

The Assessment of Restoration Needs in Scottish Lochs Suffering From Nutrient Enrichment – Approach of SNH





Classification of standing water habitat types under the Habitats Directive

1. Natural dystrophic lakes and ponds;
2. Oligotrophic waters containing very few minerals of sandy plains: *Littorelletalia uniflorae* (shoreweeds);
3. Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea* (quillworts);
4. Natural eutrophic lakes with *Magnopotamion* (pondweeds) or *Hydrocharition*-type (duckweeds) vegetation;
5. Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. (stoneworts).

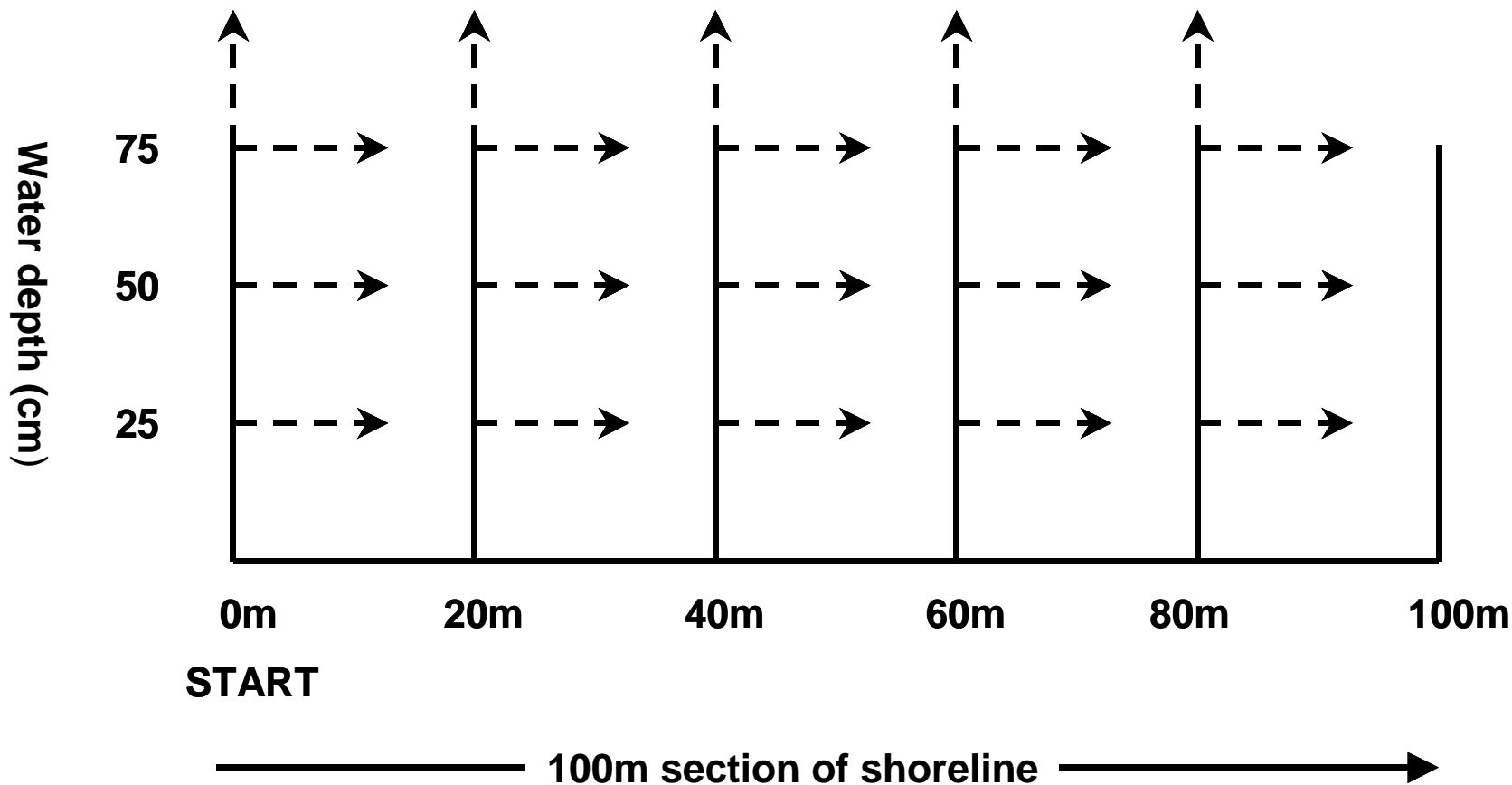
Lake attributes considered in condition assessment

