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Methodical recommendations

on the morpho-functional indexes define for unicellular and multicellular forms of aquatic vegetation

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Introduction

The ecological conveniences of the aquatic ecosystems is closely connected with peculiarities of the production process, which provide the different life forms of the aquatic vegetation, inhabiting in pelaguial and benthal of the marine and freshwater basins. The external surface of the unicellular and multicellular algae, as well as flowering macrophytes, executes the role of the phytocontour, through which the exchanging processes between autotrophic link and aquatic environment is realized. The dimensions, form, peculiarities of the morphological construction of the aquatic plants, as well as the integral magnitude of the vegetation communities surface, are very important for the operative estimation, monitoring, short-term and long-term prediction of the ecological situation of the aquatic ecosystems (Minicheva, 1998).

The complex of the indexes, based on the parameters of the surface, was used as the main instrument of the information reception in the new for hydrobiology direction - morpho-functional ecology of the seaweeds (Chaylov and others, 1978; Chaylov, 1983; Minicheva, 1998a).

For measurement of the main index of the morpho-functional parameters complex - a specific surface of the macroalgae thallus, the method of the direct surface measurement were developed (Firsov, 1979), and also the method of the specific surface calculation, on the basis of the allometric dependencies (Minicheva, 1992). More than 15 years ago, methodical recommendations on define of the complex of the indexes, connected with the seaweeds surface were published, in which the methods of direct and calculation manners of the define of the indexes for multicellular forms of the benthos vegetation are used (Minicheva, 1987).

The further development of the seaweeds morpho-functional ecology direction, has revealed the need of the use of the surface estimation parameters methods, developed on the benthos macroalgae, for other aquatic vegetation life forms. This required the developments of the new methods of the morpho-functional indexes calculation for unicellular plankton and benthos algae, as well as for flowering macrophytes, which in shallow ecosystems with multicellular algae, can play the important role in the production process. The possibility at the same time estimation in the uniform measurement all the components of the aquatic ecosystem autotrophic link, despite the difference in the life forms, dimensions, occupied biotops and systematic belonging, opens the possibility of the holistic estimation of the production block, which peculiarities of the operation form the base of the ecological material and energy transformation.

The task of that Methodical recommendation is to give the unfolded algorithms of the morpho-functional indexes calculation, for the main life forms of the aquatic vegetation including unicellular and multicellular algae of the plankton and benthos, as well as the flowering macrophytes.

The proposed indexes can be used for resolving of the complex of the applied problems connected with the expert estimation of the production process intensities, trophic status defines (the degree of local or global anthropogenetic eutrofication) of the aquatic ecosystems and saprobionte class of the aquatic environmemt, for the predictions of the expected changes in the floristic community composition, for the perspective resource species define, as well as for the number of other problems connected with the ecological management of the different marine and freshwater ecosystems (Minicheva, 1998).

The Methodical recommendations are oriented for the specialists of the algologists, aquatic botanists, hydrobiologists and ecologists.

The methods of the morpho-functional complex indexes define for unicellular forms

In this part the modified approaches of the surface area and the cell volume calculation are given, and also the methods of the whole morpho-functional indexes calculation for unicellular phytoplankton algae (Table 1). But the methods of the specific surface group indexes calculation do not have a principle differences, for unicellular algae plankton and benthos. At the surface group indexes factors calculation the algorithms of the methods take into consideration the planktonic community inhabitation peculiarities, and the total algological surface calculation for different hierarchical levels is brought to the m^3 of water column. In the case with the unicellular benthos algae communities, the surface indexes can be calculated on the bottom area unit. The calculation principle for the benthos vegetation community surface indexes is presented in the part of the given Methodical recommendation: "The methods of the morpho-functional complex indexes define for multicellular forms".

The unicellular algae specific surface indexes

Specific surface of the cell (S/W)$_c$

The unicellular algae volume and surface area calculation

The starting indexes at the unicellular algae specific surface calculation are the surface area **(S_c)** and the mass **(W_c)** of the cell. In the phytoplankton samples processing practice, the cell mass W_c (mg) is calculated indirectly, with the use of accounting cell volume of (V_c) (mkm^3) and specific weight (ρ), which equals to the unit: $V_c \bullet \rho = W_c$ (Nesterova D.A., 1988).

At the unicellular algae volume calculation V_c, the method or "true volume" is used (Kiseleva I.A., 1956). The form the cell is "closing" to the corresponding geometric figure, or complex of the figures, which volume is calculated on the cell linear parameters bases.

The cell surface area calculation S_c is produced by the similar methods. On the grounds of the linear parameters, S_c is calculated on the surface area formula of the geometric figure, corresponding to the form of the unicellular algae. In the case of the cell form "closing" to the complex of the geometric figures the lateral surfaces formulas are used.

In the table 2 the 57 volume calculation formulas are brought, of the full and lateral surface area for 20 geometric figures, using at V_c and S_c calculation of the unicellular algae.

Table 1

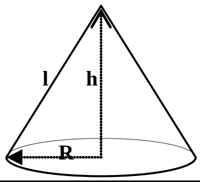
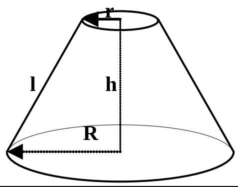
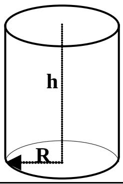
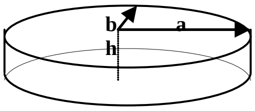
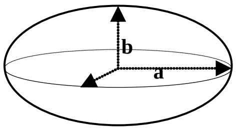
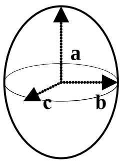
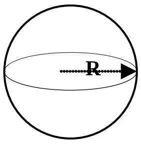
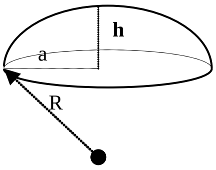
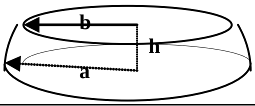
Phytoplankton morpho-functional indexes*

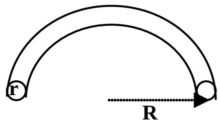
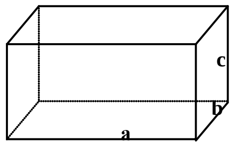
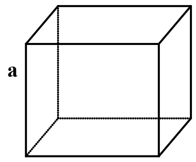
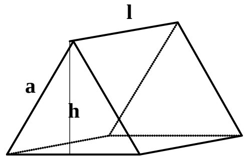
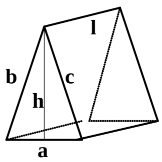
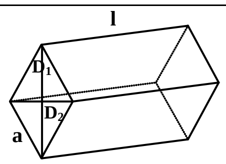
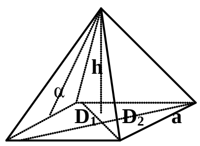
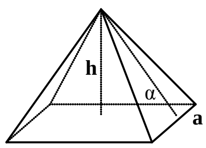
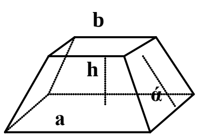
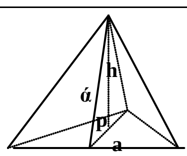
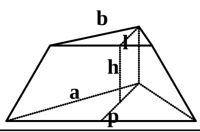
Organization levels	Specific surface indexes	Surface indexes
Cell	Specific surface of the cell $\boldsymbol{(S/W)_c}$	**-**
Uniform-sized cell group	Specific surface of the uniform-sized cell group $\boldsymbol{(S/W)_{uni.c.gr}}$	**-**
Population	Population specific surface $\boldsymbol{(S/W)_p}$	Population surface index $\mathbf{SI_p}$
Community	Community specific surface $\boldsymbol{(S/W)_{cm}}$	Community surface index $\mathbf{SI_{cm}}$
Region floristic grouping*	Floristic grouping specific surface $\boldsymbol{(S/W)_{fg}}$	Phytoplankton surface index $\mathbf{SI_{php}}$
Taxonomic section*	Taxonomic section specific surface $\boldsymbol{(S/W)_{ts}}$	Taxonomic section surface index $\mathbf{SI_{ts}}$

*The semantic define of the index ref. in the methodical recommendation text.
** The "region floristic grouping" and the "taxonomic section" are not the organization hierarchical levels of the unicellular algae in the direct sense and are given in the below order only for comfort and according to the general logic of the morpho-functional complex indexes calculation.

Table2

The volume calculation standard formulas of the unicellular algae full and lateral surface area.

