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Condition assessment of the Glutinous Snail *Myxas glutinosa* in Llyn Tegid in 2014

M.J. Willing & I. Hughes

NRW Evidence Report No. 173



Figure 1: Monitoring Site 3 (looking south).

A study supported by Natural Resources Wales & Freshwater Habitats Trust



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1. Crynodeb Gweithredol

Mae'r adroddiad yma, fel rhan o'r rhaglen Archwilio Gyffredin CNC, yn cofnodi canlyniadau'r arolwg o'r falwen ludiog *Myxas glutinosa* ar lannau Llyn Tegid yn ystod 2009, ac yn defnyddio'r Amcan Gadw a chynhyrchwyd ar gyfer y falwen hon (Willing 2004). Cynhaliwyd yr archwiliad yma dros gyfnod o ddeuddydd, canol Hydref, o fewn wyth safle o gwmpas Llyn Tegid (safleoedd a ddefnyddiwyd wyth gwaith ers 1999) i fesur a chyfri'r falwen (ac ymlusgiaid tebyg) yn ôl y rheolau samplu a manylwyd yn yr Amcan Gadw. Gwnaethpwyd yr arolwg yma o dan drwydded yr WCA o'r CNC.

Darganfuwyd y *M. glutinosa* yn saith o'r safleoedd mesur, safleoedd ble roeddent wedi eu darganfod o'r blaen, ac mewn rhifau sy'n galluogi'r feirniadaeth eu bod nhw i weld mewn cyflwr ffafriol yn Llyn Tegid, yn 2014. Barnwyd i'r cynefin ddangos cyflwr da ym mhob un o'r wyth safle mesur. Rhoddir canlyniadau'r archwiliad a chynhaliwyd ers Ebrill 2000 yn yr adroddiad yma hefyd.

Cynhaliwyd archwiliad o *M. glutinosa* ar lan y llyn ger Clwb Hwyllo Bala hefyd, yn yr ardal lle mae cynigiadau i adeiladu dwy lanfa newydd. Daethpwyd i'r canlyniad na fydd lawer o effaith ar y *Myxas* wrth adeiladu ddwy lanfa newydd; mae'n bosib fydd yr effaith yn un ffafriol gyda llai o aflonyddwch wrth ymyl y llyn ger Clwb Hwyllo Bala. Wnaeth y *Myxas* atgenhedlu erbyn diwedd yr arbrawf.

2. Executive Summary

As part of the NRW Common Standards Monitoring programme, this report documents the results of monitoring for the Glutinous Snail *Myxas glutinosa* during 2014 at Llyn Tegid using the Conservation Objective produced for this snail (Willing, 2004, 2006, 2010). Llyn Tegid was visited in late October 2014 and, over two days, eight survey-stations situated around the lake were monitored (those used on nine previous occasions since 1999) for the presence of the snail (and associated molluscs) using the sampling procedures as detailed in the Conservation Objective. Survey work was undertaken under WCA licence from NRW.

M. glutinosa was found at all 7 sites where it had previously been recorded in numbers that, using Condition Assessment standards, allows the status of the snail to be judged as in a Favourable Condition in the lake in 2014. The population has been in Favourable Condition since standardised monitoring first took place in 2002. The habitat at all of the sites was also judged to be in 'good condition' in 2014. Results from surveys undertaken since April 2000 are also included in the report.

Following status monitoring work a live sample of *M. glutinosa* was taken under licence from NRW from the lake survey to allow captive observation of the snails to be undertaken and to investigate the possibility of captive breeding of the snail. Initial observation of the captive *Myxas* has revealed that the snails emerge from beneath stones in darkness and feed upon encrusting algae both on stones and glass tank sides. *Myxas* bred in captivity at the end of the experiment.

3. Introduction

3.1. Background

The glutinous snail *Myxas glutinosa* was first discovered in Llyn Tegid, its only current station in the UK, prior to 1852 and was reported to be abundant during searches in the early 1950s (Dunn, 1961; McMillan & Millott, 1954). However, it was not recorded again after that time and feared to be extinct (either as a result of the construction of a dam at the outflow which altered the hydrology of the lake or due to increasing nutrient inputs and associated algal growth linked with deoxygenation of the water column and increased siltation) until it was rediscovered in autumn 1998 during a survey funded by the Countryside Council for Wales (CCW) and Snowdonia National Park Authority (SNPA). It was found to be widespread and abundant under stones in c. 75% of the lake margin during a period of low water levels in September, although it was absent from margins with silty substrates (Willing & Holyoak, 1998). Further work funded by SNPA and the Environment Agency was undertaken in 1999 and 2000 including diving to determine the extent of suitable habitat (Willing & Holyoak, 2000). Searches of other water bodies in southern Snowdonia have failed to locate additional populations (Willing & Holyoak, 2000; Willing, pers. obs.).

