LETTER

Harmful algal blooms in the Eastern North Atlantic Ocean

Paul Dees[a,1], Eileen Bresnan[b], Andrew C. Dale[a], Martin Edwards[c], David Johns[c], Beth Mouat[d], Callum Whyte[a], and Keith Davidson[a]

Applying a mathematical model to the period 1982–2016, in PNAS Gobler et al. (1) propose that ocean warming has expanded the niche for harmful algal blooms (HABs) of the species *Dinophysis acuminata* and *Alexandrium fundyense*, which can generate shellfish toxicity and pose risks to human health. The authors' model predicts an increase in the growth rate and in the duration of the bloom season for these species, with a "hot spot" being the North Eastern Atlantic (NEA) and North Sea (NS) waters surrounding the United Kingdom. Using ships of opportunity, the Continuous Plankton Recorder (CPR) has surveyed offshore phytoplankton populations (including *Dinophysis*, but not *Alexandrium*) in this region since 1958 (2). We used *Dinophysis* spp. data to evaluate the model's predictions, as species data were not available before 2004.

Growth rate is not easily calculated from in situ data, but one might reasonably expect enhanced growth to lead to increased cell abundance. We therefore determined the annual mean CPR surveyed *Dinophysis* concentration in the NEA and NS. Using the modified Chelton method to remove serial autocorrelation (3), we found that over the modeled period (1982–2015) and the whole CPR time series (1958–2015) there was no statistically significant positive relationship between *Dinophysis* abundance and sea-surface temperature (4) in the modeled area over either the whole year or the April to September growth season, a result consistent with a previous study (5).

Dinophysis-generated shellfish toxicity is related to short-term "bloom" events of elevated abundance. Harm from *Dinophysis* could therefore increase despite annual abundance decreases, should more frequent or larger blooms occur. Fig. 1 shows that, while there have been periods of large *Dinophysis* blooms in the region, these mostly occurred during the early 1970s and the late 1980s, and have been followed by a period of briefer bloom events from the mid-2000s until 2014. In Fig. 2, by calculating the percentage of days per year that *Dinophysis* abundance was greater than two SDs above the mean of the whole series, we also show that there is no increasing trend in number or annual duration of blooms.

Understanding the long-term trends of *Dinophysis* concentrations is important in NEA waters as significant increases in shellfish aquaculture are planned in the region. The work of Gobler et al. (1) is valuable in demonstrating the potential for increasing water temperature to increase the associated HAB risk. However, our data indicate that the modeled increases in *D. acuminata* growth rate are not evident in terms of increases in the annual mean, number of *Dinophysis* blooms, or their duration. Gobler et al. used empirical laboratory evidence of increasing *D. acuminata* growth rate with increasing temperature to parameterize an individual-based model. *Dinophysis* populations exist within a complex planktonic food web and are often comprised of more than one species, with different environmental preferences. Our results suggest that other factors, such as prey availability, predation, or ecological interactions are currently limiting any temperature-driven increase in *Dinophysis* in the region. It will be necessary to incorporate these factors within models to fully evaluate climate-driven HAB risk.

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[a]Scottish Association for Marine Science, Scottish Marine Institute, Oban PA37 1QA, United Kingdom; [b]Marine Scotland Science, Marine Laboratory, Aberdeen AB11 9DB, United Kingdom; [c]Sir Alister Hardy Foundation for Ocean Science, Citadel Hill Marine Laboratory, Plymouth PL1 2PB, United Kingdom; and [d]NAFC Marine Centre, Scalloway, Shetland ZE1 0UN, United Kingdom

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[1]To whom correspondence should be addressed. Email: paul.dees@sams.ac.uk.

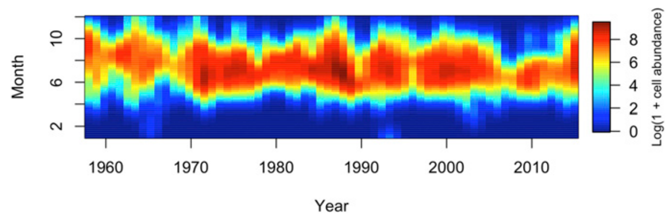

Fig. 1. **Heatmap of periods of large *Dinophysis* blooms in the modeled region by month and year.**

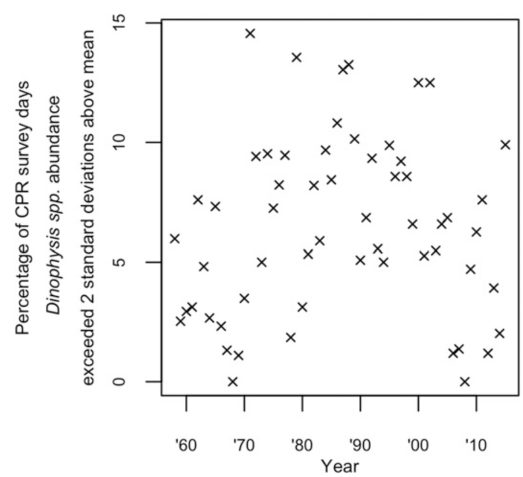

Fig. 2. **The percentage of days in each year that the abundance of *Dinophysis* spp., as detected by the CPR in the modeled region, was greater than two SD above the mean.**

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4 Rayner NA, et al. (2003) Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J Geophys Res Atmos* 108:4407.

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