Ecological status assessment of Lake Inari and River Pasvik and recommendations for biological monitoring using aquatic macrophytes

EU ENPI –project Trilateral cooperation on Environmental Challenges in the Joint Border Area

Juha Riihimäki
Finnish Environment Institute SYKE

Marit Mjelde
Norsk Institut for Vannforskning NIVA

Seppo Hellsten
Finnish Environment Institute SYKE

Contents

1. Introduction

Pasvik river basin is shared by Finland, Norway and Russia and its total area is 17902 km^2 of which 81% is in Finland, 13% in Russia and 6% in Norway (EEA 2008). Largest lake of the Pasvik basin is the Lake Inari (1084 km^2) situated 118,7 meters above sea level. Pasvik river is 143 km long outlet from the Lake Inari to the Barents Sea and it is regulated with seven hydropower plants (UNECE 2011).

Regulation of the water level of the Lake Inari and the discharge of the River Pasvik due to hydropower production is probably the strongest human induced pressure on aquatic ecosystem in the Pasvik River basin. The global climate change will also have several effects on hydrological cycle changing the timing of high water levels and discharges and thus affecting the habitat conditions of aquatic organisms (see other report).

Assessment of the ecological status of Lake Inari and River Pasvik is a part of Activity 4 in EU ENPI project KO370 "Trilateral cooperation on Environmental Challenges in the Joint Border Area (TEC)". Assessment is done using aquatic macrophytes and benthic macroinvertebrates as biological elements and this report describes the assessment using aquatic macrophytes. Assessment of ecological status using benthic macroinvertebrates is reported separately (see other report).

2. Material and methods

Macrophyte data was collected from Lake Inari, Lake Muddus, Lake Nitsi and River Pasvik (Fig. 1). Lake Muddus and Lake Nitsi are unregulated lakes and are used as reference lakes. All lakes are classified as "Large Oligohumic Lakes (North)" in Finnish lake typology (Aroviita et al. 2012). The lakes in the River Pasvik are classified as low alkalinity, clear lakes using Norwegian typology (Direktoratsgruppa 2013).

Field work on macrophyte sampling in the lakes Inari, Muddus and Nitsi was done 31.7. – 15.8. by field team consisting of Minna Kuoppala, Juha Riihimäki and Jukka Ylikörkkö . Macrophyte data was collected using the standard Finnish method called "Main belt transect method". Observations of macrophyte species were made along a 5 m wide transects perpendicular to shoreline. Starting point for the transects were at the upper eulittoral and they extended to the outer depth limit of macrophyte vegetation. All macrophyte species including helophytes and bryophytes were recorded and frequency and abundance for each species was estimated using a continuous percentage scale. More comprehensive description of the method can be found on Kuoppala et al. (2008).

Number of the transects depends on the lake area maximum number being 25 transects. All lakes studied (Lake Inari, Lake Muddus and Lake Nitsi) were planned to have 25 transects each. However one transect at Lake Inari was not surveyed as planned, resulting 24 surveyed transects, 3 and 4). Transects at Lake Inari were distributed to 5 monitoring areas (Fig. 2). Lakes Muddus and Nitsi are smaller than Lake Inari so transects were distributed more evenly (Figs. 3 and 4).

The macrophyte survey in River Pasvik took place 27-30. August 2013. Here the macrophyte data was collected using both the Finnish and the Norwegian field methods. Sampling at river Pasvik was done by Juha Riihimäki, Marit Mjelde and Hanne Edvardsen. The Norwegian method (Mjelde 2013) includes only true aquatic macrophytes (i.e. isoetids, elodeids, nymphaeids, lemnids and charophytes). Those species that can occur in both helophyte and true aquatic forms are included in the analyses but helophytes, bryophytes and filamentous algae are excluded. Different habitats, from shore to maximum vegetation depth are surveyed and the species are recorded using an aqua scope and collected by dredging from the boat. Species abundance is estimated using a semi-quantitative scale (1=rare, 2=scattered, 3=common, 4=locally dominant and 5=dominant) and maximum depth distribution of vegetation is noted.

Norwegian field method was applied also in in previous macrophyte study in Pasvik (Moiseenko et al 1993) and the same study sites on the Norwegian side of the river were used in both surveys. A total of 15 sites using Norwegian method was visited. The Finnish field method was applied for 14 of those sites, with one transect on each site. The Finnish method was not applied on site 16 (Fig 5).

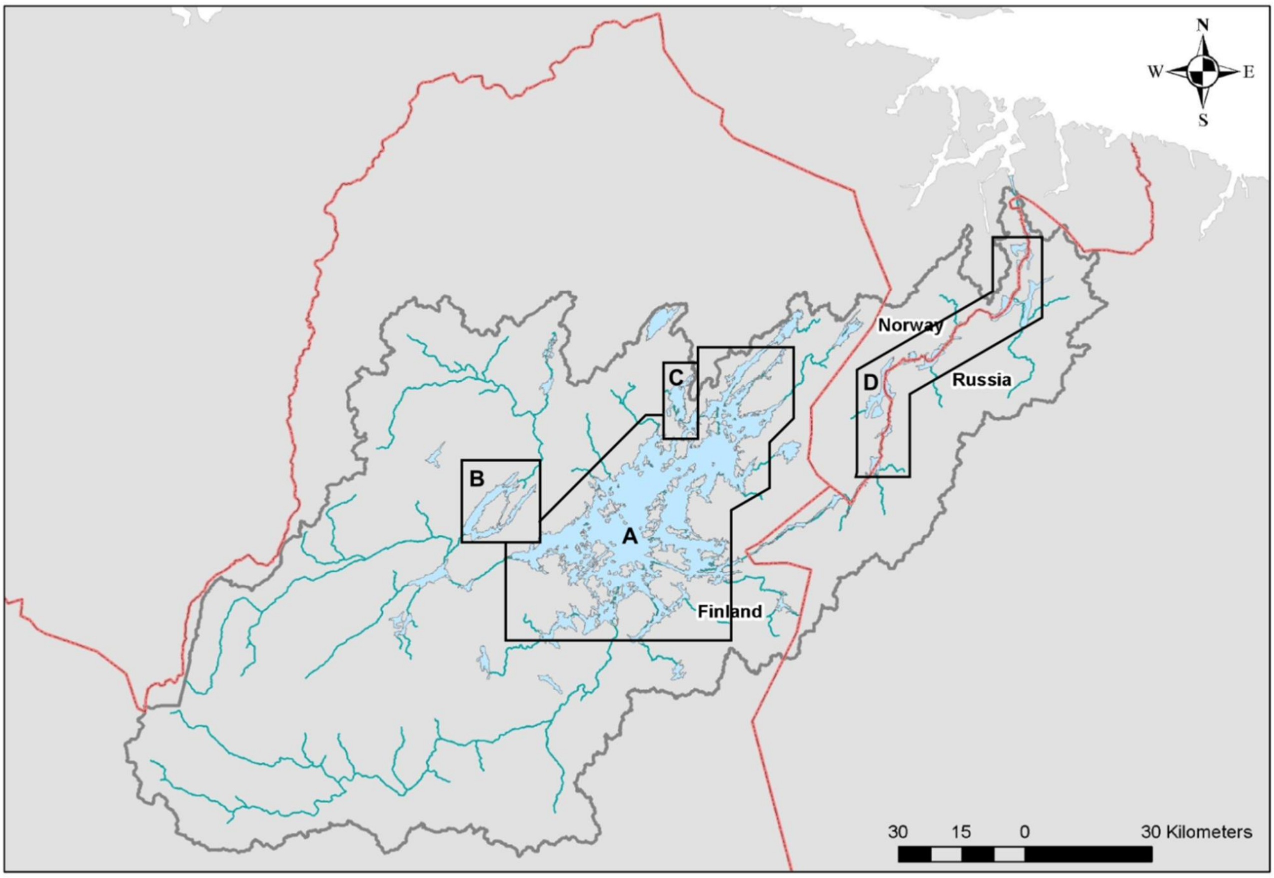

Figure 1. River Pasvik catchment and areas of vegetation studies. A) Lake Inari, B) Lake Muddus, C) Lake Nitsi and D) River Pasvik.

Ecological status of the lakes and river Pasvik was assessed using macrophytes according the European Union Water Framework Directive. For the lakes, assessment method for Finnish lake macrophytes was used. For river Pasvik both Finnish and Norwegian methods were used.