3.2. Objectives

This contract was set up jointly by The Freshwater Habits Trust and Natural Resources Wales for two purposes. Firstly as part of a monitoring programme to provide data on the population status and habitat condition for *M. glutinosa* in line with the Common Standards Monitoring (CSM) approach which has been developed for species and habitats throughout the UK. Secondly the work was planned to locate and remove a small sample of live *Myxas* (under licence from NRW) to allow captive stock to be studied behaviourally and also to assess the feasibility of captive breeding of the snail. Previous monitoring assessments in 2002, 2005 and 2009 had determined that the *Myxas* population in Llyn Tegid was in favourable condition (Willing, 2004, 2006, 2010). It was recommended to repeat the assessments at 3 to 4 year intervals.

4. Methods

The eight monitoring stations shown in Figure 2 and used on 9 occasions since 1999 were revisited on 27th and 28th October 2014. On the first day, the survey was undertaken in occasional light showers with choppy lake conditions whilst the second survey day also had choppy lake conditions but dry weather. Lake levels were 1.132m on 27th October falling slightly to 01.055m on 17th October, both above Natural Resources Wales 'sill height' (Appendix 3). These levels were below the maximum level of 1.35m detailed in the monitoring protocol as the upper lake level under which survey work can be undertaken.

At each monitoring site the following procedure was undertaken:

- the numbers of *M. glutinosa* found during approximately 30 minutes search¹ were recorded together with numbers of other molluscs present.
- cobbles and small boulders were lifted from the lake and examined for snails, particularly upon their under surfaces. Precedence was given to flat rocks of a manageable size that are not embedded in the substrate. Survey time allowed examination of rocks in water depths between approximately 0.05 – 0.5m (an effort to ensure approximately equal use of time in the different water depths).
- some *M. glutinosa* specimens were taken and preserved in 70% analytical ethanol for later measurement and possible DNA studies.

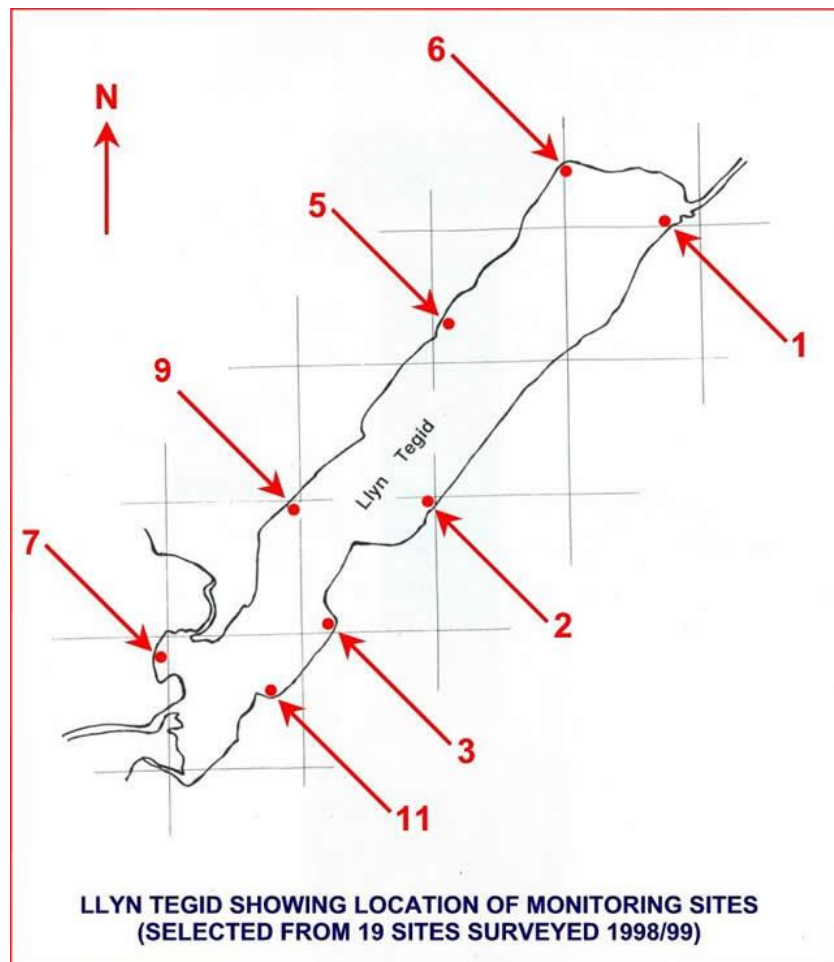


Figure 2: Map of Llyn Tegid displaying monitoring sites sampled for *Myxas glutinosa* in 2014.

