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Instigation of actions to investigate the behaviour and ecology of the Glutinous Snail *Myxas glutinosa* in field conditions in Llyn Tegid in 2016

I Hughes

NRW Evidence Report No. 199



Figure 1: Draft *Myxas* Life cycle for public and land owner engagement purposes

A study supported by Natural Resources Wales & Freshwater Habitats Trust



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1. Crynodeb Gweithredol

Mae'r falwen ludiog *Myxas glutinosa* yn rhywogaeth ddyfrol sydd yn gyfyng i boblogaeth hysbys sengl ym Mhrydain a'i leoli yn Llyn Tegid.

Yn dilyn arbrofion bridio mewn caethiwed llwyddiannus a'u datguddiadau, cafodd cynigion eu gwneud i ddefnyddio'r wybodaeth a gafwyd i ddechrau arbrofion maes a allai arwain at well dealltwriaeth o ecoleg naturiol *Myxas* a'r gweithdrefnau rheoli priodol. Mae'r adroddiad hwn yn cynnwys anogaeth y gwaith hwnnw.

Mae'r arbrofion a argymhellir yn ddull petrus i dreiddio i mewn i fywyd *Myxas* ac yn ateb y cwestiynau canlynol:

- A yw'r *Myxas* yn mudo i fyny ac i lawr y lan wrth i lefelau'r llyn encilio a chynyddu?
- A yw newidiadau mewn lefel y dŵr o fudd neu yn niweidiol i boblogaeth malwod neu a ydynt yn rhadlon?
- Pa swbstradau sydd o fudd i'r *Myxas*?
- Pa wahaniaethau ffisiogemegol sydd yn digwydd ar draws Llyn Tegid a pha effaith y maent yn ei gael ar *Myxas*?
- A fyddai'r *Myxas* yn elwa o leoliad o lochesau mewn safleoedd penodol o amgylch y llyn, ac os felly, ble ac o ba ddeunydd?
- A yw'n bosibl i reoli cynefinoedd gyda dulliau syml sydd o fudd i *Myxas* ac y gellid eu cyflogi i ddychwelyd *Myxas* i'w ystod flaenorol?

Nid ydym yn gwybod yn union beth fydd yr arbrofion yn dangos i ni ac efallai y byddant yn gwrthbrofi rhai damcaniaethau presennol ond mae'r awdur yn teimlo'n sicr y byddant yn dangos i ni yn fwy nag yr ydym eisoes yn gwybod a bydd yn helpu i ymgysylltu gweithwyr lleol ac eraill mewn cadwraeth ac astudiaeth *Myxas*.

Mae'r cam cyntaf wedi'i gwblhau gyda'r gosodiad o lochesau conchrid pwrpasol ac ail archwiliad byr o'r rhain ym mis Rhagfyr yn dangos ei bod eisoes wedi dechrau i ddarparu rhywfaint o fewnwelediad i mewn i fywyd *Myxas* gwyllt yn y llyn ac yn gyfle i ddechrau mapio ardaloedd o wely'r llyn lle *Myxas* yn digwydd.

2. Executive Summary

The Glutinous Snail *Myxas glutinosa* is an aquatic species restricted to a single known population in Britain located in Llyn Tegid.

Following on from successful captive breeding experiments and their revelations, proposals were made to use the knowledge acquired to begin field experiments that might lead to improved understanding of *Myxas* natural ecology and appropriate management procedures. This report comprises the instigation of that work.

The experiments proposed are a tentative method to probe into the life of *Myxas* and answer the following questions:

- Does *Myxas* migrate up and down the shore as lake levels recede and advance?
- Do changes in water level benefit or harm the snail population or are they benign?
- What substrates favour *Myxas*?
- What physicochemical differences occur across Llyn Tegid and what effect do they have on *Myxas*?
- Would *Myxas* benefit from the placement of refuges at particular sites around the lake and if so, where and of what material?
- Is it possible to manage habitats with simple methods that benefit *Myxas* and could be employed to return *Myxas* to its former range?

We do not know exactly what the experiments will show us and they may disprove some existing theories but the author feels sure they will show us more than we already know and will help engage local workers, land-owners and others in *Myxas* conservation and study.

The first stage has been completed with the installation of bespoke concrete refuges and a brief second inspection of these has already begun to provide some insight into the life of wild *Myxas* in the lake and an opportunity to begin mapping areas of the lake bed where *Myxas* occurs.

3. Introduction

3.1. Background

The Glutinous Snail *Myxas glutinosa* (referred to as ‘*Myxas*’ in the following pages) 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.). The population in Llyn Tegid has been monitored at regular intervals, most recently in 2014, and considered to be in favourable condition (Willing, 2004, 2006, 2010; Willing & Hughes, in prep.). Work on *Myxas* at Llyn Tegid is summarised by Willing *et al.* (2014).

It was observed both in Llyn Tegid and in captivity that *Myxas* takes refuge under stones and when brought into captivity exhibits nocturnal behaviour but gradually becomes bolder and apparently diurnal. Experiments showed that *Myxas* is more inclined to seek water when it recedes than to seek refuge beneath a stone (Hughes, 2016). This behaviour suggests that when water levels drop in Llyn Tegid, there is a migration of snails following the water line. It was also seen that captive *Myxas* can outstrip their food supply in constrained conditions and it is speculated that *Myxas* has a poor ability to slow its metabolism (aestivate/hibernate) as other snails seem to do in times of poor food supply, drought or temperature extremes. If true, this may mean that *Myxas* is particularly susceptible to competition and over-population by stripping out its own food supply or being robbed of it by species that can then ‘sit-out’ a dearth of food by going into diapause.

3.2. Objectives

The primary objective was the production and installation of artificial refuges in Llyn Tegid in liaison with SNPA wardens. This contract was set up jointly by The Freshwater Habits Trust and Natural Resources Wales to apply knowledge gleaned from surveys and from observation of captive snails to practical field experiments that may also be replicated in captivity in an attempt to:

- Establish more informed management procedures;
- Gain a better understanding of what *Myxas* needs;
- Create a system where wardens can easily survey *Myxas*, understand its needs and engage with other workers and the public in the field.

4. Methods

The standardised survey system (Willing, 2004, 2006, 2010; Willing & Hughes, in prep.) has designated eight survey locations where the populations of *Myxas* have been charted since their

discovery in 1999. Three of these locations were targeted for the current work along with two others and an intention to use all eight as we learn more.