Finnish assessment method is a multimetric index combining results of three different metrics (Vuori et al. 2009, Aroviita et al. 2012):

1. Proportion of type specific taxa (TT50), where those plant species, which are common for at least 50 % of the reference lakes, are type specific species. TT50 metric value is proportion of those species of all species observed.
2. Percent Model Affinity (PMA), where the average relative abundance values of plant species in reference lakes are used as expected values and observed values are compared to expected values.
3. Trophic index (RI), where hydrophytes are classified according their occurrence probabilities along the phosphorous gradient to tolerant, indifferent or sensitive species. Number of species in each class is used to calculate reference index.

Calculated reference index for the observed lake is compared to index value of the reference lakes.

Observed metric values of studied lakes are divided by the average metric values of reference lakes (expected values) to calculate Ecological Quality Ratio (EQR) for each metric. EQRs are scaled to common thresholds so that scaled EQR value 0,8 is threshold for high/good status, 0,6 for good/moderate, 0,4 for moderate/poor and 0,2 for poor/bad. Ecological status of the lake using macrophytes as biological element is determined as average of scaled EQRs of all three macrophyte metrics and using above mentioned thresholds.

Norwegian assessment method (TIc index) is based on the relationship between the number of sensitive and tolerant species in relation to eutrophication (Mjelde 2013). EQR is calculated using observed TIc index and expected TIc index value obtained from the reference lakes.

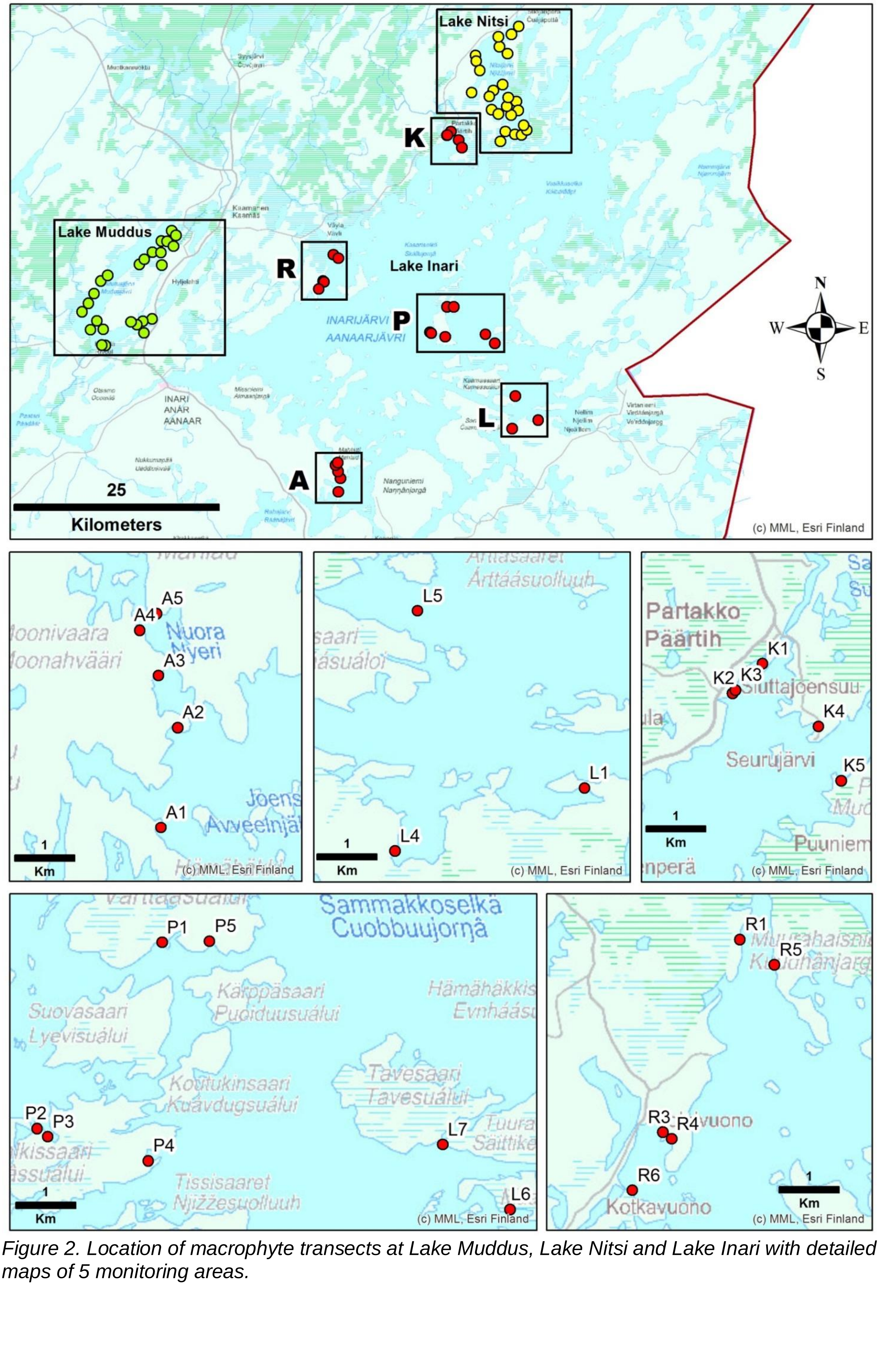

Figure 2. Location of macrophyte transects at Lake Muddus, Lake Nitsi and Lake Inari with detailed maps of 5 monitoring areas.

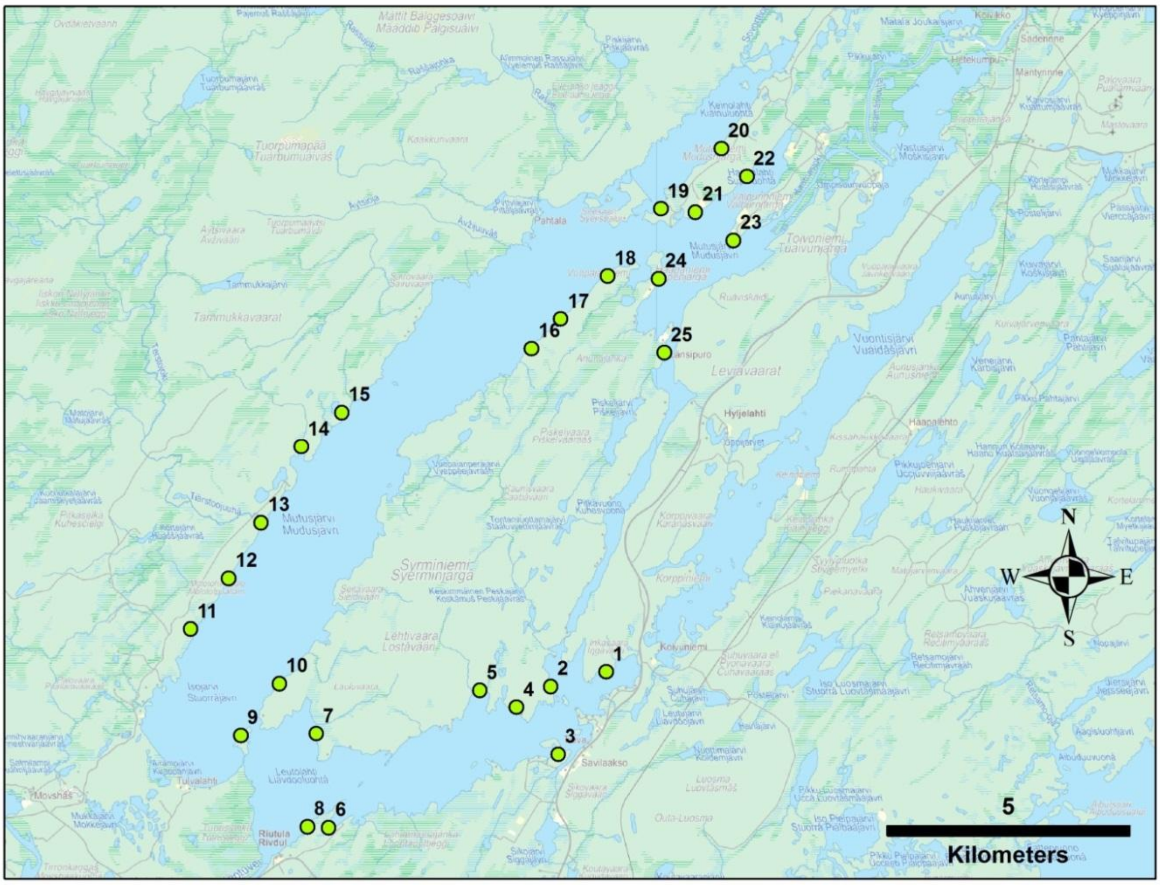

Figure 3. Detailed location of macrophyte transects at Lake Muddus.

