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Published in:

Proceedings of the National Academy of Sciences of the United States of America

Publication date:

2017

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Citation for published version (APA):

Dees, P., Bresnan, E., Edwards, M., Johns, D., Mouat, B., Whyte, C., & Davidson, K. (2017). Harmful algal blooms in the Eastern North Atlantic Ocean. *Proceedings of the National Academy of Sciences of the United States of America*, 114(46), E9763-E9764. <https://doi.org/10.1073/pnas.1715499114>

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Harmful algal blooms in the Eastern North Atlantic Ocean

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Applying a mathematical model to the period 1982-2016, Gobler et al. (1) proposed 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 model predicted 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 UK. 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 modelled 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 modelled 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. Figure 1 shows that while there have been periods of large *Dinophysis* blooms in the region, these mostly occurred during the early 1970’s and the late 1980’s, and have been followed by a period of briefer

bloom events from the mid 2000's until 2014. In Figure 2, by calculating the percentage of days per year that *Dinophysis* abundance was greater than two standard deviations 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 (1) is valuable in demonstrating the potential for increasing water temperature to increase the associated HAB risk. However, our data indicate that the modelled 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 used empirical laboratory evidence of increasing *D. acuminata* growth rate with increasing temperature to parameterise 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.

References

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Figures

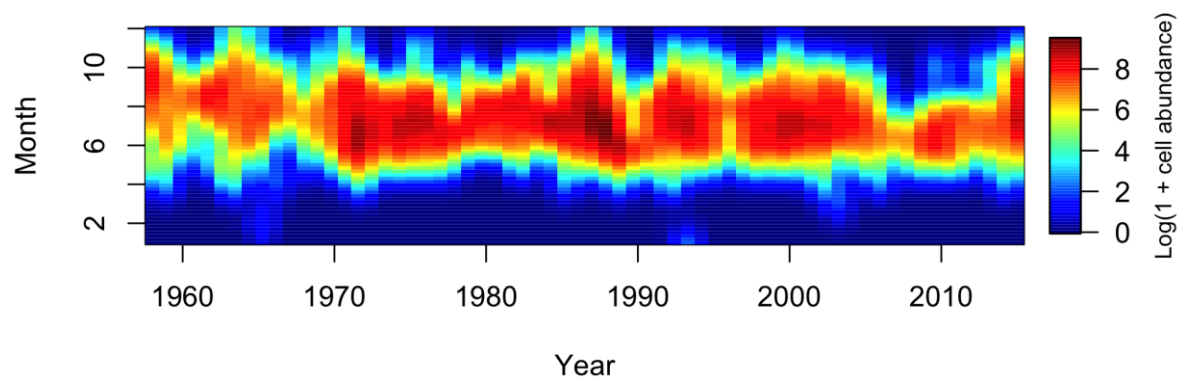


Figure 1 The $\log(x+1)$ transformed abundance of *Dinophysis spp.* as recorded by the CPR from an area limited by 49.125°N to 60.125°N; 0.125°E to 10.125°E (area defined by Gobler et al 2017). Abundance is measured per approximately 10 nautical miles of area surveyed by the CPR.

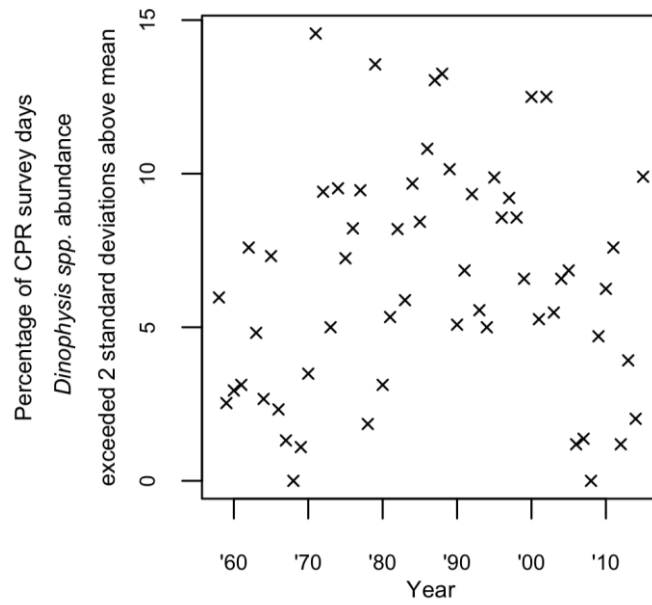


Figure 2 The percentage of days in each year that the abundance of *Dinophysis spp.* as detected by the CPR in the modelled region (1) was greater than two standard deviations above the mean of the abundance from 1958 until 2015.