Figure (measured parameters)	**Drawing**	**Volume (V)**	**Full surface area (S)**	**Lateral surface area (S_l)**
Circular cone (R,·h)		$\frac{1}{3}\pi\cdot R^2\cdot h$	$\pi\cdot R\cdot(R+l)$, $l=\sqrt{R^2+h^2}$	$\pi\cdot R\cdot l$
Truncated circular cone (R, r,·h)		$\frac{\pi h}{3}\cdot(R^2+r^2+Rr)$	$\pi(R^2+r^2+l\cdot(R+r))$, $l=\sqrt{h^2+(R-r)^2}$	$\pi\cdot l\cdot(R+r)$
Cylinder (R,·h)		$\pi\cdot R^2\cdot h$	$2\pi\cdot R\cdot(h+R)$	$2\pi\cdot R\cdot h$
Elliptical cylinder (a,·b,·h)		$\pi\cdot a\cdot b\cdot h$	$(\pi(3\frac{a+b}{2} - \sqrt{ab}))\cdot h + 2\pi ab$	$(\pi(3\frac{a+b}{2} - \sqrt{ab}))\cdot h$
Compressed ellipsoid (rotation axis 2b, a=c, a>b) (a,·b)		$\frac{4}{3}\pi\cdot a^2\cdot b$, $\varepsilon=\frac{\sqrt{a^2-b^2}}{a}$	$2\pi\cdot a^2+\frac{2\pi b^2}{\varepsilon}\cdot \ln\frac{a(1+\varepsilon)}{b}$	-
Extended ellipsoid (rotation axis 2a, b=c, a>b) (a,·b)		$\frac{4}{3}\pi\cdot a\cdot b^2$	$2\pi\cdot a\cdot b\cdot(\sqrt{1-\varepsilon^2}+\frac{arcin\varepsilon}{\varepsilon})$	-
Ball (R)		$\frac{4}{3}\pi\cdot R^3$	$4\pi\cdot R^2$	-
Ball segment (a,·h)		$\frac{1}{6}\pi\cdot h\cdot(3a^2+h^2)$	$\pi\cdot(2a^2+h^2)$	$\pi\cdot(a^2+h^2)$
Ball layer (a,·b, h)		$\frac{1}{6}\pi\cdot h\cdot(3a^2+3b^2+h^2)$	$\pi(a^2+b^2+2R\cdot h)$	$2\pi\cdot R\cdot h$

Tore (R, r,·k – whorl amount)		$(2\pi^2\cdot R\cdot r^2)\cdot k$	$(4\pi^2\cdot R\cdot r)\cdot k$	$(4\pi^2\cdot R\cdot r-2\pi\cdot r^2)\cdot k$
Square-wave parallelepiped (a,·b, c)		abc	2(ab+bc+ac)	2(ab+bc+ac)-2ab
Cube (a)		a^3	$6a^2$	$4a^2$
Triangular prism (equilateral triangle in base) (a, l)		$\frac{1}{2}a\cdot h\cdot l$, $h=\sqrt{a^2-\left(\frac{a}{2}\right)^2}$	$3a\cdot l + a\cdot h$	$3a\cdot l$
Triangular prism (isosceles triangle in base (a,·h, l)		$\frac{1}{2}a\cdot h\cdot l$, $c=b=\sqrt{h^2+\left(\frac{a}{2}\right)^2}$	$(2c+a)\cdot l+a\cdot h$	$(2c+a)\cdot l$
Rhombic prism (D_1, D_2, l)		$\frac{1}{2}\ D_1\cdot D_2\cdot l$, $a=\sqrt{\left(\frac{D_1}{2}\right)^2+\left(\frac{D_2}{2}\right)^2}$	$4al+\frac{1}{2}\ D_1\cdot D_2$	$4a\cdot l$
Rhombic pyramid (***ά***-apophemesis) (D_1, a,·h)		$\frac{1}{6}D_1\ D_2\cdot h$, $D_2=2\sqrt{a^2-\left(\frac{D_1}{2}\right)^2}$	$2a\cdot\acute{\alpha}+\frac{1}{2}D_1\ D_2$, $\acute{\alpha}=\sqrt{h^2+\left(\frac{a}{2}\right)^2}$	$2a\cdot\acute{\alpha}$
Square pyramid (***ά***-apophemesis) (a,·h**)**		$\frac{1}{3}a^2\cdot h$, $\acute{\alpha}=\sqrt{h^2+\left(\frac{a}{2}\right)^2}$	$2a\cdot\acute{\alpha}+a^2$	$2a\cdot\acute{\alpha}$
Truncated square pyramid (a,·b, h**)**		$\frac{1}{3}h\cdot$ $(a^2+b^2+\sqrt{a^2b^2}\ )$	$(\frac{4a+4b}{2})\acute{\alpha}+$ a^2+b^2	$(\frac{4a+4b}{2})\acute{\alpha}$, $\acute{\alpha}=\sqrt{h^2+(\frac{a}{2}-\frac{b}{2})^2}$
Triangular pyramid (equilateral triangle in base) (a, h)		$\frac{1}{6}a\cdot p\ h$, $p=\sqrt{a^2-\left(\frac{a}{2}\right)^2}$	$1{,}5a\cdot\acute{\alpha}+\frac{1}{2}a\cdot p$, $\acute{\alpha}=\sqrt{h^2+\left(\frac{p}{2}\right)^2}$	$1{,}5a\cdot\acute{\alpha}$
Truncated triangular pyramid (equilateral triangle in base) (a, b, h**)**		$\frac{1}{3}h(\frac{1}{2}a\cdot p+\frac{1}{2}b\cdot l+$ $\sqrt{\frac{1}{4}abpl}$), $l=\sqrt{b^2-\left(\frac{b}{2}\right)^2}$	$(\frac{3a+3b}{2})\acute{\alpha}+\frac{1}{2}a\cdot$ $p+\frac{1}{2}a\cdot l$,	$(\frac{3a+3b}{2})\acute{\alpha}$, $\acute{\alpha}=\sqrt{h^2+(\frac{p}{3}-\frac{l}{3})^2}$

			p=$\sqrt{a^2-\left(\frac{a}{2}\right)^2}$	

Surface area calculation of the "flatted" figures of rotation

For the volume and surface area calculation of the unicellular algae four figures of rotation are used: ball, cylinder, cone and ellipsoid. At the "flatting" figures of rotation (the cylinder, cone and ellipsoid) gain the third "significant" linear parameter, shaping up the figure with elliptical base (the elliptical cylinder, elliptical cone) or section ("flatted" ellipsoid), typical for the number of the unicellular algae of the plankton and benthos.

Only for the elliptical cylinder the surface area is calculated on the known geometric formula (refer to tab. 2). For the surface area and volume calculation of the "flatted" ellipsoid and elliptical cone the following methods are offered.

<u>Method of the "flatted" ellipsoid surface area and volume calculation</u>

As a result of the slashing of the ellipsoid by the planes of the symmetry the figures are formed, the lateral surface area and volume of which is a half surface area and volume of the ellipsoid. Introducing the factor K=0,5, the surface of the ellipsoid takes the type of four different configurations, submitted for fig.1. An ellipse lies in their base, and a circle in special case. Derived from ellipsoid configurations №1 and №2 (refer to fig. 1) are the flatted and extended paraboloid of rotation. The configurations №3 and №4 (refer to fig. 1) - the elliptical paraboloid segments, which height (the parameter **b)** is possible to enlarge, "supplementing" the lateral surface of the elliptical cylinder with the corresponding to linear parameter (**c** and **a**).

A free configuration combination №3, №4 and the lateral surface of the cylinder with elliptical base describes the surface of the "flatted" elliptical cells of the phytoplankton of the different form (fig. 2).

The configuration №1 and №2 are combined on the same way that allows to calculate the surface and volume of the figures of rotation "incorrect" forms. The configurations brought on fig.1, are the lateral (unclosed) surfaces. Bring them to the full form is possible, by complementing with the ellipse or around.

