

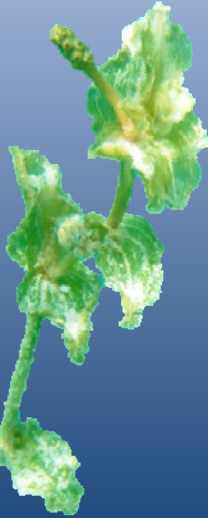
Developing Biological Tools for Monitoring in Lake Ohrid according to the WFD

Macrophyte Vegetation of Lake Ohrid



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Working Group



Goals of the Research

- Determine the Diversity of Macrophyte;
- Determine Species Composition;
- Determine the Vegetation Limit;
- Estimate the Plant Abundance;
- Calculate the Macrophytic Index;
- Assess the Trophic State of Lake Ohrid

Macrophyte Vegetation of Lake Ohrid

1. Lake Ohrid macrophyte vegetation is distributed in belts:

- Belt of *Cladophora sp.*
- Belt of reed, *Phragmites australis*.
- Belt of pondweed, *Potamogeton*.
- Belt of stoneworts, charophytes.



Lake Ohrid macrophyte vegetation

Macrophytes - biological indicator for lakes` assessment according to WFD.

The European WFD outlines two macrophyte-related quality elements that should be taken into consideration during the assessment of the ecological status of lakes:

- taxonomic composition
- average macrophytic abundance

Sampling frequency for monitoring of macrophyte vegetation is set at once per year, according to Water Framework Directive.

Sampling Localities



The collection of macrophyte vegetation has been performed in 30 localities, i.e. 20 along the Macedonian and 10 along the Albanian coastline of Lake Ohrid.

Sampling localities-ALBANIA

Dogana Tushemisht (ANR3D)
Pogradec 2 (ANR5PG2)
Udënisht (ANR3U)
Piskupat (near the rock)(ANR2)
Lini-village (ANR1L)

July 2010

➤ **Samples collected only in 0.5m.**

➤ **Samples were collected in 30 localities (10 localities in Albanian part and 20 localities in Macedonian part).**

Tushemisht - Drilon (ANR7T)
Pogradeci- Vërdovë (ANR6PG1)
Mëmëlisht- train station (ANR4M)
Piskupat (ANR2P)
Cape of Lini (AR1L)

July 2011

Sampling localities-MACEDONIA

Radozda (MRR)
Struga (MNRS)
Sateska river (MNRSR)
Grashnica
Ohrid bay (MNRZ)
H.Metropol (MNRM)
Hotel Park (MRP)
Velidab (MRV)
Trpejca (MNRT-non reference)
Cherava river (MNRCCR)

JULY 2010

Kalishta (MRK)
As (MNRA) As
Koselska (MNRK)
Blato (MNRB)
Rachanska (MNRRR)
Pestani (MNRP)
Sv.Zaum (MRZ)
Veljapesh (MRVL)
Trpejca (MRT-reference)
Sv.Naum (MNRSN)

JULY 2011

Sampling Methods

- The plant materials have been collected in the period of their maximal growth (middle of summer period - July and August).
- The material has been collected by the method of transects with transverse profiles: at each site there has been analyzed a transect of about 10 breadth, from the shoreline to the lower vegetation limit.
- In deeper waters, plants have been collected by Van-veen grab while in the shallower waters, plants were collected by snorkeling.



Collecting by van-Veen grab



Collecting the samples by diving

Laboratory Work

The determination of vascular macrophytes has been done:

- Using floristic books (floras): ***Josifović, M. (ed.) 1970-1977: Flora of S.R.Serbia, I – VIII.***
- For the determination of Charophytes the following keys have been used: ***Corillion (1957, 1975), Golerbah & Krasavina (1983), Krause (1997), Schubert & Blindow (2003) and Wood & Imahori (1964, 1965), and***
- The expertises provided by the colleagues: ***Talevska M., & Trajanovska S. 2004, Kashta L. 2007, Schneider.S and A. Melzer, 2003***

For successful determination of some macrophytes, especially very small plants there has been used a microscope.

Macrophytic index

To calculate the 'macrophytic index' the abundance value was cubed ($y D \times 3$) because the scale is not linear.

A catalogue of nine 'indicator groups' of macrophyte species (Melzer and Schneider 2001), exhibiting different sensitivity towards nutrient enrichment was developed from the lake survey.

Indicator groups - macrophyte

Indikatorgruppe 1,0	Indikatorgruppe 1,5	Indikatorgruppe 2,0
Chara hispida Chara polyacantha Chara strigosa Potamogeton coloratus Utricularia stygia	Chara aspera Chara intermedia Utricularia minor	Chara delicatula Chara tomentosa Potamogeton alpinus

Indicator groups

Indikatorgruppe 2,5	Indikatorgruppe 3,0	Indikatorgruppe 3,5
Chara contraria Chara fragilis Nitella opaca Nitellopsis obtusa Potamogeton gramineus Potamogeton natans Potamogeton x zizii	Chara vulgaris Myriophyllum spicatum Potamogeton filiformis Potamogeton perfoliatus Utricularia australis	Myriophyllum verticillatum Potamogeton berchtoldii Potamogeton lucens Potamogeton praelongus Potamogeton pusillus

Indicator groups

Indikatorgruppe 4,0	Indikatorgruppe 4,5	Indikatorgruppe 5,0
Hippuris vulgaris Lagarosiphon major Potamogeton pectinatus	Elodea canadensis Elodea nuttallii Potamogeton compressus Potamogeton crispus Potamogeton obtusifolius Ranunculus circinatus Ranunculus trichophyllus	Ceratophyllum demersum Lemna minor Potamogeton mucronatus Potamogeton nodosus Sagittaria sagittifolia Spirodela polyrhiza Zannichellia palustris

Plant Abundance Scale

Plant Abundance	Plant quantity Q
1 (very rare)	1
2 (rare)	8
3 (common)	27
4 (frequent)	64
5 (predominant)	125

***Mi* = Macrophyte index-calculation**

$$MI = \frac{\sum_{i=1}^n I_i \cdot Q_i}{\sum_{i=1}^n Q_i}$$

Mi = Macrophyte index

Ii = Indicator value of i-th species


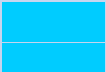





Qi = Plant quantity of i-th species

n = Total number of species with an indicator value

In Lake Ohrid there have been into consideration four depth zones: 0–2 m, 2–4 m, 4–10 m and >10 m.

Abundance of macrophytes was estimated on a five-point scale according to Tüxen & Preising (1942), 1= very rare, 2= infrequent, 3= common, 4= frequent and 5= abundant.

Macrophyte index - indicator classes

Macrophyte index		Nutrient pollution
1,00 – 2,39		very low
2,40 – 2,69		low
2,70 – 2,94		moderate
2,95 – 3,30		moderate-immense
3,30 – 3,55		immense
3,55 – 3,89		heavy
3,89 – 5,00		massive

RESULTS AND DISCUSSION

- **Species Composition**
- **Vegetation Limit**
- **Plant Abundance**
- **Macrophyte Index (MI)**
- **Assessing the Trophic state
of Lake Ohrid**

	SPECIES	FAMILY	COMMON NAME
1.	<i>Cladophora spec.</i> Kutz., 1843	Cladophoraceae	
2.	<i>Potamogeton perfoliatus</i> L.	Potamogetonaceae	Perfoliate pondweed
3.	<i>Potamogeton crispus</i> L.	Potamogetonaceae	Curly pondweed
4.	<i>Potamogeton gramineus</i> L.	Potamogetonaceae	Various-leaved pondweed
5.	<i>Potamogeton lucens</i> L.	Potamogetonaceae	Shining pondweed
6.	<i>Potamogeton pectinatus</i> L.	Potamogetonaceae	Sago pondweed
7.	<i>Potamogeton pusillus</i> L.	Potamogetonaceae	Small pondweed
8.	<i>Potamogeton x nitens</i> Weber (<i>P. gramineus</i> x <i>P. perfoliatus</i>)	Potamogetonaceae	"Bright-leaved Pondweed"
9.	<i>P. x salicifolius</i> Wlfg. (<i>Potamogeton perfoliatus</i> x <i>lucens</i>)	Potamogetonaceae	Willow leaved pondweed
10.	<i>Zannichellia palustris</i> L.	Potamogetonaceae	Horned pondweed
11.	<i>Myriophyllum spicatum</i> L.	Haloragaceae	Spiked water milfoil
12.	<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Rigid hornwort
13.	<i>Ceratophyllum submersum</i> L.	Ceratophyllaceae	Spineless hornwort
14.	<i>Elodea canadensis</i> Rich. & Michx.	Hydrocharitaceae	American Waterweed
15.	<i>Vallisneria spiralis</i> L.	Hydrocharitaceae	Tape Grass (eelgrass)
16.	<i>Ranunculus trichophyllus</i> Chaix.	Ranunculaceae	Threadleaf crowfoot
17.	<i>Najas minor</i> All.	Najadaceae	Brittle naiad
18.	<i>Najas major</i> All.	Najadaceae	Spiny naiad
19.	<i>Chara tomentosa</i> L.,1753	Characeae	Stonewort
20.	<i>Chara aspera</i> Deth.ex Willd.,1809	Characeae	
21.	<i>Chara contraria</i> A.Braun ex Kutz.,1845	Characeae	
22.	<i>Chara gymnophylla</i> A.Braun,1835	Characeae	
23.	<i>Chara globularis</i> Thuillier, 1799	Characeae	
24.	<i>Chara imperfecta</i> A.Braun,1845	Characeae	
25.	<i>Chara ohridana</i> (Kostic) Krause, 1997	Characeae	
26.	<i>Nitellopsis obtusa</i> (Desv.in Loisel.) J.Groves, 1919	Characeae	
27.	<i>Nitella hyalina</i> (De Candolle) Agardh 1824	Nitellaceae	
28.	<i>Nitella syncarpa</i> (Thuillier) Chevallier 1827	Nitellaceae	
29.	<i>Nitella opaca</i> (Bruzelius) C.Agardh 1824	Nitellaceae	

Indicator groups – macrophyte vegetation

(Melzer and Schneider, 2001)