The existing survey method involves wading in the water and lifting stones and counting the snails beneath. This probably causes little harm (and snails found are usually removed for analysis anyway) when performed on one day in every three years but is unsustainable if performed for fellow workers or public more regularly or as an intensive way to observe snails at regular intervals. This is because the water surface interferes with visibility making the location of suitable stones difficult at times and their placement back on the lake bed in the exact place and position almost impossible without injuring snails. Stone turning also willfully disturbs the snail's habitat and that of other species such as the bullhead *Cottus gobio*. The water surface interference probably leads to more stones being turned than would be in a more informed or more visible situation but it should be noted that wave action during strong winds can move considerably more stones over a much larger area.

Even when water interference is not a problem, turning stones to find snails still presents some of the problems above and is quite destructive to habitat. A warden (working with a Schedule 5 licence) with a group of people could quite easily be in a position where they have turned over 10 or more stones and not found a snail leading to frustration. Captive work shows that active snails (at least) sometimes show a reflex reaction to sudden light changes or movement and drop from the stone they are on. This means that stones being lifted may have snails but they drop before the surveyor gets to see them. Thus refuges were designed to avoid the risks of squashing snails and disturbing their habitat whilst increasing the likelihood of finding them quickly and contributing something to our understanding of *Myxas* ecology and appropriate management.

Very few *Myxas* in Llyn Tegid have been observed on wood substrates (there was one record to the author's knowledge in 2014 at Pentrepiod on a large sunken branch) or on plants but they have been found on the natural stone and on concrete and brick. In these situations they have been found almost exclusively in situations where the stones rest on other stones and thus there is a cavity underneath. For these reasons the following criteria were incorporated into the design of refuges:

- Concrete structure as a material that *Myxas* is known to take refuge under and that can be formed to the desired shape and size and is unlikely to be washed away;
- A tureen or lid-like form that can be lifted with little disturbance or danger to snails or other species living beneath;
- A base which catches any snails falling from the upper body and also holds water when the lake recedes.

The placement of the refuges was decided on assumptions from findings so far. A row of refuges descending into deeper water was installed at each site with the shallowest at the shallowest point where *Myxas* has been found when the lake level is at 'the sill'. The second refuge at each site is 250mm deeper and the third 250mm deep still with the refuges lying in a straight line.

Installation of the refuges was performed on 13th October 2016 and 17th October 2016 by selecting a permanent object on the shore and walking directly out from the object into the lake until a depth of 500mm was reached. This was the shallowest water in which *Myxas* was found on 13th October 2016 after a 10-minute search at the North Pier site. The zone where *Myxas* was found was very close to previous searches but perhaps up to 10 metres further from the shore than the shallowest specimens of the 2014 survey. Walking directly out again from the first refuge, the second and third at each of the sites was placed in the water by snorkelling and, where possible the substrate was recorded and photographed or videoed.

Sketch maps of Llyn Tegid and the refuge sites

MW - Dr. Martin Willing's survey sites
 ● - Concrete refuge sites

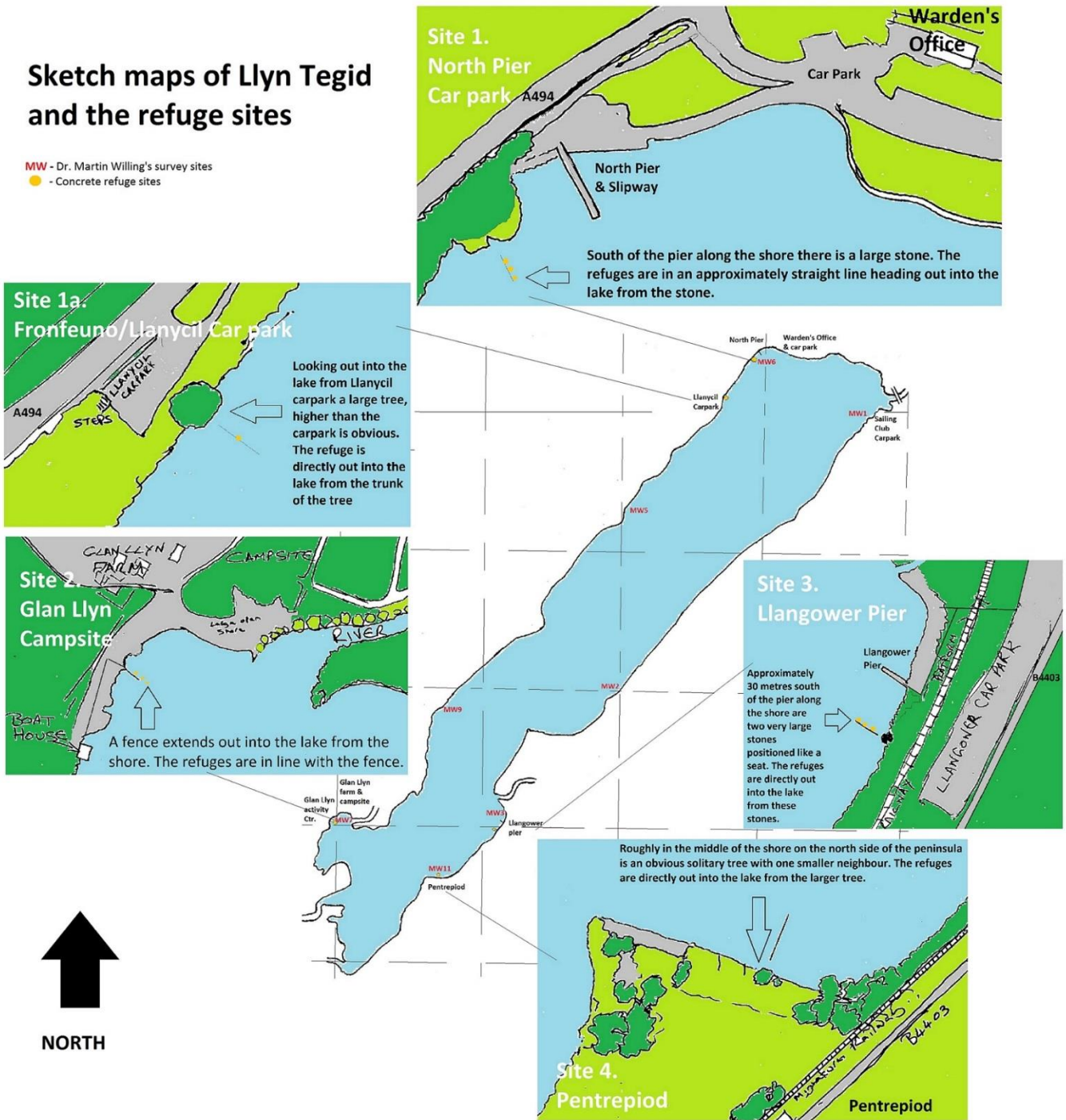


Figure 2: Sketch map of Llyn Tegid showing refuge sites and Dr. Martin Willing's long-term monitoring sites.