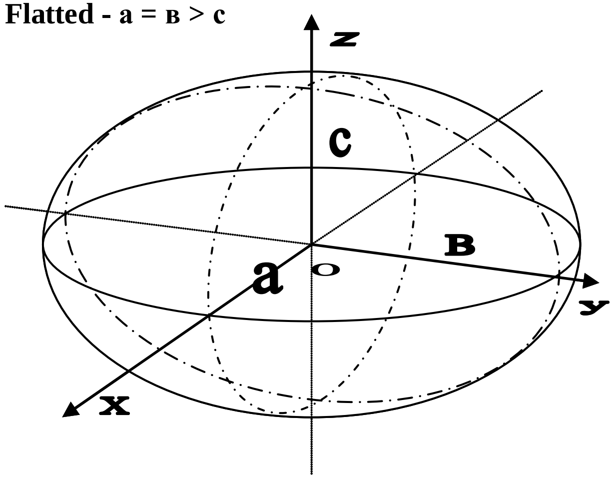
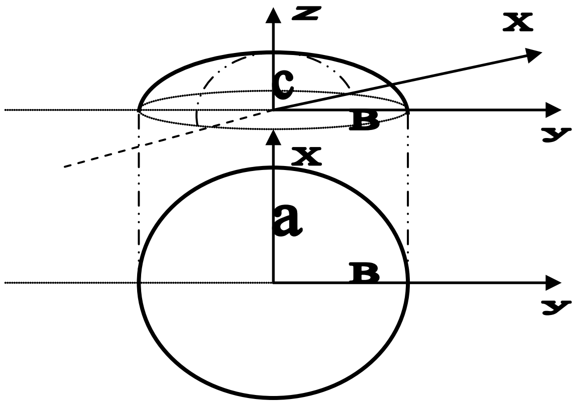
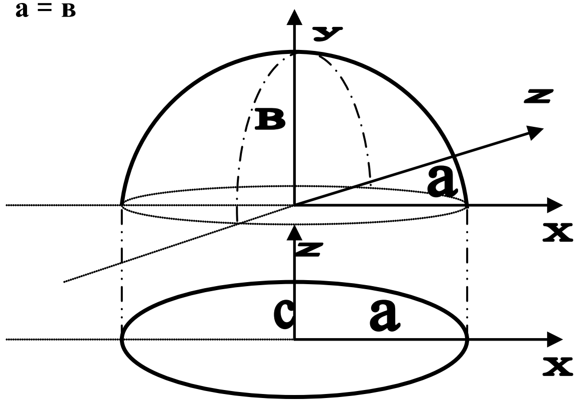
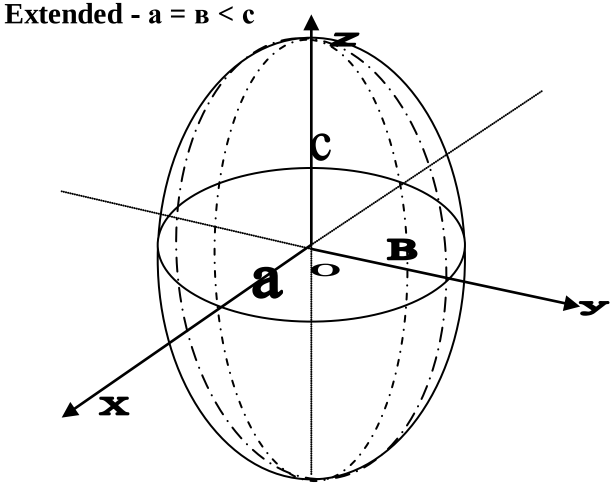
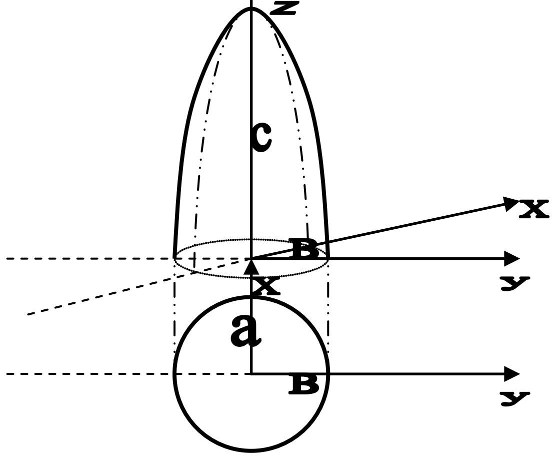
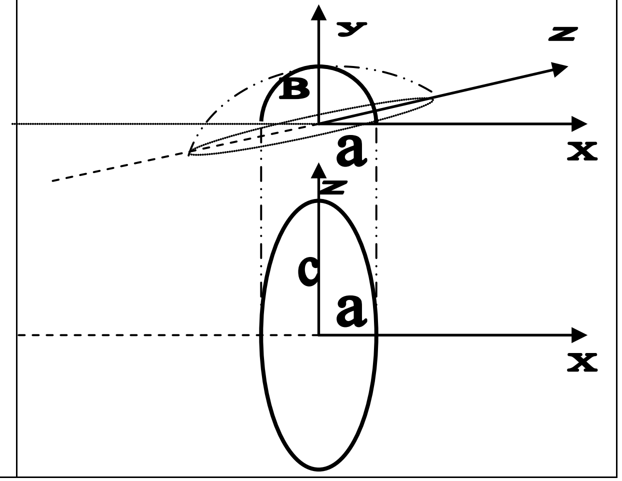
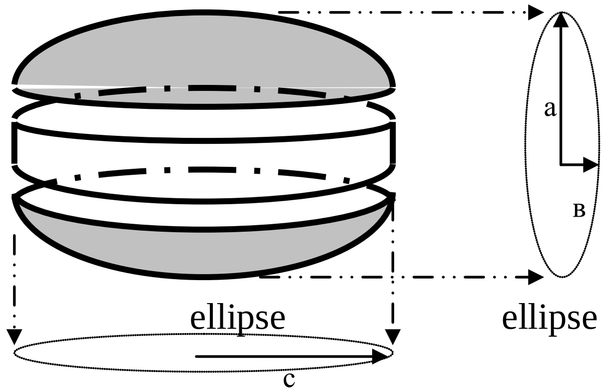
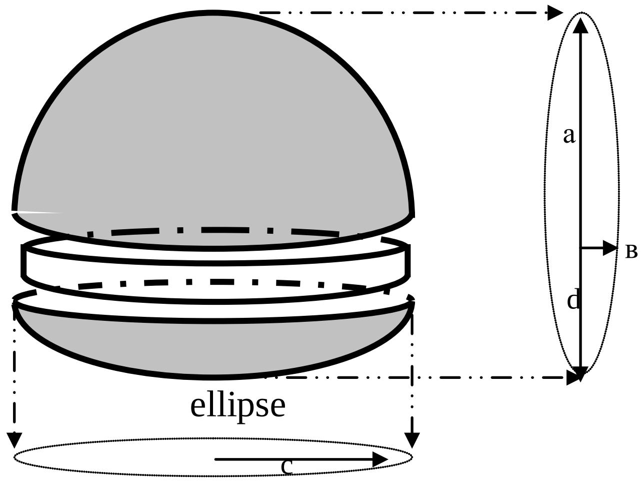
Ellipsoid $a = в \neq c$	**By xy planes**	**By xz planes**
Flatted - a = в > c 	**№1 Flatted paraboloid of rotation** 	**№3 Elliptical paraboloid segment** **a = в** 
Extended - a = в < c 	**№2 Extended paraboloid of rotation** 	**№4 Elliptical paraboloid segment a = в** 

Fig.1. The surface configurations, corresponding surface areas of the ellipsoid at factor 0,5.

<table>
<tr>
<td>Configuration №4 2
+ cylinder lateral
surface with elliptic
base
(a≠ в≠c)</td>
<td>
</td>
</tr>
<tr>
<td>Configuration №3
+ cylinder lateral
surface with elliptic
base
+ configuration №4
(a≠ в≠c≠d)</td>
<td>
</td>
</tr>
<tr>
<td>Configuration №3・2

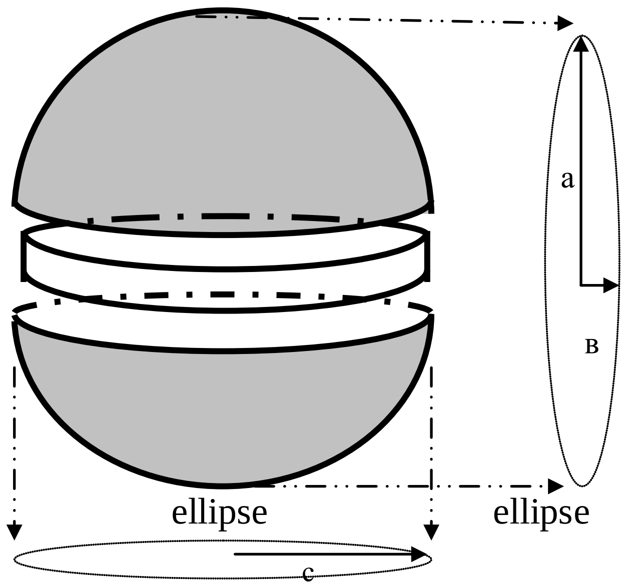
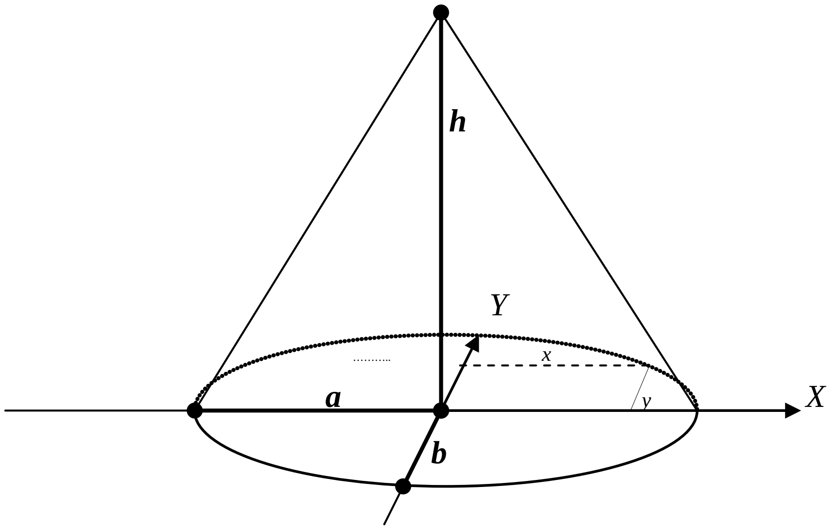
+ cylinder lateral
surface with elliptic
base
(a≠ в≠c)</td>
<td>
</td>
</tr>
</table>

Fig. 2. The examples of elliptical paraboloid segments combinations and the cylinder with elliptical base.