- Extent
- Macrophyte community composition
- Macrophyte community structure
- Water quality
- Hydrology
- Substrate
- Sediment load
- Local distinctiveness

Condition Categories

- Favourable maintained
- Favourable recovered
- Unfavourable recovering
- Unfavourable no change
- Unfavourable declining
- Partially destroyed
- Destroyed

Macrophyte monitoring methods designed by the Centre for Ecology and Hydrology and a consortium of other workers
(Gunn *et al.*, 2004)



Example of targets – mesotrophic lochs

- Presence of at least three of the characteristic *Potamogeton* species for mesotrophic waters
- Presence of at least eight characteristic species (unless there are valid reasons for absence of particular species)
- No loss of characteristic species recorded from the site
- Presence of characteristic species in at least 60% of sampling spots (boat and wader survey combined)
- No significant loss of frequency of occurrence of characteristic species at sampling spots, between surveys (boat and wader surveys combined)

Other Targets– applicable to all
habitat types

Macrophyte Community Composition - Negative Indicators

- Absence of invasive non-native plant species *Crassula helmsii*, *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum* and *Azolla filiculoides*
- Presence of less-invasive, non-native plant species at less than 25% frequency of occurrence. Examples include *Elodea nuttallii* and *Elodea canadensis*.
- Cover values of 3 for filamentous algae in less than 20% of sample points.

Macrophyte Community Structure

- Presence of characteristic zones of vegetation
- Maintain the maximum depth distribution
- Maintain at least the baseline structure

Local distinctiveness

- Maintain distinctive elements (*e.g.* rare plant or invertebrate species, notable habitat properties) at current extent/levels and/or in current locations

Water quality

The 2 most commonly used targets are as follows:

- Stable nutrient levels appropriate for lake type
- No excessive growth of cyanobacteria or green algae

Table 1. Total phosphorus targets for designated lakes (SAC, SSSI/ASSI, Ramsar)

Lake habitat feature type	Depth Category*	Upper limit of TP extent** (µg P l⁻¹)		Approximate match in WFD typology
Dystrophic***	Deep	10	na	Peat
	Shallow	10	na	
Oligotrophic	Deep	10	na	Low Alkalinity
	Shallow	10	na	
Mesotrophic	Deep	15	na	Medium Alkalinity
	Shallow	20	na	
Hard water	Deep	20	na	Marl
	Shallow	35	20-50	
Eutrophic	Deep	35	na	High Alkalinity
	Shallow	50	35-100	
Brackish	Deep	35	na	Brackish
	Shallow	35	na	

na - not applicable

* Shallow 3m or less/ Deep: >3m

**These values reflect the fact that in certain circumstances, lakes may continue to support a diverse macrophyte community, despite high TP levels, but in Scotland, it is unlikely that a target would be set within the range 50 to 100 µg P l⁻¹.

***An upper limit of 10 µg P l⁻¹ is given as the default value. However, it is understood that in humic lochs, TP levels may be higher than expected in oligotrophic waters, so site-specific targets should reflect this if necessary.

Vascular plant features

- Slender naiad presence/absence, population size/extent, regeneration

Results of first round of SCM in 2004

Designation	Favourable	Unfavourable	Unfavourable recovering
SACs	50	5	1
SSSIs	95	42	4
Ramsar	6	4	1
All	151	51	6