5. Results

Two styles of refuge were produced in concrete:

1. A heavy bunker style which weighs around 40kg and measures approximately 600mm x 350mm
2. A lighter shell style which weighs around 20kg and measures approximately 650mm x 250mm

The bunker is intended for sites where disturbance by people or wave action is more likely whilst the shell style is easier to produce and more light-weight to move around. The refuges are made of concrete with a mixture of calcium-rich and organic aggregates to speed up algal colonisation and to provide nutrients. They are placed in rows of 3 proceeding out into the lake and are identified by large white numbers and, on some, an orange piece of cloth embedded in the concrete. The shallowest refuges at each site were all placed at 500mm depth (as recorded on 13th October 2016), followed by a middle refuge at 750mm and a deep water refuge at 1 metre. Some of the deep water refuges were placed beyond the effects of wave action on the lake bed which may mean they are out of range of *Myxas*.

The refuges are made for photographic recording with a large number painted on the lid (with 'L' for lid beside it). Flip the lid and the same number is the correct way up on the underside with a circle around it indicating it is a lid's interior. The base has the same number as the lid followed by 'B'. This is expected to wash off but serves a short-term purpose. The interior of each refuge is imprinted with a mesh pattern so snails on the surface may be measured later from photographs.

Tables 1 and 2 below give information about the refuges and their locations.

Table 1. Sites

Site	How to locate	Refuge ID no's at site	Notes
1 North Pier Car park	35 metres SW of the pier by the main carpark. There is a largish (500 mm. dia.) stone on the shore (4 metres into the lake from the reeds) at SH 91972 35449. Refuge 1 is 15.3 metres SE from the rock	1, 6 & 7	Grid ref. SH 91983 35442 to 91988 35429 [500mm to 1metre deep]
1A Fronfeuno carpark	When standing in the carpark looking out into the lake, a comparatively large alder tree is prominent at SH 91715 35124. The refuges are directly offshore from this tree.	13	SH 91724 35119 [750mm deep]
2 Glan Llyn campsite	Where the road meets the shore and passes through to the Urdd ctr. buildings there is a gate where a fence extends out into the lake. Two refuges are positioned along the north side of the fence within 40cm of it and the deepest (refuge 12) is 5.2 metres from the last fence post directly out into the lake.	5, 11, & 12	SH 88944 32017 to 88954 32009 [500mm to 1metre deep]
3 Llangower Pier	Looking SW from the pier at Llangower there are two very large stones together on the shore arranged like a seat or 'troll's dressing table' at grid ref. 90180 32071	2, 3 & 8	SH 90168 32026 to 90165 32029 [500mm to 1metre deep]
4 Pentrepiod	On the north/east side of the Pentrepiod peninsula Directly offshore from the tree at SH89683155 close to where the peninsula meets the main shoreline and straightens out.	4, 9 & 10	[500mm to 1metre deep]

Table 2. Individual Refuge Details (living document).

Refuge ID Number	Location	Grid ref	Type	Substrate	Distance from shore edge (metres)	Notes (date installed) [Depth when installed] Dates checked
1	Site 1 – North Pier	SH 91983 35442	Bunker	Irregular sized, Loose, partly rounded stones above impacted silt with cobbles embedded	16 metres from reed bed	(13/10/2016) [500mm.] 5/12/2016 [out of water at water's edge]
2	Site 3 - Llangower	SH 90168 32028	Bunker	Loose even sized stones (inc. quartz) and silt	4 metres from large rocks	13/10/2016 [500mm.] 5/12/2016 [out of water at water's edge with lid off]
3	Site 3 - Llangower	SH 90167 32028	Bunker	Irregular sized stones and silt	17	13/10/2016 [750mm.]
4	Site 4 - Pentrepiod	SH 89696 31570	Bunker	Vegetation (<i>Callitriche</i>) in gritty silt with occasional loose stones & rubbish	6.3 metres from strand line	13/10/2016 [500mm.] 5/12/2016 [out of water]
5	Site 2 – Glan Llyn camp site	SH 88944 32017	Bunker	Silt, cobbles & boulders POOR Visibility	17 metres along fence from gate post	17/10/2016 [500mm.]
6	Site 1: North Pier Between 1 & 7	SH 91984 35437	Shell	Irregular sized, Loose, partly rounded stones above impacted silt with cobbles embedded	19.7 metres from reeds (=15.7m from rock)	13/10/2016 [750mm.]
7	Site 1 – North Pier	SH 91988 35429	Shell	Irregular sized, Loose, partly rounded stones above impacted silt with cobbles embedded	NOT MEASURED Approx 21 metres from reed bed	13/10/2016 [1 metre]
8	Site 3 - Llangower	SH 90165 32029	Shell	Short Vegetation on silt	21	13/10/2016 [1 metre]
9	Site 4 - Pentrepiod	SH 89696 31576	Shell	Short vegetation (5mm long <i>Callitriche</i> fronds) in silt with occasional stones & sunken wood	14.4 metres from strand line	13/10/2016 [750mm.approx] 5/12/2016 [230mm]
10	Site 4 - Pentrepiod	SH 89699 31583	Shell	Short vegetation (10mm long <i>Callitriche</i> fronds) in silt with occasional stones & sunken wood	22 metres from strand line (sill)	13/10/2016 [1 metre] 5/12/2016 [500mm]
11	Site 2 - Glan Llyn camp site	SH 88949 32013	Shell	Silt with some stones POOR Visibility	22 metres along north of fence line	17/10/2016 [750mm.*]
12	Site 2 - Glan Llyn camp site	SH 88954 32009	Shell	Mostly silt with some stones POOR Visibility	(28 .2 metres) 5.2 metres out into the lake from the end of the fence	17/10/2016 [1 metre*]
13	Site 1A Fronfeuno carpark	SH 91724 35119	Shell	Loose jagged stones	9	17/10/2016 [750mm.*]



Refuge types

Left and above left are 'bunker' style refuges (intended for shallow water) shown with lid open and closed. Various details including a fine mesh impression are incorporated into the surface of the material to help measure snails from photographs.

Above is a 'shell' style refuge to be sited in deeper water

Figure 3: Refuge types. These were made by sculpting a clay original and casting it to produce a rubber mould and subsequent concrete copies incorporating limestone to increase the calcium content and make them more 'attractive' to snails.

Installing the refuges and an initial investigation of three sites has quickly begun to reveal useful and interesting information. For instance:

Notes from 5th December 2016

It became evident on 5th December 2016, with lower water levels, that it really is feasible to map sections of lake bed/shore and recognise areas on subsequent visits and that the objects on it are meaningful. The logs had stayed where they were placed and were easily weighed down.