Method of the elliptical cone surface area and volume calculation.

The canonical ellipse equation describing it in decart coordinate has a following type: $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$, where *a=const* and *b=const* - ellipse semiaxises, *x* and *y* - the distances from axises Y and X to any point, lying on the base ellipse [x=a if b=0, y=b if a=0] (the fig. 3).



The fig. 3 Measured (*a, b, h*) parameters used at elliptical cone surface area calculation.

The lateral surface area of the elliptical cone is calculated as the surface integral the type I The full surface area of the given figure is calculated on formula:

$$S=\int_0^d dx \int_0^{b\sqrt{1-\frac{x^2}{a^2}}} \sqrt{\frac{\alpha^2\cdot\frac{x^2}{a^2}+\beta^2\cdot\frac{y^2}{b^2}}{\frac{x^2}{a^2}+\frac{y^2}{b^2}}}dx + \pi ab,$$

where a and b - semiaxises of the base ellipse , h - a height of the cone,

$\alpha^2=1+\frac{h^2}{a^2}$, $\beta^2=1+\frac{h^2}{b^2}$

(The volume of the elliptical cone is calculated on formula $V=\frac{1}{3}\pi abh$).

The most exact correspondence of the cell form and "approximate" to it figure, is reached by the free combination of the maximum number of the corresponding geometric figures (the fig. 4).

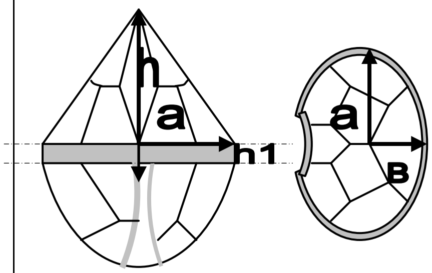
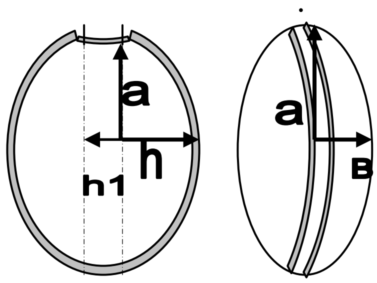
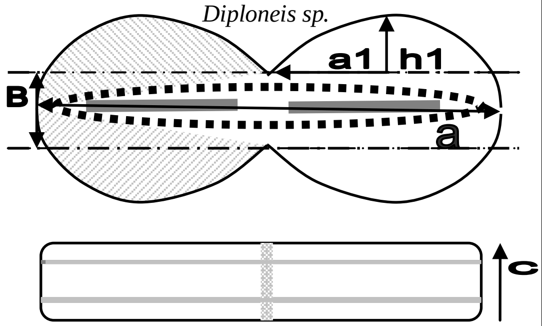
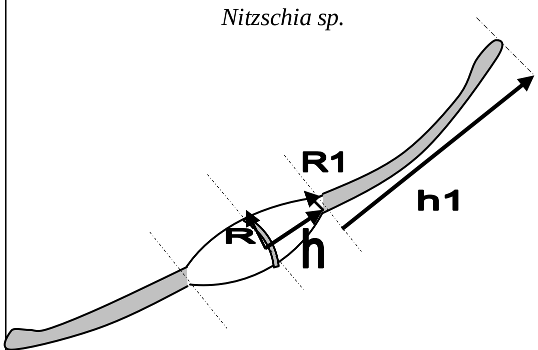
Type	Surface and volume calculation
Peridinium sp. 	The cone with elliptical base (the parameters - *a, h, b*; the lateral surface) + cylinder with elliptical base (the parameters - *a*, h_1, *b*; the lateral surface) + 0,5 ellipsoids, configuration №3 (the parameters - *a*, *h* = *a*, *b*; lateral surface)
Exuviaella sp 	0,5 ellipsoids, configuration №4 · 2 (the parameters - *a*, *h* = *b*, *b*; the lateral surface) =the full ellipsoid surface + cylinder with elliptical base (the parameters - *a*, h_1, *b*; lateral surface)
Diploneis sp. 	The cylinder with elliptical base · 2 (the parameters - a_1=*a*/4, h_1, *c*; full surface) + parallelepiped (parameters *a, b, c*, lateral surface)
Nitzschia sp. 	Cone · 2 (the parameters - *R, h*; the lateral surface) + cylinder · 2 (the parameters - R_1, h_1; lateral surface)

Fig. 4. The examples of the free figure combination at the unicellular algae volume and surface area calculation.

The cell specific surface calculation

The cell specific surface index characterizes the relation of the cell surface area to its volume $(S/V)_c$ (mkm^{-1}), or mass $(S/W)_c$ (mkm^2·mg^{-1}) (at condition $V_c \cdot \rho = W_c$ where ρ=1).

1. The methods of the cell specific surface ***(S/W)*$_c$** calculation:

1.1 Using the geometric formulas (refer to tabl. 1) and parameters of the linear sizes of the cell to calculate the value of the volume (V_c) and surface area (S_c) of the cell.

1.2 On the grounds of equality ($V_c \cdot \rho = W_c$, where ρ=1) correlate the cell surface with its mass: $(S/W)_c$ (mkm^2·mg^{-1}) $= S_c/W_c = S_c/V_c$.

1.3 Convert dimensionality to specific surface of the cell in m^2·kg^{-1}:

$$\boldsymbol{(S/W)_c}(\mathrm{m^2 \cdot kg^{-1}}) = \boldsymbol{S_c/W_c}(\mathrm{mkm^2 \cdot mg^{-1}}) \cdot \mathbf{1000}.$$

***The specific surface of the uniform-sized cells group (S/W)*$_{\mathbf{uni.c.gr.}}$**

Counting the number of the unicellular algae in the sample, the cells of one type with the same form and linear size are uniting, forming uniform-sized cells groups. The index $(S/W)_{uni.c.gr}$ corresponds in terms of quantity to $(S/W)_c$, incoming into given group. As the groups of the uniform-sized cells are marked out during the sampling processing, rather then at the specific surface calculation, in practice $(S/W)_{uni.c.gr}$ is calculated on the similar to the calculation methods $(S/W)_c$.

2. The methods of the uniform-sized cells group specific surface calculation ***(S/W)*$_{uni.c.gr}$**:

2.1 Mark out the uniform-sized cells group in the sample.

2.2 Calculate the specific surface of the cell, incoming into given uniform-sized algae group (refer to. 1.1-1.3).

2.3 Calculate the specific surface of the uniform-sized cells group on formula:

$$\boldsymbol{(S/W)_{\mathrm{uni.c.gr}}} = \Big(\sum_{i=1}^{n} \boldsymbol{(S/W)_c}\Big)/\boldsymbol{n},$$

where i - a number of the uniform-sized cells of one species in the sample.

***Specific surface of the population (S/W)*$_{\mathbf{p}}$**

The $(S/W)_p$ index is the average value, calculated for the whole value part of the uniform-sized cells groups specific surface, fixed in the given population species.

For validity level estimation of the population specific surface define the average accuracy define index is used ($\boldsymbol{C_s}$). C_s is calculated on the following formula Cs $=M/x \cdot 100$, where x - an average *S/W* value population, M - a representation mistake (Lakin G.F., 1990).

3. The methods of the unicellular algae population specific surface ***(S/W)*$_p$** calculation:

3.1 To calculate the $(S/W)_{uni.c.gr}$ values (refer to. 2.1-2.3), fixed for investigative species of the unicellular algae.

