A 100-year record of changing toxic algae in Scottish coastal waters relating to climate change

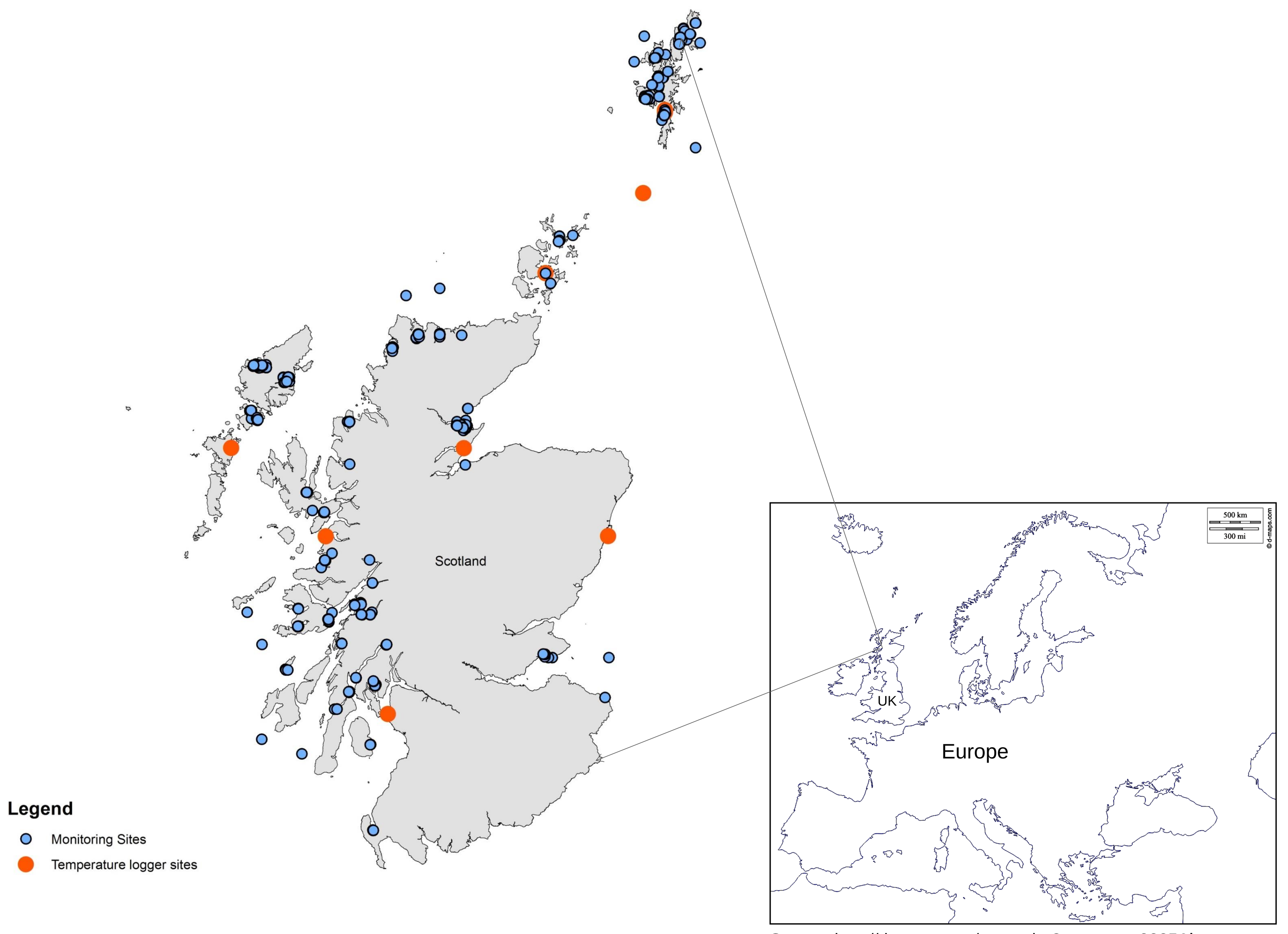
Cathy Winterton[1], William Austin[1,2], Eileen Bresnan[3] and Keith Davidson[1]

[1]Scottish Association for Marine Science, Oban, Scotland, [2]University of St Andrews, St Andrews, Scotland,
[3]Marine Scotland Science, Aberdeen, Scotland.