¹ The '30 minute search time' was 'shared, by MJW and IH; the search period was extended by about 7 – 8 minutes at sites where waves disrupted survey work. This happened as the disturbed water surface combined with low light levels (due to heavy cloud) slowed the searches for the larger cobbles and boulders that are lifted and turned to look for *Myxas*.

5. Results

Numbers of *M. glutinosa* and associated molluscs found per monitoring site are given in Table 1 in Appendix 1. Counts of *Myxas* at each of the monitoring sites for the August to October period from 2000 to 2014 are given in Table 2, whilst Table 3 gives combined survey data of *Myxas* size classes for specimens collected since April 2000.

6. Discussion

Monitoring undertaken in October 2014 produced a combined total of 51 *Myxas* from the eight monitoring stations, the same aggregate total as in 2005 but 34 *Myxas* lower than in 2009 when lower lake levels and calm lake conditions may have led to better sampling conditions and so rather higher snail counts. The snail was also found at all of the monitoring sites where it had been recorded previously, only being absent from Site 7, a shallow silty bay lying at the south-western end of the lake where the snail has not been recorded during any of the surveys undertaken since the snail's rediscovery in 1998 (Willing 2004, 2006, 2010; Willing & Holyoak 1998, 2000).

Lower numbers of *Myxas* were recorded at Sites 2, 5, 6, 9 and 11 in 2014 than in 2009, but equal or higher numbers at Sites 1 and 3. There is no obvious reason for these differences. During the 2005 survey (Willing 2006), filamentous algal 'blankets' were observed covering approximately 70% the lake floor at Site 11. No such blankets were observed at this or any of the other sites in 2014 and rock surfaces at all survey stations seemed to be free of silt or encrusting algae. The habitat at all survey sites was therefore judged to be in a 'favourable' condition in 2014.

Lake levels during the survey period were at 1.132 m on the 27th October (the main survey day) falling slightly to 1.055 m on 28th October. Levels on 27th were 0.344 m higher than those recorded during survey in October 2009, but almost identical to those of the main survey day in October 2005, being only 0.003 m higher in 2014. Although monitoring survey work was undertaken in water depths ranging from 0.05 – 0.5m, the majority of the *Myxas* recorded in 2014 were taken in approximately 0.2 – 0.4 m of water. After a period of slight rise, water levels fell in the lake to reach a then low for the year of 0.632 m in December; a fall of 0.5 m from the October survey period. This would mean that unless the *Myxas* follows the receding waters, then almost all of these snails recorded in October 2014 would be left out of water (in the case of those in shallower depths, well up the shore) and unless they were able to survive beneath stones may have died. Whilst the behaviour of *Myxas* in response to relatively rapid lake level falls requires further investigation, the fact that the population has been judged to be in favourable condition since 2002 suggests that the snail does adapt to such factors.

Cyanobacterial ('blue-green algae') and algal 'blooms' have been a characteristic feature of Llyn Tegid in recent years (Duigan *et al* 2007, Willing 2010, Willing *et al* 2014). Algal blooms were present at some survey sites (particularly 1, 3, 6 and 11) in 2009 (Willing 2010), but none was observed at any point in the lake during the two-day monitoring period in 2014.

Judged by the Objective for *M. glutinosa* in Llyn Tegid (see Appendix 2), the snail can be assessed as having favourable conservation status in the lake in 2014 because:

1. it was found living at 7 of the 8 monitoring sites (Lower limit criterion is 6 of the 8 sites);
2. a combined total of 51 live snails were found at the 8 monitoring stations (Lower limit criterion is 40 snails) and
3. in relation to habitat quality, cobbles and boulders at 7 of the 8 monitoring sites were less than 20% covered in silt or slime-forming algae.

It is recommended that the *Myxas* population present in Llyn Tegid should, in the absence of any environmental problems² affecting the lake, be monitored in 3 – 5 years' time to assess its condition.

In terms of other freshwater molluscs recorded in 2014, five species previously found in the lake - *Valvata piscinalis*, *Gyraulus albus*, *Potamopyrgus antipodarum*, *Hippeutis complanatus* and *Menetus dilatatus* - were not recorded. The disappearance of the non-native planorbid *M. dilatatus* was unexpected as this species had been recorded in large numbers (on submerged stones and timber) at Site 7 on all surveys since 1998. A newly-recorded species to the lake was the non-native *Physella acuta*, which was frequent on submerged objects at Site 7 as well as occurring commonly on stones further south on the extreme south-western lake fringes to the south of Site 7.