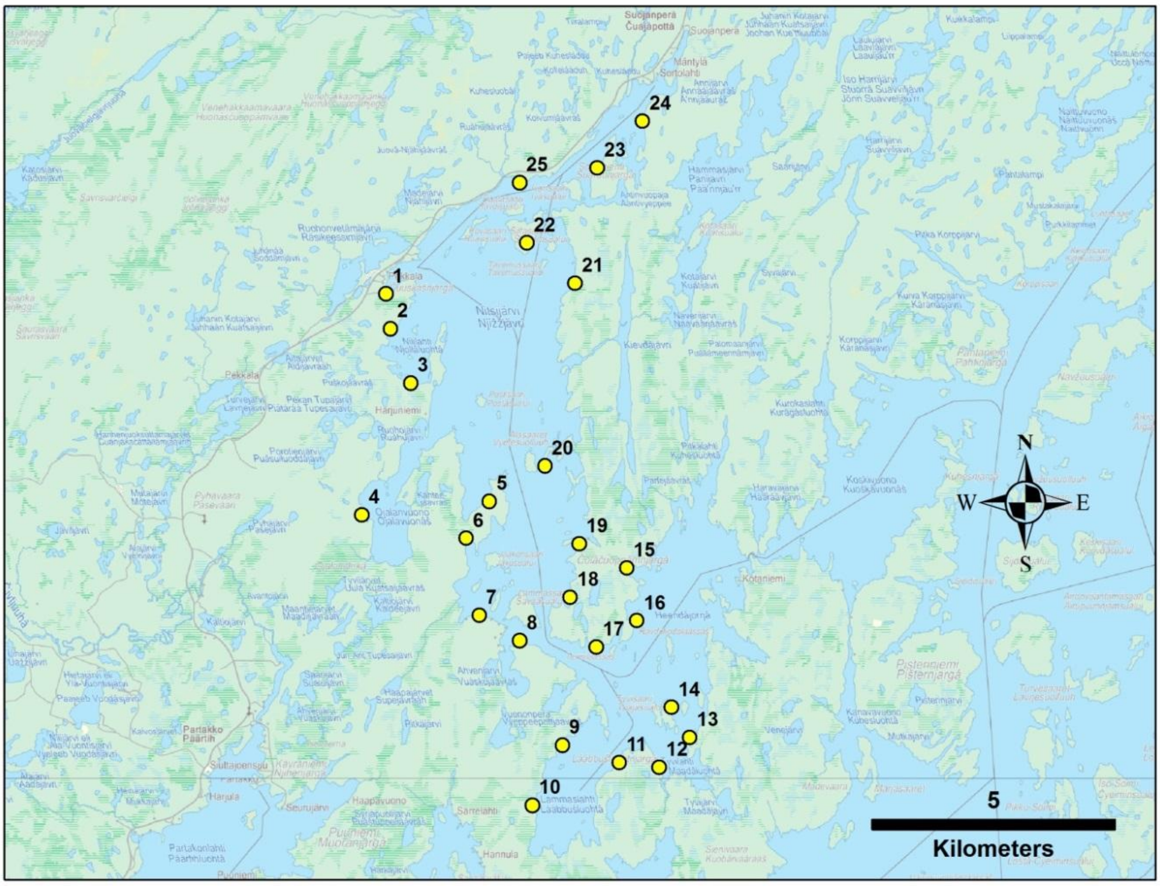

Figure 4. Detailed location of macrophyte transects at Lake Nitsi.

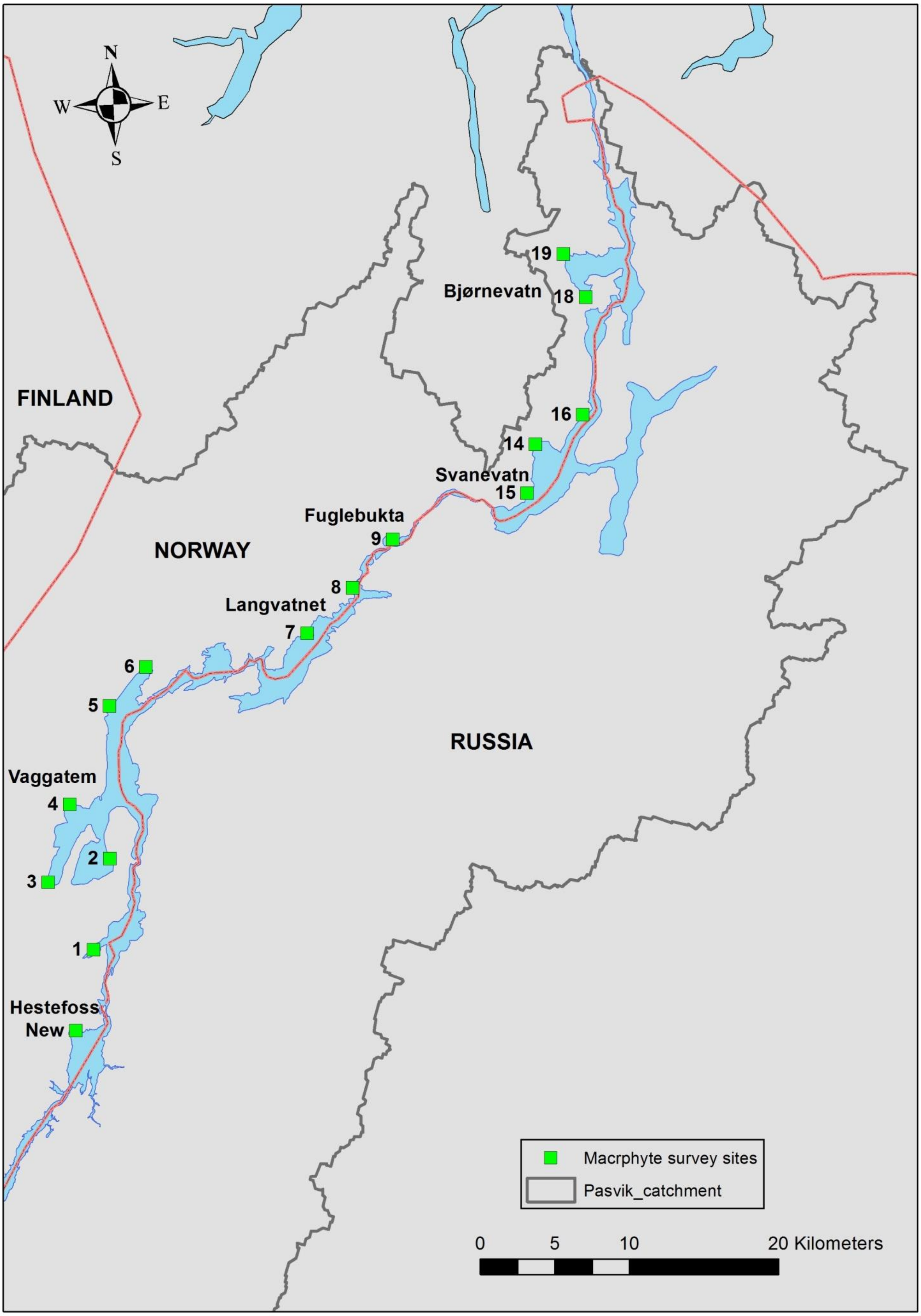

Figure 5. Detailed location of macrophyte survey sites at River Pasvik. Site numbering same as MOISEENKO et al 1993.

3. Results

3.1. Lake Inari, Lake Muddus and Lake Nitsi

3.1.1. Macrophyte communities of the lakes

Total area studied differs among the lakes since the length of transect is determined by the outer limit of the vegetation on transect. Total length of transects and hence also the total area was higher in Lake Nitsi than in Lake Inari and Lake Muddus (table 1).

Table 1. General information of lakes studied and surveyed transects.

	Lake Inari	Lake Muddus	Lake Nitsi
Number of transects	24	25	25
Total area of transects (m^2)	11885	12375	17180
Total lenth of transects (m)	2377	2475	3436

The total number of observed macrophyte species in studied lakes was 45, of which only 18 species were common to all three lakes, 12 species were common for two lakes and 15 species were observed only in one lake (table 2). However, the total number of observed species per lake was quite even.

