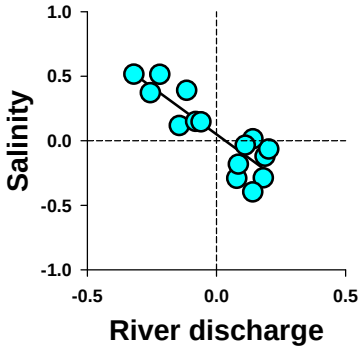


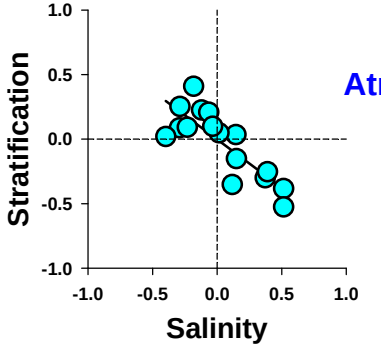




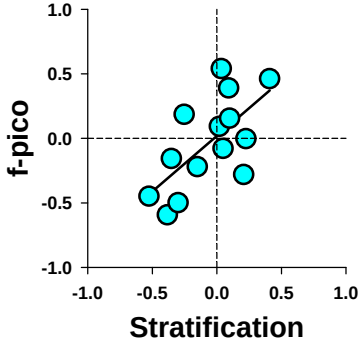
Multiyear signal propagation

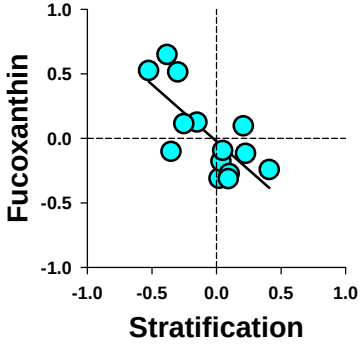


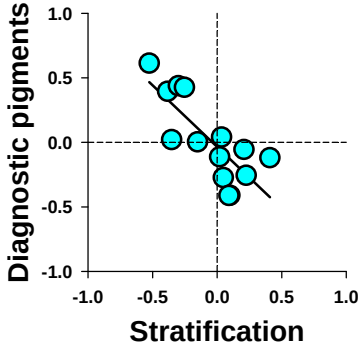


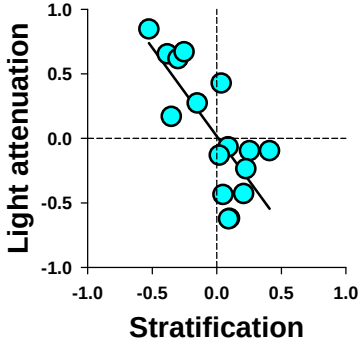


Atmosphere/Hydrosphere → Plankton



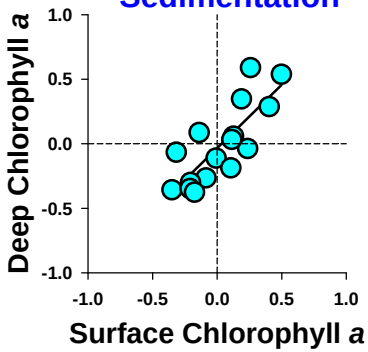




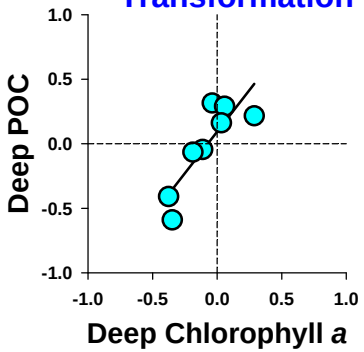


Plankton → Benthos

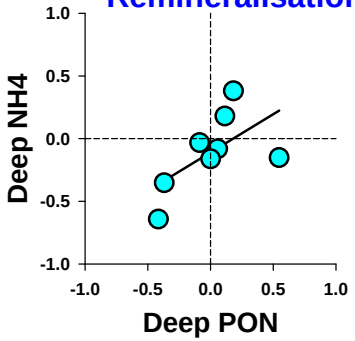
Sedimentation



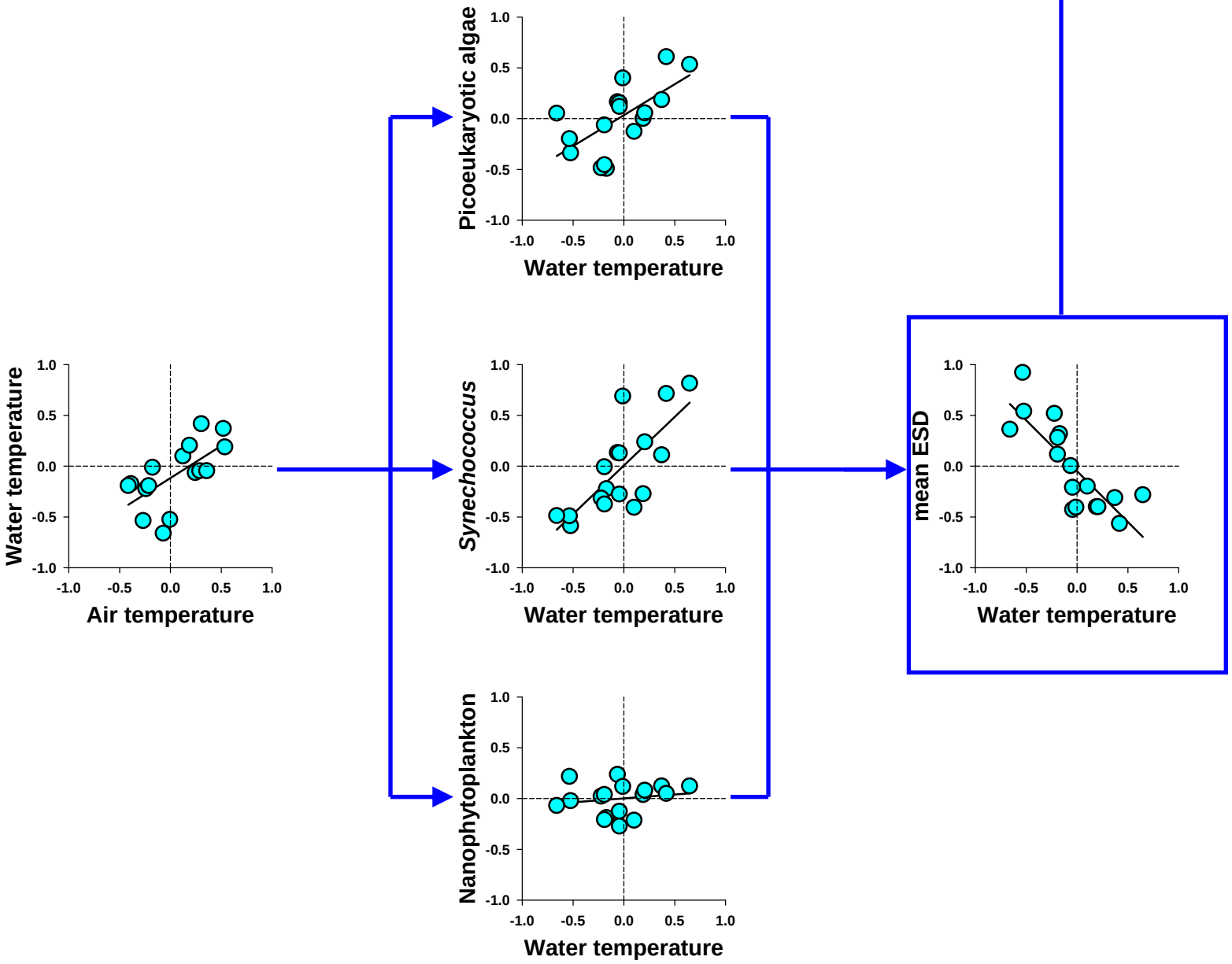
Transformation



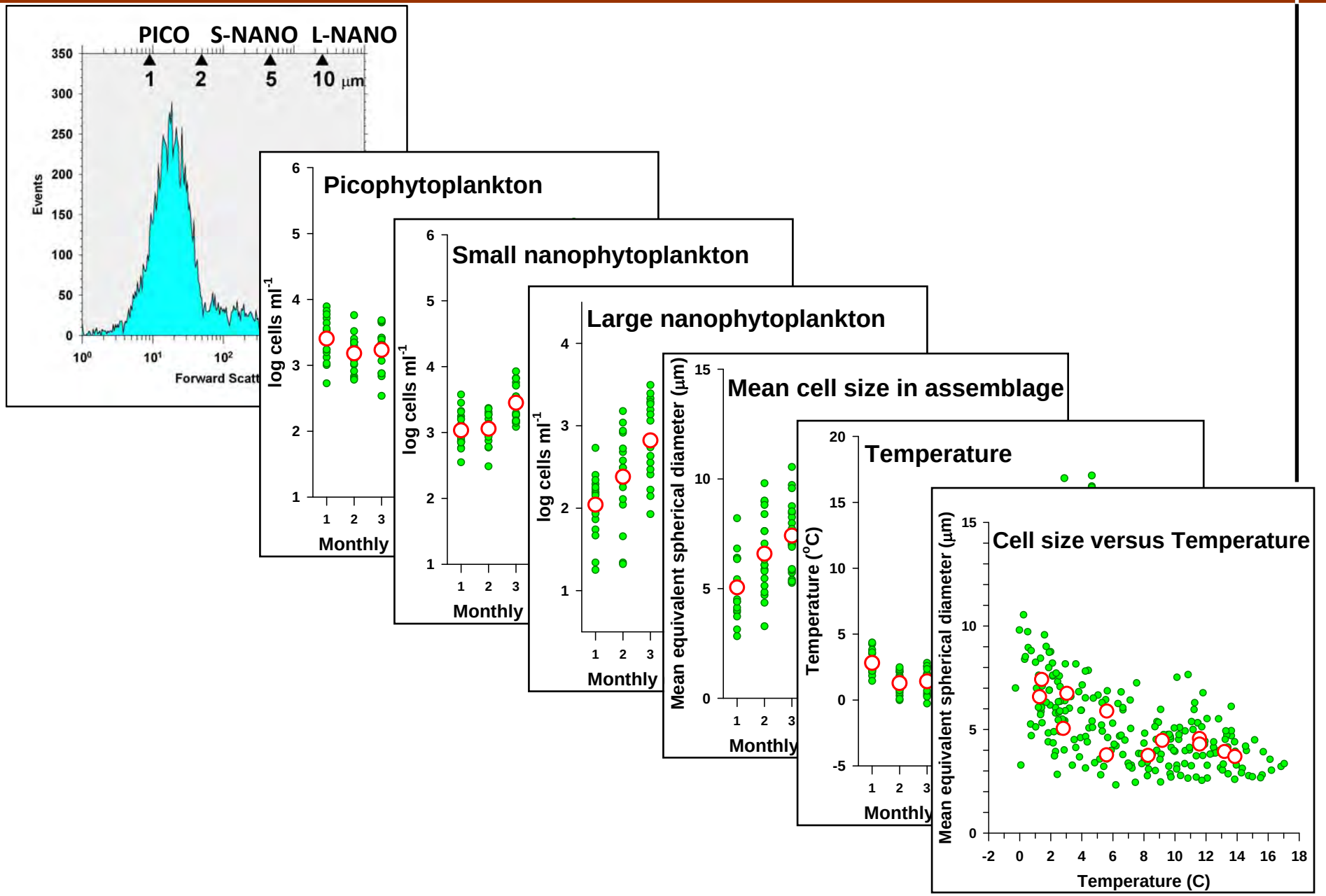
Remineralisation



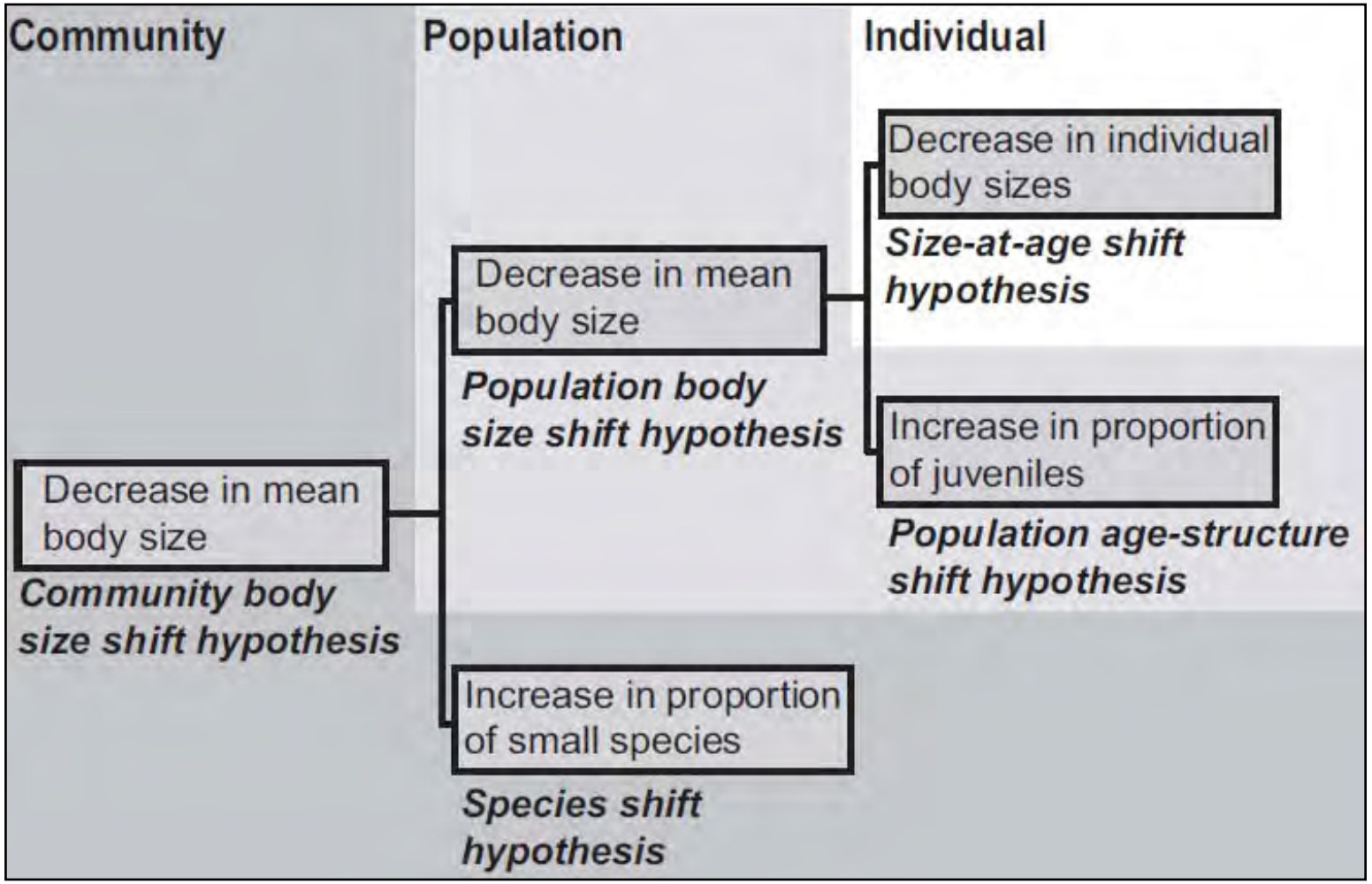
Multiyear effect of temperature



Within-year effect of temperature

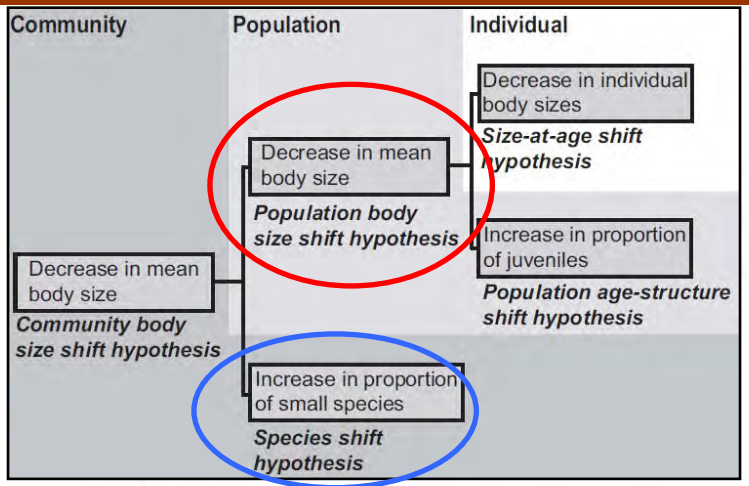


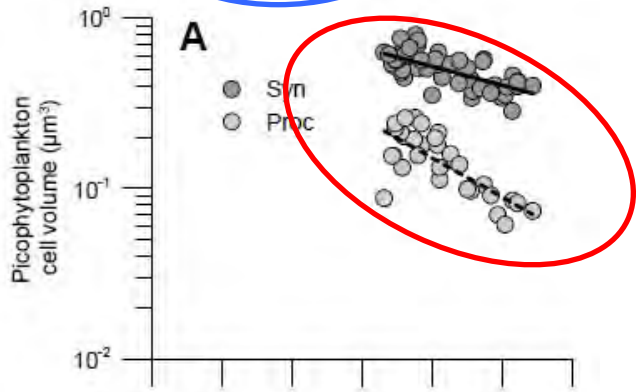
Does "*Global warming benefit the small in aquatic ecosystems*"?

