

A targeted survey of *Najas flexilis*



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**Department of
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A targeted survey of *Najas flexilis*

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Roden Ecology and Eireco

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Executive Summary

14 lakes with old or unconfirmed records for *Najas flexilis* were examined in July, August and September 2014. In addition two sites with very small populations were examined. Survey was by Snorkel with boat cover or by a pair of Snorkelers. Five extant populations were recorded. Three former populations appear to be extinct due to eutrophication. Six records are rejected as no plants were found and the original records are inconclusive. It was not possible to ascertain the status of two populations.

In addition full species lists were made of the macrophyte flora at each site. Several very rare species were recorded including *Nitella gracilis*, *N. spanioclema* and the fern *Pilularia globulifera*.

Acknowledgements

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Introduction

Background

Najas flexilis is a rare water plant within the European Union, consequently it is listed in Annex II of the 1992 Habitats Directive, as a species in need of protection in the member states. Ireland and Scotland are the species' main centre of distribution in Europe, although it is widespread in North America. The plant is a small annual which grows on the bottom of lakes, so it is difficult to find and is often overlooked. Year to year fluctuations in seed germination may also result in large variations in annual population size.

The plant is most abundant in mesotrophic loughs often within a few kilometers of the seacoast, but few populations are found either in truly oligotrophic lakes or in hard water loughs on limestone. A wide range of associated macrophytes have been recorded in Ireland but two species, *Isoetes lacustris* (often an indicator of oligotrophic water) and *Potamogeton perfoliatus* (usually found in more base rich water) have been found in many surveyed sites. This overlap of contrasting species highlights the intermediate nature of *Najas* lakes. Other macrophytes such as *Hydrilla verticillata*, *Callitriche hermaphroditica*, *Potamogeton obtusifolius* and the charophyte *Nitella confervacea* which are scarce along the west coast of Ireland, also appear to favour this type of mesotrophic lough. *H. verticillata* is only known from two Irish lakes both of which also contain *Najas flexilis*.

While the number of lakes containing *Najas* has increased steadily since the 19th century (Table 1) it is thought that this reflects increased recording rather than an increasing number of populations. In fact 17 populations have been recorded but have not been seen in more recent surveys.

Table 1. The increase in recorded populations of *N. flexilis* in Ireland from 1875 to 2013.

Year	1875	1900	1925	1950	1975	2000	2003	2004	2005	2013
No. of records	2	7	8	12	17	38	41	44	49	64

Of these 17 sites the species is thought to have become extinct at three (Ibby, Namanawaun and Fada) but the status of the remaining 14 stations is unclear. Roden (2005) examined many of these sites and suggested that their vegetation indicated sub-optimal conditions for *Najas*. Consequently populations may be small or localised, and thorough and time consuming searches may be necessary to relocate these populations.

In 2014 NPWS commissioned a survey to investigate the status of 14 unconfirmed records of *Najas flexilis* and to resurvey two sites where very small populations had been noted by Roden in 1999 and 2005. This report presents the results of this survey.

Survey methods

16 lakes were surveyed these are listed in table 2. Survey method in all cases involved one snorkeler with boat cover or for the lakes inaccessible to boats, 2 Snorkelers working as a pair. Emphasis was placed on covering as much ground as possible until *Najas* populations were located. Searching was concentrated in the euphotic zone (usually <4.0 m depth) and conducted for as long as time permitted. . All species encountered were recorded. Notes were made of euphotic depth, substrate type and any evidence of eutrophication (weed fouling, sediment etc.). Unusual species were collected and preserved as herbarium specimens. Photos were taken using an underwater camera (Lumix DMC-FT3).

Where possible (i.e. boat cover available) exact positions of snorkel sites were recorded by GPS (Garmin GPS map 60CSx), otherwise positions were calculated using landmarks and photos by snorkelers in the water. As many lakes (7) were boat inaccessible, accurate secchi readings were not possible, instead euphotic depth (deepest point at which macrophytes were encountered) was measured using a SCUBAPRO depth meter accurate to 0.1 m.

The size, location, depth, substrate, flowering condition , presence of seeds, of all *Najas flexilis* populations encountered were noted. A 2x2m relevé was taken using the Braun Blanquet scale, but in most cases few companion species were seen. Given the low species number and lack of variation, it was not considered useful to collect more than one relevé per population. Where relevés of *Najas* populations had been taken in previous surveys, these were resampled. Herbarium specimens of *Najas flexilis* were taken from all populations encountered and will be deposited in National Botanic Gardens Herbarium.

Data analysis at lake level

A spreadsheet in Excel was prepared listing all species present or absent in each lake. This was then merged with data from an existing database prepared by C. Roden in 2007 for NPWS and amended with data collected in 2013 in a separate commercial survey. In addition to lakes with *Najas* populations, a number of additional lakes with no recorded populations of *Najas* were included for comparison (data from Roden 2013). The data were analysed using the PC-ORD multivariate statistics package.

Two NMS analyses were run, one using all the spreadsheet data and in the second with *Najas* presence and absence data excluded. Both plots were generated using the “slow and thorough” option. The first produced a 3 dimensional solution (with final stress of 0.182, instability of .00161 after 400 iterations). The output is shown in figure 1 which shows a species ordination on the first 2 axes, using whole lake presence or absence data.

The second analysis was run excluding *Najas* presence or absence data, this was done to see if lakes known not to contain *Najas*, could be separated from lakes known to include the species. It was thought that including *Najas* data would bias the result. The resulting solution produced a three dimensional plot with final stress of 0.198 and final instability of .0019 after 400 iterations. The first two axes plot is shown in figure 2.

Lake presence or absence data were grouped using the TWINSpan method in PC-ORD. A frequency table was constructed showing species frequency (II>19.99%...V>79.99% frequency) in the four groups produced by the first 2 divisions of the lake data (see table 5).

Analysis at relevé level

Where relevés of *Najas flexilis* were taken these were placed in a Turboveg ready excel spreadsheet. In addition relevé data included in Roden (2007) were added to

relevés collected in this survey and analysed to describe the plant groups in which *Najas* grows in Irish lakes. A problem in the multivariate analysis of this data is the very small number of species per relevé. A frequency table, based on a TWINSpan analysis as described above, was constructed and is shown in table 6.

An updated version of the 2007 spreadsheet mentioned was submitted with this report.

Herbariums in DBN and TCD were examined for specimens of *Najas flexilis* and where possible previous recorders of *Najas flexilis* consulted about older records.

Results

The surveyed sites

The lakes listed in Table 2 were surveyed.

Table 2. The sites surveyed for *Najas flexilis* in this survey

Site	First record	Last record	Date surveyed	GRID REF	County
Adoolig	1985	1985	13/08/2014	V64627390	Kerry
Annillaunlughy	1977	1977	26/08/2014	L68464220	Galway
Cloonee	1957	1957	14/08/2014	V81076417	Kerry
Corrib	1986	1986	22/07/2014	L98225122	Galway
Fin Lough	1937	1937	21/08/2014	L84216576	Mayo
Glenade	1977	1977	08/08/2014	G82584594	Leitrim
Keel Lough	1999	1999	19/08/2014	F64810544	Mayo
Kylemore	1977	1977	27/08/2014	L77285828	Galway
Lettershask west	1975	1975	29/07/2014	L62904356	Galway
Long Range	1994	1994	05/09/2014	V93368378	Kerry
Muckross Lough	1976	1976	03/09/2014	V95008540	Kerry
Nalawney	1977	2010	26/08/2014	L69564157	Galway
Sruffauncam	1975	1975	04/08/2014	L71154449	Galway
Truska	1975	1975	29/07/2014	L67754053	Galway
Tully	1978	2004	27/08/2014	L68756186	Galway
Upper lake	1906	1994	04/09/2014	V89748159	Kerry

In the following sections a short account of each lake survey is given under the headings;

History of the record

Survey results

Present status of record

For each account a map based on the OSI 1:50000 series is presented. On it, the approximate snorkel paths of the survey are shown in red, location of *Najas* populations in green, other areas of interest in blue. Extinct *Najas* population are illustrated in magenta. As some lakes were previously examined by CR, older snorkel paths are also shown in orange.

Lough Adoolig

Grid reference V64627390

Date of survey 13/08/2014

Result No *Najas* population found

Survey method two snorkelers without boat cover



HISTORY

A drift specimen was reported by Dr T. Curtis in 1985, a subsequent shore survey in 1995 (NPWS unpublished) did not relocate the species.

2014 SURVEY

The western part of the lake was surveyed by CR and PM. Water visibility was good and euphotic depth was 6 m. The lake lies in a rocky basin which shelves steeply with a bottom of large boulders, cobbles and gravel grading to silt at depth. Vegetation was typical of oligotrophic water with *Isoetes lacustris*, *Littorella* and *Lobelia* abundant. At greater depths (2m) *Juncus bulbosus* was dominant with much *Callitriche hamulata*.

An unusual feature first noted by P. Murphy, makes the lake of exceptional conservation importance. At 2m depth in the NW sector (shown blue in map above), dense populations of two rare charophytes occur. The species grow in concentric rings about a small area of filamentous algae. The inner ring which is coloured a bright orange colour, presumably due to iron precipitation, consists of *Nitella gracilis*. Surrounding the *N. gracilis* is a *Nitella* species which closely resembles *N. spanioclema*. Both taxa are abundantly fertile. The slightly colder water in the filamentous algae zone suggests an underwater spring which is iron rich. *N. gracilis* is known in Ireland from one site in Co. Wicklow, about 10 sites in Britain and is uncommon in western Europe. *N. spanioclema* is a controversial taxon, largely because material is only known from two lakes in Donegal.

Other taxa of note include a large form of *Potamogeton berchtoldii* only encountered in Co. Kerry during this survey.

A short examination of lough to the west of Lough Adoolig was also conducted. The lake basin is very shallow and floored by peat and sand, but the only species encountered were *Juncus bulbosus*, *Isoetes lacustris*, *Potamogeton natans* and *Lobelia dortmanna*.

PRESENT STATUS

The only evidence for the occurrence of *N. flexilis* at Lough Adoolig is a single report of drift material which has not been confirmed in this or a previous shore survey. Vegetation suggests an environment too oligotrophic for large populations of *Najas*. It is suggested that the record be excluded from the Irish database until further

evidence is found. Given the importance of Lough Adoolig, further visits are likely in coming years.

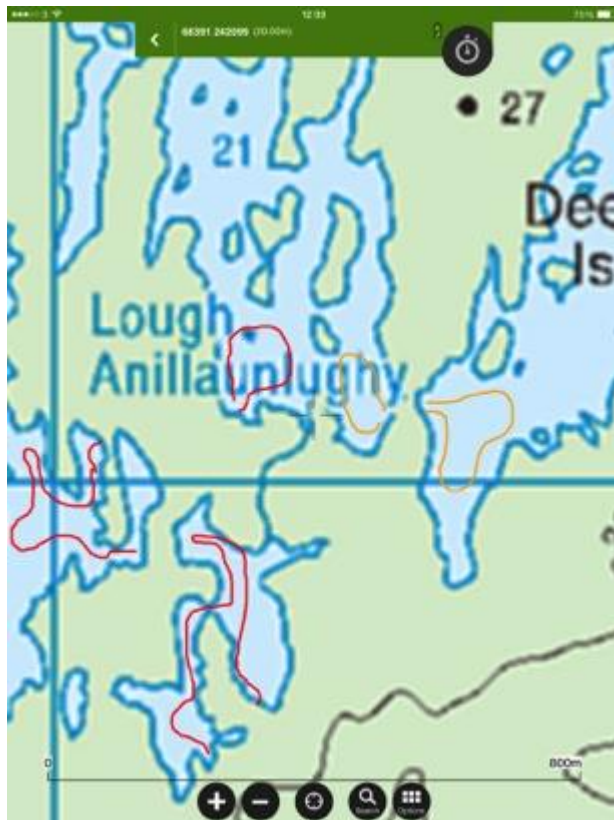
Lough Anillaunlughy

Grid reference L68464220

Date of survey 26/08/2014

Result No *Najas* populations seen

Survey method two Snorkelers without boat cover



HISTORY

J. Ryan encountered population(s) of *Najas flexilis* during fieldwork in the southern part of Roundstone bog in 1977. In the absence of GPS however the exact location was not established but was thought to be Lough Anillaunlughy. J. Ryan (pers. com.) suggests that a neighbouring lake might be the correct location.