Classification of true aquatic macrophytes (helophytes and bryophytes are omitted) according to their indicator value related to sensitivity and tolerance against eutrophication (Penning 2008 a, b) showed very similar composition among the lakes. Eutrophication tolerant species were totally missing from all of the lakes and the species pool was dominated by eutrophication sensitive species with only few indifferent species (Fig. 6)

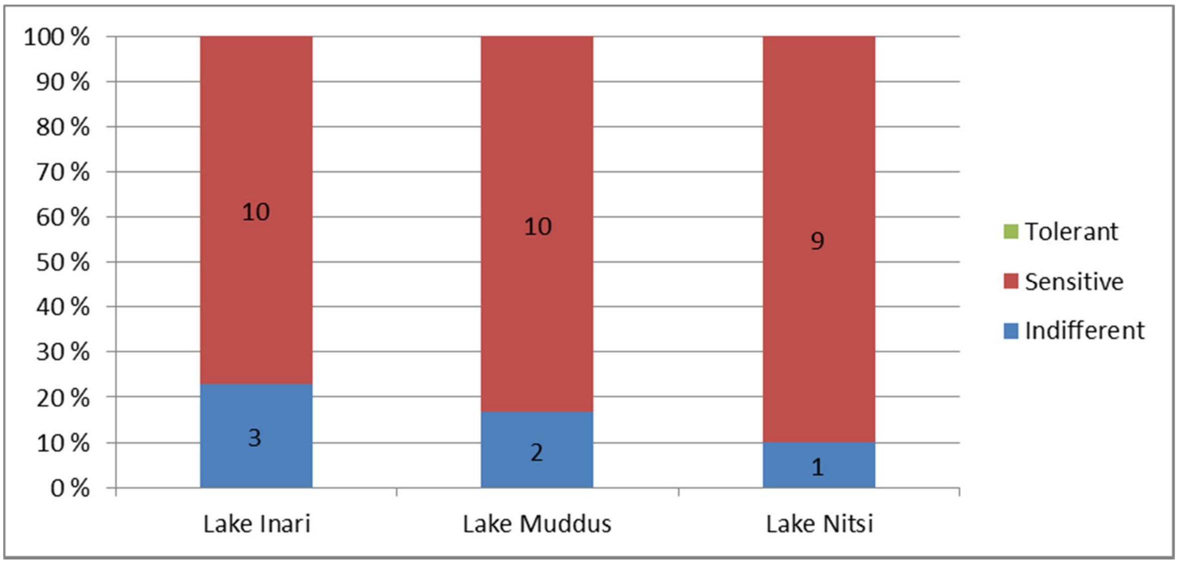

Figure 6. Proportion and number of plant species in different eutrophication indicator classes.

Table 2. Observed macrophyte species in studied lakes. Species common for all three lakes are indicated with yellow colour.

Species	Lake Inari	Lake Muddus	Lake Nitsi
Brachytecium rivulare Schimp.	x		
Calliergon cordifolium (Hedw.) Kindb.	x	x	x
Calliergon megalophyllum Mikut.	x		
Calliergon richardsonii (Mitt.) Kindb.		x	
Callitriche hamulata Kütz. ex W.D.J. Koch	x		
Caltha palustris L.	x	x	
Carex aquatilis Wahlenb.	x	x	
Carex lasiocarpa Ehrh.	x	x	x
Carex rostrata Stokes	x	x	x
Carex vesicaria L.	x		
Comarum palustre L., Potentilla palustris (L.) Scop.	x	x	x
Dichelyma falcatum (Hedw.) Myrin		x	x
Drepanocladus longifolius (Mitt.) Broth. ex Paris			x
Eleocharis acicularis (L) Roem. et Schult.	x	x	x
Equisetum fluviatile L.	x	x	x
Fontinalis antipyretica Hedw.		x	
Fontinalis hypnoides Hartm.		x	
Hippuris vulgaris L.		x	x
Isoetes echinospora Durieu	x	x	x
Isoetes lacustris L.	x	x	x
Juncus filiformis L.	x	x	x
Leptodictym riparium (Hedw.) Warnst.	x		x
Lysimachia thyrsiflora L.		x	
Menyanthes trifoliata L.		x	x
Myriophyllum alterniflorum DC.	x	x	x
Nitella flexilis (Linné) Agardh	x	x	
Philonotis fontana (Hedw.) Brid.	x		
Potamogeton berchtoldii Fieber	x	x	
Potamogeton gramineus L.	x	x	x
Potamogeton perfoliatus L.	x	x	x
Ranunculus peltatus ssp. peltatus	x	x	x
Ranunculus reptans L.	x	x	x
Scorpidium scorpioides (Hedw.) Limpr.	x	x	x
Sphagnum platyphyllum (Lindb. ex Braithw.) Sull. ex Warnst.	x		x
Sphagnum riparium Ångstr.			x
Subuluria aquatica L.	x	x	x
Utricularia intermedia Hayne	x	x	
Utricularia minor L.	x		
Utricularia vulgaris L.	x	x	x
Warnstorfia exannulata (W. Gümbel) Loeske	x		x
Warnstorfia fluitans (Hedw.) Loeske	x		
Warnstorfia procera (Renauld & Arnell) Tuom.	x	x	x
Warnstorfia trichophylla (Warnst.) Tuom. & T. J. Kop.			x
Nitella flexilis/opaca			x
Sparganium sp.		x	x
Total number of species	33	31	29

3.1.2. Ecological status assessment of the lakes

Ecological status of the Lake Inari was assessed using Finnish multimetric index for lake macrophytes. Mscrophyte data from Lake Muddus, Lake Nitsi, Lake Kitka and Lake Yli-Kitka were used as reference data. Average EQR of the three metrics was 0.81 so Lake Inari was assessed to be slightly in high ecological status based on aquatic macrophytes (boundary between high/good status is 0.80). For each separate metrics the EQR value was also clearly above good/moderate boundary (Table 3)

Table 3. Ecological status classification of the Lake Inari. Other lakes (Nitsi, Muddus, Yli-Kitka and Kitka) were used as reference lakes in current analysis.

	RI		TT50SO		PMA		Total	
Data	EQR	Status	EQR	Status	EQR	Status	EQR	Status
Lake Nitsi 2012	1.00	High	0.90	High	1.05	High	0.99	High
Lake Muddus 2012	0.90	High	1.02	High	0.98	High	0.97	High
Lake Yli-Kitka, Suonna 1978	1.00	High	0.99	High	0.67	Good	0.89	High
Lake Kitka 1984	0.72	Good	0.61	Good	0.84	High	0.72	Good
Lake Inari 2012	0.80	Good	0.71	Good	0.93	High	0.81	High

3.2.River Pasvik

Total number of the macrophyte species including true aquatic macrophytes, bryophytes and helophytes observed in the River Pasvik sites was 47, of them 37 were observed using the Finnish field method (Annex 1). Using the Norwegian field method, 34 species (only true aquatic macrophytes) were observed (Annex 2). The number of species per sites was higher using the Norwegian method in all but one site (Fig 7). Average number of species per site using the Finnish method and the Norwegian method were 11 and 14 and range (min-max) number of species 5-17 and 4-22 species respectively.

There is a clear difference in the field methods that effects on the results. In the Finnish method also helophytes and bryids are observed, which is not the case in the Norwegian method. Also the number of visited sites at river Pasvik was different. When comparing results using only common sites, and common observed growth forms, the total number of observed plant species using Finnish and Norwegian field method were 27 and 33 species respectively (table 4).

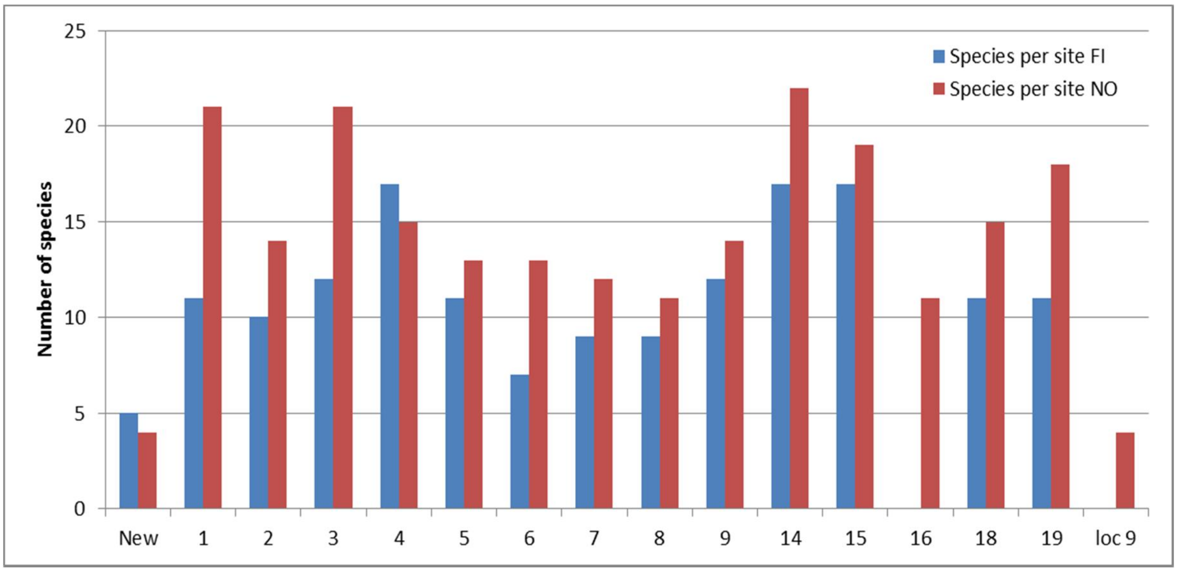

Figure 7. Number of species per site using the Finnish field method (FI) and the Norwegian field method (NO).

