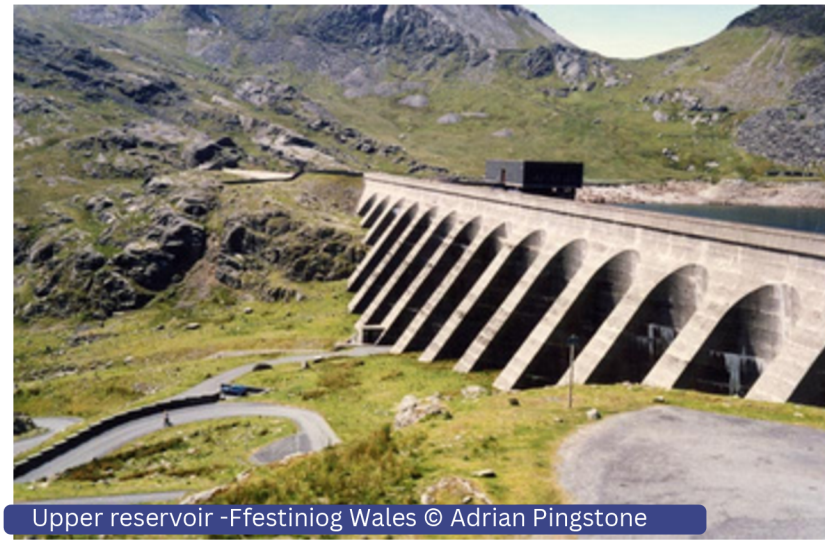
Pumped Storage Hydro

Planning Note

Pumped Storage Hydro (PSH) schemes provide a renewable and reliable source of energy and therefore have an important role to play in the transition from fossil fuels. However, these developments can have substantial environmental impacts, including reducing invertebrate habitat, diversity and abundance. Schemes are often sited in areas with sensitive habitats and rare species, making it vital that thorough impact assessments are undertaken to determine appropriate locations, develop robust mitigation measures and minimise impacts to biodiversity.



Upper reservoir -Ffestiniog Wales © Adrian Pingstone

What is Pumped Storage Hydro?

Pumped Storage Hydro is a type of hydroelectric energy generation and storage. During times of low energy demand, electricity is used to pump water from a lower reservoir to an upper reservoir. At times of high demand, water is released back to the lower reservoir through turbines to generate power.

Threats to invertebrates

As with many developments, PSH schemes can have detrimental impacts on invertebrates in multiple ways including pollution, reduced water quality, introduction of Artificial Lighting At Night (ALAN) and the spread or introduction of Invasive Non-Native Species (INNS). This briefing note considers four further impacts in more detail.

Habitat loss and fragmentation

PSH schemes need two large reservoirs for operation which often requires large areas of habitat to be flooded to create the upper reservoir. Impoundment of the lower water body may also be necessary. Development of associated infrastructure results in additional habitat loss and fragmentation, impacting both terrestrial and aquatic invertebrate communities.

Direct loss of Priority Habitats is a common impact from PSH proposals, including types of woodland, grassland and upland habitats considered of principal importance for conservation. In Scotland, schemes can impact large areas of internationally important peatland habitats. These habitats have the potential to support important invertebrate assemblages and species of conservation concern.

Many terrestrial invertebrate species are associated with very localised and specific habitats, features or combinations, that are not detectable from broad habitat assessments. Furthermore, species may be unable to disperse to surrounding habitats or may not have the opportunity to do so due to disturbance and mortality during construction. Without targeted assessment, a key area or resource for a rare or restricted species could be lost.

Impoundment of a water body floods the littoral zone (the sloping shelf where the water meets the land), often the most species rich area. This leads to either displacement or eradication of the shallow water invertebrate communities. Any new littoral habitat present after impoundment may not be successfully colonised, particularly by less mobile species, leading to reduced species richness.

Water fluctuations

The invertebrate assemblage of a waterbody is often distinctive, developing to suit conditions at the site such as substrate composition and degree of water level fluctuations [1]. PSH schemes typically increase the frequency of fluctuations in water levels (often called drawdown) and these fluctuations are likely to be more rapid and more frequent than more gradual natural fluctuations [2].

Studies of Scottish lochs show that annual water level fluctuations (AWLF) of less than 5 metres and weekly water level fluctuations (WWLF) of less than 0.5 metres support the richest littoral invertebrate communities [3]. When water fluctuations exceed either of these figures, the invertebrate community was impoverished, and where both the AWLF and WWLF are greater than these figures the invertebrate community was extremely poor.

Large-scale PSH schemes, or multiple schemes operating across the same lower reservoir often exceed the WWLF within one or two days. Research has indicated that invertebrate richness in reservoirs impacted by hydropower operations was significantly lower than in natural waterbodies [4].

Different invertebrate species have varying degrees of tolerance to water fluctuations. Invertebrates within the littoral zone, unable to track water levels, will become stranded and die or be predated. It is unclear what species, if any, can tolerate some of the very high fluctuations that may occur, with severe implications for these freshwater ecosystems.