Site 1 - North Pier SNPA office

With the lake level as it was, the area surveyed in 2014 was out of the water. No *Myxas* were found in these areas but only 10 square metres was searched near the shallowest refuges and it was not as thorough as it could have been due to cold and time constraints.

However, at the waterline, we quickly started to find *Myxas* quite easily (see Appendix B on page 40), strengthening the hypothesis that it follows the water or is wiped out as the water recedes (probably elements of both).

I wanted to make wooden lids to go alongside the concrete refuges but had to make do with the wired logs for now as the season was pressing on but the one at North Pier was already occupied by several snails (not *Myxas* (probably *Physa*) although *Myxas* was found within a metre) and what looked like a clutch of sibling bullheads (*Cottus gobio*) still living gregariously. The logs at the other sites were left in situ until the next visit.

I was interested to see the vegetation amongst the stones at North pier which I had not noticed while wading or snorkelling. It appears to be a *Callitriche* that has either been cropped by fishes or waterfowl or wave washed away.

Llangower

At Llangower I photographed the site but did not search for *Myxas*. The shallowest refuge had been opened but not damaged. With the water gone, it was very interesting to see the amount of debris along that shore and the detail of lake bed between Llangower and Pentrepiod where there is scope for more refuges which would be easy to access but unlikely to be disturbed.

Pentrepiod

Pentrepiod was accessed by kayak at the time of installation but unusual winds from the north east were blowing down the length of the lake causing wave action which is very unusual on the northern side of the peninsula (confirmed by Arwel Morris). It was thought that the refuges may have been placed a few metres away from the desired locations but the investigation on 5th December 2016 revealed them to be correctly placed.

As surmised in the brief visit in 2014, this is a good site for *Myxas*. Snails seen there were easier to find and larger than at North pier. We found them on wood in 2014 and in the last visit and in multiples. At other sites they tend to be found under stones resting on other stones but at Pentrepiod they are also found under stones and wood resting on the silt (although the silt is quite gritty there which may help facilitate water movement and snail access beneath) and the water plants (*Callitriche* again) are stronger and denser in foliage. I think the combination of shelter from south west wind and waves and from the colder river water makes Pentrepiod good for *Myxas*.

Figure 4: Installation of refuges with equipment and practical considerations.



A lightweight working platform, kayak and floating boxes facilitate installation and inspection of the refuges by providing mobile and fixed work stations.



Wetsuit, snorkel and mask allow easy viewing and manipulation of the refuges when they are submerged as well as the surrounding habitat.



Transporting refuges by kayak reduces heavy lifting and allows much of the work to be achieved without disturbing the lake bed or sediment as well as keeping assistants and paperwork dry but within hearing distance.



A cheap ('go-pro' style) underwater camera allows lake bed and other observations to be scrutinised later or to be recorded without the use of a mask or aquascope.

Figure 5: Drafts of Illustrations in production for public and landowner engagement.

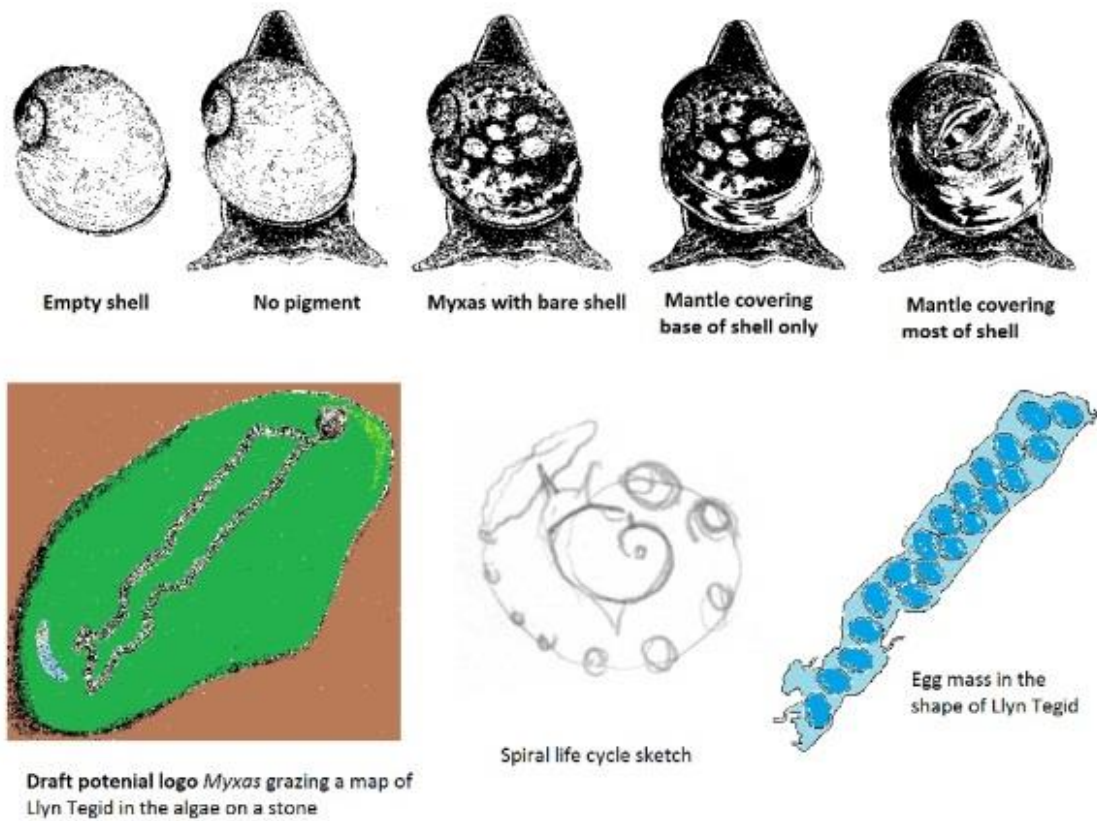


Figure 6: Three dimensional material for public engagement and other awareness work.



Myxas shells are very delicate and difficult to handle. It is difficult to see the shell on a live healthy snail because of the glutinous covering. A cast has been made from an empty shell for educational purposes.

Additional work

In tandem with the field experiments two conservation initiatives are being progressed:

Captive breeding and research

Myxas is being bred in both indoor and outdoor containers and any notable observations recorded. It is hoped that comparative studies between captive and field work will yield useful information for *Myxas* management and conservation.

Interpretation and public/landowner engagement

(See Figure 1 on the cover page and Figure 6)

Steps are underway to develop a body of work for interpretation and public engagement. Discussions with Arwel Morris (SNPA Lake Warden) have confirmed SNPA interest in including *Myxas* in school sessions and having a display of live snails in the lecture room. Arwel has produced a blog based on this work. Interpretative materials being developed are:

- A large collection of photographs of *Myxas*, its life cycle and habitat and associated conservation activities
- Life-size cast of a *Myxas* shell
- Models of *Myxas* and its life cycle
- Illustration of *Myxas* life cycle
- Illustrations of *Myxas* with and without the glutinous mantle to provide graphic explanation of the snail's morphology
- Logo and branding type material
- A simple care system and protocol for keeping captive *Myxas* at room temperature.

