Approaches to the study of a water object stability to changes of parameters of habitat and anthropogenic regimes

Stability of water objects

- Stability is an ability of a system to safe its parameters under internal and external loading
- Adaptive stability is a possibility of system to adapt to new conditions
- Regeneration stability is a possibility of a system to return back to its original conditions
- Ecological well-being
- vulnerability –opposite to “stability”

1. Mark –index estimation of water object stability to change of parameters of habitat and anthropogenic regimes

- Water object : lakes, ponds, reservoir, etc.
- The aim is an estimation of an adaptation stability
- Stability to:
  - Changing of natural habitat parameters (temperature, illumination, biogenic elements content…);
  - Increasing of eutrophication;
  - Changing of water quality

1. Mark –index estimation of water object stability to change of parameters of habitat and anthropogenic regimes

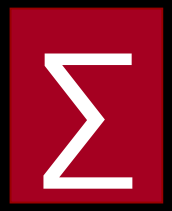
- There are three classifications:
  - Of morphometrical parameters (three parameters)
  - Of a hydrological regime (three parameters)
  - Of a water cycle (five parameters)
- Each parameter has a personal index (from 1 to 5). Choose the index of parameters for your water objects.
- Sum of indexes of each classification parameters gives three categories

$$\sum \text{indexes of parameters} = \text{category}$$

Classification of morphometrical parameters of water objects

Tabl.1

parameters	index			
	1	2	3	4
Water-surface area, m^2	>1000	101-1000	10-100	<10
Volume, m^3	>10	1,1-10	0,5-1,1	<0,5
Maximum depth, m	>50	11-50	5-10	<5

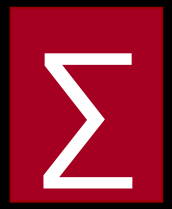


sum of parameters is from 3 to 4 - The 1st category ;
sum of parameters is from 5 to 7 - The 6th category ;
sum of parameters is from 8 to 11 - The 11th category ;
sum of parameters is from 11 to 12 - The 15th category .

Classification of hydrological regime of water objects

Tabl.2

parameters	index				
	1	2	3	4	5
Amplitude of water level fluctuations, m	<3	-	3-10	-	>10
Average water temperature in summer, ºC	>25	20-25	15-20	-	<15
Ice-covering period, months	>5	2-5	<2	-	-

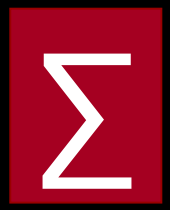


sum of parameters is from 2 to 4 - The 1st category ;
sum of parameters is from 5 to 7 - The 2nd category ;
sum of parameters is from 8 to 11 - The 3rd category .

Classification of water objects cycle

Tabl.3

parameters	index		
	1	2	3
Seasonal stratification availability	yes	not	-
Vertical mixing (how many times per year)	<2	2	>2
Flowage condition	internal-drainage	drain	circulating water reservoir
Character of regulation	perennial	seasonal	Weekly, daily
Water cycling per year	<0,1	0,1-5,0	>5



sum of parameters is 5 - The 1st category ;
sum of parameters is from 6 to 8 - The 2nd category ;
sum of parameters is from 9 to 14 - The 3rd category .

Marks estimation of water object stability to changing of physical-chemical, hydrological, trophic, and water quality parameters

∑ category → symbol and marks of a stability family (tabl.4)

Tabl.4.1

Family of stability		
symbol	**Sum of categories**	**marks**
I A	3-5	8
I B	6-9	4
II A	10-11	13
II B	12-14	10
III A	15-16	18
III B	17-19	15
IV A	20-21	22
IV B	22-23	20

Marks estimation of water object stability to changing of physical-chemical, hydrological, trophic, and water quality parameters

∑ category → symbol and marks of a stability family (tabl.4)

Tabl.4.2

Type of stability by trophic status and water quality	
Trophy or water quality	**Marks**
Eutrophic	1
Mesotrophic	5
Oligotrophic	15
or:	
Dirty (V-VI)	1
Polluted (III-IV)	5
Clean (I-II)	15

Marks estimation of water object stability to changing of physical-chemical, hydrological, trophic, and water quality parameters

Tabl.4.3 **∑ category → symbol and marks of a stability family (tabl.4)**

Combination of families and Types			
symbol	Sum of marks	symbol	Sum of marks
I B 1	5	III B 1	16
I B 2	9	III B 2	20
I B 3	19	III B 3	30
I A 1	9	III A 1	19
I A 2	13	III A 2	23
I A 3	23	III A 3	33
II B 1	11	IV B 1	21
II B 2	15	IV B 2	25
II B 3	25	IV B 3	35
II A 1	14	IV A 1	23
II A 2	18	IV A 2	27
II A 3	28	IV A 3	37

Classes of water object stability

∑ category → symbol and marks of a stability family (tabl.4)

Tabl.5

Class of stability	Marks	Symbol of combination
I (maximum)	5-11	I B 1, I B 2, I A 1, II B 1
II	13-16	I A 2, II A 1, II B 2, III B 1
III	18-23	I B 3, I A 3, III B 2, II A 2, III A 2, IV B 1, IV A 1
IV	25-28	II B 3, II A 3, IV B 2, IV A 2
V (minimum)	30-37	III B 3, III A 3, IV B 3, IV A 3

