Briefing note: Mitigation of climate change impacts on Scottish lochs and reservoirs

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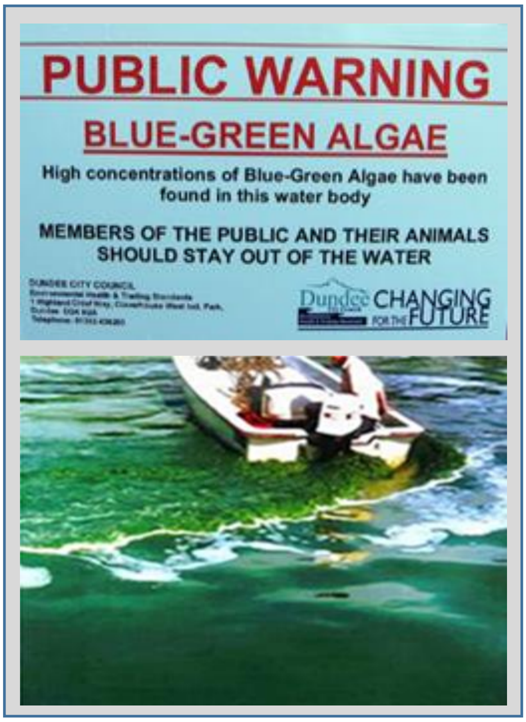
Background

Climate change is already affecting many lochs and reservoirs across Scotland by changing their water temperatures, hydrological regimes and nutrient budgets. These changes promote the development of algal blooms, which affect the sustainable use of these waterbodies for recreation, tourism and water supply, and reduce habitat value for biodiversity. Questions are now being asked about whether current loch and reservoir management practices, many of which have been in place for decades, are still fit for purpose under a changing climate and whether changes could be made to help mitigate climate change impacts in the future.



Links to policy

- EU Water Framework Directive
- EU Drinking Water Directive
- EU Habitats Directive
- Scottish Planning Policy
- Controlled activities regulations (CAR) licensing

Methods

By applying a scenario based modelling approach to data from Loch Leven, we have explored the potential for changes in discharge from the outflow to help reduce the likelihood of algal blooms in the loch. The flushing scenarios used in the study are summarised in Table 1, with the changes in outflow volume corresponding to 5%, 10% and 15% increases over the periods shown.

Table 1. Flushing scenarios tested

<table>
<tr><th>Outflow volume</th><th>Start dates</th><th>Duration (days)</th></tr>
<tr><td rowspan="2">x1.05</td><td rowspan="6">Day numbers 160, 170, 180, 190, 200</td><td>10</td></tr>
<tr><td>20</td></tr>
<tr><td rowspan="2">x1.1</td><td>10</td></tr>
<tr><td>20</td></tr>
<tr><td rowspan="2">x1.15</td><td>10</td></tr>
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Results

An example of the potential impact that a small increase in discharge from the outflow could have on in-loch algal biomass (chlorophyll*a* concentration) is shown in Figure 1. Increasing the outflow volume by about 5% for 10 days, starting at days 160 and 170, reduced the size of the bloom later in the year by up to 37%, while starting on days 180, 190 and 200 did not. In the baseline (control) data, the peak in the algal bloom occurred on day 233.

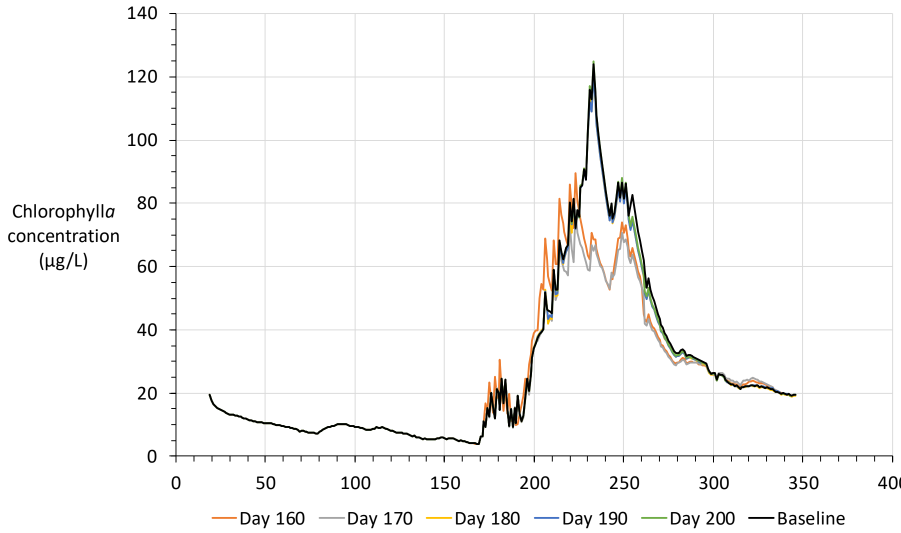

Figure 1. The effect on chlorophylla concentration of a 5% increase in discharge from the outflow for 10 days from the start dates shown

Peak chlorophyll*a* concentrations appeared to be very sensitive to relatively small changes in flushing regime (Table 2). While some scenarios had little effect on the size of the bloom, several reduced it by up to 39%. However, one scenario increased the size of the bloom by 17%, highlighting the importance of selecting the right management scenario to achieve the required outcome.

Table 2. Magnitude and direction of change of maximum chlorophylla concentrations under different flushing scenarios

		Flushing scenario					
		x1.05 & 10 days	x1.05 & 20 days	x1.1 & 10 days	x1.1 & 20 days	x1.15 & 10 days	x1.15 & 20 days
Start date	Baseline	0%	0%	0%	0%	0%	0%
	Day 160	-28%	-31%	+9%	+1%	-24%	+17%
	Day 170	-37%	-36%	-26%	-34%	-28%	+4%
	Day 180	-2%	-37%	-39%	-36%	-36%	-2%
	Day 190	-2%	-2%	-37%	-39%	-39%	-37%
	Day 200	+1%	-2%	-3%	-1%	-1%	0%

The small changes in outflow volume that occurred under each scenario had little effect on loch water levels.

Discussion

The results suggest that small, strategically timed, increases in flushing rates may be able to reduce the size of algal blooms by almost 40%. Increasing flushing rates by increasing inflow volumes is, however, difficult to achieve because of the extra water required. In contrast, reducing water retention times by increasing outflow volumes for short periods would be relatively straightforward to achieve in systems that are regulated by dams, sluice gates or abstraction points. Although decisions on how to implement such changes would need to take a wide range of factors into account, such as impacts on water levels and downstream environmental flows, our initial results suggest that this approach warrants further investigation.

Acknowledgement

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