Alderfly (*Sialis lutaria*) larva © André Karwath (CC BY-SA 2.5)

[1] White, M.S., Xenopoulos, M.A., Hogsden, K., Metcalfe, R.A. and Dillon, P.J. (2008). Natural lake level fluctuation and associated concordance with water quality and aquatic communities within small lakes of the Laurentian Great Lakes region. Hydrobiologia 613: 21-31.
[2] Patocka, F. (2014). Environmental Impacts of Pumped Storage Hydro Power Plants. Norwegian University of Science and Technology.
[3] Smith, B.D., Maitland, P.S. and Pennock, S.M. (1987). A Comparative Study of Water Level Regimes and Littoral Benthic Communities in Scottish Lochs. Biological Conservation 39: 291-316.
[4] Trottier, G., Turgeon, K., Boisclair, D., Bulle, C. and Margni, M. et al. (2022). The impacts of hydropower on freshwater macroinvertebrate richness: A global meta-analysis. PLoS ONE 17(8): e0273089.

Changes to water body characteristics

In addition to water fluctuations, PSH schemes can alter other abiotic characteristics of the reservoirs, with further impacts on the aquatic invertebrate assemblage. Schemes can cause changes to water temperatures, stratification, sediment flows, and oxygen and nutrient concentrations. These effects could extend beyond the littoral zone, with potential impacts on deeper water species that may be unable to adapt to changed conditions. The Vulnerable Arctic-alpine Pea Clam (*Euglesa conventus*) is one example of a deeper water species that could be impacted by these changes. The extent of these impacts will be highly variable depending on the individual scheme, but outcomes could be reduced species richness and abundance.

PSH and climate change

Waterbodies are warming due to climate change, resulting in a higher probability of low oxygen concentrations and harmful algal blooms. Reduced water levels and increased water temperatures are likely to have a significant detrimental effect on aquatic species. These effects may be exacerbated by changes to water temperature and water levels from PSH developments. Impact assessment must consider climatic changes during the lifetime of a proposed scheme to eliminate or reduce detrimental impacts on the ecology of the water body.

Assessing impacts on invertebrates

Aquatic invertebrates

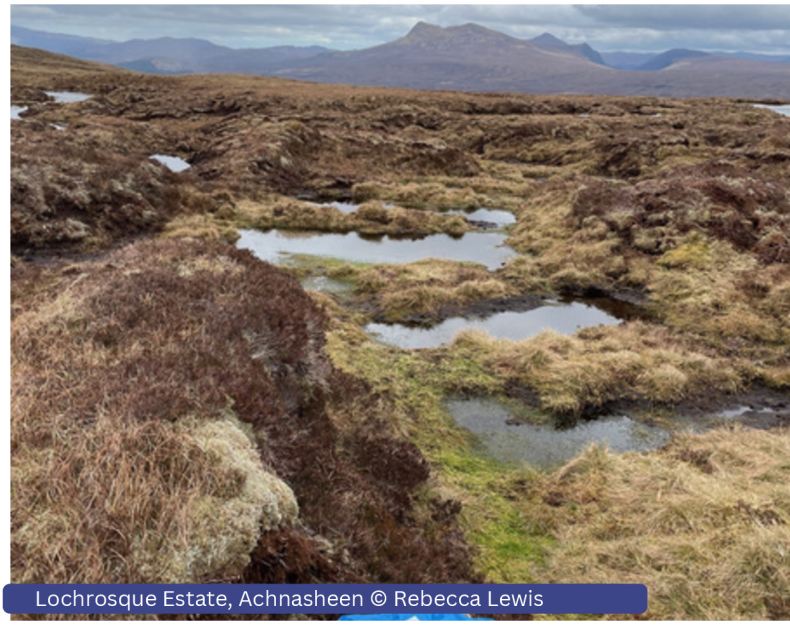
Inundation and water fluctuations affect the full extent of a water body's shoreline and can have impacts in deeper water. Survey effort needs to reflect this. Sampling should be undertaken at locations across the zone of influence of the development to ensure that adequate coverage is achieved, including shallow bay areas that will be most affected. All waterbodies impacted by the scheme (including rivers and streams) should include spring and autumn sampling as a minimum to ensure the detectable life stages of a range of taxa (such as caddisflies and mayflies) are captured. Samples should be identified to species level. For example, if Pea Mussels (Sphaeridae) are only identified to genus level, this could result in important species of conservation concern such as the Arctic-alpine Pea Clam being overlooked in the assessment.

The magnitude of change to all water body characteristics (as detailed above) must be understood and consideration given for the need for surveys to assess species in both shallow areas and deeper water.

Freshwater invertebrate communities can be assessed by a variety of metrics, however most of these can only be used on data from running waters [7]. The only metric that is currently appropriate for assessing the conservation value of an invertebrate assemblage for standing water is the Community Conservation Index (CCI) [8].

[5] Natural England (2005) Organising surveys to determine site quality for invertebrates.
[6] Hill D, Fasham M, Tucker P, Shewry M and Shaw P (eds) (2005) Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring, 387-403. Cambridge University Press, Cambridge.
[7] Murray-Bligh, J. and Griffiths, M. 2022. Freshwater Biology and Ecology Handbook. Foundation for Water Research and Freshwater Biological Association. https://www.fba.org.uk/shop/p/freshwater-biology-and-ecology-handbook
[8] Chadd, R. and Extence, C. 2004. The conservation of freshwater macroinvertebrate populations: a community-based classification scheme. Aquatic Conssrv: Mar. Freshw. Ecosyst., 14: 597-624.