Table 4. Observed macrophyte species using the Finnish field method (FI) and the Norwegian field method (NO) with common growth forms and sites.(E = Elodeid, C = Charid, I = Isoetid, L = Lemnid, N = Nypheid). Species observed with both methods are indicated with yellow colour.

Growth forms	Species	FI field method	NO field method
E	Callitriche hamulata		x
E	Callitriche hermaphroditica	x	x
E	Callitriche palustris	x	x
C	Chara virgata		x
I	Elatine hydropiper	x	x
I	Elatine orthosperma		x
I	Eleocharis acicularis	x	x
E	Hippuris vulgaris	x	x
I	Isoetes echinospora	x	x
I	Isoetes lacustris	x	x
L	Lemna trisulca	x	x
E	Myriophyllum alterniflorum	x	x
E	Myriophyllum sibiricum	x	x
C	Nitella opaca	x	x
N	Nuphar lutea		x
N	Nuphar pumila		x
N	Persicaria amphibia	x	x
E	Potamogeton alpinus	x	x
E	Potamogeton berchtoldii	x	x
E	Potamogeton compressus		x
E	Potamogeton gramineus	x	x
E	Potamogeton perfoliatus	x	x
E	Potamogeton praelongus	x	x
E	Ranunculus confervoides	x	x
E	Ranunculus peltatus	x	x
I	Ranunculus reptans	x	x
N	Sagittaria sagittifolia x natans	x	x
N	Sparganium angustifolium	x	x
N	Sparganium emersum	x	x
I	Subularia aquatica	x	x
E	Utricularia intermedia	x	x
E	Utricularia minor	x	
E	Utricularia ochroleuca		x
E	Utricularia vulgaris	x	x
	Total number of species = 34	27	33
	Common species		26

Number of species per site is clearly higher in all sites with the Norwegian method when comparison was made using only common sites and growth forms (Fig. 8). In this comparison the average number of species per site using the Finnish method and the Norwegian method were 9 and 15 and range (min-max) number of species 3-14 and 4-22 species respectively.

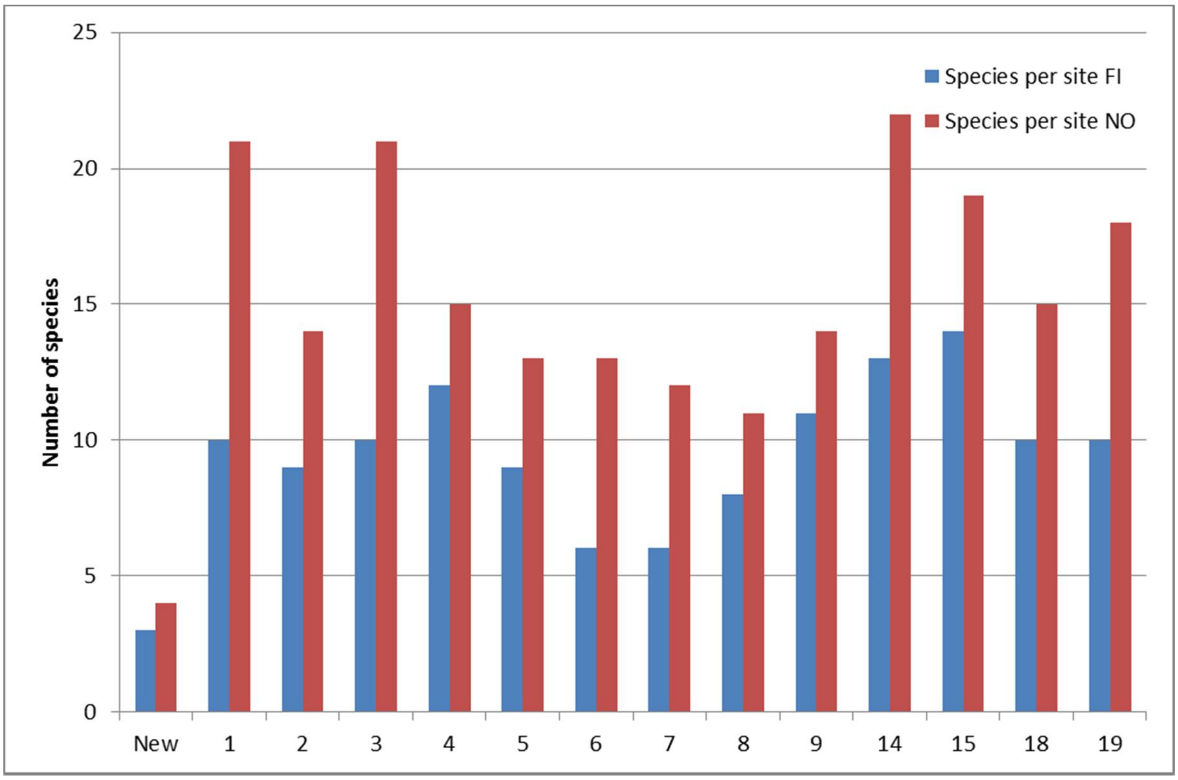

Figure 8. Number of species per site using the Finnish field method (FI) and the Norwegian field method (NO) with common growth forms and sites.

3.2.1. Ecological status assessment of River Pasvik

Ecological status assessment gave quite similar results when Finnish and Norwegian assessment methods were compared using RI index and TIc index, and all River Pasvik lakes were classified to high or good status (fig. 9 and 10). Also when combined Finnish multimetric index was used, most of the lakes were classified to high or good status except Hestefoss and Fjørevatnet, where low number of sites made PMA index unstable and lowered status (table 5). Results showed that relatively similar RI and Tix indices gave exactly the same results showing relatively high status of River Pasvik lakes.

Table 5. Ecological status assessment of river Pasvik lakes using the Finnish and Norwegian status assessment methods. Numbers after lake names indicate the site codes. The Finnish method was not applied on site 16 (fig. 5).

	RI		TT50SO		PMA		Total (FI)		Tic (NO)	
Data	EQR	Status	EQR	Status	EQR	Status	EQR	Status	EQR	Status
River pasvik (All sites)	0,72	Good	0,62	Good	0,66	Good	0,67	Good	0,90	Good
Hestefoss (New)	0,60	Good	0,70	Good	0,12	Bad	0,47	Moderate	1,11	High
Fjorvatnet (1)	0,65	Good	0,47	Moderate	0,06	Bad	0,39	Poor	0,88	Good
Vaggatem (2, 3, 4, 5, 6)	1,13	High	0,87	High	0,55	Moderate	0,85	High	0,89	Good
Langvatn (7, 8)	1,00	High	0,70	Good	0,75	Good	0,82	High	0,98	High
Fuglebukta (9)	1,13	High	1,03	High	0,63	Good	0,93	High	1,00	High
Svanvatn (14, 15, 16)	0,74	Good	0,70	Good	0,61	Good	0,68	Good	0,87	Good
Björnvatn (18, 19)	1,13	High	0,70	Good	0,46	Moderate	0,76	Good	0,91	Good