7. Recommendations

- i. Continue the standardised NRW 'Common Standards' monitoring of *Myxas* populations in Llyn Tegid on the recommended 3-4 yearly basis unless a sudden deterioration in lake conditions (e.g. a sudden and/or extreme fall in lake levels; an atypical increase in filamentous algal coverage of shallow-water rocks; a major cyanobacterial 'bloom' in the lake) suggests that a more immediate *Myxas* impact assessment be undertaken.

² Such as: (1) extensive filamentous growth in shallow, marginal areas of the lake and (2) untypical (especially rapid) fall in lake levels producing periods of more than about a day when lake levels are below.

- ii. Continue work to better understand aspects of the abiotic environment in Llyn Tegid such as water temperature ranges, pH, levels of dissolved phosphate and nitrate, water hardness and lake level changes.
- iii. Work to involve the Llyn Tegid lake wardens in *Myxas* conservation. Their involvement might include:
 - a. The development of public engagement and education initiatives;
 - b. Their training in basic *Myxas* survey techniques so that they might undertake regular monitoring at selected survey stations around the lake;
 - c. Training to develop an awareness that certain environmental events in the lake (eg. cyanobacterial blooms, noticeable increases in filamentous algal covering of shallow water rocks, rapid falls in lake levels) might justify a full *Myxas* monitoring before the planned 3-4 year monitoring event.
- iv. The continuation of captive *Myxas* breeding in order to:
 - a. Gain further information on *Myxas* autecology and
 - b. Further develop procedures that might allow the production of large numbers of snails for possible release into experimental donor sites.
- v. Consider the options (& associated issues) of a possible release of captive-bred *Myxas* into:
 - a. Purpose-constructed artificial pools (to study the possibility of breeding outside laboratory captivity);
 - b. Selected 'wild' sites (both in Wales and possibly England) to explore whether translocation techniques might allow the establishment of new self-sustaining populations of the snail (possibly in enclosed 'ark sites' such as abandoned gravel pits and flooded quarry workings).

8. Acknowledgements

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10. Appendices

10.1. Appendix 1: Results data

Table 1: Occurrence of *Myxas glutinosa* and other gastropods at Llyn Tegid, 27th-28th October 2014. Counts = 30 minutes search per site.

| Monitoring Site No. (& Grid. Ref.) | 1 | 2 | 3 | 5 | 6 | 7 | 9 | 11 |
|------------------------------------|----------|----------|-----------|-----------|-----------|----------|----------|-----------|
| | SH 92787 | SH 90999 | SH 90213 | SH 90911 | SH 91969 | SH 88966 | SH 89952 | SH 89704 |
| | 35015 | 32986 | 32110 | 34164 | 35457 | 32054 | 33074 | 31557 |
| <i>Myxas glutinosa</i> | 5 | 1 | 10 | 11 | 12 | - | 1 | 11 |
| <i>Ancylus fluviatilis</i> | - | - | 1 | - | - | - | - | - |
| <i>Bathyomphalus contortus</i> | - | - | - | - | - | - | - | 1 |
| <i>Radix balthica</i> | - | 16 | 1 | 6 | - | - | 1 | - |
| <i>Physa fontinalis</i> | 3 | 14 | 3 | 4 | 7 | 1 | 1 | 17 |
| <i>Physella acuta</i> | - | - | - | - | - | 3 | - | - |

Table 2: Occurrence of *Myxas glutinosa* at Llyn Tegid between 2000 and 2014. Results expressed as *Myxas* collected in 30 minutes survey time.

| | Site 1 | Site 2 | Site 3 | Site 5 | Site 6 | Site 7 | Site 9 | Site 11 | Total Myxas |
|---------------------|----------|----------|-----------|-----------|-----------|----------|----------|-----------|-------------|
| August 2000 | 13 | 5 | 23 | 13 | 18 | - | 1 | 5 | 78 |
| September 2001 | 1 | 8 | - | 6 | 1 | - | 1 | 6 | 23 |
| September 2002 | 8 | 7 | 7 | 14 | 6 | - | 11 | 17 | 70 |
| October 2005 | 11 | 5 | 10 | 1 | 17 | - | 4 | 3 | 51 |
| October 2009 | 5 | 2 | 2 | 16 | 41 | - | 3 | 16 | 85 |
| October 2014 | 5 | 1 | 10 | 11 | 12 | - | 1 | 11 | 51 |

Table 3: Size classes of *Myxas glutinosa* sampled at Llyn Tegid between 2000 and 2014. All sites are combined to produce a total for the sampling period.