2014 SURVEY

CR and PM were joined by J. Ryan and H. Heuff on this survey. A number of possible sites were examined by the party (see map above) but all had a typical oligotrophic vegetation of *Isoetes*, *Lobelia*, *Eriocaulon* and *Juncus bulbosus*. Water clarity was excellent and a euphotic depth of 4-5m was noted. Lake bottom is largely sand, fine silt occasional boulders and some peat. Water depths of more than 5 m show that the lakes lie in rock rather than merely peat basins.

PRESENT STATUS

The only evidence for the occurrence of *N. flexilis* in the southern part of the Roundstone bog is a single report which has not been confirmed in this or a previous survey. Vegetation suggests an environment too oligotrophic for large populations of *Najas*. It is suggested that the record be excluded from the Irish database until further evidence is found.

It should be noted that the species does occur in nearby Lough Nalawney. This lake is partly surrounded by rock outcrops and cliffs of the Errisbeg Gabbro, this is not the case for the lakes lying on the flat expanse of the bog to the north. The eastern shore of Lough Bollard to the east of Anillaunlughy is also bordered by similar rock outcrops and records of the lime requiring *Adiantum capillus-veneris* from there (Webb and Scannell 1983) suggest less oligotrophic conditions.

There are no obvious threats to the lake.

Cloonee Lough

Grid reference V81076417

Date of survey 14/08/2014

Result No *Najas* population found

Survey method snorkeler with boat cover



HISTORY

N. flexilis was first recorded in 1957 when D.A. Webb found a drift specimen which is now in the TCD herbarium. The location given is Cloonee lakes which could include any one of the three inter linked water bodies. Dr M. Wyse Jackson, on the basis of a grid square reference in the first Atlas of the British and Irish flora (Perring and Walters 1962) suggests that the North shore of the middle lake is the most likely spot where the drift material was found. Despite several subsequent surveys, including snorkel surveys by CR in 2004/05 no further material has been located.

2014 SURVEY

Cloonee Middle is located in a rock basin of Old Red Sandstone. A maximum depth of 7m was noted with a euphotic depth of 5.1m. Water is slightly peat coloured. Vegetation is typical for an oligotrophic lake with *Isoetes lacustris* and *I. echinospora*, *Lobelia* and *Eriocaulon*. At depth *Nitella translucens* is abundant. The only unusual taxon was a very large (1.0m) form of *Potamogeton berchtoldii*.

PRESENT STATUS

The exact status of *N. flexilis* at Cloonee is difficult to establish. The herbarium specimen proves the plant occurred in the lake system but in the absence of exact location details, one cannot be certain about which lake. All three lakes have been examined by snorkeling (CR) since 2004 and all three have vegetation which is marginal for *N. flexilis*. But as the example of Upper Lake Killarney (see below) shows small isolated populations can occur in such habitats. While some damage may have occurred the lakes are in good condition. A species list given in Praeger (1934) matches closely that produced in 2014, indicating little change in the last 80 years or more. The probability is that a small population still occurs in either the Cloonee lakes or just possibly Lough Inchiquin, further upstream.

There was some evidence of ecological damage with very localized signs of eutrophication in the northwest corner and rock clearance along the north shore on the day of the survey.

Lough Corrib

Grid reference L98225122

Date of survey 22/07/2014

Result No *Najas* population found

Survey method snorkeler with boat cover



HISTORY

There is only one record for *N. flexilis* from Lough Corrib. In 1986 Krause identified a few specimens in shallow water in the north west arm of this large lake (Krause and King 1994). No further drift specimens have been recorded nor was it noted during an extensive snorkel survey along the main navigation channel in 2012 (Roden 2012).

2014 SURVEY

Krause and King (1994) indicate that *Najas* was recorded in shallow water near the northwest shore of the lake. This area was examined by snorkeling. As noted by Krause and King, vegetation dominated by *Lobelia* and *Eriocaulon* occur in shallow water with *Isoetes lacustris* at greater depth. Larger species present included several species of *Potamogeton* including *P. perfoliatus* and in one location *Nitella confervacea* (often a companion species of *Najas*). This vegetation can support large populations of *N. flexilis*. In addition isolated plants of the invasive *Lagarosiphon major* were noted as well as large quantities of the Zebra mussel. The euphotic depth was shallow (2m) as was the Secchi reading of 2.75m. A possible site on the eastern shore was also examined without success.

PRESENT STATUS

The evidence of the presence of *N. flexilis* rests on one published record of the species which has never been confirmed. The vegetation of the site is suitable however and frequent companion species such as *Isoetes lacustris*, *Potamogeton perfoliatus* and *Nitella confervacea* were noted. On 13/07/2004 CR surveyed another site on the northwest arm of the Corrib at M032493. He noted a euphotic depth of about 5m and an absence of any signs of eutrophication and similar companion species of *Najas*. By 2012 the northwest arm showed unmistakable signs of environmental damage including dark water, a shallow euphotic zone (2m) and abundant Zebra mussels (Roden 2012). The most probable scenario is that an initially very small population of *Najas* has declined or become extinct due to recent environmental pressure on the lake.

Fin Lough

Grid reference L839657

Date of survey 21/08/2014

Result No *Najas* population found

Survey method two snorkelers without boat cover



HISTORY

The evidence of *Najas flexilis* occurring at Fin Lough rests on one drift specimen collected by a Mrs Gough in 1937 and shown to Praeger (Praeger 1939) the record is supported by a herbarium specimen. No further attempts were made to relocate the population until 2014.

2014 SURVEY

The small size of the lake allowed for an almost complete survey of the euphotic zone. Water clarity was very good and the euphotic zone was at least 4m. The lake has a very deep centre but with a shallow (1-2m) “flange” along the east shore. On the south and west side deep gullies cut through the flange leading to the deeper centre. Exposed mud has a whitish marl like consistency. The vegetation contains several species including *Isoetes lacustris* and *Potamogeton perfoliatus* which accompany *Najas* but no plants were found. Less common species included a large population of *Subularia aquatica* and *Pilularia globulifera*. *P. globulifera* seemed centred around a spring at 1m on the east shore. A small population of Pearl Mussel was noted near the river mouth at the north end.

A drift line survey of the neighbouring Doo Lough yielded *Isoetes lacustris*, *Myriophyllum alterniflorum*, *Lobelia dortmanna*, *Littorella uniflora*, *Juncus bulbosus*, *Chara virgata* (in abundance) and *Nitella flexilis*.

PRESENT STATUS

As in the case of Cloonee, the reliability of the record is not matched by exact details of location. While found in Fin Lough the plant could have come from further upstream in the much larger Doo Lough, as suggested by Praeger. However a short snorkel inspection of that lake at its north end by CR in 2005 yielded only sparse *Isoetes lacustris* growing amongst large boulders in very clear water. The species seen along the drift line also indicate a very oligotrophic lake. In contrast, Fin Lough species do indicate suitable habitat, which led to a very thorough search but without success. In the absence of exact details about location, it is suggested that the record be excluded from the Irish database until further evidence is found.

The presence of the Flora protection order species *Pilularia globulifera* is of note. The lake is in excellent condition with no environmental damage.

Glenade Lough

Grid reference G82584594

Date of survey 8/08/2014

Result No *Najas* found

Survey method two snorkelers with boat cover



HISTORY

This population was documented in Heuff (1984) the exact location and companion species were given. Two snorkeling surveys by CR in 2004 and 2005 did not locate the species in other parts of the Lough.

2014 SURVEY

The survey team included Dr D. Lynn, J. Ryan as well as CR and PM. Using both published data from the 1977 survey and expert knowledge of J. Ryan the exact location of the recorded population was examined. No *Najas flexilis* was found. Water transparency was moderate, Secchi depth was 3.0m and euphotic depth was 2.8m. Species present included *Isoetes lacustris* and *Potamogeton perfoliatus*. The vegetation resembled that of other mesotrophic *Najas* lakes with *Callitriche hermaphroditica*, *Potamogeton gramineus* and *P. lucens*. However *Cladophora* sp. or blanket weed and *Lemna trisulca* were very common. A less expected species *Elatine hexandra* occurred very locally at 1-2m .

In the 1977 survey *Najas* was recorded both in *Schoenoplectus lacustris* beds and at depth. In 2014 Relevés in the same habitat were taken for comparison both sets of data are shown below in Table 3.

Table 3. comparison of 1977 and 2014 relevés from Glenade.

	Reed bed 1977	Reed bed 2014	Deep water 1977 (3 m)	Deep water 2014 2.0 m
<i>Schoenoplectus lacustris</i>	2?	3		
<i>Najas flexilis</i>	+		1	
<i>Potamogeton pusillus</i>	+			
<i>Nitella flexilis</i>	+	(+)	+	
<i>Tolypella glomerata</i>	+			
<i>Callitriche hermaphroditica</i>	+		+	
<i>Chara virgata</i>	+	2		
<i>Elodea canadensis</i>		1	+	
<i>Potamogeton gramineus</i>		1		
<i>Equisetum fluviatile</i>		1		
<i>Menyanthes trifoliata</i>		1		
<i>Potamogeton praelongus</i>			2	
<i>Sparganium emersum</i>			+	
<i>Nuphar lutea</i>				2
<i>Potamogeton x zizii</i>				2

PRESENT STATUS

It would appear that *Najas* is now extinct in Glenade Lough as a thorough search in its known location failed to find any plants. Further searches in the general area were also unsuccessful. Searches in different parts of the lake in 2004-2005 by CR were also unsuccessful. Several species recorded as common in 1977 were not rediscovered including *Potamogeton praelongus*, *Tolypella glomerata* and *Najas* itself. *P. praelongus* is regarded as an indicator of “clear mesotrophic waters” Preston (1995); it was abundant in 1977 at the *Najas* site, it has now also gone indicating a real change in the lake’s ecology. The abundance of *Cladophora* also indicates increased eutrophication. The presence of Zebra mussels further degrades the lake.

Keel Lough

Grid reference F64810544

Date of survey 19/08/2014

Result No *Najas* found.

Survey method snorkeler with boat cover



HISTORY .

On 3/08/1999 CR (Roden 1999) discovered a small number of *Najas flexilis* plants growing at 2 m depth in the southeast section of Keel Lough. They were accompanied by *Fontinalis antipyretica*, *Nitella flexilis* and *Elodea canadensis* in an open community on sandy silt at 2m. Some *Potamogeton perfoliatus* and *P. crispus* were noted at the west end of the Lough. A herbarium specimen was taken and kept by CR. The water was heavily peat stained with moderate visibility.

2014 SURVEY

The same locality was visited in 2014. The vegetation had changed to a dense growth of large (1-2m) *Potamogeton perfoliatus* with an understory of *P. crispus*, *Elodea canadensis*, *Callitriche hermaphroditica* and *P. berchtoldii*. No *Najas flexilis* was seen. Searches in other parts of the lake also failed to locate any plants. As in 1999 the water was dark and the euphotic depth was about 2.5 m. but this could only be measured in the deeper northern end of the lake.

PRESENT STATUS

Since 1999 the vegetation in the southern part of Keel Lough has greatly changed. An open community of low growing plants has been replaced by a dense near monoculture of *P. perfoliatus* which has reduced even further the limited available light reaching the lake bed. In addition fewer of the open areas exist which are necessary for the annual *N. flexilis*. It appears that ongoing nutrient enrichment (possibly from septic tanks of surrounding houses) has allowed the lake to support large stands of *Potamogeton* in place of a shorter open vegetation. This process was probably underway even in 1999 as CR noticed a *Potamogeton perfoliatus*/*P. crispus* community at the western edge of the lake. This community has now spread to the eastern edge of Keel Lough.

In 1999 the Keel population of *N. flexilis* was very small and possibly suffering from lake eutrophication. It would now appear to be extinct.

	1999	2014
<i>Najas flexilis</i>	1	
<i>Nitella flexilis</i>	1	
<i>Fontinalis antipyretica</i>	+	
<i>Elodea canadensis</i>	+	1
<i>Potamogeton perfoliatus</i>		4
<i>Potamogeton berchtoldii</i>		1
<i>Potamogeton crispus</i>		1
<i>Callitriche hermaphroditica</i>		1
<i>Elatine hexandra</i>		+

Table 4 . Relevés taken in 1999 and 2014 in 1.5-2.0 m in the S.E. corner of Keel Lough (magenta oval on map above)

Date of survey 27/08/2014

Result No *Najas* found

The screenshot shows a mobile map application interface. At the top, a green header bar contains the text "Binn Fhrao" and a compass icon. Below the header, the map displays a detailed topographic view with brown contour lines indicating elevation. Several place names are visible, including "Kylemore Lough", "Loch na Coille Móire", "Benbaun Binn Bhán", and "Benbrack". A red circle highlights a specific location on the map, near the center-right. The bottom of the screen features a navigation bar with icons for zooming in (+), zooming out (-), a compass, a search magnifying glass, and a grid icon. The overall scene is a digital representation of a physical landscape, likely from a hiking or outdoor activity app.