<p>Indikatorgruppe 1,0</p>	<p>Indikatorgruppe 1,5</p>	<p>Indikatorgruppe 2,0</p>
<p><i>Chara hispida</i> <i>Chara polyacantha</i> <i>Chara strigosa</i> <i>Potamogeton coloratus</i> <i>Utricularia stygia</i></p>	<p><u><i>Chara aspera</i></u> <i>Chara intermedia</i> <i>Utricularia minor</i></p>	<p><i>Chara delicatula</i> <u><i>Chara tomentosa</i></u> <i>Potamogeton alpinus</i></p>
<p>Indikatorgruppe 2,5</p>	<p>Indikatorgruppe 3,0</p>	<p>Indikatorgruppe 3,5</p>
<p><u><i>Chara contraria</i></u> <u><i>Chara fragilis</i></u> <u><i>Nitella opaca</i></u> <u><i>Nitellopsis obtusa</i></u> <u><i>Potamogeton gramineus</i></u> <i>Potamogeton natans</i> <i>Potamogeton x zixii</i></p>	<p><i>Chara vulgaris</i> <u><i>Myriophyllum spicatum</i></u> <i>Potamogeton filiformis</i> <u><i>Potamogeton perfoliatus</i></u> <i>Utricularia australis</i></p>	<p><i>Myriophyllum verticillatum</i> <i>Potamogeton berchtoldii</i> <u><i>Potamogeton lucens</i></u> <i>Potamogeton praelongus</i> <u><i>Potamogeton pusillus</i></u></p>
<p>Indikatorgruppe 4,0</p>	<p>Indikatorgruppe 4,5</p>	<p>Indikatorgruppe 5,0</p>
<p><i>Hippuris vulgaris</i> <i>Lagarosiphon major</i> <u><i>Potamogeton pectinatus</i></u></p>	<p><u><i>Elodea canadensis</i></u> <i>Elodea nuttallii</i> <i>Potamogeton compressus</i> <u><i>Potamogeton crispus</i></u> <i>Potamogeton obtusifolius</i> <i>Ranunculus circinatus</i> <u><i>Ranunculustrichophyllus</i></u></p>	<p><u><i>Ceratophyllum demersum</i></u> <i>Lemna minor</i> <i>Potamogeton mucronatus</i> <i>Potamogeton nodosus</i> <i>Sagittaria sagittifolia</i> <i>Spirodela polyrhiza</i> <u><i>Zannichelia palustris</i></u></p>

List of macrophyte species not comprised by the Indicator groups - macrophyte

SPECIES

Cladophora spec.

Potamogeton nitens

Potamogeton salicifolius

Ceratophyllum submersum

Vallisneria spiralis

Najas major

Najas minor

Chara imperfecta

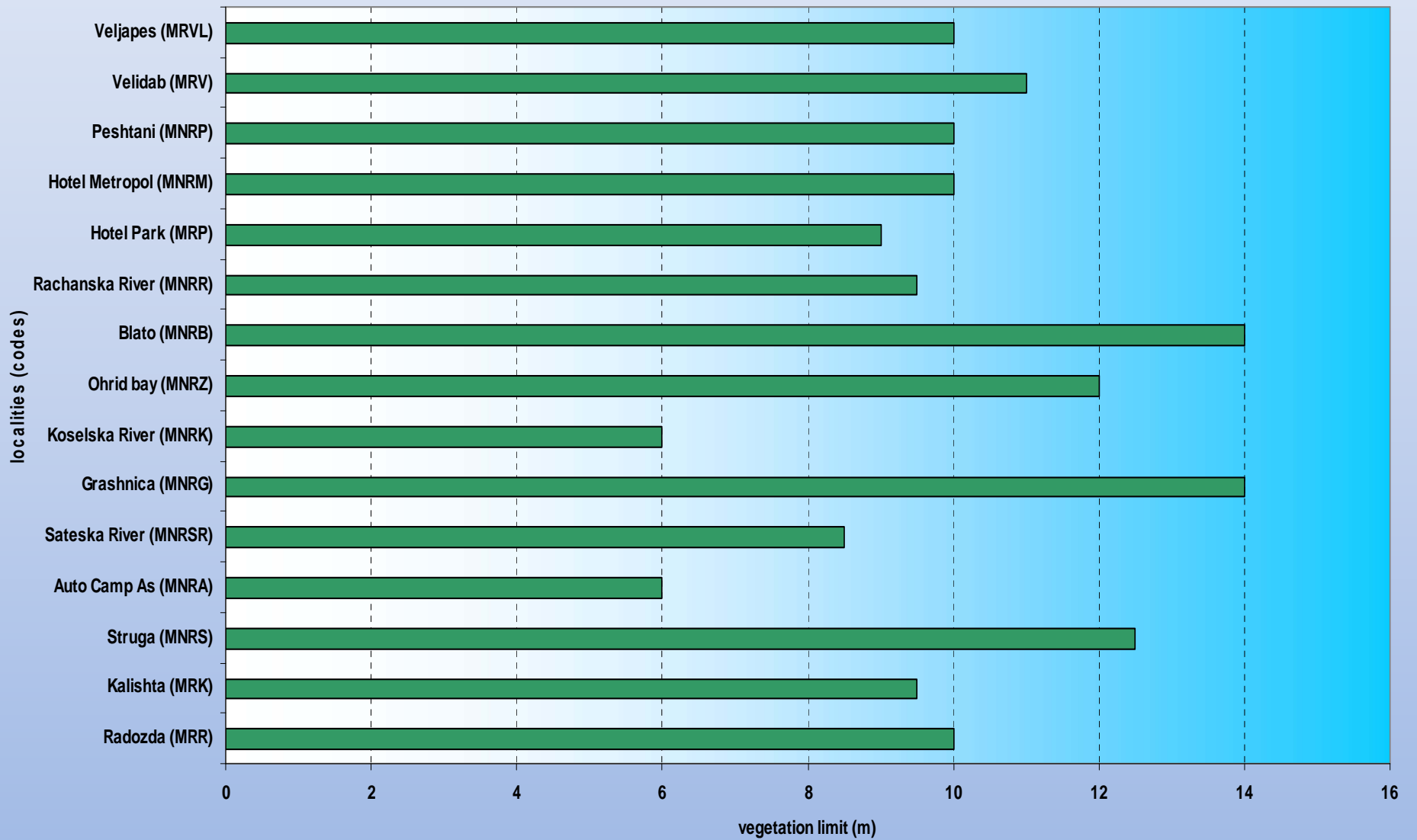
Chara gymnophylla

Chara ohridana

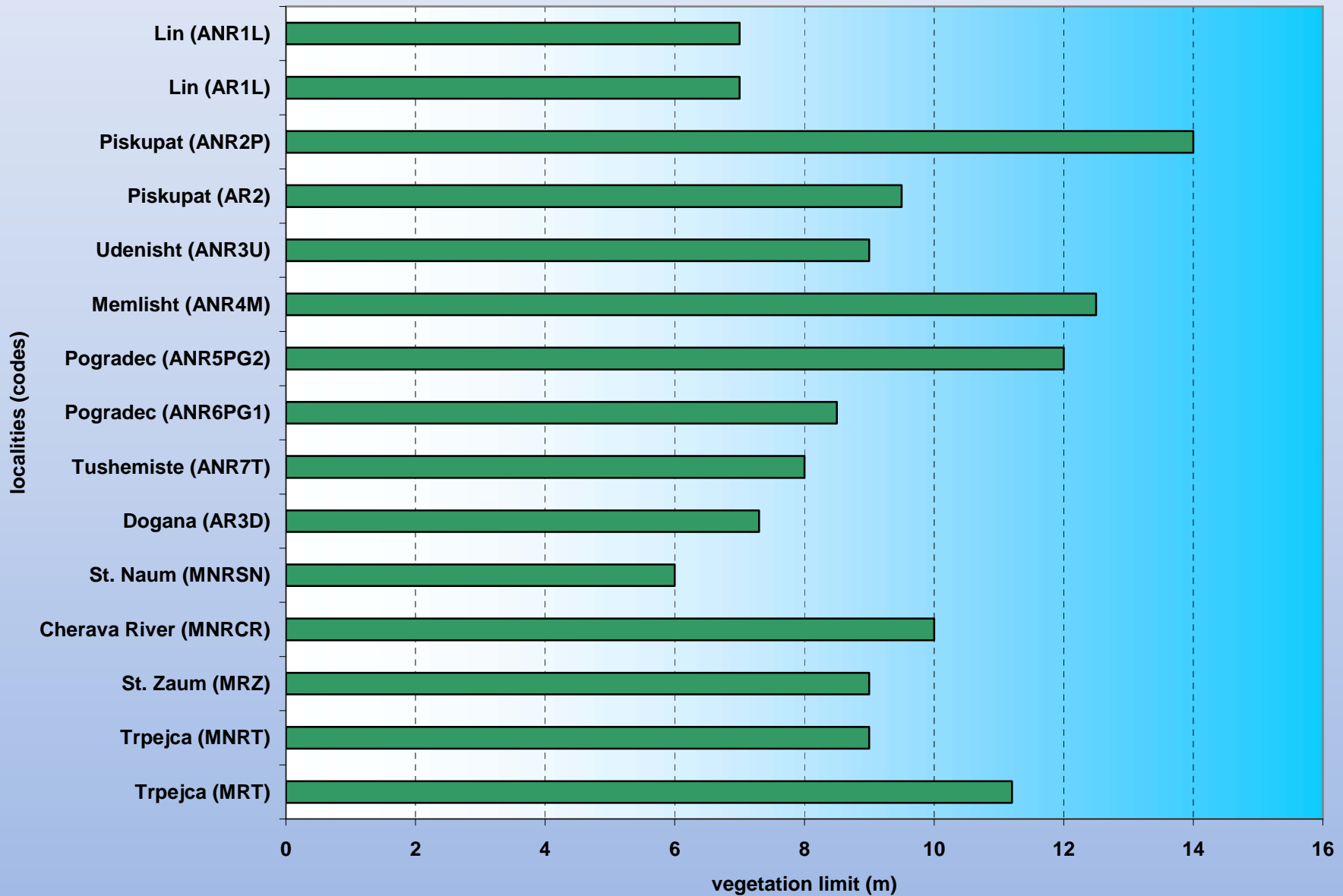
Nitella hyalina

Nitella syncarpa

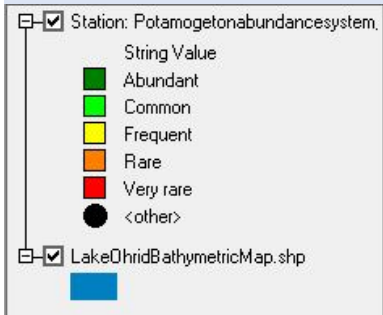
VEGETATION LIMIT (m)