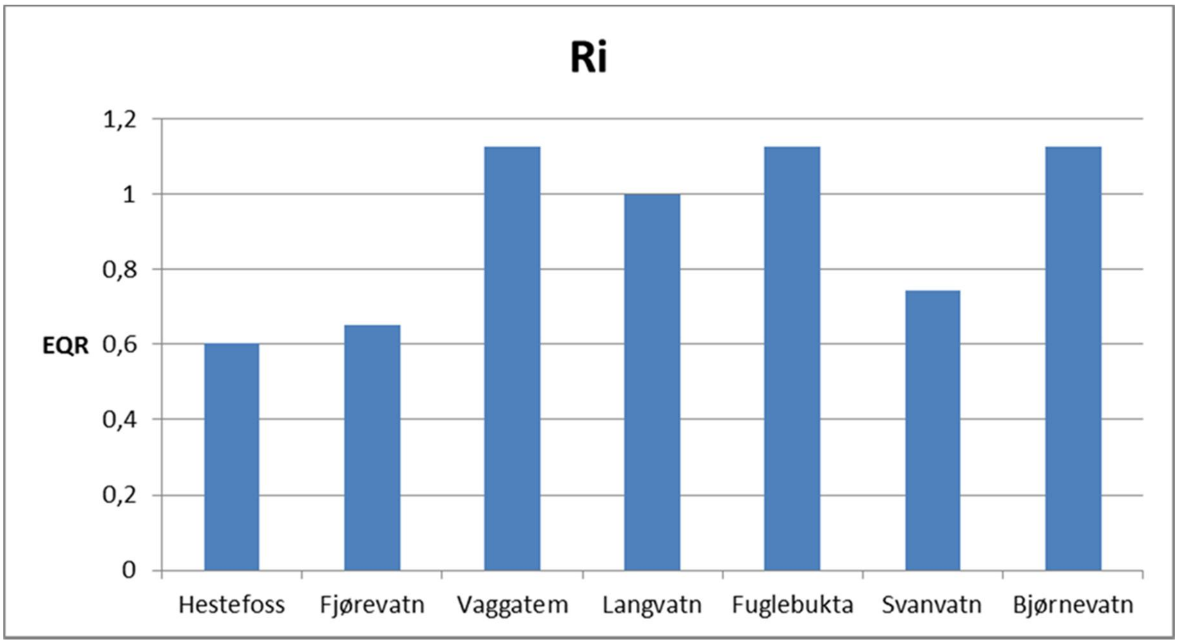

Figure 9. Ecological classification of river Pasvik lakes using the Finnish assessment method. Boundary between good moderate status is EQR value 0,6.

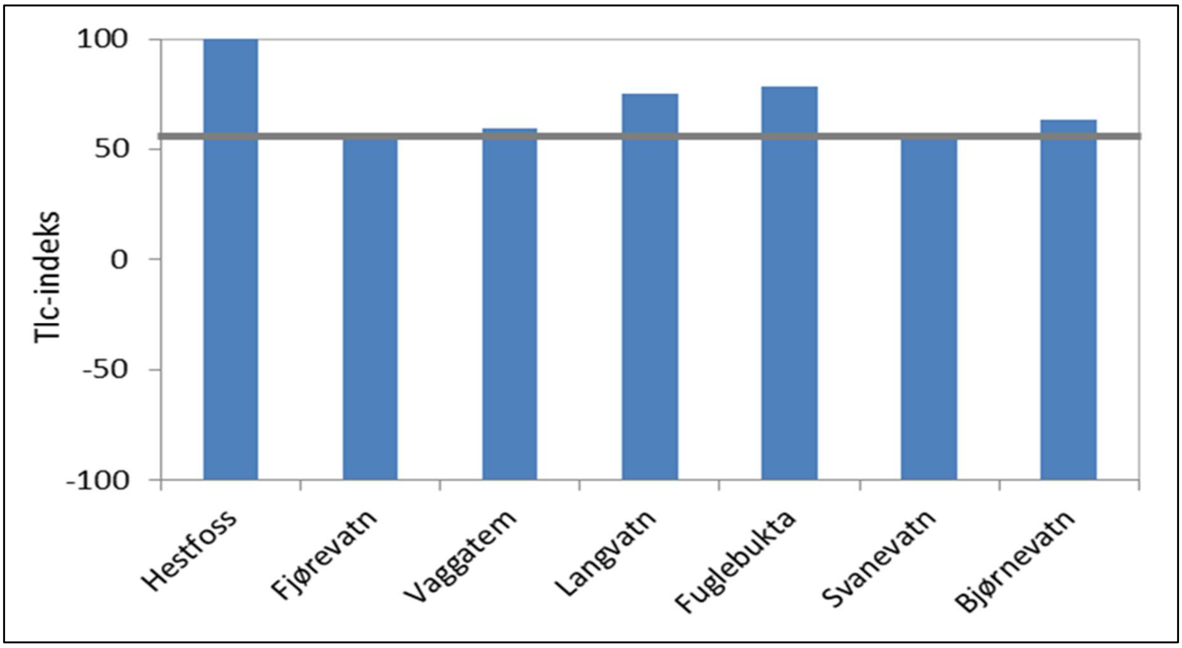

Figure 10. Ecological classification of river Pasvik lakes using the Norwegian assessment method. Boundary between good moderate status is marked with grey line.

3.2.2. Hydromorphological status assessment of river Pasvik

Macrophyte composition was also assessed by using water level regulation index developed by Mjelde et al. (2012). The index showed that all lakes except Hestefoss and Langvatn were in better than moderate status. However, this index is developed for Hep-reguleted lakes with (more or less) considerable winter drawdown. The lakes in the River Pasvik have different regulation regimes, with limited winter drawdown.

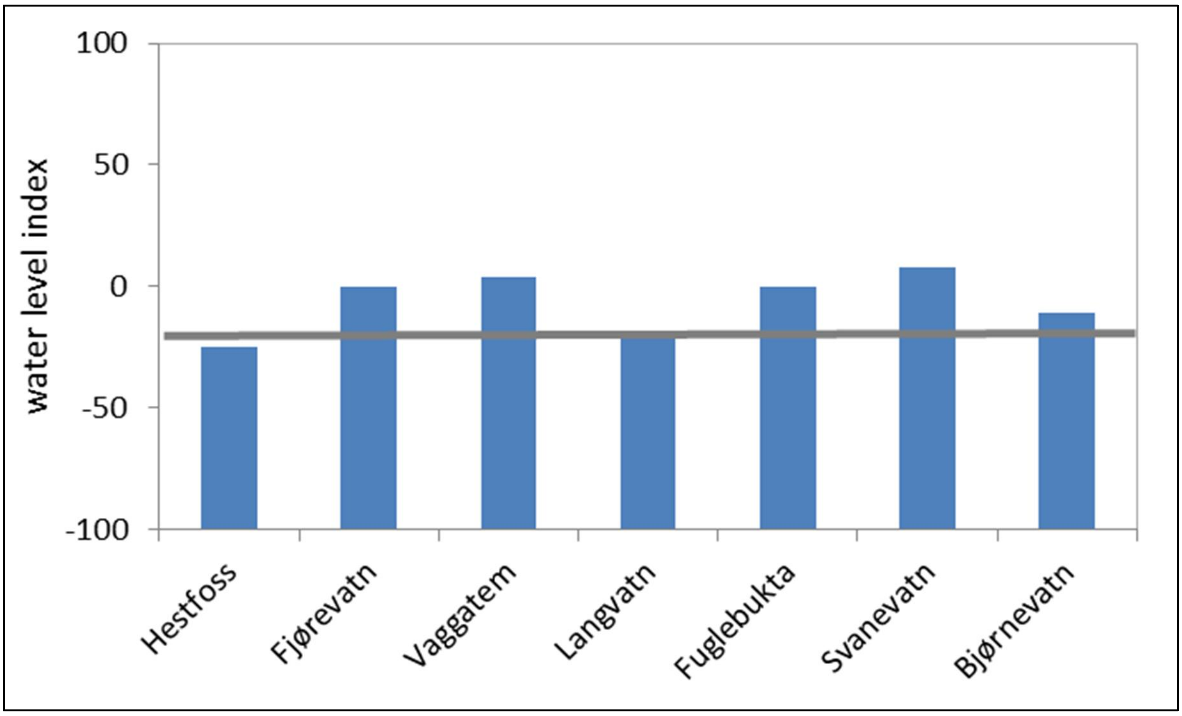

Figure 11. The water level fluctuation (Wlc) index values for River Pasvik lakes (Mjelde et al 2012). Preliminary boundary between good moderate hydromorphological status is marked with grey line.

3.2.3. River Pasvik status compared to other large rivers

Aquatic macrophyte diversity of River Pasvik have been compared in Fig 12. Diversity is significantly higher compared to other large rivers in Norway (excluding River Glomma, which is situated in southern Norway and represents naturally higher diversity gradients).