6. Discussion

This is a very early stage of this project but the objective of producing and installing the refuges is complete.

I would like to continue with more concrete refuges but I am now keener than ever to try wood and to experiment with wave action interruption at each site (I think a 2 metre square plank frame weighed down at each site with one corner facing into the waves to deflect them). This should be simpler than concrete and easier to investigate. I think wave action is a double-edged sword in that it helps create an easy food supply but also makes life difficult and is one reason why *Myxas* hides under stones. After two weeks in captivity they don't hide anymore and I think if they were avoiding predators they would carry on hiding but they come out because they are responding to changed conditions (less water movement?). I think the rising and falling water level is also a double-edged sword that creates habitat but also puts strain on the population (possibly keeping it at a manageable level so snails don't compete with each other). I think competition with other snails would be a factor on different geology and this may be *Myxas*' niche - it likes calcium and warmth but struggles where other snail species are doing well or predator populations are high. They must have some defence against fish (especially bullheads). My experience of fish with snails (not thin-shelled *Myxas* though) is that adult snails are left alone as are egg masses but newly emerging snaillets disappear. I've seen fish take snails into their mouths and spit them out (in apparent disgust) and I suspect this kills small snails too. So I think the drop in water level in winter may create a shallow (10mm deep) intricate (lots of stones and gaps and puddles) zone on a new shoreline (with a wider shore creating a buffer against terrestrial predators) where fish are largely absent but small snails have a fairly predator free existence at a very important stage. So the narrow migrating shoreline may be a reliable nursery zone. Speculation but something to look for and I think it will tell us where (what depth) to place large rocks or other refugia to enhance *Myxas* survival around the lake (see Figure 7).

Speculative chart of Llyn Tegid habitat and its possible importance to Myxas

These ideas are subject to change as new information emerges but the aim is to discover what happens in different zones so appropriate management is understood and survey is easy and informative

Highest water level	<p>This is an opportunist zone and snails venturing here are at risk of predation from terrestrial predators and water shrews as well as fish and desiccation but it may offer an essential additional niche when water levels are high.</p>	<p>Upper shore, littoral zone and sill. Stony & wave washed</p>
Medium high water level	<p>This dynamic zone could be the critical area of very shallow water that allows hatchling snails to survive to adulthood by migrating back and forth. The dynamic forces keep competitors and predators to a minimum</p>	<p>Usually shallow water 10 to 20mm deep but regularly exposed as shore Stony & wave washed (some short vegetation in certain areas)</p>
Medium low water level	<p>This area is probably the most reliable for Myxas breeding and growth with occasional wave action managing the habitat and shallow water keeping fish to a minimum for some of the time</p>	<p>Usually 20 to 500mm deep but sometimes exposed Stony with patches of vegetation</p>
Lowest water level	<p>Usually deep water, with lower light levels and minimal wave action. This area is the last refuge when lake levels drop but with a high risk of predation by fish and poor habitat opportunities</p>	<p>Permanent water in living memory A less even surface than the above with more frequent large stones and extensive areas of vegetation</p>

Figure 7: A draft living discussion document intended to examine the challenges and opportunities for *Myxas* at different depths and distances to be extended to include gradient and a measure of shelter/exposure.

7. Recommendations and Proposals

- Continue producing refugia and surveying them for at least 3 years to acquire a clearer picture of *Myxas* behaviour and ecology and the zones it uses and thrives in. The author is keen to continue this work but the material and suggestions are in place for others to participate and build up expertise on site.
- In the above work, experiment with the effects of wave action on *Myxas* populations in the field.
- Seek out opportunities to create additional self-sustaining populations of Llyn Tegid *Myxas* to insure against the extinction of this gene pool and strengthen the status of *Myxas* in the UK.

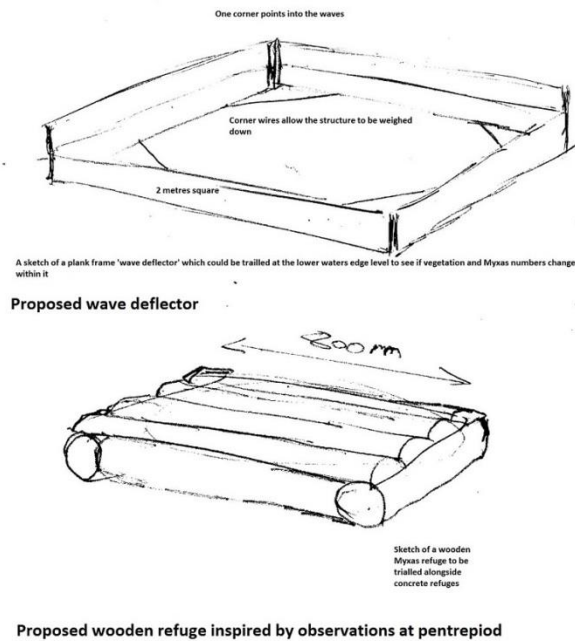


Figure 8: Sketches of devices proposed to further investigate *Myxas* behaviour.

8. Acknowledgements

Many thanks to Dr. Mike Howe (NRW) for approving the project and finding funds for the production and installation of the refuges. Thanks also to Hannah Shaw and Naomi Ewald of Freshwater Habitats Trust for finding funding to support re-visiting the refuges and other work. Dr. Martin Willing is also thanked for supporting the project and making useful comments on the proposals as well as providing an 18 year backdrop of information on Llyn Tegid and its snails! On the practical side, thanks are very much deserved by Arwel Morris (Snowdonia National Park Authority) and the lake wardens and supervisors for granting access and giving advice and up to the minute information on lake conditions and for helping secure access permissions to certain lake sites. Mr. Idris Hughes of Gwynant, Llangower very kindly gave permission to work on the lake shore on his land (the best site for *Myxas* so far!) to undertake survey work, as did the owners of the Glan Llyn campsite. The Hughes family (Kerry, George and Ben) have been both helpful and tolerant throughout including kayaking with a marker tree in a concrete base as a destabilising passenger and taking web cam photos from home while we worked within sight of the warden's office to get an idea of lake levels in the future. Finally, many thanks to Alice Eckland-Walker for a very prompt translation of the summary.