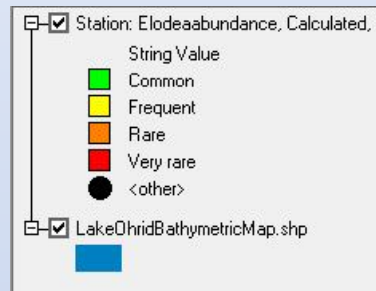
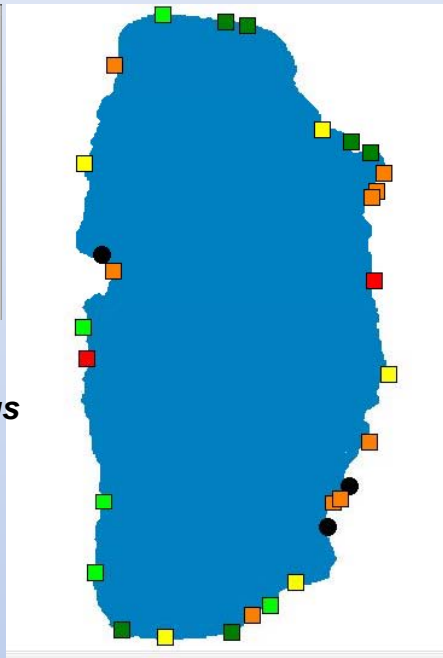
VEGETATION LIMIT (m)



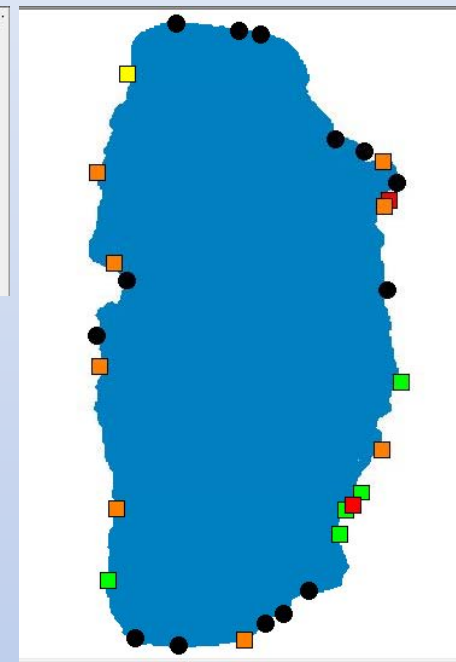
Plant Abundance (Averages)



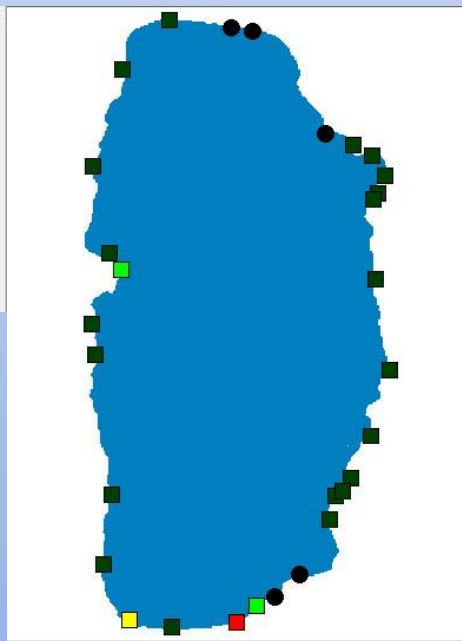
Abundance of *Potamogeton perfoliatus*



Abundance of *Elodea canadensis*



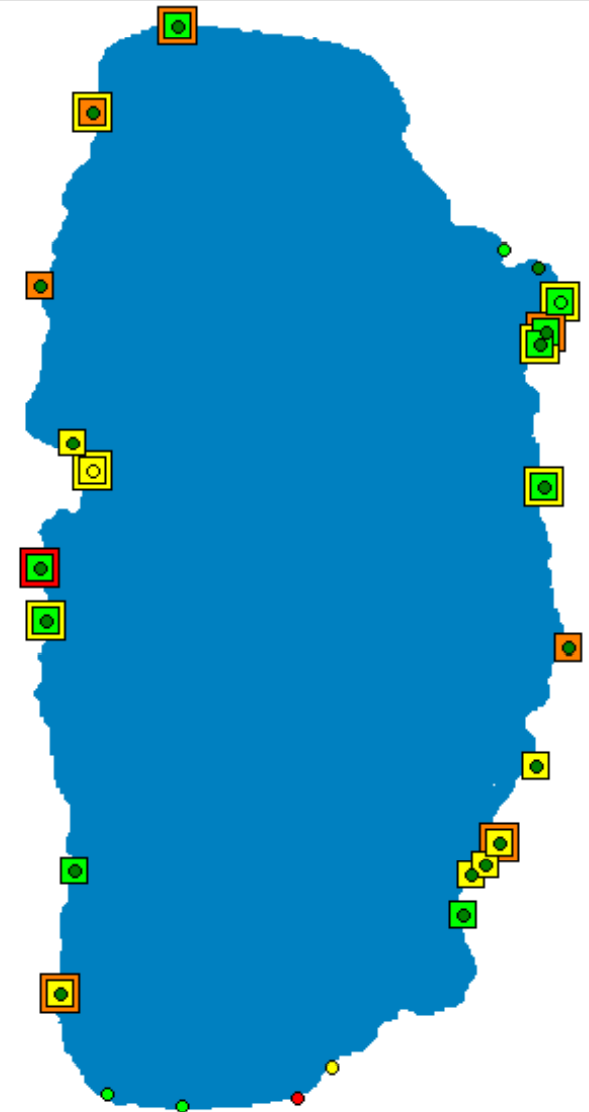
Abundance of *Chara tomentosa*



Chara tomentosa (abundance per depth zone per station)

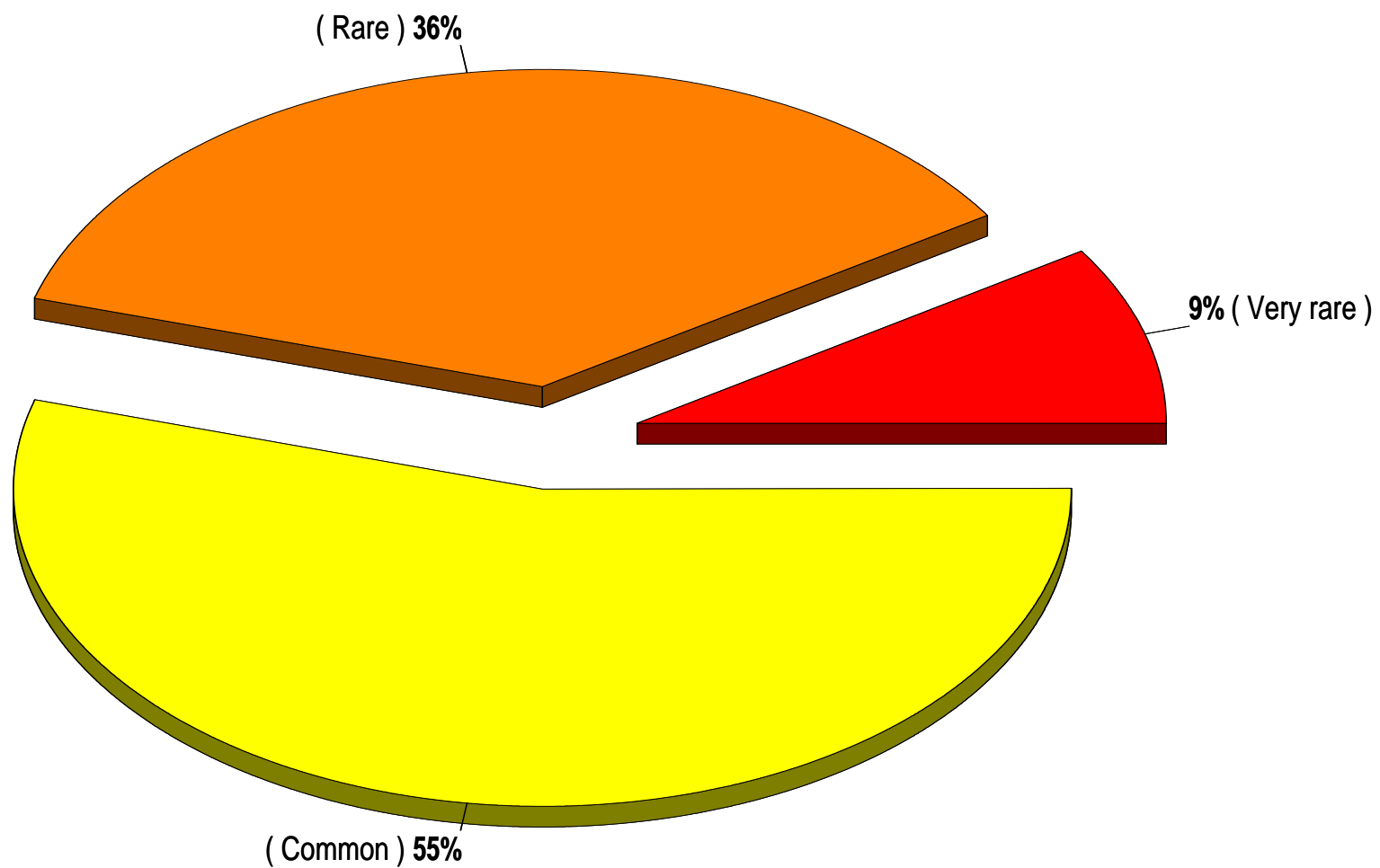


- Station: Ch tomentosa abundance (4-10), Calculated, 7/
String Value
 - Abundant
 - Common
 - Frequent
 - Very rare
- Station: Chara Tomentosa abudance (2-4), Calculated, 7/
String Value
 - Common
 - Frequent
 - Rare
- Station: Chara Tomentosa abudance (0-2), Calculated, 7/
String Value
 - Common
 - Rare
 - Very rare
- LakeOhridBathymetricMap.shp
■