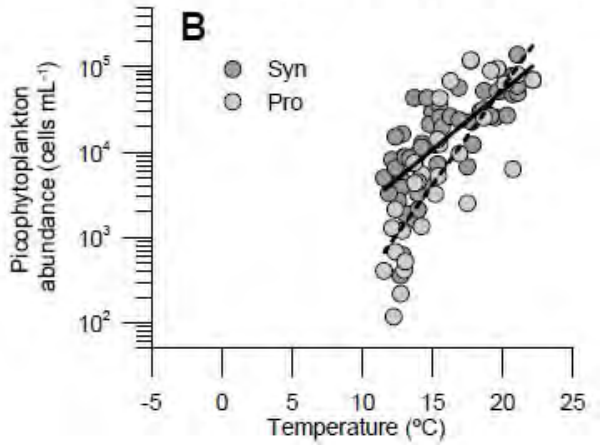


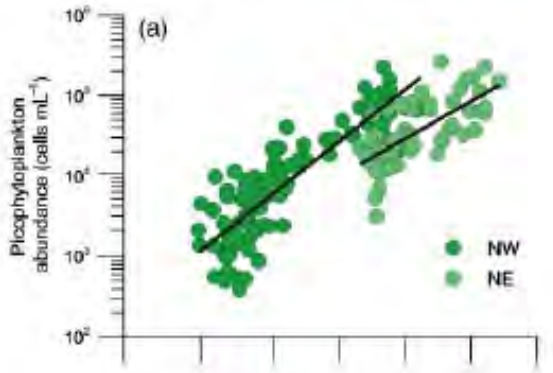
Global warming benefits the small in aquatic ecosystems (Daufresne, Lengfellner, Sommer 2009 PNAS 106:12788–12793)

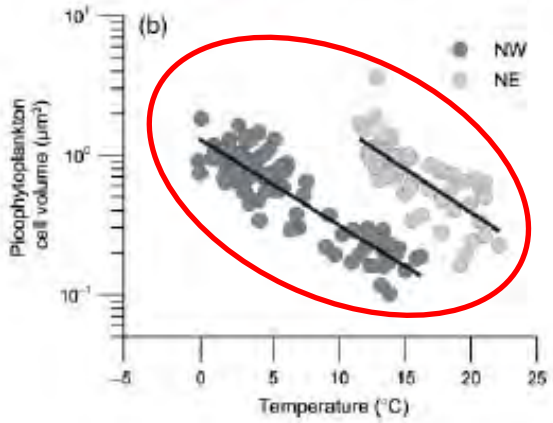
Increasing importance of small phytoplankton in a warmer ocean ??

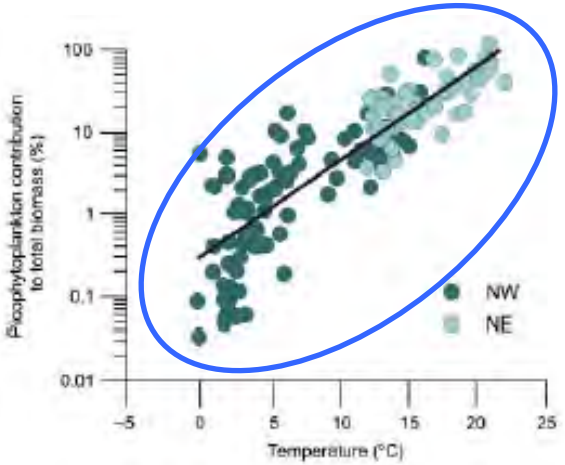


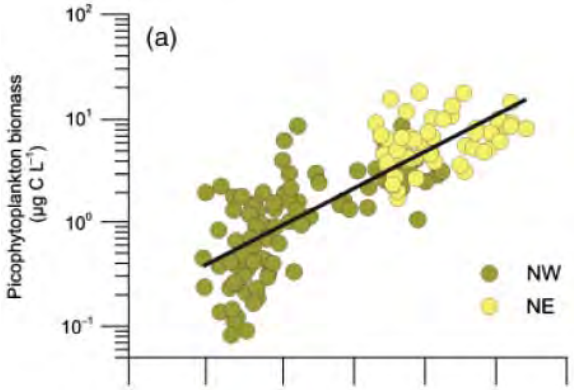












Diatoms and Dinoflagellates (Continuous Plankton Recorder)

nature climate change

LETTERS

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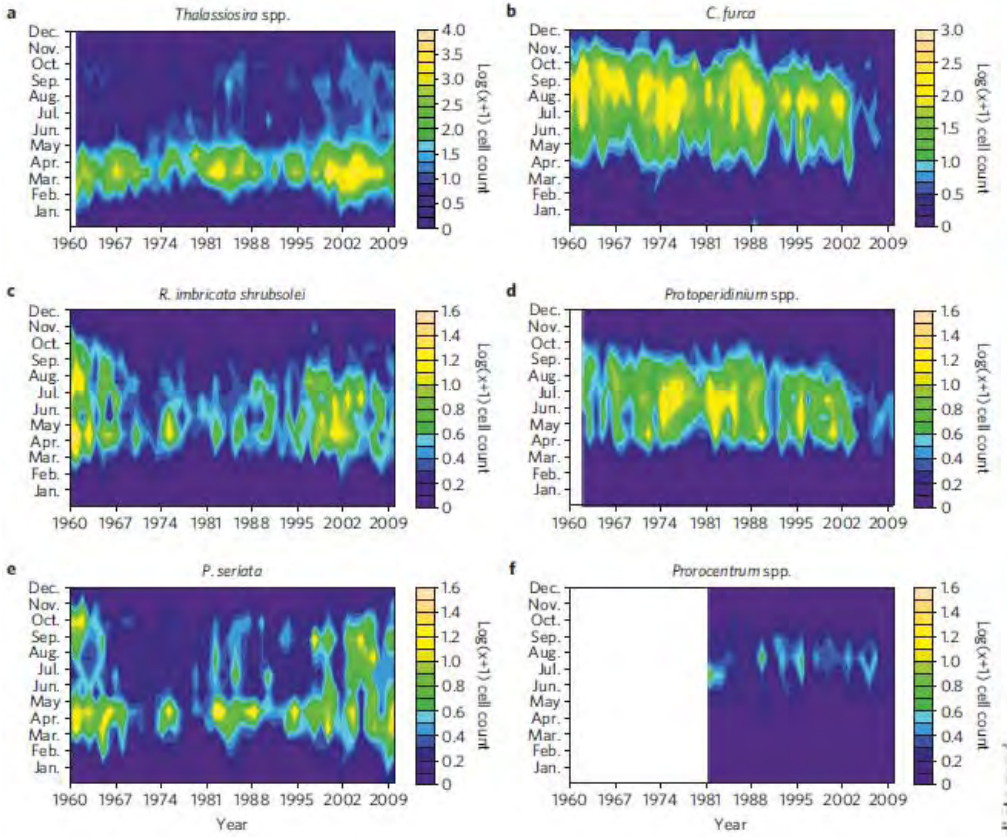
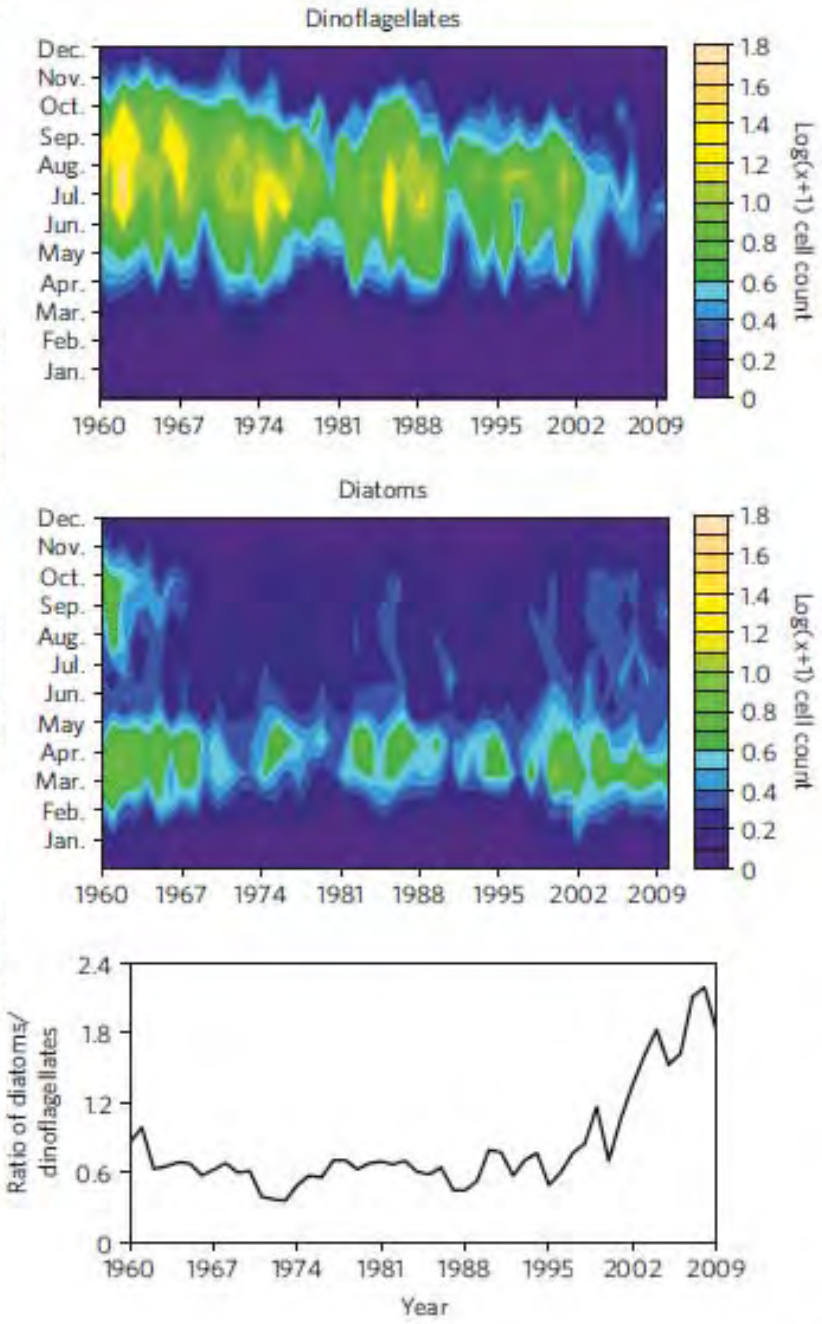
Changes in marine dinoflagellate and diatom abundance under climate change

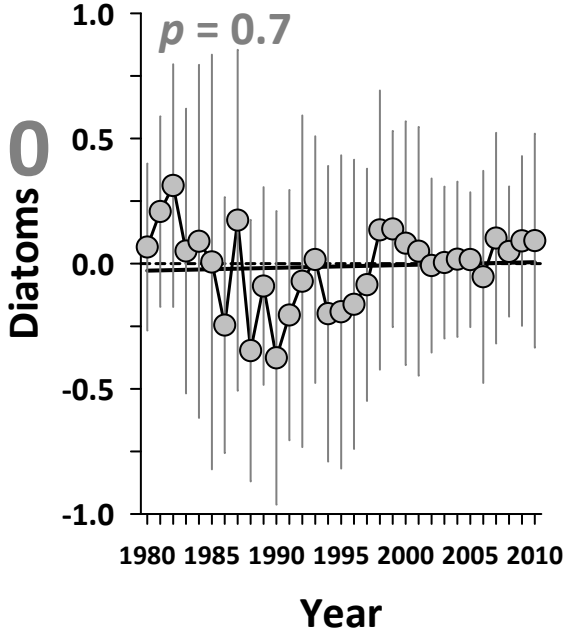
Stephanie L. Hinder[1,2†], Graeme C. Hays[2*†], Martin Edwards[3,4], Emily C. Roberts[2], Anthony W. Walne[3] and Mike B. Gravenor[1†]

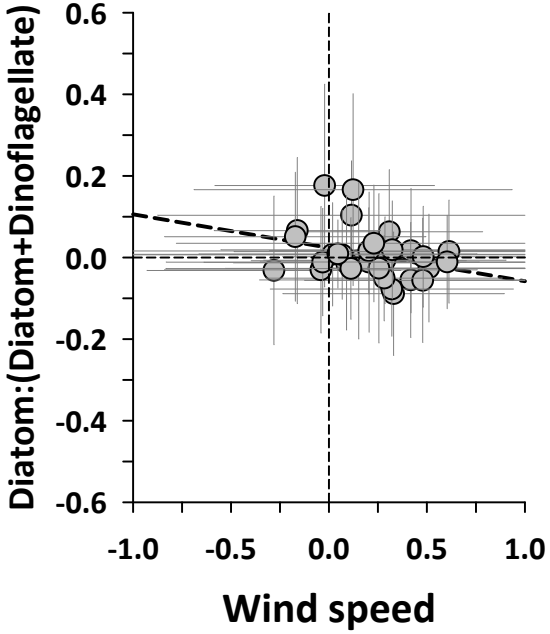


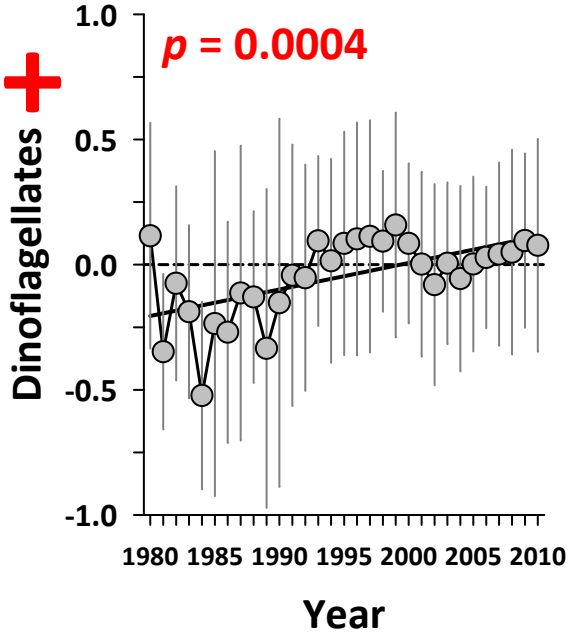
spp.) taxa, increasing in abundance. Overall these changes have led to a marked increase in the relative abundance of diatoms versus dinoflagellates. Our analyses, including Granger tests to identify criteria of causality, indicate that this switch is driven by an interaction effect of both increasing sea surface temperatures combined with increasingly windy conditions in summer.