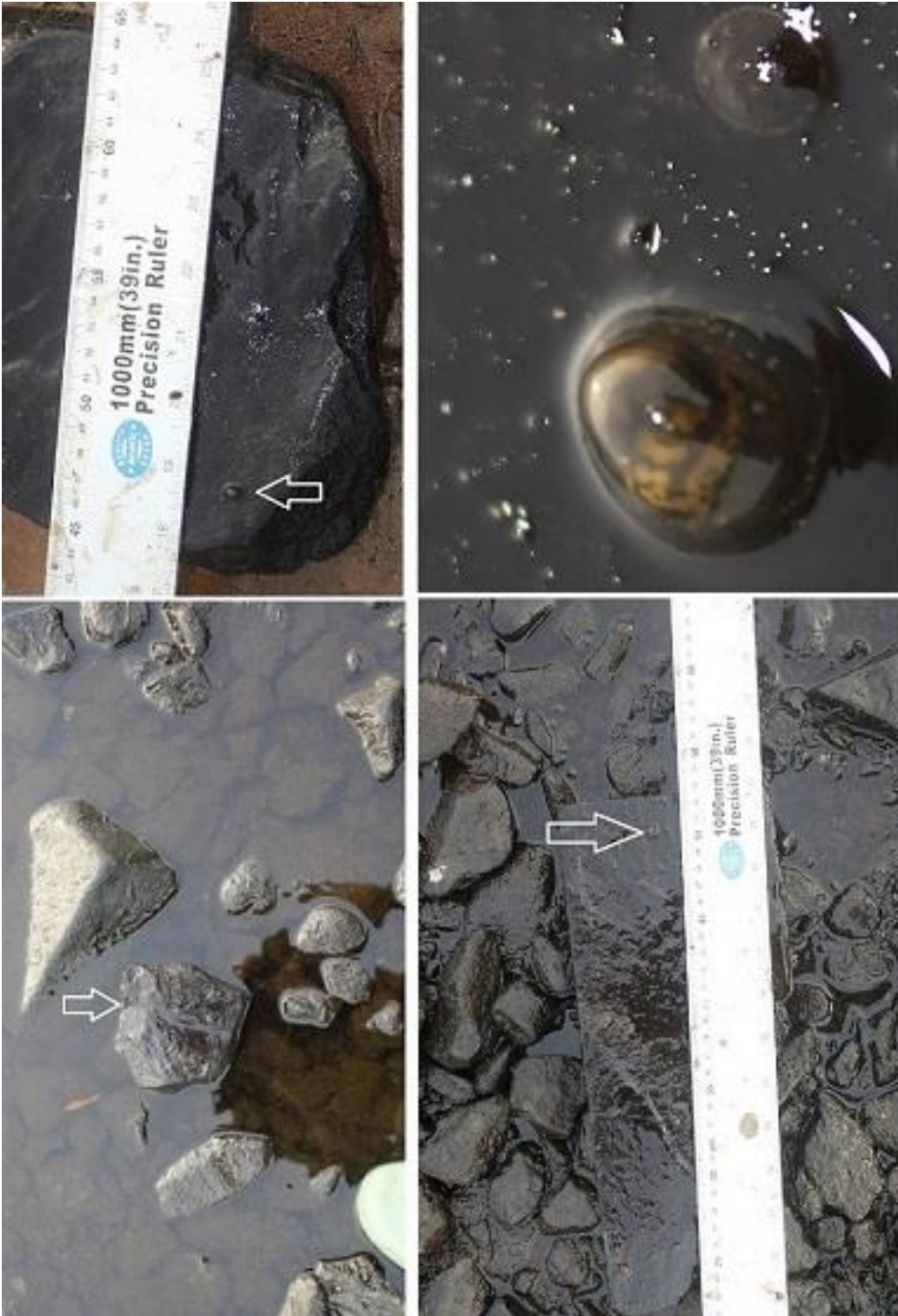
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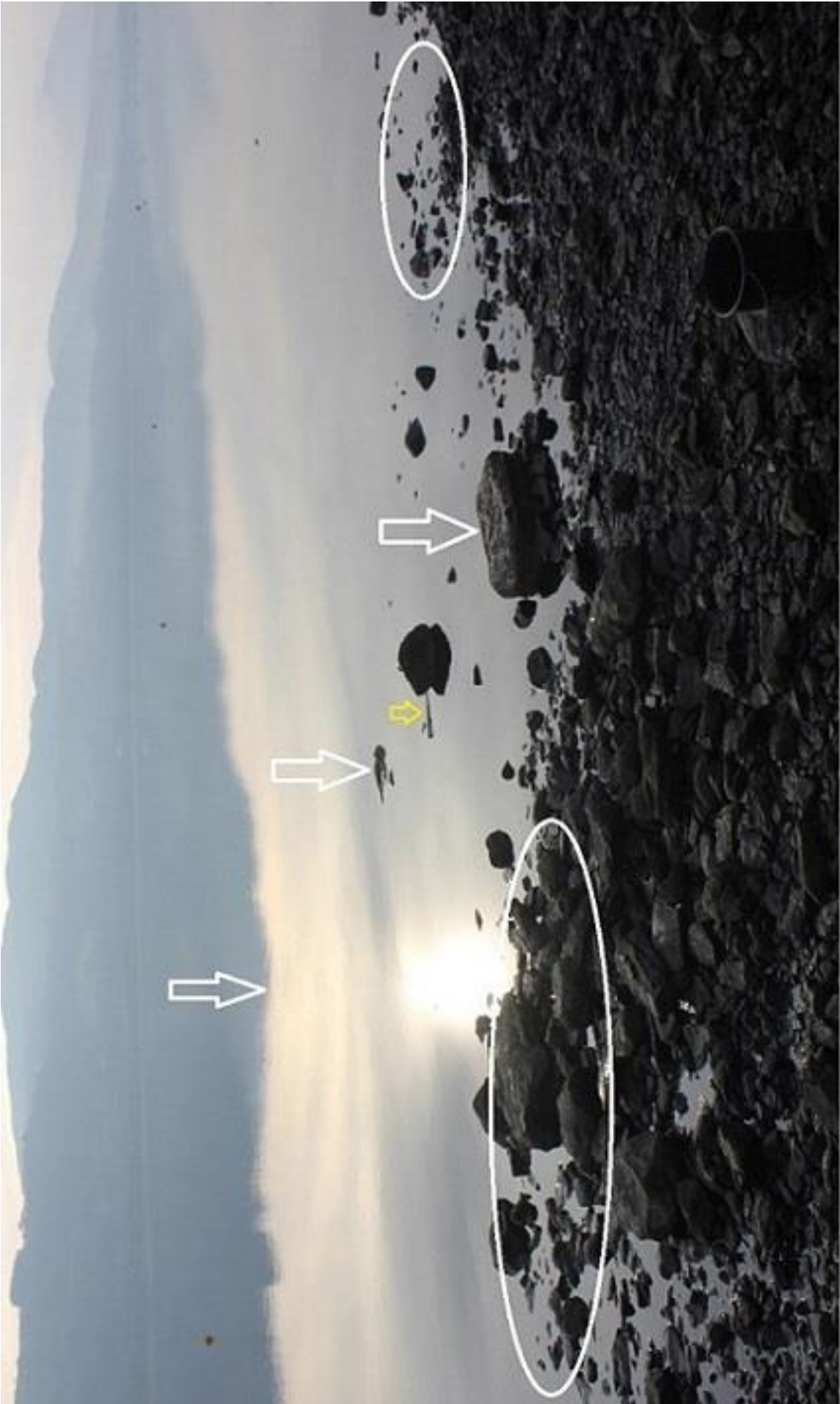
10.1. Appendix A. Annotated site photographs