3.2 To calculate the specific surface of the population on formula:

$$(S/W)_p=(\sum_{i=1}^{n}(S/W)_{uni.c.gr})/n,$$

where *i*- a number of the uniform-sized cells groups, fixed for given phytoplankton population.

***Specific surface of the community (S/W)*$_{cm}$**

The $(S/W)_{cm}$ index characterizes the average value, calculated for the whole value part of the specific surface of the different species cells, fixed in the sample.

4. The methods of the unicellular algae community specific surface $(S/W)_{cm}$ calculation:

4.1 To calculate the $(S/W)_{uni.c.gr}$ values (refer to. 2.1-2.3) for all groups of uniform-sized cells, met in sample.

4.2 Using standard methods (Nesterova D.A., 1988), get the values of the number of the cells in the uniform-sized cells groups ($N_{uni.c.gr}$), met in sample.

4.3 To calculate the total number of the cells in the sample (N_{cm})

4.4 To calculate the community specific surface on formula:

$$(S/W)_{cm}=(\sum_{i=1}^{n}((S/W)_{uni.c.gr}\cdot N_{uni.c.gr}))/N_{cm},$$

where *i* - a number of the groups of the uniform-sized cells in the sample (community).

***Specific surface of the floristic grouping (S/W)*$_{fg}$**

The $(S/W)_{fg}$ index is an average value, calculated for value part of the specific surface community, noted in investigative basin or on the investigative part the area of water.

5. The methods of the unicellular algae floristic grouping specific surface $(S/W)_{fg}$ calculation:

5.1 To group all the values $(S/W)_{cm}$ (refer to. 2.1-2.3), fixed for given basin or the investigative part the area of water.

5.2 To calculate the specific surface of the floristic grouping on formula:

$$(S/W)_{fg}=(\sum_{i=1}^{n}(S/W)_{cm})/n;$$

where *i* - a number of the samples, fixed for the basin or the investigative part the area of water.

***Specific surface of the taxonomic section (S/W)*$_{ts}$**

The $(S/W)_{ts}$ index is an average value, calculated for the value part of the specific surface of the uniform-sized cells groups, forming species populations, referring to given section.

6. The methods of the specific surface of the unicellular algae taxonomic section $(S/W)_{ts}$ calculation:

6.1 To group the values $(S/W)_{uni.c.gr}$ (refer to. 2.1-2.3), fixed for given taxonomic section of the unicellular algae.

6.2 To calculate the specific surface of the taxonomic section on formula:

$$\boldsymbol{(S/W)_{ts}=(\sum_{i=1}^{n}(S/W)_{\mathrm{uni.c.gr}})/n};$$

where i - a number of the uniform-sized cells groups forming the taxonomic section.

Surface indexes of the planktonic algae

The surface indexes of the planktonic algae characterize the total surface area of the certain phytoplankton cells group referred to the determined volume of the water column, and are non-dimensional value (m^{-1}).

***The surface index of the population* $\mathbf{SI_P}$**

The surface index of the population SI_P of the planktonic algae characterizes the total surface met in the cells sample of the certain species (population), referred to m^3 water column.

7. The methods of the phytoplankton population surface index $\mathbf{SI_P}$ calculation:

7.1 To calculate the values $(S/W_{\mathrm{uni.c.gr}}$ (refer to. 2.1-2.3), fixed in the sample for given phytoplankton species.

7.2 Using standard methods (Nesterova D.A., 1988), calculate the biomass of the sample (of the community) (B_{cm}) in the dimensionality $kg \cdot m^{-3}$.

$$B_{\mathrm{cm}}\ (kg \cdot m^{-3}) = B_{\mathrm{c}}\ (mg \cdot m^{-3})/1000000$$

7.3 On the grounds of the values $N_{\mathrm{uni.c.gr}}$, N_{cm} (refer to. 4.3), and B_{cm} to calculate the index to surfaces to populations (m^{-1}) on formula:

$$\mathbf{SI_P}=\sum_{i=1}^{n}((((S/W)_{\mathrm{uni.c.gr}} \cdot N_{\mathrm{uini.c.gr}})/N_{\mathrm{cm}}) \cdot B_{\mathrm{cm}});$$

where i - a number of the groups of the uniform-sized cells of the given species in the sample.

***The community surface index* $\mathbf{SI_{cm}}$**

The surface index of the community SI_{cm} characterizes the total area to surfaces of the cells, met in sample, referred to m^3 of the water column.

8. The methods of the phytoplankton community surfaces index $\mathbf{SI_{cm}}$ calculation:

8.1 To calculate the specific surface of the phytoplankton community (refer to. 4.1-4.4).

8.2 Using standard methods, calculate the total biomass of the cells in sample $(\boldsymbol{B}_{\mathrm{cm}})$.

8.3 To calculate the surface index of the community on formula:

$$\mathbf{SI_{cm}}=\boldsymbol{(S/W)_{cm} \cdot B_{cm}}$$

***The phytoplankton surface index* $\mathbf{SI_{php}}$**

The phytoplankton surface index $SI_{\mathbf{php}}$ characterizes the total surface of the cells met in the given basin or on the investigative ecosystem area, referred to m^3 water column.

9. The methods of the phytoplankton surface index $\mathbf{SI_{php}}$ calculation:

9.1 To calculate the $\mathbf{SI_{cm}}$ values (refer to. 8.1-8.3) for all samples, got for given basin or investigative water area.

9.2 To calculate the phytoplankton surface index on formula:

$$\mathbf{SI_{php}} = (\sum_{i=1}^{n} \mathbf{SI_{cm}})/n$$

where *i* - an number of the $\mathbf{SI_{cm}}$ values, fixed for the basin or water column.

The taxonomic section surface index $\mathbf{SI_{ts}}$

The surface index of the taxonomic section $\mathbf{SI_{ts}}$ characterizes the total surface met in sample of the cells of the given taxonomic section, referred to m^3 of the water column.

10. The methods of the phytoplankton taxonomic section surface index $\mathbf{SI_{ts}}$ calculation:

10.1 To calculate the SI_p values (refer to. 7.1-7.3), populations met in the sample, referring to one taxonomic section.

10.2 To calculate the taxonomic section surface index on formula:

$$\mathbf{SI_{ts}} = \sum_{i=1}^{n} \mathbf{SI_p}$$

where *i* - a populations number met in the sample, referring to the given taxonomic section.

Methods of the morpho-functional indexes define for the multicellular forms

In the that part is considered the relative classification of the morphological structure of the macroscopic forms of the benthos vegetation, taken with the aim of the problem simplification of the specific surface group indexes calculation, also are given the methods of the calculation of the whole complex of the morpho-functional indexes of the macrophytobenthos (table. 3). There is no principle difference in the methods of the indexes complex calculation for multicellular algae and flowering macrophytes, unlike the unicellular plankton and benthos algae. That's why the calculation algorithms, brought in given part for macroalgae, is possible to apply also for flowering macrophytes without principle distinction.

All the morphological variety of the benthos vegetation structure elements, from which the multicellular algae thalluses consist and the single plants of the submerged macrophytes, is possible to bring to the three main geometric forms: the cylinder, the lamella and the ball. Each of these forms has a parameter, that is directly connected and defines the specific surface value when change the size of the figure. For the ball and cylinder this is a diameter, for lamella - a thickness (Minicheva, 1992).

For the simplification of the specific surface calculation problem it's necessary to take the following relative classification of the morphological types of the benthos vegetation macroscopic forms, on the grounds of which the methods of the specific surface calculation of the structure elements are built.

Table 3

Macrophytobenthos morpho-functional indexes

Organization levels	Specific surface indexes	Surface indexes
Structure elements	Specific surface of the structure elements $(S/W)_{se}$	-
Thallus (single plant)	Specific surface of the thallus $(S/W)_{t}$	-
Population	Specific surface of the population $(S/W)_{p}$	Population surface index SI_{p}
Community	Specific surface of the community $(S/W)_{cm}$	Community surface index SI_{cm}
Floristic grouping of the region	Specific surface of the floristic grouping $(S/W)_{fg}$	Phytobentos surface index SI_{phb}
Taxonomic section	Specific surface of the taxonomic section $(S/W)_{ts}$	Taxonomic section surface index SI_{ts}

* Refer to the text of the methodical recommendations to find the semantic define of the index.