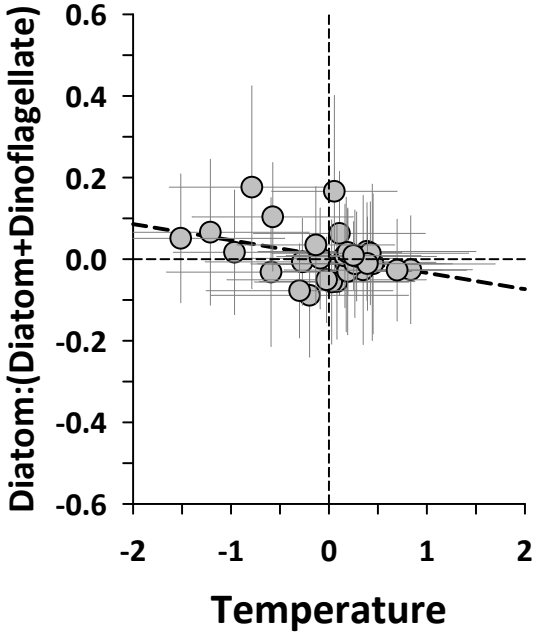


Monitoring stations: site-averaged annual average anomaly









Helgoland Roads

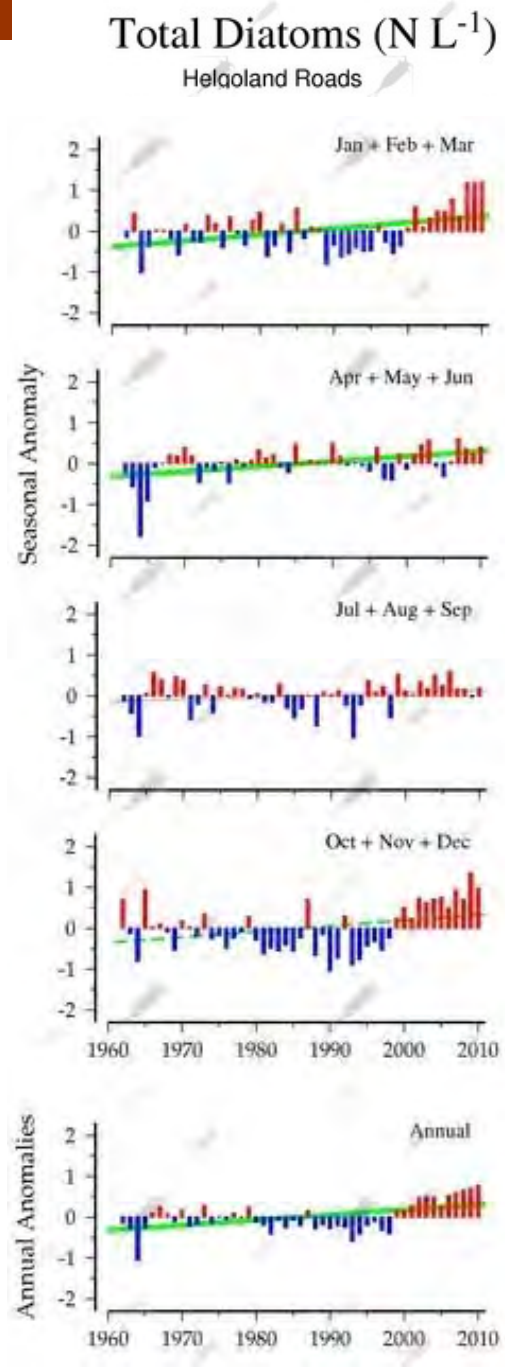
JAN + FEB +MAR

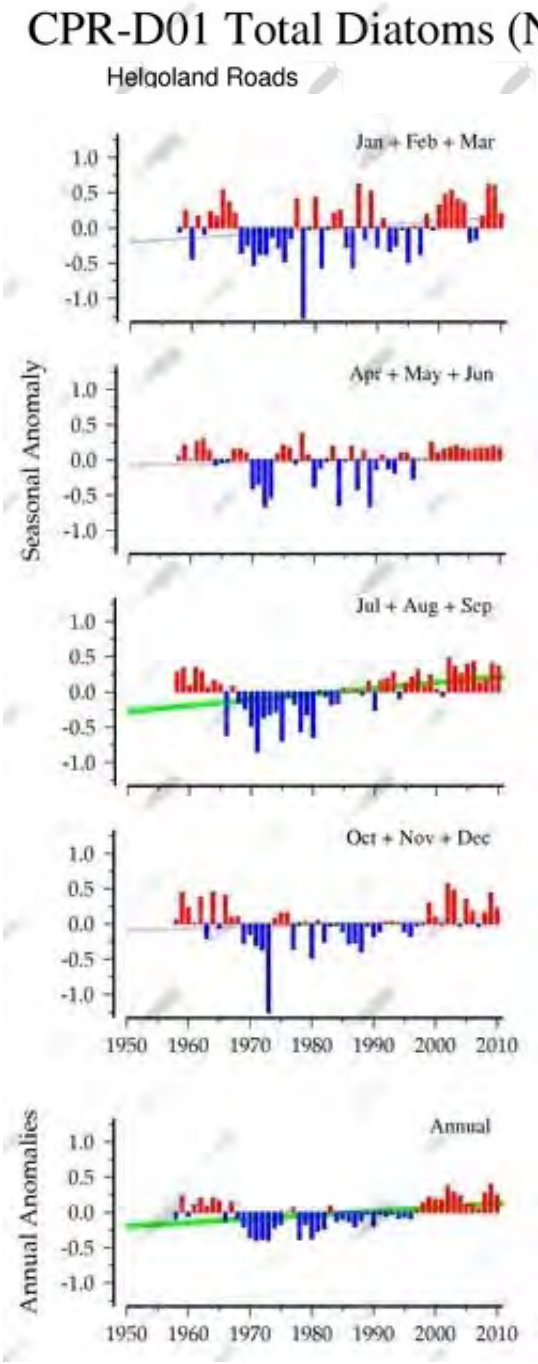
APR + MAY + JUN

JUL + AUG +SEP

OCT + NOV + DEC

ANNUAL





Helgoland Roads

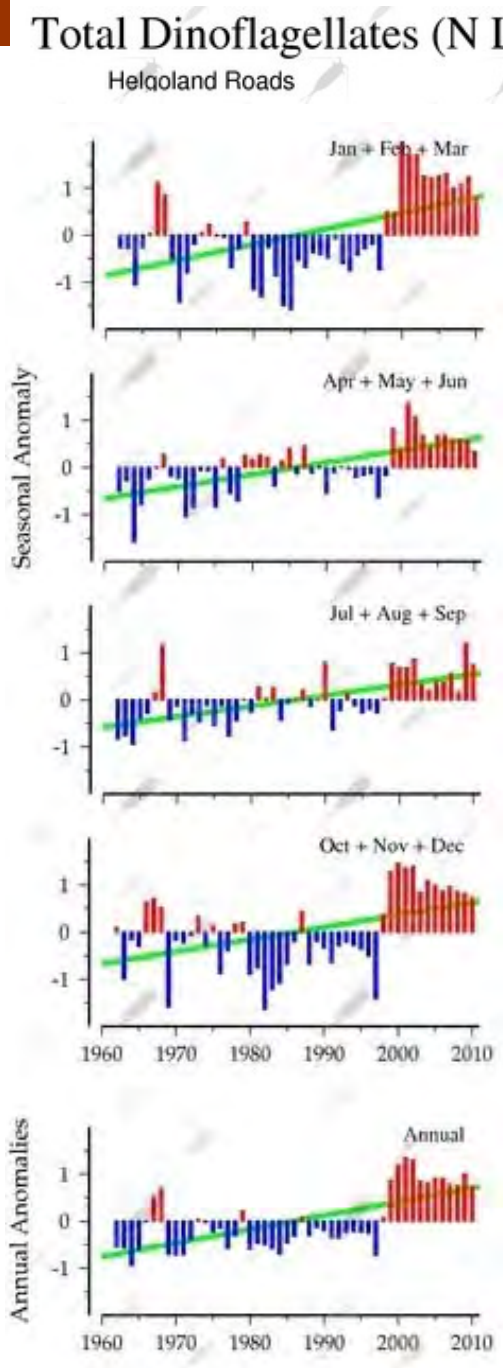
JAN + FEB +MAR

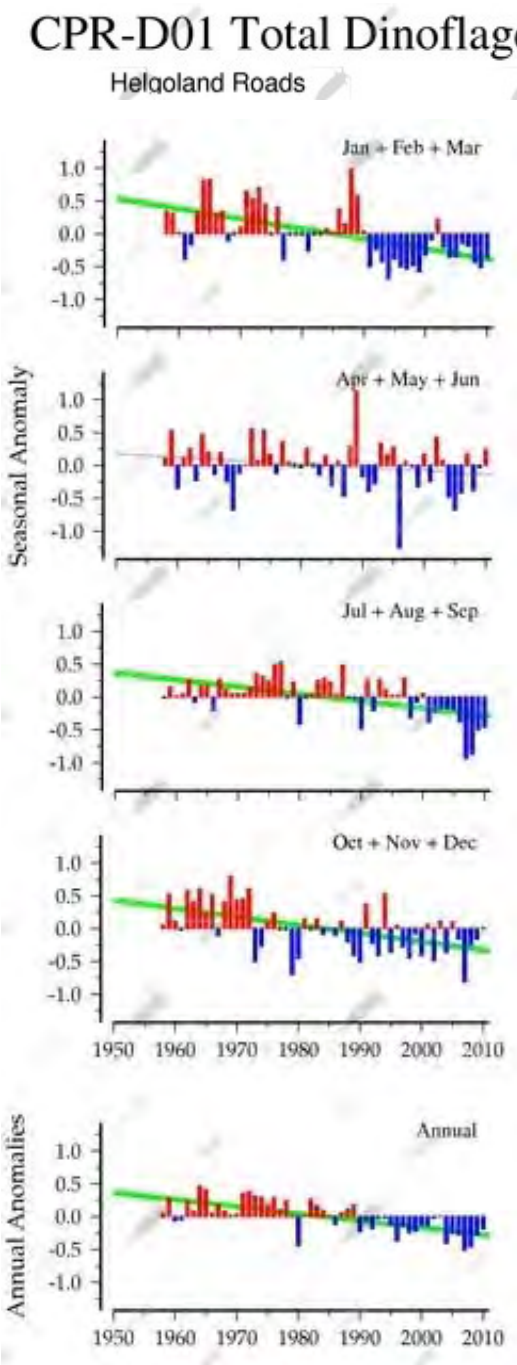
APR + MAY + JUN

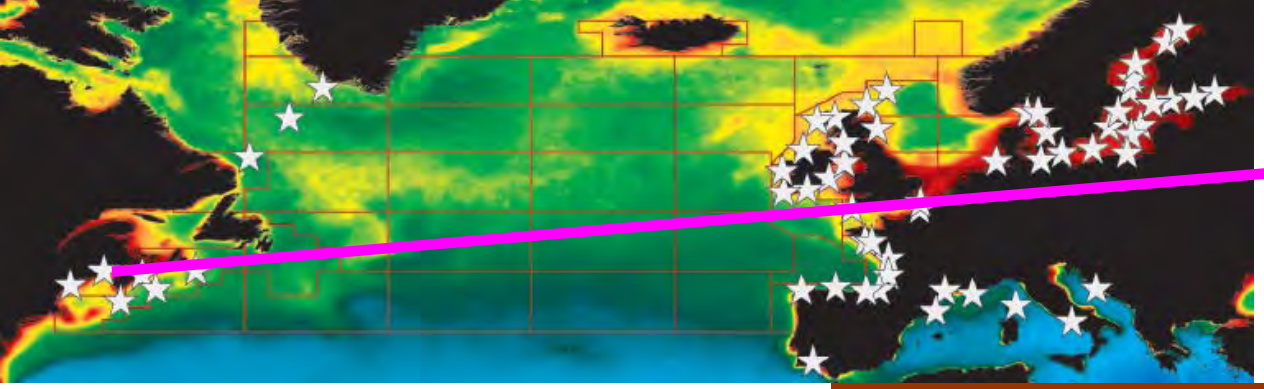
JUL + AUG +SEP

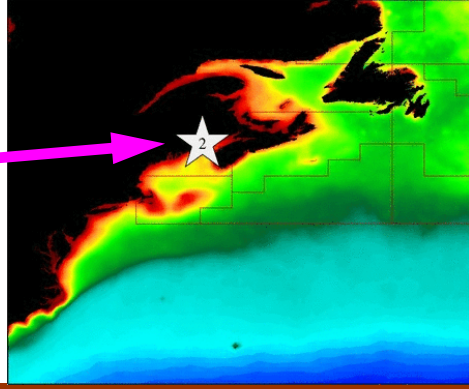
OCT + NOV + DEC

