atures above 80 °C. Recent interest in the Pompeii worm has focused on a unique assemblage of symbiotic filamentous proteobacteria that cover the dorsal surface of the animal[9,10]. Like their hosts, these bacteria are positioned within this extreme thermal gradient and survive the same high-temperature environment laden with heavy metals and hydrogen sulphide. Studies of the worm and its associated microflora afford a unique opportunity to discover the biochemical adaptations that allow organisms to thrive in such an extreme thermal regime.

S. C. Cary
College of Marine Studies, University of Delaware, Lewes, Delaware 19958, USA
e-mail: caryc@udel.edu
T. Shank
Institute of Marine and Coastal Sciences, Rutgers, State University of New Jersey, P.O. Box 231, New Brunswick, New Jersey 08903-0231, USA
J. Stein
Diversa Corporation, 10665 Sorrento Valley Road, San Diego, California 92121-1623, USA

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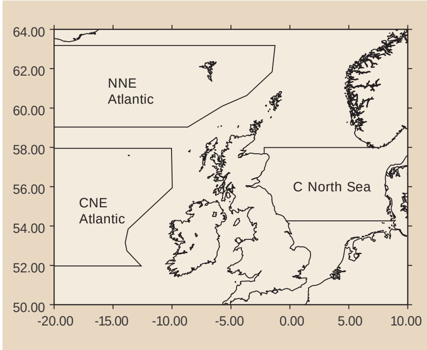
A marked increase in global temperature over the last century was confirmed by the second Assessment Report of the Intergovernmental Panel on Climate Change[1]. Here we report significant positive and negative linear trends from 1948 to 1995 in phytoplankton measured by the Continuous Plankton Recorder survey in the northeast Atlantic and North Sea that might reflect a response to changing climate on a timescale of decades. Spreading of unusually cold waters[2] from the Arctic might have contributed to the decline in phytoplankton north of 59° N. Further south, phytoplankton season length and abundance seem to have increased.

The Continuous Plankton Recorder (CPR) survey[3] is the only biological monitoring programme that operates on an ocean basin scale. Merchant ships voluntarily tow CPRs, at a depth of ~10 m, on their normal routes of passage[4]. The survey is unique in that the methodology and plankton analysis procedures for ~400 taxa and Phytoplankton Colour have been maintained with little change for more than 50 years.



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Phytoplankton Colour is a visual index of chlorophyll based on the intensity of the green coloration of the CPR filtering silk, which is assigned numerical values in four categories. Calculated annual primary production averaged for seven areas of the North Sea[5] is statistically comparable to mapped Phytoplankton Colour averaged for the same areas ($r^2 = 0.9$, $p < 0.01$), suggesting that the colour index might also reflect variation in plant production in the sea.

Results averaged for each month during 1948–95 for three areas of the North Sea and northeast Atlantic (Fig. 1) were analysed. An increasing trend is evident in the North Sea and the Atlantic between 52° and 58° N (Fig. 2), with evidence for a stepwise increase after the mid-1980s. The results for these areas show similar changes in trend and increased season length over the years 1981–91 to a satellite-derived vegetation index for the Northern Hemisphere above 50° N (ref. 6). An inverse pattern of change is seen in Phytoplankton Colour for the northern northeast Atlantic in an area that has tended to experience colder surface temperatures.

The eastward spread of negative-anomaly sea-surface temperatures towards the Faeroes in the northern northeast Atlantic[2] is most likely to be related to progressive changes in regional atmospheric forcing. Changes in the North Atlantic Oscillation have altered the centre of deep-water convection from the Greenland Sea to the Labrador Sea after 1988 (ref. 7). The likely sources of these colder waters are stronger westerlies, increased formation of Arctic surface water in the Greenland Sea and/or a larger export of fresh water from melted ice[8] and permafrost[9] in and around the Arctic Sea as a response to high

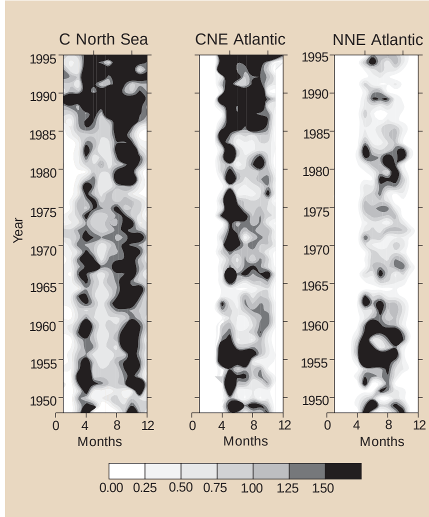

Figure 2 t t t y yt
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positive-temperature anomalies in northern Eurasia and Alaska.

Our observations provide the first marine surface time-series evidence for a vegetation response to what seems to be climatic forcing. This has implications for CO_2 fluxes and the productivity of the North Atlantic. The results draw attention to the possible importance of shelf phytoplankton growth to the global carbon budget, and highlight the paucity of comparable information that exists as time series for other shelf regions and for the Southern Hemisphere.

Philip C. Reid, Martin Edwards*, Harold G. Hunt, Andrew J. Warner
Sir Alister Hardy Foundation for Ocean Science, The Laboratory, Citadel Hill, Plymouth PL1 2PB,UK
e-mail: pcre@wpo.nerc.ac.uk
**also at: Department of Biological Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, UK*

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