| | April 2000 | Aug 2000 | Feb 2001 | Sep 2001 | Sep 2002 | Oct 2005 | Oct 2009 | Oct 2014 |
|---|---------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 1.5 - 2.9 | | 4 | | | | | | |
| 2.0 - 2.4 | | 4 | | | | | | |
| 2.5 - 2.9 | | 13 | | 2 | | | | |
| 3.0 - 3.4 | | 19 | | 2 | 1 | 1 | | 1 |
| 3.5 - 3.9 | 1 | 23 | | 4 | 12 | 1 | 1 | |
| 4.0 - 4.4 | 1 | 14 | 1 | 8 | 17 | 3 | 13 | 3 |
| 4.5 - 4.9 | 1 | 2 | 5 | 5 | 12 | 16 | 17 | 3 |
| 5.0 - 5.4 | 1 | 3 | 14 | 2 | 15 | 11 | 20 | 11 |
| 5.5 - 5.9 | | | 6 | | 11 | 11 | 7 | 11 |
| 6.0 - 6.4 | 1 | | 4 | | 2 | 3 | 17 | 12 |
| 6.5 - 6.9 | 1 | | 6 | | | 1 | 9 | 8 |
| 7.0 - 7.4 | | | 3 | | | 1 | 1 | 1 |
| 7.5 - 7.9 | | | | | | | | 1 |
| 8.0 – 8.4 | | | | | | 3 | | |
| Total <i>Myxas</i> measured (n) | 6 | 82 | 39 | 23 | 70 | 51 | 85 | 51 |
| Mean length mm | 5.13 | 3.43 | 5.59 | 4.1 | 4.6 | 5.3 | 5.3 | 5.712 |
| 1 Standard deviation | 1.17 | 0.76 | 0.79 | 0.68 | 0.73 | 1.0 | 0.83 | 0.867 |
| Total counted on survey (* counts adjusted from years pre-2002) 30 minutes per site | 3* | 78* | 42* | 22* | 70* | 51 | 85 | 51 |

10.2. Appendix 2: Conservation Objective for the Glutinous Snail *Myxas glutinosa* in Llyn Tegid SSSI.

RATIONALE

The Glutinous Snail *Myxas glutinosa* has been known in Llyn Tegid since at least 1852. There was a hiatus in recorded presence in the lake between 1953 and 1998 when a CCW/Snowdonia National Park Authority funded survey relocated the species. The snail was found to be widely distributed around about 8.5km of lake margin (>80% of the total shore margin), but was not found in the silty bay where the River Dee enters the south-western end of the lake. Where present, the snail was found almost exclusively on the lower surface of cobbles and small boulders lying on sand, gravel, cobbles or boulders. Survey sampling undertaken by divers at several of the monitoring stations in November 1999 found that *Myxas* only lives in the littoral regions of Llyn Tegid, extending to depths of only about 2.4m at 'winter' lake levels (1.4m for low summer levels). This reliance of the snail upon the shallow margins of the lake may make it particularly vulnerable to sudden or extreme lake level changes. Subsequent surveys and studies undertaken at different times of the year between 1998 and 2001 suggest that the snail has an annual life cycle. The adult snails appear to reach maturity in late winter, mostly dying off after reproducing in February/March. In the period April – June snails are very difficult to locate. By August, partially grown snails are relatively easy to locate around most of the lake margins (at sites previously shown to support the snail). These grow throughout the autumn, with population numbers declining over the winter period due to predation and/or other factors.

When populations of the snail were monitored in September 2001 the whole lake was affected by a 'blue-green algal' bloom which lasted several weeks. Total numbers of snails recorded during the monitoring programme was significantly lower than in the years 1998 – 2001, but, given the increase in numbers in 2002, this is likely, at least in part, to be a consequence of poor visibility hampering searches rather than fluctuating population levels. Monitoring visits should therefore avoid episodes of algal bloom if at all possible.

At the time of writing this Conservation Objective, Llyn Tegid supports the only known extant population of *Myxas* on the British mainland and this makes the implementation and regular review of this Conservation Objective of the utmost importance.

SAMPLING GUIDANCE

The presence and population numbers of *Myxas* in Llyn Tegid should be assessed every three to four years, with a single 1½ day visit to the eight monitoring stations (see Map A). This programme should, however, revert temporarily to an annual basis following any adverse disturbance to the lake such as a pollution incident, major cyanobacterial bloom or extreme fall in lake level. The person/s responsible for the

implementation of this objective should ensure that regular updates on lake conditions are received from a representative of Natural Resources Wales in Bala.