Najas flexilis was first recorded by Ryan (Heuff 1984) in 1977 in the northwest corner of the lake. Subsequently drift specimens were recorded on the eastern sandy beach in 1995 (NPWS data). Roden (2004) reexamined the area noted by Heuff and Ryan but failed to find any *N. flexilis*. He did however confirm Heuff and Ryan's report of a large population in the adjoining Pollacappul Lough.

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Because of bad weather and a misunderstanding with one of the fishery managers this survey was not as complete as desired. The lake was surveyed by J. Ryan, H. Heuff, CR and PM. Complete species lists were made in the east of the lake but another examination of the 1977 site would be desirable. An oligotrophic flora was recorded but both *Isoetes lacustris* and *Potamogeton perfoliatus* were present. In shallow water a *Lobelia Littorella* community occurs with *Isoetes lacustris* and then *Nitella flexilis* and *Nitella translucens* at depth. *Potamogeton* sp. are very scarce.

PRESENT STATUS

The most important feature about Kylemore lake is that it is separated from Pollacappul lake only by a half-submerged glacial moraine, thus exchange of material must be frequent. As Pollacappul has a very large population of *Najas flexilis* (last surveyed by King in 2010) it is very probable that drift plants and seeds enter Kylemore Lough. The flora recorded by Heuff and Ryan is very similar to that noted in 2014 and suggests a marginal habitat for *N. flexilis*. It is possible that the Pollacappul population extends into the west end of Kylemore, at least in good seed production years. Given the close connection of the 2 lakes it might be better to combine *Najas* records for both as it seems likely that any threat to one population must also involve the second. At present both lakes are in good condition.

Lettershask West

Grid reference L62904356

Date of survey 29/07/2014

Result small population of *Najas flexilis* in northeast bay.

Survey method two snorkelers without boat cover



HISTORY

This lake is one of three lakes termed Lettershask by Van Groenendael (1975) who termed it Lettershask North. On the O.S. map it is termed Lettershask Lough, the southern lakes being in Foorglass townland and not named on O.S. maps. Roden (2006) refers to the 2 southern lakes as Foorglass lakes but apparently Van Groenendael referred to the western Foorglass lake as Lettershask west. Robinson (1990) terms it Loch Seainin. On account of this confusion Lettershask Lough was surveyed rather than Foorglass (Lettershask) west.

2014 SURVEY

The lake is typical of coastal lakes near Roundstone and contains both *Isoetes lacustris* and *Potamogeton perfoliatus* and *P. x nitens*. Rare plants include *Subularia aquatica* and *Najas flexilis*. The *Najas* population is small and confined to the northeast bay where it grows in 1-2 m depth on bare silty mud or amongst *Chara virgata*. About 20-50 plants were noted. Euphotic depth is 4 m. There are signs of eutrophication including heavy epiphyte load on all macrophytes and a very dense growth of *P. x nitens*.

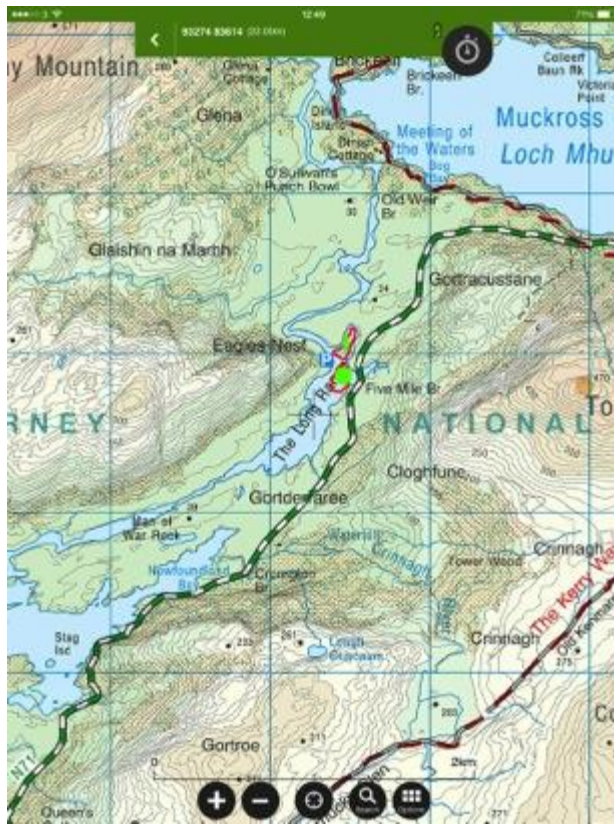
PRESENT STATUS

As this is a new station it is not possible to logically evaluate the Lettershask /Foorglass record in Van Groenendael et al. (1975) however it is clear that Lettershask Lough and Lettershask W. lough (=Loch Seainin) contain a very similar flora including *Najas*, *Subularia* and *P. x nitens*. Van Groenendael et al. (1975) state that the two lakes are often connected when water levels are high. The third lake Lettershask east or Foorglass Lake also contains these species. Van de Weyer (pers. com.) recorded *N. flexilis* in abundance in Foorglass east in 2010. Given that all three lakes are within 50 m of each other and 2 out of three contained *Najas* within the last five years, it seems probable that the Lettershask west population is still extant, but the matter will be resolved by a visit in 2015.

A slatted shed and farm yard on the northwest shore of the lake would appear to be a serious threat to Lettershask N.

Date of survey 5/09/2014

Survey method two snorkelers without boat cover



There are no records of *N. flexilis* in the Long Range before 1994 when it was recorded by Preston and FitzGerald.

The Long Range has a flora typical of old Red Sandstone lakes with mainly oligotrophic species including *Isoetes lacustris*, *Juncus bulbosus*, and *Callitriche hamulata*. Nevertheless a very large population of *Najas flexilis* was recorded at the

northeast end of the lake. In addition the scarce charophyte *Nitella confervacea* was also recorded. The *N. flexilis* occurred in both the northern most bay and to the west of the Five Mile Bridge. It occurs at depths of 2-3m near the base of the euphotic zone with *P. berchtoldii*, *Isoetes lacustris* and *Nitella translucens*. The population is very large west of Five Mile Bridge with at least 1000 individuals growing between 3-3.5m on silt over gravel. Euphotic depth is about 4m.

PRESENT STATUS

The population in the Long Range appears to be in excellent condition with many hundreds of plants. It differs from many sites in having so large a population in conditions which appear to be marginal. A possible threat could be boat traffic as in the Lower Lake (Roden and Murphy 2013). This danger is less likely as boats in the upper lake are smaller and traffic over many years has not damaged the population.

Muckross Lough

Grid reference V95008540

Date of survey 3/09/2014

Result No *Najas flexilis* found

Survey method snorkeler with boat cover



HISTORY

It appears there is only one record for *Najas flexilis* from Muckross Lake; K. McDaid collected some drift material in 1976. Earlier records listed in Scully, assumed to be from the boathouse of Muckross House are in fact for the boathouse of Muckross Hotel, as this hotel was in Killarney town, the boathouse was in nearby Lough Leane (Scully 1916). CR and PM searched for *Najas* in this lake in 2004 and 2013 without success.

2014 SURVEY

Four areas of the lake were searched in early September 2014 at both the east and west ends. No *Najas flexilis* was found even though the flora suggests a suitable habitat. Water transparency was excellent, Secchi transparency was 4m as was the euphotic depth. *Littorella/Lobelia* communities give way to *Isoetes* communities and occasional stands of *Potamogeton* species. *Nitella translucens* and *N. flexilis* occur at the base of the euphotic zone. *Potamogeton praelongus* may be a new record in the Lake. An unusual community of *Pilularia globulifera* and what appears to be a mat forming variety of *Baldellia* covers large areas in the west of the lake, (area shown in blue on map).

PRESENT STATUS

Of the four lakes in the Killarney system (Upper, Long Range, Muckross and Leane), Muckross is the only lake with no known population of *Najas*. This is surprising as it appears suitable because of clear water and appropriate companion species. The material found by McDaid could be either indigenous to the lake or drift material from the abundant populations in Leane and the Long Range. There are no obvious ecological threats to the lake. Like the Kylemore/Poulnacappul system in west Galway, any Muckross population would be part of a larger metapopulation spread throughout the Killarney group of lakes. Until good material is found growing in Muckross the record should be removed from the NPWS database.

Lough Nalawney

Grid reference L69564157

Date of survey 26/08/2014

Result large population of *Najas* in eastern basin

Survey method three snorkelers without boat cover



HISTORY

Najas flexilis was first recorded by J. Ryan in 1977. It was also collected by King in 2010 (King 2012). It was not recorded by Van Groenendael *et al.* who surveyed the lake in 1975.

2014 SURVEY

The lake was surveyed for *Najas* in August 2014 by H. Heuff, J. Ryan, CR and PM. The lake has clear water and is shallow (<2m) in the western half. A semi enclosed

bay in the eastern half reaches 3-4m. The euphotic depth is about 4 m. In shallower areas, *Eriocaulon/Lobelia/Isoetes* are dominant, with increasing *Juncus bulbosus* becomes more dominant. In the deeper water a lot of fine peaty silt occurs and here *Najas* occurs along with some *Urticularia*. The total population exceeds 100 plants. *Potamogeton* sp. occur occasionally.

PRESENT STATUS

The lake seems a typical habitat for *Najas* with both *Isoetes* and *Potamogeton perfoliatus* present. There are no obvious threats to the population.

Lough Sruffauncam

Grid reference L71154449

Date of survey 5/08/2014

Result No *Najas flexilis* found

Survey method two snorkelers without boat cover



HISTORY

This lake is one of several where Van Groenendael *et al.* (1975) recorded *Najas flexilis* in the Roundstone bog region in 1975. In a repeat survey in 1988, none of the records were confirmed (Van Groenendael *et al.* 1993). No other naturalist has reported *Najas* from this lake.

2014 SURVEY

The entire lake was examined by snorkeling by CR and PM. No *Najas flexilis* was found. The flora was typical of an oligotrophic peaty lake with *Lobelia/Eriocaulon/*

Isoetes in shallow water giving way to *Isoetes* and *Nitella translucens* at depth. *Nitella confervacea* also occurred. The euphotic depth was about 2m. The lake bottom consisted of rocks and gravel merging into peaty silt at depth. A deep hole of 6m was found in one place near the lake centre. There is no evidence of environmental damage to the lake. A film of algae, see plate 10, was noted, but similar layers are found in other oligotrophic lakes, which, as far as we know, do not indicate abnormal conditions.

PRESENT STATUS

The records of Van Groenendael *et al.* for *N. flexilis* in the Roundstone bog pose a number of difficulties. Herbarium specimens were not collected (Van Groenendael *pers. com.*) they were only recorded in 1975 but not in 1988. Only shore surveys were conducted, drift material may have been seen but hardly material at depth. Neither Sruffauncam nor Truska appear to offer very suitable habitat for *Najas*, based on associated species. In addition *N. flexilis* persists in two lakes, Nalawney and Foorglass (Lettershask East of Van Groenendael *et al.*) even though Van Groenendael *et al.* (1993) did not record the species in any lakes (including these sites) examined in 1988. They suggest that increased agriculture between 1975 and 1988 led to the extinction of *Najas* at the lakes, but this claim contrasts with the continued presence of large *Najas* populations at several lakes in the area, particularly along the coast-the area most farmed. It is difficult to see how farming would impact on Sruffauncam, located as it is near the centre of the Roundstone bog.

If the Van Groenendael records for Sruffauncam and Truska are accepted, it follows that a noticeable change occurred in the ecology of these lakes between 1975 and 1988. Until these matters are resolved it seems reasonable to remove the records from the data base unless further documentation can be located.

