Chapter (non-refereed)

Bindloss, M.E.. 1977 Productivity of phytoplankton in Loch Leven, Kinross. In: *Annual report of the Institute of Terrestrial Ecology 1976.* NERC/ITE, 45-46

In *H. splendens*, old segments on each shoot are continuously drying at ground level, but the production of new segments at the surface of the moss carpet results in an indefinite life span for each whole shoot. However, as new segments are only produced from one-year-old segments, any damage to the youngest segments will result in the eventual death of the whole shoot. In addition, sexual reproduction is rare, with archegonia aborting during most seasons. *H. splendens* is, therefore, extremely sensitive to damage by trampling or grazing, and, once damaged, the regeneration of a carpet will be extremely slow.

By way of contrast, the above-ground shoots of *P. commune* show finite life expectancies (about six years maximum). In this species, damage to an above-ground shoot is not particularly serious because the underground system would not be greatly affected and would continue to reproduce vegetatively, giving rise to new above-ground shoots. Moreover, sexual reproduction in *P. commune* is regularly successful so that the species can invade newly or continuously disturbed areas where its growth strategy will enable it to survive.

In summary, *H. splendens* may be said to show a conservative growth strategy, whereas, in *P. commune*, the strategy is opportunistic. It is not surprising, therefore, that *H. splendens* occurs most commonly in habitats where disturbance is minimal and where shading and the production of a closed carpet can prevent desiccation. In these habitats, its continuous apical growth allows it to compete favourably with other species. On the other hand, *P. commune* is better able to withstand environmental fluctuations, but it is susceptible to competition from other species: another reason why it is often found on exposed and disturbed ground. The unreliable production of spores by *H. splendens* and the need for conservation of water between tightly packed shoots results in the production of extensive carpets of this moss, the extent of these carpets being rather paradoxical in view of the restricted vegetative reproductive capacity. In contrast, the branching underground system of *P. commune*, and its successful spore production, leads to numerous small colonies, often with widely scattered individual shoots.

T.V. Callaghan and N.J. Collins

References

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Freshwater habitats

PRODUCTIVITY OF PHYTOPLANKTON IN LOCH LEVEN, KINROSS

One of the commonest methods of determining gross rates of phytoplankton productivity involves calculating rates of photosynthesis from changes in amounts of dissolved oxygen in water samples before and after being incubated in clear and blackened bottles held at different depths within a loch. Oxygen changes are attributable to both photosynthesis and respiration in clear bottles, whereas, in dark bottles, only respiration is operative. In practice, however, interpretation of the data is vitiated by an imprecise knowledge of how much photosynthate is respirated by the algae themselves, and how much remains as net production to appear as algal biomass.

In the past, estimates of net production have often been made assuming that (a) oxygen uptake in the dark bottle is primarily attributable to algal respiration, with a negligible contribution from bacteria and zooplankton, and (b) rates of dark respiration are independent of light history and hence are unaffected by diurnal changes in incident light or by the vertical gradient of irradiance in the water column. But, like that from elsewhere, evidence accumulated during the IBP study on Loch Leven suggests that these assumptions are not universally valid. To determine more precisely the nature of varying rates of respiration, influenced by depth and diurnal factors, attempts have been made to partition respiration related to the phyto- and zooplankton entities within Loch Leven. At the start, larger crustacean zooplankton were removed using a '60 mesh' (200μ aperture) nylon net. Attempts were then made to estimate bacterial O_2 uptake after removing algae by filtering loch water through GF/C glass fibre filters. Preliminary results suggest that a variable proportion (10–35%) of total O_2 uptake was attributable to non-algal oxidation of dissolved organic material, but more observations are required for an accurate seasonal assessment (Table 4).