The monitoring visit should ideally occur in mid-September as:

- this will allow comparisons with monitoring data collected since 1999;
- snails have been present in good numbers (in certain parts of the lake) at this time and have grown to a size (mean length 4mm in previous years) that is easily located;

Monitoring should take place in calm conditions to minimise the difficulties caused by wave action, with lake water levels at a maximum height of 1.35m (above NRW 'sill level'³). Mid to late September is ideal as NRW lowers water levels in early September from the artificially high position generally maintained in August. If rainfall causes levels to be high in September then monitoring should take place at the first suitable period in October. The identification of young *Myxas* is rather difficult as they can be readily confused with similar sized *Radix balthica* (= *Lymnaea peregra*) and *Physa fontinalis* that are frequently present on the same rocks as *Myxas*. It is therefore important to ensure that monitoring personnel have received such identification training that they are proficient in separating these species. The sampling procedure should take place as follows:

- At each monitoring station snail counting should take place for 30 minutes.
- During the survey time cobbles and small boulders should be lifted from the lake and examined for snails, particularly upon their under surfaces. Precedence should be given to flat rocks of a manageable size that are not embedded in the substrate. Survey time should allow examination of rocks in water depths between approximately 0.1 – 0.6m (with an effort to ensure equal use of time in the different water depths);
- Surveyors should wear chest waders or a 'dry suit'. To allow the search period to proceed for uninterrupted snail counting and also for health and safety reasons, another member of the survey team should record snail data whilst located on the lakeshore.

³ 'Sill height' = is a Natural Resources Wales datum point for Llyn Tegid lake levels measured from top of sluice gate outlet of Llyn Tegid at Dee Bridge, Bala (sill height is 159.06m AOD)

| | | |
|--|------------------------|--|
| <p>Conservation objective (for when the feature is in favourable condition)</p> | | <p>To maintain the Glutinous Snail <i>Myxas glutinosa</i> in Llyn Tegid SSSI in favourable condition where:</p> |
| <p>Lower limit</p> | | <p>The combined total number of semi-grown snails present at the 8 monitoring sites is 40.</p> |
| <p>Lower limit</p> | | <p>and where: The snail is recorded at 6 of the 8 monitoring sites (see Map A)</p> |
| | | <p>And</p> |
| <p>Habitat extent:</p> | | |
| <p>Lower limit</p> | | <p>Cobbles and boulders at 6 of the 8 monitoring stations have no more than 20% of the rock surfaces covered in silt and/or slime forming algae.</p> |
| <p>Definition of suitable Glutinous Snail habitat</p> | <p>of Snail</p> | <p>In water depths of 0m – ca 2.5 m (with lake levels between 0.75m – 1.35m) the habitat consists predominantly of cobbles and boulders lying on varying mixtures of sand, gravel and cobbles (but not noticeable amounts of mud or silt). There is little organic detritus between the stones and filamentous and slime forming algal species are scarce or absent from the rock surfaces. The lower surfaces of rocks appear blackened and, with the exception of occasional freshwater sponges, are largely devoid of other living encrustations. Lake water (judged in still weather with a calm or reasonably calm lake surface) has good clarity such that stones can be seen clearly to a depth of at least 1.5m. Water is not turbid due to silt suspension or floating cyanobacterial blooms.</p> |

| | |
|--|--|
| <p>Recovery target (for when the feature is in unfavourable condition)</p> <p>To restore the Glutinous Snail <i>Myxas glutinosa</i> in Llyn Tegid SSSI to a favourable condition where:</p> | |
| <p>Recovery target:</p> | |
| <p>Lower limit</p> | <p>The combined total number of semi-grown snails present at the 8 monitoring sites shown on map A is 65.</p> |
| <p>Lower limit</p> | <p>and where:</p> <p>The snail is recorded at 6 of the 8 monitoring sites (see Map A)</p> |
| | <p>And</p> |
| <p>Habitat extent:</p> | |
| <p>Lower limit</p> | <p>Cobbles and boulder at 6 of the 8 monitoring stations have no more than 10% of the rock surfaces covered in silt and/or slime forming algae.</p> |
| <p>Definition of suitable Glutinous Snail habitat</p> | <p>In water depths of 0m – ca 2.5 m (with lake levels between 0.75 - 1.35m) the habitat consists predominantly of cobbles and boulders lying on varying mixtures of sand, gravel and cobbles (but not noticeable amounts of mud or silt). There is little organic detritus between the stones and filamentous and slime forming algal species are scarce or absent from the rock surfaces. The lower surfaces of rocks appear blackened and, with the exception of occasional freshwater sponges, are largely devoid of other living encrustations. Lake water (judged in still weather with a calm or reasonably calm lake surface) has good clarity such that stones can be seen clearly to at least 1.5m depth. Water is not turbid due to silt suspension or floating cyanobacterial blooms.</p> |

10.3. Appendix 3: Further research and survey.

This conservation objective is based upon data currently available for *Myxas* living in Llyn Tegid. Continued monitoring of the eight monitoring stations that lie fairly evenly spaced around the lake should clarify population levels, help to confirm life cycle details and indicate the snail's ability to withstand episodes where the lake is subject to cyanobacterial blooms. Aspects of the autecology are still unclear and examples include:

- To what extent and at what rate are the snails able to move within the littoral zone of the lake when water levels are artificially adjusted by NRW;
- Does the relatively rapid fall in Llyn Tegid lake levels (such as the 0.5 m fall between 27.10.2014 and 6.12.2014) result in the death of snails that were living beneath stones at shallow water depths (e.g. < 0.5 m).
- Are apparently different mean growth rates in snail populations at different locations around the lake due to minor habitat variance or to isolated sub-population differences?
- Work is ongoing with captive *Myxas* to study behaviour and to investigate the possibility of captive breeding.