Chara tomentosa (abundance, 0-2m)

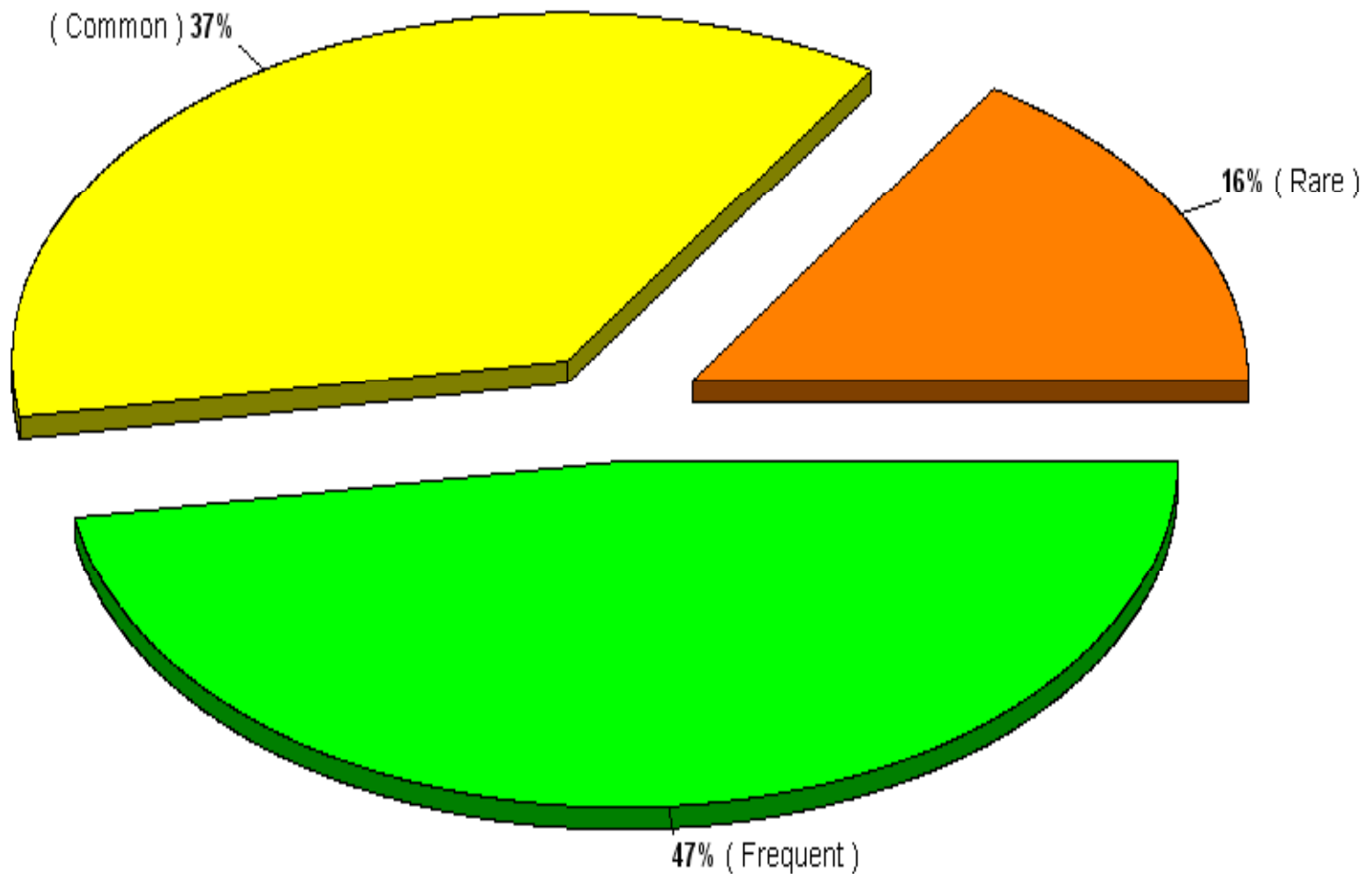
Station quality statistics



* Zero Data, (Frequent), (Abundant)

Chara tomentosa (abundance, 2-4m)

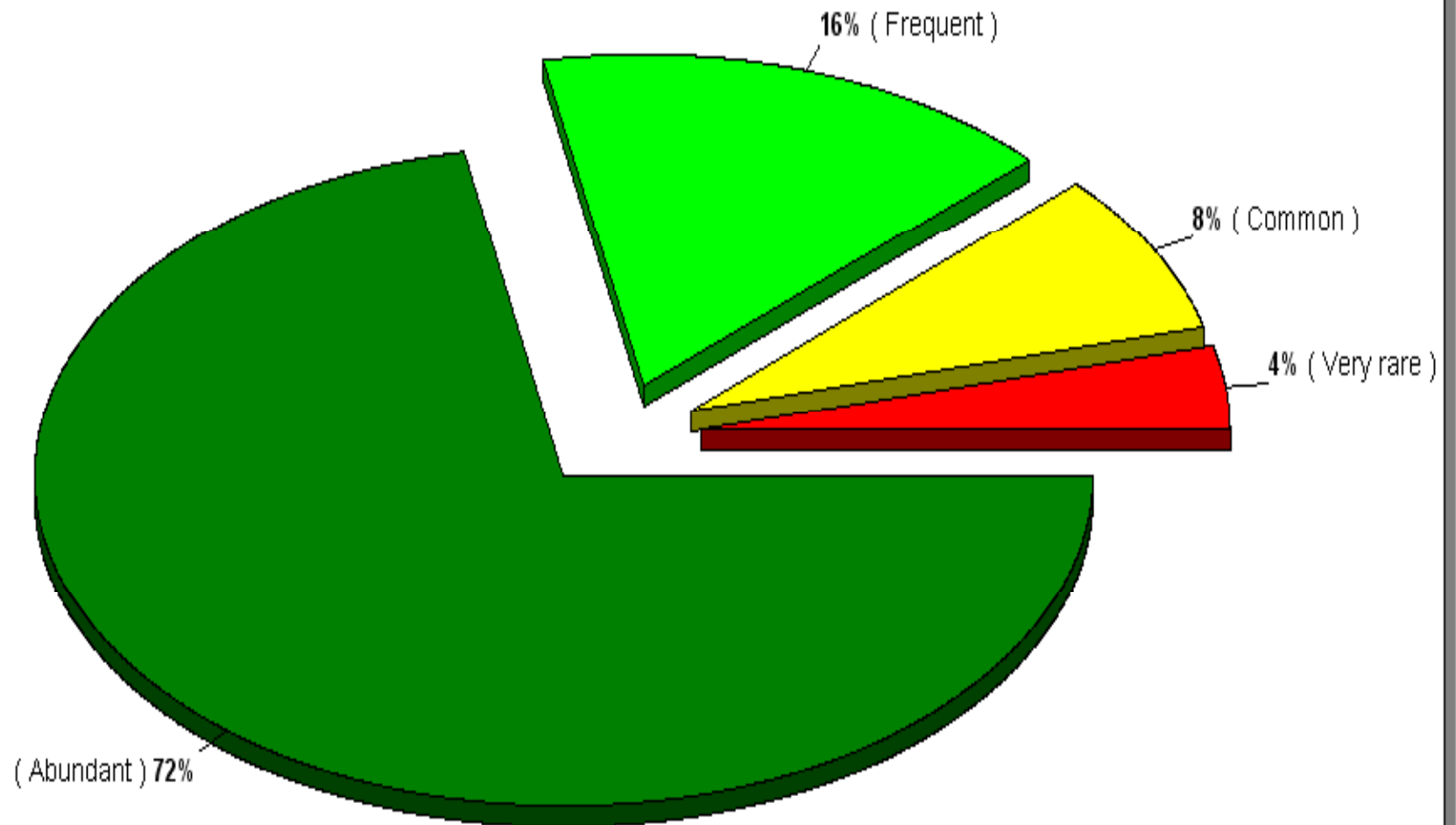
Station quality statistics



* Zero Data, (Very rare), (Abundant)

Chara tomentosa (abundance, 4-10m)