Lough Truska

Grid reference L67754053

Date of survey 28/07/2014

Result No *Najas* found

Survey method two snorkelers without boat cover



HISTORY

See discussion in Lough Sruffauncam above

2014 SURVEY

The greater part of the euphotic zone was surveyed. The lake has a slightly larger flora than Sruffauncam but it does not appear very suitable habitat for *N. flexilis*. An *Eriocaulon/Lobelia/Littorella* community occurs in shallow water, followed by *Isoetes* and then *Nitella translucens* at depth. The euphotic zone is 3.5-4.0 m and water visibility is good. No *N. flexilis* was found.

PRESENT STATUS

See discussion under Sruffauncam. Again it seems reasonable to remove the records from the database unless further documentation can be found. Possible threats include sheep grazing around the lake and causing some eutrophication.

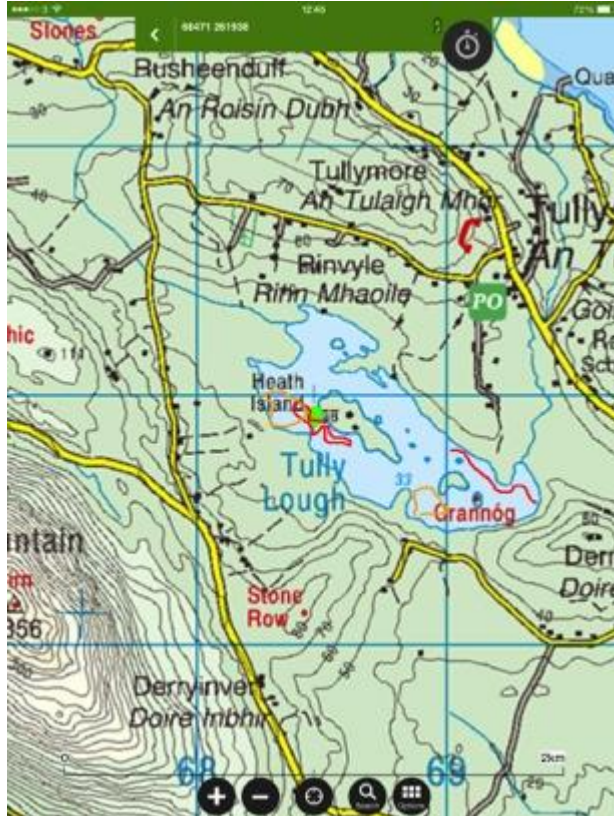
Tully Lough

Grid reference L68756186

Date of survey 27/08/2014

Result A localized population of *Najas flexilis* was located.

Survey method snorkeler with boat cover.



HISTORY

L. Farrell noted 10 drift *Najas* plants along the shore on 25/09/1978. Roden found only two depauperate plants during two surveys in 2003 and 2004.

2014 SURVEY

A population of more than fifty plants was found on the northwest shore of the large island with a few additional plants on the opposite mainland shore. The plants grow

at the base of the euphotic zone at 2.0m along with *Potamogeton berchtoldii* and some *Elodea canadensis* in an open community.

The lake has a typical vegetation of *Lobelia/Eriocaulon/Littorella* followed by *Isoetes lacustris* and then *P. berchtoldii* with *Najas* in one place. Euphotic depth is at most 2m. Maximum recorded depth is 6m.

PRESENT STATUS

This survey has established that a larger and more established population of *Najas* occurs than was previously thought. There is heavy encrustation of epiphytes on all macrophytes and *Elodea* is exceptionally abundant in places, but as the lake serves as a water supply it is to be hoped that further eutrophication will be prevented.

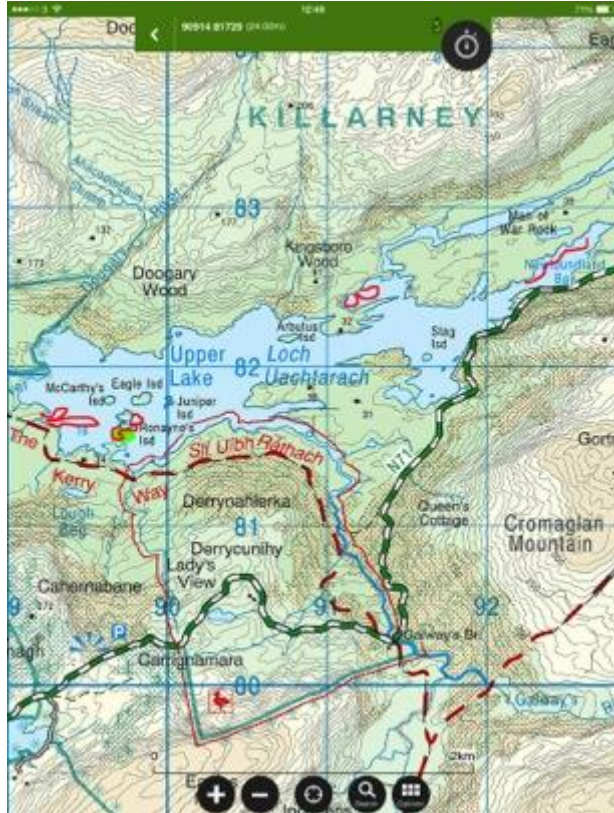
Upper Lake Killarney

Grid reference V 89748159

Date of survey 4/09/2014

Result a localized population of *Najas* was found.

Survey method snorkeler with boat cover



HISTORY

Najas flexilis was first recorded near Roynane Island in 1906 (Scully 1916). It was again located there in 1994 by FitzGerald and Preston. Roden (2004) did not succeed in locating the species along the mainland shore.

2014 SURVEY

The survey team included C. Heardman, CR and PM. While four different areas of the lake were examined, *N. flexilis* was only found between Roynane Island and Duck Island, precisely the area known since 1906. In general the Upper Lake has a typical oligotrophic flora and vegetation. *Lobelia* and *Littorella* are found in shallow water with *Isoetes lacustris* and then *Nitella translucens* occurring at depth. Other species include *Juncus bulbosus*, *Potamogeton berchtoldii*, *Callitriche hamulata* and *Elatine hexandra*. The euphotic depth is 3-4m and water clarity is good. The bottom is largely steeply sloping rock giving way to a reddish silt at depth.

The community south of Roynane Island is very unusual however, four charophytes, *Nitella translucens*, *N.confervacea*, *N.gracilis* and an unusual form of *C. virgata* cover much of the ground with *Najas flexilis*, *Urticularia* sp. and *Potamogeton berchtoldii* growing between the charophytes. About 30 plants were seen. This community occurs from 3 to at least 4m. Along with Lough Adoolig it is the only station for *N. gracilis* recently known in Ireland (one other station is known in Wicklow where the plant was seen in the 1980's). It is not known why the community is confined to the Roynane Island area but it is possible that like Lough Adoolig an underwater spring causes a local enrichment.

PRESENT STATUS

The survey confirms the continuing existence of a small *N. flexilis* colony in one small area of the Upper Lake where it has been known for 108 years. The existence of small but persistent colonies of *Najas* in apparently marginal habitats shows that unlikely early records from large sites such as Fin Lough/ Doo Lough or Cloonee may be explained by localized enrichment. Finding such sites however will require immense effort or good luck.

Brief description of additional lakes surveyed

In addition to the 16 lakes listed in the RFT, the contractors were required to survey additional sites which might contain *Najas*, if their field work schedule permitted.

While no further *Najas* populations were located, the lakes are of interest and are briefly described here.

Levally Lough Co. Mayo G145041

A 2 square km lake southwest of Lough Conn on granite bedrock. The northwest section was snorkeled on 7/08/2014. The substrate was sandy mud. Depth in the section examined was 3m maximum.

The flora resembled that of many *Najas* lakes with a shallow water zone of *Lobelia dortmanna*, *Isoetes lacustris* and *Isoetes echinospora* with some *Elatine hexandra* and *Baldellia ranunculoides*. At depth *Nitella translucens* was common. *Potamogeton* species included *P. perfoliatus*, *P. praelongus*, *P. berchtoldii*, and *P. lucens*. Other macrophytes included *Chara virgata*, *Myriophyllum alterniflorum*, *Elodea canadensis*, *Nymphaea alba* and *Nuphar lutea*. The water was rather turbid and *Cladophora* sp. was abundant suggesting some degree of eutrophication.

Species of note include *Isoetes echinospora*, *Elatine hexandra* and *Potamogeton praelongus*.

The lake was selected because the majority of Irish *Najas* populations grow in mesotrophic water defined by the presence of both *Isoetes lacustris* and *Potamogeton perfoliatus*. Many *Najas* sites are known in Connemara, far fewer records are known in Mayo and it seems possible that this is due to a lack of recording rather than the absence of the species.

Lough Talt Co. Sligo G401145

A 1.5 square km lake on the south east side of the Ox Mountains at 150 m altitude. Resting on Dal Radian schists, the flora strongly indicates marble or metamorphic limestone nearby. It was examined by snorkeling on 8/08/2014. Depth exceeds 12 m with a 4m euphotic depth. The substrate was rock and then silt.

The flora is dominated by charophytes, 7 species were recorded; *Chara aspera*, *Chara curta*, *Chara contraria*, *Chara virgata*, *Chara rudis*, *Nitella flexilis* and *Tolypella glomerata*. Angiosperms included *Potamogeton perfoliatus*, *P. berchtoldii*, *Elodea canadensis*, *Callitriche hermaphrodita*, *Myriophyllum alterniflorum*, *M. spicatum* and *Littorella uniflora*.

In addition crayfish and a white sponge occur.

It was expected that the lake might be slightly base rich and thus suitable for *Najas*. In fact the lake is best classified as a marl lake with charophytes dominant. Why so lime rich a lake should occur in the schists quartzites and granites of the Ox Mountains is unclear, but the site should be surveyed in detail as part of any further work on the marl lake habitat (3140).

Lough Nakeerogue , Achill, Co. Mayo F596076

This spectacular coastal lake is about 10 ha and is separated from the sea by a 30m high moraine. Its water appears to be extremely base poor and somewhat coloured by peat. It was examined on 20/08/2014 by snorkeling. Depth exceeds 6m, euphotic depth is 2m.

The flora is extremely small which is typical for very oligotrophic lakes. *Littorella uniflora*, *Lobelia dortmanna* and *Isoetes lacustris* grow in a shallow zone succeeded by *Juncus bulbosus* in abundance with locally common *Myriophyllum alterniflorum* and

Elatine hexandra in places. Two *Potamogeton* species occur *P. natans* and the underwater form of *P. polygonifolius*.

The lake was selected for examination as many *Najas* lakes in Connemara are close to the sea; on a map Lough Nakeerogue appears to be a coastal lake par excellence. The flora indicates however that the sea has little or no affect on water chemistry or nutrients.

Lough Curreel, Connemara, Co. Galway L885445

Lough Curreel is about 40 ha in size. It is about 2 m deep with many large emergent boulders. It was examined by snorkeling on 12/09/2014. Euphotic depth is 2 m. The bootom is a mix of peaty silt and granite rock.

The flora is typical of oligotrophic lakes with a band of *Lobelia dortmanna*, *Eriocaulon aquaticum*, and *Littorella uniflora* followed by abundant *Juncus bulbosus*, *Elatine hexandra* and *Isoetes lacustris*. *Urticularia intermedia* and *Urticularia australis* occur at depth. Emergent or floating species include *Nymphaea alba*, *Nuphar lutes* and *Sparganium angustifolium*. An unusual feature was patches of *Sphagnum* sp. at depths of 1-1.5m.

The lake was chosen for examination partly for comparison with oligotrophic lakes in the Roundstone bog and partly because there is a large population *Luronium natans* downstream of this lake.

PHOTOS



Plate 1. *Nitella gracilis* growing in Lough Adoolig at 2m depth.



Plate 2. Large form of *Potamogeton cf. berchtoldii* growing in Cloonee middle.