**"Floristic grouping of the region" and "taxonomic section" are not the hierarchical levels of the macrophytobenthos organization in direct understanding and are placed in the given order only for comfort and in accordance with the general logic of the morpho-functional complex calculation

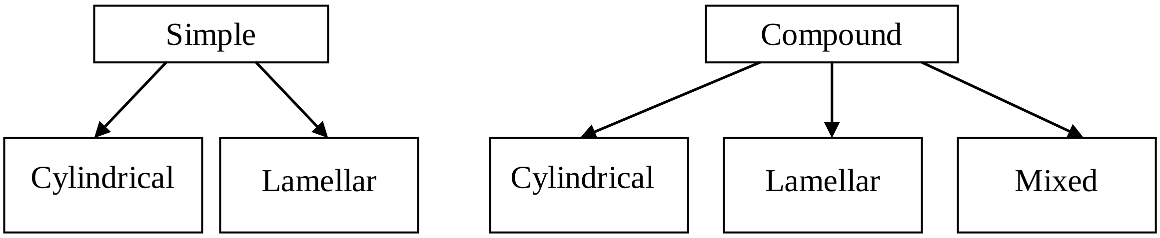


Fig. 5. The scheme of the morphological types of the macroscopic forms benthos vegetation.

All the morphological variety of the macrophytes thallus structure given by this scheme is possible to divide into the simple and compound type. The plants pertain to the *simple* type, as it's different parts of the thallus have the same morphological form and minor size differences (the maximum value of the functionally depending parameters exceeds the minimum for not more than in 5 times). To the *compound* type of the morpho-functional structure pertain the plants in which composition enter the groups of the structure elements, that have different morphological form, or having essential differences in the parameters functionally connected with the specific surface (the maximum value functionally depending parameters exceeds the minimum for more than in 5 times).

In turn the simple type is divided into the cylindrical and lamellar ones. To the *simple cylindrical* type pertain the plants, which thallus is characterized by cylindrical form and minor diameter size differences values (the maximum value exceeds the minimum for not more than in 5 times). To the *simple lamellar* type pertain the plants of the lamellar form with the close values of the thallus thickness (the maximum value exceeds the minimum for not more than in 5 times).

The compound thallus type is divided into the compound cylindrical, compound lamellar and mixed compound (refer to fig. 5). In the plants of the *compound cylindrical* type exist several structure elements groups for which, the average values of the diameters differ for more than in 5 times. In the plants of the *compound lamellar* type exist several structure elements groups, for which, the average values of the thallus thickness differ for more than in 5 times. To the *mixed compound* type pertain the plants, in which the structure elements groups of the lamellar, cylindrical or spherical forms are present simultaneously.

The main morphological types of the macrophytes thallus were submitted on the Fig.6.

The specific surface indexes of the multicellular algae and flowering plants

Specific surface of the structure elements $(S/W)_{se}$

The define methods of the given index $(S/W)_{se}$ has the differences for morphological structures of the cylindrical, lamellar and spherical forms. Earlier, in practice, mostly was used the method of the direct surface area measurement, the main essence of which is brought to the selection of the cognate with the layer form geometric figure and the surface area calculation on the known mathematical formulas. For instance, cylindrical and spherical structures area is possible to calculate on the formulas of the cylinder and the ball. Besides, the *S/W* layer fragment of the lamellar seaweeds define was done by the "method of the etalon" (Firsov, 1979). However a practice has shown that the least labour-intensive and the most uitable method of the specific surface value define is the allometric method (Minicheva, 1992).

The cylindrical type of the structure elements

The value $\boldsymbol{(S/W)_{se}}$ of the cylindrical macrophytes is inversely proportional to their diameter.

11. The methods of the specific surface of the structure elements $\boldsymbol{(S/W)_{se}}$ calculation of the simple cylindrical species:

11.1 Prepare the structure elements preparation of the cylindrical type.

11.2 With the help of the microscope (binocular, sliding) to measure the diameter of the structure elements: d_1, d_2, … d_n.

11.3 To calculate the average reliable value of the structure elements diameters - d_x.

11.4 To conduct the specific surface value calculation on the equation:

$$\boldsymbol{(S/W)_x = 3334\, d_x^{-0{,}916}},$$

where d_x - is an average structure elements diameter (mkm), $(S/W)_x$ - is an average specific surface of the structure elements - $\boldsymbol{(S/W)_{se}}$ ($m^2\ kg^{-1}$).

The lamellar type of the structure elements

The $\boldsymbol{(S/W)_{se}}$ value lamellar macrophytes is inversely proportional to their thickness.

12. The methods of the specific surface calculation of the structure elements $\boldsymbol{(S/W)_{se}}$ of the lamellar type:

12.1 To prepare the preparation of the structure elements transverse cut of the thallus of the lamellar type.

12.2 With the help of the microscope (binocular, sliding) to measure the height of the cut - a structure elements' thickness: h_1, h_2, … h_n.

12.3 To calculate the reliable average value of the cut thicknesses - h_x.

12.4 To conduct the specific surface value calculation on equation:

$$\boldsymbol{(S/W)_x = 2000 * h^{-0{,}988}},$$

where h_x - is an average thickness value of the cut (mkm), $(S/W)_x$ - is an average specific surface of the structure elements - $\boldsymbol{(S/W)_{se}}$ ($m^2\ kg^{-1}$).

The spherical type of the structure element

The $\boldsymbol{(S/W)_{se}}$ value of the spherical macrophytes is inversely proportional to their diameter.

13. The methods of the specific surface calculation of the structure elements $\boldsymbol{(S/W)_{se}}$ of the spherical species:

13.1 To prepare the structure elements preparation of the spherical type.

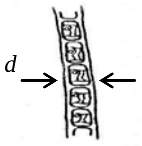
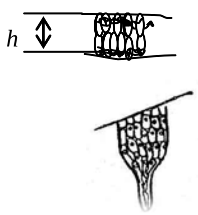
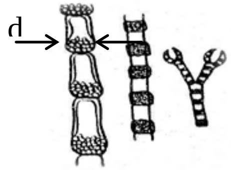
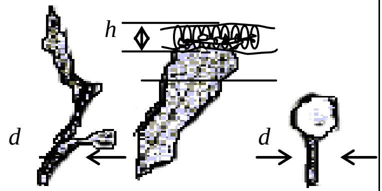
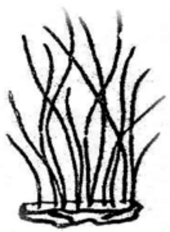
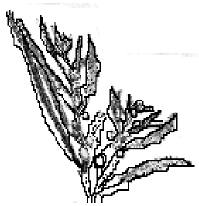
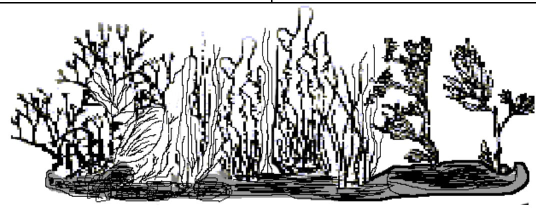
Organization levels / Morphological thallus types	**SIMPLE CYLINDRICAL**	**SIMPLE LAMELLAR**	**COMPOUND CYLINDRICAL**	**MIXED**
STRUCTURE ELEMENTS				
SINGLE PLANT				
POPULATION				
COMMUNITY				

Fig. 6. Some morphological types of the macrophytes on the different organization levels.

13.2 With the help of the microscope (binocular, sliding) to measure the structure elements diameters: d_1, d_2, … d_n.

13.3 To calculate the reliable average value of the structure elements diameter - d_x.

13.4 To conduct the specific surface value calculation on the equation:

$$\mathbf{(S/W)_x = 6058{,}87 * d^{-1{,}0026}},$$

where d_x - is an average structure elements diameter (mkm), $(S/W)_x$ - is an average specific surface of the structure elements, equal $\mathbf{(S/W)_{se}}$ ($m^2\ kg^{-1}$).

Specific surface of the thallus $\mathbf{(S/W)_t}$

<u>*Simple cylindrical thallus type*</u>

The methods of the thallus specific surface calculation of the simple cylindrical type corresponds to the principle algorithm of the to structure element specific surface calculation of the cylindrical type (refer to ii. 11.1 - 11.4).

<u>*Simple lamellar thallus type*</u>

The methods of the thallus specific surface calculation of the simple lamellar type corresponds to the principle algorithm of the structure element specific surface calculation of the lamellar type (refer to ii. 12.1 - 12.4).

<u>*Compound cylindrical thallus type*</u>

The compound cylindrical type macrophytes $\mathbf{(S/W)_t}$ value is the morphological structures groups sum $\mathbf{(S/W)_{se}}$, from which the thallus composes. Herewith the $\mathbf{(S/W)_t}$ reflects the composite contribution of all the morphological structure groups , from which the thallus composes.

14. <u>The methods of the thallus specific surface calculation $\mathbf{(S/W)_t}$ of the compound cylindrical species:</u>

14.1 To select the structure elements groups in the thallus, ratio between maximum and minimum diameter value that does not exceed 5-times value: d_1, d_2 … d_n.

14.2 To calculate the specific surface of each structure element group $((S/W)_{se})_1$, $((S/W)_{se})_2$,… $((S/W)_{se})_n$ (refer to ii. 12.1 - 12.4).