Station quality statistics

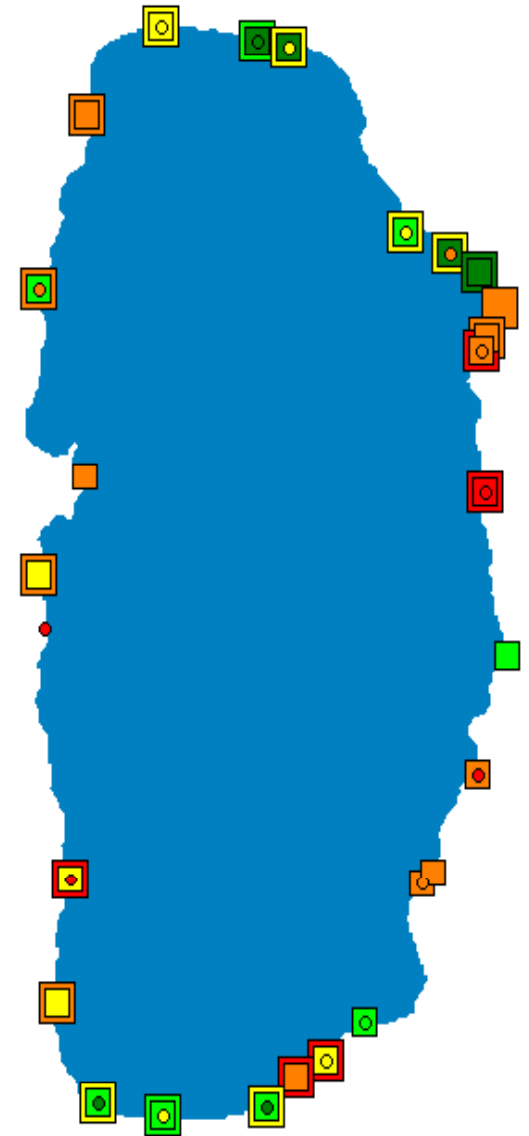
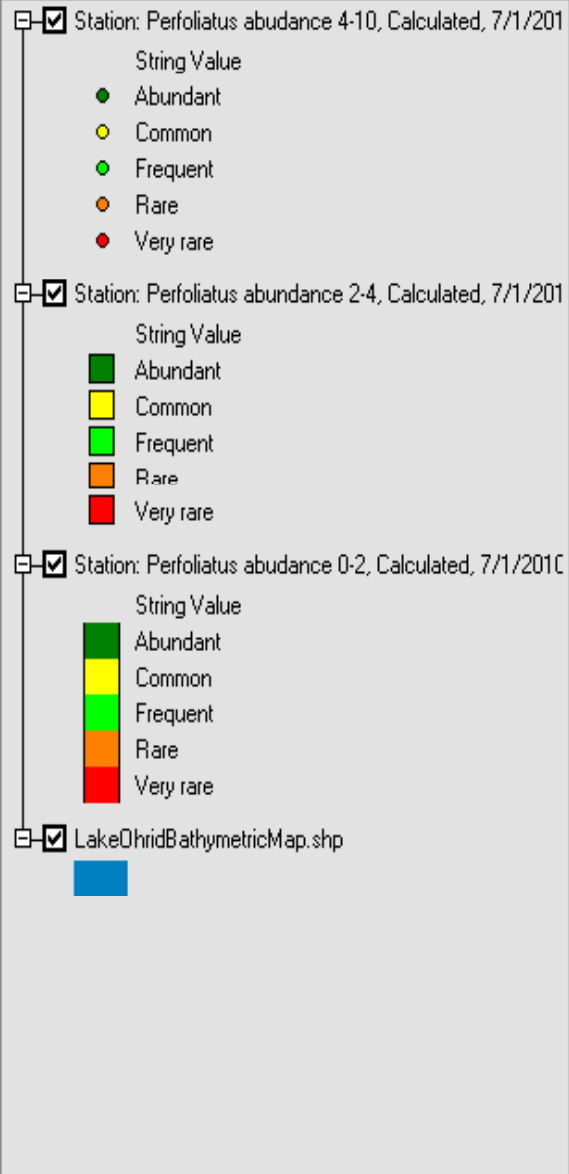


* Zero Data, (Rare)

Potamogeton perfoliatus (abundance per depth zone per station)

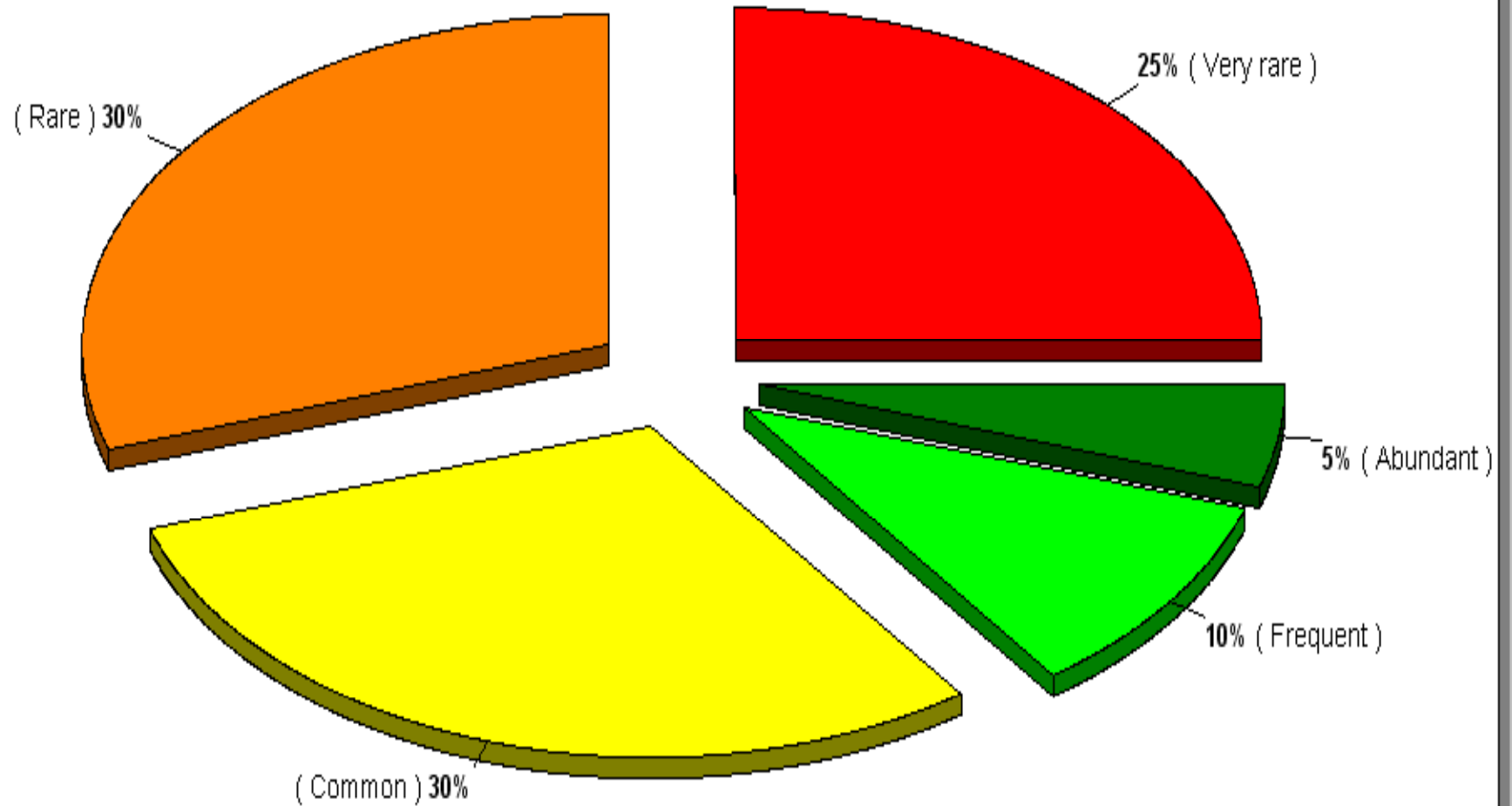


Underwater photo of *Potamogeton perfoliatus* by Susanne Schneider



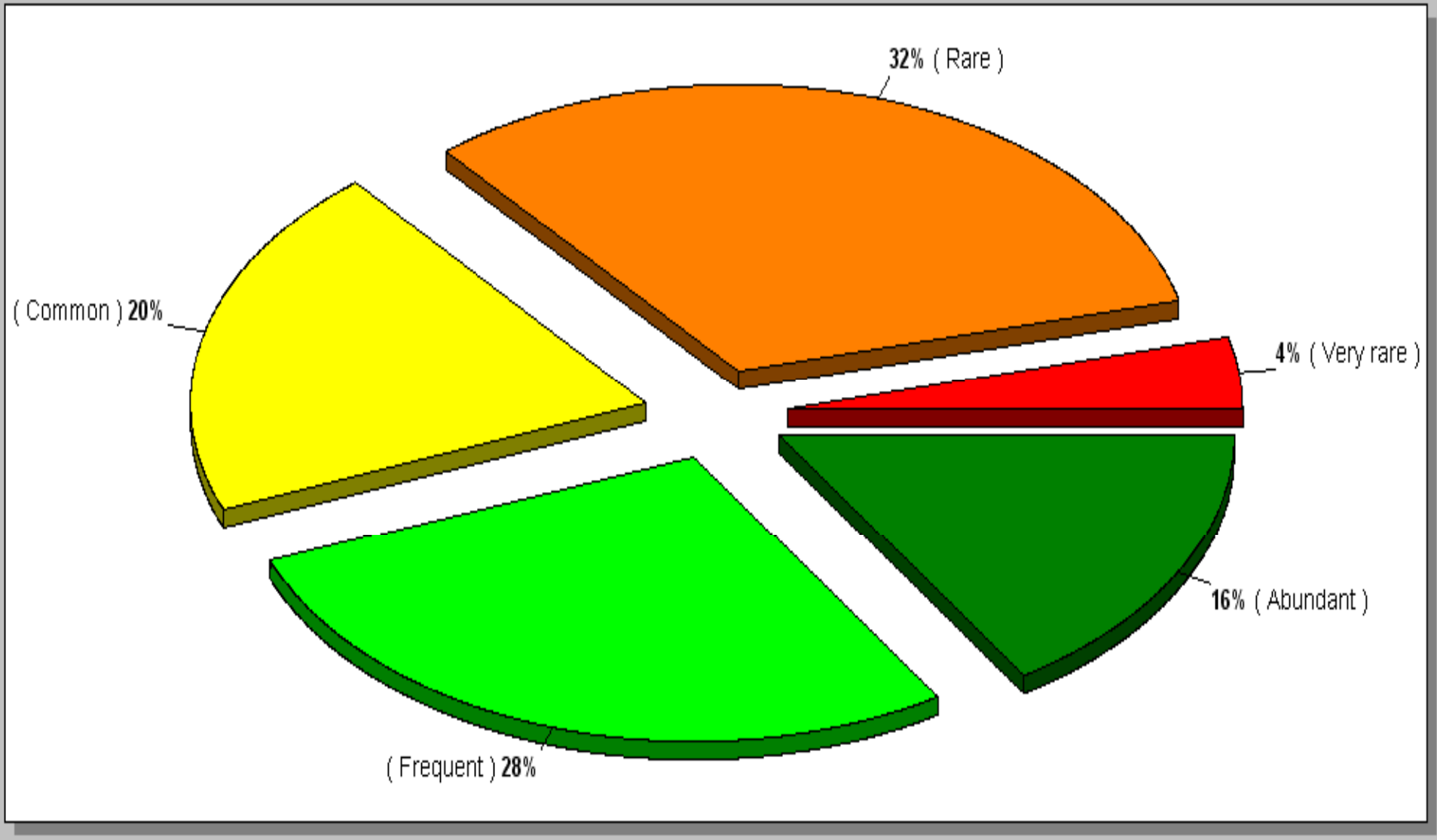
Potamogeton perfoliatus (abundance, 0-2m)