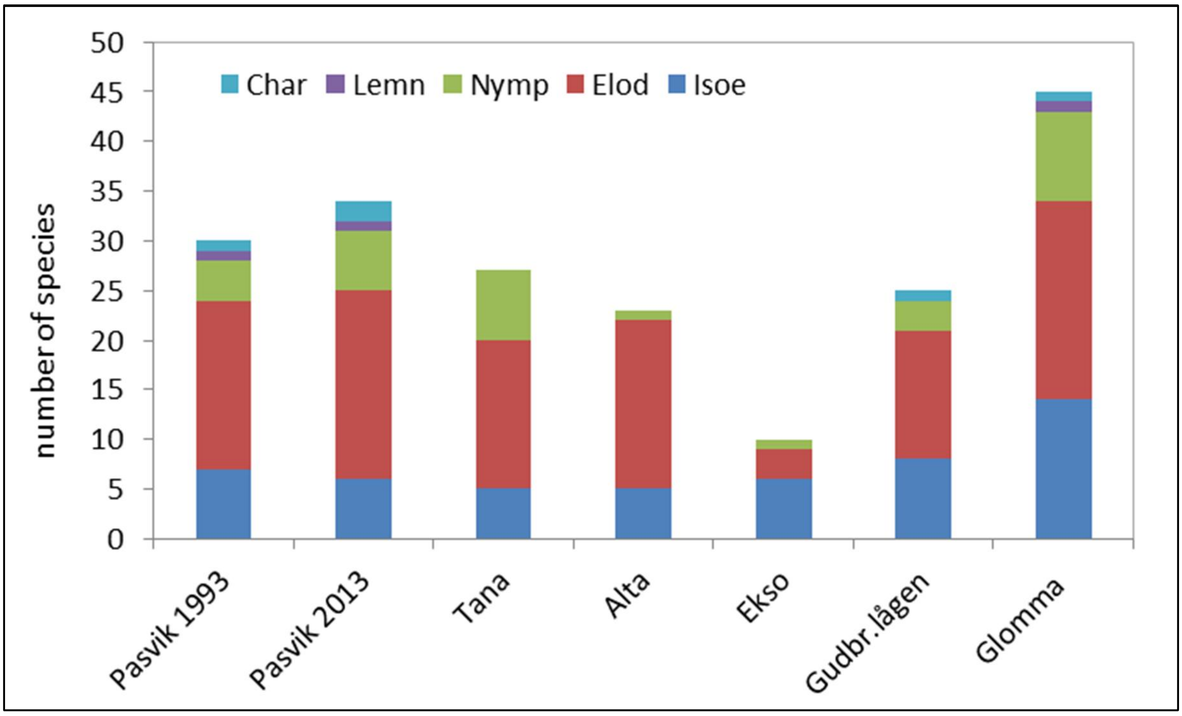

Figure 12. Number of macrophyte species in large rivers of Norway (Mjelde unpublished data). Previous Pasvik study is developed by similar methods than in 2013 (Moiseenko et al. 1993).

4. Discussion

The ecological status of Lake Inari based on aquatic macrophytes was high. Water level regulation for the hydropower production is considered to be the dominant human induced pressure to Lake Inari, while nutrient loads due to human activity are estimated to be relatively low. Estimated phosphorous load assortment for Finnish area of Pasvik basin shows that less than 1 % of total phosphorous (totP) load originates from point source loads, only 10 % of totP load is diffuse load from human activity and rest of the totP load are from aerial deposition and natural leaching 17 % and 73% respectively (Lapin ympäristökeskus 2010). Average water level fluctuation during the period 2000 – 2009 has been about 1.40 meters, which is about 0.30 meters lager than the natural water level fluctuation (Puro-Tahvanainen et. al. 2011). Water level regulation induced effects on littoral areas at Lake Inari are limited and the macrophyte communities are well adapted to the current conditions. However, it should be noted that vertical extension of sedges (Carex sp.) is has decreased, so has areas of spring-flood depended vegetation.

The macrophyte survey in the River Pasvik lakes showed similar high - good status in all lakes. Despite the fact that the whole river has changed significantly and consists of cascades of hydropower reservoirs, plant species composition resembles natural one with species such as Isoetes lacustris and Myriophyllum alterniflorum. It should be noted, that water level of lakes is relatively stable and without significant drawdown of water level during winter. Winter drawdown is one of the most significant factors negatively affecting the status of lake macrophytes as shown in several studies (Mjelde et al. 2013, and references herein). On the other hand, more or less stable water level (as in the River Pasvik lakes) positively affects the abundance of several aquatic macrophyte species. However, abundance of helophytes and especially sedges is much lower than in lakes with normal spring flood reflecting decreased water level fluctuation.

River Pasvik water quality reflects largely the outflow of Lake Inari, which in general is in good status. Therefore also species indicating eutrophication is low even in areas affected by Nickel smelters.

Biological monitoring of Lake Inari and River Pasvik using macrophytes is well established and usable in its current state. Both Finnish and Norwegian field methods and ecological status assessment methods show similar results regardless of the obvious disparities in the field methods. Aquatic macrophyte surveys are lacking from the Russian area of the

Pasvik River basin, hence we recommend setting up comparable macrophyte monitoring and status assessment system to be applied also on Russian area of the river basin.

Acknowledgements

We wish to thank Hanne Edvardsen (NIVA), Minna Kuoppala (SYKE) and Jukka Ylikörkkö (ELY for Lapland) for the valuable participation to the macrophyte sampling on River Pasvik, Lake Inari,Lake Muddus and Lake Nitsi. Also we want to thank Paul Eric Aspholm (Bioforsk) and Martti Salminen (ELY for Lapland) for guidance and logistics on study areas.

5. References

Aroviita, J., Hellsten, S., Jyväsjärvi, J., Järvenpää, L., Järvinen, M., Karjalainen S. M., Kauppila, P., Keto, A., Kuoppala, M., Manni, K., Mannio, J., Mitikka, S., Olin, M., Perus, J., Pilke, A., Rask, M., Riihimäki, J., Ruuskanen, A., Siimes, K., Sutela, T., Vehanen, T. and Vuori, K.-M. 2012. Ohje pintavesien ekologisen ja kemiallisen tilan luokitteluun vuosille 2012–2013 − päivitetyt arviointiperusteet ja niiden soveltaminen. (Guidelines for the ecological and chemical status classification of surface waters for 2012–2013 – updated assessment criteria and their application). Ympäristöhallinnon ohjeita 7/2012, 144 pp.

Kuoppala M., Hellsten S. & Kanninen A. 2008. Sisävesien vesikasviseurantojen laadunvarmennus (Development of quality control in aquatic macrophyte monitoring). Suomen ympäristö 36: 1–93.

EEA 2008. European River Catchments. GIS database. http://www.eea.europa.eu/data-and-maps/data/european-river-catchments-1

Hellsten, S., Willby, N., Ecke, F., Mjelde, M., Phillips, G., Tierney, D., Poikane S. (ed.). 2014. Water Framework Directive Intercalibration Technical Report: Northern Lake Macrophyte ecological assessment methods. JRC Technical Reports. Luxembourg: Publications Office of the European Union., ISBN: 978-92-79-35470-0

Lapin ympäristökeskus. 2010. Tenon–Näätämöjoen–Paatsjoen vesienhoitoalueen vesienhoitosuunnitelma vuoteen 2015. (Teno – Näätämö – Paatsjoki River basin management plan for 2015). 123 pp.

Mjelde, M. 2013. Vannplanter. I: Direktoratsgruppa 2013. Veileder 02:2013 Klassifisering av miljøtilstand i vann (in Norwegian).

Mjelde, M., Hellsten, S. & F. Ecke. 2013. A water level drawdown index for aquatic macrophytes in Nordic lakes. Hydrobiologia 704:141–151

Moiseenko, T., Mjelde, M., Brandrud, T., Brettum, P., Dauvalter, V., Kagan, L., Kashulin, N., Kudriavtseva, L., Lukin, A., Sandimirov, S., Traaen, T.S., Vandysh, O. & Yakovlev, V. 1994. Pasvik River Watercourse, Barents Region: Pollution Impacts and Ecological

Responses. Investigations in 1993. - Institute of North Industrial Ecology Problems (Russia), Norwegian Institute for Water Research (Norway). NIVA-report OR-3118. 87 p.

Penning, W. E., Dudley, B., Mjelde, M., Hellsten, S., Hanganu, J., Kolada, A., van den Berg, M., Maemets, H., Poikane, S., Phillips, G., Willby, N., & Ecke, F. 2008a. Using aquatic macrophyte community indices to define the ecological status of European lakes. Aquatic Ecology 42:253-264.

Penning, W. E., Mjelde, M., Dudley, B., Hellsten, S., Hanganu, J., Kolada, A., van den Berg, M., Maemets, H., Poikane, S., Phillips, G., Willby, N., & Ecke, F. 2008b. Classifying aquatic macrophytes as indicators of eutrophication in European lakes. Aquatic Ecology 42:237-251.

Puro-Tahvanainen, A., Aroviita, J., Järvinen, E. A., Kuoppala, M., Marttunen, M., Nurmi, T., Riihimäki, J.,Salonen, E. 2011. Inarijärven tilan kehittyminen vuosina 1960–2009, (Development of the status of Lake Inari between 1960 and 2009). Suomen ympäristö 19/2011, 89 pp.