This is the lake bed (beach) near the north Pier in the area where we surveyed and collected *Myxas* in October 2014 (currently out of the water) I believe the plant is close cropped (or stunted?) starwort (*Callitriche*) but have not investigated it closely. We could not find *Myxas* under any of the stones out of the water.



Myxas under stones around refuges near North Pier - 7 were found within 1 metre of the shallowest refuge on 5/12/2016



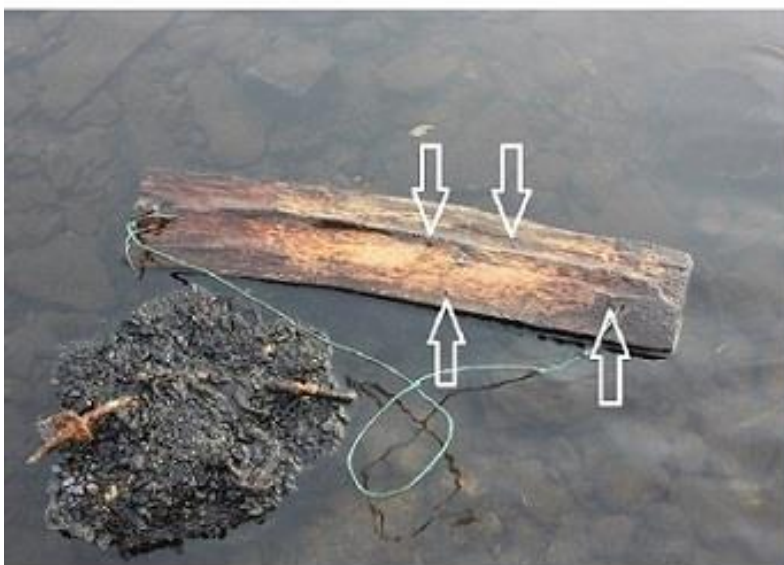
North Pier Site on 5/12/2016 - The white arrows show the three refuges descending into deeper water. The yellow arrow is the log. The circled areas appear to have concentrations of Myxas which I think have migrated with the receding water.



The open refuge at the shallowest point at **Site 1 North Pier** just over one month after installation (in 500mm deep water)



Site 1 North Pier with the marker stone and refuges (shown with white arrows) viewed from the deepest refuge which is under water. The yellow arrow is a sunken log weighed down with rocks.

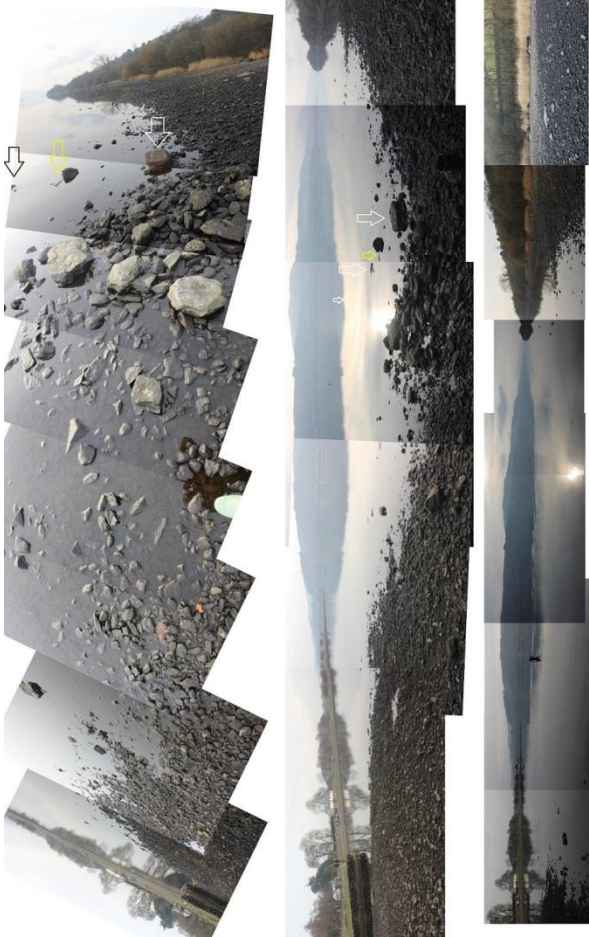


Top left: Myxas under a stone close to refuge.

Bottom left: One of the logs I am attempting to sink with Physa living beneath it.

Top right: Bullhead (6 or so juveniles were living under the log)

Bottom right: Physa beneath log



Site 1 North Pier 5/12/2016 - The area where Myxas was surveyed and collected in October 2014 is out of the water
White arrows indicate the refuges and the yellow arrow is the weighted-down log.



Site 1 North Pier (Dr. Martin Willing's 'Site 6') viewed on 5/12/2016 and 27/10/2014 when the area that is exposed in the more recent photos was under water and occupied by Myxas recorded in the survey.



Site 1A Llanycil/Frofeuno Carpark with the marker tree labelled. The refuge is sited directly out into the lake from the tree's trunk.



The refuge on the lake bed on 17/10/2016



The marker tree and carpark as viewed from the site of the refuge.



Site 2 Glan Llyn showing the author in standing on the deepest refuge on 17/10/2016



Glan Llyn Farm and the marker fence viewed from the site of the deepest refuge.



The lake bed at Glan Llyn before work



The shallowest refuge (Number 5 'bunker style') at Glan Llyn photographed after the silt had settled.



Silt disturbance during installation at Glan Llyn



Site 2 Glan Llyn is Dr. Martin Willing's 'Site 7'. *Myxas* has never been recorded here. There is a lot of amenity activity as well as silt deposition from the nearby rivers.