Station quality statistics



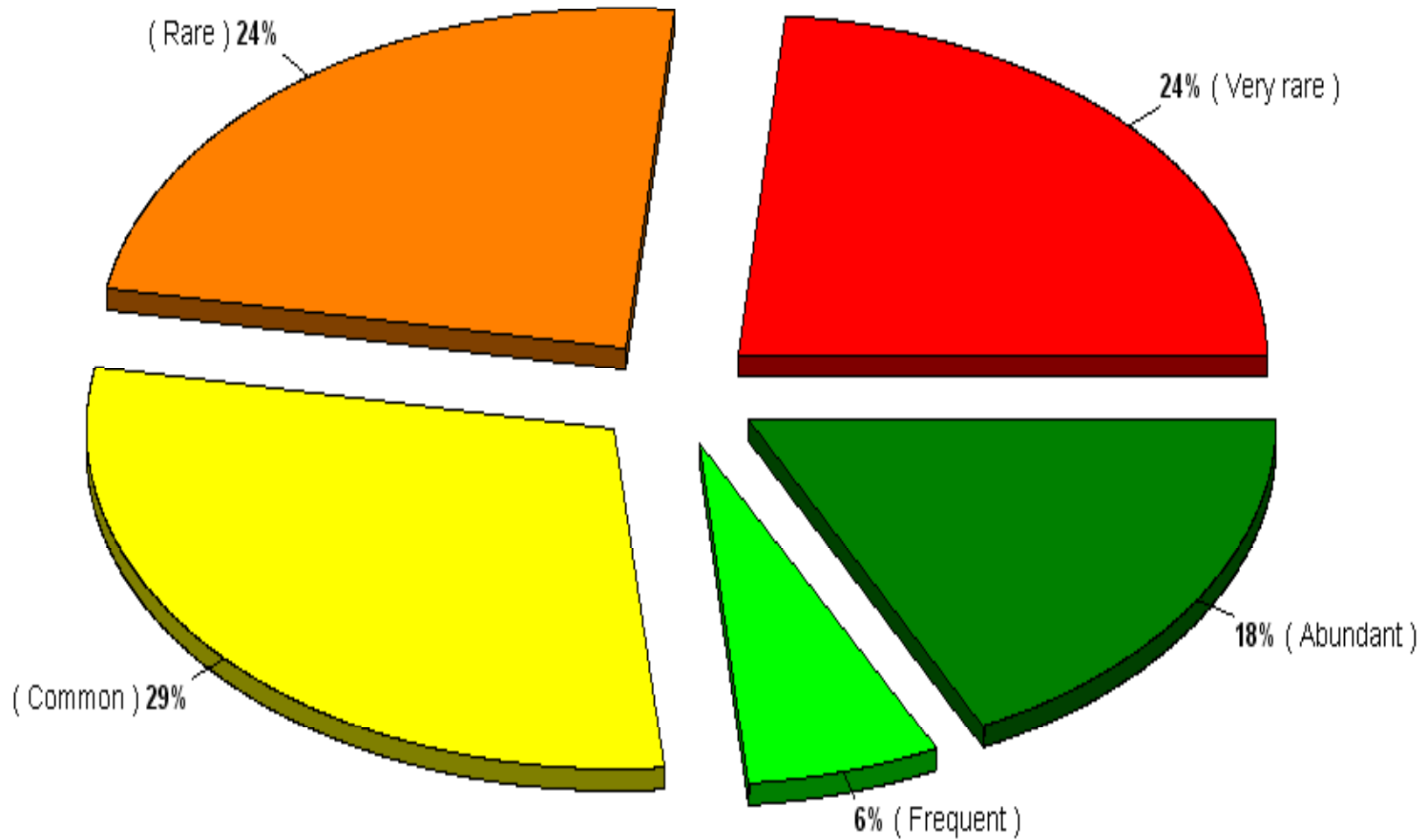
Potamogeton perfoliatus (abundance, 2-4m)

Station quality statistics



Potamogeton perfoliatus (abundance, 4-10)

Station quality statistics



Elodea canadensis (abundance per depth zone per station)

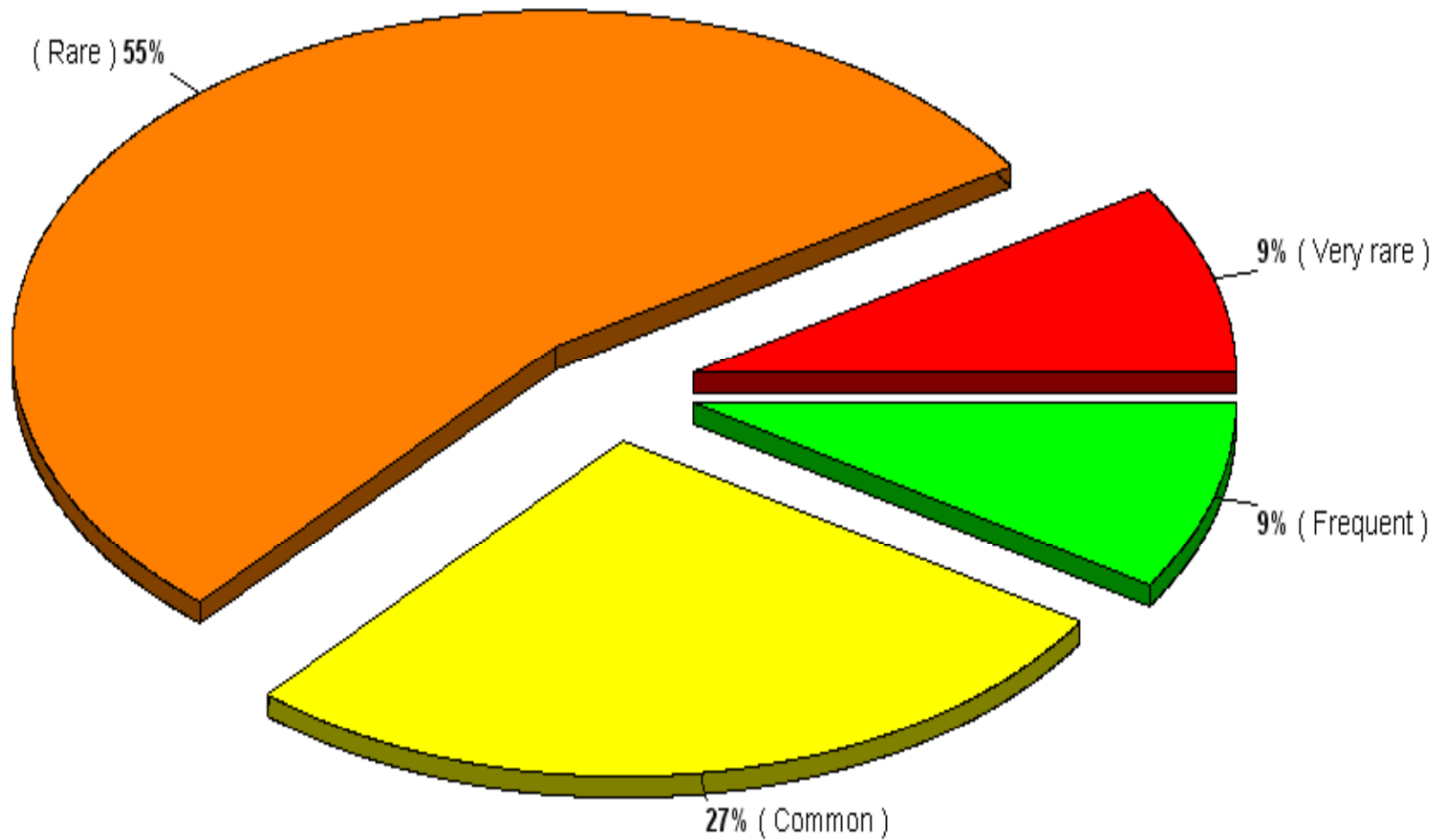


Underwater photo of *Elodea canadensis* by
Susanne Schneider



Elodea canadensis (abundance, 0-2m)