Information gained from the monitoring described above will help to refine the limits for the Feature and this Objective should be reviewed accordingly as results become available.

10.4. Appendix 4: Images of survey sites.



Figure 3: *Myxas glutinosa* monitoring Site 1 in October 2014.



Figure 4: *Myxas glutinosa* monitoring Site 1 showing 'choppy' lake surface during survey conditions on 27th October 2014.



Figure 5: Monitoring Site 2.



Figure 6: Monitoring Site 3.



Figure 7: *Myxas glutinosa* monitoring Site 5 (showing Dr M. Howe examining rocks for *Myxas*).



Figure 8: Monitoring Site 6.



Figure 9: Monitoring Site 7.



Figure 10: Monitoring Site 9.



Figure 11: Monitoring Site 11 in October 2014.



Figure 12: Ian Hughes gathering *Myxas glutinosa* at Site 6 for captive study.



Figure 13: Ian Hughes with rock and water samples taken from Llyn Tegid for use to supply *Myxas* captivity tanks.



Figure 14: Captive *Myxas* grazing on algae.



Figure 15: Under water *Myxas* habitat in lake shallows of Llyn Tegid.

10.5. Appendix 5: Notes on captive *Myxas* (including some observations up to 28/3/2015).

Methods

A sample of 10 *Myxas* were taken on 28th October for preliminary observation prior to collecting a group for attempted breeding. This work was conducted to determine how sensitive the snails are to handling, disturbance, transportation and new environments. Rocks and water were removed from the lake at the same time to supply the captivity aquaria.

Captivity observations

Of the 10 *Myxas* collected on 28th October at least two had died by 14th November and appeared to have done so at least one day before this date as mould had begun to develop. From this period onwards, only four snails had been seen at any one time indicating that 6 snails died within about two weeks of collection. A suggestion is that *Myxas* is vulnerable to damage of the glutinous layer (present on the exposed outer areas of *Myxas* bodies) through handling. Injuries possibly become infected, this being exacerbated by the initial stresses of captivity. Future captured specimens will be transported on the rocks they are found on.

The four remaining snails behaved nocturnally, retiring beneath rocks in the day and emerging to feed on the surface of rocks at night. By 1st December 2014 this behaviour had altered and snails now often rested on the walls of the aquarium but generally fed at night. Initially all feeding observed was on algal films; filamentous algae appearing to be ignored, but this behaviour changed as the time in captivity continued and snails were observed to 'climb' long strands of filamentous algae consuming it as they moved. Captive *Myxas* showed little interest in crushed lettuce (*Omphiscola glabra* can be sustained on lettuce in captivity) and only one snail approached and came into contact with *Spirulina* flakes, but it did not appear to feed. Feeding activity has been observed at temperatures as low as 3.5°C.

After introducing the snails to the aquarium the rocks were not disturbed. It began to seem possible that lack of food was a contributory factor to the early mortality as *Myxas* feed voraciously and deaths ceased (arguably) when algae began to appear on the aquarium walls. The snails kept the walls clear of algae. This may explain why *Myxas* are typically (but not always) found in isolation in Llyn Tegid; they may occupy a 'grazing field' that supports them and may meet other *Myxas* mostly on the perimeter of a 'territory'. This hypothesis appears to be supported by captive observations, as the snails are usually as widely spaced from each other as it is possible to be. Only a single 'meeting' was observed over a four month period in a 30cm cube aquarium and this resulted in the snails rapidly moving in opposite directions!

On 28/3/2015 two clutches of eggs were seen in the morning on the glass wall of the aquarium. One clutch with approximately 10 eggs had been laid at least an hour before behind a stone, but the second with 12 eggs was in the process of being laid. The egg mass is milky and partially opaque on production but become transparent within an hour. The individual egg cases within the mass were iridescent and oval.

After these initial observations, adult snails were gradually moved on to additional aquaria, which were prepared prior to breeding using Llyn Tegid stones and water. Algal growth, including filamentous algae, is much richer in aquaria without snails demonstrating that they can keep algal cover low by grazing within a snail 'territory'.

The captive produced egg masses hatched and the young snails were successfully captive-reared to adulthood.