ANNUAL

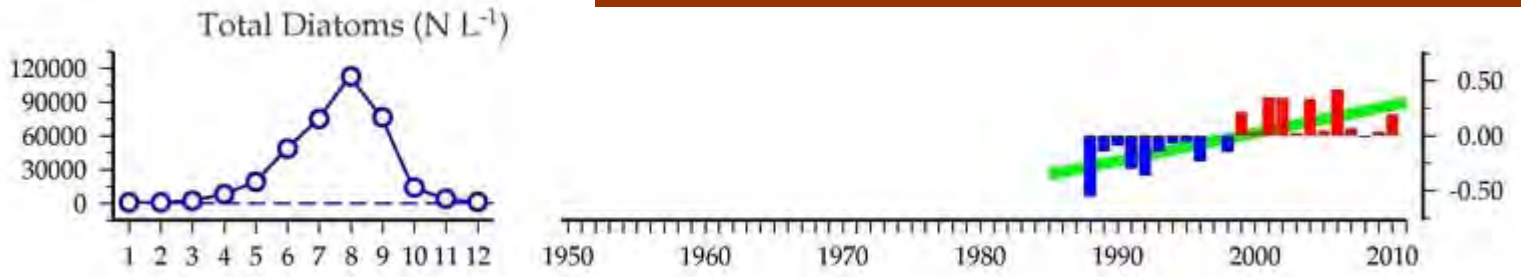


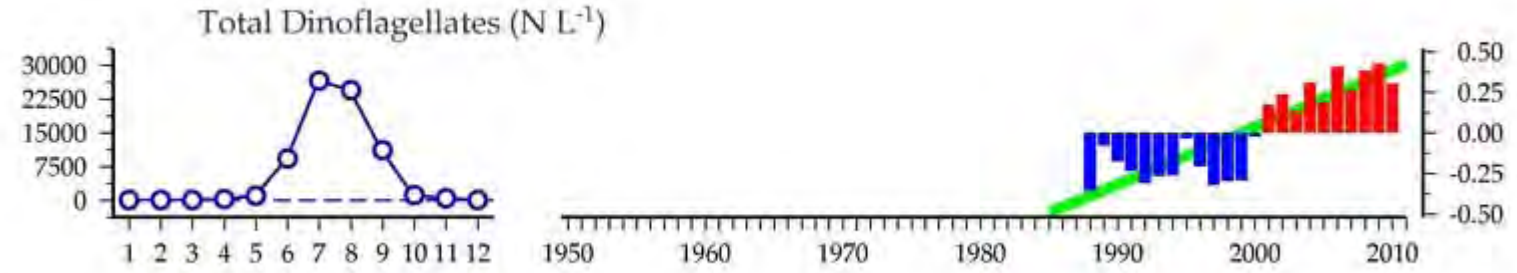


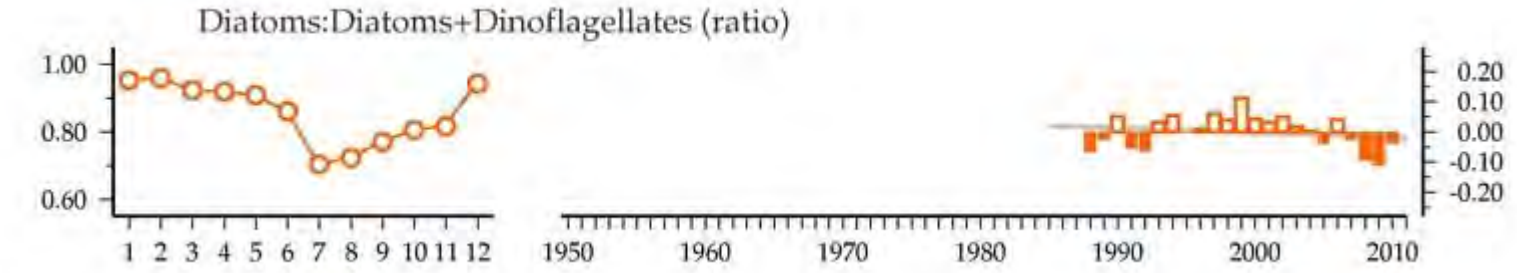


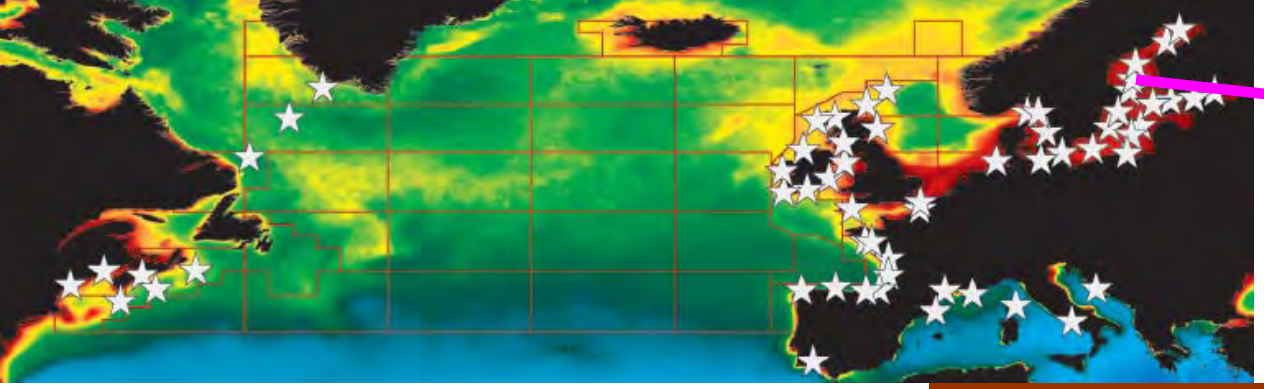


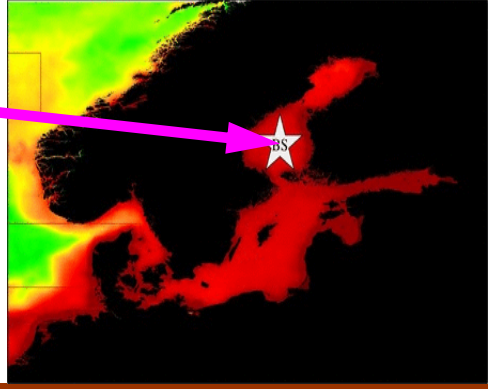
Bay of Fundy (Site 2) – Northwest Atlantic Shelf



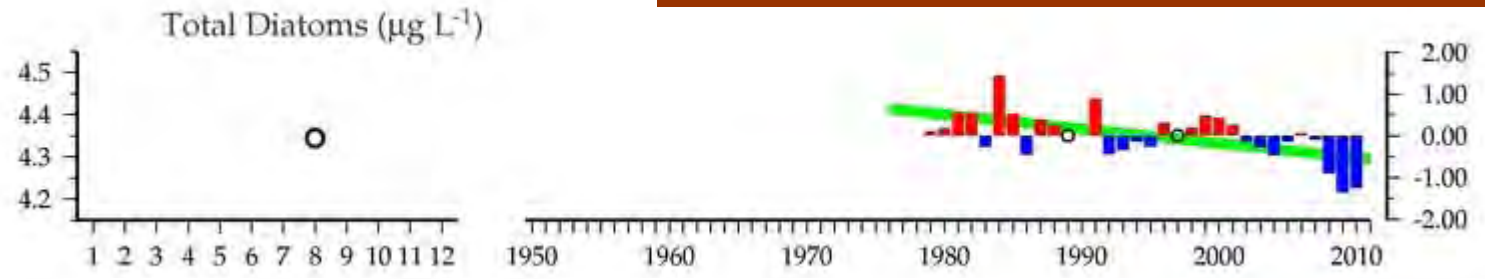


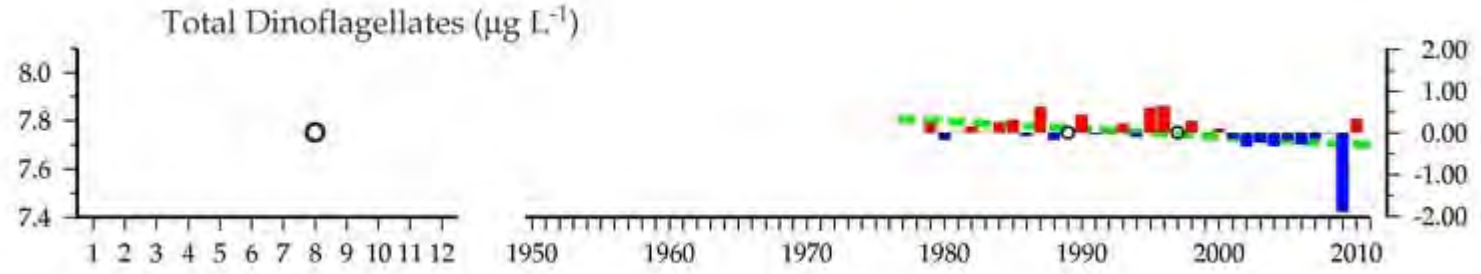


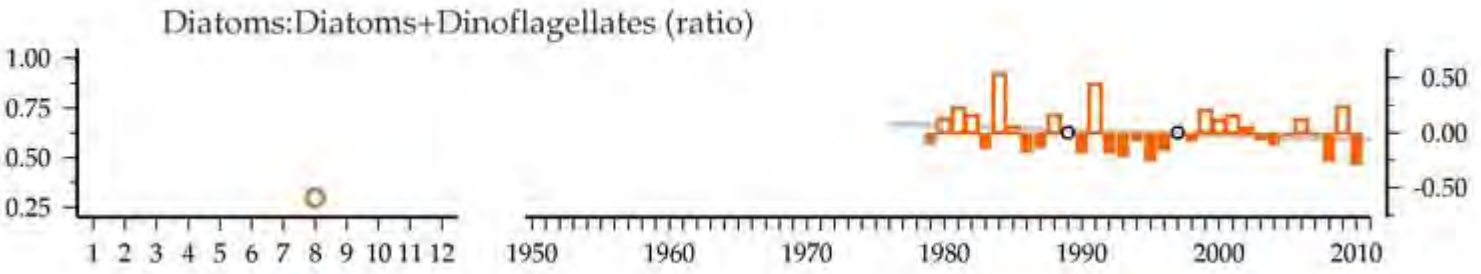


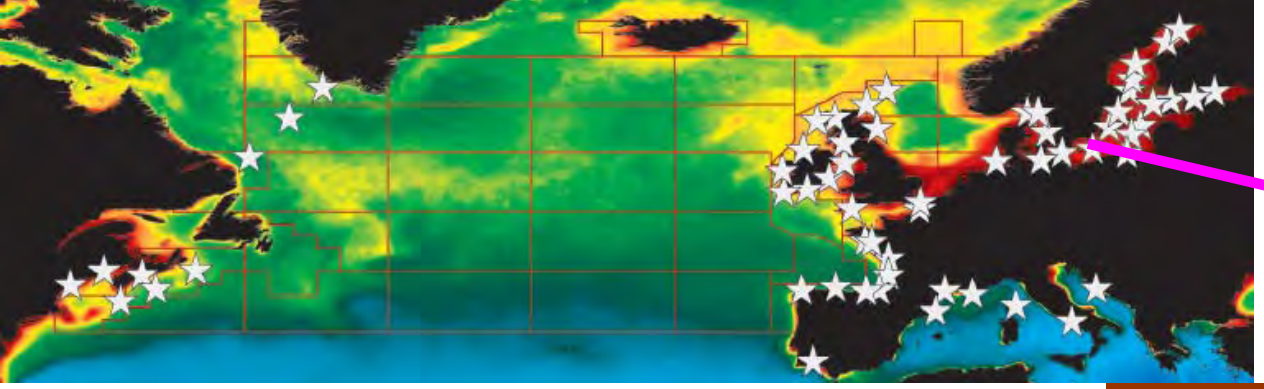


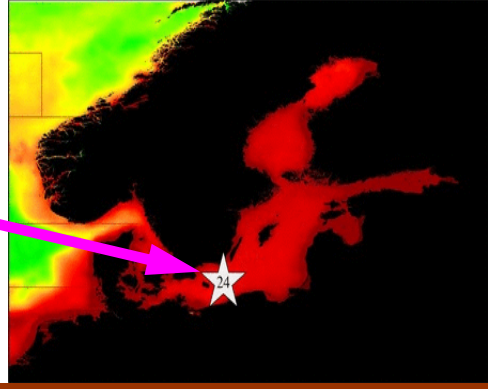
Bothnian Sea (sites 12-14) – Northern Baltic