Background

Dinoflagellates are known to have responded to climate change. Data from the Continuous Plankton Recorder (CPR) show that regional distribution and abundance of some HAB genera have changed in the northeast Atlantic in the past 50 years. These changes correspond to increasing sea surface temperatures and windier summers, drivers that are associated with climate change (Edwards et al., 2006, Hinder et al., 2012).

In Scottish waters, the Group I strain in the *Alexandrium tamarense* species complex are potent producers of paralytic shellfish poisoning (PSP) toxins. The non toxin producing Group III strain (as defined by Lilly et al., 2007) —previously thought to be limited to the south coast of England— has recently been recorded around the Scottish coast (Collins et al., 2009, Brown et al., 2010).



Source: http://d-maps.com/carte.php?num_car=2225&lang=en

Figure 1| Understanding of HABs depends on monitoring. Outline of Scotland, including the western and northern isles, showing the location of inshore, coastal HAB monitoring sites (since 2006) and temperature loggers (since 2000). Monitoring sites data courtesy of SAMS phytoplankton monitoring programme for Food Standards Scotland (FSS) and temperature logger data from Marine Scotland Science.

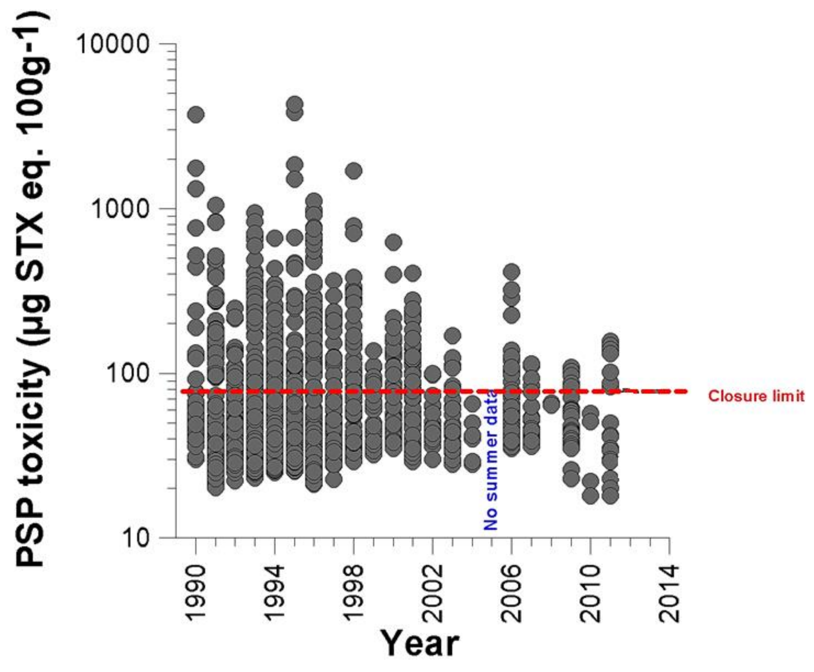


Figure 2| PSP concentrations in Scottish shellfish (1991-2013).