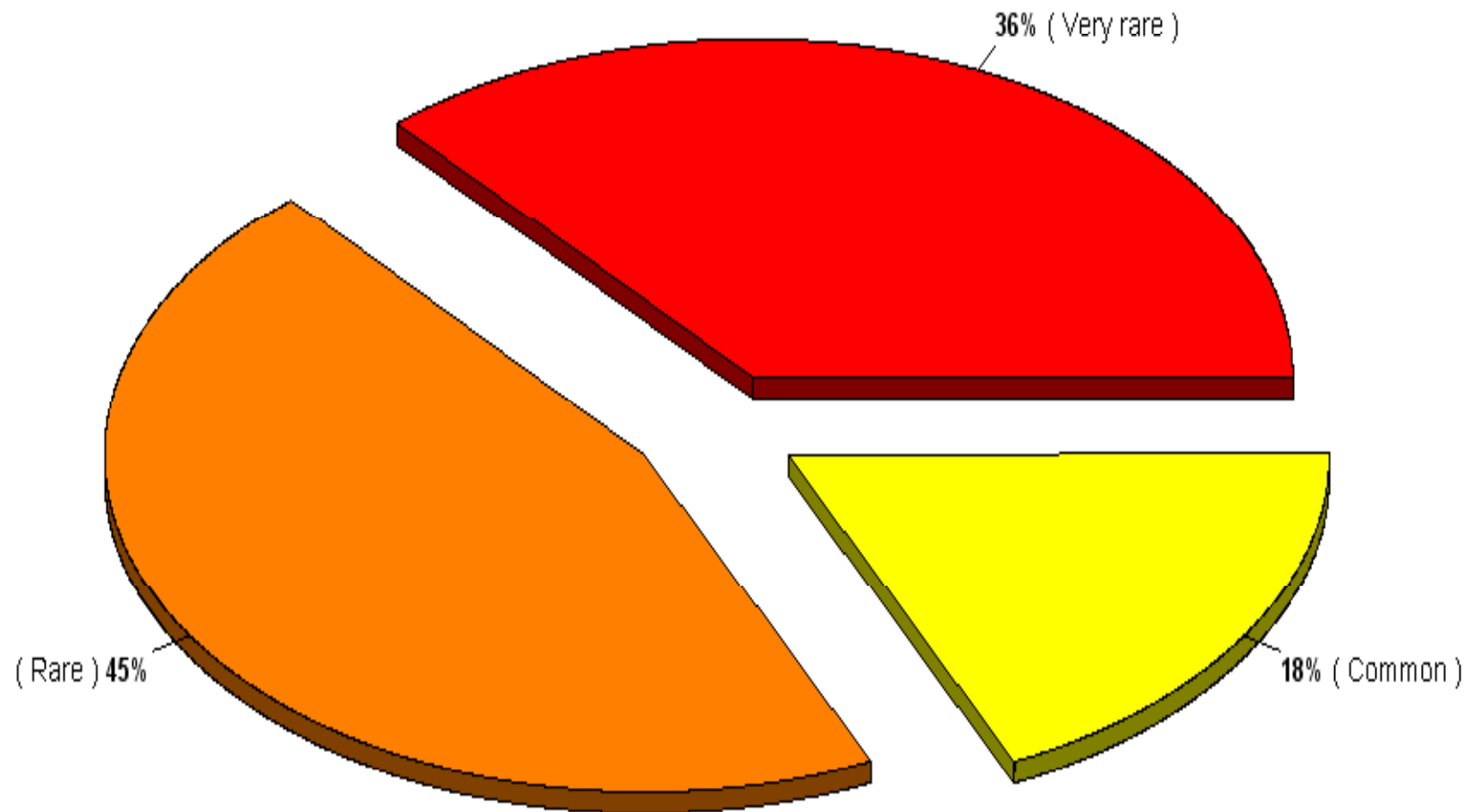
Station quality statistics



* Zero Data, (Abundant)

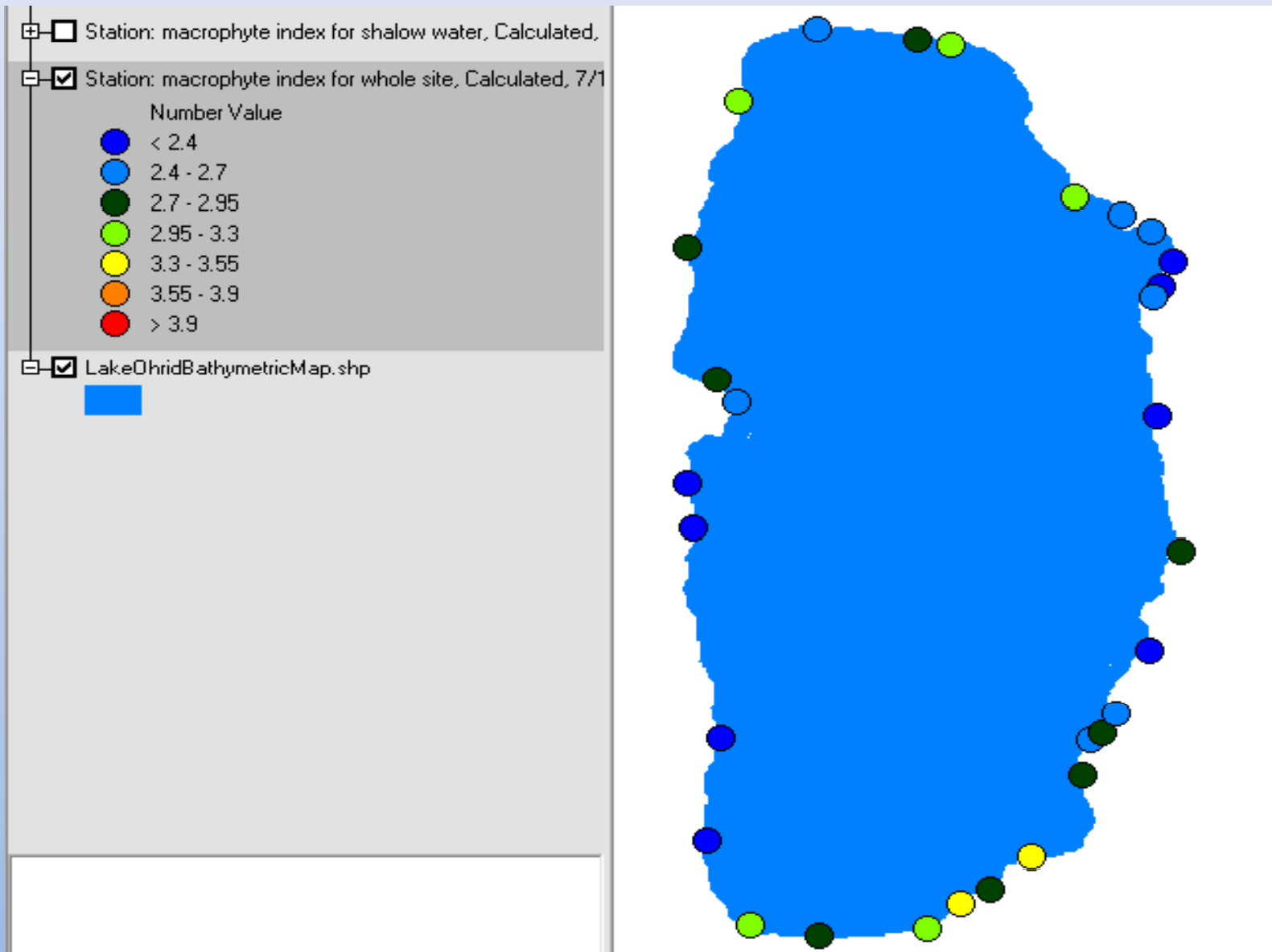
Elodea canadensis (abundance, 2-4m)

Station quality statistics

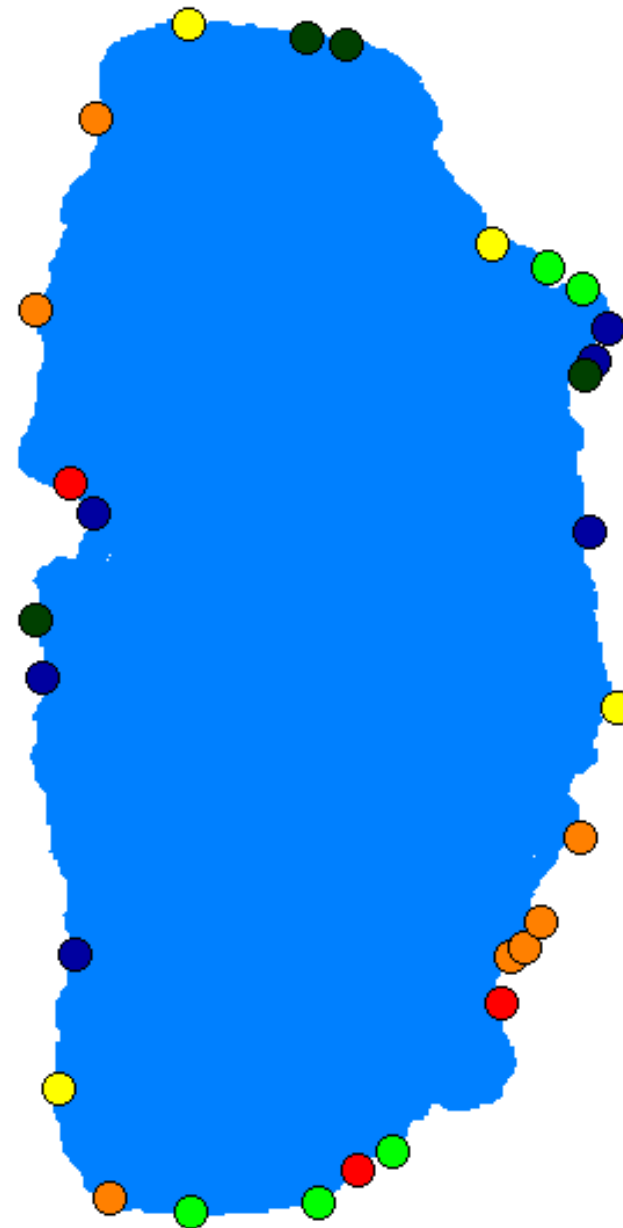
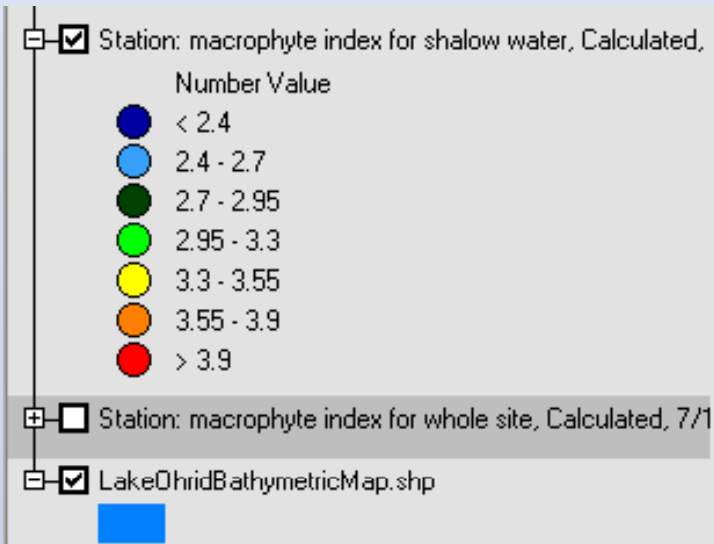


* Zero Data, (Frequent), (Abundant)

