Remediation project at Loch Flemington:
A shallow loch in deep trouble?

Sebastian Meis (CEH); Bryan Spears (CEH); Stephen Maberly (CEH); Rupert Perkins (University of Cardiff). Contact: sebisa@ceh.ac.uk

Background

Loch Flemington is a shallow loch (<3m average depth) situated within the Kildrummie Kames Site of Special Scientific Interest (SSSI) near Inverness (Scotland). The loch hosts three European Protected Species; (1) Slavonian Grebe (*Podiceps auritus*); (2) the rare aquatic plant Slender naiad (*Najas flexilis*) (3) and the Great Crested Newt (*Triturus cristatus*). In recent years the loch has become increasingly eutrophic. Currently, the ecology of the loch is threatened by two factors: i) internal loading of phosphorus and associated algal blooms and ii) invasive aquatic plant species. We outline the process of designing and conducting a whole lake remediation project in a site with multiple pressures.

Internal loading

Loch Flemington has experienced high external nutrient loading, leading to a build up of nutrients, especially phosphorus (P), in the sediments. Despite improvements in the management of the catchment the lack of a surface outflow prevented P being flushed out of the system. Consequently, P is being cycled between the water column and the sediment. P release from the sediment, termed internal loading, occurs mainly during summer/autumn (Fig. 1) and the magnitude of sediment P release has not decreased significantly over the last decade (Fig. 1, inset).

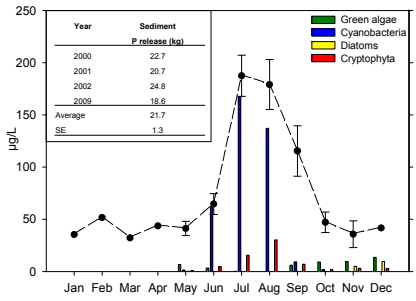

Figure 1 Monthly mean total P concentrations* (●) and phyto-plankton community composition in 2009**. Inset: P released from sediment***. (*, calculated as average of 2000-02 & 2009; n=1-4; error bars=standard error; **, measured with BBE fluoroprobe; *** based on differences min/max total P concentrations and loch volume of May *et al*., 2001)

Figure 2 Water colour in spring (left) and summer (right) 2009. Inset photos show accumulation of algal scum in sheltered areas around the edges of the loch. In 2009 Secchi depth as a measure of water clarity decreased from 1.8m in May to 0.3 m in July coinciding with the highest algal biomass.

Threats to ecosystem

Algal blooms

Sediment P release fuels the growth of phytoplankton, causing algal blooms during summer months (Fig. 2). The release of P from the sediments in late summer generally coincides with low nitrogen (N) concentrations. This can favour the growth of cyanobacteria, which were dominating the phytoplankton community in summer 2009 (Fig. 1, bar charts).

Invasive species

New Zealand pygmyweed (*Crassula helmsii*) was first observed in August 2009 (Fig. 3). *Crassula helmsii* can form very dense stands, which can outcompete other aquatic plants, causing loss of habitat heterogeneity & species diversity.

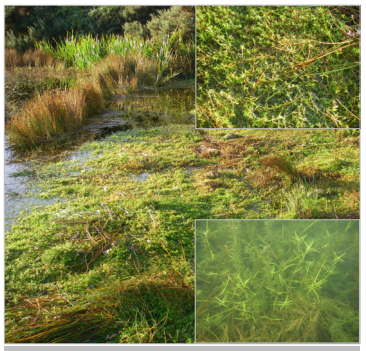

Figure 3 *Crassula helmsii* was first observed in semi-aquatic patches along the water line. Submerged stands were also found later in the growing season (inset bottom right).

Remediation options

Internal loading & algal blooms

The general decision support process for controlling internal loading is shown (Fig. 4). A successful reduction in sediment P release will lead to a reduction in algal biomass (given external nutrient sources are insignificant) .

Invasive species *Crassula helmsii*

According to the literature chemical control seems the only available option for larger patches as *Crassula helmsii* can grow from fragments formed during mechanical clearing. Smaller patches can potentially be controlled by shading (2-6 months) which is currently being trialled.