Bilberry Bumblebee (*Bombus monticola*) © Charlotte Rankin



Lochrosque Estate, Achnasheen © Rebecca Lewis

It is also key that assessment identifies taxa present that are less tolerant of excessive water fluctuations, as this is one of the main impacts of PSH schemes. Just some of the taxa sensitive to water fluctuations include alderflies (*Sialidae*), cased caddisflies (*Trichoptera*), flatworms (*Planariidae*), hog-lice (*Asellidae*), leeches (*Hirudinea*), riffle beetles (*Elmidae*), molluscs (*Mollusca*), stoneflies (*Plecoptera*) and worms (*Oligochaeta*).

Assessment must include the assemblage as a whole and not only consider the presence of protected or notable species. Reduced species richness and abundance of invertebrates has consequences for the whole ecosystem.

Terrestrial invertebrates

Whilst desk studies to inform the assessment often include terrestrial invertebrate records, many of the locations where PSH schemes are located will not be well-surveyed and information is often limited. All schemes should be subject to an initial walkover survey by an entomologist. This will provide an indication of the likely importance of the development area to invertebrates, identify key areas of habitats and associated features, inform the selection of invertebrate groups for further survey, and the potential for notable species to be present. Further targeted surveys can then be undertaken to ensure a robust impact assessment, the provision of appropriate mitigation measures, including informing any habitat management plans that may be developed.

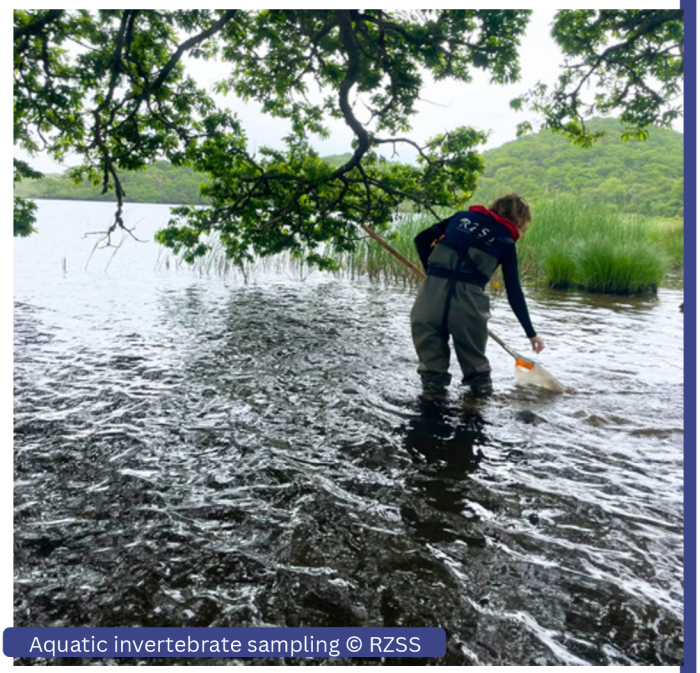
Mitigation and compensation

Whilst planning policies across the UK are rightly supportive of renewal energy development, substantial weight must be given to the nature crisis. The mitigation hierarchy must be applied to PSH schemes with the understanding that the ecological harm from some proposals in certain locations is just too great. Rare upland species with restricted ranges may be especially vulnerable due to their habitats overlapping with the types of locations suitable for PSH developments and the cumulative habitat loss from multiple schemes.

Alongside measures to prevent further declines or extinctions to species of conservation concern, consideration should also be given to preventing overall biodiversity loss.

Summary

- PSH schemes can have substantial adverse impacts on both the species richness and abundance of invertebrate populations, with consequences for rare species and for aquatic and terrestrial ecosystems.
- The zone of influence of proposed schemes should be properly defined to take account of the full extent of hydrological changes expected.
- Surveys for aquatic invertebrates need to be undertaken in locations across the zone of influence of the development, including the littoral zones and possibly deep water areas.
- Survey effort across seasons is needed to ensure detection of taxa with aquatic larval stages.
- Specimens should be identified to species.
- Assessment of aquatic invertebrate data should include their conservation value and the sensitivity of the assemblage to water fluctuations, regardless of whether the species present have legislative protection or are of conservation concern.



Aquatic invertebrate sampling © RZSS

- An invertebrate walkover survey should be undertaken of terrestrial habitats, with further targeted surveys undertaken as recommended.
- The cumulative impact of habitat loss and water level fluctuations from multiple PSH schemes must be considered.
- Appropriate and informed mitigation and compensation measures may be able to avoid key features and help maintain important invertebrate populations. Maintenance of invertebrate biodiversity and persistence of rare species may only be achievable through appropriate mitigation and compensation measures.
- Adherence to the mitigation hierarchy is essential in site selection and scheme design. Some locations will not be suitable for PSH development due to ecological harm that cannot be mitigated.

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