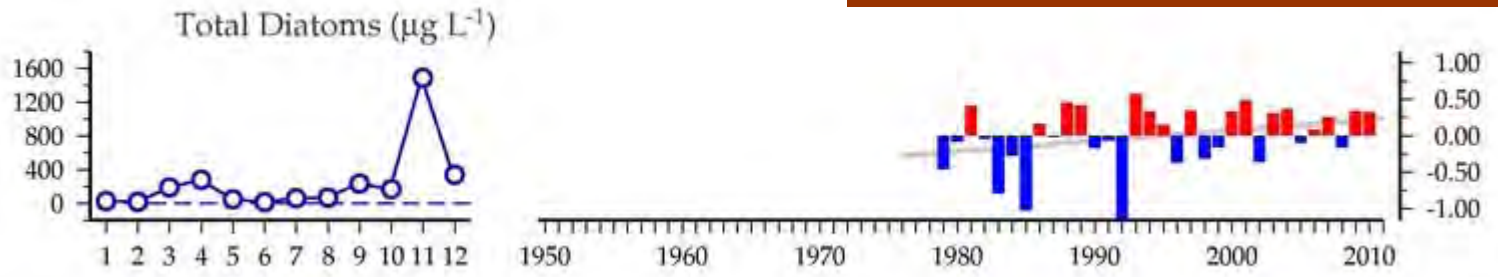


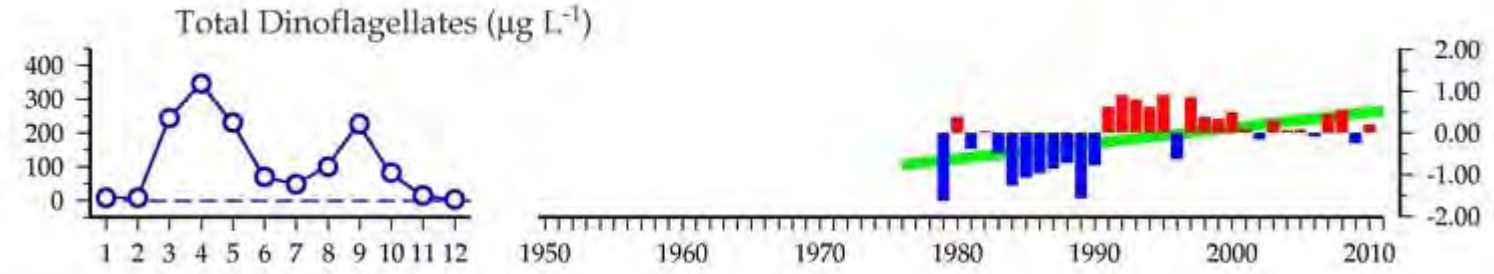


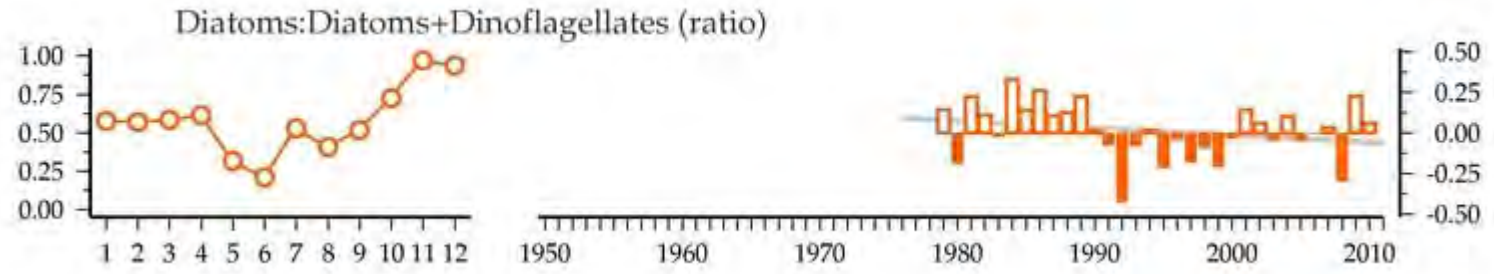


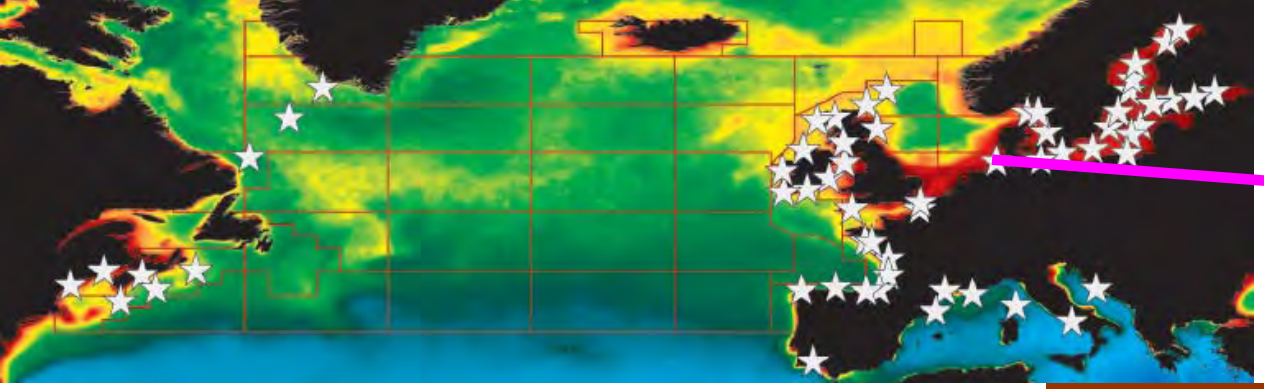


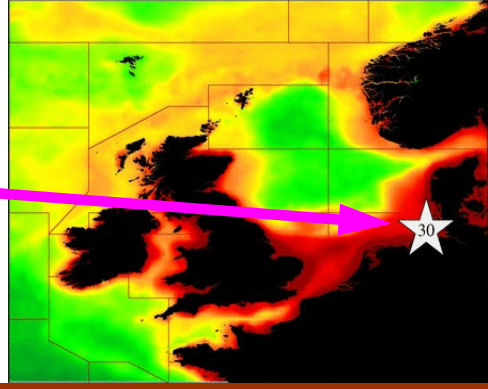
Bornholm Sea (Site 24) – Baltic Sea



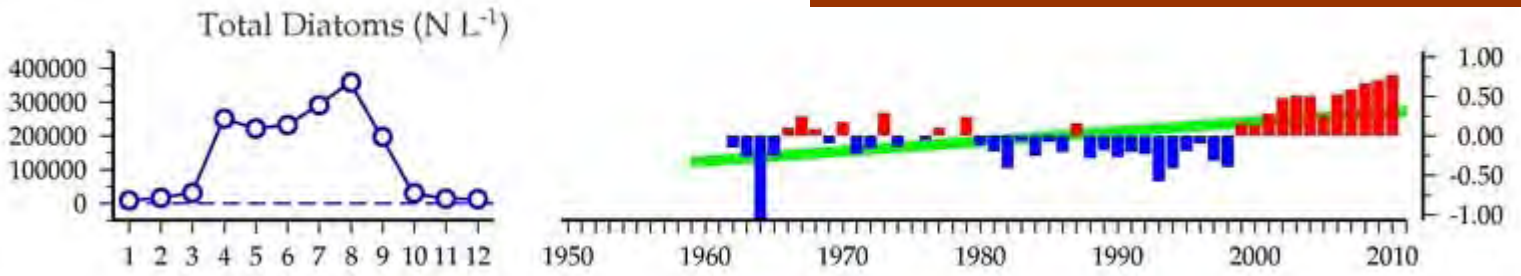


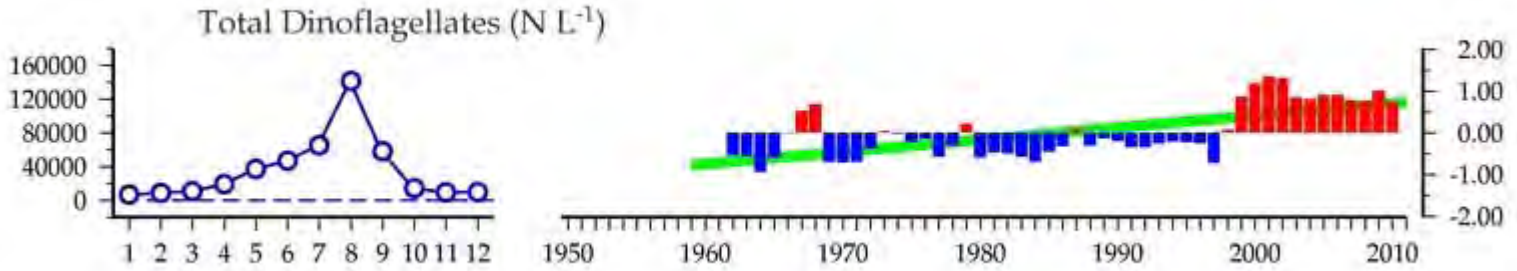


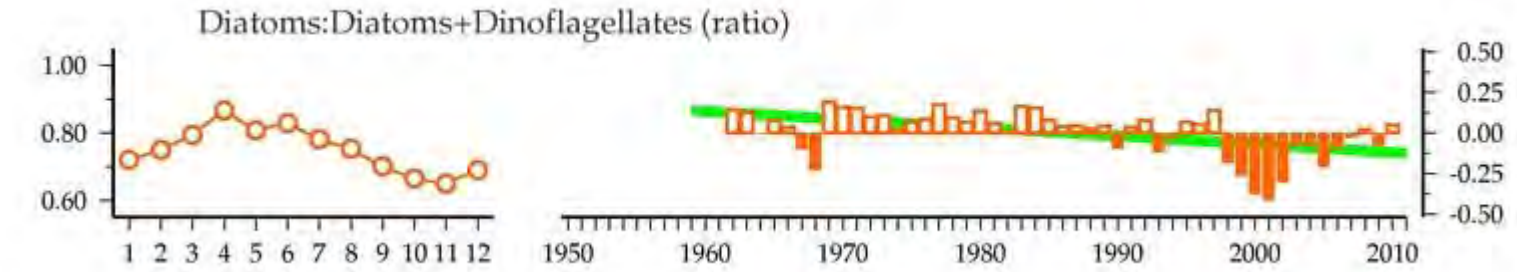


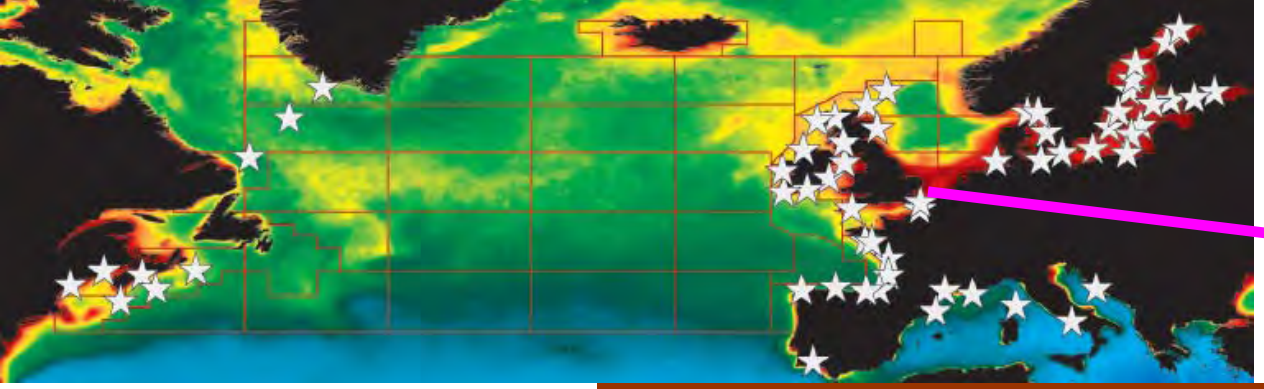


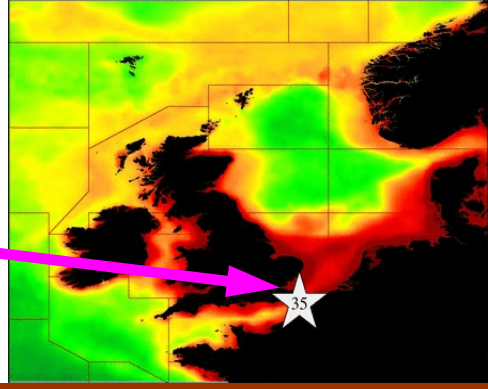
Helgoland Roads (Site 30) – North Sea



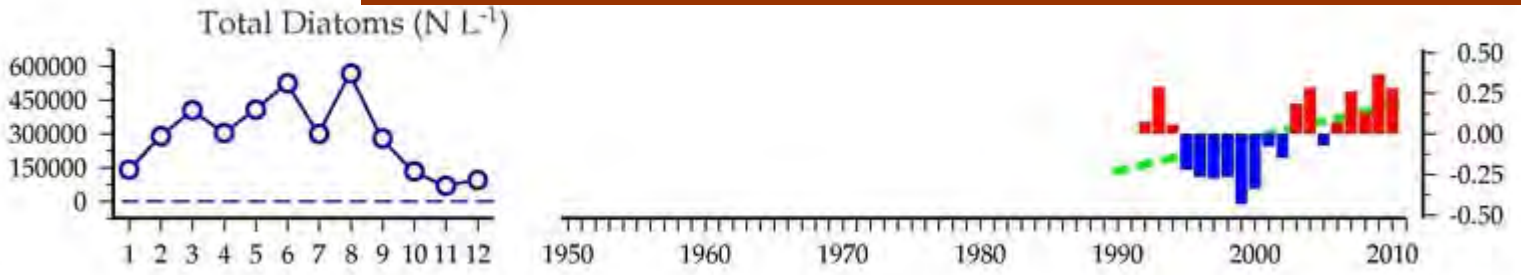


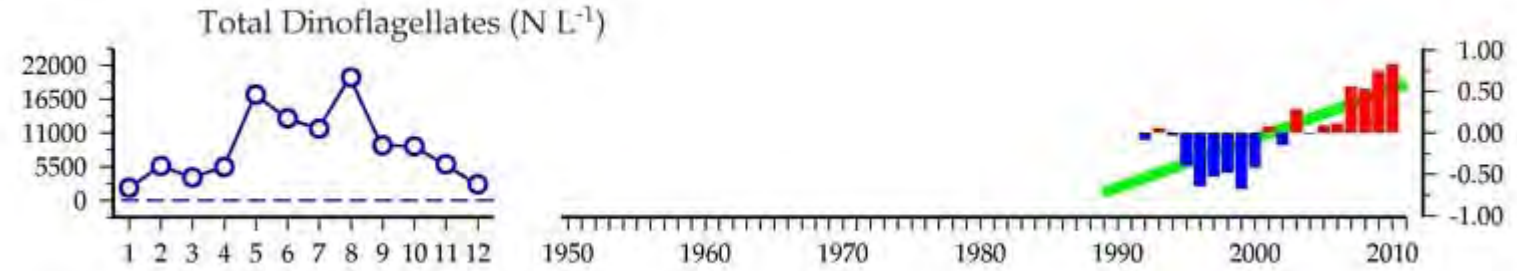


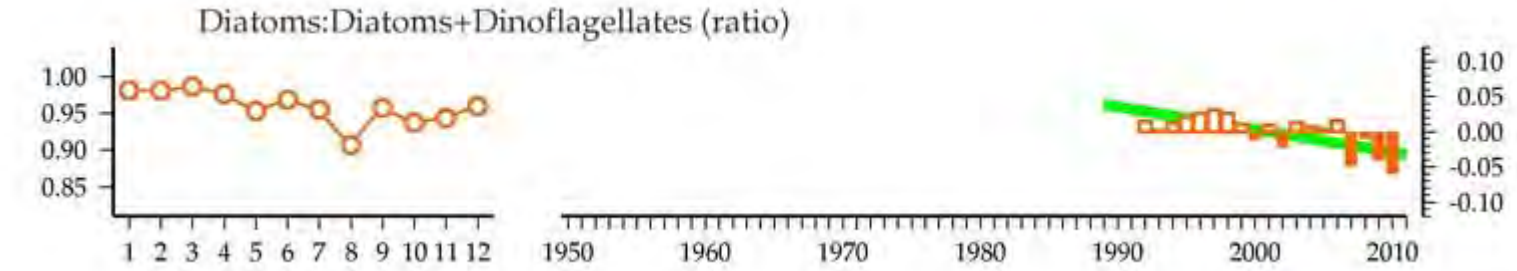


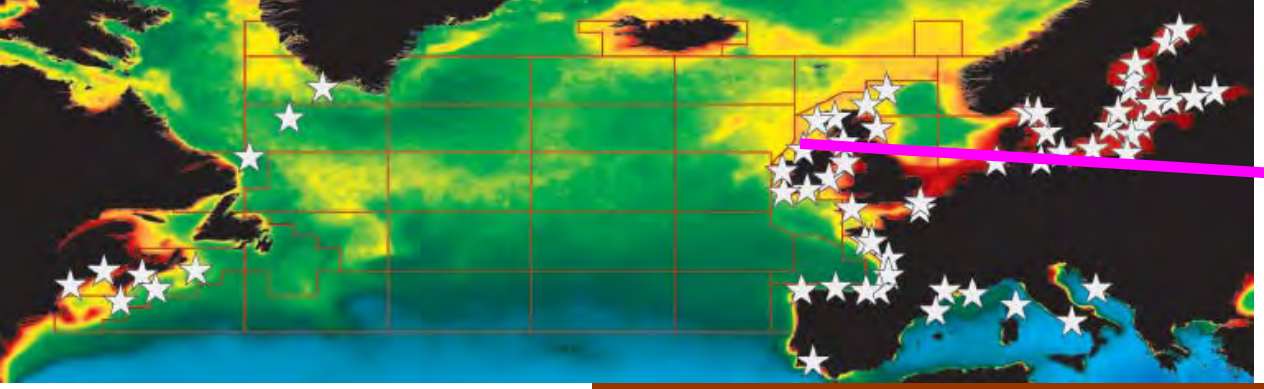


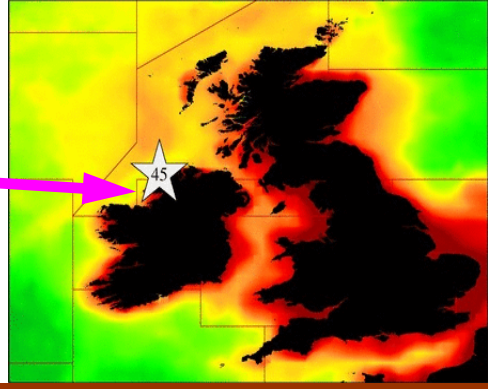
REPHY Point 1 SRN Boulogne (Site 34) – English Channel