Time frames and key milestones in remediation project

The timelines for the project are shown (Fig 5). In order to reduce internal P loading in Loch Flemington a lanthanum modified clay (Phoslock®) was applied in March 2010 (Fig. 6). Monthly post-application monitoring to assess effects on site attributes will continue for at least a year to evaluate the success of the treatment. Trials investigating methods of controlling invasive macrophytes (i.e. shading and clear cutting) are ongoing.

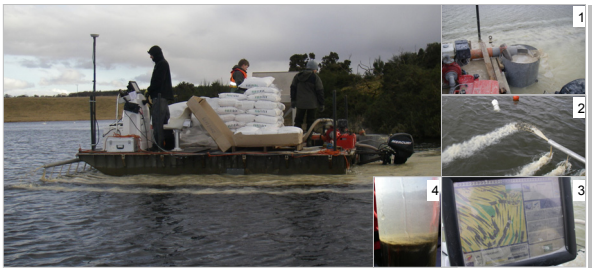

Figure 6 Phoslock® was applied as a slurry (inset 1 & 2) from a GPS guided (inset 3) pontoon. One day after the application signs of Phoslock® were visible in the sediment (inset 4).

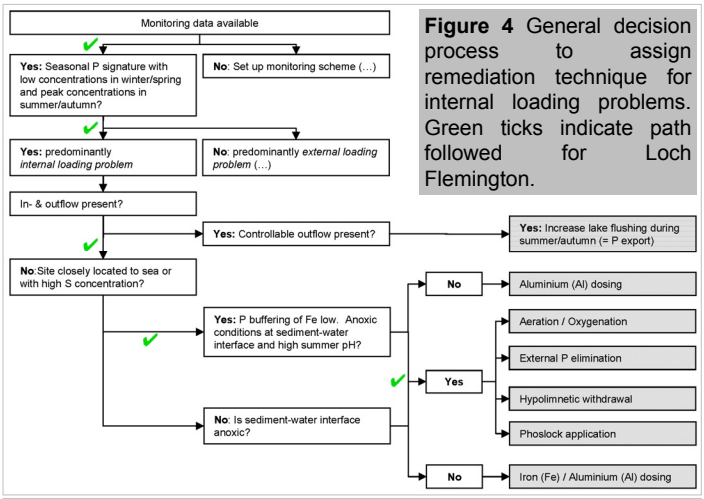

Figure 4 General decision process to assign remediation technique for internal loading problems. Green ticks indicate path followed for Loch Flemington.

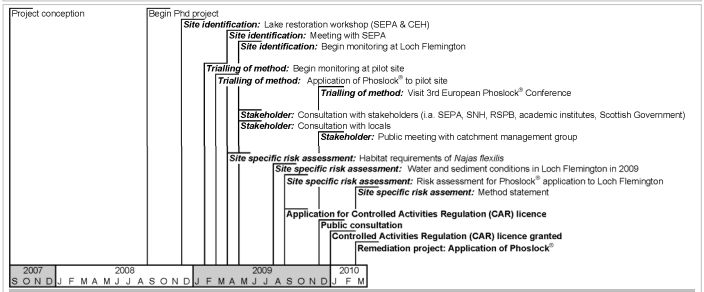

Figure 5 Chronological overview about remediation project in Loch Flemington.

Acknowledgements: We would like to acknowledge Ian Milne & Andrew Steel (SEPA), Ben Leyshon & Tim Dawson (SNH), Dr. Linda May (CEH) and Alastair Noble for their help and constructive comments on this project. We are also indebted to Mike O'Malley for his hard work and good humour in the field. Furthermore we wish to thank Nigel Trail (Phoslock ® Europe), Nicolai Nowak (Institute Dr Nowak) and their team for conducting the application.

References: May, L., Gunn, I. & A. Kiriika (2001) Phosphorus study at Loch Flemington. CEH.

For further information please see:
http://www.ceh.ac.uk/sci_programmes/water/LochFlemington.html

Integrated science for our changing world
www.ceh.ac.uk