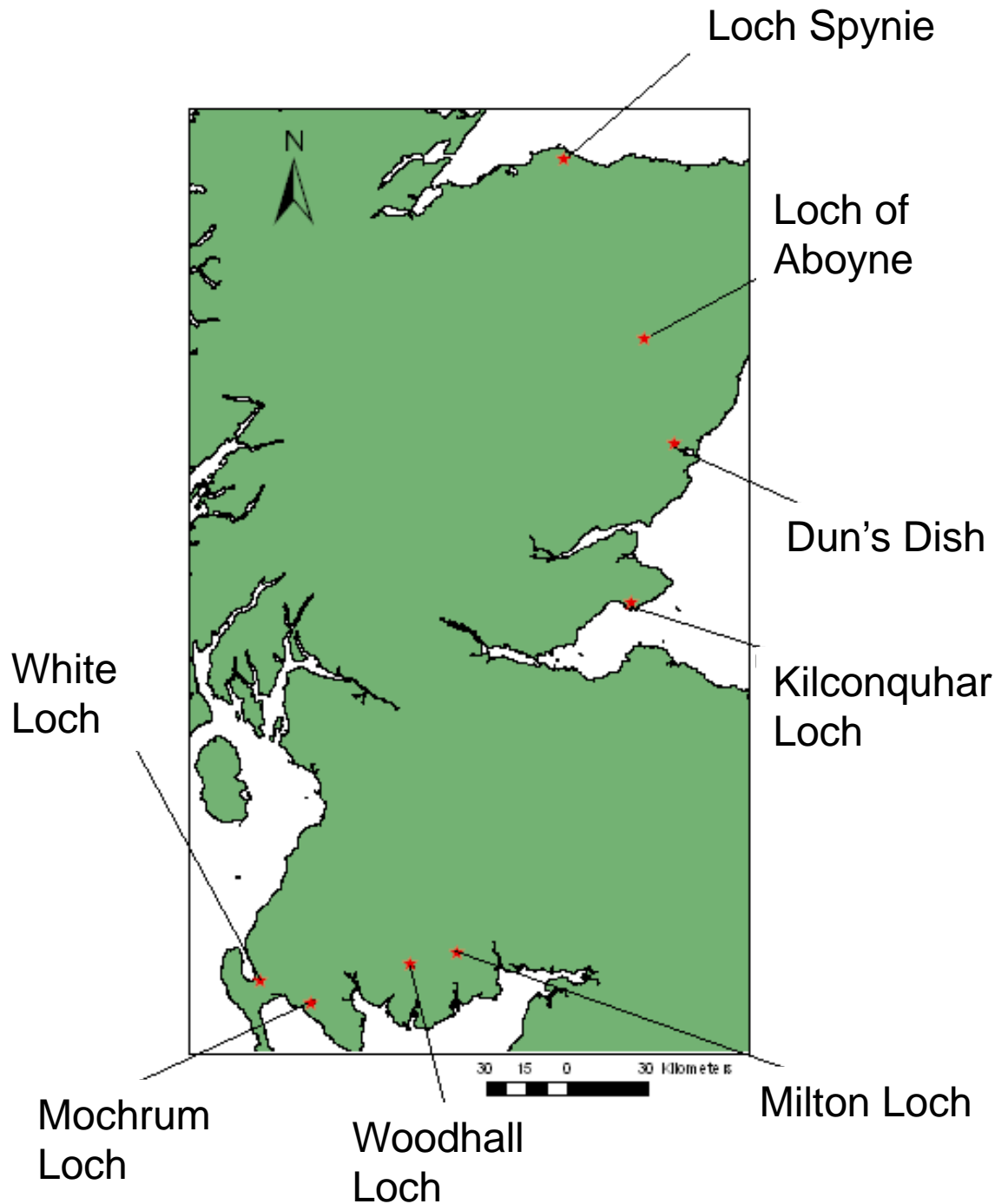
Unfavourable declining

- Argyll and Stirling: Mugdock Wood, Tangy Loch;
- Dumfries and Galloway: **Mochrum Lochs**;
- Grampian: Corby, Lily and Bishop's Lochs, **Loch of Aboyne**, **Loch Spynie**, Loch of Strathbeg;
- Forth and Borders: Balerno Common, Ballo and Harperleas Reservoirs, Camilla Loch, Cullaloe Reservoir, Carriston Reservoir, Duddingston Loch, Faldonside Loch, **Kilconquhar Loch**, Linlithgow Loch, Lochmill Loch;
- Strathclyde and Ayrshire: Castle Semple Barr Lochs, Loch Doon, Loch Libo;
- Tayside and Clackmannanshire: **Dun's Dish**, Lochs Clunie and Marlee, Round Loch of Lundie;
- Western Isles: Bornish and Ormiclate Machairs, South Uist Machair

Unfavourable no change

- Argyll and Stirling: Loch Fada, Taynish and Knapdale Woods;
- Dumfries and Galloway: Lochmaben Lochs, **Milton Loch**, **White Loch** Lochinch, **Woodhall Loch**;
- East Highland: Kildrummie Kames, Loch Eye;
- Forth and Borders: Black Loch Abdie, Lindores Loch, Yetholm Loch;
- Northern Isles: Lochs of Harray and Stenness, Lochs of Tingwall and Asta;
- Strathclyde and Ayrshire: Martnaham Loch and Wood;
- Tayside and Clackmannanshire: Loch of Kinnordy, Loch of Lintrathen, Rescobie and Balgavies Lochs;
- Western Isles: Balranald Bog and Loch nam Feithean, North Harris, North Uist Machair