Table 4 'Bacterial respiration' in water from Loch Leven after removing algae by filtration

Date	Water temperature (°C)	Respiratory Rates (O_2 uptake ($\mu g\ l^{-1}\ h^{-1}$))		B as % of A
		Unfiltered water (Bacteria and algae) (A)	Filtered water (Bacteria) (B)	
6.4.76	5	6·9	0·7	10
6.7.76	20	40·7	13·1	32
13.7.76	19	55·1	19·3	35
20.7.76	18	34·5	10·7	31
3.8.76	15	23·5	4·1	17

Weekly laboratory measurements are being made of rates of (a) O_2 uptake and (b) the carbohydrate content of water samples taken from different depths in Loch Leven, these data being related to chlorophyll *a* contents which are regarded as estimates of algal populations. Rates of O_2 uptake were greater in surface samples than in samples at a depth even though temperature and algal concentrations were virtually uniform throughout the whole water 'column', there usually being a difference of 10–30%, although the difference sometimes exceeded 80%. Differences in amounts of O_2 uptake were generally correlated with differences in carbohydrate content which may therefore be used as an index of respiratory rate. If this relation were substantiated, it would facilitate a more detailed description of spatial variation in respiratory rates.

M.E. Bindloss

ECOLOGICAL EFFECTS OF AQUATIC HERBICIDES ON FRESHWATER ECOSYSTEMS

Most freshwater ecosystems are subject to some form of periodic management, and the plant and animal communities present are a response to a particular management régime. Any modification of an established management practice can be expected to produce a corresponding change in the structure and function of these communities. For example, an increase in the frequency of dredging or the adoption of block weed clearance routines may affect the rate and pattern of recolonisation by macrophytes and their associated fauna.

The ecological effects of traditional methods of weed control are not fully understood, but are to some extent predictable; the short-term effects are severe, but recovery of the system is generally rapid, particularly if recolonisation from adjacent watercourses is possible. Aquatic herbicides cannot be assumed to produce only those sorts of effect that result from other forms of management. There may also be additional problems associated with persistence, selectivity and possible direct toxic and indirect effects of the chemical on non-target organisms, all of which may fundamentally alter the characteristics of the ecosystem. The current research programme funded by the Nature Conservancy Council was developed primarily to examine the long-term ecological effects of specific herbicides, with some attempt to relate these effects to those resulting from other forms of management.

Field experiments with cyanatryn were carried out on a local dyke system whose management history was known. One section was treated in March, but required a further application in May. A second section was divided by means of a polythene barrier and cyanatryn was applied to one-half early in May, the area upstream of the barrier being left untreated. Regular monitoring of a range of physical/chemical parameters, including dissolved oxygen and herbicide residues, was continued throughout the summer. The aquatic vegetation was mapped each month to follow changes in percentage cover following herbicide treatment and a range of aquatic organisms, including bacteria, phytoplankton, periphyton and invertebrates, were sampled at regular intervals. Preliminary observations indicate some unexpected results.

First, release of the herbicide was extremely slow, so that maximum concentrations in the water were not achieved until five or six months after treatment, instead of the two to three weeks predicted. All submerged weeds were completely eradicated but, because of the slow release, eradication was not attained until some twelve weeks after treatment.

Second, the polythene barrier did not prevent movement of the herbicide into the untreated area and almost all the submerged macrophytes were again eliminated, although some species present in the area furthest away from the barrier showed early signs of recovery. This effect may be of some relevance to the management of freshwater ecosystems where total eradication of vegetation is not desirable. It may be possible to adjust the dose so that such unwanted species as the filamentous algae are removed, while only temporarily suppressing the growth of other susceptible species.

Third, it is becoming clear that certain groups of organisms, particularly some of the Mollusca and the Hemiptera, have suffered drastic reductions in numbers following herbicide treatment and loss of aquatic macrophytes. Although the untreated section proved to be of limited value as a control because of the effects of herbicide seepage, a further section upstream of the untreated area remained totally unaffected and thus provided a useful measure of comparison. There is little doubt that some groups have suffered, but whether this is due simply to the loss of a favourable habitat or to some direct or indirect effect of the herbicide is not yet clear. Laboratory experiments may help to determine whether the prolonged exposure to sub-acute concentrations of the herbicide experienced during the experiment may have contributed to the observed declines.

Recovery of the experimental sites is already well-established, but, as yet, only in those areas which inadvertently received very low doses of the herbicide. The pattern of recolonisation by plants and animals in