14.3 To divide the thallus on the detailed structure element groups and define their weight - w_1, w_2, … w_n.

14.4 To calculate the value of the external surface of each structure elements group : s_1, s_2, … s_n on proportions: $s_i = ((S/W)_{se})_i * w_i$,

where i - is a structure elements group.

14.5 To calculate the total surface and weight of the thallus:

$$\sum_{i=1}^{n} s_i \text{ и } \sum_{i=1}^{n} w_i.$$

14.6 To correlate the thallus surface s_i to its weight w_i, getting value $\mathbf{(S/W)_t}$.

Compound lamellar thallus type

The thallus specific surface of the compound lamellar species $\boldsymbol{(S/W)_t}$ is calculated on the grounds of the $(S/W)_{se}$ values of the lamellar type (refer to i. 12), and corresponds to the principle algorithm of the thallus specific surface calculation of the compound cylindrical type (refer to ii. 14.1 - 14.6).

Mixed thallus type

The specific surface of the thallus of the mixed type $\boldsymbol{(S/W)_t}$ is calculated on the grounds of the corresponding structure elements values$(S/W)_{se}$ (cylindrical (refer to i. 11), lamellar (refer to i. 12) and spherical type (refer to i. 13)), and corresponds to the principle algorithm of the thallus specific surface calculation of the compound cylindrical type (refer to ii. 14.1 - 14.6).

Specific surface of the population $(S/W)_p$

At the specific surface calculation of the macrophytes population is necessary to take into consideration the population structure, which is formed due to the age, dimensional, morphological, and also other heterogeneities, inherent to the populations. In this connection, for the $\boldsymbol{(S/W)_p}$ calculation, it is necessary to have the individual's sample, $(S/W)_t$ which representively reflects the dispersal of the given values within population.

15. The methods of the populations specific surface $\boldsymbol{(S/W)_p}$ calculation:

15.1 On the population growing area, keeping stated step on the locality, is selected a motivated thallus number. At the cylindrical structures diameter before 100 mkm step of the thallus selection forms 15-30 cm. At the greater diameter sizes, the step of the selection is not less than 3-5 м. For the lamellar forms with the layer thickness less than 50 mkm the first variant is available, at the more high values - the second variant is available.

15.2 Using corresponding methods, designed for the thallus specific surface value define of the different morphological type, to calculate the specific surface of the selected thalluses - $(S/W)_t$.

15.3 With the help of the standard methods of the statistical processing, on the base of the got values $(S/W)_{ti}$ to calculate the population specific surface value:

$$\boldsymbol{(S/W)_p = \left(\sum_{i=1}^{n} (S/W)_{Ti}\right)/n},$$

where i - a thallus number in the population.

Specific surface of the community $\boldsymbol{(S/W)_c}$

The $\boldsymbol{(S/W)_c}$ value is an average value $(S/W)_p$, for all the species of the benthos vegetation, including micro- and macroalgae, and also aquatic plants, incoming in the community.

16. The methods of the community specific surface calculation $\boldsymbol{(S/W)_{cm}}$:

16.1 To calculate the $(S/W)_{pi}$ values for all the species, incoming to the community (refer to ii. 15.1 - 15.3).

16.2 With the help of the standard methods of the statistical processing, on the base of the got values $(S/W)_{pi}$ to calculate the community specific surface value $\mathbf{(S/W)_{cm}}$:

$$\mathbf{(S/W)_{cm}=(\sum_{i=1}^{n} (S/W)_{pi})/n}$$

where i - a population number, incoming to the community.

Specific surface of the floristic grouping $(S/W)_{fg}$

The $\mathbf{(S/W)_{fg}}$ is an average value, calculated for the value part of the populations specific surface of all the benthos species vegetation of the investigative region or marked part of the water area. A floristic composition of the region can be characterized quantitatively by the means of the functional activity rows (FAR). FAR is the list species benthos vegetation, incoming into the investigative region, put according to the value of their $(S/W)_p$. FAR is quantitatively described with the parameters, $(S/W)_{min}$, $(S/W)_{max}$, $(S/W)_x$, $(S/W)_{\sum}$, which depending on concrete factors, defining the intensity of the production process (light, temperature rate, trophic level), naturally change their own values. In practice it is comfortable to use the FAR parameters for comparative morpho-functional analysis of the different ecosystems bottom vegetation, and also for the comparative estimation of the eutrofication degree of the region.

17. The methods of the floristic grouping specific surface $\mathbf{(S/W)_{fg}}$ calculation:

17.1 Define the value $(S/W)_p$ of each species, incoming into floristic composition of the investigative region, on the methods, corresponding to the type of the of the thallus macrophytes morphological structure.

17.2 Dispose the species in the row in accordance with their $(S/W)_p$ value .

17.3 Define the size of the row by the number of the species incoming into it - n.

17.4 Calculate reliable average value $\mathbf{(S/W)_{fg}}$

17.5 Define the parameters FAR -

$$(S/W)_{fg(min)} = (S/W)_{p(min)};$$

$$(S/W)_{fg(max)} = (S/W)_{p(max)};$$

$$(S/W)_{fg(x)} = (\sum_{i=1}^{n} (S/W)_{pi})/n;$$

$$(S/W)_{fg(\sum)} = \sum_{i=1}^{n} (S/W)_{pi};$$

$$(S/W)_{fg[x-min]} = [(S/W)_{fg(x)} - (S/W)_{fg(min)}];$$

$$(S/W)_{fg[x-max]} = [(S/W)_{fg(x)} - (S/W)_{fg(max)}].$$

Specific surface of the taxonomic section $(S/W)_{ts}$

The $\mathbf{(S/W)_{ts}}$ value is the average $(S/W)_p$ value for all the species of the benthos vegetation, met in the investigative region or in the mark part of the water area, related to one taxonomic section.

18. Methods of the taxonomic section specific surface $\mathbf{(S/W)_{ts}}$ calculation :

18.1 To calculate the value of the specific surface of the population - $(S/W)_p$, met in investigative region or of the mark part of the water area, related to one taxonomic section (refer to ii. 15.1 - 15.3).

18.2 To calculate the taxonomic section specific surface $\mathbf{(S/W)_{ts}}$:

$$\mathbf{(S/W)_{ts} = (\sum_{i=1}^{n} (S/W)_{pi})/n}$$

where i - a populations number of the given investigative region or of the mark part of the water area, related to one taxonomic section.

Benthos vegetation surfaces indexes

Population surface index $\mathbf{SI_p}$

The macrophytes $\mathbf{SI_p}$ value characterizes total monocenosis photosynthesizing surface, formed by species of the bottom vegetation, in calculation on the m^2 of the bottom.

19. Methods of the population surface index $\mathbf{SI_p}$ calculation:

19.1 To calculate the specific surface of the investigative population - $(S/W)_p$. (refer to ii. 15.1 - 5.3).

19.2 Using standard phytocenosis studies methods (Morozova-Vodyanickaya, 1936; Kalugina-Gutnik, 1969; Eremenko, 1980) define the average population biomass - B_p.

19.3 To calculate the population surface index on the formula:

$$\mathbf{SI_p = (S/W)_p * B_p},$$

where $(S/W)_p$ - a specific surface of the population ($m^2 * kg^{-1}$), B_p - a population biomass ($kg * m^{-2}$), $\mathbf{SI_p}$ - a population surface index (un.).

Community surface index $\mathbf{SI_{cm}}$

The $\mathbf{SI_{cm}}$ value characterizes total photosynthesizing surface of the species, incoming into the community, in calculation on m^2 of the bottom.

20. Methods of the community surface index $\mathbf{SI_{cm}}$ calculation:

20.1 To calculate the population specific surface - $(S/W)_{pi}$ of all the species of bottom vegetation, incoming into the structure of investigative community (refer to ii. 15.1 - 15.3).

20.2 Using standard methods of the marine phytocenosis studies (Morozova-Vodyanickaya, 1936; Kalugina-Gutnik, 1969; Eremenko, 1980), define the cenopopulations biomass, composing phytocenosis - B_i.

20.3 To calculate the surface indexes coenopopulations, composing community, on formula: $SI_{pi}= (S/W)_i \cdot * B_i$,

20.4 To calculate community surface index on formula:

$$\mathbf{SI_{cm}=\sum_{i=1}^{n} SI_{p\mathit{i}}},$$

where *i* - a coenopopulations number , composing community.

Phytobenthos surface index $\mathbf{SI_{phb}}$.

The $\mathbf{SI_{phb}}$ is the average value SI_c community, forming bottom vegetation of the aquatic ecosystem.