Water analysis from Llyn Tegid on 28th October (used for aquarium)

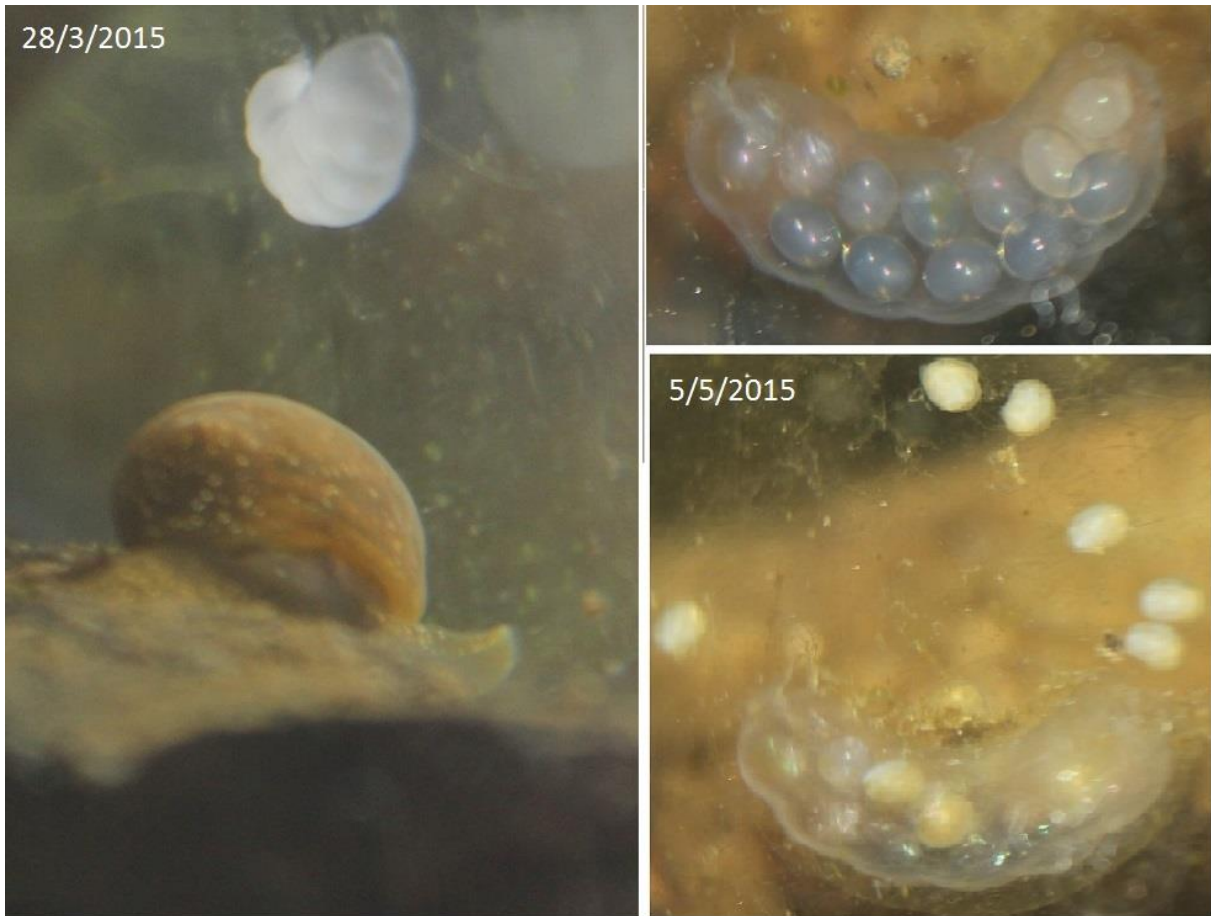
Nitrate – None detectable
Phosphate – None detectable
pH – 7.7
Conductivity – 60 μ S/cm
Calcium – 10 mg/l

Water analysis from aquarium with *Myxas* on 22nd January 2015

Nitrate – None detectable
Phosphate – None detectable
pH – 9.91
Conductivity – 116 μ S/cm
Calcium – 10 mg/l

Water analysis from aquarium without *Myxas* on 22nd January 2015

Nitrate – None detectable
Phosphate – None detectable
pH – 10
Conductivity – 226 μ S/cm
Calcium – 10 mg/l



Egg-clutch 2 in Tank 1 from deposition to hatching. Note the milky appearance of the freshly deposited eggs on the left.

Figure 16: Captive breeding success.

10.6. Data Archive Appendix

The data archive contains:

- [A] The final report in Microsoft Word and Adobe PDF formats.
- [B] Species records, which are held on the NRW Recorder 6 database.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue <http://libcat.naturalresources.wales> or <http://catllyfr.cyfoethnaturiol.cymru> by searching 'Dataset Titles'. The metadata is held as record no 120044.



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