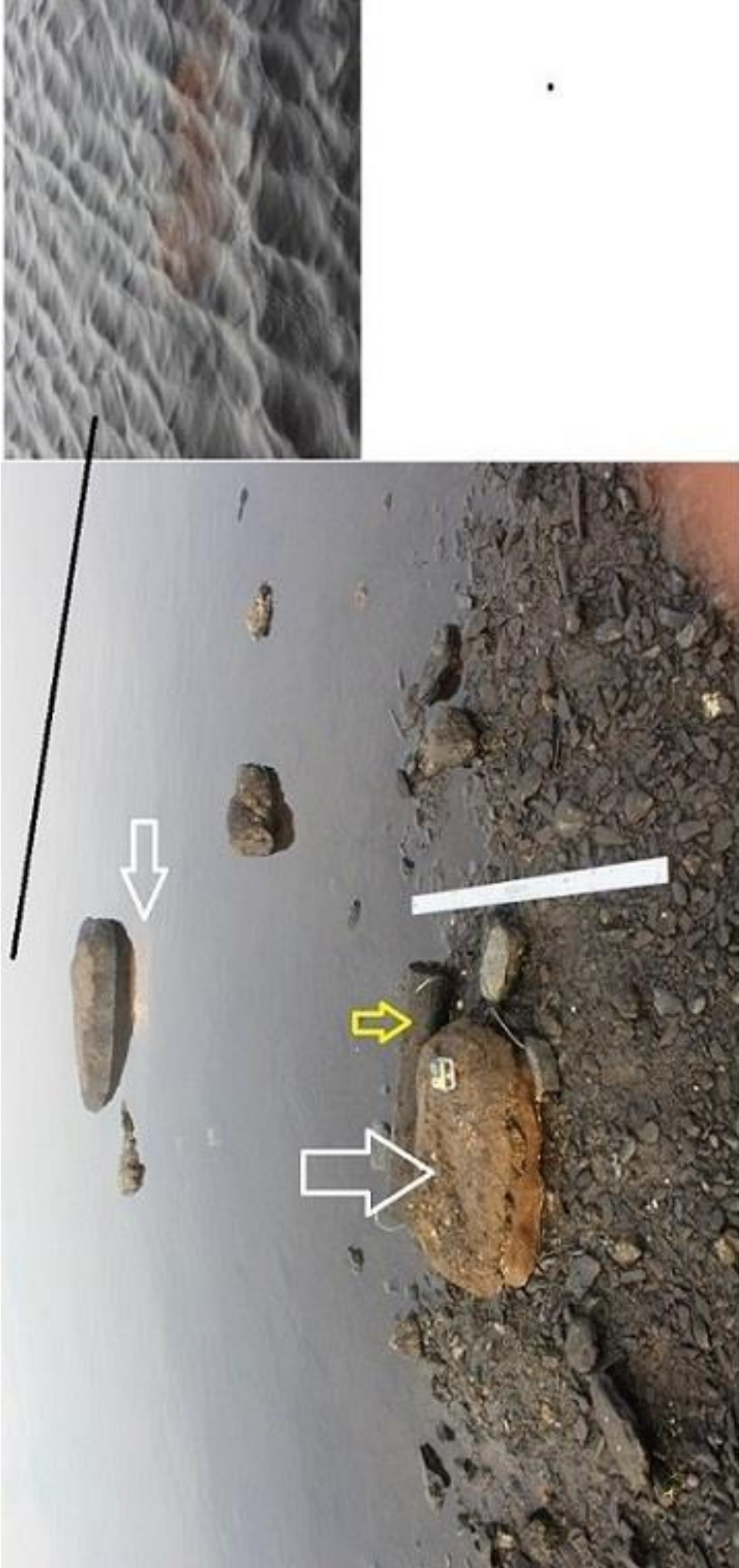


Llangower 5/12/2016 - The top two photographs show refuges 2 and 3 (bunker type). There is another refuge (shell type) further out. The bottom picture is the pair of stones used as a marker. The refuges are directly out into the lake from this point.



Llangower photographed from the marker stone





Llangower showing shallow, mid and 'deep' water refuges on 5/12/2016. The yellow arrow shows the site's 'log' weighed down to become saturated.



Llangower 5/12/2016 showing marker stone and refuge locations



Llangower viewed from the pier 5/12/2016 showing marker stone and refuge locations



Site 4 Pentrepiod 5/12/2016 showing the shallowest refuge exposed





Pentrepid 5/12/2016 - The curved line is actually a straight line going out from the tree through the refuge sites. The snails are bigger and more abundant here and are found on wood as well as stones and on stones resting in silt and weed. I think they benefit from the shelter from cold river water from the north and the prevailing wind and subsequent reduced wave action.





Site 4 Pentrepiod 5/12/2016 showing the marker tree and the positions of the refuges. Llangower Peninsula and pier are visible in the distance.



Refuge Number 4 at Pentrepiod shown closed and open with surrounding terrain.



Pentrepiod mid & deep water refuges (9&10). The marker tree is shown with black arrow and shallow refuge with a white arrow.



Almost every object resting in water at Pentrepiod has *Myxas* on it (shown with arrows).

10.2. Appendix B: Table of *Myxas glutinosa* observations during the installation of refuges.

Location	Grid reference	Date	Number of <u>Myxas</u> found	Deliberate search conducted?	<i>Myxas</i> found here on previous occasions?
Site 1 – North Pier	SH 91983 35442	13/10/2016	1	Yes, to find the minimum depth where <i>Myxas</i> was present.	Yes, common
1A Fronfeuno carpark	SH 91724 35119	17/10/2016	0	No	Yes, common
Site 2 – Glan Llyn camp site	SH 88944 32017	17/10/2016	0	No	No
Site 3 - Llangower	SH 90168 32028	13/10/2016	0	Yes	Not by author
Site 4 - Pentrepiod	SH 89696 31570	13/10/2016	0	No	Yes, very common
Site 1 – North Pier	As above	5/12/2016	0 above the water level. 0 in shallowest & mid-depth refuges. 7 under stones within 1 metre of shallowest refuge	Yes, to assess whether <i>Myxas</i> was present above the water level.	As above
1A Fronfeuno carpark	As above	5/12/2016	0	Not visited	As above
Site 2 – Glan Llyn camp site	As above	5/12/2016	0	Not visited	As above
Site 3 - Llangower	As above	5/12/2016	0	5 stones turned on the lake edge and refuge investigated	As above
Site 4 - Pentrepiod	As above	5/12/2016	8 on a small branch and 3 stones within 10 metres of the shallowest refuge. 0 found in the refuge which was out of the water		As above
Site 1 – North Pier	As above	26/1/17	0	Yes	As above
1A Fronfeuno carpark	As above	26/1/17	0	No	As above
Site 2 – Glan Llyn camp site	As above	26/1/17	0	Yes	As above
Site 3 - Llangower	As above	26/1/17	0	Yes	As above
Site 4 - Pentrepiod	As above	26/1/17	0	Yes	As above

11. 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 118108.



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