21. The methods of the phytobenthos surfaces index $\mathbf{SI_{phb}}$ calculation:

21.1 To calculate the community surface index value SI_{ci}, incoming into the composition of bottom vegetation of the investigative region (refer to ii. 20.1 - 20.4).

21.2 To calculate the phytobenthos surface index on formula:

$$\mathbf{SI_{phb}=(\sum_{i=1}^{n} SI_{c\mathit{i}})/\mathit{n}}$$

where *i* - a community number in the basin or investigative water area.

Taxonomic section surface index SI_{ts}

The $\boldsymbol{SI_{ts}}$ is the average value SI_p for all the species of benthos vegetation, met in investigative region or part of the ecosystem, related to one taxonomic section.

22. Methods of the taxonomic section surface index $\boldsymbol{SI_{ts}}$ calculation:

22.1 To calculate the SI_{pi} value for all the species of the benthos vegetation, met in investigative region or part of the ecosystem, related to one taxonomic section (refer to ii. 19.1 - 19.3).

22.2 To calculate the taxonomic section surface index on the formula:

$$\boldsymbol{SI_{ts} = (\sum_{i=1}^{n} SI_{pi})/n},$$

where *i* - a species number, related to one taxonomic section.

Annex

The population specific surface coefficient of the unicellular and multicellular algae and flowering macrophytes of the mass species of the north- western part of the Black Sea and adjoining basins

№	Type	S/W_p	+/-*m*
	One-celled algae		
	Dinophyta		
1	*Gymnodinium sanguineum* Hirasaka	157,05	6,44
2	*Ceratium furca* (Ehrbg.) Clap. Et Lacym.	212,37	11,72
3	*Dinophysis cassubica* Wolosz.	233,42	14,86
4	*Diplipsalis lenticula* (Bergh.) Schill.	274,69	11,62
5	*Prorocentrum micans* Ehr.	290,35	9,30
6	*Ceratium fusus* (Ehr.) Duj.	291,01	3,02
7	*Heterocapsa triquetra* (Ehr.) Stein	386,00	22,01
8	*Prorocentrum compressum* (Ostf.) Abe	394,92	15,30
9	*Prorocentrum cordata* (Ostf.) Dodge.)	469,06	34,88
	Bacillariophyta		
10	*Amphora hyalina* Kutz.	312,09	15,70
11	*Pseudosolenia calcar avis* (Schul.) Sandstrom	362,15	12,59
12	*Rhizosolenia fragilissima* Bergon.	482,58	26,74
13	*Cocconeis scutellum* Ehr.	507,21	23,06
14	*Cerataulina pelagica* (Cl.) Hendey	510,16	15,68
15	*Licmophora gracilis* (Ehr.) Grun.	572,52	35,11
16	*Navicula cancellata* Donk.	644,77	36,63
17	*Cyclotella Kuetzingiana* Thw.	727,50	38,52
18	*Navicula pennata A.S. var. pontica* Mer.	732,72	17,57
19	*Chaetoceros simplex* Ostf.	782,34	27,41
20	*Bacillaria paradoxa* Gmel.	873,80	16,24
21	*Amphipleura rutilans* (Trentep.) Cl.	876,75	21,40
22	*Leptocylindrus danicus* Cl.	937,12	49,22
23	*Chaetoceros similis - f. solitarius* Pr.-Lavr.	947,27	30,12
24	*Diatoma elongatum* (Lyngb.) Ag.	957,10	27,51
25	*Rhoicosphenia curvata* (Kutz.) Grun.	968,36	34,49
26	*Synedra tabulata* (Ag.) Kutz.	1008,54	66,68
27	*Chaetoceros socialis* Pr.-Lavr.	1029,76	62,08
28	*Thalassionema nitzschioides* Grun.	1343,04	23,00
29	*Sceletonema costatum* (Grev.) Cl.	1416,71	34,94

30	*Pseudonitzschia delicatissima* Cl.Heiden	1758,28	68,83
31	*Leptocylindrus minimus* Gran.	1794,68	107,09
32	*Cylindrotheca closterium* (Ehr.) Reimanet Lewin	2209,11	109,39
33	*Nitzschia reversa* W. Sm.	2325,12	128,21
34	*Nitzschia tenuirostris* Mer.	3926,57	232,21
	Chlorophyta		
35	*Scenedesmus acuminatus* (Lag.) Chod.	500,53	3,07
36	*Oocystis borgei* Snow	709,53	2,59
37	*Scenedesmus quadricauda* (Turp.) Breb.	720,82	5,67
38	*Monoraphidium arcuatum* (Korsch.) Hind.	1148,61	4,91
39	*Micractimium crassisetum* Hortob.	1270,14	2,07
40	*Monoraphidium contortum* (Thur.) Kom. Legn.	2037,21	3,10
41	*Binuclearia lauterbornii* (Schmidle) Pr.-Lavr.	2375,41	2,86
42	*Monoraphidium griffithii* (Berk.)Kora.Legn.	2808,52	5,60
	Cyanophyta		
43	*Anabaena subcylindrica* Borge	845,01	52,55
44	*Microcystis marginata* (Menegh.) Kutz.	1113,64	49,06
45	*Anabaena spiroides* Kleb.	1122,52	61,46
46	*Gloeocapsa cohaerens* (Breb.) Hollerb.	1581,76	120,11
47	*Aphanizomenon issatschenkoi (*Ussaczev) Pr.-Lavr.	1601,36	117,00
48	*Gomphosphaeria lacustris* Chodat	1917,56	135,99
49	*Oscillatoria geminata* Menegh.	2229,15	82,86
50	*Merismopedia punctata* Meyen B	2698,11	102,11
51	*Aphanothece clathrata* W. et G. S. West.	2835,18	114,66
52	*Merismopedia minima* G. Beck	5804,40	284,32
	Multi-celled algae		
	Phaeophyta		
53	*Ectocarpus confervoudes* (Roth.) Le Jolis.	172,90	4,10
54	*Scytosiphon lomentaria* (Lyngb.) J. Ag.	27,04	0,59
55	*Punctaria latifolia* Grev.	*22,74*	1,47
	Rhodophyta		
56	*Bangia fuscopurprea* (Dillw.) Lyngb.	88,31	3,42
57	*Porphyra leucosticta* Thur.	63,05	2,36
58	*Kylinia virgatula* (Harv.) Papenf.	270,7	4,20
59	*Ceramium rubrum* (Huds.) Ag.	25,32	1,23

60	*Ceramium elegans* Ducl.	26,17	1,14
61	*Callithamnion corymbosum* (J. E. Smith) Lyngb.	165,00	4,21
62	*Polysiphonia denudata* (Dillw.) Kutz.	56,98	1,29
63	*Polysiphonia elongata* (Huds.) Harv.	20,8	3,6
	Chlorophyta		
64	Ulothrix implexa *(Kutz.) Kutz., 1849*	317,80	7,01
65	*Ulothrix zonata* (Web. Et Mohr) Kutz.	150,00	4,29
66	*Enteromorpha clathrata* (Roth.) Grev., 1830	61,83	3,54
67	*Enteromorpha intestinalis* (L.) Link, 1820	36,16	1,11
68	*Enteromorpha linza* (L.) J. Ag., 1882-1883	39,00	1,8
69	*Ulva rigida* Ag., 1822	36,34	1,64
70	*Chaetomorpha chlorotica* (Mont.) Kutz., 1849	32,25	1,12
71	*Chaetomorpha linnum* (Mont.) Kutz., 1845	21,15	0,57
72	*Chaetomorpha. aerea* (Dillw) Kutz., 1849	28,37	0,58
73	*Rhizoclonium implexum* (Dillw.) Kutz.	219,40	5,17
74	*Cladophora vadorum* (Aresch.) Kutz.	90,89	4,27
75	*Cladophora vagabunda* (L.) Hoek.	47,82	2,84
76	*Cladophora albida* (Huds.) Kutz.	85,50	3,48
77	*Cladophora laetevirens* (Dillw.) Kutz.	46,20	2,8
78	*Cladophora liniformis* Kutz.	88,10	3,44
79	*Cladophora siwaschensis* C. Meyer.	113,14	2,24
80	*Urospora penicilliformis* (Roth) Aresch.	119,00	7,20
81	*Bryopsis plumosa* (Huds.) Ag.	23,56	1,13
	Cyanophyta		
82	*Lyngbya confervoides* C. Agardh.	318,1	2,70
83	*Calothrix aeruginea* (Kutz.) Thuret	400,00	9,80
84	*Lyngbya lutea* (Ag.) Gomont	650,00	5,30
	Thalassiophita		
85	Zostera marina L.	10,15	2,3
86	Zostera noltii *(Cavol.) Nolte*	19,77	2,15
87	Potamogeton pectinatus	6,5	1,05

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