The method of summary parameters

- The 1st stage: selection of parameters ***qi***, quality metering scale building for each class of state
- The 2nd stage: normalization of parameters

$$q_i \in [0;1]$$

direct relation

$$q_i = q_i(x_i) = \begin{cases} 0, & x_i \le \min_i, \\ \left(\dfrac{x_i - \min_i}{\max_i - \min_i}\right), & \min_i < x_i \le \max_i, \\ 1, & x_i > \max_i. \end{cases}$$

inverse relation

$$q_i = q_i(x_i) = \begin{cases} 1, & x_i \le \min_i, \\ \left(\dfrac{\max_i - x_i}{\max_i - \min_i}\right), & \min_i < x_i \le \max_i, \\ 0, & x_i > \max_i. \end{cases}$$

The method of summary parameters

- The 3rd stage: interpreter function selection of integral index
  - q_i – normalized parameter,
  - p_i – weighting coefficient,
  - i=1,…,n, n – number of estimation criteria
- The 4th stage: taking weighting coefficients into account
- The 5th stage: integral index building (calculation)

$$I = \sum q_i p_i,$$

$$q_i \in [0;1]$$

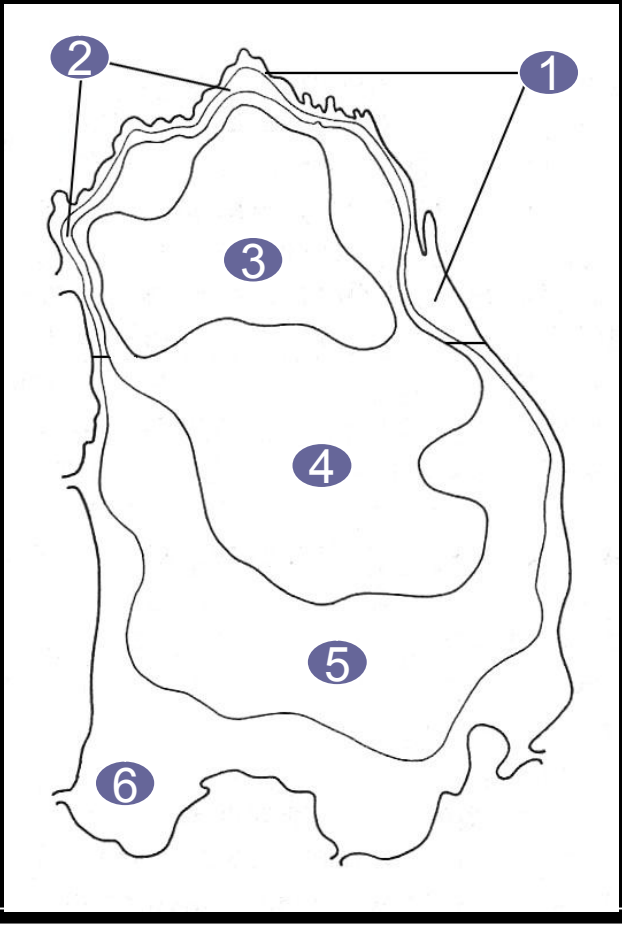
$$p_i \in [0;1], \sum p_i = 1$$

$$p_1 = p_2 = p_3 = \ldots,$$

$$p_1 = p_2 > p_3 = p_4$$

$$p_i = 1 / n$$

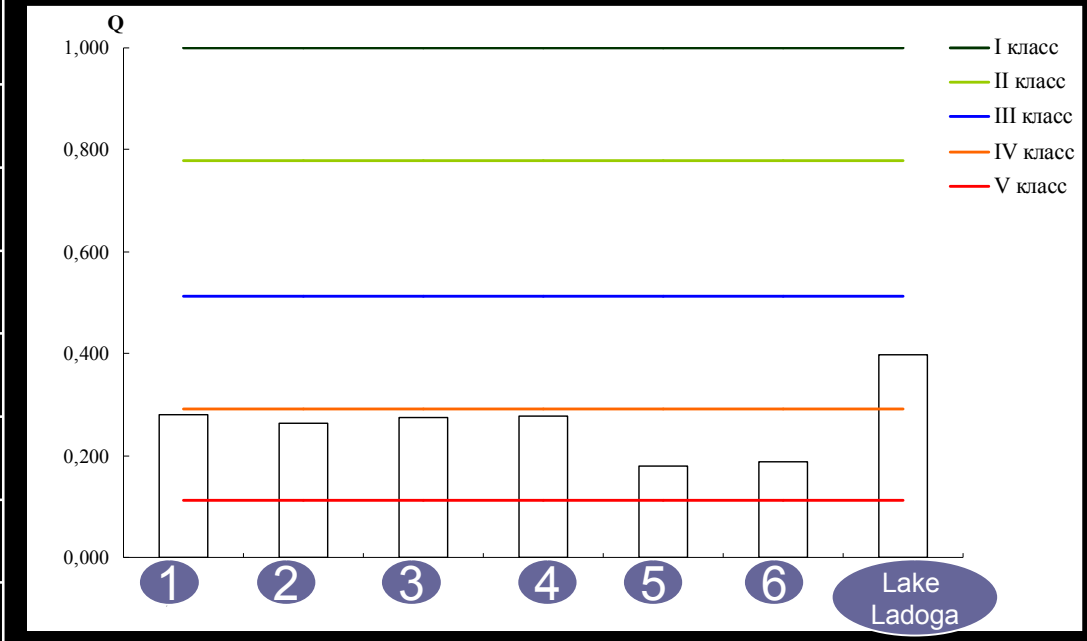
Zoning of Lake Ladoga on isobaths, in view of current directions



1 – northern coastal
2 – northern
3 – ultradeep
4 – deep
5 – southern
6 – southern coastal

The Results of a research of a water object stability to changes of parameters of habitat and anthropogenic regimes

Area of Lake	Q	Class
1	0,281	IV
2	0,264	IV
3	0,274	IV
4	0,276	IV
5	0,178	IV
6	0,186	IV
As a whole	0,397	III



Thank you