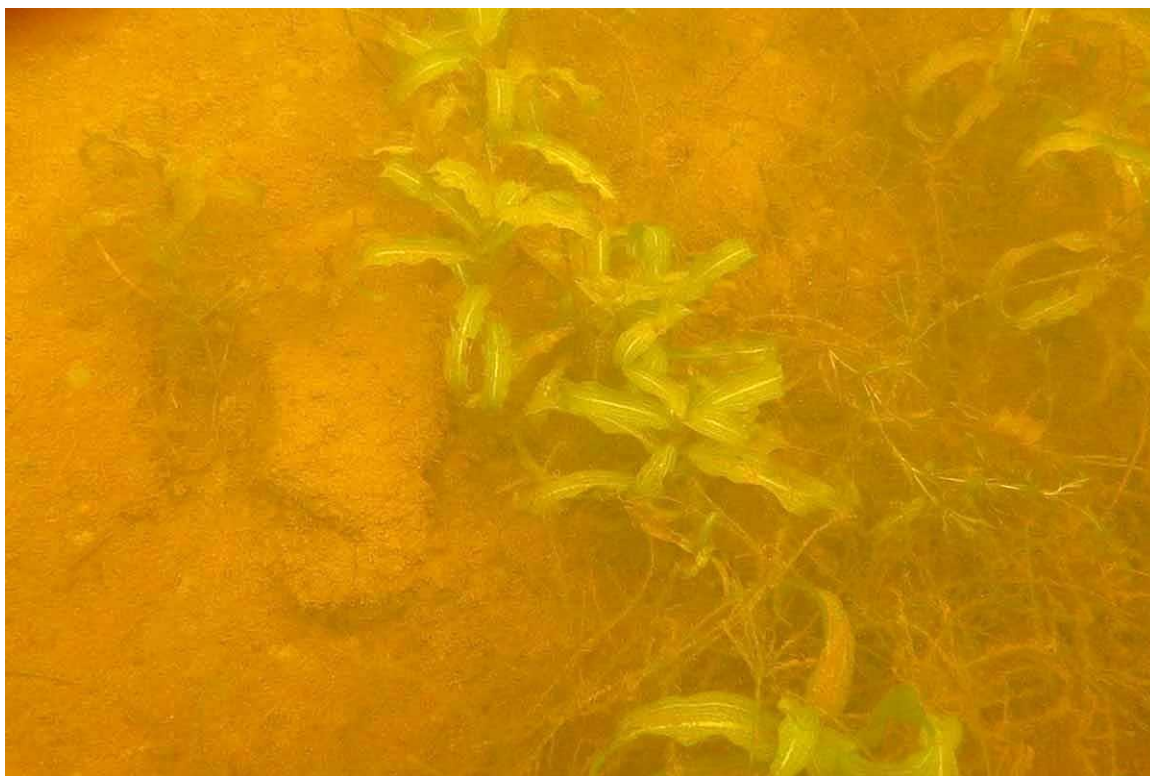


Plate 3. *Potamogeton alpinus* in Lough Corrib at 1.5 m.



Plate 4. *Juncus bulbosus*, *Myriophyllum alterniflorum* and *Eriocaulon septangulare* in Fin Lough



Plate 5. Heavy epiphyte growth on *Potamogeton* sp. in Glenade Lough



Plate 6. Dense growth of *Potamogeton perfoliatus* and *Elodea canadensis* in Keel Lough on site of former *Najas flexilis* population.

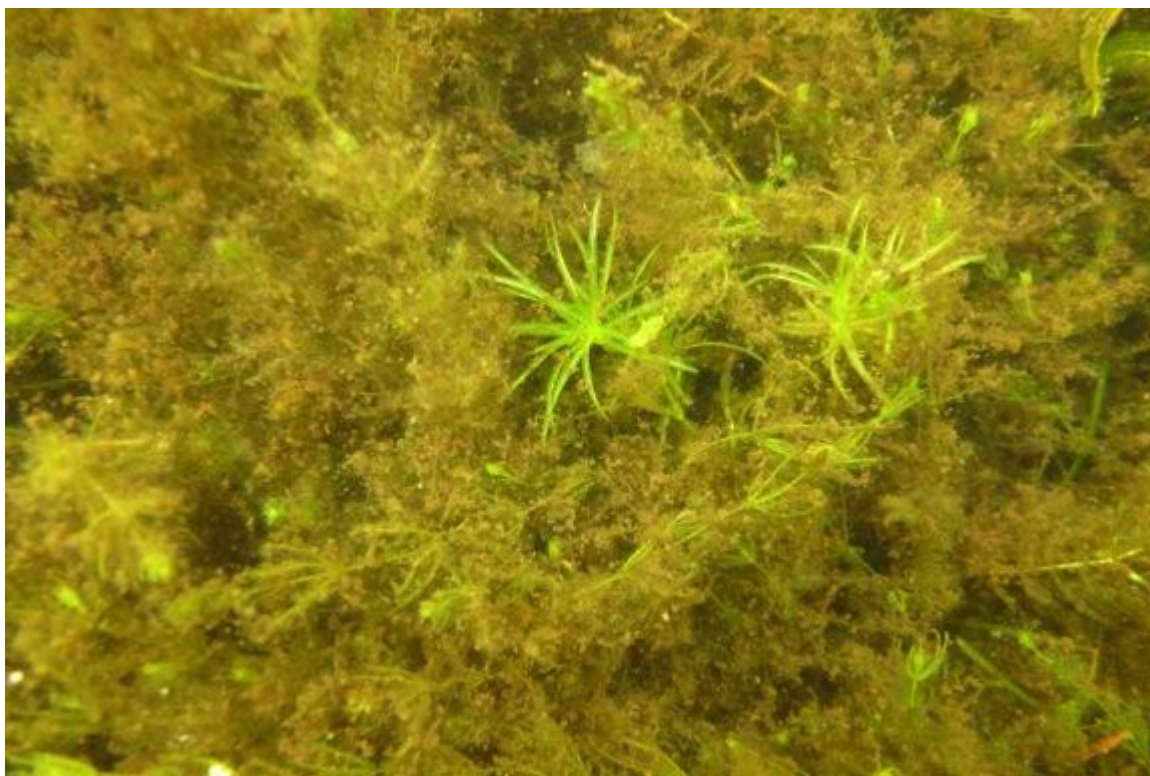


Plate 7. *Najas flexilis* growing amongst *Chara virgata* in Lettershask Lough at 1 m. Note the very heavy epiphyte and sediment fouling on the plants.



Plate 8. *Potamogeton praelongus* in Muckcross Lough at 3m.

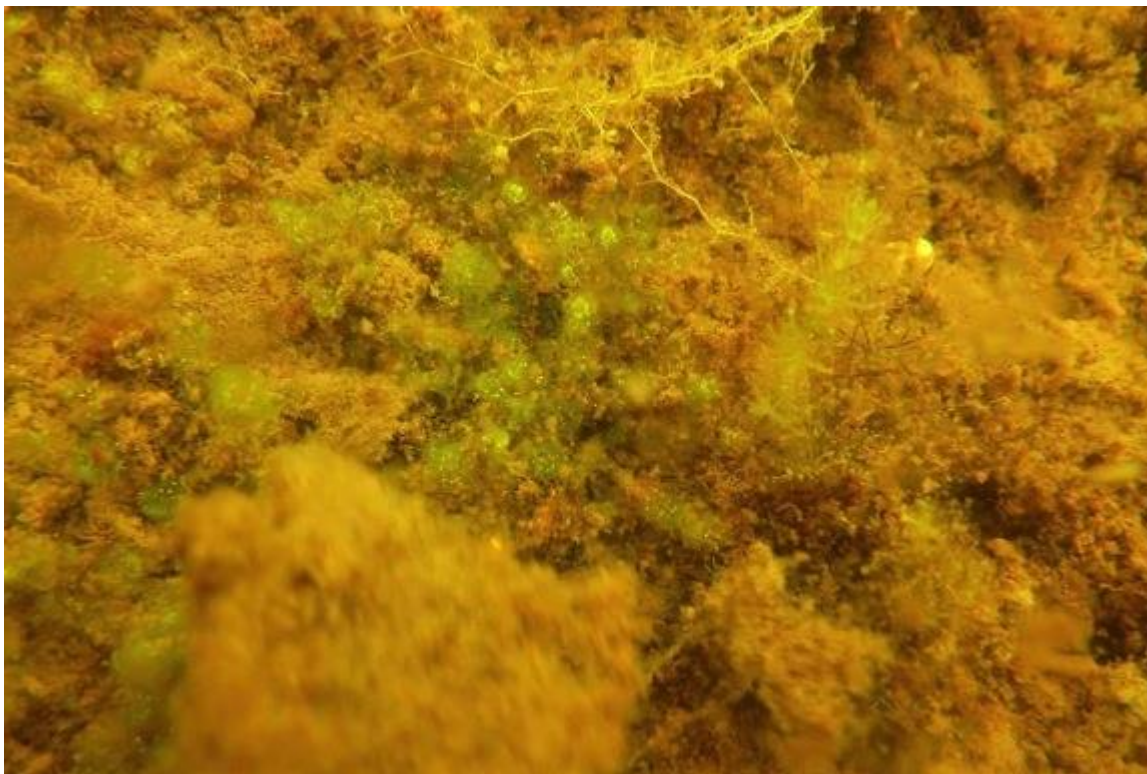


Plate 9. *Nitella confervacea* in Lough Nalawney; the white flecks are the plant's oospores. *Urticularia* sp. at the top of the picture.



Plate 10. Algal scum draped over *Isoetes* sp. at 2m in Sruffauncam Lough.

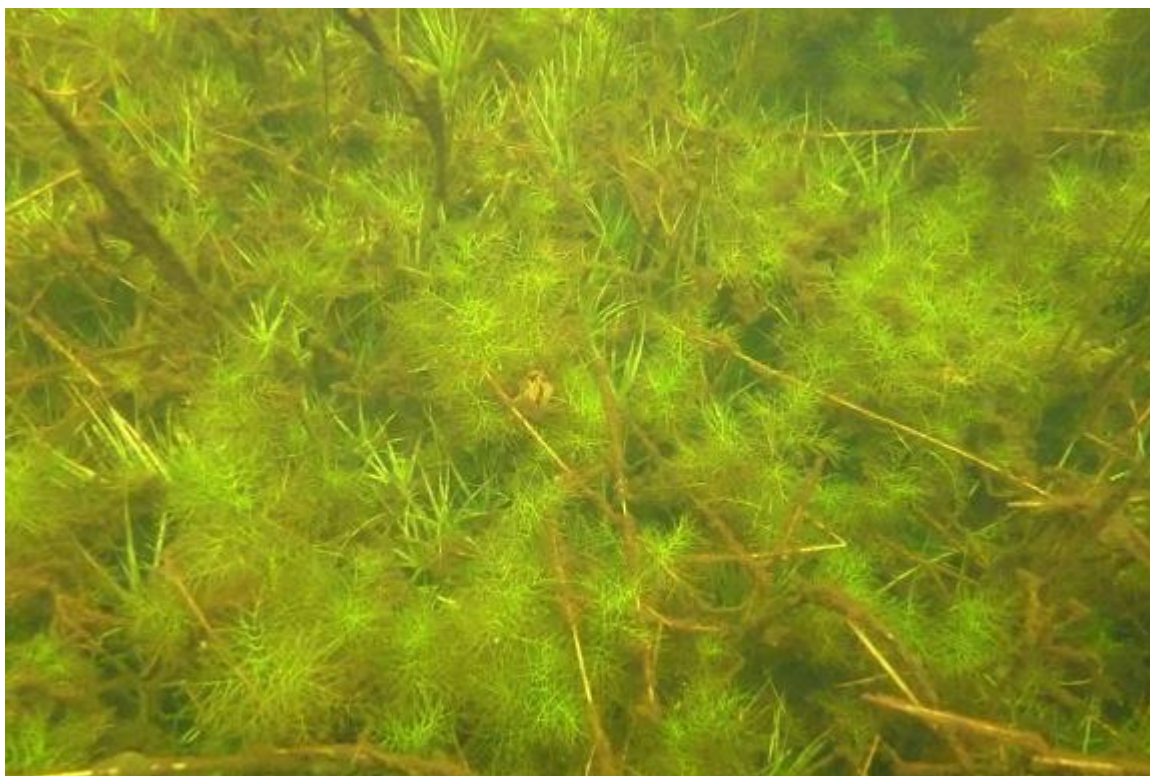


Plate 11. *Eriocaulon aquaticum* and *Apium inundatum* at 1.5m in Lough Truska



Plate 12. *Najas flexilis* at 2m in Tully Lough with *Isoetes lacustris*.