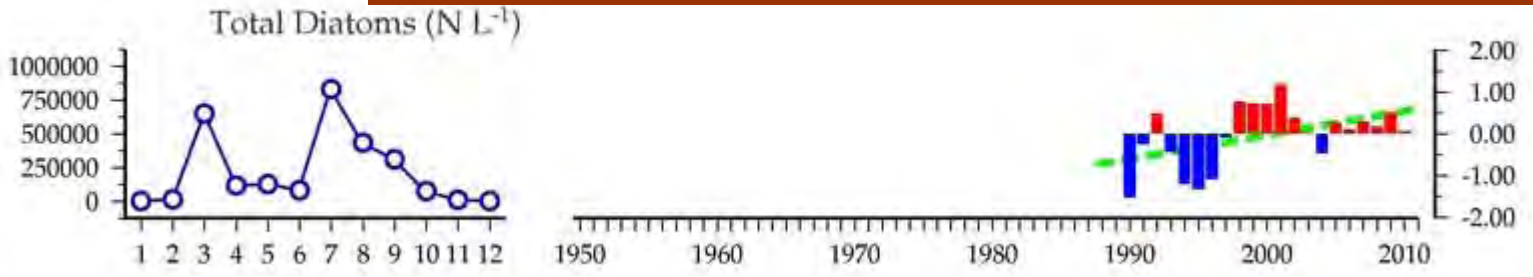


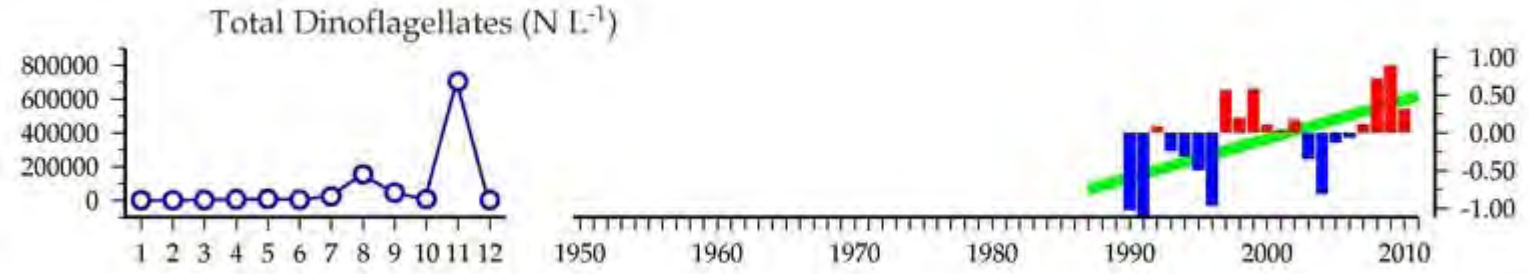


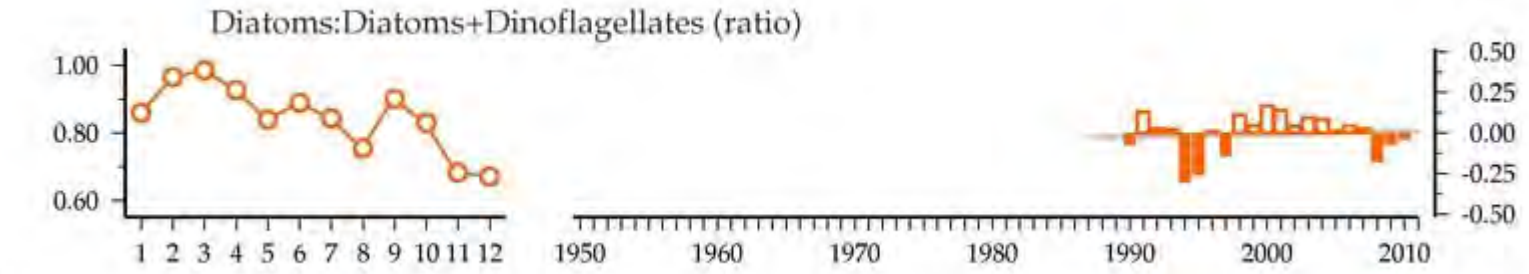




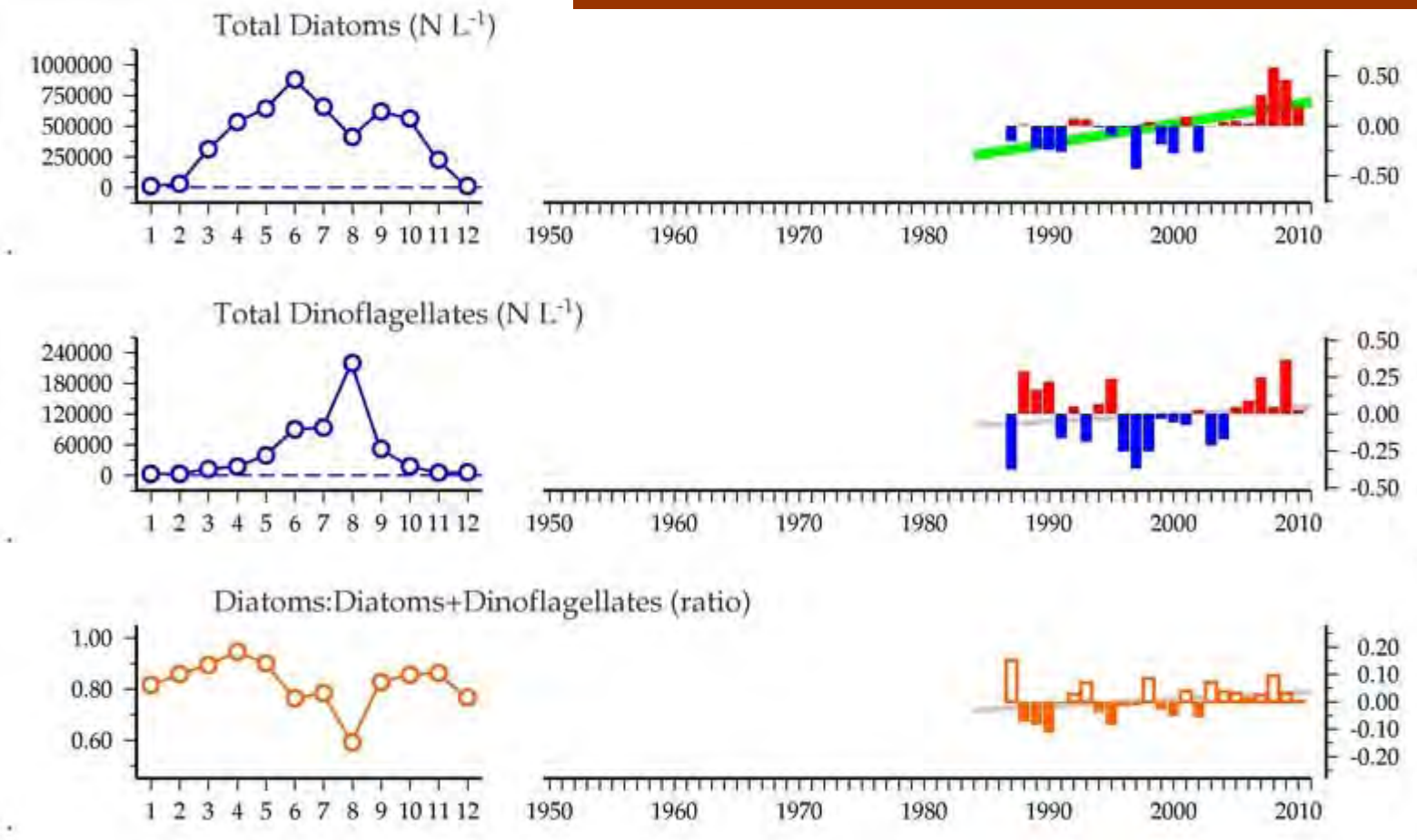
Northwest Coast Ireland (Site 45) – Northeast Atlantic Shelf

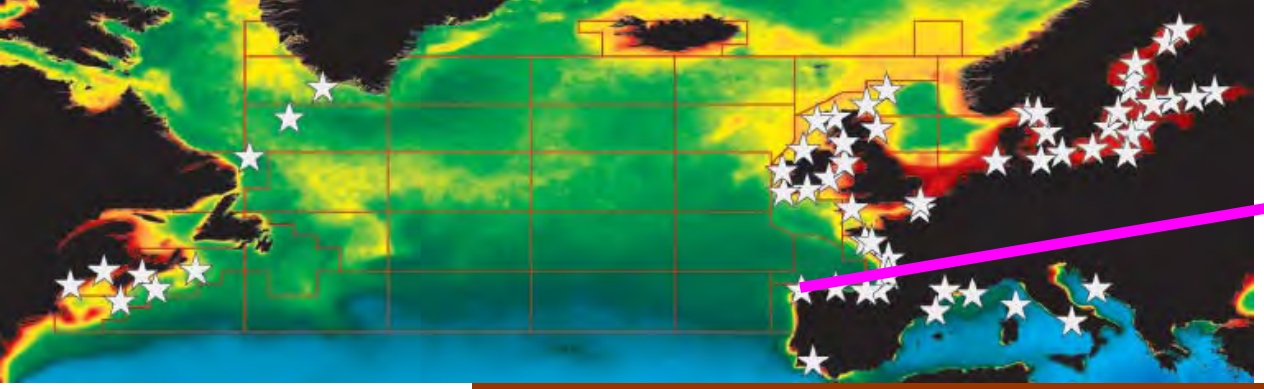


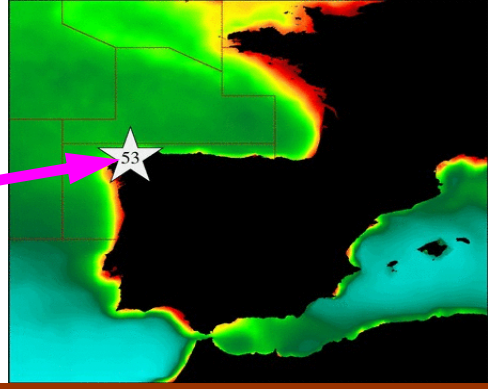




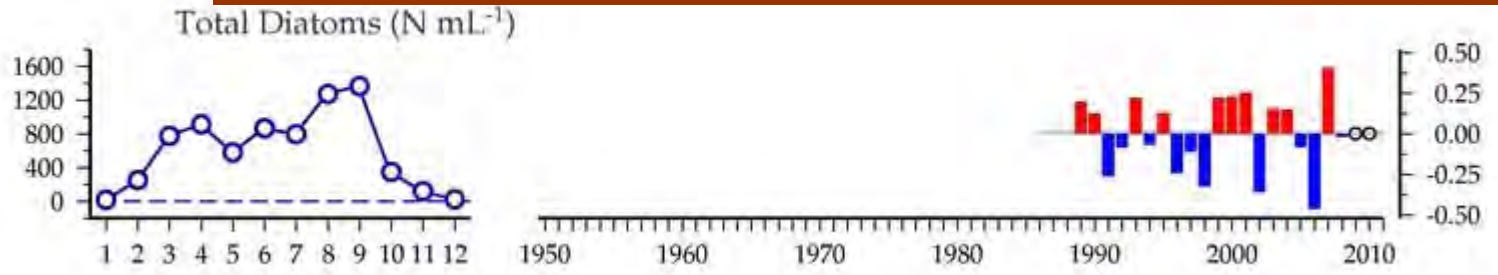
REPHY Ouest Loscolo (Site 47) – Bay of Biscay

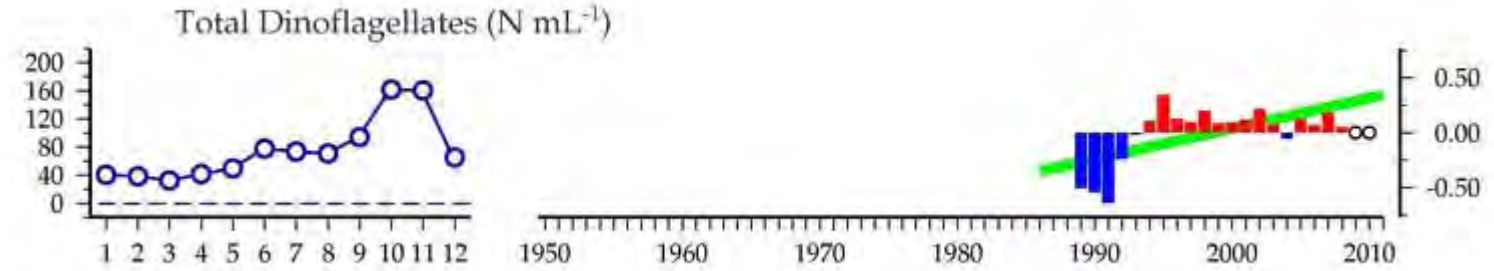


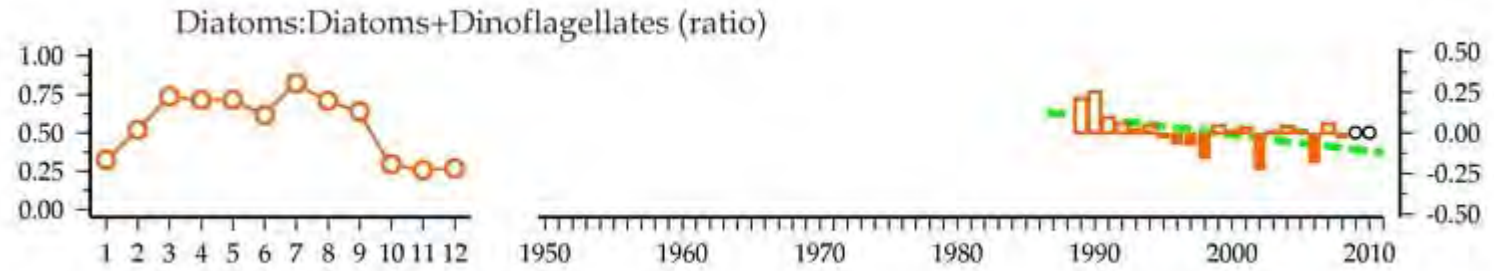


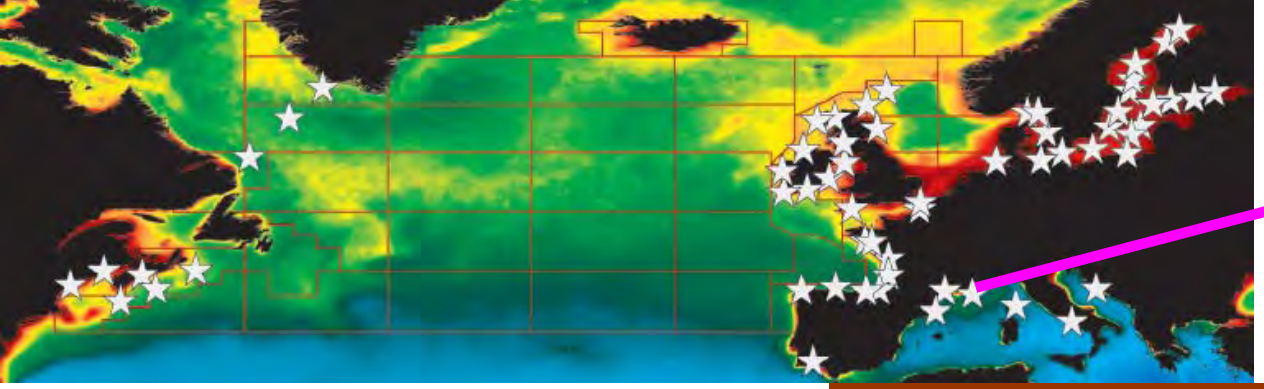


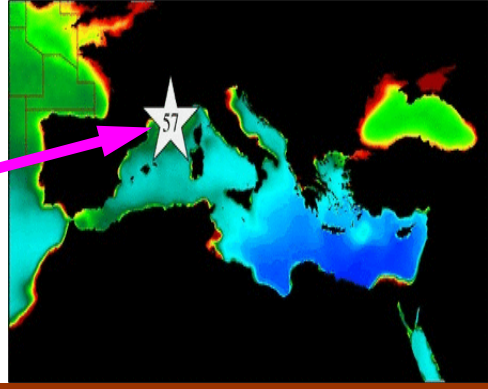
RADIALES A Coruña Station 2 (Site 53) – Western Iberian Shelf