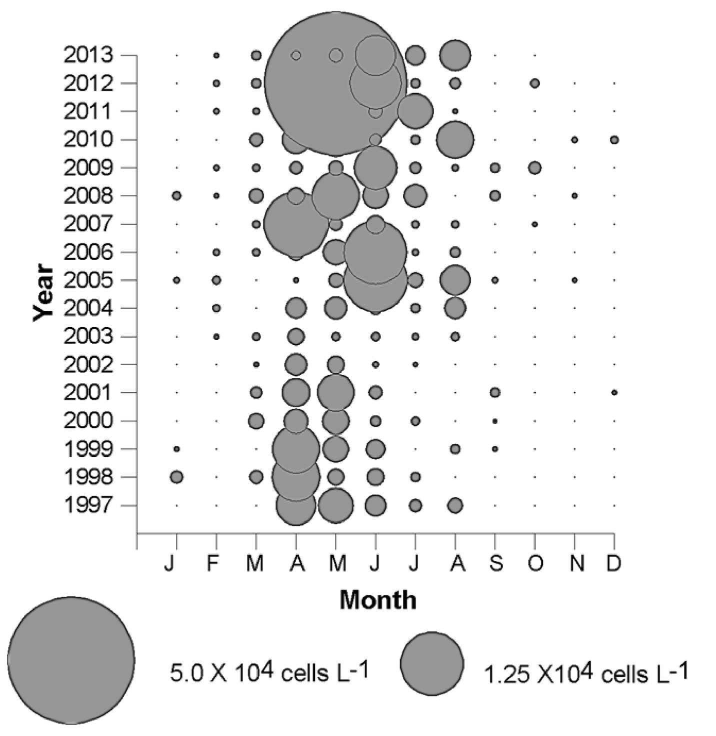


Figure 3| Monthly averaged *Alexandrium* cell counts from Stonehaven monitoring site (1996-2013).

Figures 2 & 3 are derived from coastal ecosystem monitoring programmes. **Figure 2** combines data from Marine Scotland Science (MSS) and Food Standards Scotland (FSS). **Figure 3** is based on MSS data. These plots show the changes in the toxicity of Scottish shellfish since monitoring began (fig. 2), alongside *Alexandrium* cell counts at MSS's Stonehaven monitoring site on the east coast of Scotland (fig.3). The cell counts show variability in the abundance and timing of *Alexandrium* blooms (source: Eileen Bresnan, MSS).

Around Scotland (Fig.1), routine monitoring of PSP toxins in shellfish began in 1991 (Fig.2), and of phytoplankton in 1996 (Fig.3). Since monitoring began, a marked decrease in the toxicity of Scottish shellfish has been seen (Bresnan et al., 2008). The reasons for this decline have yet to be identified.

These time series are too short to fully examine the changes in toxicity, abundance and diversity of *Alexandrium* in Scottish waters. A much longer time series is also needed to investigate the impacts of climate change further.

Currently, the Scottish Government is promoting the expansion of the shellfish industry to 13,000 tonnes, nearly double its current size, by 2020 but there is no mechanism to assess the vulnerability of new sites to the impacts of PSP or to assess how climate change may influence the abundance or diversity of *Alexandrium* in Scottish waters.

This PhD project is to address this knowledge gap.

This project

This project (2015-2019) aims to generate a multidecadal time series of the *Alexandrium tamarense* species complex by investigating the abundance and diversity of *Alexandrium* cysts (Fig.4) in the sediment record at specific areas around the Scottish coast. We will focus our investigation on sea lochs where marine aquaculture is concentrated because sea lochs offer a unique, often very expanded, sediment archive of the recent past (e.g. Cage & Austin, 2010).

Consequently, this project aims to:

i. Provide the first profile of *Alexandrium* cysts from sediment cores from Scottish sealochs.

   We will use a combination of multicores, longer gravity cores, and Craib cores (Fig.5) to extend the sediment record back over 100 years. Dating techniques, including ^{210}Pb, ^{137}Cs and ^{14}C, will be used to constrain the timing of changes in the sediment archive. These dated cores will provide an *Alexandrium* cyst profile over a multidecadal scale.

ii. Isolate *Alexandrium* cysts from the sediment and grow laboratory cultures.

   Alexandrium cultures will be identified to species/strain level using molecular techniques to identify if they are toxin or non toxin producing strains/species. A times series of the Group I/III strains of *Alexandrium tamarense* will be generated.

iii. Use Foraminiferal-based proxies of palaeoclimate (ie temperature) to reconstruct the long-term pattern of climate change.

   Cage & Austin (2010) suggest sub-decadal resolution can be obtained from these sea loch (fjord) sediment records. We will also use available instrumental climate and SST data series.