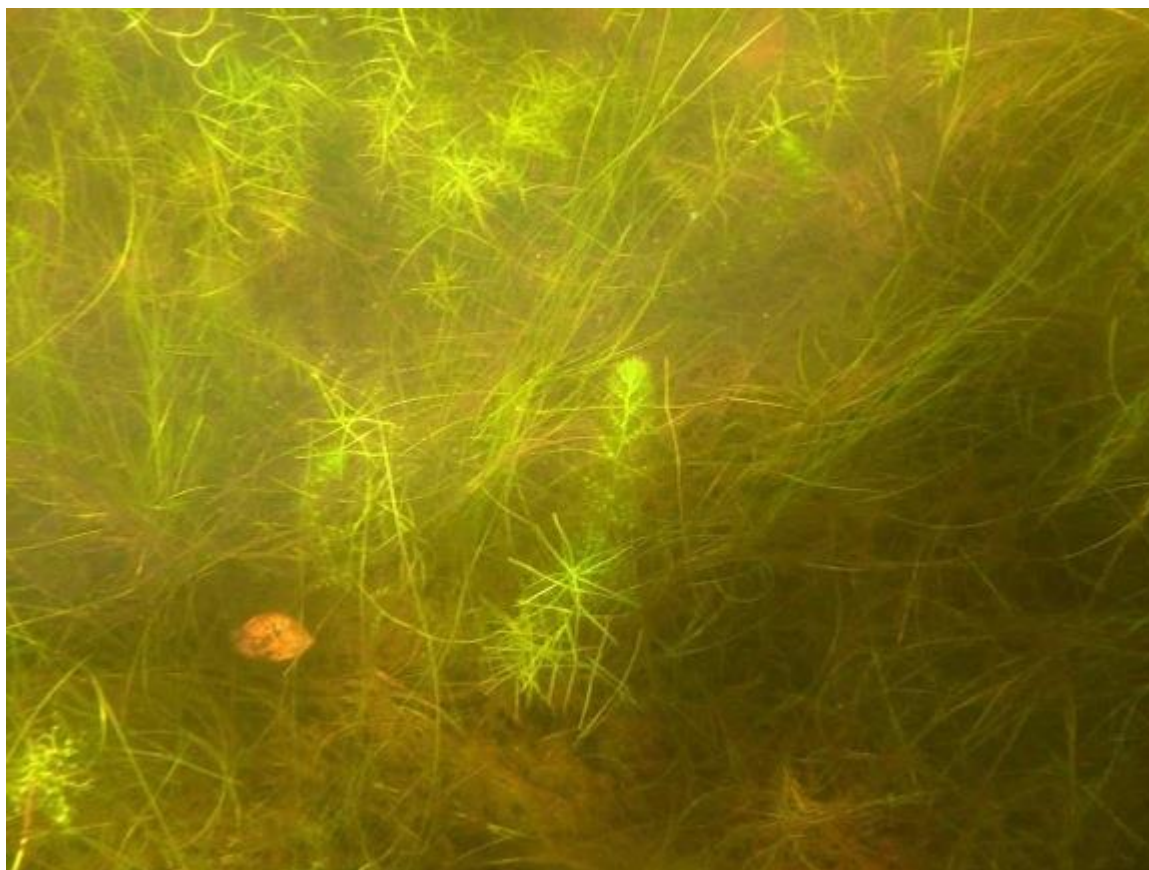


Plate 13. *Juncus bulbosus*, *Callitriche hamulata* and *Utricularia* sp. at 2m in the Upper Lake of Killarney.



Plate 14. *Najas flexilis* at 3m in Lough Nalawney. (video grab)

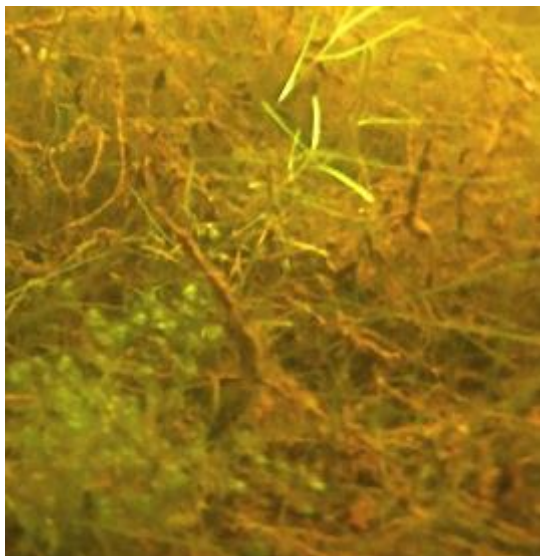


Plate 15. *Nitella confervacea* (lower left), *Najas flexilis* (upper centre) and *Nitella translucens* (lower right) growing at 3 m in the Upper Lake, Killarney. (Video grab)

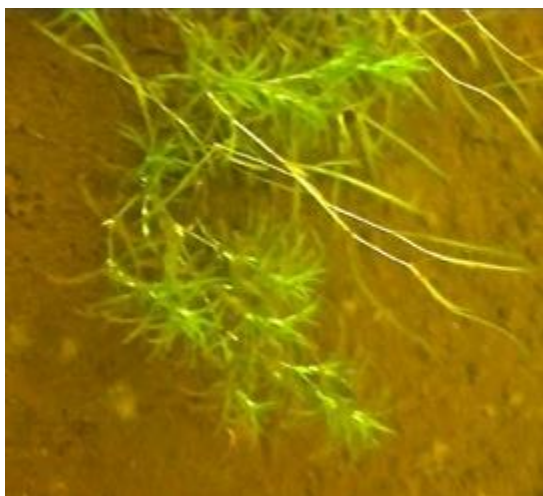


Plate 16. *Najas flexilis* and *Potamogeton berchtoldii* at 2m in Tully Lough. (Video grab).

Discussion

The primary purpose of this survey was to relocate old records of *Najas flexilis*, but at the end of the survey only five populations out of a supposed sixteen, were found. Furthermore, of the five populations, only one in The Long Range exceeded 500 plants. The remainder occurred at low densities, in a small part of each lake with few companion species. As it was essential to determine if the plant occurred at each site surveyed, most of the survey time was spent covering as large as possible a section of the lake sub littoral rather than in collecting quantitative data as might be expected in a general lake survey. Using the data collected during this survey alone, it would be difficult to undertake any analysis of *Najas* distribution either within or between lakes.

Fortunately, however, other data exists which has been collected using snorkeling surveys of Irish lakes. J. Ryan and H. Heuff pioneered this method of study in Ireland during the 1970's. Since 2000, Wingfield, King, Murphy and Roden have also used this technique. This work has resulted in a database which shows the size of *N. flexilis* populations and their associated species. Much of this data was assembled by Roden (2007) in an Excel spreadsheet prepared for NPWS. Since that date some further populations have been discovered (e.g. Roden 2013) and the current study has produced extra data. All this data is combined in the spreadsheet accompanying this report. This database is used to analyse the within and between lake distribution of *Najas* and to interpret the results of the present survey.

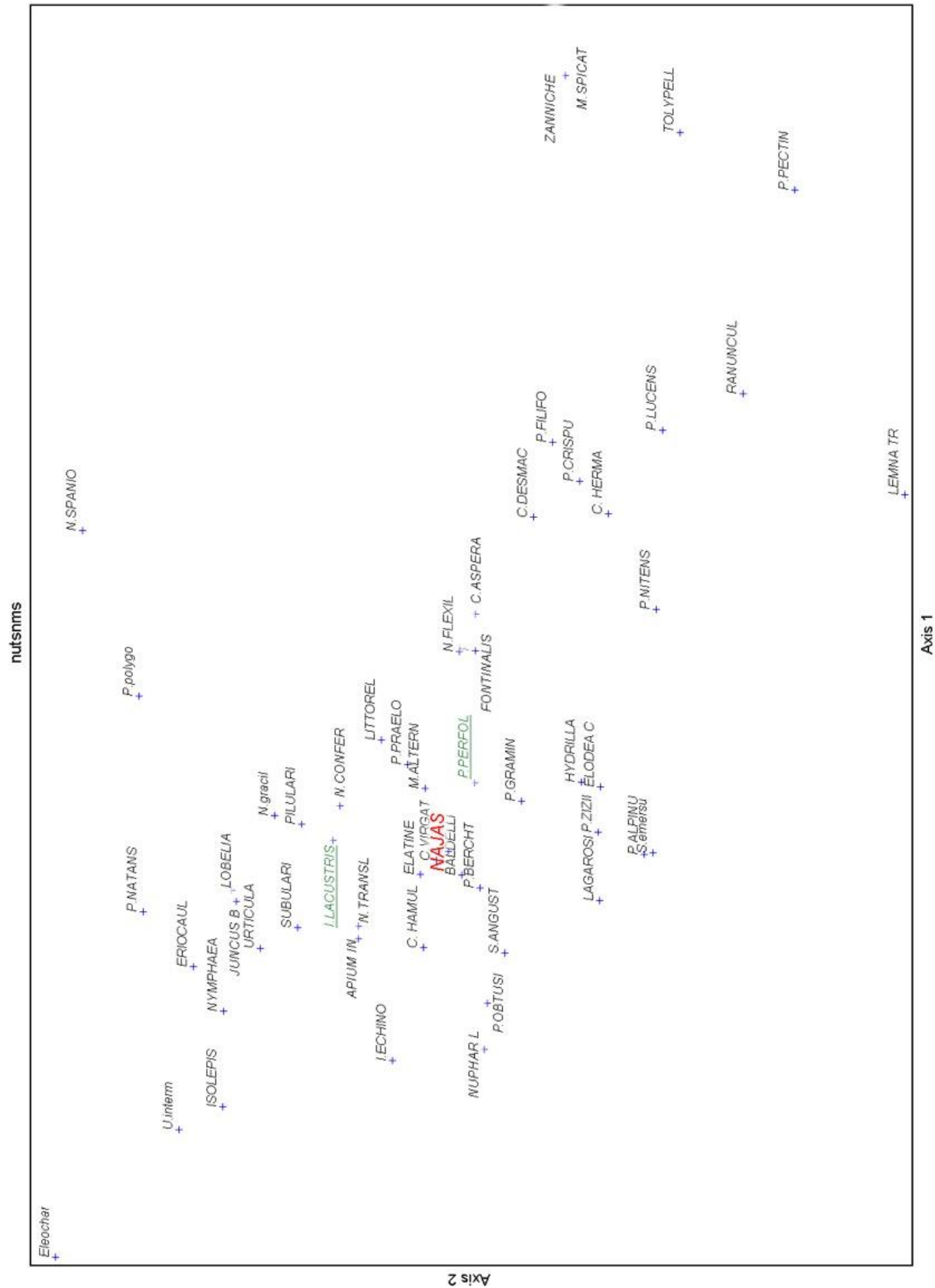


Figure 1. NMS plot of first 2 axes of 3 axes solution (stress value 0.183)

Defining *Najas flexilis* lakes based on associated species

In figure 1 a NMS ordination of associated species is shown. In the upper right corner are species known to grow in poor acidic water such as *Lobelia dortmanna* or *Juncus bulbosus*. In the lower left are species often found in more base rich lakes such as *Potamogeton lucens* or *Chara curta* (C.desmac). Note the nearby positions of *Isoetes lacustris* (I.lacust) and *Potamogeton perfoliatus* (P.perfol). Of 44 populations of *Najas* 30 or 68% contain both these species. The point is of note because many classifications of aquatic vegetation distinguish between Isoetoid communities of base poor water and base rich water with *Potamogeton* species (e.g. Rodwell 1995, EU Habitats manual 2007). *Najas* lakes often contain an intermediate community with several associated rarities such as *Hydrilla* or *Nitella confervacea*. Excellent examples of such lakes are Ballinakill and Rusheenduff Loughs in Connemara. Of the 44 lakes containing *Najas* used in the analysis, only 6 do not contain *P. perfoliatus* and in only one of these, the Long Range Killarney, do substantial *Najas* populations occur. We interpret this distribution to mean that *Najas flexilis* is at best a marginal species in truly base poor oligotrophic lakes in Ireland.