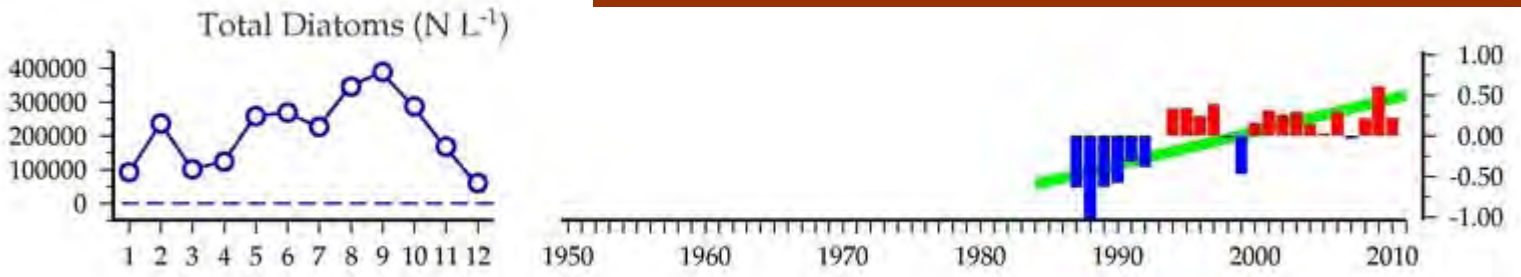


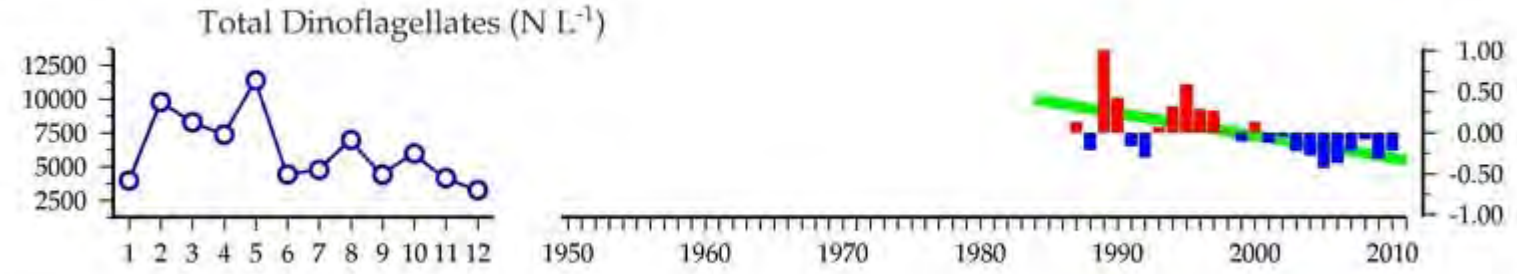


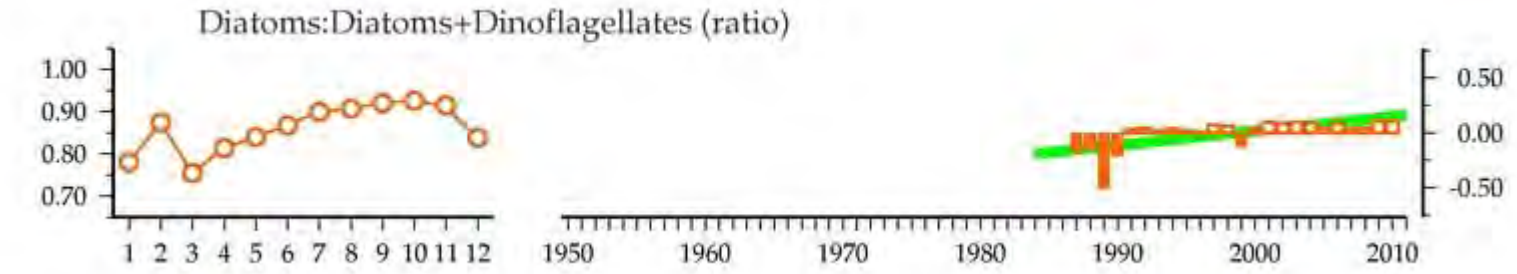


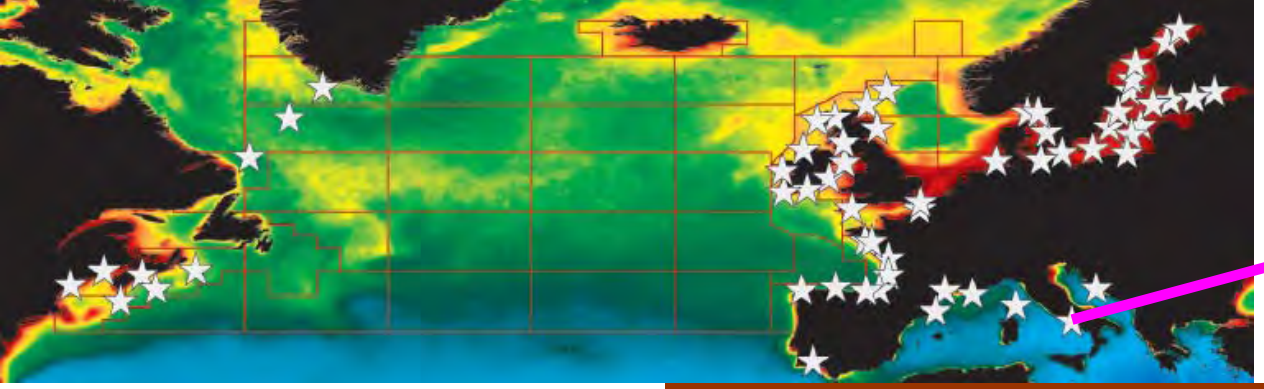


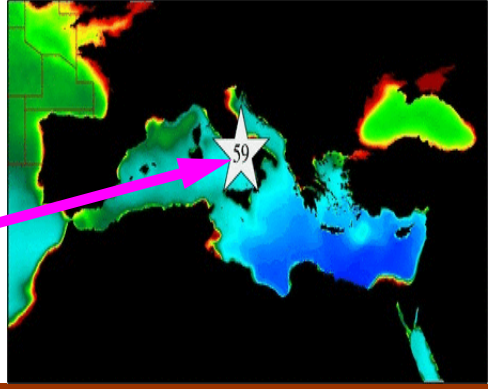
REPHY Lazaret A (Site 57) – Mediterranean Sea



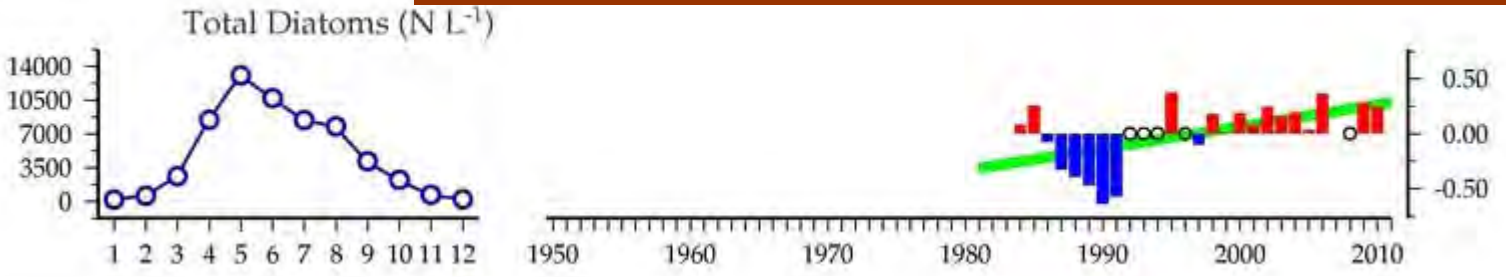


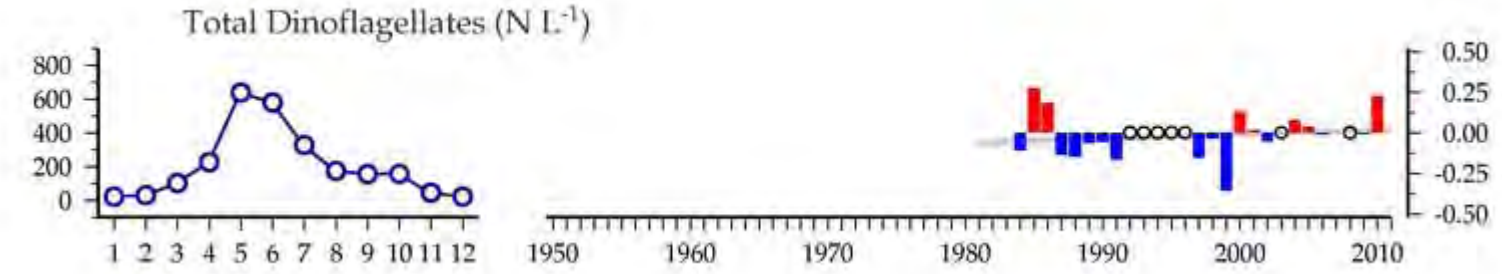


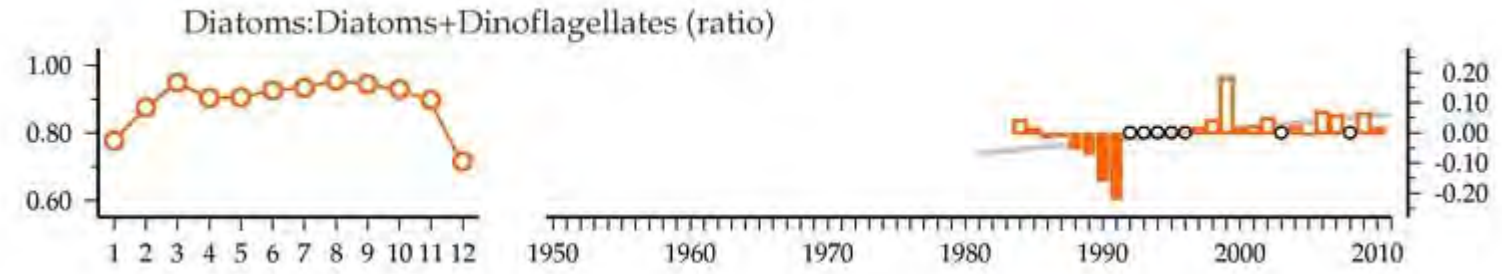




Gulf of Naples LTER-MC (Site 59) – Mediterranean Sea







Diatoms and Dinoflagellates : century-scale perspective

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100-years-changes in the phytoplankton community of Kiel Bight (Baltic Sea)

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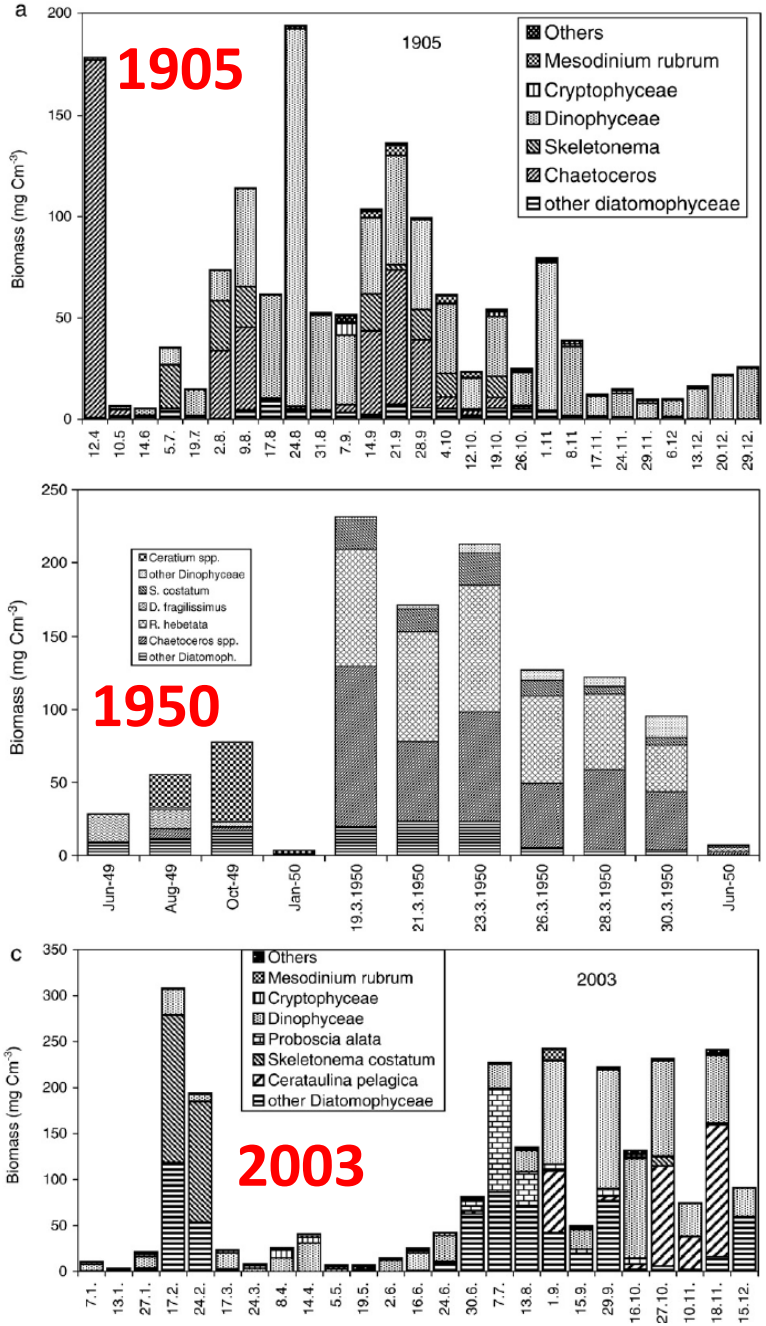
Abstract

Literature data from 1905/06, 1912/13 and 1949/50 were compared with recent data (2001–2003) from Kiel Bight in order to investigate changes in phytoplankton composition and biomass, which may serve as indicators of environmental changes. In terms of biomass, diatomophyceae and dinophyceae are by far the most important groups. Their ratio is still close to unity. The share of diatomophyceae increased strongly in years with exceptionally high summer blooms (2001) or exceptionally early spring blooms (2003). The summer and autumn blooms of *Chaetoceros* and *Skeletonema*, detected in the early 20th century, are replaced by other diatoms (*Cerataulina pelagica, Dactyliosolen fragilissimus, Proboscia alata, Pseudo-nitzschia* spp.). *Chaetoceros* and *Skeletonema* are still important components of the spring blooms. Now as before, the autumn blooms are dominated by *Ceratium* spp., sometimes also by diatoms. Newly appearing bloom-forming species are mostly potentially toxic (*Dictyocha speculum, Prorocentrum minimum, Pseudo-nitzschia* spp.). The total phytoplankton biomass has roughly doubled in the course of the last century. The reference condition for phytoplankton biomass in Kiel Bight in the sense of the Water Framework Directive was defined at 55 mg C m^{-3} (±10%, annual mean). The mean annual biomass of diatomophyceae and dinophyceae was 25 mg C m^{-3} (±40%) for each, indicating that the sum of their carbon biomass amounted to 90% (±10%) of the total phytoplankton biomass on an annual average. Diatomophyceae represented at least 80% of carbon biomass in the spring bloom peak at the beginning of the 20th century.

Keywords: Phytoplankton biomass; Species shift; Reference conditions for phytoplankton; The EU Water Framework Directive; Baltic Sea; Kiel Bight



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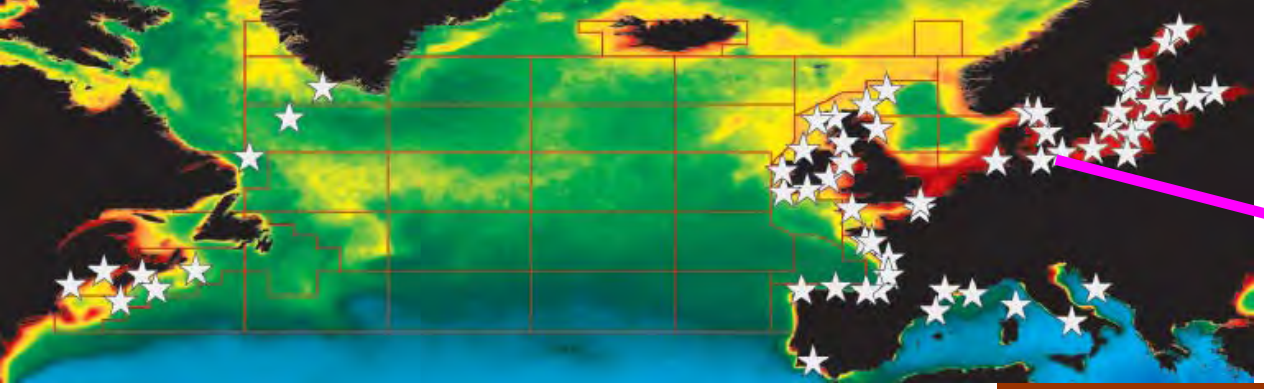
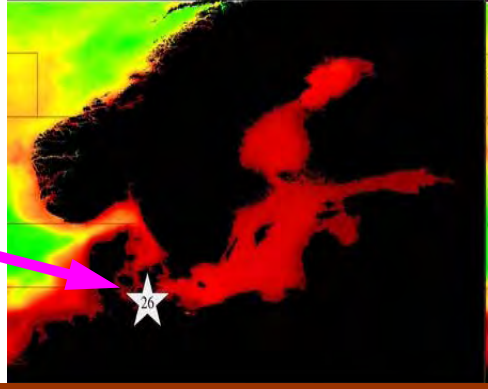
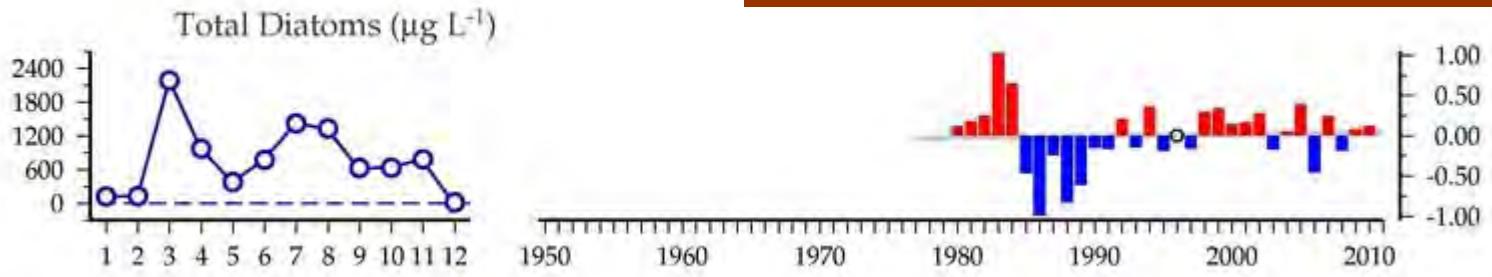
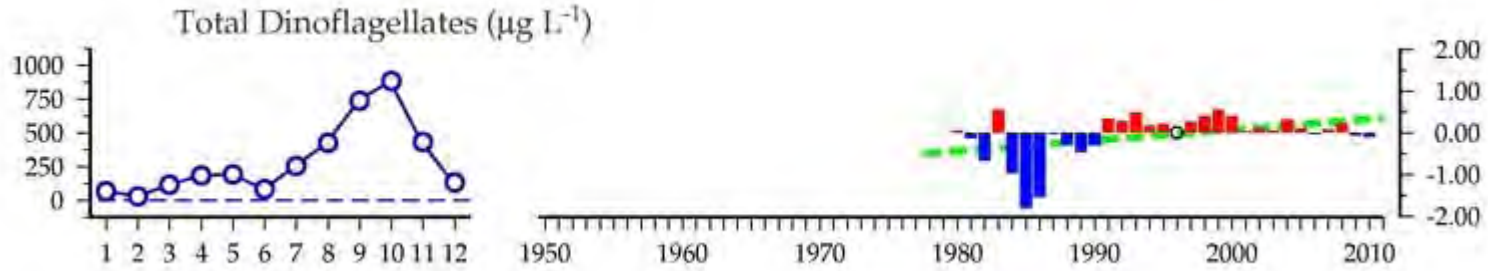
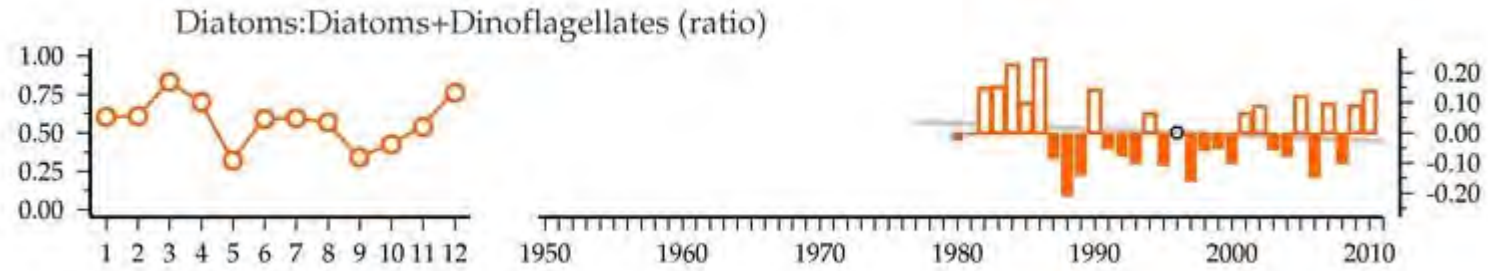