The Eight Target Lochs



Target loch sites – reasons for inclusion

- They are SSSIs designated for loch features
- SCM revealed them to be in unfavourable condition
- Enrichment due to diffuse pollution or unknown reasons
- They have all had low water quality and algal blooms
- There are no current measures in place (except Mochrum)

The lochs

Loch	Trophic status	Size (ha)	Altitude (m)	Catchment area (ha)	Catchment character (interpreted from Google Earth aerial photography, and onsite observation)
Mochrum Loch	Oligotrophic	91	75	529.5	Some forest plantation including several different ages and some recently felled; few dwellings; large areas of rough, unimproved grassland and heathland; low intensity sheep grazing.
Milton Loch	Mesotrophic	58.1	128	369.5	Improved pasture; lush fields for cattle grazing; few dwellings
White (Loch Inch)	Eutrophic	58.2	18	231.5	Managed estate; improved parkland and deciduous/mixed mature woodland; small catchment; several buildings
Woodhall Loch	Oligotrophic	65.4	54	2642.25	Plantation with large felled areas; some rough, some improved pasture; few dwellings
Kilconquhar Loch	Eutrophic	37.2	17	126.75	Improved agricultural land with ploughed fields; mature woodland and wet woodland; village on north shore and scattered farm buildings
Loch of Aboyne	Mesotrophic	12.2	136	223	Forest plantation with felled areas; some agricultural and some unimproved land; several dwellings; small catchment
Loch Spynie	Eutrophic	25.4	3	5472.25	Forest plantation; wetland and wet woodland; extensive reedbeds; very large catchment; intensive agriculture; Loch Spynie Canal cutting off catchment to the north
Dun's Dish	Eutrophic	16.1	75	244.5	Woodland and wet woodland; reedbeds; tilled land with ploughed fields; improved grassland; farmyard; few other dwellings

Eutrophication – diffuse!

- Sources
- Amounts depend on

Our Approach



- 1) Nutrient budget of loch. A budget of P inputs will derived from the following sources:
 - a. The P loading required to give the monitored loch P which can be done using a Vollenweider loch P model;
 - b. The seasonality of P concentrations in the loch will be used to estimate the extent of which the internal P loading is contributing to the current P concentration in each loch. This is considered an important objective as it will help in assessing the extent to which the current trophic status of each loch reflects current as opposed to historic P, loads to the loch.

- 1) A break down of P sources to each loch. As set out below, this will require the integration of all sources of information and data compiled throughout the project:
 - a. Loadings based on the nutrient export coefficients using land use coverage in each loch catchment. How these land use types are spatially located within the loch catchment will be determined in order to quantify how they contribute to specific inflows to each loch;
 - b. This land cover based budget data will be supplemented by estimates of P loads from other sources within the catchment. These could include septic tanks, farm yards, wintering bird populations and forest management activities. These will be primarily desk based estimates;
 - a. The budgets outputs from *a* and *b* will be informed by the tentative P loadings based on monitoring results from the inflows to each loch. In particular this monitoring will assist in the definition of inflows draining areas with unusually high P losses.

- 1) As has been discussed previously source definition is difficult and in many cases relies on circumstantial evidence as opposed to the direct observation of P loss sources and events. In this regard the monitoring of nutrients other than Total P can be used in source definition:
 - a. The seasonality of P in both the loch and inflows will be used to determine how seasonal inputs are influencing the overall trophic status of each loch. Some agricultural sources exhibit a distinct seasonality in their P loss profile so that information on seasonality can be of use in source definition;
 - b. High levels of particulate P (measured as the difference between total and total soluble P) indicates erosional losses of P that are characteristic of arable agriculture and the exposure of bare soil through cultivation;
 - c. High levels of ammonium point to organic pollution from septic tanks or manures. If present in field losses to water, high ammonium suggests a rapid loss of P following manure applications. In these instances high ammonium is generally accompanied by high concentrations of SRP;
 - d. A high proportion of SRP in runoff is characteristic of P losses from fertilised grassland with high levels of soil P. These often show a marked seasonality with highest concentrations in runoff that occur in summer and autumn.