UNECE 2011. Second Assessment of transboundary rivers, lakes and groundwaters. EDE/MP.WAT/33, United Nations.

Vuori, K., Mitikka, S., Vuoristo, H. 2009. Pintavesien ekologisen tilan luokittelu (Guidance on ecological classification of surface waters in Finland. Part 1: Reference conditions and classification criteria, Part 2: Environmental impact assessment). Ympäristöopas 3/2009, 120 pp.

Annex 1.

Abundance of River Pasvik macrophytes 2013 - Finnish field method

	Hestfoss	Fjørev	Vaggatem					Langvatn		Fuglebukta	Svanevatn		Bjørnevatn	
Species	0	1	2	3	4	5	6	7	8	9	14	15	18	19
Calliergon giganteum (Schimp.) Kindb.	0	0	0	60	0	0	0	0	0	0	0	0	0	0
Calliergon megalophyllum Mikut.	0	0	0	0	0,15	0	0	0	0	0	0	0	0	0
Callitriche hermaphroditica L.	0	12	0	0	0,0025	0	0	0	0	0	0	0,75	0	0,2
Callitriche palustris L.	0	0	0	0	0	0	0	0	0	0	0	0,0025	0	0
Carex acuta L.	0	0	0	0	0	0	0	0	1,5	0	0	2,7	0	0
Carex aquatilis Wahlenb.	0	0	0	0	0,45	0	0	0	0	0	1	0	0	0
Carex lasiocarpa Ehrh.	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Carex rostrata Stokes	0	0	0	0	0,45	0	1,5	1,2	0	0	0	0	0	0
Comarum palustre L., Potentilla palustris (L.) Scop.	0	0	0	0	0,03	0	0	0,09	0	0	0	0	0	0
Elatine hydropiper L.	0	0	0	0,035	0	0	0	0	0	0	0	0,03	0,0025	0
Eleocharis acicularis (L) Roem. et Schult.	0	0	0,05	0,015	0,03	1	0	0	0	3	0,6	0,25	0	1,2
Eleocharis palustris (L.) Roem. et Schult.	0	0	0	0	0	0	0	0	0	0	0	4,5	0	0
Equisetum fluviatile L.	0,4	0	12	0	0	0	0	0,015	0	0	12	0,15	3,5	0,21
Fontinalis antipyretica Hedw.	0	0	0	0,0025	0	0	0	0	0	0,03	0,005	0	0	0
Hippuris vulgaris L.	0	0	0	0	0,07	0	0	0,1	0,4	0	0	0	0	0
Isoetes echinospora Durieu	0	0	0,05	2,1	0,05	2	0,01	0	0	3	0,6	18	0,5	9
Isoetes lacustris L.	0	0	72	16	63	63	0	0	0	0,1	6	0	0,015	0,005
Lemna trisulca L.	0	0	0	0	0	0	0	0	0	0	0,015	12	0	0
Menyanthes trifoliata L.	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum alterniflorum DC.	0	0	1,8	3	9,9	0,7	0,6	12	0,5	13,5	0,6	54	0,4	0,3
Myriophyllum sibiricum Kom.	0	90	0	0	0	0	0	0	0	0	0	0	0	0
Nitella flexilis (Linné) Agardh	0	0	0	0	0	0	0	0	0,0025	0	0	0	0,0025	2
Persicaria amphibia (L.) Delarbre	0,01	0	0	0	0	0	0	0	0	0	1,05	2	0	0
Potamogeton alpinus Balb.	0	0,7	0	0	0	0	0	3	0	0	0	0	0	0
Potamogeton berchtoldii Fieber	0	3	0	0	0	0	0	0	0,7	2,4	0,0025	0,005	0	0
Potamogeton gramineus L.	0	0	0	0	0,0025	0	0	0	0,35	0,05	0	0	0	0
Potamogeton perfoliatus L.	0	0	0,75	6	1,2	0,15	0,01	0	0	2,1	0,07	5,6	0,0025	0,1
Potamogeton praelongus Wulfen	0	1,2	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus confervoides (Fr.) Fr.	0	0,01	0	0	0	0	0	0	0	0	0	0	0	0,0025
Ranunculus peltatus Schrank	0	0	0,01	0,8	2,1	0,7	0,4	0,4	2,1	0,3	0,2	1	0,3	0,1
Ranunculus reptans L.	0	0	0,05	0,1	0,015	0,1	0	0	1,8	0,4	1	0	0,9	0
Sagittaria natans x sagittifolia	0	0,05	0	0	0	0	0	0	0	0	0	0	0	0
Scorpidium scorpioides (Hedw.) Limpr.	0	60	0	0	8	2	0	0	0	0	0,28	0	0	0
Sparganium angustifolium Michx.	1,5	0	4	6	1	6	0,25	1,5	0	4,5	0,025	0,5	2,1	0
Sparganium emersum Rehmann	0	0,15	0	0	0	0	0	0	8	0	0	0,7	0,005	0
Subuluria aquatica L.	0	0	0,1	0,2	0,15	0,015	0,0025	0,0025	0	0,025	3	0	0	5
Utricularia intermedia Hayne	0,0025	0,07	0	0	0	0	0	0	0	0	0	0	0	0
Utricularia minor L.	0	0	0	0	0	0	0	0	0	0	0	0,0025	0	0
Utricularia vulgaris L.	0	0,01	0	0	0	0	0	0	0	0	0,005	0	0	0
Total number	**5**	**12**	**11**	**13**	**18**	**12**	**8**	**10**	**10**	**13**	**18**	**18**	**12**	**12**

Abundance combines estimated cover and frequency of spesies in each transect and is calculated: (mean cover of species * frequency) / 100

Annex 2.

	Abundance of River Pasvik macrophytes 2013 - Norwegian field method																
lifeform		Hestfoss	Fjørev	Vaggatem					Langvatn		Fuglebukta	Svanevatn			Bjørnevatn		downstream
groups	Species	0	1	2	3	4	5	6	7	8	9	14	15	16	18	19	loc 9
E	Callitriche hamulata		1		1												
E	Callitriche hermaphroditica		4	2	1,5	1,5	2,5			2	2	2	2		2	2	
E	Callitriche palustris				1				1				1,5		1,5	2	
C	Chara virgata		4														
I	Elatine hydropiper				3							2	2				
I	Elatine orthosperma				1												
I	Eleocharis acicularis		4	3	3	3	4	3		2	4	2	3	3	3,5	3,5	
E	Hippuris vulgaris	2	5		2	3			2	1		2,5					
I	Isoetes echinospora			2	2	3	3	4	2		2,5	2	3	2	3		
I	Isoetes lacustris			5	4,5	4,5	5	5	1		2	4,5	4,5	4,5	4	2	
L	Lemna trisulca											4,5	3		1	1	
E	Myriophyllum alterniflorum	2	3	4	3	3	4	3,5	3		4	2,5	4,5	3	2,5	3	
E	Myriophyllum sibiricum		5									2,5					
C	Nitella opaca			1		1,5		2	1	2,5			2		3	2	
N	Nuphar lutea		4														
N	Nuphar pumila											2					
N	Persicaria amphibia			4	3	4						-1	4	4			
E	Potamogeton alpinus		2				3		4	3	1	2				2	
E	Potamogeton berchtoldii		2					1,5		3	3	1	2,5		2	2	
E	Potamogeton compressus			2													
E	Potamogeton gramineus		2		1	3,5	4,5	2			3	2,5	2			-1	4
E	Potamogeton perfoliatus		3	3	3	3	3	2			4	3,5	4	3	3	3	4
E	Potamogeton praelongus		3				2,5	1									
E	Potamogeton x sparganifolius																5
E	Ranunculus confervoides		2,5	1		2				2	2	1,5			1	1,5	
E	Ranunculus peltatus		2	2	4	4	4	3,5	3	3	4	3	4	4	3	3	
I	Ranunculus reptans		3	3	3		3	3	4	3	3		2,5		3	3	
N	Sagittaria sagittifolia x natans		2		2,5												
N	Sparganium angustifolium	3		4	4	4	3	4	4	3,5	5	3	3	3,5	3	4	4
N	Sparganium emersum		2		2							3,5	2	2			
I	Subularia aquatica		2	3	3,5	2,5	3	3	1,5	1,5	3	2	2,5	2	3	3	
E	Utricularia intermedia	1	3									2					
E	Utricularia ochroleuca				1	2										1	
E	Utricularia vulgaris		2		2				1			3	1,5	2		1	
	total number	**4**	21	14	21	15	13	13	12	11	**14**	22	19	11	15	18	4