A twinspan analysis (Table 5a,5b) of the data indicates in general terms the species associations in which *Najas* occurs. As there is only one record of *Najas* in group 1 (1/15= 7%), the species is not listed in this group in table45. As already shown in the NMS analysis *Najas* occurs in communities with both base poor and base rich indicator species. In table 5a it is seen that most unconfirmed records are in lakes with base poor communities (group 1). On the other hand the assumed extinctions occur in the more base rich typical communities (Lough Corrib is intermediate).

	group 1	group 2	group 3	group 4
<u>Number of lakes</u>	15	20	13	15
<i>SUBULARIA AQUATICA</i>	II			
<i>PILULARIA GLOBULIFERA</i>	II			
<i>BALDELLIA RANUNCULOIDES</i>	II			
<i>UTRICULARIA INTERMEDIA</i>	II			
<i>NYMPHAEA ALBA</i>	II	II		
<i>POTAMOGETON NATANS</i>	III	II		
<i>APIUM INNUNDATUM</i>	III	II		II
<i>UTRICULARIA SP.</i>	III	II		II
<i>NITELLA CONFERVACEA*</i>	II	III		III
<i>ISOETES ECHINOSPORA</i>	II	III	II	
<i>ERIOCAULON AQUATICUM</i>	IV	IV		
<i>JUNCUS BULBOSUS</i>	V	IV		II
<i>ELATINE HEXANDRA*</i>	IV	IV	III	III
<i>MYRIOPHYLLUM</i>				
<i>ALTERNIFOLIUM</i>	III	IV	II	III
<i>LOBELIA DORTMANNIA</i>	V	V	IV	
<i>ISOETES LACUSTRIS*</i>	V	V	IV	IV
<i>NITELLA TRANSLUCENS*</i>	IV	IV	IV	II
<i>POTAMOGETON PERFOLIATUS*</i>	II	IV	V	V
<i>POTAMOGETON BERCHTOLDII*</i>	II	V	IV	IV
<i>LITTORELLA UNIFLORA</i>	III	IV	II	IV
<i>CHARA VIRGATA*</i>	II	IV	IV	III
<i>NAJAS FLEXILIS*</i>		V	V	V
<i>SPARGANIUM ANGUSTIFOLIUM</i>		IV	II	II
<i>NITELLA FLEXILIS*</i>		II	II	IV
<i>FONTINALIS ANTIPYRETICA*</i>	II	II		IV
<i>CALLITRICHE</i>				
<i>HERMAPHRODITICA*</i>				IV
<i>ELODEA CANADENSIS</i>		II		II
<i>NUPHAR LUTEA</i>		II		
<i>POTAMOGETON</i>				
<i>OBTUSIFOLIUS*</i>		II		
<i>POTAMOGETON GRAMINEUS</i>			II	II
<i>CHARA ASPERA*</i>				II
<i>POTAMOGETON CRISPUS</i>				II
<i>CHARA DESMACANTHA</i>				II
<i>POTAMOGETON PRAELONGUS</i>				II
<i>POTAMOGETON NITENS</i>				II
<i>POTAMOGETON FILIFORMIS</i>			II	
<i>POTAMOGETON LUCENS</i>			II	
<i>number of lakes in 2014 survey</i>	7	5	2	2
<i>existing Najas populations</i>	1	3	1	
<i>extinct populations</i>		1		2
<i>not refound</i>	6	1	1	

Table 5. Summary of TWINSpan grouping of lakes. II,III,IV,V show frequency of each species in each group (II>19.99%...V>79.99% frequency). Note frequencies less than 19.99% not shown. * indicates species found in *Najas* relevés

ORDER OF SPECIES INCLUDING RARER ONES											
18	LAGAROSI	31	NYMPHAEA	33	P.ALPINU	41	P.OBTUSI	9	Eleochar		
27	N.gracil	28	N.SPANIO	32	PILULARI	53	U.interm	1	APIUM IN		
11	ERIOCAUL	17	JUNCUS B	39	P.NATANS	54	URTICULA	14	I.ECHINO		
16	ISOLEPIS	21	LOBELIA	30	NUPHAR L	2	BALDELLI	8	ELATINE		
29	N.TRANS	44	P.polygo	51	SUBULARI	10	ELODEA C	15	I.LACUST		
20	LITTOREL	22	M.ALTERN	25	N.confer	3	C. HAMUL	47	P.ZIZII		
49	S.ANGUST	7	C.VIRGAT	24	NAJAS FL	34	P.BERCHT	26	N.FLEXIL		
40	P.NITENS	43	P.PERFOL	45	P.PRAELO	13	HYDRILLA	37	P.GRAMIN		
50	S.emersu	12	FONTINAL	6	C.DESMAC	23	M.SPICAT	42	P.PECTIN		
46	P.PUSILL	48	RANUNCUL	52	TOLYPELL	55	ZAMNICHE	4	C. HERMA		
19	LEMNA TR	35	P.CRISPU	36	P.FILIFO	38	P.LUCENS	5	C.ASPERA		
ORDER OF SAMPLES											
6	Truska	8	Sruffaun	16	Nalawney	53	Tawnagh	57	Athry		
2	Muckross	54	Glendoll	58	Derrycla	59	Ballynah	12	Annillau		
48	Ardderry	49	Shindill	50	Oorid	3	Adoolig	10	Finn Lou		
4	Cloonee	15	Long Ran	25	Emloughn	1	upper la	32	Mullagh		
56	Cøige Ru	20	Derrywak	26	Polacapp	27	Nageltia	33	Mullagh		
34	Barnahal	35	Rusheend	51	Chluain	13	Tully	28	Caolaidh		
29	Caorain	31	Altora	55	Cøige Ru	5	CORRIB	62	Leane		
21	NaGCaisl	63	natawnym	14	Kylemore	18	Acoose	22	Troscan		
30	Nacaor	45	Easerd	61	Maumean	7	Lettersh	17	Dahybaun		
23	Carragh	24	Tully	52	Derrynee	9	Glenade	11	Keel Lou		
36	Ballinak	37	Akibbon	38	Kiltoori	39	Shannagh	40	Keel		
43	Seskinmo	60	Seanchro	44	Clooney	47	Sessiagh	19	Lehanagh		
41	Port	42	Kindrum	46	Loch na						

Table 5b. Twinspan ordering of species and lakes. The four groups summarized in 2a are coded as follows; group 1 =red, group 2=green, group 3=blue, group 4=yellow.

An NMS plot of the lakes presents the same picture, despite the high stress value of 0.198. Lakes with extinct populations are surrounded by sites with existing *Najas* populations. The unconfirmed records largely appear close to lakes with no recorded *Najas* populations and mainly dominated by species of base poor water. (An interesting exception is Muckross Lough which might be expected to support *N. flexilis* and is connected to other lakes with large populations, but to date only a single drift record is known).

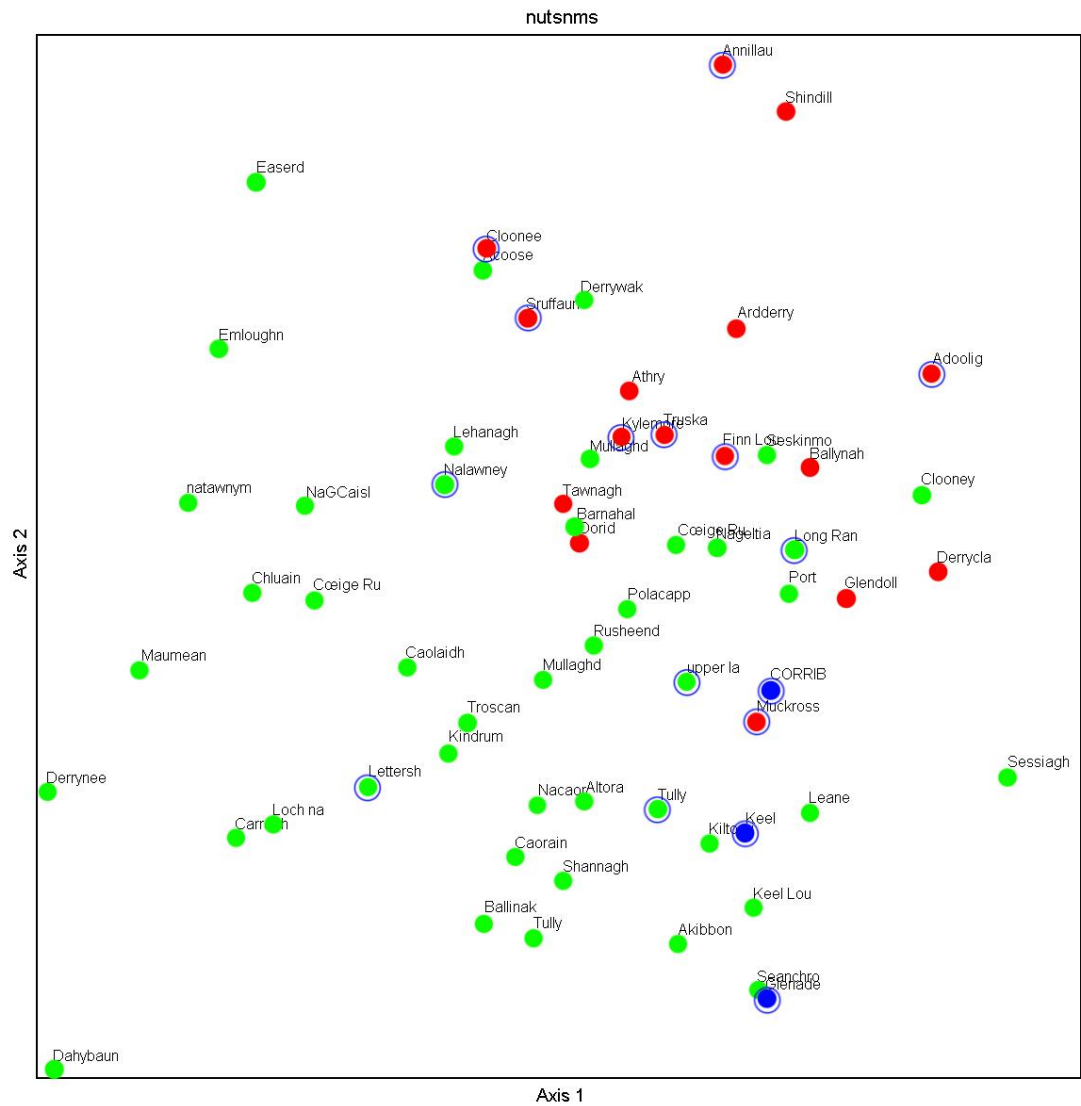


Figure 2. An NMS plot of all lakes in the accompanying spreadsheet. Green indicates presence of *Najas flexilis*, red indicates absence, blue indicates extinct population (based on 2014 survey data). Blue circles indicate lakes sampled in this survey. (first 2 axes of 3 dimensional solution, stress = 0.198).

Within lake distribution of *Najas flexilis*

The preceding analysis indicates the types of lakes (as defined by species) where *Najas* may be expected to be found, it does not indicate where *Najas* tends to occur within a given lake. It had been intended to use the 2014 field data to define good and marginal *Najas* habitat by taking vegetation samples (relevés). In the event only 5 *Najas* populations were found four of which contained less than 150 individuals. Furthermore these populations were restricted in habitat, being largely confined to the base of the euphotic zone-as is frequently the case with *Najas*. However relevés

have been taken in previous surveys. These data are used to investigate *Najas*' within lake habitat and as a context to interpret the 2014 data.

	GROUP 1	GROUP 2	GROUP 3	GROUP 4
number of relevés	7	17	12	12
average depth (m)	1.28	2.44	2.46	2.4
substrate	sand/silt	silt/sand/mud	silt mud	silt mud
average species no. per relevé	3.43	4.18	4.83	2.6
% cover	48	60	60	26
average cover score for <i>Najas</i>	0.6	1.3	1.5	1.6
<i>Najas flexilis</i>	V	V	V	V
<i>Potamogeton berchtoldii</i>	II	III	III	IV
<i>Chara virgata</i>	V	II		
<i>Chara aspera</i>	II			
<i>Potamogeton obtusifolius</i>	II			
<i>Potamogeton perfoliatus</i>	II	II	III	
<i>Nitella confervacea</i>		III	II	
<i>Isoetes lacustris</i>		II	III	
<i>Callitriche hermaphroditica</i>		II		
<i>Fontinalis antipyretica</i>		II		
<i>Nitella flexilis</i>		III		
<i>Elatine hexandra</i>			III	
<i>Nitella translucens</i>			IV	
<i>Hydrilla verticillata</i>			II	
<i>Callitriche hamulata</i>				II
No. of 2014 relevés	1	0	1	3

Table 6 . Summary table of a TWINSpan analysis of 48 relevés containing *Najas*.

Table 6 summarizes a TWINSpan analysis of the available Irish relevé data. Like many aquatic macrophytes, *Najas* has very few companion species. Consequently it is difficult to define sub communities. It can be seen that only one species *Potamogeton berchtoldii* accompanies *Najas* in all four sub groups. Variation between the groups can be partly explained in terms of depth with group 1 occurring in shallow water dominated by *Chara virgata*. *Najas* is rarely abundant in this grouping which is largely found in coastal lakes. The small population in Lettershask lake can be placed here.