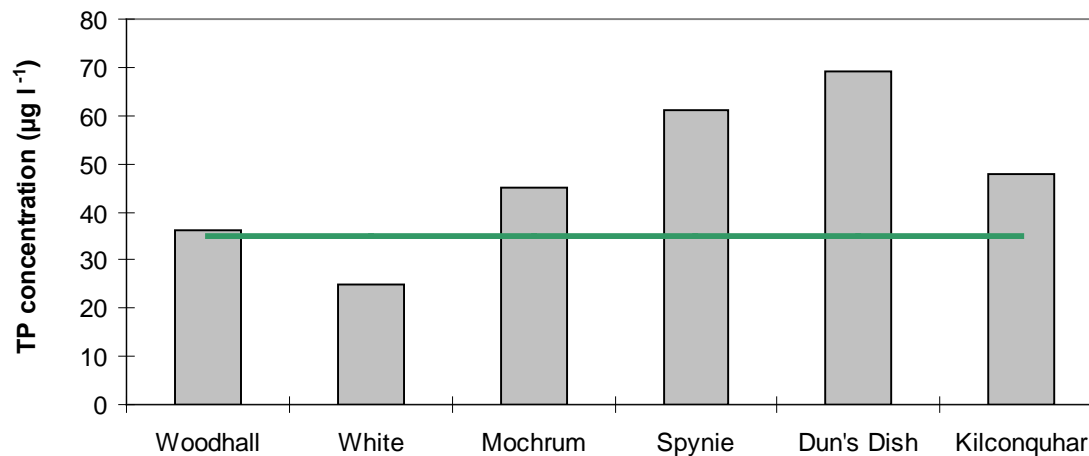
What we have found so far



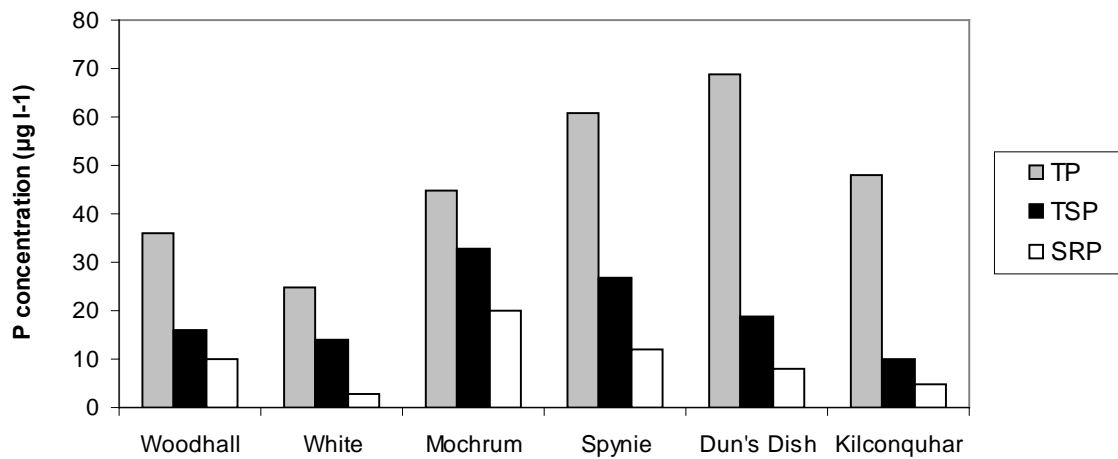




Total phosphorus - February 2010



All P fractions - February 2010



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Loch uses

- Farming – arable, sheep, cattle, pig, hard standings
- Waterski club
- Golf course
- Estate owners/managers
- Forestry
- Ramsar/SPA bird life
- Urban

Catchment investigations

- Golf courses, abstractions, fertilizers
- Deep lochs with small catchments and no discernable inflows
- Conifer plantation, sheep grazing, parkland, caravan park
- Non-functioning septic tanks – inflowing field drains with TP in excess of 700 ug l⁻¹
- Major inflows diverted out of catchment
- Water levels so low due to abstraction that the outflow flows only 9 months of the year

Recommendations

- Catchment and in loch
- Very restricted by use of lochs, water or land use
- Stakeholders issues will be paramount
- Management of diffuse
- Very clear aims of improvement measures

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