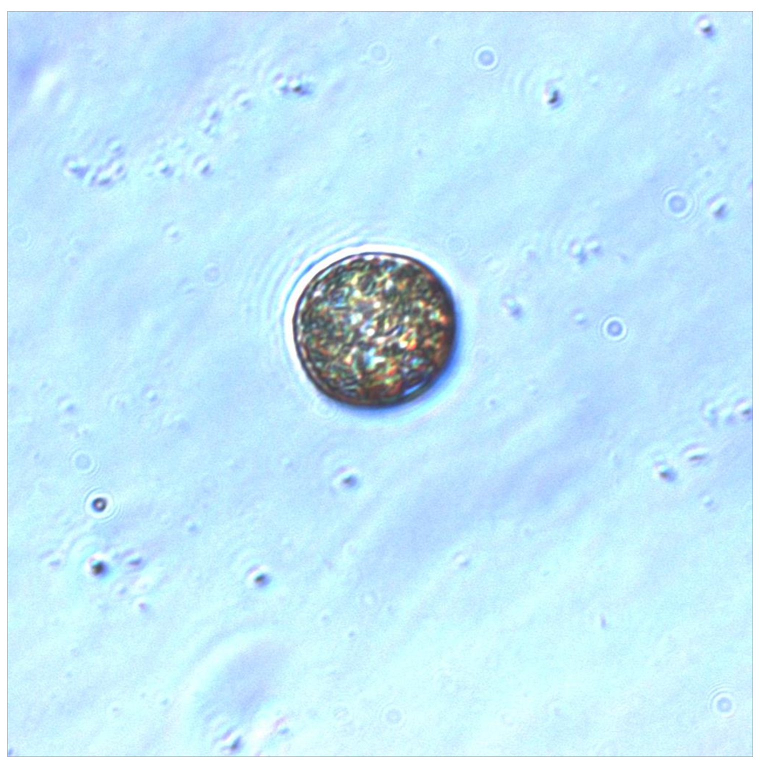


Figure 4| Alexandrium tamarense. (Source: CCAP. Courtesy of SAMS photo-library)

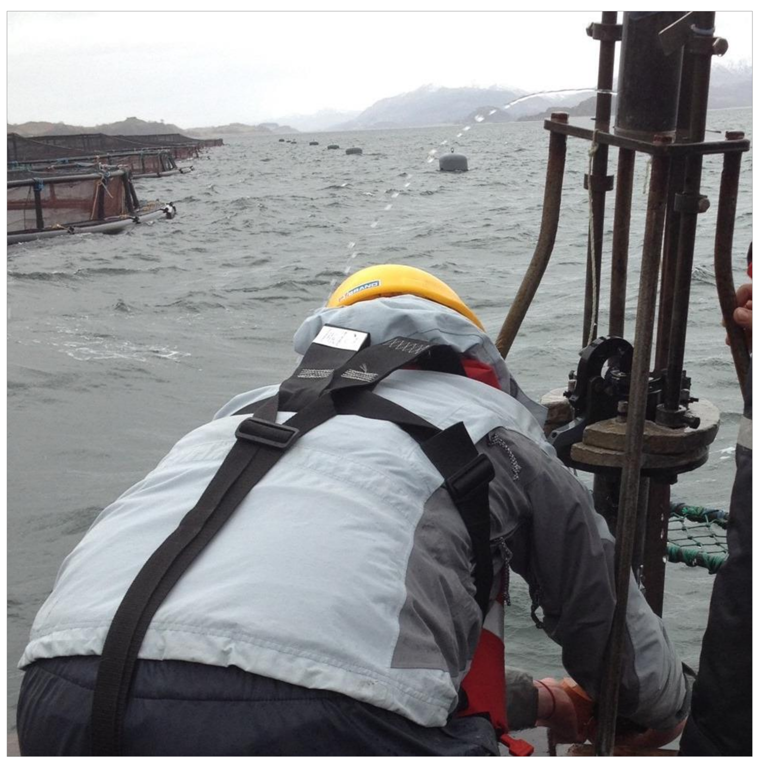


Figure 5| Sediment sampling with a Craib corer. PhD student Joanna Gosling collecting surface sediment samples from the Lynn of Lorn, February 2015 (Source: Cathy Winterton, SAMS)

In sum, this project will

- investigate the relationship between the diversity of *Alexandrium* cysts in the sediment profile and changing temperature,
- provide much needed data to investigate if climate change is driving the change in PSP toxicity in Scottish shellfish, and
- generate from the same sediment record a "co-registered" response in climate proxies and *Alexandrium* cysts.

References and acknowledgements

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SAMS, Scottish Marine Institute, Oban, Scotland PA37 1QA   www.sams.ac.uk   cathy.winterton@sams.ac.uk