Groups 2 and 3 represent the most species rich *Najas* communities and 60% of all relevés but only one population (Upper Killarney Lake) fits here.

The final group 4 is characterized by very few species and much lower cover values. It is typically found close to the base of the euphotic zone in muddy silt. On occasion however, large near monocultures of *Najas* occur here, as indicated by the high average *Najas* cover score. 3 of the five 2014 records are placed in this sub group, including the large population in the Long Range Killarney.

Najas is an annual plant, most often found in bare mud, either at the base of the euphotic zone where other species do not colonize or in bare patches within other vegetation at shallower (brighter) depths. In some lakes it grows in more complex communities with more species and higher cover values. These differences in habitat are reflected in table 6, but are difficult to predict or explain. Thus in Lettershask *Najas* grows close to the surface surrounded by *Chara virgata*, but was not found at depth. In contrast the species grows at depth in Tully Lough but not in surface communities. In other lakes (not sampled in 2014 e.g. Sessiagh in North Donegal) the plant grows from 1m to 5 m. As the plant must grow from seed every year, the factors determining within lake distribution may be subtle and include water movement, thermocline formation and availability of open space. In addition year to year variation both in population size and areas colonized must be considered.

It is not easy to define suitable habitat for *Najas* in Irish lakes, other than noting companion species. All but the shallowest lakes have large areas of bare mud near the base of the euphotic zone which might appear suitable for the species but clearly in many cases e.g. Sruffauncam or Fin Lough, *Najas* does not occur in this habitat. This absence can be related to the total species list present in a lake, which presumably in turn reflects chemical or nutritional factors that influence *Najas*. As few of these species grow close to *Najas* in any lake sampled, direct competition for space does not appear a likely factor.

Equally the reason that *Najas* is confined to the edge of the euphotic zone in some lakes but grows throughout the euphotic zone in other lakes (e.g. Sessiagh vs Nalawney) is not yet understood.

Explanations for unconfirmed records

The results of the multivariate statistics analysis are central to analyzing the results of the 2014 survey. A failure to refind a population can be explained in 3 ways:

- A small marginal population was not refound because it only occurs in a small part of a lake.
- The population was at best transient and in an unfavourable habitat and has now become extinct.
- The population has become extinct due to an unfavourable change in the lake habitat.
- The unsuitable or marginal habitat makes it unlikely the population actually existed.

The first possibility is supported by results from the Upper Lake in Killarney where a small deep population only occurs in one small area for reasons which are unknown at present. (The example of Lough Adoolig suggests that underwater iron or nutrient rich springs may be an explanation). Unless its exact position was already known it would have taken several days to refind. Other areas of the lake examined appear unlikely sites for *N. flexilis*. The old records for Cloonee and Fin Lough might be thus explained.

It is thought that *N. flexilis* populations in Ireland and Scotland are relict and the species does not colonize new areas, but in fact little is known of how *Najas* populations behave, other than that abundant seed is produced in most years. Lake Island studies have shown that most islands are colonized by transient species that last for a short time and then go extinct (e.g. Cody 2006,

Roden 1998). Freshwater lakes are also “ecological” islands which probably experience colonization and extinction of populations. It is quite possible that lakes with marginal conditions for *Najas*, but close to lakes with large populations might be temporarily colonized, only to be followed by extinction events. Obvious examples are Muckcross Lough and Kylemore Lough.

The documented extinctions in Glenade and Keel Loughs were accompanied by very obvious changes in lake ecology which indicate increasing eutrophication. No such obvious changes were seen in most of the unconfirmed sites for *Najas*; indeed some are possibly too oligotrophic for the species (see figure 2). So if unfavourable habitat change occurred in sites such as Sruffauncam it would be most likely increased acidification or possibly peat deposition. But there is no evidence of such changes. Consequently this is a less probable explanation.

All botanists make mistakes! The possibility of false records must be recognized. In general terms, lack of herbarium voucher specimens, inexact location details or records never confirmed by other botanists tend over time to be rejected by the majority of botanists, unless new evidence can be found. The possibility that some *Najas* records are unsound must be considered.

Evaluating the records

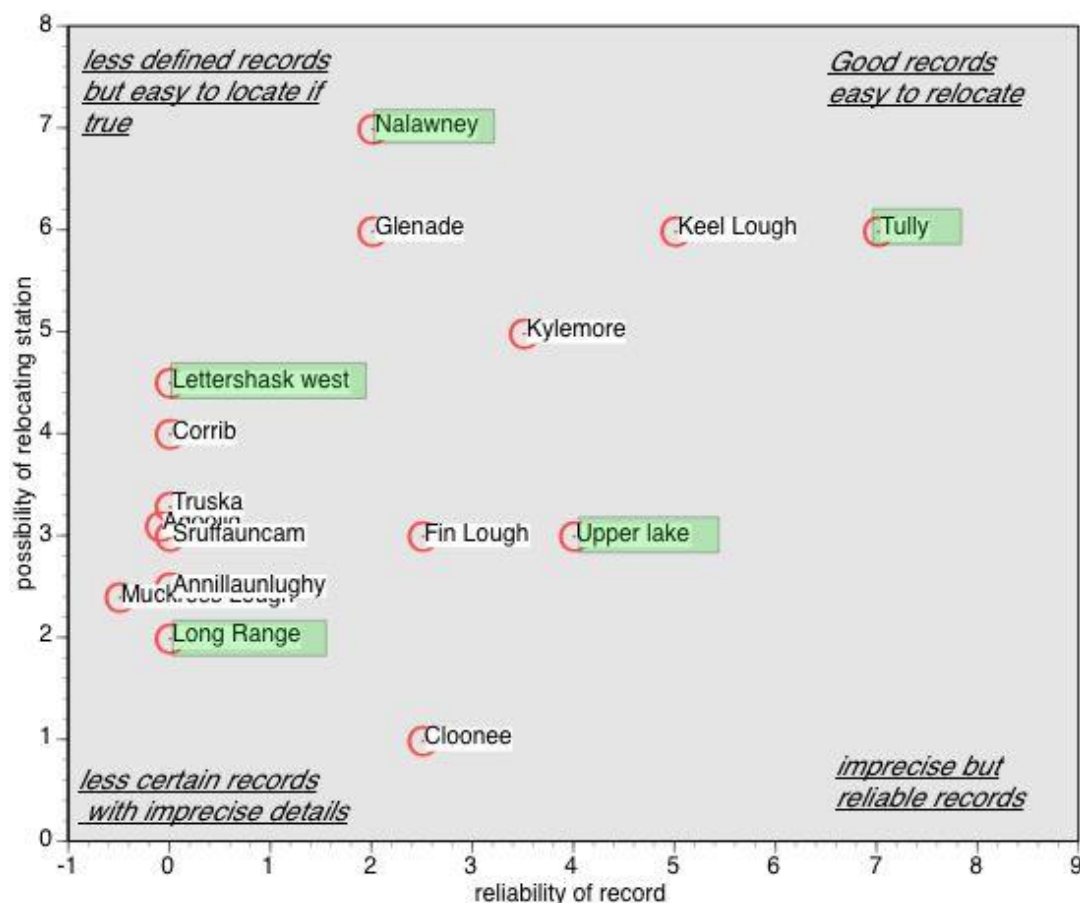


Figure 3. A scoring scheme to classify the 16 records. Confirmed populations are in green. To prevent masking of data some points are displaced by up to 0.5 units.

In figure 3, the 16 *Najas* records are scored under two broad headings; reliability of the record and ease of relocation. For record reliability the following features are scored;

- 1) existing herbarium material (3 if known, 0 if not)
- 2) exact position of population (2 if known, 0 if not, excludes drift material)
- 3) confirmed by later botanists (2 if so, 0 if not)
- 4) possibility of drift material coming from a nearby lake. (-0.5 if drift is possible)

Allowing that a record is valid, probability of relocation is scored. The following features are used;

- 1) lake size (3 if small, 2 if medium, 0 if large)
- 2) Suitable habitat based on NMS ordination (1 if yes, 0 if no)
- 3) Exact position known (2 if known, 0 if not, excludes drift material)
- 4) Examined by snorkeling previously (1 if yes, 0 if no).

By plotting the two factors against each other, some guidance can be obtained to evaluate the records, this is done in figure 3. Four classes of records can be distinguished;

- Good records easy to locate (Tully, Glenade, Kylemore, Nalawney, Keel and Upper Lake)
- Good records difficult to locate (Long Range, Cloonee)
- Uncertain records but easy to locate if true (Fin, Corrib, Lettershask, Sruffauncam, Truska, Adoolig,)
- Less precise records with poor locality data (Anillaunlughy, Muckcross)

Proposed current status of the 16 records

Using the four categories proposed above we proposed that the status of the 16 recorded sites is as follows.

Good records easy to locate

Failure to find a population probably means it has become extinct, on this basis we classify the sites as follows

Population still present

Tully, Nalawney,

Extinct

Glenade, Keel.

Uncertain

Kylemore

Good records difficult to locate

Failure to find a population does not prove extinction, therefore the record is classified as undetermined

Uncertain

Cloonee Lakes

Uncertain records but easy to locate if true (Fin, Corrib, Lettershask, Sruffauncam, Truska, Adoolig)

Failure to find a population indicates either extinction or a record that should be rejected until further evidence can be obtained

Population still present

Lettershask, Upper Lake

Extinct

Corrib

Reject

Fin, Sruffauncam, Truska, Adoolig.

Uncertain records with poor locality data

Failure to confirm these records results in rejection,

Population still present

Long Range

Reject

Anillaunlughy Muckcross.

Conclusion

This survey has shown that of 16 unconfirmed *Najas* populations in Ireland at least 5 are still in existence. 3 are almost certainly extinct, 6 records are rejected as the location was thoroughly searched and there was no evidence of environmental change or very suitable habitat. 2 records are indeterminate.

Extinctions are linked to noticeable eutrophication in 3 lakes, Corrib, Glenade and Keel. In addition both Tully Lough and Glenshask Lough also showed signs of nutrient enrichment. This emphasizes the continuing threat to our lakes from excess nutrients. We argue above that *Najas* lakes form a recognizable unit intermediate between EU types 3120, 3130 and 3150. In the absence of explicit recognition of this unusual lake type, its loss will not be well documented. Extinction and damage to both species and habitat documented in this report underline the need for continuing protection.

It is of course, very possible that records that we reject are in fact correct. It seems likely that a small *N. flexilis* population exists somewhere in The Doo Lough system in Co. Mayo and probably somewhere in Cloonee system, including Lough Inchiquin. In conservation terms the existence of populations in Kylemore Lough and Muckross Lough are of less importance as very large populations exist within a few metres in neighbouring and connected lakes. The remaining records are difficult to explain. It is unlikely that *Najas* grows in Sruffauncam, Truska or Lough Adoolig and the evidence it once did so rest on single observations, never repeated and unsupported by herbarium specimens. *Najas* may well grow in some lake close to the base of Errisbeg but there is little firm evidence of any exact location to date.

In addition to gathering data on the existence of *N. flexilis* populations the survey also discovered unusual species and habitats, especially in the Old Red Sandstone lakes in Kerry. The discovery of two new stations for *Nitella gracilis* (Adoolig and

Upper Lake) suggests that the species may be commoner than thought in lakes on this rock type in Kerry and Cork. It may also indicate the importance of under-water springs in increasing macrophyte biodiversity in apparently very oligotrophic lakes.

Recommendations on future monitoring

- A definitive list of *Najas* lakes in Ireland should now be established with three categories; present, extinct or not relocated. Only records supported by herbarium specimens should be included. All other records should not be included on the definitive list.
- Certain *Najas* lakes are of very exceptional interest with unusual aquatic vegetation and macrophyte species, others do not differ greatly from typical soft water oligotrophic lakes. Irish *Najas* sites should be classified not just in terms of the population of *Najas* present but also in terms of general vegetation and other species present. The 10-20 exceptional sites should be identified and protected as these are unusual in western Europe.
- Terrestrial and aquatic vegetation are not directly comparable. Many aquatic studies analyse vegetation at the river or lake level rather than at the quadrat level. Such data is not readily logged using the NPWS turboveg protocol. It may be useful to construct a database system that can accept such data.
- Aquatic relevés will be largely poor in species (1-7), more useful data might be gathered using shore to base of euphotic depth transects.
- Wingfield's work on population fitness (2004) may prove useful in monitoring the health of *Najas* populations but it does require collection of sufficient material.

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