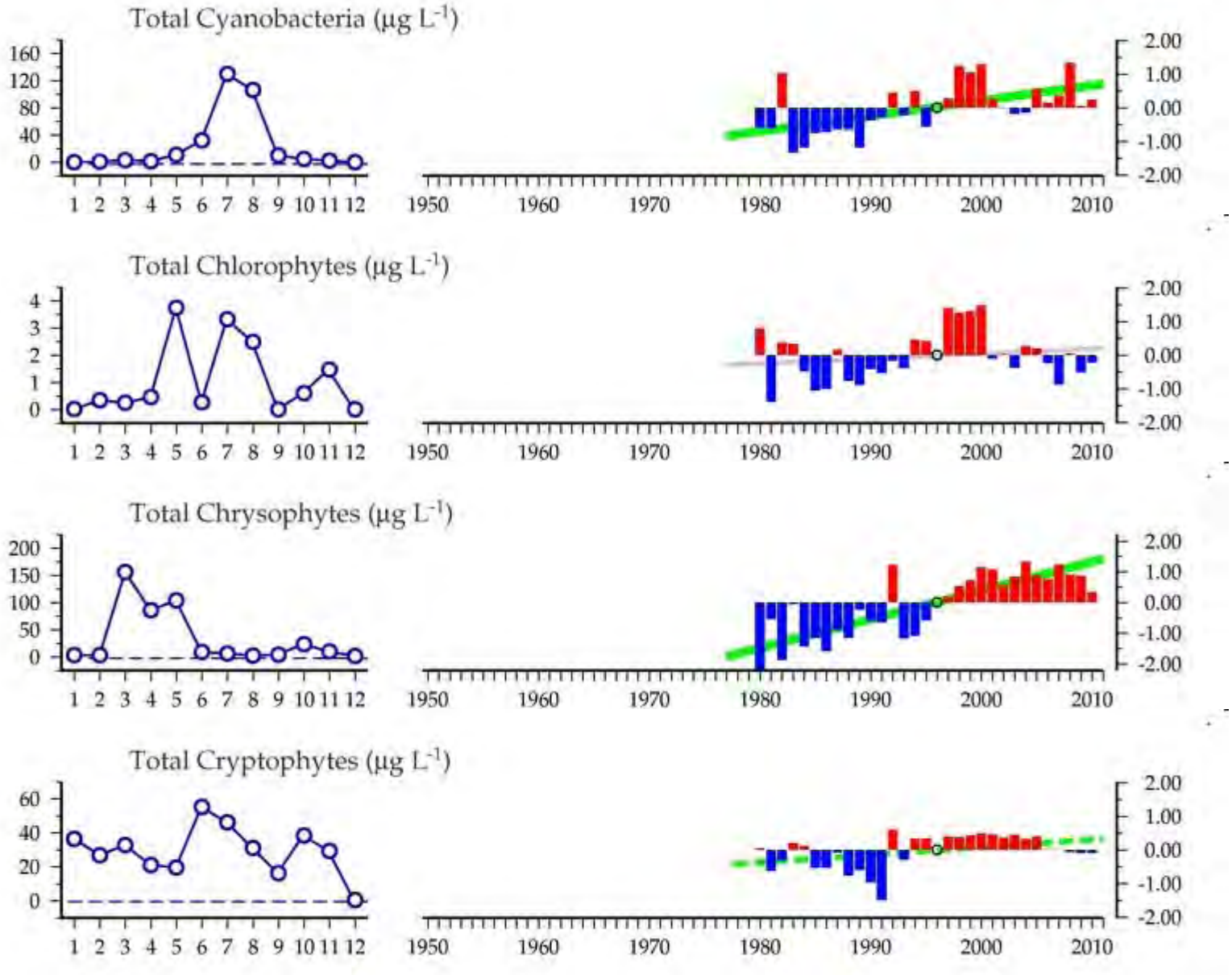
Mecklenburg Bight (Site 26) – Baltic Sea



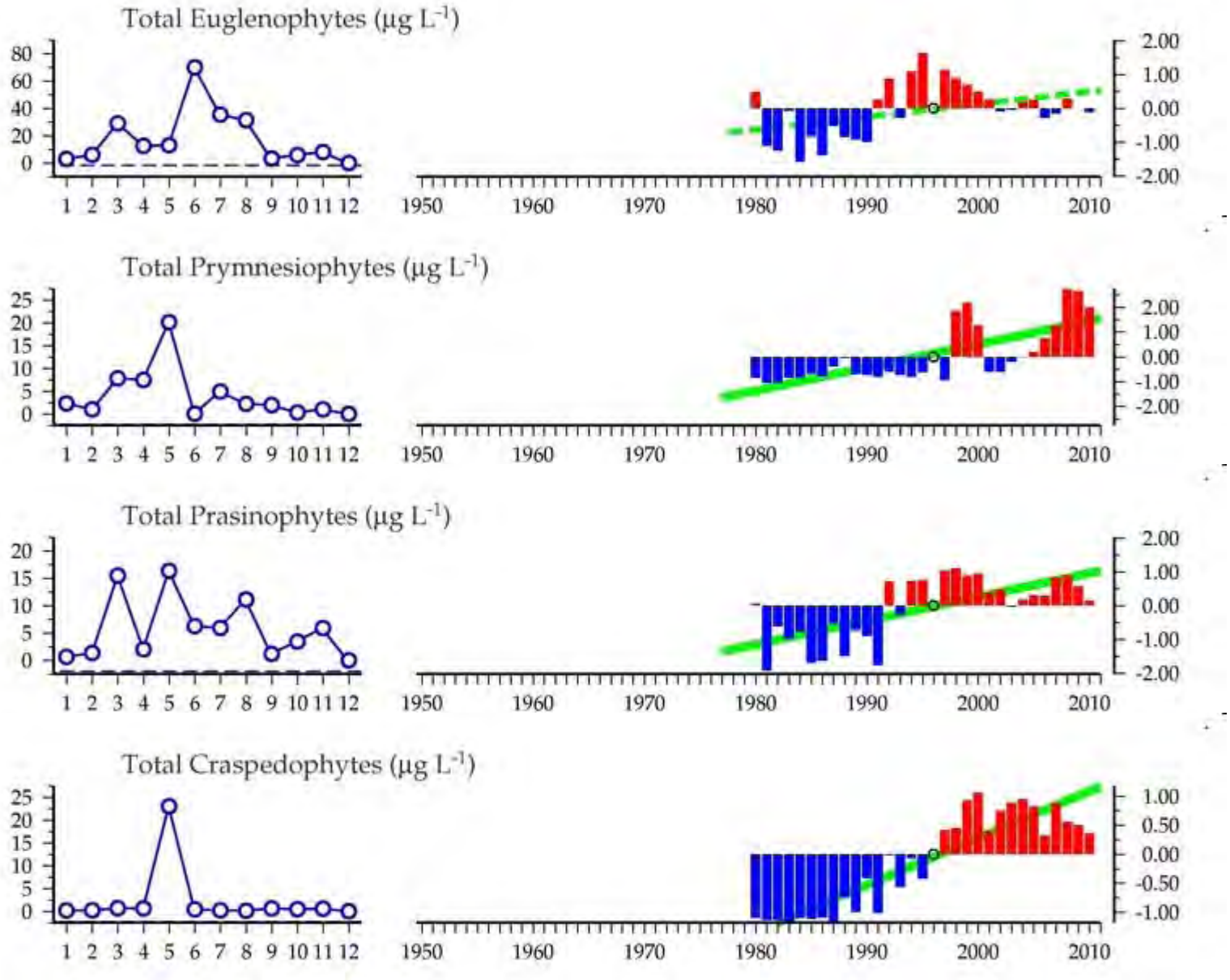




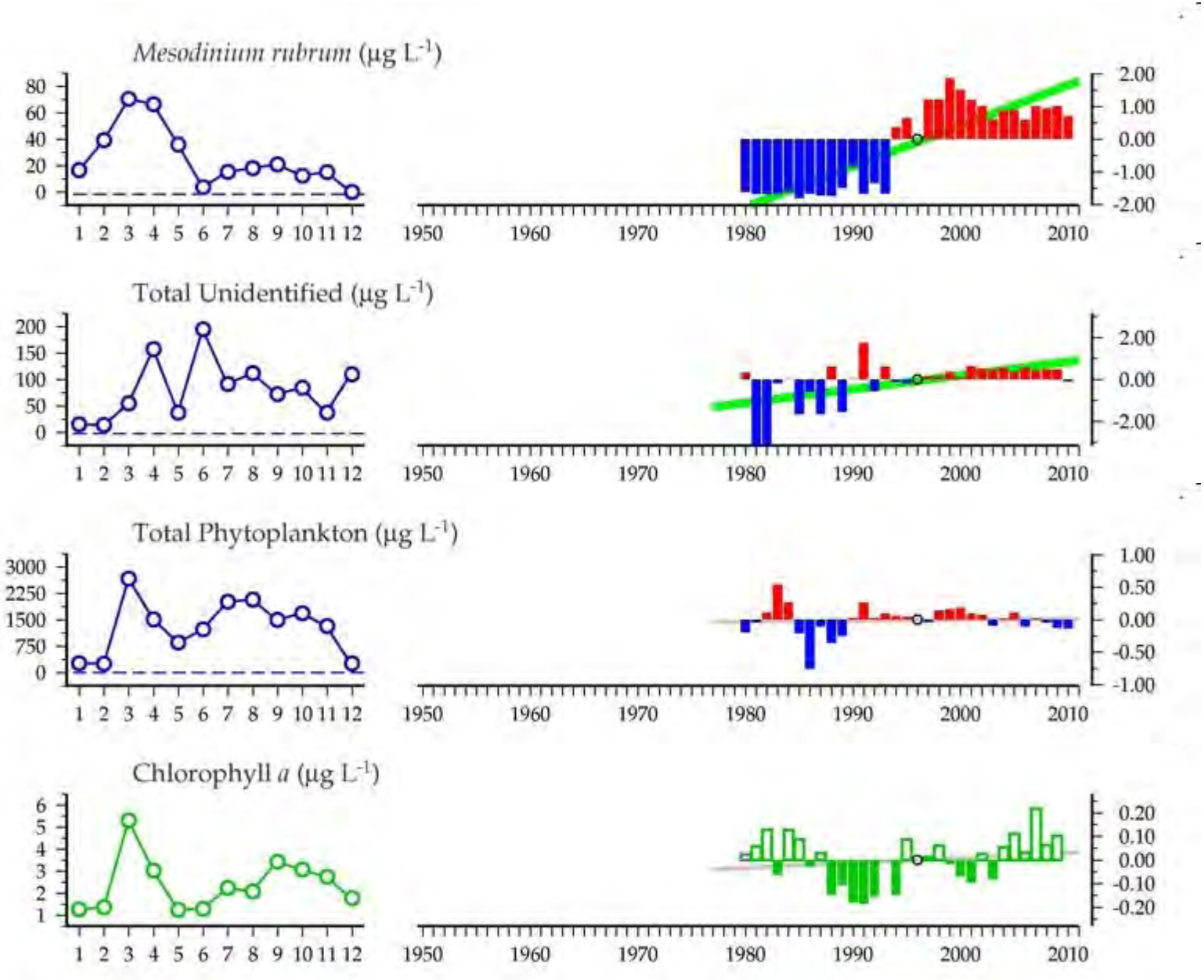
Mecklenburg Bight (Site 26) – *other phytoplankton*



Mecklenburg Bight (Site 26) – *other phytoplankton*



Mecklenburg Bight (Site 26) – *other phytoplankton*



Summary

TOPIC	SUMMARY
1. Context and timeline	2007 PGPYME - 2010 WGPME - 2012 CRR
2. Ecological status report	7 geographical regions 61 monitoring stations 40 CPR areas FROM: subpolar (Labrador Sea) TO: subtropical (Iberia Shelf) INCLUDING: Mediterranean Sea
3. Pan-North Atlantic patterns	INCREASE: SST, Chl *a* , picophytoplankton, dinoflagellates DECREASE: nitrate, diatom:dinoflagellate ratio
4. Case studies	picoplankton diatom:dinoflagellate ratio
5. Future plans	Data: drill down (seasonal effects, species, etc) Time series: hydrography - phytoplankton/microbes - zooplankton ICES: integrated ecosystem assessment

ICES CIEM International Council for the Exploration of the Sea - Conseil International pour l'Exploration de la Mer

ICES COOPERATIVE RESEARCH REPORT
RAPPORT DES RECHERCHES COLLECTIVES

NORTH ATLANTIC

Ocean Climate

Phytoplankton and Microbes

Zooplankton

Climate Change

2012/2/SSGEF11 Workshop on the synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time series in the North Atlantic and adjacent seas (WKSERIES), chaired by Lidia Yebra, Spain (WGZE), and Alexandra Kraberg, Germany (WGPME), will be held at ICES Headquarters, Copenhagen, Denmark, in late 2013.

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