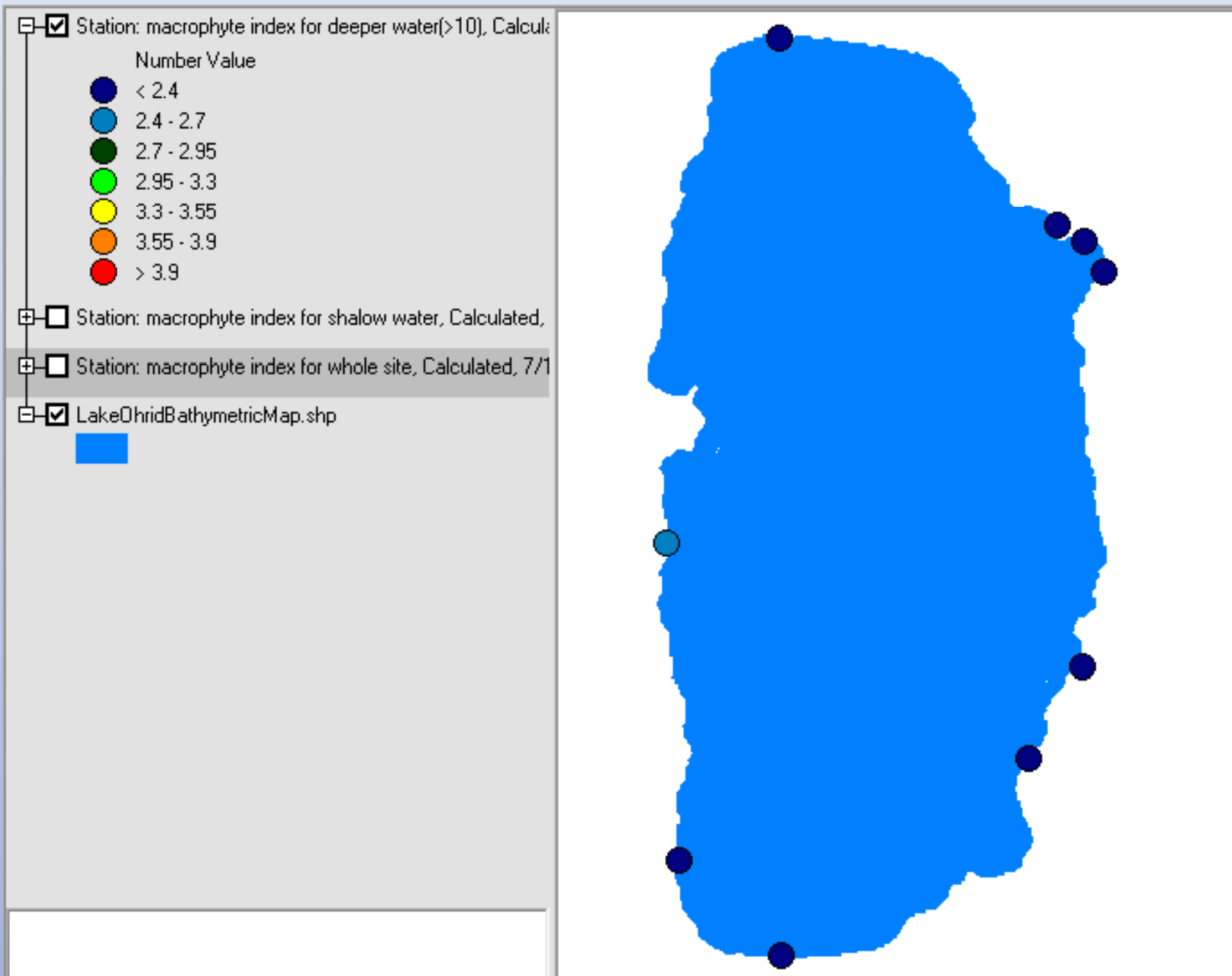
Macrophyte index for the whole lake (stations)- average



Macrophyte index for the shallow water 0-2m

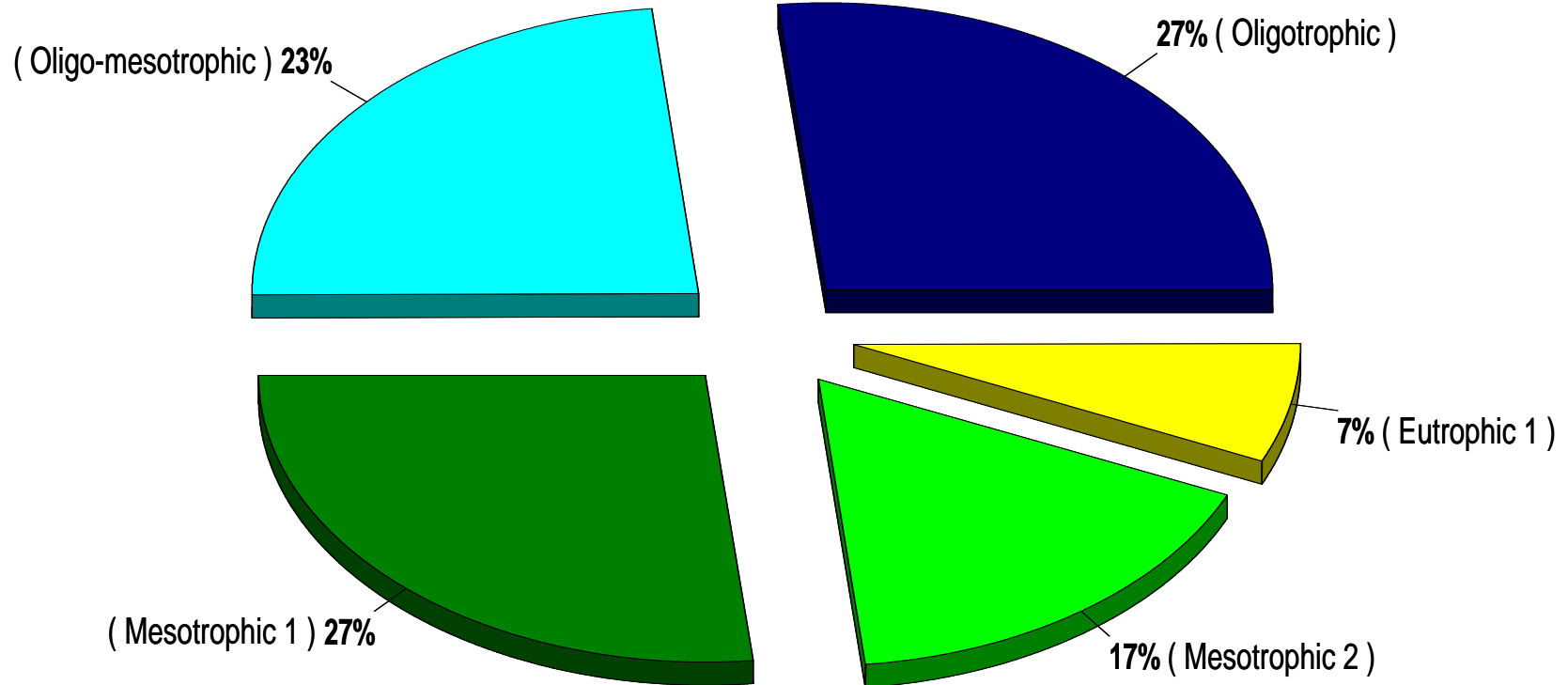


Macrophyte index for deeper water >10m



Trophic State of Lake Ohrid (for all stations)

Station quality statistics



* Zero Data, (Eutrophic 2), (Eutrophic 3)

CONCLUSIONS

- For the realization of the planned project goals the collection of macrophyte vegetation was performed in 30 stations along the Macedonian (20) and Albanian (10) coastline from Lake Ohrid.
- In all researched stations there were evidenced total of 29 macrophytic species, which belong to 9 families
- Out of 29 evidenced macrophyte species, 17 species belong to macrophyte indicator groups (Melzer and Schneider, 2001), while 12 species are not comprised by the indicator macrophyte group.

CONCLUSIONS

- Maximum depth vegetation limit is 14 meters (*Chara tomentosa*), while the minimum depth vegetation limit is 6 meters (*Potamogeton perfoliatus*).
- From all investigated stations, *Potamogeton perfoliatus* was present in 27, while it was not recorded in 3 stations (Lin, St. Zaum and Veljapesh). This species is the most abundant in the depth zone 2-4 meters.
- From all investigated stations *Chara tomentosa* was present in 25, while was not recorded in 5 stations (Sateska, Cherava River, St. Naum, Auto Camp As and River Koselska). This species is the most abundant in the depth zone 4-10 meters.
- From the 30 investigated stations *Elodea canadensis* was present in 16 stations, while was not recorded in 14 stations (Sateska, Pogradec, Pogradec 2, Dogani, Piscupat, Grashnica, Metropol, Cherava River, Struga, St. Naum, Blato, Auto Camp As, Lin, and River Koselska). This species is the most abundant in the depth zone 0-2 meters.

CONCLUSIONS

- The values of the macrophytic index for the entire lake indicate that nutrient pollution is very low or low in the majority of the researched stations.
- The values of the macrophytic index in the deeper waters indicate that the nutrient pollution is very low.
- The values of the macrophytic index in the shallow waters indicate that the nutrient pollution is moderate or moderate-immense.
- The nutrient pollution is mainly driven by the shallow waters.
- According to the macrophytic index the trophic state of the littoral of Lake Ohrid is 50% oligotrophic and oligo-mesotrophic.

RECOMMENDATIONS

- By taking into consideration that 12 out of 29 recorded macrophyte species from Lake Ohrid are not comprised by none of the 9 macrophyte indicator groups, according to Melzer and Schneider (2001), while some of them are quite frequent, it should be recommended that the existing table with groups of indicator species should be modified in accordance to the present macrophyte species from the Lake.
- Also, *Chara ohridana* which is a Balkan endemic species, present in 16 of the researched stations, and *Vallisneria spiralis* was present in 16 of the researched stations.
- Another recommendation is that more stations should be investigated in the future, not being limited to these 30.
- To undertake some measures for prevention of parts of the lake where the values of the Macrophytic Index indicated increased nutrient pollution.

A scenic view of a lake with a boat and a house on the shore. The water is blue and calm, reflecting the sky. In the background, there are mountains and a house with a red roof on the right side. The sky is blue with some clouds.

Thank You for the attention!

Faleminderit!

Благодариме!

Danke!

Tusen Takk.